I-73 LOCATION STUDY

BENEFIT COST ANALYSIS
TECHNICAL REPORT

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S.0 EXECUTIVE SUMMARY

S.1 INTRODUCTION

A Benefit Cost Analysis (BCA) is a systematic economic means of measuring or comparing the economic feasibility of investments. A BCA measures the direct benefits and costs that a project causes or creates for highway agencies, travelers (users), and, to some non-users affected by the project. Direct benefits and costs are the first order or immediate impacts of the transportation project on users and non-users, and include changes in travel time, accidents, vehicle operating costs, agency construction costs, and pollution costs. The BCA does not measure or determine indirect impacts on the economy, such as changes in employment, wages, business sales, or land values or use. These broader indirect impacts can be measured using an economic impact analysis which is not a part of this report.

A BCA is used in highway-decision making, to answer the following questions; 1) which among the many project alternatives should be considered, 2) which should not be considered and or 3) when does it make sense to consider these projects? However, a BCA does not answer the question of how a project should be funded because a BCA is not the same as financial analysis. While a project cannot survive without strong financial backing, the economic measure of a project as measured by BCA is generally not affected by how the project is financed. Accordingly, this technical report only looks at the economic feasibility of the project and does not include financial feasibility analysis.

S.2 METHODOLOGY

Benefit-Cost methodology used in this project is consistent with the methodology recommended and accepted by various government agencies, including the FHWA. The methodology is based on the 1977 AASHTO "Manual on User Benefit Analysis of Highway and Bus-Transit Improvements", also known as the "1977 Redbook". A computer software application known as MicroBENCOST, which was developed by the Texas Transportation Institute based on the 1977 Redbook, was used in this process.

The MicroBENCOST program estimates the benefit by comparing the continuing cost of an existing facility to the cost of a proposed facility. Detailed documentation is available with the software and for brevity's sake will not be discussed in this report. For more information the reader is directed to the input and output data listed in the Appendix. . The remainder of this report outlines the framework for analysis, discusses the components included in the analysis, and outlines the inputs and the results of the analysis.

The benefits of the proposed new facility are compared to the existing facility or base case.

- Base Case: The base case is the existing I-581/US220 corridor between I-81 in Roanoke, VA and VA/NC state line. The base case serves the cities of Roanoke and Martinsville; the towns of Boones Mill, Rocky Mount and Ridgeway as well as the unincorporated community of Sydnorsville. Except for the 6-lane expressway standard in Roanoke and the Martinsville Bypass in Henry County, the majority of US220 is a 4-lane divided rural arterial.
- Proposed Facility: The proposed I-73 facility known as the Adopted Location Corridor or ALC is primarily a 4-lane interstate. A major portion of the ALC is in a rural setting and on new alignment. The section from I-81, through Roanoke is in an urban setting and involves widening and upgrading the existing I-581 and US220.

Benefits included in this analysis are savings measured in dollars as a result of reductions in travel-time, vehicle operating costs, and accidents. These are briefly described as follows:

- Travel Time Savings: Estimating the value of time is a research project in itself because it is based on the purpose of travel and location (including origin and destination) and the magnitude of savings. For

example, an hour of business travel is valued higher than non-business travel; the value of an hour of time is higher in urban areas than in rural locations; value of freight (trucks) is higher than autos. MicroBENCOST considers any time saving a benefit.

- Passenger and commercial vehicles: For the purpose of this analysis two values of travel time were used; autos and commercial vehicles. Based on USDOT recommendation (Feb 23, 2003 memorandum) a composite value of $15.00 and $19.91 were used for auto and commercial vehicles respectively. The model calculates the amount of time saved by people using the new facility. This time saving is then multiplied by the *value of time.*

- Vehicle Operating Cost Savings: The model calculates the cost of operating a vehicle. The various vehicle operating cost components (fuel, oil) and maintenance cost (wear and tear, regular maintenance) is dependent on the highway facility (example are, surface condition, vertical and horizontal alignment, and traffic conditions). Average vehicle operating cost per mile ranges between $0.30 and $0.40 for autos and between $0.50 and $1.75 for commercial vehicles. The BCA software documentation has a detail cost breakdown by operating cost categories and vehicle types.

- Accident Cost Savings: In order to quantify economic benefit, the model estimates the number of accidents that could be prevented by the new highway and multiplies it by a dollar value assigned to the type of accident. Research by USDOT, FHWA, and National Transportation Institute (NTI) recommends using $2.7 million to $3.0 million for reducing each fatal accident. A value of $3.0 million savings per fatal accident was used in this analysis. Similarly, a value of $24,800 and $2,100 was used for injury and property damage only accidents respectively.

There are costs associated with the I-73. The two major cost components used in the analysis were the initial capital cost (e.g. construction) and the increase in periodic maintenance and rehabilitation costs. These are described as follows:

- Construction Cost: One of the major capital costs is the construction of the new facility. Cost of construction is estimated in constant dollars (excludes the impact of inflation).

- Maintenance and Rehabilitation Cost: Any facility, old or new, has to be maintained. These are real costs and they depend on the traffic volume, age and condition of the facility. The analysis used the model's default values in estimating the maintenance and rehabilitation costs.

In addition to the above, there are other direct benefits and costs that can be applied to the project. The MicroBENCOST program calculates carbon-monoxide emissions as well as the impact of induced traffic. Other variables, including periodic rehabilitation costs, salvage value, and other user costs (vehicle operating, travel-time, accident) are included as benefits (positive or negative)

Two indicators are calculated to gauge the feasibility of the project; net present value and the benefit-to-cost ratio. These terms are discussed as follows:

- Net present value (NPV): The purchasing power of a dollar today is not the same as the purchasing power of a dollar in the future. Therefore, streams of future benefit and cost assumptions, over the life of the project, are discounted to the present value or base year. The present values of costs are subtracted from the present value of benefits, resulting in the NPV. A positive NPV indicates that pursuing the project at this time makes good economic sense.

- Benefit-to-Cost ratio (BCR): The BCR ratio is calculated by dividing the present value of benefits by the present value of costs. If the ratio is greater than 1.0, the project yields more benefit than cost. Therefore, the project is worth pursuing because it makes economic sense.

Although NPV and BCR are used in this project, other measures could also be used to evaluate the economic feasibility of a project. For example the uniform equivalent annual approach converts the NPV into equal annual amounts. The internal rate of return (IRR) estimates the discount rate at which the NPV is equal to zero. However, other factors such as funding availability, local policy issues, and external risks should also be included in the final decision making process.

S.3 PROJECT STAGING AND SEQUENCING

When a project is being implemented there are many variables to manage. Large transportation projects take years to be completed and open to traffic. It is also likely that major sections of this project will be open at different times. Construction sequencing has an impact on the construction cost, traffic volume estimates and related benefits and costs. For comparative purposes, it is assumed that the project is completed today and the benefits and costs start accruing the following year for the next thirty (30) years.

This is generally accepted practice and is based on sound economic principles for the level of comparison required at this phase of the project. This assumption has the following benefits:

- It relieves the user from having to estimate future inflation to escalate construction cost.
- It eliminates making decisions as to the construction sequencing and timing of various sections of the project.
- It eliminates the need to plan and predict the incremental development as a result of newly opened sections. This includes population, employment, and other socio-economic data forecast for trip generation models.
- It saves time because traffic forecast for multiple years are not required.

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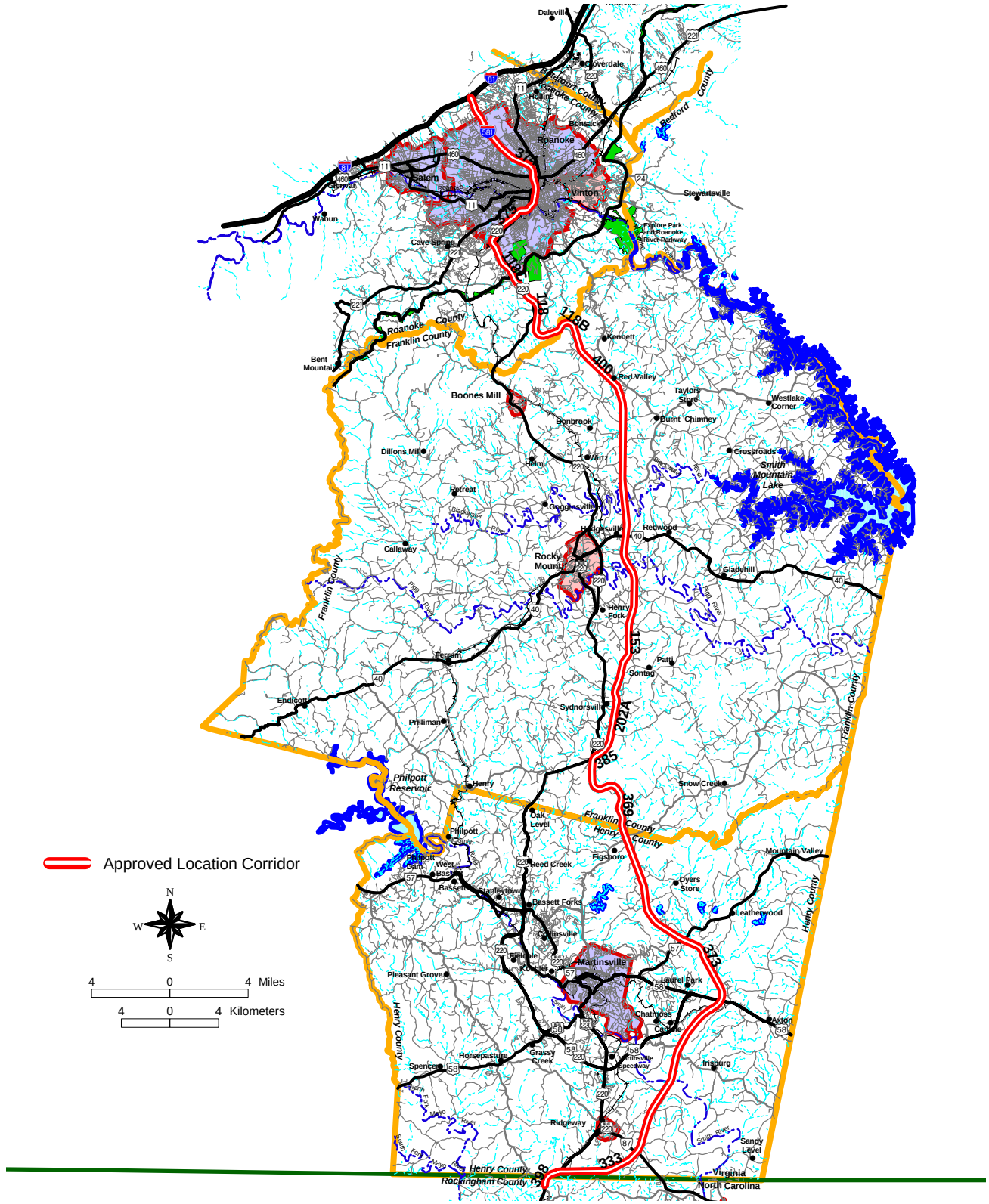
1.0 PROJECT DESCRIPTION

The focus of the BCA is to compare the changes in benefits and costs of I-73 to the base case of existing I-581/US220 between I-81 in Roanoke, VA and VA/NC state line. Existing I-581/ US220 serves Roanoke, Boones Mill, Rocky Mount, Sydnorsville, Martinsville, and Ridgeway. The new facility will be constructed to meet interstate/ freeway standards. Figure 1-1 shows the map of the Adopted Location Corridor (ALC) as adopted by the Commonwealth Transportation Board on July 15, 2004.

Figure 1-1
I-73 PROJECT MAP FOR BENEFIT COST ANALYSIS



1.1 PROJECT LIMITS

The MicroBENCOST program requires detail input data from the user. It also has built in default values. The entire I-73 corridor is approximately 71.7 miles in length and traverses an area with changing terrain type, land use development, and varying levels of improvement requirements. To facilitate the BCA and to conform to the constraints of the MicroBENCOST input parameters, the I-73 corridor was sub-divided into four sub-projects. Table 1-1 lists basic information derived from the I-73 Draft EIS published in October of 2000.

Table 1-1:
PROJECT INFORMATION USED IN BENEFIT COST ANALYSIS

Project 1	**Description**
	Project limits = From I-81 to Elm Avenue, consisting of Segment 374.
	Length = 6.3 miles
	1999 Cost = $193.3 Million
	Type = Improve existing freeway and interchanges for enhanced capacity and safety.
Project 2	**Description**
	Project limits = Elm Avenue to Buck Mountain near Route 668, consisting of Segments 375 and 118C.
	Length = 7.1 miles
	1999 Cost = $250.6 Million
	Type = Widen existing freeway and structures to interstate standard.
Project 3	**Description**
	Project limits = Buck Mountain near Route 668 to south of Sydnorsville, consisting of Segments 118,118B, 400, 153 and 202A.
	Length = 27.5 miles
	1999 Cost = $396.1 Million
	Type = New interstate alignment providing bypasses east of Boones Mill and Rocky Mount.
Project 4	**Description**
	Project limits = South of Sydnorsville to VA/NC state line south of Ridgeway, consisting of Segments 385, 369, 373, 333 and 398.
	Length = 30.8 miles
	1999 Cost = $458.31 Million
	Type = New interstate alignment providing bypasses east of Martinsville and Ridgeway.

1.2 ASSUMPTIONS

Data input for the MicroBENCOST program could be grouped into three broad categories; global data, route specific data, and segment specific data. The following section provides a summary of the critical data. A detail description of other input data is included in the program documentation.

1.2.1 Global project data variables

Global variables apply to the entire project regardless of the facility type, type of improvements, traffic conditions, and location. Some types of global variables are as follows:

- Discount rate – This is the rate used to discount all future streams of benefits and costs to the base year, present value. Choice of discount rate has a direct impact on whether the investment in the project makes economic sense – does the benefit outweigh the cost. Historically, US Office of Management and Budget (OMB) have recommended using a discount rate of 7.0%. However, this rate is being evaluated and OMB has provided some guidance to federal agencies in using lower rates for BCA analysis based on Federal borrowing costs. In January 2003, OMB reported 10 and 30-year historical rates at 2.5% and 3.2%. In November of 2004, 30 year Treasury bonds were sold with a yield of 4.84%.
- Analysis period – Federal guidance in BCA, especially of major infrastructure investments, is to include and compare the streams of benefits and costs for 30-years.
- Base year – Project's benefits and costs are discounted to a common base year which is 2004 for this analysis. The 1999 capital costs developed in the DEIS were revised to reflect current year costs (2004) and illustrated in Tables 2-1, 2-2 and 2-3.
- Traffic forecast for interim years uses the annual growth rate method based on base year and forecast year (2020 and 2025) traffic.

1.2.2 Route level data variables

These variables are specific to the route being studied and it is required for existing and proposed routes. Some examples of major route level variables are area type (urban or rural), type of improvement (widening, new location, etc.), traffic composition (autos and trucks) and growth rate, through traffic and growth rate, facility type, and number of segments.

1.2.3 Segment level data variables

Both the base case and the ALC can be divided into multiple segments of uniform characteristics. The number segments used per facility (existing and proposed), per route, is directly proportional to the amount of work, input data, and time needed for analysis. Guidelines used in developing segments for this project include:

- A particular route could have segments based on varying horizontal curves and vertical grade alignments.
- Segments could be defined by varying amounts of traffic volume and congestion levels.
- Some segments could be required based on access types; full access control (restrictive access) and/ or curb-cuts with minimum/ no access control.
- Minor/ cross-street variation in traffic volume, roadway geometry, and operational conditions could also warrant more segments.

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2.0 RESULTS

As discussed in the earlier section, MicroBENCOST requires detailed input data for the base case and the ALC. Based on the input provided by the user, the program provides detailed output. It reports costs "before" and "after" improvements on both base case and proposed facilities. Then it calculates the savings/ benefits by comparing the "before" and "after" costs. In addition, the model also calculates summary of benefits, costs, and measures of economic feasibility. Table 2-1 shows a summary of the discounted benefits, costs, and the key economic measures for the proposed I-73 Corridor.

Capital cost includes the cost of constructing the facility. Benefits represent the difference in travel time cost, vehicle operating cost and accident costs between the base case and the ALC. Agency cost is the cost incurred by VDOT, calculated as the total cost of construction plus maintenance and operation less the salvage value. NPV, net present value, is the difference between the discounted user benefit and discounted agency cost. BCR, benefit-cost-ratio, is the ratio derived by dividing the discounted user benefit by the discounted agency cost.

Table 2-1: SUMMARY OF USER BENEFIT AND COST

(Millions of 2004 Dollars using 7% Discount Rate)

Measures	Project 1	Project 2	Project 3	Project 4	All Projects
Capital Cost	$213.489	$276.773	$437.512	$506.112	$1,433.886
Benefits	$290.016	$293.132	$558.703	$323.522	$1,465.374
Agency Cost	$189.075	$242.961	$412.59	$474.122	$1,318.757
NPV	$100.941	$50.171	$146.104	($150.599)	$146.617
BCR	1.534	1.206	1.354	0.682	1.110

Project 1: I-81 to Elm Avenue
Project 2: Elm Avenue to Rte 668
Project 3: Rte 668 to Sydnorsville
Project 4: Sydnorsville to VA/NC state line

Table 2-1 shows that Project 1 (Between I-81 and Elm Avenue) has a positive NPV and a BCR over 1.0. This is an urban section through the City of Roanoke carrying between 75,000 and 95,000 vehicles per day. The benefit to the existing traffic in terms of higher level of service and faster travel time at comparatively smaller improvement cost produces these positive results.

Project 2 (between Elm Avenue and Rte 668) carries between 35,000 and 56,000 vehicles per day. This section has more structures and goes through the Blue Ridge Parkway just north of Rte668. Although Project 2 has a positive NPV and BCR higher than 1.0, because the total cost to the agency is much higher it results in a lower NPV and BCR as compared to Project 1.

Project 3 (between Rte668 and Sydnorsville) shows a positive NPV and a BCR higher than 1.0. This section provides an alternative to US220 and acts as a bypass of Boones Mill, Rocky Mount and Sydnorsville. The new facility (I-73) and the existing US220 are almost equal in distance, but I-73 provides a faster travel option. Existing traffic benefits from travel time savings provided by the new facility.

Table 2-1 shows that Project 4 (between Sydnorsville and VA/NC state line) has a negative NPV and BCR less than 1.0. This section is almost 30 miles in length (existing facility is 28 miles in length) and serve as a bypass on the east side of Martinsville. Martinsville already has a bypass on the west side and carries approximately 18,000 vehicles per day. The negative NPV and less than 1.0 BCR is a result of low traffic volume, negligible travel time savings, a large capital investment, and increased cost of maintaining the existing western bypass plus the proposed eastern bypass.

In summary, using a 7.0 percent discount rate, the total project BCR of 1.110 provides a clear indication that this is an economically viable long-term investment. A sensitivity analysis was conducted to test the impact of the changes in the travel demand and discount rate.

2.1 SENSITIVITY ANALYSIS

The result of the BCR is only as good as the assumptions that go into the analysis. Some of the assumptions such as the discount rate and traffic forecasts have a direct and material impact on the outcome of the analysis. Therefore, a sensitivity test was conducted to test the impact of the change in traffic forecast and the discount rate.

- Traffic volume – Travel on an interstate highway saves time and money. The traffic forecast is directly correlated to the amount of benefits derived from this investment. Traffic forecasts could be higher or lower than estimated volumes. Therefore a conservative approach was taken to gauge the impact of under-estimating traffic volume by ten (10) percent. Table 2-2 shows that if traffic forecast was reduced by ten percent, the sections north of Sydnorsville still exhibit a positive NPV and a BCR greater than 1.0. As expected, the section south of Sydnorsville shows a negative NPV and BCR less than 1.0. However it should be noted that the ten (10) percent change in traffic volume is not significant and the entire project still exhibits a BCR greater than 1.0.

Table 2-2: SENSITIVITY TEST
TRAFFIC FORECAST/GROWTH REDUCED BY 10%

Summary of User Benefit and Cost (Millions of 2004 Dollars using 7% Discount Rate)					
Measures	**Project 1**	**Project 2**	**Project 3**	**Project 4**	**All Projects**
Capital Cost	$213.489	$276.773	$437.512	$506.112	$1,433.886
Benefits	$283.366	$290.415	$558.355	$313.332	$1,445.468
Agency Cost	$189.075	$242.961	$412.599	$474.122	$1,318.757
NPV	$94.291	$47.454	$145.756	($160.789)	$126.712
BCR	1.499	1.195	1.353	0.661	1.096

Project 1: I-81 to Elm Avenue
Project 2: Elm Avenue to Rte 668
Project 3: Rte 668 to Sydnorsville
Project 4: Sydnorsville to VA/NC state line

- Discount Rate – The OMB's recommended 7.0% discount is very conservative and has not changed in 10 years despite the lower interest environment that has dominated the money market recently. As discussed in the earlier section, in January 2003, OMB reported 10 and 30-year historical rates at 2.5% and 3.2% respectively. In the last week of November 2004, 30 year Treasury bonds were sold with a yield of 4.84%. Therefore, a discount rate of 4.84% was used in the sensitivity test. Table 2-3 indicates the impact of a lower discount rate. Although the section south of Sydnorsville still shows a negative NPV, the BCR is very close to unity. The overall project now has a positive NPV of $621 million and a 1.517 BCR. Therefore, at a discount rate of 4.84%, the proposed project makes more economic sense.

Table 2-3: SENSITIVITY TEST
DISCOUNT RATE OF 4.84%

Summary of User Benefit and Cost (Millions of 2004 Dollars using 4.84% Discount Rate)					
Measures	**Project 1**	**Project 2**	**Project 3**	**Project 4**	**All Projects**
Capital Cost	$213.489	$276.773	$437.512	$506.112	$1,433.886
Benefits	$355.873	$366.761	$677.789	$424.609	$1,825.032
Agency Cost	$169.190	$216.213	$381.268	$436.726	$1,203.398
NPV	$186.684	$150.548	$296.521	($12.117)	$621.636
BCR	2.103	1.696	1.778	0.972	1.517

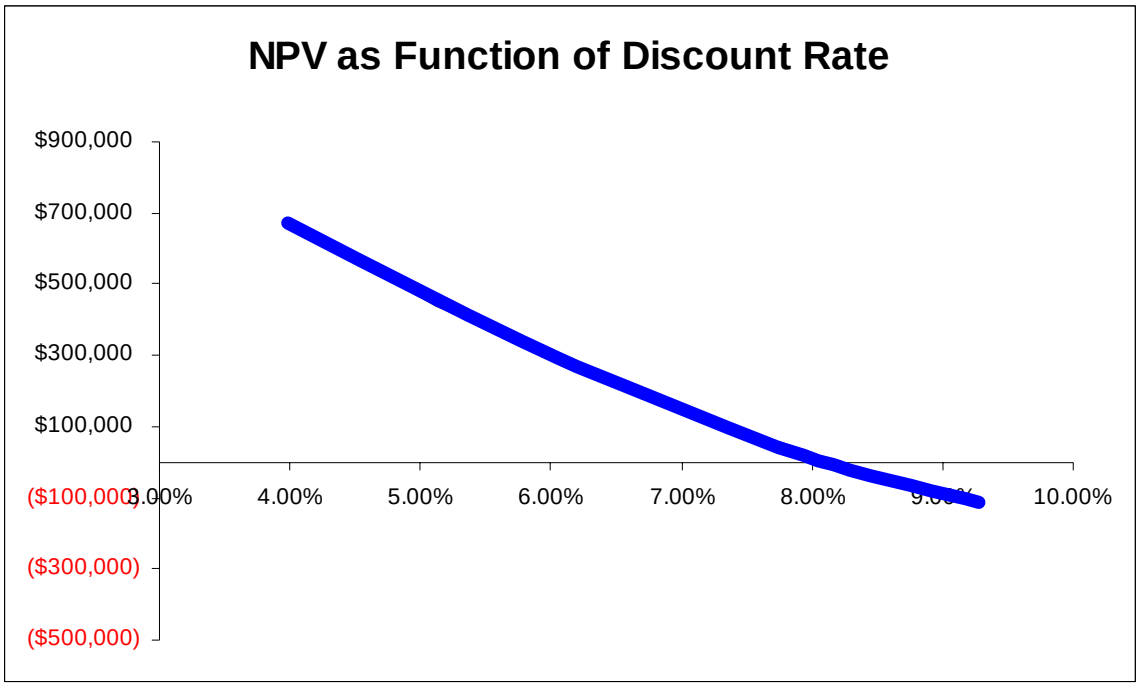
Project 1: I-81 to Elm Avenue
Project 2: Elm Avenue to Rte 668
Project 3: Rte 668 to Sydnorsville
Project 4: Sydnorsville to VA/NC state line

2.2 CONCLUSIONS

There are many factors in determining the feasibility of a project. Some are tangible factors such as benefits from reduction in travel time, vehicle operating costs, and accident costs. These factors have been addressed in the foregoing analysis. However, there are intangible factors such as funding availability, local policy issues, external risks, and other indirect benefits that are more subjective and not easily quantifiable. These factors have not been included in the above analysis. Therefore the following conclusions are based within the context of the analysis as discussed above.

- The ALC makes good economic sense and is a sound investment at discount rates of 8% or lower (see Figure 2-1). The northern segments individually perform better at higher discount rates due to their lower marginal costs and higher travel demand or utilization. The southernmost segments have a lower BCR because of the higher construction costs and materially less travel demand. However, the southern segments are expected to yield indirect economic benefits to the City of Martinsville, Danville, and surrounding area. Indirect benefits such as employment, land valuation and fiscal revenues collected by local governments are not captured in this analysis.
- Sections south of Sydnorsville show a negative NPV and BCR less than 1.0. However, this should not be used to change the project limits because traffic forecasts for other sections assume that this southern section is also constructed.
- When using the very conservative 2000 FHWA discount rate of 7.0% a BCR of 1.110 results. Although the BCR is greater than 1.0, other factors and impacts as measured by broader a based economic impact analysis could be taken into consideration for a comprehensive picture of the indirect benefits such as employment, tax revenues, land valuation and development activity.
- Figure 2-1 illustrates that if everything is held constant, investment in the proposed I-73 project is a sound economic decision based solely on direct costs and benefits. The graph indicates that the entire project exhibits a positive NPV and BCR greater than 1.0 at discount rates up to 8.0 percent.
- Underestimating future traffic volume does not have a major impact in the outcome of the analysis. A 10% reduction in forecast traffic growth on the proposed I-73 facility still results in a positive NPV and BCR greater than 1.0.

Figure 2-1: **NET PRESENT VALUE VERSUS DISCOUNT RATE**



Values along vertical axis are in thousands of dollars ($000)

Benefit Cost Computer Run Printouts Are Available upon Request