APPENDIX A
Interstate Needs

Introduction

This edition of the C&P report includes the results of a study on Interstate Needs required by Section 1107(c) of the Transportation Equity Act for the 21st Century (TEA-21). The three required elements of the study contained in this Appendix are: First, to determine the expected condition of the Interstate System over the next 10 years and the needs of States and Metropolitan Planning Organizations to reconstruct and improve the Interstate System; second, to determine the resources necessary to maintain and improve the Interstate System; and third, to determine the means to ensure that the Nation's surface transportation program can address the needs identified in this Appendix, and to allow for States to address any extraordinary needs.

This appendix begins with a brief description of the current conditions and performance of Interstate Highways and Bridges based on 1997 data. This is followed by a discussion of the analytical processes used to project expected Interstate conditions in 2007. Rural and Urban Interstate Highways are examined separately, to show the impact that different levels of highway reconstruction and 3R (restoration, rehabilitation, and resurfacing) would have on average pavement roughness, and on the miles of pavement in poor condition. The analysis then expands to also consider the impact of widening improvements, and evaluates the impacts that different levels of investment would have on both Interstate pavement condition and operational performance. An analysis of Rural and Urban Interstate Bridges identifies the level of investment for bridge replacement and bridge rehabilitation required to maintain and improve bridge conditions. This section of the report concludes by combining the results of the highway and bridge analyses.

The third section of this appendix identifies the resources needed to Maintain and Improve the Interstate System over the next 10 years, and compares these needs with projected spending levels from 1998 through 2007. This is followed by an analysis examining how the structure and funding levels for the components of the Federal-aid Highway Program align with Interstate System needs.

Background

The Dwight D. Eisenhower System of Interstate and Defense highways, from its inception to its fulfillment as the foundation for the national Highway system, has more than achieved its founders' expectations. It has provided a rapid and efficient means of travel to the American public, allowed the growth of a highly efficient trucking industry, and formed a transport infrastructure foundation for the nation's economic growth and development.

It has been more than 40 years since the establishment of the Highway Trust Fund for financing of the nation's highways, in particular the Interstate system. What better time to look at the condition and performance of this system, the core of the more recently enacted National Highway System. It is also a good time to look at the investment requirements to maintain and improve this system.

The Interstate system has served its purposes well. In many instances, anticipated usage levels of the system were reached as much as a decade earlier than expected by the planners. America's reliance on the Interstate system creates major challenges for transportation agencies. The system has provided a reliable basis for long distance surface movement and has been fully integrated into the freight logistics of major producers and suppliers. Consequently, the reliability of the system and the preservation of its physical assets are key policy and programmatic concerns for the entire transportation community.

For long- and medium-distance travel by automobile and for freight movement by truck, the system is aiding the mobility and productivity of the nation. In spite of congestion in the larger metropolitan areas, travel on the Interstate system is usually faster than on the alternative street systems.

Much of the pavement on the Interstate system was constructed 20 to 40 years ago. However, some highways with even older pavements—mostly in the Northeast—were incorporated into the system to provide logical connectivity without increasing the cost of the system for highway users. Some of the pavements have been completely reconstructed over the years. Some are still fairly new. Some have been resurfaced one or more times. Most have undergone some form of rehabilitation, restoration, resurfacing, or reconstruction since the original construction.

Interstate pavement condition and congestion data used in this study are taken from the Highway Performance Monitoring System (HPMS), a database that has been in place since 1978. The States furnish data annually for all of the Interstate and other arterial systems and most of the collector roads. This is a sample section database that provides a statistically valid sample of each of the categories of highway in the data system. More that half of all Interstate mileage is included in the sample sections. Thus, the Interstate is well represented in the HPMS database.

The National Bridge Inventory (NBI) contains data for each public road bridge in the nation. This database is updated on a continuing basis by the States. Most bridges are inspected every two years, and the data from these inspections are reported to the Federal Highway Administration and incorporated into the NBI. Deficient bridges are classified as structurally deficient or functionally obsolete. A structurally deficient bridge is one that has been restricted to light vehicles (no heavy trucks), one that requires immediate rehabilitation to remain open, or is closed. A functionally obsolete bridge has deck geometry, load carrying capacity, clearance, or approach roadway alignment that no longer meets the criteria for the system of which the bridge is a part, in this case the Interstate system.

For many years congestion has been a growing problem on urban Interstates and on Interstate routes approaching and connecting major metropolitan areas. However, congestion is difficult to measure. Historically the ratio of the volume of traffic to the capacity of the roadway to accommodate that volume has been used as a measure of the severity of congestion. This measure addresses only the peak hour of travel. Delay to the user of the system is now being used in an effort to measure the effects of congestion throughout the day. However, it is difficult to measure delay. The current procedures are based on modeling of speed and delay, and are subject to revisions in the future. Other measures, such as reliability, have been proposed. Reliability is the consistency of the travel time between any two points. This is also difficult to measure, and is not included in this report. The volume of travel per lane, such as VMT per lane-mile, is a measure of the density of travel and is information that is readily available. While it is not directly a measure of congestion, it does provide a valuable indication of travel density on the system.

This study evaluates current conditions and performance of the Interstate system roadways and bridges, and analyzes these data to project the investment requirements for the next 10 years to maintain and improve the system.

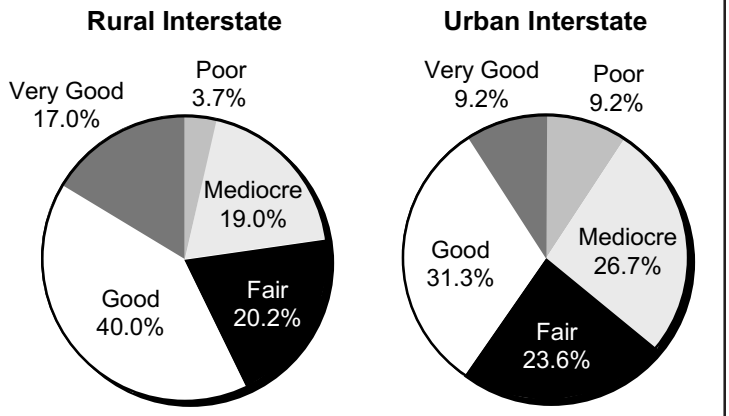
Highway Conditions

Chapter 3 discusses the current highway and bridge conditions for all functional systems, including Interstate highways. Exhibits 3-9 and 3-10 show trends in pavement condition for Rural Interstates and Urban Interstates from 1993 to 1997. The 1997 data are highlighted in Exhibit A-1.

In 1997, 96.3 percent of rural Interstate mileage met the *Federal Highway Administration 1998 National Strategic Plan* standard for "acceptable ride quality" having an International Roughness Index (IRI) value of less than or equal to 170 inches per mile. The remaining 3.7 percent of rural mileage is identified as having "poor" pavement in Exhibit A-1. Of urban Interstate mileage, 90.8 percent was classified as having "acceptable ride quality" and the remaining 9.2 percent is identified as "poor" pavement in Exhibit A-1. The percentage of Interstate pavement with acceptable ride quality has increased in recent years.

Exhibit A-1

Interstate Pavement Condition, by Percent Total Miles, 1997



Condition Term	Very Good	Good	Fair	Mediocre	Poor
IRI Rating (inches/mile)	<60	60 - 94	95 - 119	120 - 170	> 170

The average IRI reported for HPMS sample sections on rural Interstates was 93 inches per mile, which falls in the "good" range in Exhibit A-1. The average IRI for urban Interstate sections was 114, which would be classified as "fair."

Lane Widths, Curves, Grades, and Access Control

Chapter 3 also discusses other factors that affect the level of service and safety of the highway system. *[See Exhibits 3-14, 3-15, 3-17, and 3-18.]* Rural and Urban Interstate Lane Width are shown in Exhibit A-2. In 1997, 99.8 percent of rural interstate mileage had lane widths of 12 feet or wider. For urban Interstate mileage, 99.4 percent met or exceeded the 12 foot standard.

Exhibit A-2

Rural and Urban Interstate Lane Width, 1997

Rural Lane Width			Urban Lane Width		
10 foot	11 foot	12 foot+	10 foot	11 foot	12 foot+
0.0%	0.2%	99.8%	0.1%	0.5%	99.4%

Exhibit A-3 shows the horizontal and vertical alignment adequacy for rural Interstate highways. Of total rural Interstate highways mileage, 95.5 percent is rated as "Code 1" for horizontal alignment, meaning that all curves meet appropriate design standards. The remaining 4.5 percent are below design standards. For vertical alignment, 93.0 percent of rural Interstate mileage is rated as "Code 1," meaning that all grades meet appropriate design standards. The remaining 7.0 percent are below design standards.

Exhibit A-3

Rural Interstate Horizontal and Vertical Alignment, 1997

Rating	Horizontal Alignment	Vertical Alignment	Description
Code 1	95.5%	93.0%	All curves and grades meet appropriate design standards.
Code 2	2.4%	6.4%	Some curves or grades are below design standards for new construction, but curves can be negotiated safely at prevailing speed limits. Truck speed is not substantially affected.
Code 3	0.7%	0.2%	Infrequent curves or grades occur that impair sight distance or severely affect truck speeds. May have reduced speed limits.
Code 4	1.4%	0.4%	Frequent grades occur that impair sight distance or severely affect truck speeds. Generally, curves are unsafe or uncomfortable at prevailing speed limit, or the speed limit is severely restricted due to the design speeds of the curves.

The vast majority of Interstate mileage consists of divided highways with at least four lanes and full access control. However, in 1997 there were 1,100 miles of rural interstate that did not meet this standard, concentrated mainly in Alaska. None of Alaska's 1,034 rural Interstate miles meet this criteria. For urban Interstates, 104 miles do not meet the criteria specified; 53 of these miles are in Puerto Rico.

Highway Operational Performance

Chapter 4 includes data for several operational performance indicators. *[See Exhibits 4-3, 4-5, 4-6, 4-7 and 4-9.]* Daily Vehicle Miles of Travel (DVMT) per Lane-Mile is a basic measure of traffic density. Since 1993, rural Interstate DVMT per Lane-Mile has increased an average annual rate of 3.4 percent per year, from 3,530 to 4,952. Over the same period, urban Interstate DVMT per Lane-Mile has grown at an average annual rate of 2.0 percent, from 11,230 to 13,696.

The Volume/Service Flow (V/SF) ratio measures the volume of traffic using a highway during the peak hour and the theoretical capacity of the highway to accommodate traffic. Sections with a V/SF ratio above 0.80 are traditionally considered to be congested. In 1997, 53.3 percent of urban Interstate highways had a V/C ratio greater than or equal to 0.80, up from 52.6 percent in 1993.

Delay is another calculated measure of operational performance. In 1997, average delay on rural Interstates was 2.313 hours per 1000 vehicle miles traveled (VMT). Delay has been increasing on rural Interstates in recent years. Average delay on Interstates in small urban areas was 0.496 hours per 1000 VMT. In urbanized areas under 200,000 in population, average delay per 1000 VMT on Interstates was 0.909 hours. In urbanized areas over 200,000 in population, delay was much higher, at 2.533 hours per 1000 VMT. Delay on urban interstates has fluctuated in recent years, but 1997 delay is smaller than delay calculated using 1993 data.

Bridge Conditions

Chapter 3 also discusses the bridge deficiencies for all functional systems, including Interstate highways. Exhibit 3-29 show trends for rural Interstates and urban Interstates from 1993 to 1997. The 1997 data are highlighted in Exhibit A-4.

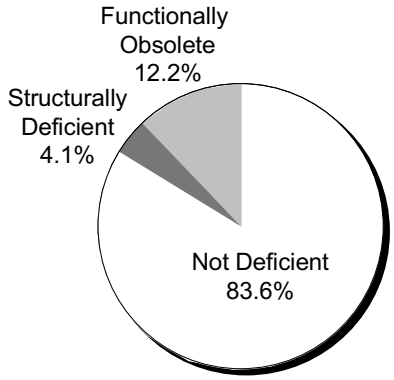
In 1998 there were 55,010 bridges on the Interstate Highway System. The number of rural and urban Interstate bridges is virtually equal, as approximately 50.0 percent of the total are in rural areas. Of the total number of rural Interstate bridges, 16.4 percent were classified as deficient, including 4.1 percent that were structurally deficient, and 12.2 percent that were functionally obsolete. In urban areas, 26.8 percent of Interstate bridges were deficient in 1998, including 6.7 percent classified as structurally deficient and 20.1 percent classified as functionally obsolete.

The percentage of deficient Interstate bridges has declined in recent years in both rural and urban areas, and for both structural and functional deficiencies. Since 1992, the number of deficient Interstate bridges has fallen from 13,725 to 11,880.

Exhibit A-4

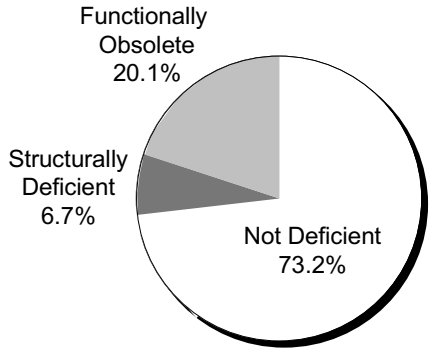
Interstate Bridge Condition, 1998

Rural Interstate



	Number	Percent
Rural Bridges	27,530	
Deficient Bridges	4,504	16.4%
Structural	1,135	4.1%
Functional	3,369	12.2%

Urban Interstate



	Number	Percent
Urban Bridges	27,480	
Deficient Bridges	7,376	26.8%
Structural	1,850	6.7%
Functional	5,526	20.1%

Projected Conditions and Performance in 2007

The future condition of the Interstate system is a function of several factors, including the current condition of the system, projected travel growth, and the level of future investment. This study uses current condition data, performance data, and travel growth projections from the Highway Performance Monitoring System (HPMS) database to predict what impact different levels of investment over the 10-year period from 1998 through 2007 would have on the Interstate system. Data from the National Bridge Inventory are used to project future Interstate Bridge conditions.

Since rural and urban Interstate data are available, and the characteristics of rural and urban Interstate routes are different, this study examines them separately. Investment requirements for highway preservation, bridge preservation and system expansion are separately identified, to facilitate more detailed analysis of physical conditions separate from operational performance. This section includes nine analyses of projected Interstate conditions and performance. The first examines the impact that different levels of investment for highway reconstruction and 3R (restoration, rehabilitation, and resurfacing) would be expected to have on rural Interstate pavement conditions. The second analysis adds widening improvements, and describes the combined effect that pavement improvements and widening improvements would be expected to have on the operational performance of rural Interstate highways. The third and fourth analyses contain comparable material for urban Interstate highways. The fifth and sixth analyses combine the earlier analyses, and examine rural/urban tradeoffs. The seventh and eighth analyses project future rural and urban bridge conditions. The ninth analysis combines the separate highway and bridge analyses and serves as the starting point for the identification of the resources required to maintain and improve the Interstate system, which is discussed in the next section.

Each separate analysis includes a table and chart showing the potential impacts of a range of different investment levels. Each table identifies the effects of continuing to invest at 1997 levels in constant dollar terms over the next 10 years, and the investment required to achieve certain performance targets. Since highway capital spending is expected to grow in constant dollar terms as TEA-21 is implemented, this section includes a simple forecast of 10-year funding levels, which is referenced in each of the analyses of future conditions and performance.

The highway condition and performance forecasts utilize the Highway Economic Requirements System (HERS), while the bridge analysis is based on the Bridge Needs and Investment Process (BNIP). These models were generally utilized in this analysis in the same manner as was used to develop the investment requirements in Chapter 7. There are differences in the results however, since Chapter 7 presents average annual values for a 20-year analysis, while this study is based on a 10-year analysis. Note that all dollar values cited in this section are stated in constant 1997 dollars.

Projected 10-Year Funding Levels for Interstate Highways and Bridges

Chapter 8 contained a projection of constant dollar highway capital spending by all levels of government for 1998-2003. This study extended this projection out to 2007 using the same basic methodology. **Note that Federal funding levels can not be accurately predicted beyond 2003, the final year covered by TEA-21.** For the purposes of this analysis, a simplifying assumption was made that Federal-aid highway obligations after 2003 would increase to keep pace with inflation, remaining at the same level as in 2003 in constant dollar terms. State and local spending was projected to increase approximately 2.8 to 3.0 percent annually in constant dollar terms from 2003 to 2007. Based

on these assumptions, total highway capital expenditures by all levels of government for all functional systems for the 10 years from 1998 to 2007 were projected to be $555.7 billion stated in constant 1997 dollars.

Current Expenditure Patterns

All levels of government spent $11.0 billion for capital improvements to Interstate highways and bridges in 1997, which constituted 22.6 percent of the $48.7 billion of capital outlay on all functional classes. Exhibit A-5 breaks down this total by type of improvement. Only the $8.4 billion expended for the preservation and widening of existing Interstate highways and bridges corresponds to the analyses included in this section. Expenditures for new construction and for system enhancements (including traffic operational improvements, safety improvements and environmental enhancements) are not modeled by HERS or BNIP, and are not discussed in this section.

Exhibit A-5

Interstate Capital Expenditures, 1997	Total Invested (Billions of Dollars)			Percent of Total	Percent of Total for all Functional Classes		
	Rural	Urban	Total	Interstate	Rural	Urban	Total
Highway/Bridge Preservation & Widening							
Work on Existing Highways							
Highway Preservation	1.6	2.5	4.0	36.7%	3.2%	5.1%	8.3%
Widening	0.6	2.1	2.6	23.9%	1.2%	4.2%	5.4%
Subtotal, Existing Highways	2.1	4.5	6.7	60.6%	4.4%	9.3%	13.7%
Bridge Work	0.4	1.3	1.7	15.6%	0.8%	2.7%	3.5%
Subtotal Work on Existing Highways & Bridges	**2.5**	**5.9**	**8.4**	**76.3%**	**5.2%**	**12.0%**	**17.2%**
New Construction	0.4	1.2	1.6	14.4%	0.7%	2.5%	3.3%
System Enhancements	0.3	0.7	1.0	9.3%	0.6%	1.5%	2.1%
Total Investment	**3.2**	**7.8**	**11.0**	**100.0%**	**6.5%**	**16.0%**	**22.6%**

Projected Interstate Funding

Exhibit A-6 applies the percentages from Exhibit A-5 to the $555.7 billion projected spending level on all functional classes. Assuming the 1997 pattern of expenditures remains unchanged, and expenditures grow at the rate predicted, approximately $126.0 billion would be used for capital improvements to Interstate highways and bridges over the 10-year period 1998 through 2007.

Exhibit A-6

Projected 10-Year Capital Expenditures on Interstates	1997 Percent of Total for all Functional Classes			Projected 10-Year Spending (Billions of 1997 Dollars)		
	Rural	Urban	Total	Rural	Urban	Total
Highway/Bridge Preservation & Widening						
Work on Existing Highways						
Highway Preservation	3.2%	5.1%	8.3%	17.8	28.4	46.2
Widening	1.2%	4.2%	5.4%	6.6	23.5	30.1
Subtotal, Existing Highways	4.4%	9.3%	13.7%	24.4	51.9	76.4
Bridge Work	0.8%	2.7%	3.5%	4.6	15.2	19.7
Subtotal Work on Existing Highways & Bridges	**5.2%**	**12.0%**	**17.2%**	**29.0**	**67.1**	**96.1**
New Construction	0.7%	2.5%	3.3%	4.2	14.0	18.2
System Enhancements	0.6%	1.5%	2.1%	3.3	8.4	11.7
Total Investment	**6.5%**	**16.0%**	**22.6%**	**36.5**	**89.5**	**126.0**

Expected Rural Interstate Pavement Condition in 2007

Exhibit A-7 shows the impact that different levels of highway reconstruction and 3R investment would have on average rural interstate IRI. Note that all dollar values cited in this analysis are stated in constant 1997 dollars.

As indicated in Exhibit A-5, in 1997, all levels of government spent approximately $1.6 billion for rural Interstate roadway preservation. If this type of investment grows only by the rate of inflation over the next 10 years, cumulative investment for the 1998-2007 period would be $15.5 billion. As shown in Exhibit A-7, at this level of investment, average IRI would be expected to worsen by 23.7 percent, increasing from 93 to 115 inches per mile. This would represent a shift in average pavement condition from "good" to "fair," using the verbal descriptions shown in Exhibit A-1. Note that the average IRI values shown in Exhibit A-7 and in subsequent exhibits are weighted by VMT rather than by mileage. This approach emphasizes the impact that pavement conditions have on highway users, who bear the costs of driving on poor pavement, rather than on highway agencies, who bear the costs of repairing poor pavement. The current average IRI of 93 represents the pavement roughness that the average vehicle traveling on rural Interstate highways experiences. If current levels of investment are maintained in constant dollar terms, the percent of VMT occurring on roads with an IRI greater than or equal to 122 would increase from 18.9 percent to 37.9 percent.

As shown in Exhibit A-7, system preservation investment on rural Interstates would need to reach $21.2 billion over 10 years in order to maintain average IRI at 93 inches per mile. To prevent an increase in the percentage of VMT on roads with an IRI greater than or equal to 122 would require a cumulative investment from 1998 through 2007 of $20.2 billion. The $25.0 billion on the first line of the table represents the maximum amount that could be economically invested for rural Interstate system preservation.

Projected Pavement Conditions at Forecast Funding Levels for 1998-2007

As indicated earlier, this study projects that highway capital outlay on all functional systems will total $557.5 billion (1997 dollars) for the 10-year period from 1998 through 2007. In 1997, 3.2 percent of total highway capital outlay by all

Q. **How does the projected split between reconstruction and 3R compare with current spending patterns on rural Interstates?**

A. In 1997, 11 percent of rural Interstate highway system preservation spending went for reconstruction. The pattern of investment derived from HERS shown in Exhibit A-7 suggests that if current spending levels are maintained for 10 years, only 5 percent will be needed for reconstruction. The exhibit also shows that at higher levels of investment, less reconstruction would be needed, presumably because performing needed 3R work in a timely fashion reduces the need for major reconstruction.

Part of the difference between the values shown in Exhibit A-7 and current spending data provided by States may be the result of differences in the way States distinguish between reconstruction and 3R, versus the approach HERS uses.

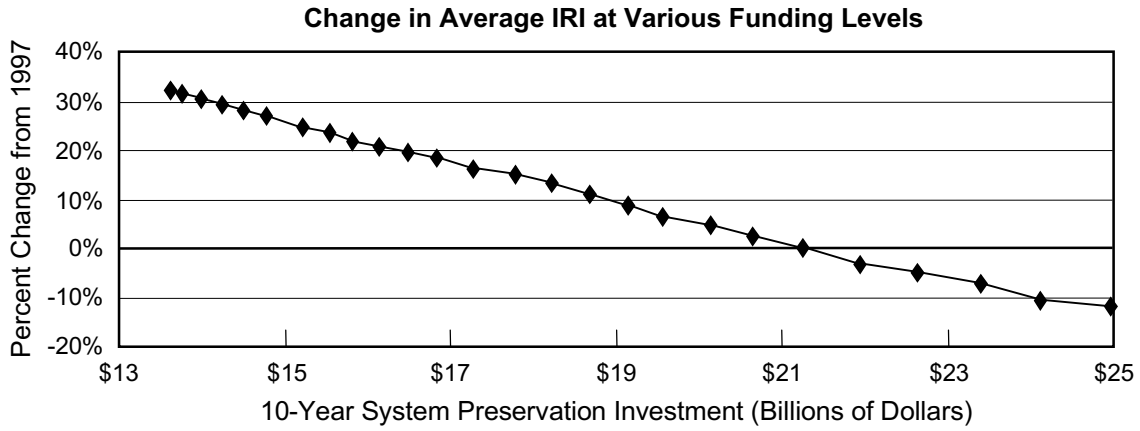
Q. **Does the IRI threshold of 122 shown in Exhibit A-7 have any special significance?**

A. No. As part of its internal calculations, HERS utilizes a PSR threshold value roughly equivalent to an IRI of 122 and shows the percentage of pavement that does not meet this threshold as part of its standard output. However, this value has no special significance in terms of the verbal descriptions of pavement shown in Exhibit A-1. This threshold includes all of the pavement identified as "poor" in Exhibit A-1 and most of the pavement identified as "mediocre".

This percentage was included in Exhibit A-7 to show the impacts of various levels of investment on one end of the IRI scale, and provide a broader perspective than could be obtained by looking at average IRI alone.

Exhibit A-7

Projected Rural Interstate Pavement Condition in 2007, for Different Possible Funding Levels



Total 10-Year System Preservation Investment (Billions of 1997 Dollars)			Average IRI (Weighted by VMT)		Percent of VMT on Roads with IRI>=122		Funding Level Description: Investment Required to Maintain…
Total	Recon-struction	3R	IRI in Inches per Mile	Percent Change from 1997	Percent	Change from 1997	
25.0	0.5	24.4	82	-11.8%	1.8%	-18.6%	
24.1	0.6	23.5	83	-10.8%	3.3%	-17.1%	
23.4	0.6	22.8	86	-7.5%	5.7%	-14.8%	
22.6	0.7	22.0	88	-5.4%	8.2%	-12.2%	
21.9	0.7	21.3	90	-3.2%	10.7%	-9.8%	
21.2	0.6	20.6	93	**0.0%**	13.9%	-6.6%	...Average IRI
20.7	0.7	20.0	95	2.2%	16.5%	-4.0%	
20.2	0.7	19.4	97	4.3%	18.9%	**-1.6%**	…VMT with IRI>=122
19.6	0.7	18.8	99	6.5%	21.4%	0.9%	
19.1	0.7	18.4	101	8.6%	23.6%	3.1%	
18.7	0.7	18.0	103	10.8%	25.1%	4.6%	
18.2	0.7	17.5	105	12.9%	27.7%	7.3%	
17.8	0.7	17.1	107	15.1%	29.9%	9.4%	
17.3	0.7	16.6	108	16.1%	31.4%	10.9%	
16.8	0.7	16.1	110	18.3%	32.7%	12.3%	
16.5	0.7	15.8	111	19.4%	33.9%	13.5%	
16.1	0.7	15.5	112	20.4%	35.3%	14.8%	
15.8	0.6	15.2	113	21.5%	36.7%	16.2%	
15.5	0.7	14.9	115	23.7%	37.9%	17.5%	…Spending at 1997 Level
15.2	0.7	14.5	116	24.7%	39.6%	19.1%	
14.8	0.7	14.1	118	26.9%	41.0%	20.5%	
14.5	0.7	13.8	119	28.0%	42.1%	21.6%	
14.2	0.7	13.5	120	29.0%	43.7%	23.2%	
14.0	0.8	13.2	121	30.1%	45.1%	24.6%	
13.8	0.8	13.0	122	31.2%	46.0%	25.6%	
13.6	0.8	12.8	123	32.3%	46.7%	26.3%	
			93		20.5%		1997 Values

levels of government was used for system preservation on rural Interstates. If this percentage is maintained in the future, approximately $17.8 billion would be spent for rural interstate system over the next 10 years, as shown in Exhibit A-6. Based on Exhibit A-7, this level of investment would be

expected to result in average IRI increasing (worsening) by 15.1 percent from 93 to 107 inches per mile, moving from the "good" to the "fair" range. The percent of VMT on roads with IRI>122 would be expected to increase to 29.9 percent. Note that the projections of 10-year capital outlay by all levels of government are based on certain simplifying assumptions about future Federal, State and local funding patterns. Federal funding beyond 2003 has yet to be determined.

Expected Rural Interstate Pavement Condition and Performance in 2007

Exhibit A-8 combines the investment requirements shown for system preservation in Exhibit A-7 with widening improvements that have a comparable rate of return according to the benefit-cost analysis performed by HERS. The second and fourth columns in Exhibit A-8, showing preservation investment and percent change in average IRI respectively, duplicate information provided in the first and fifth column of Exhibit A-7 and are included as reference points to relate the two analyses together. All values shown in this analysis are stated in constant 1997 dollars.

Exhibit A-5 shows that in addition to the $1.6 billion spent by all levels of government on rural Interstate system preservation in 1997, another $0.6 billion was used for widening existing Interstate routes. If the combined level of investment in these two types of improvements grows only by the rate of inflation over the next 10 years, cumulative investment for the 1998–2007 period would be approximately $21.4 (stated in 1997 dollars). Exhibit A-8 does not have a row that exactly corresponds to this level of investment. The closest one is for $21.8 billion.

Effects of Investing at 1997 Spending Levels

If highway investment for the 10-year period though 2007 remains constant at 1997 levels, HERS would recommend a change in the distribution of funding between system preservation and widening. Reading across the "$21.8 billion" row in Exhibit A-8, shows that if a cumulative $21.8 billion were invested on existing rural Interstates over 10 years, the HERS analysis recommends that $19.6 billion be invested in system preservation improvements, and $2.3 billion be invested in additional lanes. However, if 1997 spending patterns were continued for 10 years, only $15.5 billion would be invested in system preservation improvements, and $6.3 billion would be invested in adding lanes. In Exhibit A-8, the row containing widening spending of $6.3 billion is much higher on the table than the row containing preservation spending of $15.5 billion. The implication of this difference is that current rural Interstate spending patterns do a much better job addressing investment requirements for widening than investment requirements for pavement, and that a greater share of future increases in funding should be directed towards system preservation. (Note that the system preservation figures cited above would include reconstruction or resurfacing of existing lanes of an Interstate route that was done in conjunction with a widening improvement.)

Assuming the $21.8 billion were invested in the manner recommended by HERS, average IRI would be expected to increase by 6.5 percent by 2007. Average travel time costs per VMT would rise 1.1 percent, and average total user costs would rise 1.3 percent. The percentage of VMT occurring on rural Interstate routes with a (V/SF) ratio greater than or equal to 0.80 would be expected to increase from 12.5 percent in 1997 to 23.3 percent in 2007.

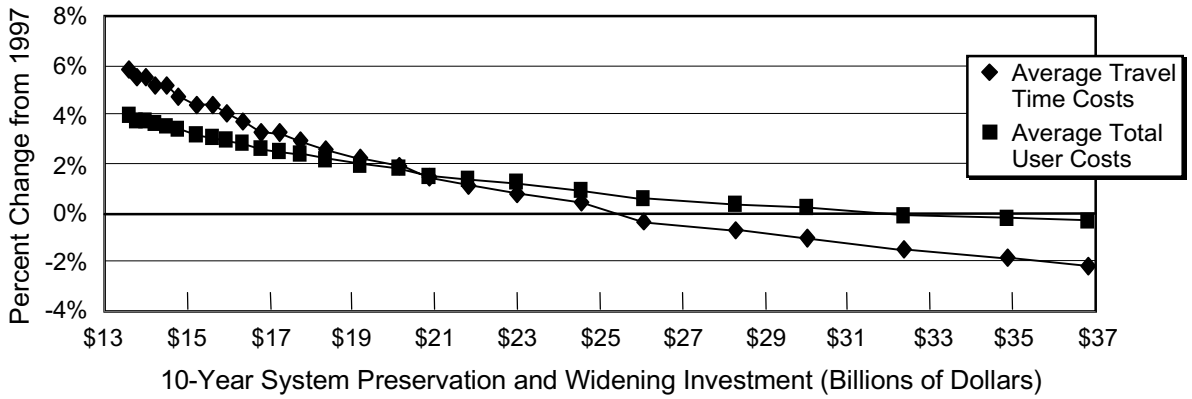
Q. **Does the V/SF ratio threshold of 0.80 shown in Exhibit A-8 have any special significance?**

A. Yes. At V/SF ratios above 0.80, travelers on the road experience significant interference with free travel flow. This is the traditional cut-off point used in the C&P report to describe congestion.

Exhibit A-8

Projected Rural Interstate Pavement Condition and Operational Performance in 2007, for Different Possible Funding Levels

Change in Average Travel Time Costs and Total User Costs at Various Funding Levels



Total 10-Year Preservation and Widening Investment (Billions of 1997 Dollars)			Percent Change from 1997			Percent of VMT on Roads with V/SF>=0.80		Funding Level Description: Investment Required to Maintain…
Total	Preser-vation	Widening	Average IRI	Average Travel Time Costs	Average Total User Costs	%	Change from 1997	
36.8	25.0	11.8	-11.8%	-2.2%	-0.4%	13.5%	3.1%	
34.9	24.1	10.7	-10.8%	-1.8%	-0.3%	14.1%	3.7%	
32.4	23.4	9.0	-7.5%	-1.5%	**-0.1%**	16.0%	5.6%	...Total User Costs
30.0	22.6	7.4	-5.4%	-1.1%	0.1%	17.4%	7.0%	
28.3	21.9	**6.3**	-3.2%	-0.7%	0.3%	18.5%	8.2%	…Widening at 1997 Level
26.1	21.2	4.8	**0.0%**	**-0.4%**	0.6%	20.5%	10.1%	…IRI & Travel Time Costs
24.6	20.7	3.9	2.2%	0.4%	0.9%	21.8%	11.4%	
23.0	20.2	2.8	4.3%	0.7%	1.2%	23.0%	12.7%	
21.8	19.6	2.3	6.5%	1.1%	1.3%	23.3%	13.0%	…Spending at 1997 Level
20.9	19.1	1.7	8.6%	1.5%	1.4%	23.7%	13.3%	
20.2	18.7	1.5	10.8%	1.8%	1.7%	24.0%	13.6%	
19.2	18.2	1.0	12.9%	2.2%	1.9%	24.7%	14.3%	
18.4	17.8	0.6	15.1%	2.6%	2.2%	25.0%	14.6%	
17.7	17.3	0.4	16.1%	2.9%	2.3%	25.1%	14.7%	
17.3	16.8	0.4	18.3%	3.3%	2.4%	25.3%	14.9%	
16.8	16.5	0.3	19.4%	3.3%	2.6%	25.6%	15.2%	
16.4	16.1	0.2	20.4%	3.7%	2.7%	25.6%	15.2%	
15.9	15.8	0.1	21.5%	4.0%	2.9%	25.7%	15.3%	
15.6	**15.5**	0.1	23.7%	4.4%	3.0%	25.8%	15.4%	…Preservation at 1997 Level
15.2	15.2	0.0	24.7%	4.4%	3.2%	26.0%	15.6%	
14.8	14.8	0.0	26.9%	4.8%	3.3%	26.5%	16.1%	
14.5	14.5	0.0	28.0%	5.1%	3.5%	26.4%	16.0%	
14.2	14.2	0.0	29.0%	5.1%	3.6%	26.3%	15.9%	
14.0	14.0	0.0	30.1%	5.5%	3.7%	26.2%	15.8%	
13.8	13.8	0.0	31.2%	5.5%	3.7%	26.2%	15.8%	
13.6	13.6	0.0	32.3%	5.9%	3.9%	26.2%	15.8%	
						12.5%		1997 Percentage

Investment Required to Achieve Certain Performance Targets

As shown in Exhibit A-8, combined system preservation and widening investment on rural Interstates would need to reach $26.1 billion over 10 years in order to maintain average IRI at 93 inches per mile. Coincidentally, this same level of investment would also be expected to keep average travel time costs from increasing. To prevent average total user costs (including travel time costs, vehicle operating costs, and crash costs) from increasing would require a cumulative investment from 1998–2007 of $32.4 billion. Since the slope of the total user costs line in the graph in Exhibit A-8 is flatter than the slope of the travel time costs line, this implies that on rural Interstates, vehicle operating costs and crash costs are less sensitive to changes in the level of investment than travel time costs are.

The $36.8 billion shown on the top row of Exhibit A-8 represents the maximum amount that could be economically invested for rural Interstate system preservation and widening. Even at this level of investment the percentage of rural Interstate VMT on routes with a V/SF ratio greater than or equal to 0.80 would still increase. This implies that it is not economically efficient to try to address rural congestion problems through the widening of existing routes alone.

Projected Pavement Condition and Operational Performance at Forecast Funding Levels for 1998–2007

As shown in Exhibit A-6, 4.4 percent of total highway capital outlay by all levels of government in 1997 was used for system preservation or widening of existing rural Interstate routes. If this percentage remains constant, and total highway capital outlay for 1998–2007 on all functional systems reaches $557.5 in constant 1997 dollars, approximately $24.4 billion would be spent for rural interstate system preservation or widening over the next 10 years. Exhibit A-8 does not have a row that exactly corresponds to this level of investment. The closest one is for $24.6 billion.

This level of investment would be expected to result in average IRI increasing (worsening) by 2.2 percent. In constant dollar terms, average travel time costs would be expected to increase by 0.4 percent while average total user costs would increase by 0.9 percent over 1997 levels. The percent of VMT on roads with a V/SF ratio greater than or equal to 0.80 would increase to 21.8 percent.

Expected Urban Interstate Pavement Condition in 2007

Exhibit A-9 is the urban Interstate equivalent of Exhibit A-7. Exhibit A-9 shows the impact that different levels of highway reconstruction and 3R investment would have on urban interstate IRI. All values cited in this analysis are stated in constant 1997 dollars.

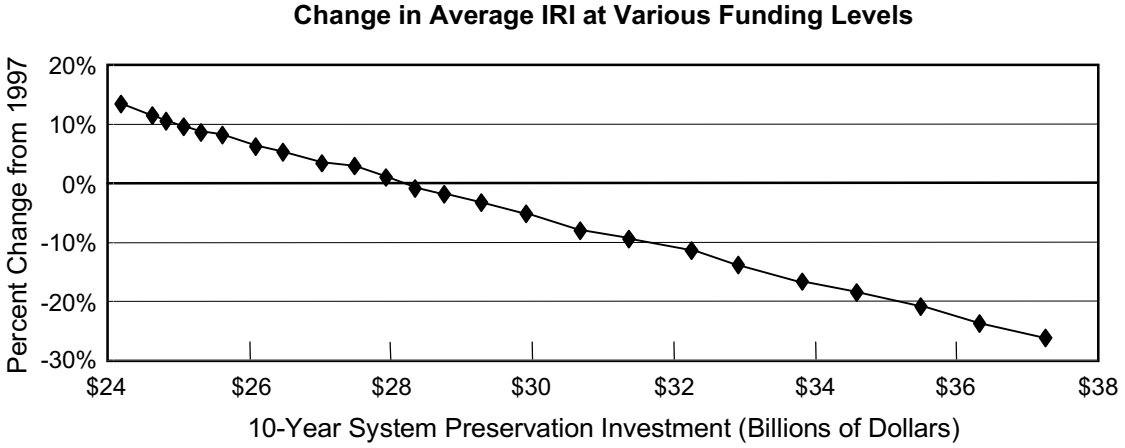
Exhibit A-5 shows that in 1997, all levels of government spent approximately $2.5 billion for urban Interstate roadway preservation. If this type of investment grows at the rate of inflation over the next 10 years, cumulative investment for the 1998-2007 period would be $24.8 billion (stated in 1997 dollars). Exhibit A-9 shows that at this level of investment, average IRI would be expected to increase (worsen) by 10.5 percent, increasing from 114 to 126 inches per mile. This would represent a shift in average pavement condition from "fair" to "mediocre," using the verbal descriptions shown in Exhibit A-1. If

Q. **How does the projected split between reconstruction and 3R compare with current spending patterns on urban Interstates?**

A. In 1997, 29 percent of urban Interstate highway system preservation spending went for reconstruction. The pattern of investment derived from HERS shown in Exhibit A-9 suggests that if current spending levels are maintained for 10 years, 33 percent will be needed for reconstruction.

Exhibit A-9

Projected Urban Interstate Pavement Condition in 2007, for Different Possible Funding Levels



Total 10-Year System Preservation Investment (Billions of 1997 Dollars)			Average IRI (Weighted by VMT)		Percent of VMT on Roads with IRI>=101		Funding Level Description: Investment Required to Maintain…
Total	Recon-struction	3R	IRI in Inches per Mile	Percent Change from 1997	Percent	Change from 1997	
37.3	8.4	28.9	84	-26.3%	14.1%	-40.4%	
36.3	8.4	27.9	87	-23.7%	17.7%	-36.9%	
35.5	8.4	27.1	90	-21.1%	21.0%	-33.6%	
34.6	8.5	26.1	93	-18.4%	24.1%	-30.4%	
33.8	8.5	25.3	95	-16.7%	26.0%	-28.5%	
32.9	8.4	24.5	98	-14.0%	28.9%	-25.7%	
32.2	8.5	23.7	101	-11.4%	31.4%	-23.2%	
31.4	8.5	22.9	103	-9.6%	34.3%	-20.3%	
30.7	8.4	22.2	105	-7.9%	36.6%	-18.0%	
29.9	8.3	21.6	108	-5.3%	39.3%	-15.3%	
29.3	8.4	20.9	110	-3.5%	41.0%	-13.5%	
28.8	8.3	20.4	112	-1.8%	43.5%	-11.1%	
28.4	8.5	19.9	113	**-0.9%**	45.5%	-9.1%	...Average IRI
27.9	8.5	19.4	115	**0.9%**	47.2%	-7.3%	
27.5	8.4	19.1	117	2.6%	48.8%	-5.7%	
27.0	8.3	18.7	118	3.5%	50.3%	-4.3%	
26.5	8.3	18.2	120	5.3%	52.1%	-2.4%	
26.1	8.2	17.8	121	6.1%	53.4%	-1.1%	
25.6	8.1	17.5	123	7.9%	54.5%	**-0.1%**	…VMT with IRI>=101
25.3	8.1	17.2	124	8.8%	55.5%	1.0%	
25.1	8.2	16.9	125	9.6%	56.4%	1.9%	
24.8	8.2	16.6	126	10.5%	57.0%	2.4%	…Spending at 1997 Level
24.6	8.3	16.4	127	11.4%	57.6%	3.0%	
24.2	8.2	16.0	129	13.2%	59.0%	4.4%	
23.8	8.1	15.8	130	14.0%	59.8%	5.3%	
23.5	8.1	15.4	131	14.9%	61.3%	6.7%	
			114		54.6%		1997 Values

current levels of investment are maintained in constant dollar terms, the percent of VMT occurring on roads with an IRI greater than or equal to 101 would increase from 54.6 percent to 57.0 percent.

Q. Does the IRI threshold of 101 shown in Exhibit A-9 have any special significance?

A. No. As part of its internal calculations, HERS utilizes a PSR threshold value roughly equivalent to an IRI of 101 and shows the percentage of pavement that does not meet this threshold as part of its standard output. However, this value has no special significance in terms of the verbal descriptions of pavement shown in Exhibit A-1. This threshold includes all of the pavement identified as "poor" and "mediocre" in Exhibit A-1 and much of the pavement identified as "fair".

Exhibit A-9 shows that system preservation investment on urban Interstates would need to reach between $27.9 billion and $28.4 billion over 10 years in order to maintain average IRI at 114 inches per mile. To prevent an increase in the percentage of VMT on roads with an IRI greater than or equal to 101 would require a cumulative investment from 1998 to 2007 of $25.6 billion. The $37.3 billion on the first line of the table represents the maximum amount that could be economically invested for urban Interstate system preservation.

Projected Pavement Conditions at Forecast Funding Levels for 1998–2007

As shown in Exhibit A-6, highway capital outlay on all functional systems is projected to total $557.5 billion (1997 dollars) for the 10-year period from 1998 to 2007, based on certain assumptions made about future Federal, State and local funding. In 1997, 5.1 percent of total highway capital outlay by all levels of government was used for system preservation on urban Interstates. If this percentage is maintained in the future, approximately $28.4 billion will be spent for urban interstate system over the next 10 years. Exhibit A-9, shows that this level of investment would be expected to result in average IRI improving by 0.9 percent, declining from 114 to 113 inches per mile. The percent of VMT on roads with IRI>101 would decline from 54.6 percent to 45.5 percent.

Expected Urban Interstate Pavement Condition and Performance in 2007

Exhibit A-10 combines the investment requirements shown for system preservation in Exhibit A-9 with widening improvements that have a comparable rate of return according to the benefit-cost analysis performed by HERS. The columns in Exhibit A-10 showing preservation investment and percent change in average IRI duplicate information provided in Exhibit A-9, and are included as reference points to relate the two analyses together. All values shown in this analysis are stated in constant 1997 dollars.

As shown in Exhibit A-5, in addition to the $2.5 billion spent by all levels of government on urban Interstate system preservation in 1997, $2.1 billion was used for widening existing Interstate routes. If the combined level of investment in these two types of improvements grows only by the rate of inflation over the next 10 years, cumulative investment for the 1998–2007 period would be approximately $45.4 (stated in 1997 dollars). Exhibit A-10 does not have a row that exactly corresponds to this level of investment. The closest one is for $45.0 billion.

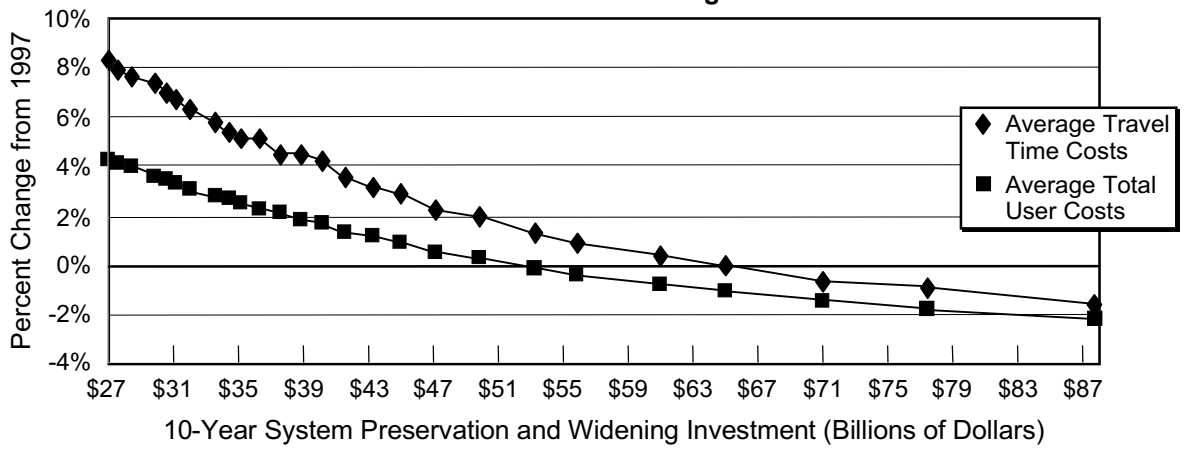
Effects of Investing at 1997 Spending Levels

If highway investment for the 10-year period though 2007 remains constant at 1997 levels, HERS would recommend a change in the distribution of funding between system preservation and widening. Reading across the "$45.0 billion" row in Exhibit A-10, shows that if a cumulative $45.0 billion were to be invested on existing urban Interstates over 10 years, the HERS analysis recommends that

Exhibit A-10

Projected Urban Interstate Pavement Condition and Operational Performance in 2007, for Different Possible Funding Levels

Change in Average Travel Time Costs and Total User Costs at Various Funding Levels



Total 10-Year Preservation and Widening Investment (Billions of 1997 Dollars)			Percent Change from 1997			Percent of VMT on Roads with V/SF>=0.95		
Total	Preser-vation	Widening	Average IRI	Average Travel Time Costs	Average Total User Costs	Percent	Change from 1997	Funding Level Description: Investment Required to Maintain…
87.7	37.3	50.5	-26.3%	-1.6%	-2.2%	29.9%	**-0.4%**	…% VMT with V/C>=0.95
77.4	36.3	41.0	-23.7%	-1.0%	-1.8%	32.8%	2.5%	
71.0	35.5	35.5	-21.1%	-0.6%	-1.4%	35.0%	4.7%	…Total User Costs
65.0	34.6	30.4	-18.4%	**0.0%**	-1.1%	36.9%	6.6%	…Average Travel Time Costs
61.0	33.8	27.2	-16.7%	0.3%	-0.8%	38.1%	7.8%	
55.8	32.9	22.9	-14.0%	1.0%	-0.4%	39.8%	9.5%	
53.2	32.2	**21.0**	-11.4%	1.3%	**-0.1%**	40.7%	10.5%	...User Costs & 97 Widening $
49.9	31.4	18.5	-9.6%	1.9%	0.3%	41.9%	11.6%	
47.1	30.7	16.4	-7.9%	2.2%	0.5%	42.8%	12.5%	
45.0	29.9	15.1	-5.3%	2.9%	0.9%	43.4%	13.1%	…1997 Total Spending
43.2	29.3	14.0	-3.5%	3.2%	1.2%	43.8%	13.6%	
41.6	28.8	12.8	-1.8%	3.5%	1.3%	44.6%	14.3%	
40.1	28.4	11.8	**-0.9%**	4.1%	1.7%	45.1%	14.8%	...Average IRI
38.8	27.9	10.9	**0.9%**	4.4%	1.8%	45.7%	15.4%	
37.5	27.5	10.0	2.6%	4.4%	2.1%	45.3%	15.0%	
36.3	27.0	9.3	3.5%	5.1%	2.2%	45.6%	15.3%	
35.1	26.5	8.6	5.3%	5.1%	2.5%	45.4%	15.1%	
34.5	26.1	8.4	6.1%	5.4%	2.6%	45.4%	15.1%	
33.6	25.6	8.0	7.9%	5.7%	2.8%	45.5%	15.2%	
32.1	25.3	6.7	8.8%	6.3%	3.0%	45.6%	15.4%	
31.2	25.1	6.1	9.6%	6.7%	3.3%	45.4%	15.1%	
30.6	**24.8**	5.7	10.5%	7.0%	3.4%	45.5%	15.2%	..1997 Preservation Spending
29.9	24.6	5.2	11.4%	7.3%	3.6%	45.5%	15.3%	
28.4	24.2	4.2	13.2%	7.6%	4.0%	45.7%	15.5%	
27.6	23.8	3.8	14.0%	7.9%	4.1%	45.6%	15.3%	
27.0	23.5	3.5	14.9%	8.3%	4.2%	45.6%	15.3%	
						30.3%		1997 Percentage

$29.9 billion be invested in system preservation improvements, and $15.1 billion be invested in additional lanes. However, if actual 1997 spending patterns were continued for 10 years, only $24.8 billion would be invested in system preservation improve-ments, and $21.0 billion would be invested in adding lanes. The row containing widening spending of $21.0 billion is much higher in the table in Exhibit A-10 than the row containing preservation spending of $24.8 billion. The implication of this difference is that current urban Interstate spending patterns do a much better job addressing investment requirements for widening than investment requirements for pavement, and that a greater share of future increases in funding should be directed towards system preservation. (Note that the system preservation figures cited above would include reconstruction or resurfacing of existing lanes of an Interstate route that was done in conjunction with a widening improvement.)

Q. Does the V/SF ratio threshold of 0.95 shown in Exhibit A-10 have any special significance?

A. Yes. At V/SF ratios above 0.95, travelers on the road are likely to experience stop and go traffic. Any incident can be expected to produce a serious breakdown of traffic flow, with excessive queuing. This is the traditional cut-off point used in the C&P report to describe severe congestion.

Assuming the $45.0 billion were invested in the manner recommended by HERS, average IRI would be expected to decrease (improve) by 5.3 percent by 2007. Average travel time costs per VMT would rise 2.9 percent, and average total user costs would rise 0.9 percent. The percentage of VMT occurring on urban Interstate routes with a (V/SF) ratio greater than or equal to 0.95 would be expected to increase from 30.3 percent in 1997 to 43.4 percent in 2007.

Investment Required to Achieve Certain Performance Targets

Exhibit A-10 shows that combined system preservation and widening investment on urban Interstates would need to reach between $38.8 billion and $40.1 billion over 10 years in order to maintain average IRI at 114 inches per mile. To prevent average total user costs (including travel time costs, vehicle operating costs, and crash costs) from increasing would require a cumulative investment from 1998–2007 of $53.2 billion. Maintaining the travel time costs component alone would require a 10-year investment of $65.0 billion. The average travel time costs line in the graph in Exhibit A-8 is always higher then the average total user costs line, which implies that on urban Interstates, it is easier to maintain vehicle operating costs and crash costs than travel time costs.

The $87.7 billion shown on the top row of Exhibit A-10 represents the maximum amount that could be economically invested for urban Interstate system preservation and widening. Only at this level of investment would there be a decline in the percentage of urban Interstate VMT on routes with a V/SF ratio greater than or equal to 0.95.

Projected Pavement Condition and Operational Performance at Forecast Funding Levels for 1998–2007

Exhibit A-6 shows that in 1997, 9.3 percent of total highway capital outlay by all levels of government was used for system preservation or widening of existing urban Interstate routes. If this percentage remains constant, and total highway capital outlay for 1998–2007 on all functional systems reaches $557.5 in constant 1997 dollars, approximately $51.9 billion would be spent for urban interstate system preservation or widening over the next 10 years. In Exhibit A-10, this would fall between the $49.9 billion and the $53.2 billion rows.

This level of investment is close to the amount required to maintain user costs, though average travel time costs would be expected to rise by 1.3 to 1.9 percent. The percent of VMT on roads with a V/SF ratio greater than or equal to 0.95 would increase from 30.3 percent to between 40.7 and 41.9 percent. Average IRI would be expected to improve by 9.6 to 11.4 percent.

Expected Rural and Urban Interstate Pavement Condition in 2007

The total 10-year investment levels for each row in Exhibits A-7 and A-9 were selected to have a comparable rate of return according to the benefit-cost analysis performed by HERS. (See Exhibit 7-3 in Chapter 7 for a graphical illustration of how different minimum benefit-cost ratio cutoff points in HERS correspond to different levels of investment). Therefore the values in each row for these two exhibits can be combined directly into the same row in Exhibit A-11, which compares the impacts of different levels of investment on rural and urban pavement condition. Some columns in Exhibit A-11 duplicate those in Exhibits A-7 and A-9, to facilitate comparisons with the more detailed condition information provided in these exhibits. The second and third columns of Exhibit A-11, showing rural and urban system preservation investment, match the first column in Exhibits A-7 and A-9, respectively. The sixth and seventh columns in Exhibit A-11, showing the percent change in rural and urban average IRI, correspond to the fourth column in Exhibits A-7 and A-9. Note that all dollar values cited in this analysis are stated in constant 1997 dollars.

As indicated in Exhibit A-5, all levels of government spent approximately $4.0 billion for Interstate roadway preservation in rural and urban areas combined in 1997. If this type of investment grows at the rate of inflation over the next 10 years, cumulative investment for the 1998–2007 period would be about $40.5 billion (stated in 1997 dollars). Exhibit A-11 shows that at this level of investment, average IRI would be expected to increase (worsen) by 15.2 percent, increasing from 105 to 121 inches per mile. This would represent a shift in average pavement condition from "fair" to "mediocre," using the verbal descriptions shown in Exhibit A-1. Based on the pattern of investment recommended by HERS, average IRI for rural Interstates would increase by 24.7 percent, while average IRI for urban Interstates would only get 8.8 percent worse. (Note that average IRI for rural Interstates would still be lower for rural Interstates than for urban Interstates in 2007, since rural Interstate IRI is currently about 22 percent lower than urban Interstate IRI.)

Rural/Urban Tradeoffs

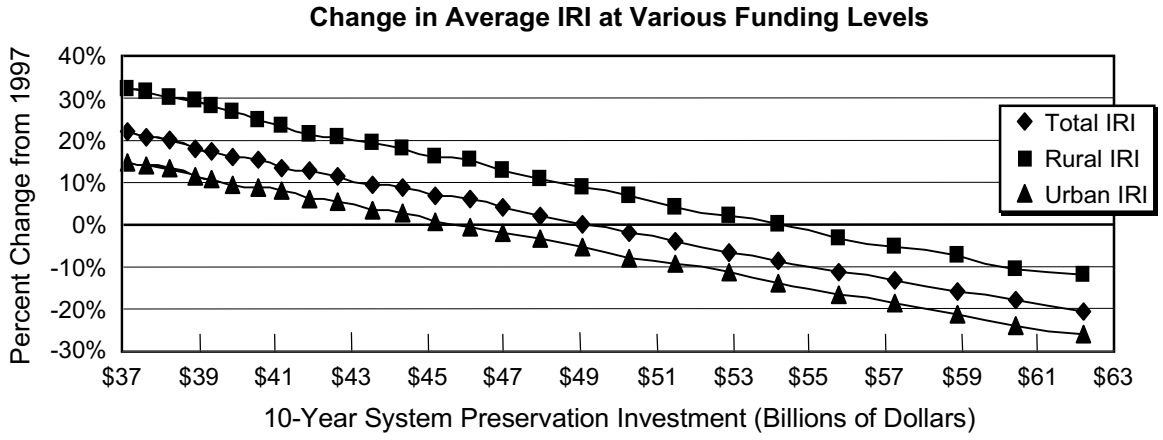
At a 10-year Interstate system preservation investment level of $40.5 billion, HERS would recommend spending slightly more in urban areas, and slightly less (about 2 percent) in rural areas. This can be seen in Exhibit A-11, as the row containing current rural Interstate system preservation of $15.5 billion is higher than the row containing total Interstate system preservation of $40.5 billion.

The graph in Exhibit A-11, shows that based on the pattern of investment recommended by HERS, urban Interstate IRI would fare better than rural Interstate IRI at all levels of investment. The exhibit shows that a combined rural and urban system preservation investment of $49.1 billion over 10 years would maintain overall average IRI, but that average rural IRI would get 8.6 percent worse, which would be offset by a 5.3 percent improvement in urban IRI.

At a combined rural and urban system preservation level of $54.2 billion, average rural Interstate IRI would be maintained, while urban Interstate IRI would improve by 14.0 percent. Urban IRI could be maintained if 10-year investment is approximately $45.2 to $46.1 billion. At this level of investment rural Interstate IRI would be expected to increase (worsen) by 5.7 to 6.7 percent.

Exhibit A-11

Projected Rural and Urban Interstate Pavement Condition in 2007, for Different Possible Funding Levels



Total 10-Year System Preservation Investment (Billions of 1997 Dollars)			Average IRI				Funding Level Description: Investment Required to Maintain…
			Total in Inches per Mile	Percent Change from 1997			
Total	Rural	Urban		Total	Rural	Urban	
62.2	25.0	37.3	83	-21.0%	-11.8%	-26.3%	
60.4	24.1	36.3	86	-18.1%	-10.8%	-23.7%	
58.9	23.4	35.5	88	-16.2%	-7.5%	-21.1%	
57.2	22.6	34.6	91	-13.3%	-5.4%	-18.4%	
55.8	21.9	33.8	93	-11.4%	-3.2%	-16.7%	
54.2	21.2	32.9	96	-8.6%	**0.0%**	-14.0%	...Average Rural IRI
52.9	20.7	32.2	98	-6.7%	2.2%	-11.4%	
51.5	20.2	31.4	101	-3.8%	4.3%	-9.6%	
50.3	19.6	30.7	103	-1.9%	6.5%	-7.9%	
49.1	19.1	29.9	105	**0.0%**	8.6%	-5.3%	...Average IRI
48.0	18.7	29.3	107	1.9%	10.8%	-3.5%	
47.0	18.2	28.8	109	3.8%	12.9%	-1.8%	
46.1	17.8	28.4	111	5.7%	15.1%	**-0.9%**	…Average Urban IRI
45.2	17.3	27.9	112	6.7%	16.1%	**0.9%**	
44.3	16.8	27.5	114	8.6%	18.3%	2.6%	
43.5	16.5	27.0	115	9.5%	19.4%	3.5%	
42.6	16.1	26.5	117	11.4%	20.4%	5.3%	
41.9	15.8	26.1	118	12.4%	21.5%	6.1%	
41.2	**15.5**	25.6	119	13.3%	23.7%	7.9%	…Rural Spending at 1997 Level
40.5	15.2	25.3	121	15.2%	24.7%	8.8%	…Total Spending at 1997 Level
39.9	14.8	25.1	122	16.2%	26.9%	9.6%	
39.3	14.5	**24.8**	123	17.1%	28.0%	10.5%	...Urban Spending at 1997 Level
38.9	14.2	24.6	124	18.1%	29.0%	11.4%	
38.2	14.0	24.2	126	20.0%	30.1%	13.2%	
37.6	13.8	23.8	127	21.0%	31.2%	14.0%	
37.1	13.6	23.5	128	21.9%	32.3%	14.9%	
			105				1997 Values

Projected Pavement Conditions at Forecast Funding Levels for 1998–2007

As shown in Exhibit A-6, highway capital outlay on all functional systems is projected to total $557.5 billion (1997 dollars) for the 10-year period from 1998 to 2007, based on certain assumptions about future Federal, State and local funding levels. In 1997, 8.3 percent of total highway capital outlay by all levels of government was used for system preservation on urban Interstates. If this percentage is maintained in the future, approximately $46.2 billion will be spent for urban interstate system over the next 10 years. This level of investment would be sufficient to maintain urban Interstate IRI at 1997 levels, though rural Interstate IRI would increase.

Expected Rural and Urban Interstate Pavement Condition and Performance in 2007

Exhibit A-12 combines the rural and urban pavement condition and performance results shown separately in Exhibits A-8 and A-10. This table incorporates the system preservation investments included in Exhibit A-11 as well as rural and urban widening improvements with a comparable benefit-cost ratio. The second and third column in Exhibit A-12 showing rural and urban 10-year preservation and widening investment duplicate the first column of Exhibits A-8 and A-10. The fourth column with the percent change in average IRI data matches the fifth column in Exhibit A-11. The seventh and eighth columns covering the percent change in rural and urban average highway user costs match the sixth column in Exhibits A-8 and A-10, respectively. These duplicate columns are included to serve as reference points to relate this analysis back to the more detailed analyses developed earlier. All values shown in this analysis are stated in constant 1997 dollars.

Effects of Investing at 1997 Spending Levels

In addition to the $4.0 billion spent by all levels of government on rural and urban Interstate system preservation in 1997, $2.6 billion was used for widening existing Interstate routes, as shown in Exhibit A-5. If the combined level of investment in these two types of improvements grows only by the rate of inflation over the next 10 years, cumulative investment for the 1998–2007 period would be approximately $66.7 (stated in 1997 dollars). Exhibit A-12 does not have a row that exactly corresponds to this level of investment. The closest one is for $65.9 billion.

As discussed earlier, HERS would recommend that a greater share of both rural and urban Interstate spending be devoted to system preservation than is currently the case. If this shift in expenditure patterns were to occur and highway investment remained constant at 1997 levels over 10 years, then average IRI would be maintained at current levels. At this level of investment, average travel time costs would be expected to increase by 2.0 percent. Overall average highway user costs would increase by 1.0 percent, while highway user costs on rural Interstates would increase by 1.4 percent.

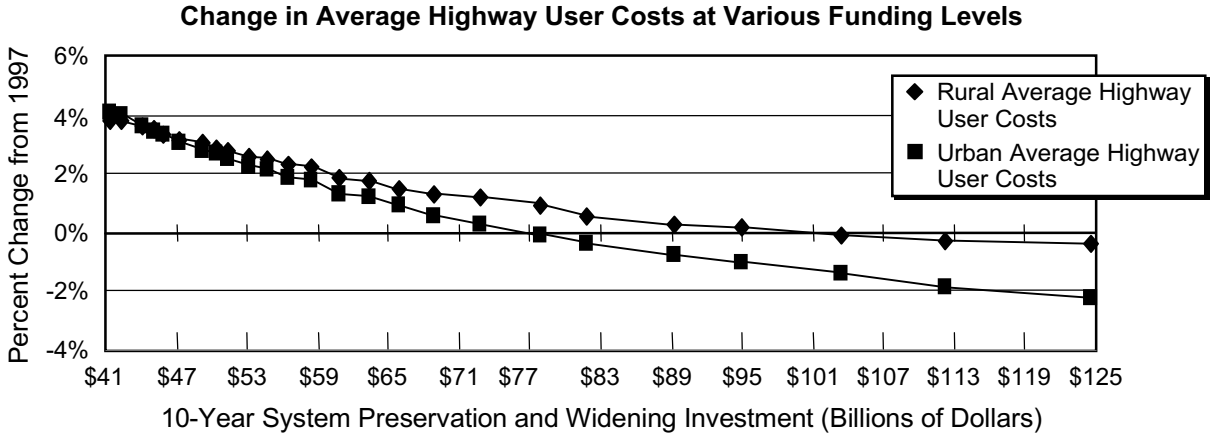
Investment Required to Achieve Certain Performance Targets

As shown in Exhibit A-12, combined system preservation and widening investment on rural and urban Interstates would need to reach $89.3 billion over 10 years in order to maintain average travel time costs. Maintaining total highway user costs would require a cumulative investment from 1998–2007 of $81.9 billion. At this level of investment, urban highway user costs would decrease by 0.4 percent while rural highway user costs would increase by 0.6 percent.

At higher funding levels, the investment pattern recommended by HERS has more of an impact on reducing urban highway user costs than rural highway user costs. However, the lines in the graph in Exhibit A-12 do cross, indicating that at lower funding levels, the investments recommended by HERS would allow urban highway user costs to grow more quickly than rural highway user costs.

Exhibit A-12

Projected Rural and Urban Interstate Pavement Condition and Operational Performance in 2007, for Different Possible Funding Levels



Total 10-Year Preservation and Widening Investment (Billions of 1997 Dollars)			Percent Change from 1997					Funding Level Description: Investment Required to Maintain…
					Average Highway User Costs			
Total	Rural	Urban	Average IRI	Average Travel Time Costs	Total	Rural	Urban	
124.5	36.8	87.7	-21.0%	-2.0%	-1.6%	-0.4%	-2.2%	
112.2	34.9	77.4	-18.1%	-1.3%	-1.2%	-0.3%	-1.8%	
103.4	32.4	71.0	-16.2%	-1.0%	-1.0%	**-0.1%**	-1.4%	…Rural User Costs
95.1	30.0	65.0	-13.3%	-0.7%	-0.7%	0.1%	-1.1%	
89.3	28.3	61.0	-11.4%	**-0.3%**	-0.4%	0.3%	-0.8%	…Travel Time Costs
81.9	26.1	55.8	-8.6%	0.3%	**-0.1%**	0.6%	-0.4%	...Total User Costs
77.8	24.6	53.2	-6.7%	0.7%	0.1%	0.9%	**-0.1%**	…Urban User Costs
72.9	23.0	49.9	-3.8%	1.3%	0.5%	1.2%	0.3%	
68.9	**21.8**	47.1	-1.9%	1.7%	0.7%	1.3%	0.5%	…Rural Spending at 1997 Level
65.9	20.9	**45.0**	**0.0%**	2.0%	1.0%	1.4%	0.9%	…Urban/Total Spending, & IRI
63.4	20.2	43.2	1.9%	2.7%	1.2%	1.7%	1.2%	
60.8	19.2	41.6	3.8%	3.0%	1.5%	1.9%	1.3%	
58.5	18.4	40.1	5.7%	3.4%	1.8%	2.2%	1.7%	
56.6	17.7	38.8	6.7%	3.7%	1.9%	2.3%	1.8%	
54.8	17.3	37.5	8.6%	4.0%	2.0%	2.4%	2.1%	
53.1	16.8	36.3	9.5%	4.4%	2.2%	2.6%	2.2%	
51.5	16.4	35.1	11.4%	4.4%	2.5%	2.7%	2.5%	
50.4	15.9	34.5	12.4%	4.7%	2.6%	2.9%	2.6%	
49.2	15.6	33.6	13.3%	5.0%	2.7%	3.0%	2.8%	
47.3	15.2	32.1	15.2%	5.4%	2.9%	3.2%	3.0%	
46.0	14.8	31.2	16.2%	5.7%	3.1%	3.3%	3.3%	
45.1	14.5	30.6	17.1%	6.0%	3.3%	3.5%	3.4%	
44.1	14.2	29.9	18.1%	6.4%	3.4%	3.6%	3.6%	
42.4	14.0	28.4	20.0%	6.7%	3.7%	3.7%	4.0%	
41.4	13.8	27.6	21.0%	7.0%	3.8%	3.7%	4.1%	
40.7	13.6	27.0	21.9%	7.0%	4.0%	3.9%	4.2%	

Projected Pavement Condition and Operational Performance at Forecast Funding Levels for 1998–2007

In 1997, 13.7 percent of total highway capital outlay by all levels of government was used for system preservation or widening of existing rural and urban Interstate routes. As shown in Exhibit A-6, if this percentage remains constant, and total highway capital outlay for 1998–2007 on all functional systems reaches $557.5 in constant 1997 dollars, approximately $76.4 billion would be spent for rural and urban interstate system preservation or widening over the next 10 years. In Exhibit A-12, this would fall between the $72.9 billion and the $77.8 billion rows.

This level of investment is close to the amount required to maintain urban highway user costs, though rural highway user costs would be expected to rise about 0.9 to 1.2 percent. Average travel time costs would be expected to rise by 0.7 to 1.3 percent. Average IRI would be expected to improve by 3.8 to 6.7 percent.

Expected Rural Interstate Bridge Conditions in 2007

Chapter 7 defined the bridge investment backlog as the cost of improving all bridges that are currently deficient. The current investment requirement backlog includes the costs to repair or replace all bridges identified as functionally obsolete or structurally deficient in Exhibit A-4, as well as the costs of additional repairs or partial replacements required to correct less severe problems with individual bridge components. (These less severe problems are described in BNIP as "condition deficiencies," and includes such items as bridge decks in need of rehabilitation. However, this term is not widely utilized, and is not referenced elsewhere in this study to avoid confusion with the common definition of "bridge deficiencies" which includes only structural and functional deficiencies.)

The BNIP model estimates that the current investment backlog on rural Interstate bridges is $6.3 billion. This section examines the effect that different levels of investment would be expected to have on the size of this backlog. All dollar values cited in this analysis are stated in constant 1997 dollars.

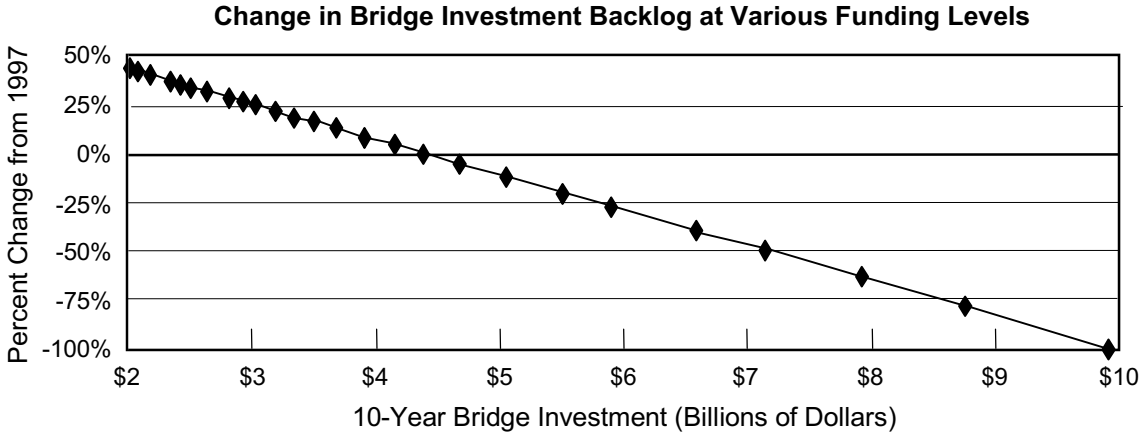
Exhibit A-13 projects the percent of rural Interstate bridges that would be deficient in 2007, the total percent of rural Interstate bridges needing to be repaired or replaced in 2007, and the cost to address these structural deficiencies, functional deficiencies, and other bridge needs. Exhibit A-5 shows that all levels of government spent approximately $0.4 billion for the repair, rehabilitation and replacement of existing rural Interstate bridges in 1997. If this level of investment were sustained over the next 10 years, cumulative investment for the 1998–2007 period would be approximately $3.9 billion (stated in 1997 dollars).

Effects of Investing at 1997 Spending Levels

The pattern of investments recommended by BNIP is intended to minimize the investment requirement backlog, rather than the number of deficient bridges or the total number of bridges needing repairs. If current funding levels were sustained in constant dollar terms over the next 10 years, and $3.9 billion were invested in bridges, the model predicts the bridge investment backlog would increase from $6.3 billion to $6.8 billion. The percent of bridges that are deficient would fall from 16.4 percent to 10.6 percent. However, the total percent of bridges needing repairs (including deficient bridges as well as bridges with less severe problems) would rise from 30.9 percent to 47.5 percent. These results suggest that the BNIP model is choosing to address a smaller number of severe deficiencies that are expensive to correct, while it is letting a number of less severe problems to continue to accrue.

Exhibit A-13

Projected Rural Interstate Bridge Investment Backlog in 2007, for Different Possible Funding Levels



10-Year Bridge Investment (Billions of 1997 Dollars)	Percent of Bridges That Would be Deficient in 2007				Bridge Investment Backlog in 2007: (Deficiencies & Other)			Funding Level Description: Investment Required to Maintain…
					Percent of Bridges Needing Repairs	Cost to Address		
	Struc-tural	Func-tional	Total	Change from 1997		Billions of 1997 Dollars	Percent Change from 1997	
$9.9	0.0%	0.0%	0.0%	-16.4%	0.0%	$0.0	**-100.0%**	
$8.8	0.7%	0.6%	1.3%	-15.1%	11.1%	$1.4	-78.4%	
$7.9	1.2%	1.7%	2.9%	-13.5%	17.4%	$2.3	-63.4%	
$7.1	1.7%	2.7%	4.4%	-12.0%	23.2%	$3.2	-49.4%	
$6.6	2.0%	3.4%	5.4%	-10.9%	27.3%	$3.8	-39.6%	
$5.9	2.5%	4.3%	6.8%	-9.6%	32.6%	$4.6	-27.1%	
$5.5	2.7%	4.8%	7.5%	-8.8%	35.5%	$5.0	-20.2%	
$5.0	3.0%	5.4%	8.4%	-7.9%	38.9%	$5.6	-11.8%	
$4.7	3.2%	5.9%	9.1%	-7.2%	41.8%	$6.0	-5.1%	
$4.4	3.4%	6.3%	9.7%	-6.7%	43.9%	$6.3	**0.0%**	...Backlog at 1997 Level
$4.2	3.6%	6.6%	10.1%	-6.2%	45.7%	$6.6	4.2%	
$3.9	3.7%	6.9%	10.6%	-5.8%	47.5%	$6.8	8.6%	…Spending at 1997 Level
$3.7	3.9%	7.2%	11.0%	-5.3%	49.1%	$7.1	12.5%	
$3.5	4.0%	7.4%	11.4%	-5.0%	50.5%	$7.3	15.8%	
$3.3	4.1%	7.6%	11.7%	-4.7%	51.8%	$7.5	18.8%	
$3.2	4.2%	7.8%	12.0%	-4.4%	52.9%	$7.7	21.6%	
$3.0	4.3%	8.0%	12.3%	-4.1%	54.1%	$7.8	24.4%	
$2.9	4.3%	8.2%	12.5%	-3.9%	54.9%	$7.9	26.2%	
$2.8	4.4%	8.3%	12.7%	-3.7%	55.7%	$8.1	28.2%	
$2.6	4.5%	8.5%	13.0%	-3.3%	57.1%	$8.3	31.5%	
$2.5	4.6%	8.7%	13.3%	-3.1%	58.0%	$8.4	33.7%	
$2.4	4.6%	8.8%	13.4%	-2.9%	58.7%	$8.5	35.2%	
$2.3	4.7%	8.9%	13.6%	-2.7%	59.3%	$8.6	36.8%	
$2.2	4.8%	9.1%	13.9%	-2.4%	60.5%	$8.8	39.7%	
$2.1	4.9%	9.3%	14.1%	-2.2%	61.3%	$8.9	41.5%	
$2.0	4.9%	9.3%	14.2%	-2.1%	61.8%	$9.0	42.7%	
	4.1%	12.2%	16.4%		30.9%	$6.3		1997 Values

Investment Required to Eliminate or Maintain the Bridge Investment Backlog

The top row in the table in Exhibit A-13 represents the cost to eliminate the rural Interstate bridge investment backlog by 2007. To achieve this would require a cumulative 10-year investment of $9.9 billion on rural Interstate highways. This level of investment would address all structural deficiencies, functional deficiencies, and all other less severe bridge condition problems identified by BNIP.

Q. How does the pattern of investments recommended by BNIP compare with current spending patterns on Interstate bridges?

A. The expenditure data available does not distinguish between amounts spent to correct structural and functional deficiencies versus other bridge expenditures. However, since 1996, the percent of deficient Interstate bridges has declined, while the number of bridges with less severe problems with individual bridge components has risen. This implies that current spending patterns are consistent with those recommended by BNIP, in broad terms.

To maintain the bridge investment backlog at its 1997 level would require a 10-year investment of $4.4 billion. Based on the pattern of investment recommended by BNIP, this level of investment would reduce the percent of deficient bridges from 16.4 percent to 9.7 percent. The percent of bridges with condition problems that eventually would need to be repaired would rise to 43.9 percent.

Projected Bridge Investment Backlog at Forecast Funding Levels for 1998–2007

Exhibit A-6 shows that 0.8 percent of total highway capital outlay by all levels of government was used for rural Interstate bridge repair, rehabilitation, or replacement in 1997. If this percentage remains constant, and total highway and bridge capital outlay for 1998–2007 on all functional systems reaches $557.5 billion in constant 1997 dollars, approximately $4.6 billion would be spent on rural Interstate bridges. At this level of investment, the rural Interstate bridge investment backlog in 2007 would be expected to be between 0.0 and 5.1 percent lower than the current level.

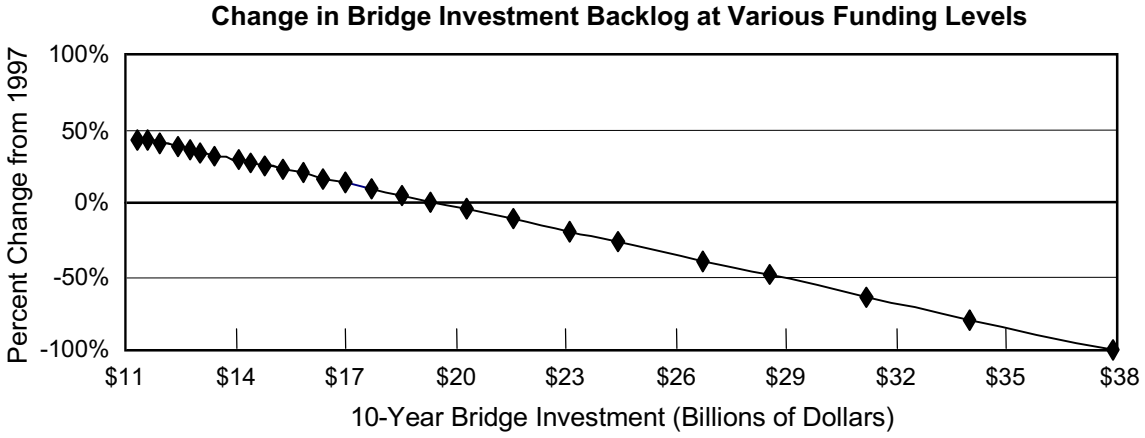
Expected Urban Interstate Bridge Conditions in 2007

The BNIP model estimates that the current investment backlog on urban Interstate bridges is $18.7 billion. This includes the costs to repair or replace all bridges identified as functionally obsolete or structurally deficient in Exhibit A-4, as well as the costs of additional repairs or partial replacements required to correct less severe problems with individual bridge components. This section examines the effect that different levels of investment would be expected to have on the size of this backlog. All dollar values cited in this analysis are stated in 1997 dollars.

Exhibit A-5 shows that all levels of government spent approximately $1.3 billion for capital improvements to urban Interstate bridges in 1997. If this level of investment were sustained over the next 10 years, cumulative investment for the 1998–2007 period would be approximately $13.4 billion (stated in 1997 dollars). As indicated in Exhibit A-14, if this level of investment was utilized in the manner recommended by BNIP, the bridge investment backlog would increase from $18.7 billion to $24.6 billion. The total percent of bridges needing repairs (including deficient bridges as well as bridges with less severe problems) would rise from 35.6 percent to 74.3 percent, and the percent of urban Interstate bridges that are structurally deficient would rise from 6.7 percent to 9.8 percent. The percent of functionally obsolete bridges would decline sharply, as BNIP appears to emphasize addressing them.

Exhibit A-14

Projected Urban Interstate Bridge Investment Backlog in 2007, for Different Possible Funding Levels



10-Year Bridge Investment (Billions of 1997 Dollars)	Percent of Bridges That Would be Deficient in 2007				Bridge Investment Backlog in 2007: (Deficiencies & Other)			Funding Level Description: Investment Required to Maintain…
					Percent of Bridges Needing Repairs	Cost to Address		
	Struc-tural	Func-tional	Total	Change from 1997		Billions of 1997 Dollars	Percent Change from 1997	
$37.9	0.0%	0.0%	0.0%	-26.8%	0.0%	$0.0	**-100.0%**	
$34.0	1.3%	1.2%	2.5%	-24.4%	13.3%	$3.9	-79.4%	
$31.2	2.5%	2.0%	4.5%	-22.4%	21.6%	$6.7	-64.2%	
$28.6	3.6%	2.8%	6.3%	-20.5%	29.4%	$9.3	-50.0%	
$26.7	4.3%	3.3%	7.6%	-19.2%	34.8%	$11.2	-40.1%	
$24.4	5.3%	4.0%	9.3%	-17.6%	41.7%	$13.5	-27.5%	
$23.1	5.8%	4.4%	10.2%	-16.6%	45.6%	$14.9	-20.4%	
$21.5	6.5%	4.9%	11.3%	-15.5%	50.2%	$16.4	-12.0%	
$20.3	7.0%	5.2%	12.2%	-14.6%	54.0%	$17.7	-5.2%	
$19.3	7.4%	5.5%	12.9%	-13.9%	56.8%	$18.7	**0.0%**	...Backlog at 1997 Level
$18.5	7.7%	5.8%	13.5%	-13.4%	59.1%	$19.5	4.2%	
$17.7	8.0%	6.0%	14.0%	-12.8%	61.6%	$20.3	8.8%	
$17.0	8.3%	6.2%	14.6%	-12.3%	63.8%	$21.0	12.7%	
$16.4	8.6%	6.4%	15.0%	-11.9%	65.6%	$21.7	16.0%	
$15.8	8.8%	6.6%	15.4%	-11.4%	67.2%	$22.2	19.0%	
$15.3	9.0%	6.7%	15.8%	-11.1%	68.8%	$22.8	21.8%	
$14.8	9.3%	6.9%	16.1%	-10.7%	70.3%	$23.3	24.7%	
$14.4	9.4%	7.0%	16.4%	-10.5%	71.3%	$23.6	26.5%	
$14.1	9.5%	7.1%	16.6%	-10.2%	72.4%	$24.0	28.5%	
$13.4	9.8%	7.3%	17.1%	-9.8%	74.3%	$24.6	31.9%	…Spending at 1997 Level
$13.0	10.0%	7.4%	17.4%	-9.5%	75.5%	$25.0	34.1%	
$12.7	10.1%	7.5%	17.6%	-9.3%	76.4%	$25.3	35.7%	
$12.5	10.2%	7.6%	17.8%	-9.1%	77.2%	$25.6	37.3%	
$11.9	10.4%	7.7%	18.2%	-8.7%	78.8%	$26.2	40.2%	
$11.6	10.6%	7.8%	18.4%	-8.4%	79.8%	$26.5	42.0%	
$11.4	10.7%	7.9%	18.6%	-8.3%	80.5%	$26.7	43.2%	
	6.7%	20.1%	26.8%		35.6%	$18.7		1997 Values

Investment Required to Eliminate or Maintain the Bridge Investment Backlog

The top row in the table in Exhibit A-14 indicates that eliminating the urban Interstate bridge investment backlog by 2007 would require a cumulative 10-year investment of $37.9 billion. This level of investment would address all structural deficiencies, functional deficiencies, and all other less severe bridge condition problems identified by BNIP.

Q. Why might BNIP correct a higher percentage of functional deficiencies than structural deficiencies?

A. Correcting structural deficiencies frequently requires the replacement of the bridge, while correcting functional deficiencies may be possible by modifying the existing structure, which would be less expensive.

To maintain the bridge investment at its 1997 level would require a 10-year investment of $19.3 billion. Based on the pattern of investment recommended by BNIP, this level of investment would reduce the percent of deficient bridges from 26.8 percent to 12.9 percent. However, the percent of structurally deficient bridges would rise from 6.7 percent to 7.4 percent. The total percent of bridges with condition problems that eventually would need to be repaired would also rise, from 35.6 percent to 56.8 percent.

Projected Bridge Investment Backlog at Forecast Funding Levels for 1998–2007

In 1997, 2.7 percent of total highway capital outlay by all levels of government was used for urban Interstate bridge repair, rehabilitation, or replacement. If this percentage remains constant, and total highway capital outlay for 1998–2007 on all functional systems reaches $557.5 billion in constant 1997 dollars as projected in Exhibit A-6, approximately $15.2 billion would be spent on urban Interstate bridges over the next 10 years. At this level of investment, the urban Interstate bridge investment backlog in 2007 would be expected to grow by about 21.8 percent, from $18.7 billion to $22.8 billion. Note that the projections of 10-year capital outlay by all levels of government are based on certain simplifying assumptions about future Federal, State and local funding patterns. Federal funding beyond 2003 has yet to be determined.

Expected Rural and Urban Interstate Highway and Bridge Conditions and Performance in 2007

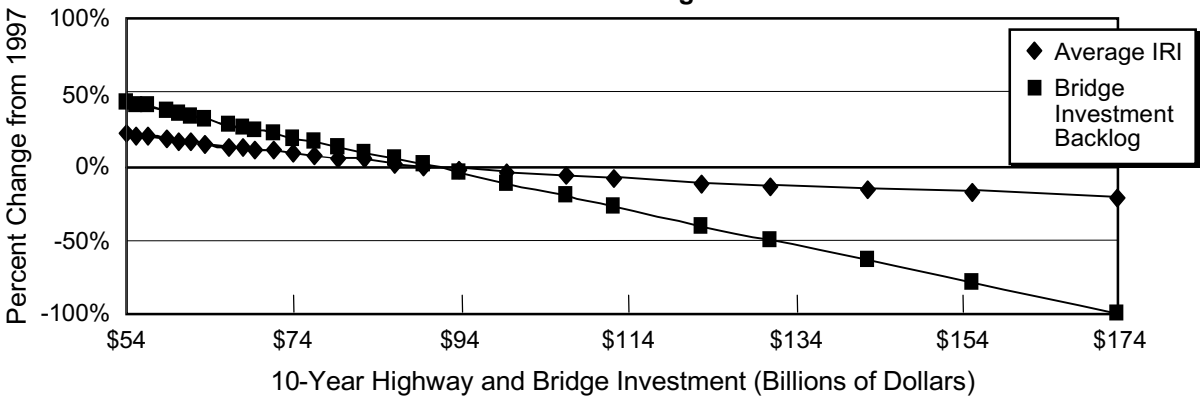
The total 10-year bridge investment levels for the rows of Exhibits A-13 and A-14 were selected to line up with their highway investment counterparts for the rows in Exhibit A-12. The top rows in Exhibits A-13 and A-14 represent the level of investment required to eliminate the current investment backlog for rural and urban Interstate bridges respectively, while the top row in Exhibit A-12 represents the maximum level of rural and urban Interstate highway investment that can be economically justified. The levels of investment required to maintain the current Interstate bridge investment backlog for rural and urban Interstates respectively were assigned to the tenth row of Exhibits A-13 and A-14 in order to line up with the tenth row of Exhibit A-12, which contains the level of investment required to maintain average IRI on rural and urban Interstates at current levels. The bridge investment levels for the remaining rows in Exhibits A-13 and A-14 were selected to be consistent with the slope of the highway investment requirement levels for the rows in Exhibit A-12.

Exhibit A-15 combines Exhibits A-12, A-13 and A-14. As described above, the rows in this table were intentionally lined up to demonstrate the relative differences between current investment levels and investment requirements for Interstate highways, rural Interstate bridges, and urban Interstate bridges. However, no analysis was performed to determine the relative benefits of Interstate highway

Exhibit A-15

Projected Interstate Highway and Bridge Conditions and Performance in 2007, for Different Possible Funding Levels

Change in Average IRI and Bridge Investment Backlog at Various Funding Levels



Total 10-Year Highway and Bridge Preservation and Widening (Billions of 1997 Dollars)				Percent Change from 1997				
		Bridge						
Total	Highway	Rural	Urban	Average IRI	Average Travel Time Costs	Average Highway User Costs	Cost to Address Bridge Backlog	Funding Level Description: Investment Required to Maintain...
172.3	124.5	9.9	37.9	-21.0%	-2.0%	-1.6%	-100.0%	
154.9	112.2	8.8	34.0	-18.1%	-1.3%	-1.2%	-79.1%	
142.5	103.4	7.9	31.2	-16.2%	-1.0%	-1.0%	-64.0%	
130.8	95.1	7.1	28.6	-13.3%	-0.7%	-0.7%	-49.8%	
122.6	89.3	6.6	26.7	-11.4%	**-0.3%**	-0.4%	-40.0%	…Average Travel Time Costs
112.2	81.9	5.9	24.4	-8.6%	0.3%	**-0.1%**	-27.4%	…Average Highway User Costs
106.4	77.8	5.5	23.1	-6.7%	0.7%	0.1%	-20.4%	
99.5	72.9	5.0	21.5	-3.8%	1.3%	0.5%	-12.0%	
93.9	68.9	4.7	20.3	-1.9%	1.7%	0.7%	-5.2%	
89.6	**65.9**	4.4	19.3	**0.0%**	2.0%	1.0%	**0.0%**	…Average IRI, Bridge Backlog, and 1997 Highway Spending
86.1	63.4	4.2	18.5	1.9%	2.7%	1.2%	4.2%	
82.4	60.8	**3.9**	17.7	3.8%	3.0%	1.5%	8.7%	…1997 Rural Bridge Spending
79.2	58.5	3.7	17.0	5.7%	3.4%	1.8%	12.6%	
76.4	56.6	3.5	16.4	6.7%	3.7%	1.9%	15.9%	
73.9	54.8	3.3	15.8	8.6%	4.0%	2.0%	19.0%	
71.6	53.1	3.2	15.3	9.5%	4.4%	2.2%	21.8%	
69.3	51.5	3.0	14.8	11.4%	4.4%	2.5%	24.6%	
67.8	50.4	2.9	14.4	12.4%	4.7%	2.6%	26.4%	
66.1	49.2	2.8	14.1	13.3%	5.0%	2.7%	28.4%	
63.4	47.3	2.6	**13.4**	15.2%	5.4%	2.9%	31.8%	…1997 Urban Bridge Spending
61.5	46.0	2.5	13.0	16.2%	5.7%	3.1%	34.0%	
60.2	45.1	2.4	12.7	17.1%	6.0%	3.3%	35.6%	
58.9	44.1	2.3	12.5	18.1%	6.4%	3.4%	37.2%	
56.5	42.4	2.2	11.9	20.0%	6.7%	3.7%	40.1%	
55.0	41.4	2.1	11.6	21.0%	7.0%	3.8%	41.8%	
54.0	40.7	2.0	11.4	21.9%	7.0%	4.0%	43.1%	
								1997 Percentage

improvements compared to Interstate bridge investments, or of rural Interstate bridge improvements compared to urban Interstate bridge improvements. Therefore, this exhibit is not intended to identify direct highway/bridge investment tradeoffs, or rural bridge/urban bridge tradeoffs.

Exhibit A-15 indicates that if current levels of Interstate highway investment were sustained over 10 years in constant dollar terms, and utilized in the manner recommended by HERS, average IRI could be maintained at current levels. However, if Interstate bridge investment remained constant, the Interstate bridge investment backlog would increase, especially in the case of urban Interstate bridges. Other implications of this exhibit are discussed in the next section of this study.

Resources Needed to Maintain and Improve the Interstate System

The preceding portion of this report projected the conditions and performance of Interstate highways and bridges based on a variety of funding levels. This section looks in more detail at the level of investment required to "maintain" the Interstate system (corresponding to the tenth row in Exhibit A-15), and the level of investment required to "improve" the Interstate system (corresponding to the first row in Exhibit A-15). This analysis determines where there are "gaps" between the estimated investment requirements and the projected level of available resources identified in Exhibit A-6.

Cost to Maintain and Improve the Interstate System

The funding levels shown in Exhibit A-15 consider only Interstate highway and bridge preservation and widening improvements. This analysis did not factor in expenditures for new Interstate construction, or for Interstate system enhancements, which are not modeled in HERS or BNIP. As indicated earlier in Exhibit A-6, 14.4 percent of Interstate capital expenditures went for new construction in 1997, and 9.3 percent went for system enhancements. Assuming these non-modeled items continued to receive the same percentage of total Interstate funding, the total investment required to maintain and improve the Interstate system would need to be factored up to accommodate them.

Exhibit A-15 indicated that an investment of $89.6 billion in Interstate highway and bridge preservation and widening over 10 years on the Interstate and the backlog of Interstate bridge investments at their respective 1997 levels. As shown in Exhibit A-16, factoring up this projection to include new construction and system enhancements results in an overall Cost to Maintain Interstate Highways and Bridges of $117.5 billion over 10 years.

Q. **Would the operational performance of the Interstate system be maintained if investment reached the Cost to Maintain level?**

A. No. The tenth row in Exhibit A-15 shows that this level of investment would maintain the physical conditions of Interstate highways and bridges, but that travel time costs would rise by 2.0 percent, and highway user costs would rise by 1.0 percent. Maintaining operational performance would be significantly more expensive than simply maintaining physical conditions.

Exhibit A-16

1998-2007 Cost to Maintain and Cost to Improve the Interstate System

	10-Year Cost to Maintain (Billions of 1997 Dollars)			10-Year Cost to Improve (Billions of 1997 Dollars)		
	Rural	Urban	Total	Rural	Urban	Total
Highway/Bridge Preservation & Widening						
Work on Existing Highways						
Highway Preservation	19.1	29.9	49.1	25.0	37.3	62.2
Widening	1.7	15.1	16.8	11.8	50.5	62.3
Subtotal, Existing Highways	20.9	45.0	65.9	36.8	87.7	124.5
Bridge Work	4.4	19.3	23.7	9.9	37.9	47.8
Subtotal Work on Existing Highways & Bridges	**25.2**	**64.4**	**89.6**	**46.7**	**125.6**	**172.3**
New Construction	*3.6*	*13.3*	*17.0*	*6.7*	*25.9*	*32.6*
System Enhancements	*2.9*	*8.0*	*10.9*	*5.4*	*15.6*	*21.0*
Total Investment	***31.8***	***85.7***	***117.5***	***58.8***	***167.1***	***226.0***

The top row of Exhibit A-15 shows a maximum investment level recommended by HERS and BNIP of $172.3 billion over 10 years. Factoring up this total to account for new construction and system enhancements would increase this amount to $226.0 billion. Exhibit A-16 identifies this value as the Cost to Improve Highways and Bridges.

Q. **What effect would investing at the Cost to Improve Interstate Highways and Bridges level have on conditions and performance?**

A. The highway portion represents the maximum level of investment that can be economically justified. The bridge portion represents the investment required to eliminate all deficiencies. As shown in Exhibit A-15, investing at this level would be expected to result in a 21.0 percent improvement in average IRI, a 2.0 percent decline in average travel time costs and a 1.6 percent reduction in average highway-user costs. The backlog of bridge deficiencies would be eliminated.

Cost to Maintain Conditions Compared to Projected Spending

Exhibit A-17 compares the Cost to Maintain Interstate Highways and Bridges identified in Exhibit A-16 with the projected 10-year capital expenditures on Interstates identified in Exhibit A-6. **Note that these projected expenditures are estimates based on simplifying assumptions about future Federal, State and local funding patterns.** Positive values in the last two columns of Exhibit A-17 indicate that where is a "gap" between projected spending and investment requirements. Negative values indicate that projected spending exceeds the investment requirements for that category.

Exhibit A-17

1998-2007 Cost to Maintain Interstates Compared to Projected Interstate Spending

	Cost to Maintain Cumulative 10-Year Investment Required (Billions of 1997 Dollars)			Projected 1998-2007 Interstate Spending ($Billions)	Cost to Maintain Compared to Projected Spending	
	Rural	Urban	Total		Difference ($Billions)	Percent Difference
Highway/Bridge Preservation & Widening						
Work on Existing Highways						
Highway Preservation	19.1	29.9	49.1	46.2	2.8	6.1%
Widening	1.7	15.1	16.8	30.1	-13.3	-44.2%
Subtotal, Existing Highways	20.9	45.0	65.9	76.4	-10.5	-13.7%
Bridge Work	4.4	19.3	23.7	19.7	4.0	20.3%
Subtotal Work on Existing Highways & Bridges	25.2	64.4	**89.6**	**96.1**	-6.5	**-6.7%**
New Construction	3.6	13.3	17.0	18.2	-1.2	-6.7%
System Enhancements	2.9	8.0	10.9	11.7	-0.8	-6.7%
Total Investment	31.8	85.7	117.5	126.0	-8.5	-6.7%

The table shows a $2.8 billion gap between the investment required for highway preservation and projected spending over 10 years, as well as a $4.0 billion gap between investment requirements and spending for bridges over 10 years. However, if current expenditure patterns continue, investment for widening would be $13.3 billion above the Cost to Maintain level over 10 years. If a portion of these resources were redirected toward highway and bridge preservation, IRI and the backlog of bridge investments could be maintained at this funding level.

In 1997, 14.4 percent of Interstate spending went for new construction. Exhibits A-6, A-16, and A-17 all assumed that this percentage would remain unchanged in the future. If instead, this percentage was reduced, additional resources would be available to put into other types of Interstate improvements. Based on the assumptions used to develop Exhibit A-6, projected 10-year new Interstate construction totals $11.7 billion. This funding would be more than adequate to close the highway preservation and bridge preservation gaps identified above.

As indicated earlier, the Cost to Maintain Interstate Highways and Bridges represents the level of investment required to maintain physical conditions. Maintaining travel time costs or highway user costs would require a significantly higher level of investment.

Cost to Improve Compared to Projected Spending

Exhibit A-18 compares the Cost to Improve Interstate Highways and Bridges identified in Exhibit A-16 with the projected 10-year capital expenditures on Interstates identified in Exhibit A-6. The gaps between projected spending and this level of investment are identified in the second to last column, while the last column shows the additional resources above projected levels that would be required to close the gaps.

Exhibit A-18

1998-2007 Cost to Improve Interstates Compared to Projected Interstate Spending

	Cost to Improve Cumulative 10-Year Investment Required (Billions of 1997 Dollars)			Projected 1998-2007 Interstate Spending ($Billions)	Cost to Improve Compared to Projected Spending	
	Rural	Urban	Total		Difference ($Billions)	Percent Difference
Highway/Bridge Preservation & Widening						
Work on Existing Highways						
Highway Preservation	25.0	37.3	62.2	46.2	16.0	34.7%
Widening	11.8	50.5	62.3	30.1	32.2	106.7%
Subtotal, Existing Highways	36.8	87.7	124.5	76.4	48.2	63.1%
Bridge Work	9.9	37.9	47.8	19.7	28.1	142.4%
Subtotal Work on Existing Highways & Bridges	46.7	125.6	**172.3**	**96.1**	76.3	**79.4%**
New Construction	6.7	25.9	32.6	18.2	14.4	79.4%
System Enhancements	5.4	15.6	21.0	11.7	9.3	79.4%
Total Investment	58.8	167.1	226.0	126.0	100.0	79.4%

Overall, the Cost to Improve Interstate Highways and Bridges is 79.4 percent ($100.0 billion over 10 years) above the level of projected Interstate spending. As in the case for the Cost to Maintain, bridge spending would need to increase by a larger percentage than highway spending in order to close the gap. However, unlike the Cost to Maintain, the gap for widening ($32.2 billion over 10 years) is larger than the gap for highway preservation (16.0 billion over 10 years). The implication of this is that at lower levels of funding, the HERS model would recommend investing a greater share of available resources in system preservation, rather than widening. However, if funding levels increased, there are a significant number of cost-beneficial widening projects that HERS would recommend funding.

Implications

The Cost to Maintain Interstate highways and bridges can be viewed as a "floor." This is the level of investment required to maintain the physical conditions of the Interstate assets already in place. However, operational performance would be expected to decline at this level of investment. The Cost to Improve Interstate highways and bridges can be viewed as a "ceiling." This level of investment would address all cost-beneficial highway investments and correct all bridge deficiencies. Investments above this level would not be expected to have a positive rate of return.

If current highway and bridge spending patterns remain constant, and the overall level of highway and bridge spending increases as predicted in this report, $126.0 billion (in constant 1997 dollars) will be expended for capital improvements to Interstate highways and bridges over the next 10 years. This level of investment would be 6.7 percent above the $117.5 billion Cost to Maintain level, but would need to rise 79.4 percent to reach the $226.0 billion Cost to Improve level. Using the analogy introduced above, this level of investment would lift us a little ways off the floor, but we would still be far away from the ceiling.

This study shows that if additional resources become available for capital improvements to the Interstate system, they could be utilized in a productive fashion. There is substantial room for improvement to highway and bridge conditions and performance in terms of improving pavement conditions, reducing bridge deficiencies, reducing congestion, and reducing the overall costs experienced by highway users traveling Interstate routes. Additional investment may also tend to have favorable impacts that are not modeled, such as improved system reliability and economic productivity.

Addressing Interstate System Needs

Much of the analysis in this appendix compares the needs identified in the two scenarios to projected spending on the Interstate System. Those projections of spending are based on the assumption that States will spend on the Interstate System the same proportion of the funds available to them in future years as they did in 1997. These comparisons provide a benchmark measure of the ability and willingness of States to apply the resources required to meet the scenario goals.

The following analysis examines how the structure and funding levels for the components of the Federal-aid Highway Program (FAHP) align with Interstate System needs: Would the level and categories of Federal funding enable States to meet Interstate needs? Are they likely, under the current demands across the systems, to do so?

To get a true picture of the current Federal funds available to address Interstate System needs, one must understand the FAHP structure overall. The Transportation Equity Act for the 21st Century (TEA-21) continued the longstanding trend in authorizing legislation which increased the flexibility afforded the States under the FAHP while providing a substantial increase in funding. First, a key characteristic of the FAHP is that project selection is clearly a State prerogative within the Federal funding categories and subject to the planning processes. Second, national priorities are expressed in the structure of the FAHP, with categories provided for key eligibilities which can be system-based or improvement-based (e.g., Interstate Maintenance, the National Highway System, the Highway Bridge Replacement and Rehabilitation Program). Third, TEA-21 increased the ability of States to transfer among program categories so that there is some flexibility allowed States to move funds from one eligibility category to another, depending upon competing demands on other systems and for other purposes.

Therefore, many categories can be used to fund specific types of improvements to the Interstate System but only the Interstate Maintenance (IM) category must be used for the Interstate alone. For example, improvements from the IM category can only be applied to system preservation or the addition of HOV lanes on the Interstate. Likewise, the only improvements made on the Interstate from the Highway Bridge Replacement and Rehabilitation Program (HBRRP) funds are for the repair or replacement of deficient bridges, including the addition of lanes on those bridges. States can choose to supplement IM with programs which have broad eligibilities, such as the Surface Transportation Program (STP) (essentially a block grant), on their Interstates. National Highway System (NHS) and HBRRP funds are routinely used for improvements off the Interstate System.

FAHP Funds Available for Interstate by Category

For purposes of this analysis, available Federal funds, by category, were projected for the 10-year period assuming that the FY 2003 funding levels in TEA-21 would be continued through 2007.

System Preservation

The IM Program was authorized specifically to fund preservation of highways on the Interstate System. The primary eligibilities are the resurfacing, restoration, rehabilitation, and reconstruction of existing Interstate System facilities. IM Program funding for the 10-year period 1998-2007 is estimated at $47 billion including the Minimum Guarantee funds that are added to the IM Program by law. When matched by State or local governments at a 90 percent Federal share, there would be an estimated $52 billion available for Interstate Maintenance activities for the 10-year period. This

would cover the $49.1 billion highway preservation needs under the Cost to Maintain Scenario and fund about 16 percent of the additional highway preservation costs under the Cost to Improve scenario.

Widening

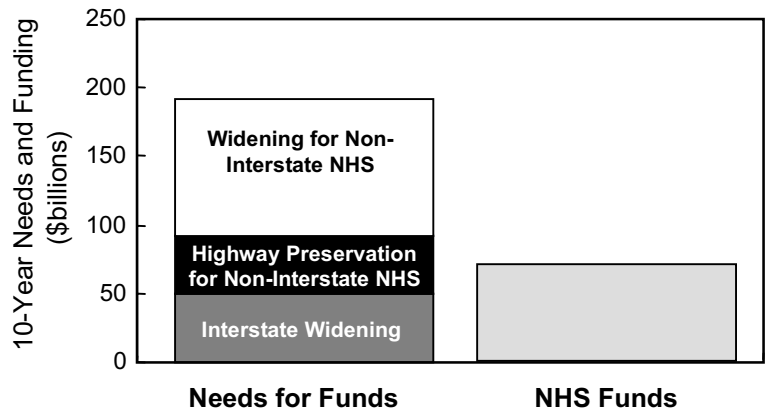
The IM Program funds described above may not be used to add lanes to the Interstate System unless those lanes are for high occupancy vehicles. The prime categories for Interstate widening in the form of single occupant vehicle lanes are the NHS Program and the STP.

Q. If we use NHS funds for the widening in the Interstate Cost to Maintain scenario, will other NHS needs be met?

A. Not completely. The remaining $39 billion of NHS funds would not quite cover the $43 billion in highway preservation needs identified in the Cost to Maintain scenario for non-Interstate NHS facilities (based on average annual NHS highway system preservation needs from Exhibit B-10 multiplied by 10 years). If States make system preservation their top priority, none of the system expansion needs in the Cost to Improve scenario could be funded from NHS funds. [See Exhibit A-19].

Exhibit A-19

NHS Funding Shortfall under Interstate Cost to Maintain Scenario



Projected authorizations for the NHS Program for the 1998-2007 are $56 billion, including the Minimum Guarantee funds that are added to the NHS Program by law. When matched by State or local governments at an 80 percent Federal share, there would be an estimated $70 billion available for activities eligible under the NHS Program. If about a quarter of the funds were used to fund widening the Interstate, the widening component of the Cost to Maintain scenario would be fully funded at $16.8 billion. With the Interstate System constituting about 29 percent of NHS mileage and serving over half of NHS vehicle miles of travel, the use of one-fourth of the NHS Program funding for Interstate widening seems reasonable.

Bridge

The Highway Bridge Replacement and Rehabilitation Program provides funding for the repair or replacement of deficient highway bridges on Federal-aid highways–generally those roads functionally classified as arterials, urban collectors, or rural major collectors. The program may also fund bridge repair or replacement on roads that are generally not eligible for Federal-aid–roads functionally classified as rural minor collectors and local roads. In fact, States are required to spend at least 15 percent of their HBRRP funds (and not more than 35 percent) on such roads. Thus, the HBRRP serves a broader category of highway facilities than most other Federal highway programs.

Projected authorizations for the HBRRP for 1998-2007 are $38 billion, including the Minimum Guarantee funds that are added to the HBRRP by law. When matched by State or local governments at an 80 percent Federal share, there would be an estimated $48 billion available for activities eligible

under the HBRRP. The $23.7 billion bridge component of the cost to maintain would require almost half of the available HBRRP funding. As Interstate bridge needs in the Cost to Maintain scenario are about half of total bridge needs (including local roads), States might choose to fully fund the Interstate bridge maintenance needs from HBRRP funds (see Exhibit 7-8).

Summary

The Interstate Needs identified in the Cost to Maintain scenario can be satisfied if 90 percent of IM, one-fourth of NHS, and one-half of HBRRP funds were targeted to this system. If States did so, they would be able to meet the Cost to Maintain scenario on the NHS overall only by supplementing their NHS funds with STP (or non-Federal) funds. Implementation of the Cost to Improve scenario for the Interstate System can be accomplished only at the expense of meeting Cost to Maintain needs on other roads and bridges.