U.S. Department
of Transportation

Federal Highway Administration

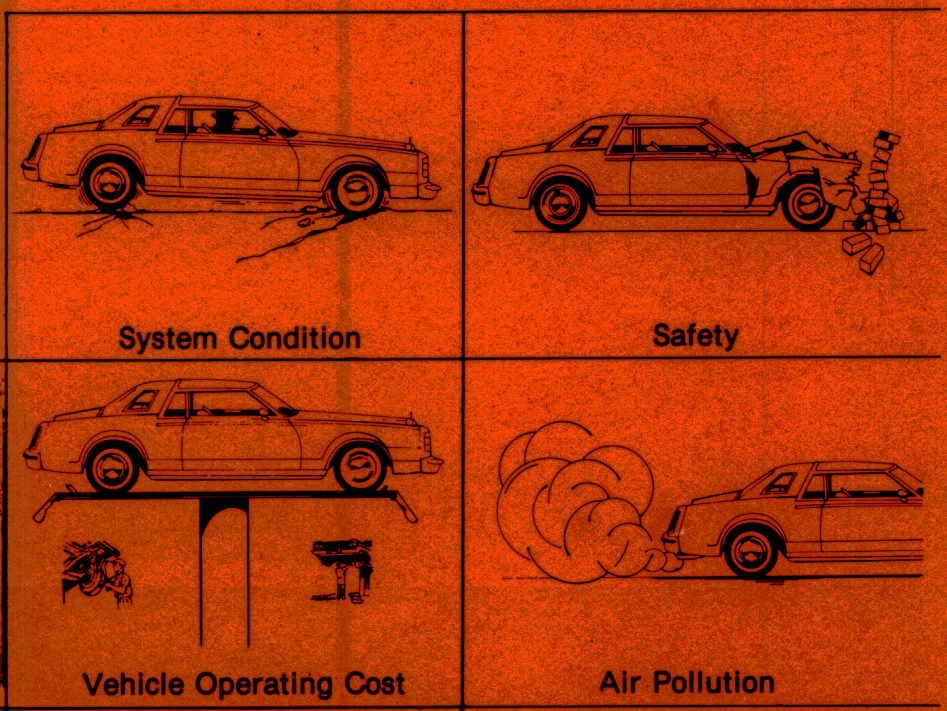
Office of Planning

Highway Performance Monitoring System Analytical Process

Sensitivity Analysis

Part 2: Sensitivity to Data

Part 3: Sensitivity to Minimum Tolerable Conditions



June 1988

FHWA-ED-88-041

HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS

SENSITIVITY ANALYSIS

Part 2: SENSITIVITY TO DATA

Part 3: SENSITIVITY TO MINIMUM TOLERABLE CONDITIONS

Report No. FHWA-ED-88-041

Federal Highway Administration
Office of Planning
Highway Performance Analysis Branch (HPN-21)

June 1988

PREFACE

The Highway Performance Monitoring System (HPMS) data base contains the most complete and accurate information available on our national highway network. Information from this data base is included yearly in the FHWA publication "Highway Statistics." In addition, the data is used biennially in determining future highway program needs, for Interstate 4R apportionment, and as support for the "Report to the Congress on the Status of the Nations Highways: Conditions and Performance."

In order to improve the utility of HPMS, the Highway Performance Analysis Branch (HPN-21) has reviewed the HPMS data base and the Analytical Process. The purpose of this review was to determine the sensitivity of the HPMS Analytical Process to the input data and to the minimum tolerable conditions (MTC) used as threshold levels to identify deficiencies. The three principal areas of review were as follows:

1. Determine the characteristics of the data, i.e., what values are coded for specific data items. Besides providing "nice-to-know" information about the coding practices, this information provided input to part 2 of the review. The results were used in determining which data elements would be reviewed in the sensitivity analysis.

2. Determine the sensitivity of the Analytical Process to changes in certain coded data items, e.g., what happens to the results of the Analytical Process if traffic growth is different than coded, or if the percent trucks is different.

3. Determine the sensitivity of the model to changes in the MTCs, e.g., using the current national default MTCs as a benchmark, what happens to the results of the Analytical Process if we are willing to accept a higher level of congestion before adding lanes, or to accept narrower lanes.

This report contains the results of Parts 2 and 3 of the project. The results of Part 1 are contained in a companion volume dated May 1987.

HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS

SENSITIVITY ANALYSIS

Table of Contents

INTRODUCTION

BACKGROUND

The Highway Performance Monitoring System (HPMS) includes inventory and performance data for a set of sample highway sections in each State. The Federal Highway Administration (FHWA) analyzes this data for various purposes, including the preparation of a biennial report to the Congress "The Status of the Nation's Highways: Conditions and Performance." These data are updated each year by the State Highway Agencies and furnished to the FHWA.

The HPMS Analytical Process is a system of computer programs which analyze this sample section data. This process was developed by the FHWA and is available to the States. It is used to estimate highway needs for the base year (inventory year) and for an analysis period of future years. Needs are the estimated costs of improvements to correct the identified deficiencies. The needs for the base year are called backlog needs. Future needs are estimated by applying the projected traffic contained in the data and estimating the future congestion levels and pavement deterioration based on these projected traffic loads.

The Analytical Process applies a set of criteria called the minimum tolerable conditions (MTCs) to the data to identify deficient highway sections. Improvements are then selected to correct these deficiencies. The accuracy of both the inventory data as coded by the States and the MTCs as provided by the user of the Analytical Process are important to the goal of obtaining realistic needs estimates.

PURPOSE OF STUDY

The purpose of this report is to demonstrate the sensitivity of the HPMS Analytical Process to selected sample section data elements and to the minimum tolerable conditions (MTC) used in the analysis. States may wish to know which data elements and MTCs are the most critical to achieving realistic results when using the Analytical Process.

The first part of this study demonstrates the degree to which specific data elements affect the results of the analysis. Some data elements may affect the analytical results to only a small degree, while others may affect the results dramatically. For analytical purposes, emphasis should be given to the accuracy of the data that have a large effect on the results of the analysis.

The second part of this study demonstrates the degree to which MTCs affect the needs and improvement mileage estimated by the analysis. States which use the HPMS Analytical Process will wish to note which MTCs have the greatest effect on the analysis results. The value of these MTCs should be given most careful consideration when they are set to represent the desired minimum conditions within the State.

The sensitivity of certain options available with the Analytical Process are also reported. While these are not actually data elements or MTCs, they are related features that have a significant effect on the result of the process. These user options include the pavement deterioration rates and the truck travel growth relative to overall ADT growth. Another item analyzed was the set of ESAL factors (18,000 pound equivalent single axle load per vehicle) for trucks. Changing these factors involves modifying a table in the program code. This can be done when a State has data supporting axle loads significantly different from those used in the Analytical Process pavement deterioration model.

PROCEDURES

The HPMS Analytical Process uses the sample highway section data to estimate miles of improvements by type and dollars of improvement needs. This may be done for the inventory year and for future years over a specified analysis period.

The analyses for this report were made for one 10 year analysis period, beginning with the base year of 1985. The future traffic reported was for the year 2005. The analysis cycle length was one year. The cycle-ahead period for pavement improvements, to determine whether a major capacity improvement would be needed, was 5 years. All costs are in current (1985) dollars, and funding was made available for all improvements.

It should be noted that for a single analysis period, the process will select only one improvement. This means that if an improvement is simulated early in the analysis period, any additional improvement needed late in the period will not be simulated. For an analysis period of 10 years, it is unlikely that a second improvement will be needed for many sections.

Additional analysis of several data items related to pavement improvement was done using two 5-year funding periods. Use of the two consecutive funding periods allowed a second improvement to be simulated on sections where changes in the conditions warranted another improvement within the 10 year overall analysis period.

The results of this study are presented in two parts: Sensitivity of the HPMS Analytical Process to Data Elements, and Sensitivity of the HPMS Analytical Process to Minimum Tolerable Conditions. A

data set using the sample section data for 17 States was used for these analyses. This data set contained approximately 35 percent of the national sample records. While these data are considered to be representative of conditions nationwide, results of a similar study for any one State could be significantly different from the findings presented in this report.

DATA ANALYSIS

This analysis demonstrates the sensitivity of the HPMS Analytical Process to the value of selected data items. The results are in terms of needs and miles of improvement. Also the composite index at the end of the analysis period is also shown. These measures indicate which of the data elements have the greatest influence on the analysis results.

Two of the items analyzed represent options that are available to the user of the Analytical Process. These are relative truck growth and pavement deterioration rate. Both can be modified easily by the user. Also listed is the truck ESAL factor, which is the 18 kip single axle load equivalent that is used in the pavement deterioration model.

The data elements chosen for this analysis are

SN or D
Pavement Condition
Pavement Deterioration Rate *
Lane Width
Right Shoulder Width
Left Shoulder Width
Widening Feasibility
Percent Trucks
Relative Truck Growth *
K Factor
Directional Factor
Current AADT
Future AADT
Combination of both Current and Future AADT
Truck ESAL Factors +

* Analytical Process options, not inventory items
+ Contained within the Analytical Process

MINIMUM TOLERABLE CONDITION ANALYSIS

This section demonstrates the sensitivity of the HPMS Analytical Process to the minimum tolerable conditions. The results of this study show which of the MTC values are the most critical to the analysis. These MTCs should be selected with the most care.

The MTCs are listed below:

RURAL

- Volume/Capacity Ratio
- Operating Speed
- Lane Width
- Pavement Condition
- Shoulder Type
- Right Shoulder Width
- Surface Type
- Horizontal Alignment
- Vertical Alignment

URBAN

- Volume/Capacity Ratio
- Operating Speed
- Lane Width
- Pavement Condition
- Shoulder Type
- Right Shoulder Width
- Surface Type

Tables III-1 and III-2 contain the default values of the MTCs used in the Analytical Process. The analysis of the pavement condition MTC includes both the threshold for identifying a need for resurfacing and the threshold for identifying a need for reconstruction.

SUMMARY OF RESULTS

Sensitivity to Data Elements

Figure I-1 graphically illustrates the sensitivity of the HPMS Analytical Process to the selected data elements. It shows the ratio of the magnitude of the percent change in needs compared to the magnitude of the percent change in the item analyzed. For example, in the case of lane width the ratio of the percent change was 3.5. This means that a one percent increase in lane width produces a 3.5 percent change in needs.

As an aid to understanding the results of this analysis, Table I-1 shows 1 percent of the improvement mileage, needs, and composite index for each item. This will give the reader an appreciation of the magnitude of the actual numerical change that caused the percent changes shown in this report. It is important not to give too much weight to large percent changes when the base value for the comparison was relatively small.

The items analyzed were placed into three basic categories based on their effects on the model:

Category 1. These items have a one-time effect in the analysis period. They generate immediate needs which when once corrected no longer generate additional needs:

Lane Width
Widening Feasibility
Right Shoulder Width
Left Shoulder Width

Category 2. These items affect capacity continuously throughout the analysis period:

Combination of both Current and Future AADT
K Factor
Future AADT
Directional Factor
Current AADT

Category 3. These items affect the pavement continuously throughout the analysis period:

Pavement Condition
Pavement Deterioration Rate
SN or D
Relative Truck Growth
Percent Trucks
Truck ESAL Factors

The data in Category 1 generally had the greatest effect on needs generated by the process, but the influence of these items would decrease over a longer period of time. The items in Category 2 had more influence on needs than did those in Category 3. This is due to the higher cost of capacity related improvements generated by items in Category 2 compared to resurfacing related improvements generated by those in Category 3.

After the backlog has been eliminated, the process limits most pavement related improvements to resurfacing. With unlimited funds, pavements are resurfaced before reconstruction is needed. With constrained funding, where more of the pavements are allowed to fail, there is a greater effect on needs because of the increased cost of subsequent pavement reconstruction.

The items analyzed generally affected the mileage of improvements less than they affected needs. The items below were the only ones that did affect mileage to a large degree:

Lane Width
Pavement Condition
Pavement Deterioration Rate
SN or D

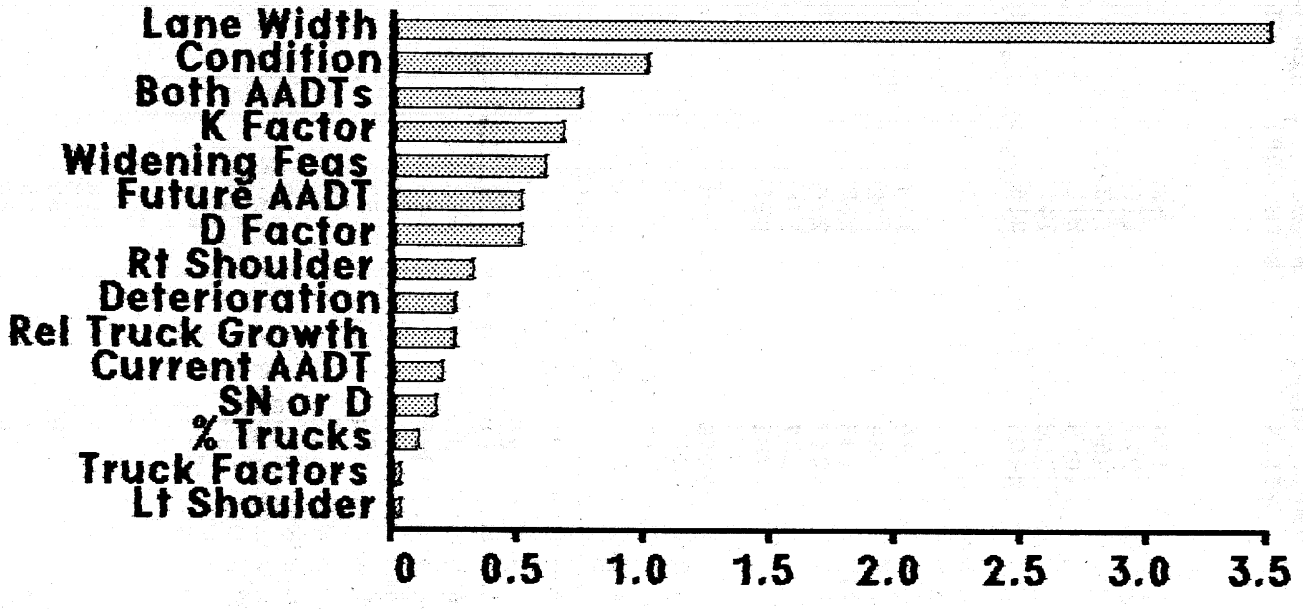
Generally, for traffic related items (Category 2), the effects of changes were greater in urban areas than in rural areas. For pavement related items (Category 3), the reverse was true. In rural areas, the traffic related items generally affected the higher functional classes more than the lower; however, for the pavement related items the effect varies. For truck related items (relative truck growth, percent trucks, and truck ESAL factors), higher functional classes were affected more than the lower classes; for pavement related items the reverse was true.

Additional analysis was done for pavement related items using two 5-year funding periods instead of the single 10-year funding period used for most of the analyses. The second funding period allows the process to simulate a second improvement on a highway section if a deficiency is identified. An analysis was also done changing the truck ESAL factors.

FIGURE I-1

MODEL EFFECTS

Relative magnitude of changes



% Change in Needs($) / % Change in Item

1985 HPMS Data

TABLE I-1

ONE PERCENT OF
IMPROVEMENT MILES, NEEDS, AND COMPOSITE INDEX

FUNCTIONAL CLASS	IMPROVEMENT MILES	NEEDS ($000,000)	COMPOSITE INDEX
RURAL			
Interstate	124	63	0.9
Other Principal Arterial	277	166	0.9
Minor Arterial	455	173	0.9
Major Collector	1009	271	0.9
Minor Collector	598	142	0.8
Total	2464	815	
URBAN			
Interstate	49	153	0.8
Other Freeway & Expresswa	34	92	0.8
Other Principal Arterial	195	267	0.7
Minor Arterial	257	235	0.8
Collector	257	146	0.9
Total	792	893	
TOTAL	3256	1708	
IMPROVEMENT TYPE			
RURAL			
Reconstruct to Freeway	23	53	
Reconstruct more lanes	15	35	
Reconstruct wider lanes	88	76	
Pavement reconstruction	378	243	
Pavement recon & alignmen	81	59	
Major widening	34	57	
Minor widening	44	14	
Resurf & shoulder impr	420	75	
Resurfacing	1096	98	
Resurf, shldr, and align	124	65	
Resurf & align improv	159	42	
Total	2464	815	
URBAN			
Reconstruct to Freeway	1	12	
Reconstruct more lanes	9	55	
Reconstruct wider lanes	1	5	
Pavement reconstruction	26	56	
Major widening	89	386	
Minor widening	29	45	
Resurf & shoulder impr	206	99	
Resurfacing	430	235	
Total	792	893	

Sensitivity to Minimum Tolerable Conditions

The sensitivity analysis of changes to the minimum tolerable conditions (MTC) can be divided into two categories of MTCs, major and minor. The major MTCs identify specific deficiencies which result in additional improvements, whereas the minor MTCs generally affect only the type of improvements. In general, the analysis was more sensitive to changes in the major MTCs than in the minor MTCs.

Major MTCs

Operating Speed
Volume/Capacity Ratio
Lane Width
Pavement Condition

Minor MTCs

Shoulder Type
Right Shoulder Width
Surface Type
Horizontal Alignment
Vertical Alignment

The sensitivity of the results of the Analytical Process to the MTCs is discussed in terms of needs (costs of improvements) because they showed greater change than miles of improvements. Figure I-2 shows the sensitivity of the needs to changes in the major MTCs of approximately 10%. The results were relatively insensitive to rural volume/capacity ratio and urban operating speed, so these results are not shown.

In the rural analysis, the largest changes were the result of (1) increasing the lane width and (2) changing the pavement condition MTCs for both resurfacing and reconstruction together. Changing the pavement condition MTCs for resurfacing and reconstruction individually has less effect.

In the urban analysis, the largest changes were the results of increasing and decreasing the MTCs for pavement condition, lane width, and volume/capacity ratio. A significant finding was the high sensitivity of the process to lane width.

Figure I-3 shows the sensitivity of the costs of improvements to changes in the minor MTCs by one category number or 2 feet for shoulder width. (One category number means changing the coded value by "1" numerically, e.g., changing surface type from 3 to 4.) The largest change by far was due to the increase in quality of rural surface type. When the surface type MTC for collectors with less than 400 ADT was changed from gravel to low, a large demand for reconstruction was generated. Moderate changes occurred when

the quality of vertical and horizontal alignment (rural areas only) and rural shoulder type were increased.

In the urban analysis, the largest changes were the results of decreasing the MTC for shoulder width. The other urban needs changes are very small and are not shown. The significance of these findings is that the surface type MTC should be carefully chosen where there is a large mileage of low standard roads, particularly gravel. Also the choice of the horizontal and vertical alignment MTC values are quite important.

FIGURE I-2

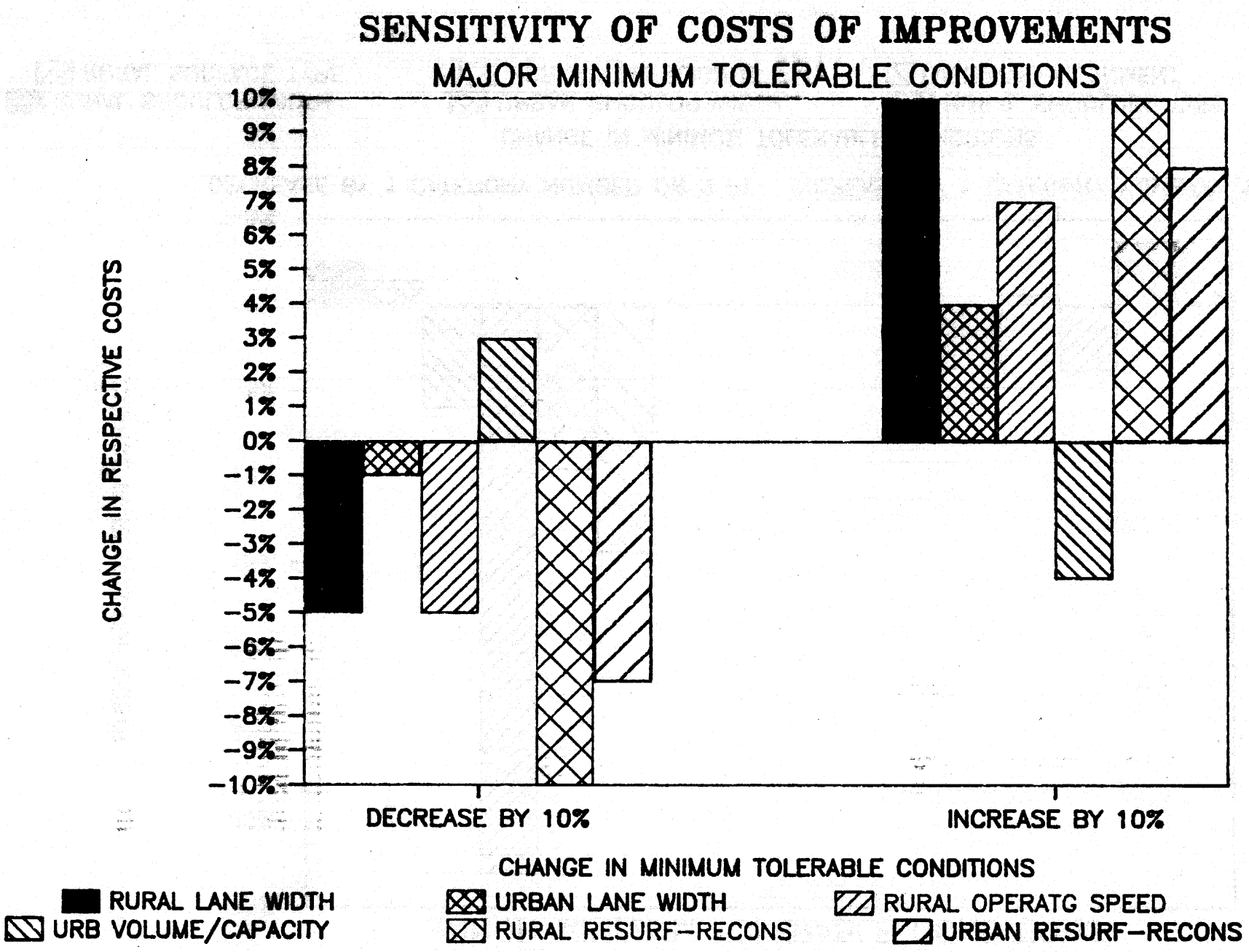
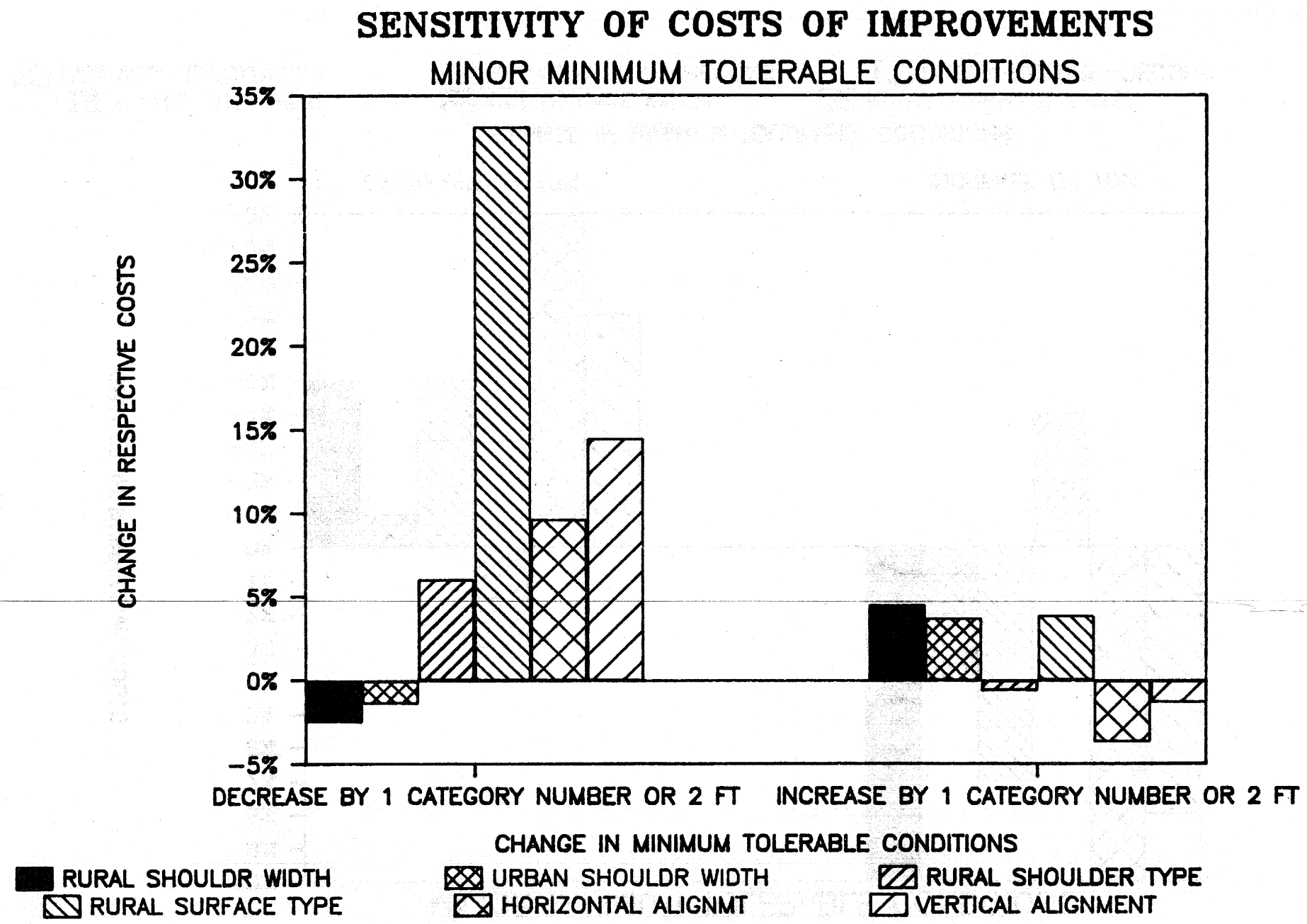

SENSITIVITY OF COSTS OF IMPROVEMENTS
MAJOR MINIMUM TOLERABLE CONDITIONS
CHANGE IN RESPECTIVE COSTS
10%
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
-1%
-2%
-3%
-4%
-5%
-6%
-7%
-8%
-9%
-10%
DECREASE BY 10%
INCREASE BY 10%
CHANGE IN MINIMUM TOLERABLE CONDITIONS
RURAL LANE WIDTH
URBAN LANE WIDTH
RURAL OPERATG SPEED
URB VOLUME/CAPACITY
RURAL RESURF-RECONS
URBAN RESURF-RECONS

FIGURE I-3


SENSITIVITY OF COSTS OF IMPROVEMENTS
MINOR MINIMUM TOLERABLE CONDITIONS
35%
30%
25%
20%
15%
10%
5%
0%
-5%
CHANGE IN RESPECTIVE COSTS
DECREASE BY 1 CATEGORY NUMBER OR 2 FT
INCREASE BY 1 CATEGORY NUMBER OR 2 FT
CHANGE IN MINIMUM TOLERABLE CONDITIONS
RURAL SHOULDR WIDTH
URBAN SHOULDR WIDTH
RURAL SHOULDER TYPE
RURAL SURFACE TYPE
HORIZONTAL ALIGNMT
VERTICAL ALIGNMENT

Part 2: SENSITIVITY TO DATA

GENERAL COMMENTS

This analysis was done to study the sensitivity of the HPMS Analytical Process to various data elements. The Analytical Process was used to generate needs, miles of improvement, and composite index values. About half of the items analyzed affect the value of capacity and v/c ratio. After the values of these items were changed for testing, the HPMS Submittal Software was used to calculate the changes to capacity and v/c ratio resulting from changing these data elements.

The results for some items include only rural results, even though the item may be collected for both rural and urban locations. This was the case where the item would have affected the State-coded urban capacity. Since the submittal software does not recalculate the urban capacity, there was no reasonable way to adjust the capacity as a State would have done.

Certain items whose values were discrete in nature, like terrain or surface type, were not analyzed. It was difficult to change these by a certain percent, and it did not seem useful to analyze each section with one particular value. Where a specific value was added to each data item for the analysis, the resulting value was then checked to make sure that it was not impossible, like a directional factor greater than 100%.

Data elements analyzed were those items that were generally estimated by the States, those where there may be some confusion about the coding, or those items that had unusual results from the "Characteristics of the Data," part 1 of this project, published separately.

A distinction is made between adding or subtracting set percentage points from the originally coded values (for example, 15% + 5% = 20%), as opposed to multiplying the items by 100 plus a certain percent (for example 15% x 105% = 15.75%), a result of increasing the original value by 5 percent.

Figures II-1 and II-2 show the percentage distribution of each major category of improvement miles before changes were made in the data elements, for rural and urban areas respectively.

ANALYSIS OF SPECIFIC DATA ELEMENTS

The data elements analyzed in this study are given below with a brief explanation of the results of the analysis. The item numbers shown in the parentheses are from the HPMS Field Manual, 1986

edition. Appendix A contains the tables that present the detailed results of the study. Selected results are illustrated in figures and tables in this section of the report.

SN or D (Item 35)

Where this item was coded as heavy, medium, or light it was given a representative value for SN or D before changes were made to this data item. The values used are the default values used in the HPMS Analytical Process and are listed below:

	Heavy	Medium	Light
Flexible pavement (SN)	5.3	3.8	2.3
Rigid pavement (D)	10.0	8.0	6.0

(Light rigid pavement was set to 6.0 instead of the Analytical Process default value of 6.5 because the value of D must be coded as an integer in the sample section data.)

Changing this data item had a small but significant effect on needs (Figure II-3) -- the needs changed about 1/6 the magnitude of the data item change (assuming 8 inch thick rigid pavement or flexible pavement with an SN of 4.0). Rural changes were slightly larger than for urban areas.

The composite index was not very sensitive to changes in SN or D. Differences across functional classes were not very significant. There was a major effect on miles of improvement compared to other items analyzed. This is generally true of pavement related data elements.

Improvement types shifted to more work involving reconstruction/ resurfacing at the expense of simple capacity improvements. For example, when 2 inches of rigid pavement thickness or 1 SN value for flexible pavement were subtracted, all additional miles of work are generated as pavement related improvements.

An analysis was done to measure the effect of changing all SNs of 0, 1, and 6 to other values, under the assumption that such values were either impossible (0) or attempting to satisfy the edit routine (1 & 6). The rural Interstate needs increased by 1 percent, and the other changes were insignificant.

Pavement Condition (Item 36)

Changing the estimated pavement condition has a major effect on both improvement mileage and needs -- the change was about the same magnitude as the percent change in the data item, assuming

average 3.2 PSR and changing only paved sections, (Figures II-3 and II-4).

The effect of changing this data item in rural areas was about 50 percent greater than in urban areas. Changes in the composite index were small. The effect was mixed across the functional classes, although there was a slightly greater effect on the lower rural functional classes.

Most of the effects of changing this data item occurred in the pavement reconstruction or resurfacing improvements. For example, deficient mileage increased by 16% when pavement condition was reduced with most of the net increase showing up as pavement reconstruction or resurfacing.

Pavement Deterioration Rate (Analytical Process Option)

Increasing the rate of pavement deterioration has the effect of shortening the life of the pavements compared to that reflected in the AASHTO equations (both rigid and flexible); the reverse is true for decreasing the deterioration rate.

Changing this model option causes a relatively small effect in the model needs -- the needs change about 1/4 the magnitude of the percent change in the deterioration rate (Figure II-3). Rural needs change approximately twice the magnitude of urban needs.

Changes in improvement mileage are comparable to or exceed corresponding percent changes in the needs. These effects are greater in lower functional classes than in the higher classes (Figure II-16). Changes in the composite index were minor. In the analysis of the urban improvement types, all additional improvement mileage shows up as pavement needs.

This is a change that would have a greater effect on needs over a longer period of time, such as a 20-year overall analysis period using several funding periods. This would give time for additional improvements to be made. The expected effect from this change would be for a larger number of improvements to be made over time, not for any change in the type of improvement.

Lane Width (Item 39)

The effects of changing lane width are shown only for rural areas. Adding additional width has relatively minor effects since few sections were originally deficient. Subtracting width has a major effect on needs and improvement mileage (Figure II-5). Needs change about 3 1/2 times the magnitude of data change, assuming an initial lane width of 12 feet.

The composite index for the lower functional classes increases directly with lane width. The shift in projects by improvement type indicates a much higher proportion of capacity related work, as would be expected when lane widths are reduced (Figure II-6).

Right Shoulder Width (Item 42a)

The effects of changing this element are shown only for rural areas. Adding additional width has relatively minor effects since few sections were originally deficient. Subtracting width has an intermediate effect on needs; the change is about 1/3 the magnitude of the data change (Figure II-5), if the shoulder width is 8 feet.

The higher minimum tolerable condition (MTC) on the Interstate system causes large needs increase when width is subtracted. A major effect on improvement types is to add shoulder improvements to resurfacing/alignment improvements that are already needed (Figure II-7). There is relatively little effect on the total mileage of improvements.

Left Shoulder Width (Item 42b)

This item applies only to divided highways. The effects of changing this item are shown only for rural areas, and the effect on needs, mileage of improvements, and composite index was insignificant. (The results are shown only in Appendix A.)

Widening Feasibility (Item 46)

This data item was changed so that either (1) all sections had no widening feasibility, or (2) all sections could be widened 2 lanes or more. This change had a relatively major effect on needs -- the needs changed about 3/5 the magnitude of the data item change, assuming 60% full widening feasibility to start. The change in needs was somewhat larger for eliminating widening feasibility (about 35%) than for allowing unlimited widening (about 27%), (Figure II-8). It should be noted that the model considers "needs" as costs of improvements to correct deficiencies that are feasible to correct. That is why coding all sections as not having any widening feasibility results in reduced needs.

Since urban areas had fewer sections coded with unrestricted widening feasibility than rural sections, increasing the widening feasibility caused a significantly larger change in urban needs than in rural areas (44% vs. 4%). Rural areas have relatively few capacity problems compared to urban facilities. The other principal arterial functional class had the greatest potential capacity problem, or traffic demand restricted by widening feasibility limitations.

By changing the widening feasibility, the improvements selected shifted to a higher proportion of capacity related work (Figure II-9). There was a shift from minor widening to major widening when greater widening was feasible.

Percent Trucks (Items 54a, 54b)

Comparable percentage changes were made to both the peak and the off-peak percent trucks. For analysis of these items, relative truck growth was held constant. The effects are shown only for rural areas, as capacity changes for urban areas could not be recalculated automatically (Figure II-10).

Changes to this item had relatively small effects on rural needs -- the needs change about 1/10 of the magnitude of the data item change (assuming 10% trucks initially). The needs by improvement type showed a minor shift to reconstruction with more lanes, and major widening increased with increasing percentage of trucks, reflecting the effect of trucks on both pavement and capacity. In general, the effects of changing this item are greater in the higher functional classes where the percent trucks tends to be higher initially.

An analysis was also made where the only change was to recode any section with 0% trucks as 3%, under the assumption that nearly all highway sections carry some truck traffic. This change had no significant effect on needs.

Relative Truck Growth (Analytical Process Option)

Changing this option has the effect of changing the percent truck figure over time, as would occur if the truck population were growing at a different rate from the passenger car population. For example, if we start with a percent truck figure of 15%, then changing the relative truck growth by +10% would result in 16.5% trucks the second year (15% x 1.1), 18.15% trucks the third year (16.5% x 1.1), etc. If, in this example, the overall traffic were increasing at 3% a year, then the truck traffic would be increasing at 13% a year.

Because of the relative compounding effect of fractions compared to integers, the effect on needs is much greater for increases than for reductions; compounding +10% for 10 years results in a 160% increase, while compounding -10% results in only a 65% decrease (Figure II-11).

This option had relatively small effect on needs. Needs changed about 1/5 the magnitude of the percent truck increase (comparing the average percent truck to the original figure) and 1/10 the

magnitude of the percent truck decrease (Figure II-10). The effects of changing this item are greatest on the higher functional classes, which have the greatest truck volumes. Increasing truck growth gave a greater emphasis to reconstruction and capacity improvements compared to resurfacing.

K Factor (Item 55)

This item as coded tends to have little variability. The changes tested had a major effect on the needs -- dollar needs changed about 2/3 of the magnitude of the data item change (Figure II-8), assuming 11% initially. The K factor indicates the peaking characteristic of the traffic for the design hour and is directly related to capacity needs.

In the rural areas, needs greatly decrease with lower functional class; the effect across the functional classes is less marked in urban areas (Figure II-12). Urban needs are affected more than twice as much as rural needs (Figure II-13).

The composite index changes in urban areas resulting from changing the K factor were as high as any measured in this project, indicating future capacity needs that will be even greater than the already large needs documented for the analysis period. Improvements involving added capacity become a greater proportion of the overall needs mix, as expected, with higher K factors (Figure II-9).

Directional Factor (Item 56)

This is a capacity related data item in urban areas and on rural multilane roads. On 2-lane roads, this item has no effect on the capacity calculated using the 1965 Highway Capacity Manual. It does affect capacity in the 1985 HCM, but these procedures had not been incorporated into the Analytical Process at the time of this study. The directional factor was not allowed to go below 50% when it was reduced.

The changes tested have an intermediate effect on total needs; they change about 1/2 the magnitude of the change in the data item (Figure II-8), assuming a D factor of 60 percent initially. As would be expected, urban needs are significantly more affected than rural needs (Figure II-13). The effects tends to be similar across urban functional classes, but are limited to the multilane routes in the rural areas. As with the K factor, the improvements selected show a shift towards capacity-related improvements.

Current AADT (Item 24)

Increasing the current AADT increases needs as average traffic over the period is increased; the converse is true for reducing current AADT (Figure II-14). This demonstrates the need for accurate traffic counting and estimation.

The urban and rural results are similar except that urban needs decrease twice as much as rural (10.1% vs. 5.6%) with a 30% AADT decrease. There are minor shifts in improvement mileage of about 1 to 2 percent within functional classes.

Changing this data item has a relatively small effect on needs; the change is about 1/5 the magnitude of the AADT percent change. The composite index changes more for urban areas than for rural areas indicating more future needs accruing. Increasing the traffic has less effect on lower functional classes because of their reserve capacity.

Changes in AADT affect both capacity and pavement condition, so improvement types shift accordingly (reconstruction or widening instead of resurfacing improvements) The relative occurrence of major or minor widening depends on initial conditions and widening constraints.

Future AADT (Item 61)

The effects are similar to those for current AADT (changed growth rate, change in average traffic), but since the upper limit is changed instead of the lower, the traffic volumes are on a higher plane compared to the "current" data item modification, so the changes are larger.

Changes in this data item cause an intermediate change in needs, about 1/2 the magnitude of the data item change (Figure II-14). Urban changes are approximately twice the magnitude of rural changes (Figure II-15). Changes in the mileage of improvements are relatively minor.

There are similar percent changes across all urban functional classes, but changes are more pronounced in the higher functional classes in rural areas. Increasing future traffic causes a shift in improvement types to more reconstruction/capacity related work compared to simple pavement improvements.

Current and Future AADT (Items 24, 61)

The analysis that tested changing both of these data items kept the estimated growth rate the same. As would be expected, this condition resulted in larger effects than modifying either of the data items individually, since the average traffic change over the analysis period would be greater than in the other two cases.

Changing these items had a major effect on needs -- the needs changed about 3/4 of the magnitude of the data item change. The urban needs were affected more than rural needs for each incremental change in the data items. In rural areas the needs are much greater in the higher functional classes (Figure II-16), but the percentage changes are relatively the same across the urban functional classes.

The AADT changes affect both capacity and pavement condition, so improvement types shifted accordingly with more reconstruction/widening at the expense of simple pavement related improvements. The relative occurrence of major or minor widening depends on initial conditions and widening feasibility.

Truck ESAL Factors

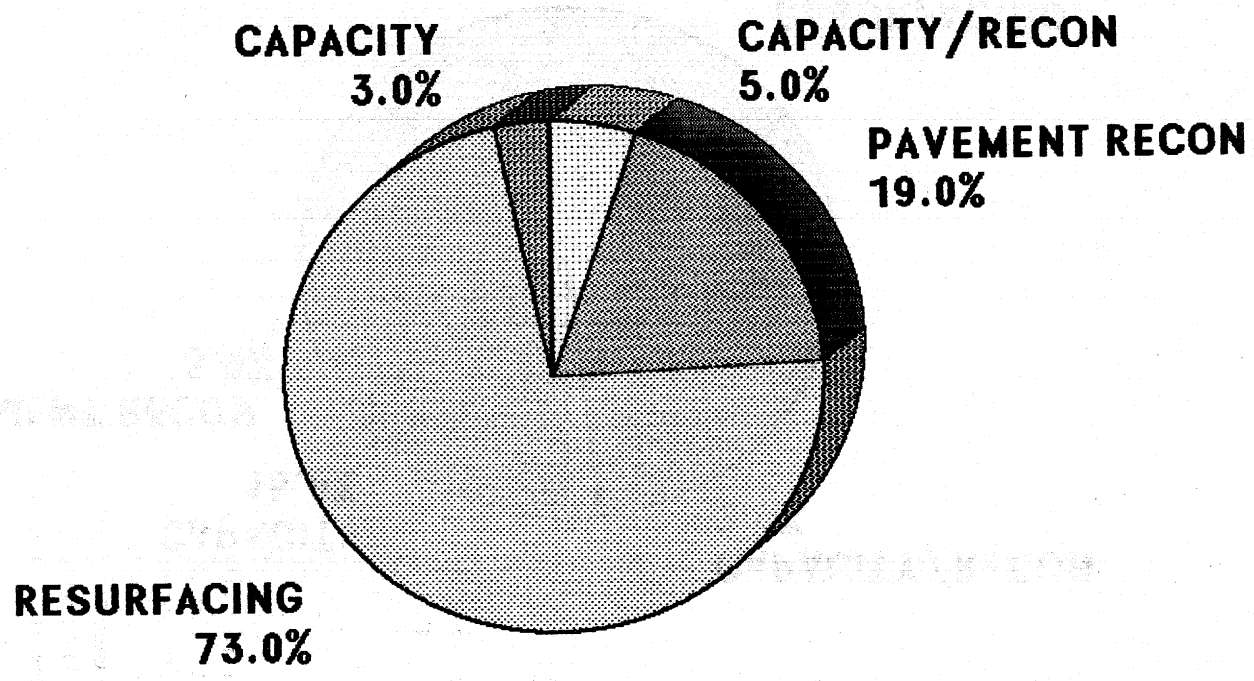
The truck ESAL factors (18,000 pound equivalent single axle loads per vehicle) are contained in a table in the pavement deterioration model, a part of the Analytical Process. The current default values are shown in Table II-1. The values represent average truck factors for a given distribution of trucks by functional class. All trucks (2-axle, 6-tire single unit and heavier) are included as "percent trucks" in the HPMS sample data. This data element is used in predicting the damage that will be done to the pavement by the traffic loads over time.

Changing these truck factors had a relatively small effect on total needs for the analysis period. The needs changed about 1/30 the magnitude of the percent change in the item (Figure II-10). The percent change in needs was similar in both urban and rural areas. In general, the effects are greatest on the Interstate system. Needs by improvement type generally shifted as expected: a greater proportion of pavement related mileage was simulated when the truck factors were increased.

FIGURE II-1

RURAL MILES OF IMPROVEMENT

BY IMPROVEMENT TYPE

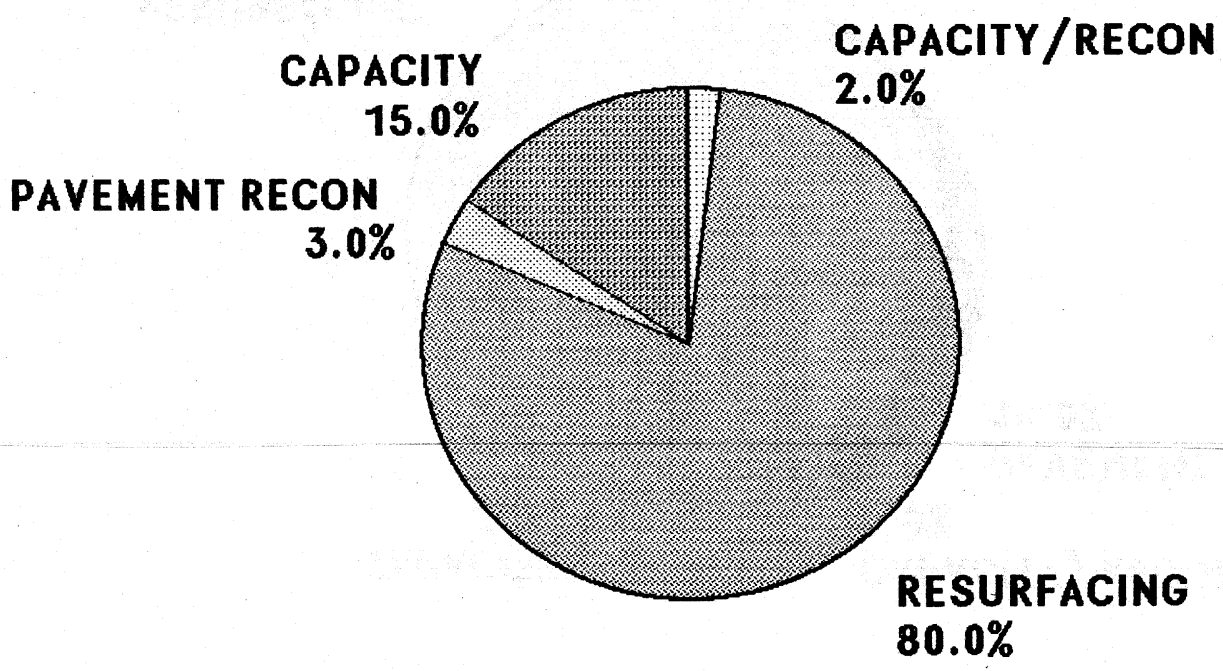


FOR THE BASE MODEL

FIGURE II-2

URBAN MILES OF IMPROVEMENT

BY IMPROVEMENT TYPE



FOR THE BASE MODEL

FIGURE II-3

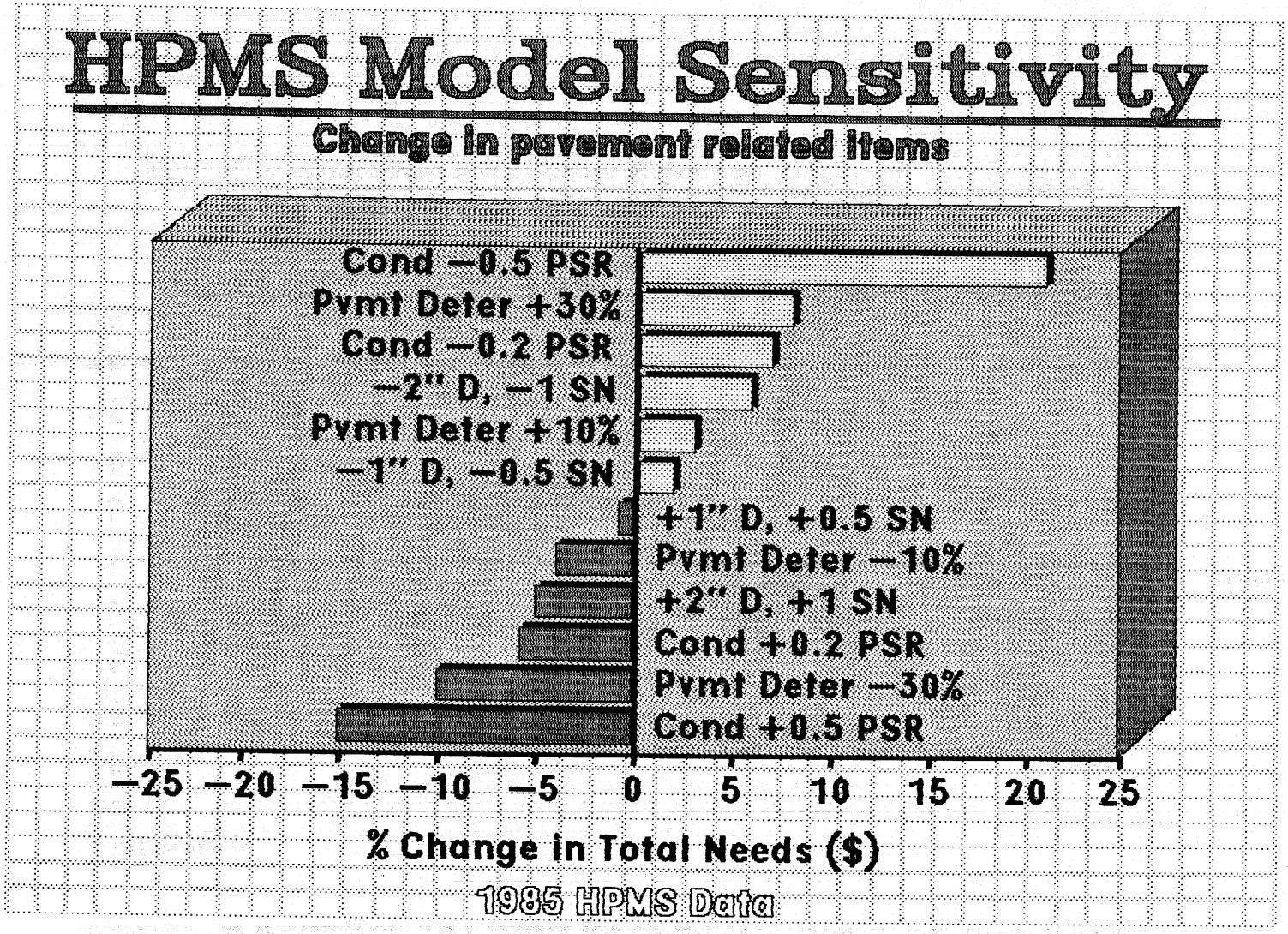

HPMS Model Sensitivity
Change in pavement related items
Cond −0.5 PSR
Pvmt Deter +30%
Cond −0.2 PSR
−2" D, −1 SN
Pvmt Deter +10%
−1" D, −0.5 SN
+1" D, +0.5 SN
Pvmt Deter −10%
+2" D, +1 SN
Cond +0.2 PSR
Pvmt Deter −30%
Cond +0.5 PSR
−25 −20 −15 −10 −5 0 5 10 15 20 25
% Change in Total Needs ($)
1985 HPMS Data

FIGURE II-4

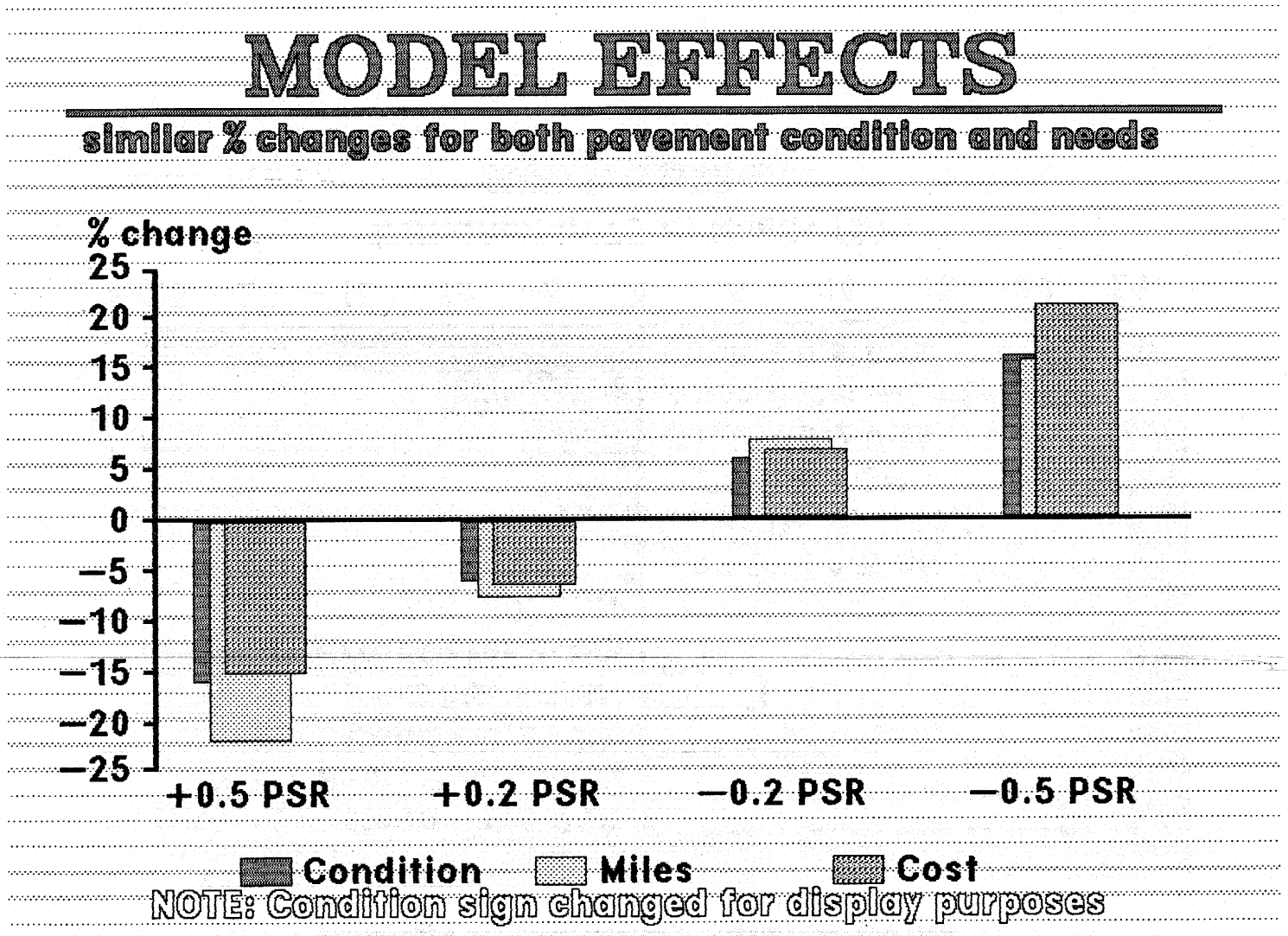

MODEL EFFECTS
similar % changes for both pavement condition and needs
% change
25
20
15
10
5
0
−5
−10
−15
−20
−25
+0.5 PSR
+0.2 PSR
−0.2 PSR
−0.5 PSR
Condition
Miles
Cost
NOTE: Condition sign changed for display purposes

FIGURE II-5

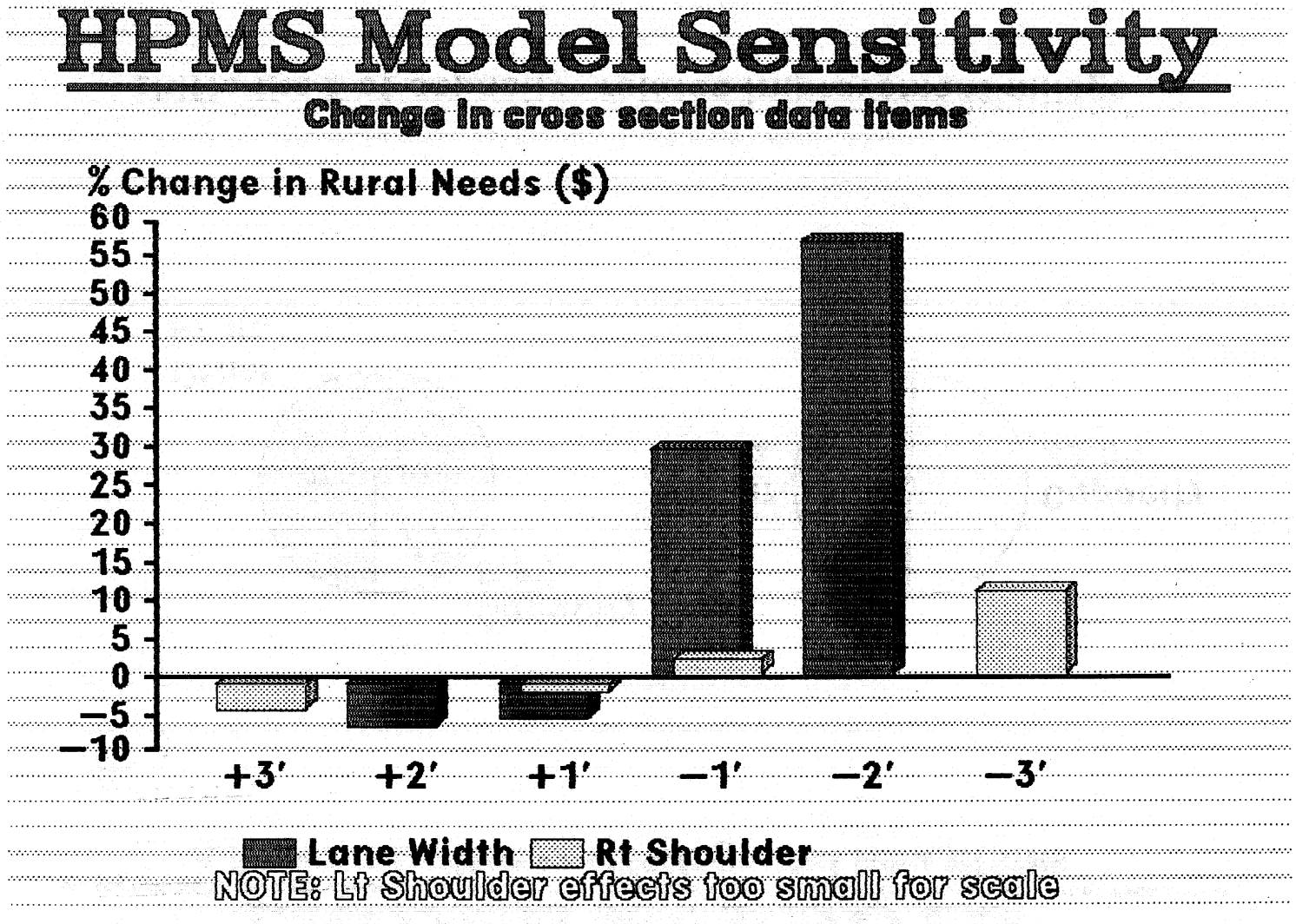
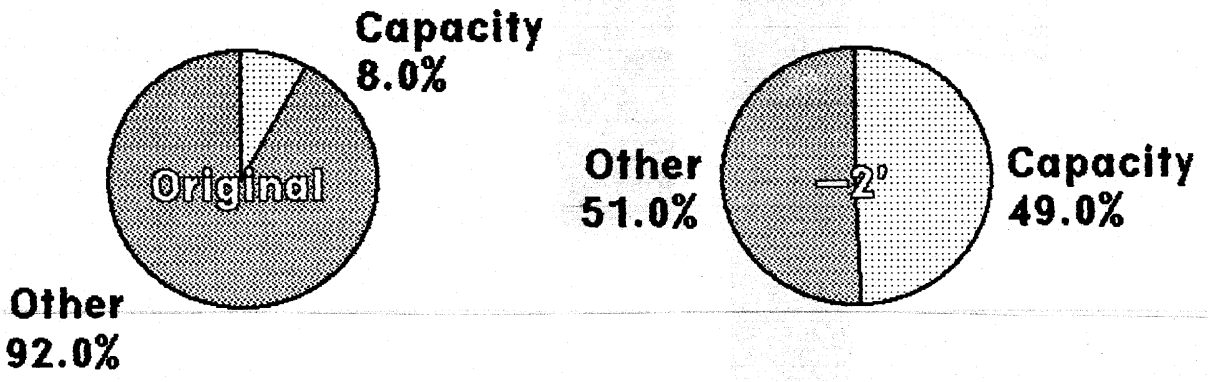

HPMS Model Sensitivity
Change in cross section data items
% Change in Rural Needs ($)
60
55
50
45
40
35
30
25
20
15
10
5
0
−5
−10
+3′
+2′
+1′
−1′
−2′
−3′
Lane Width
Rt Shoulder
NOTE: Lt Shoulder effects too small for scale

FIGURE II-6

MODEL EFFECTS

A 2 foot reduction in existing rural lane widths



shifts the % of capacity—related improvement milege

FIGURE II-7

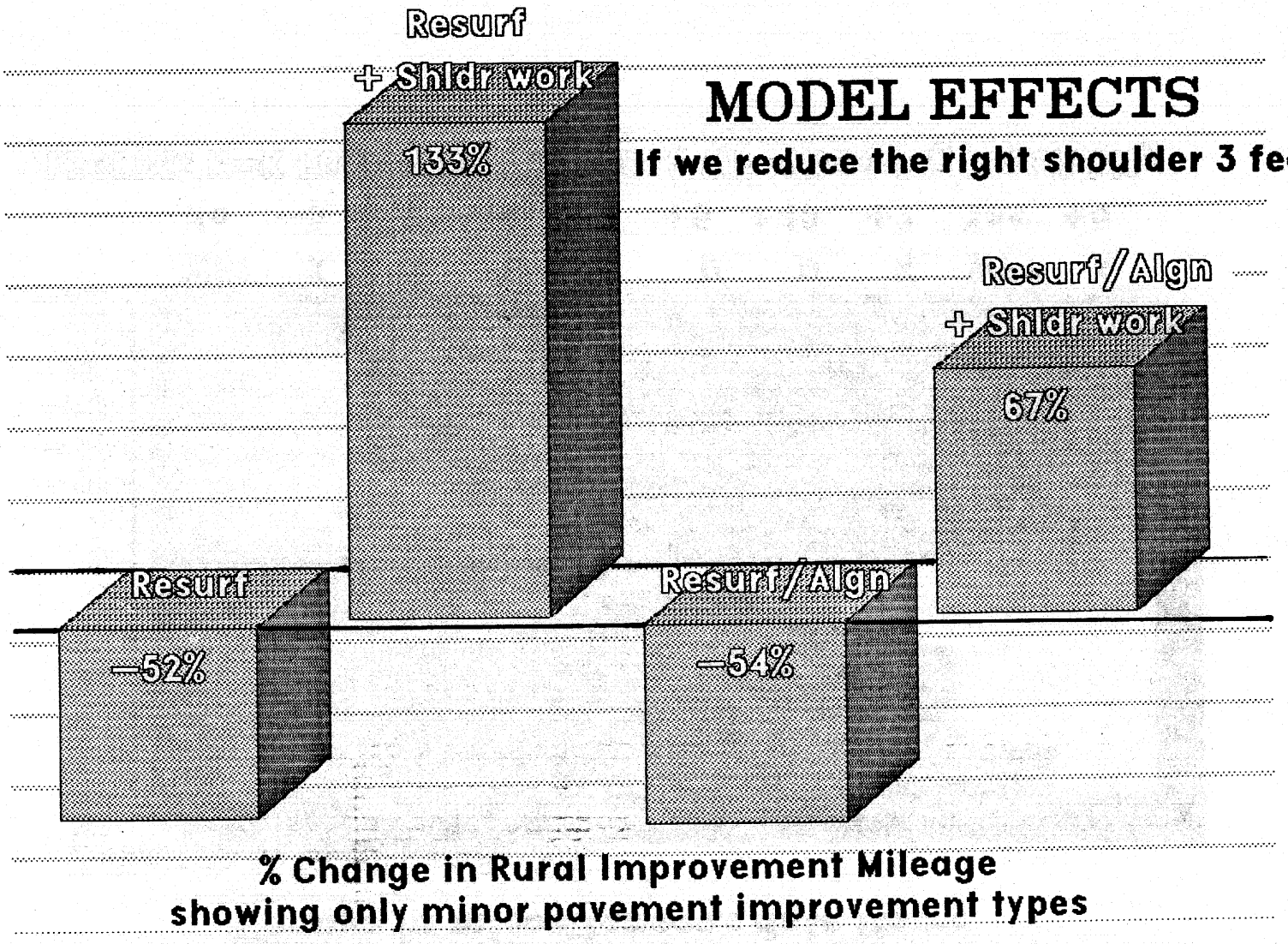

Resurf
+ Shldr work
133%
MODEL EFFECTS
If we reduce the right shoulder 3 feet
Resurf/Algn
+ Shldr work
67%
Resurf
—52%
Resurf/Algn
—54%
% Change in Rural Improvement Mileage
showing only minor pavement improvement types

FIGURE II-8

HPMS Model Sensitivity

Change in miscellaneous data items

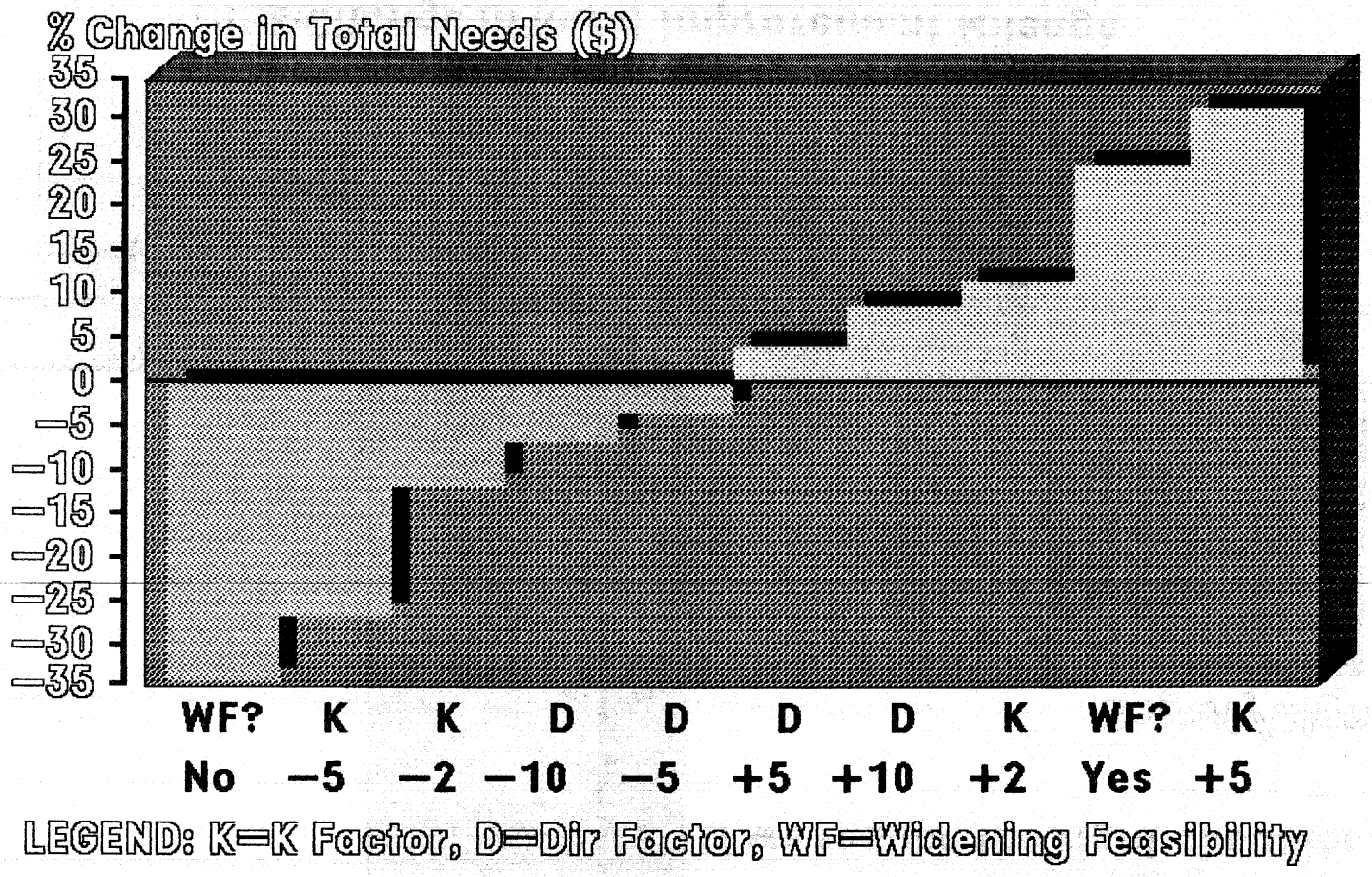
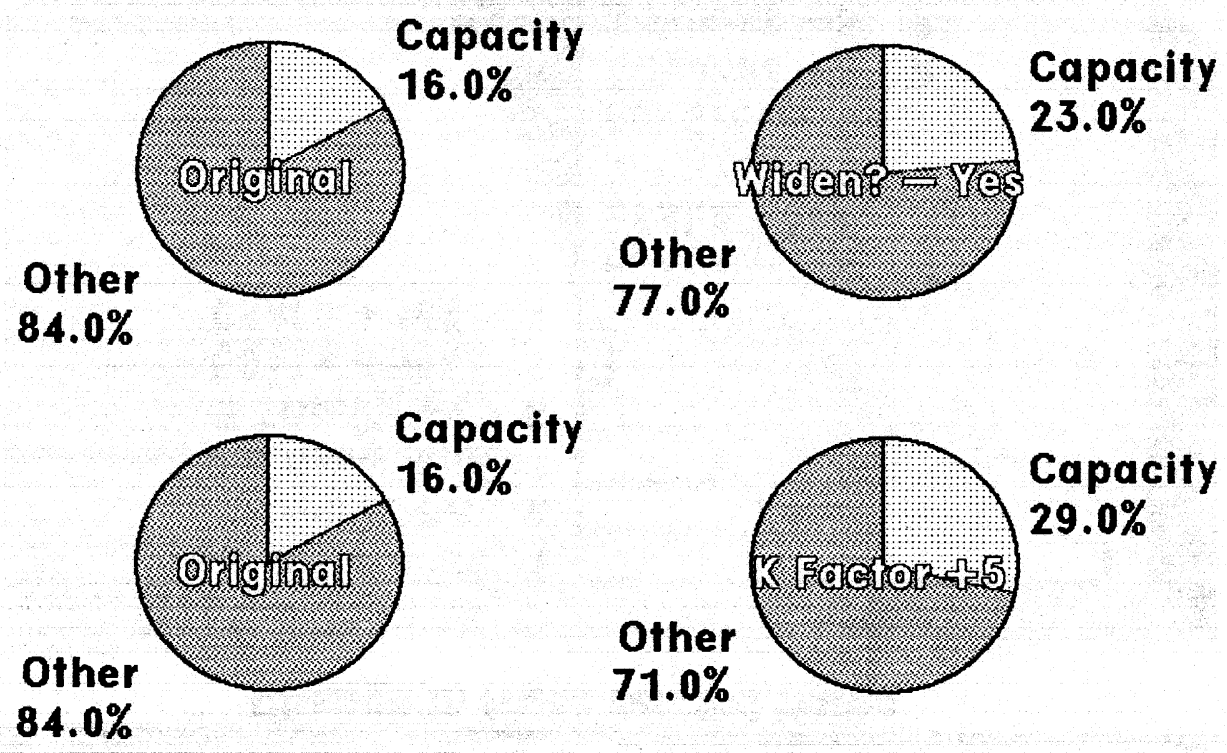


FIGURE II-9

MODEL EFFECTS

Changing urban widening feasibility and K Factor



similar effect on % of capacity—related improvement mileage

FIGURE II-10

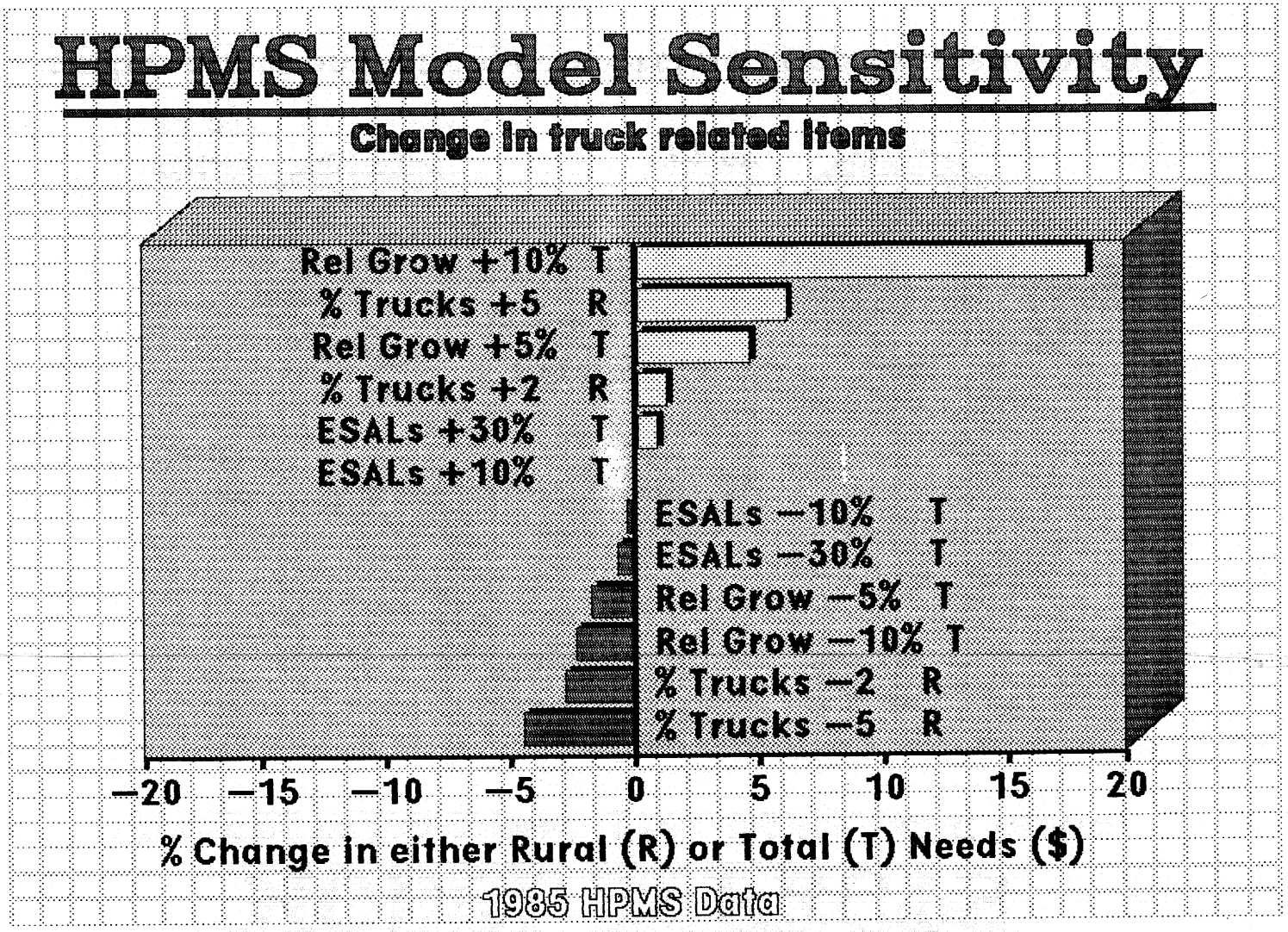

HPMS Model Sensitivity
Change in truck related items
Rel Grow +10% T
% Trucks +5 R
Rel Grow +5% T
% Trucks +2 R
ESALs +30% T
ESALs +10% T
ESALs −10% T
ESALs −30% T
Rel Grow −5% T
Rel Grow −10% T
% Trucks −2 R
% Trucks −5 R
−20 −15 −10 −5 0 5 10 15 20
% Change in either Rural (R) or Total (T) Needs ($)
1985 HPMS Data

FIGURE II-11

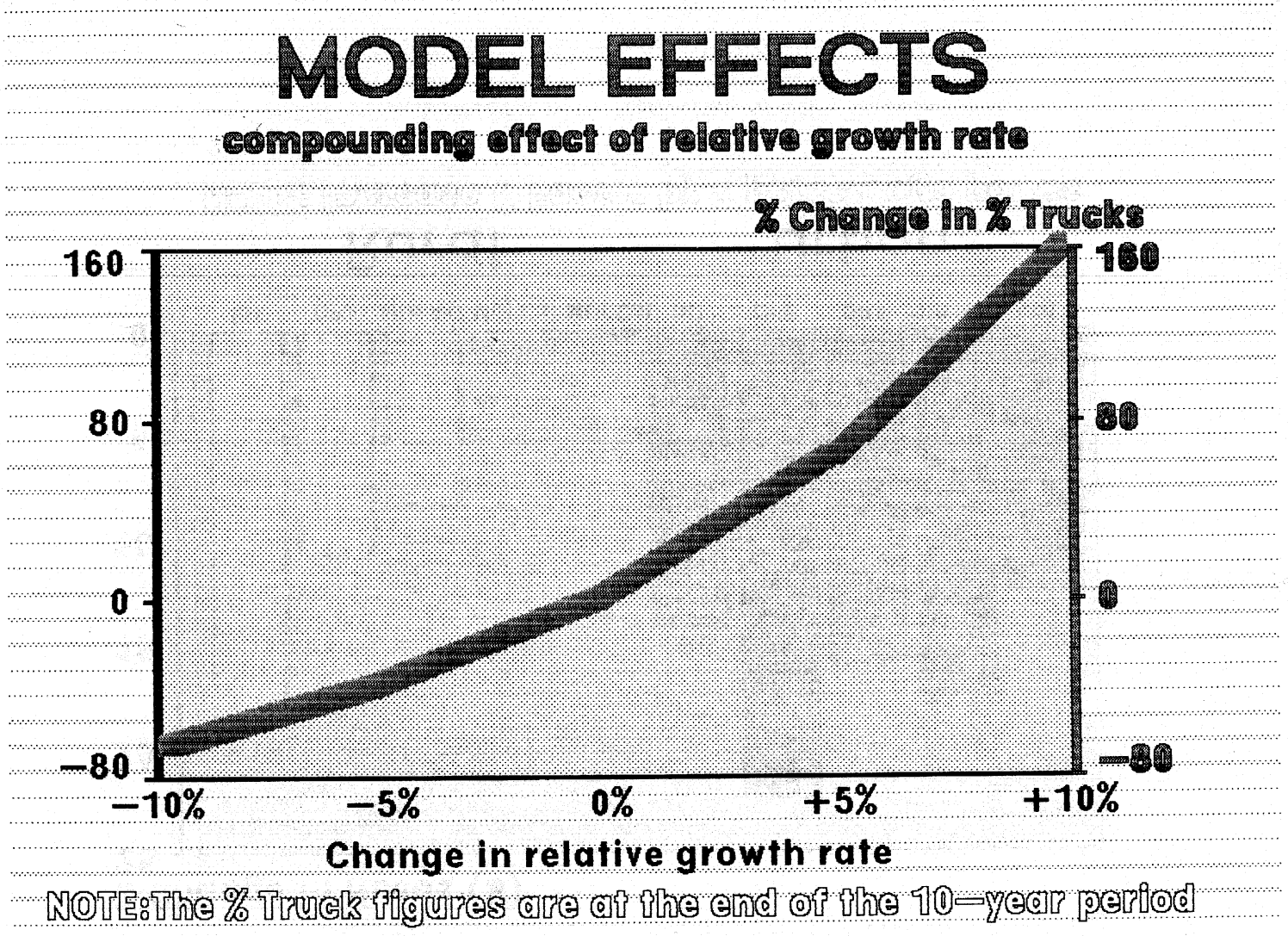
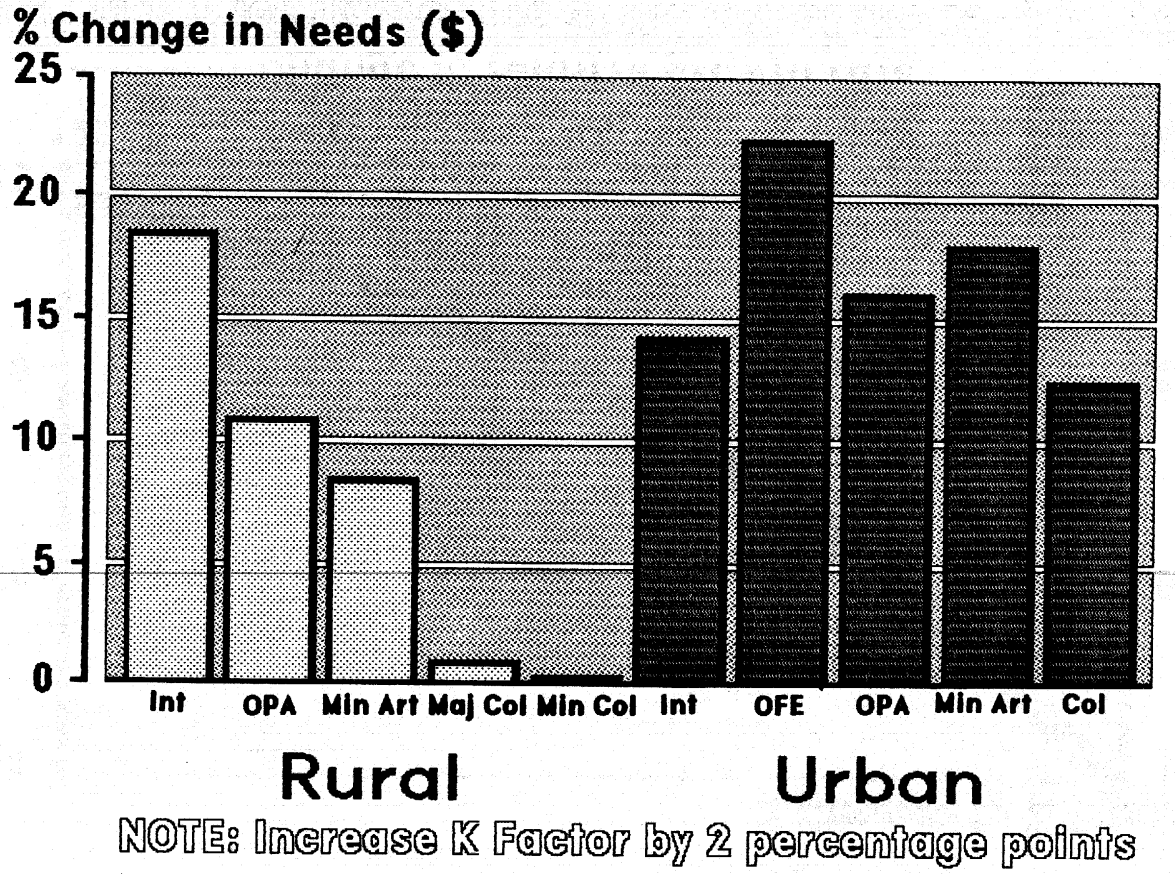

MODEL EFFECTS
compounding effect of relative growth rate
% Change in % Trucks
160
80
0
-80
160
80
0
-80
-10%
-5%
0%
+5%
+10%
Change in relative growth rate
NOTE:The % Truck figures are at the end of the 10-year period

FIGURE II-12

MODEL EFFECTS

Increase in K Factor affects functional classes differently



NOTE: Increase K Factor by 2 percentage points

FIGURE II-13

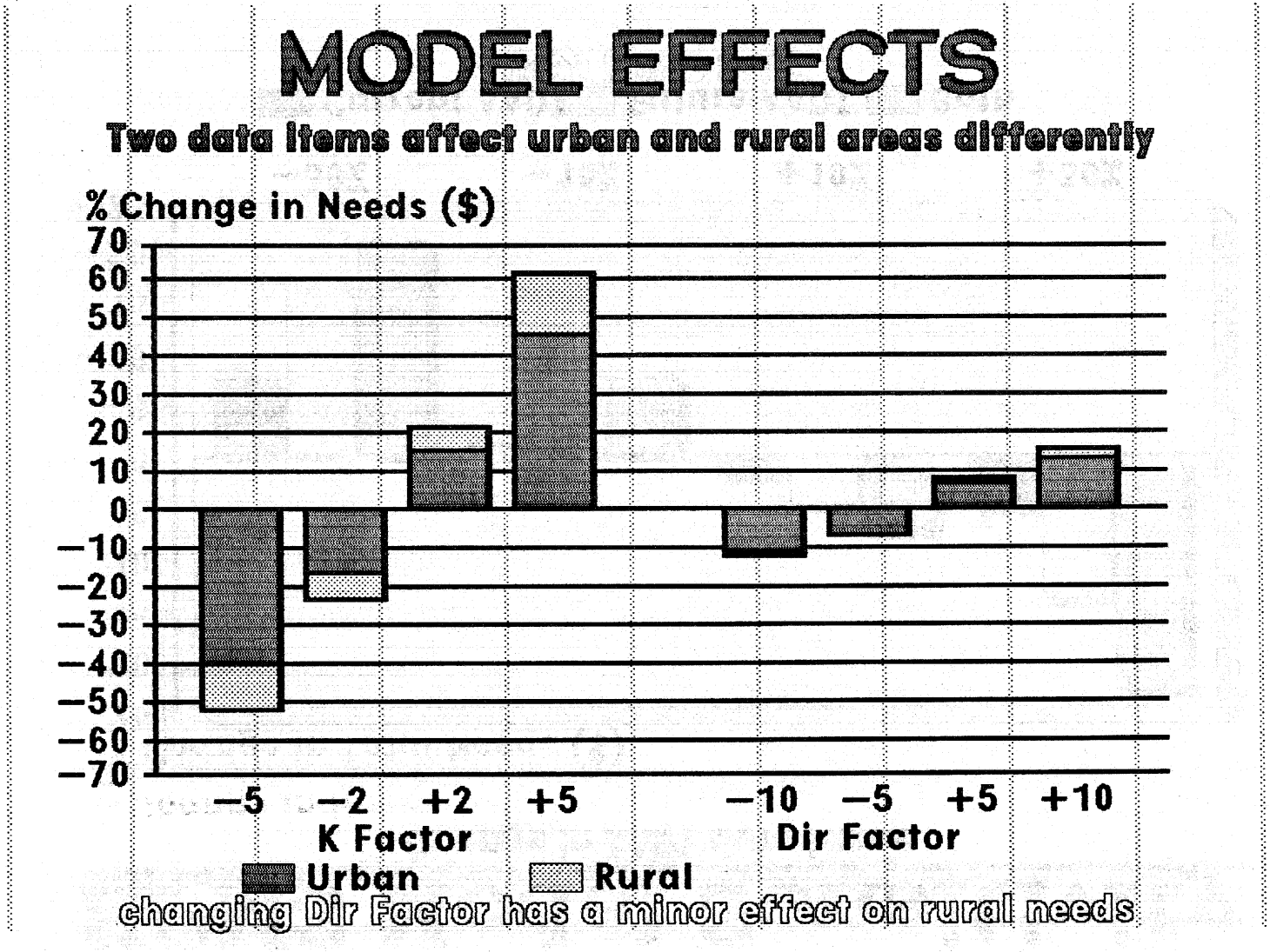

MODEL EFFECTS
Two data items affect urban and rural areas differently
% Change in Needs ($)
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
−5
−2
+2
+5
K Factor
−10
−5
+5
+10
Dir Factor
Urban
Rural
changing Dir Factor has a minor effect on rural needs

FIGURE II-14

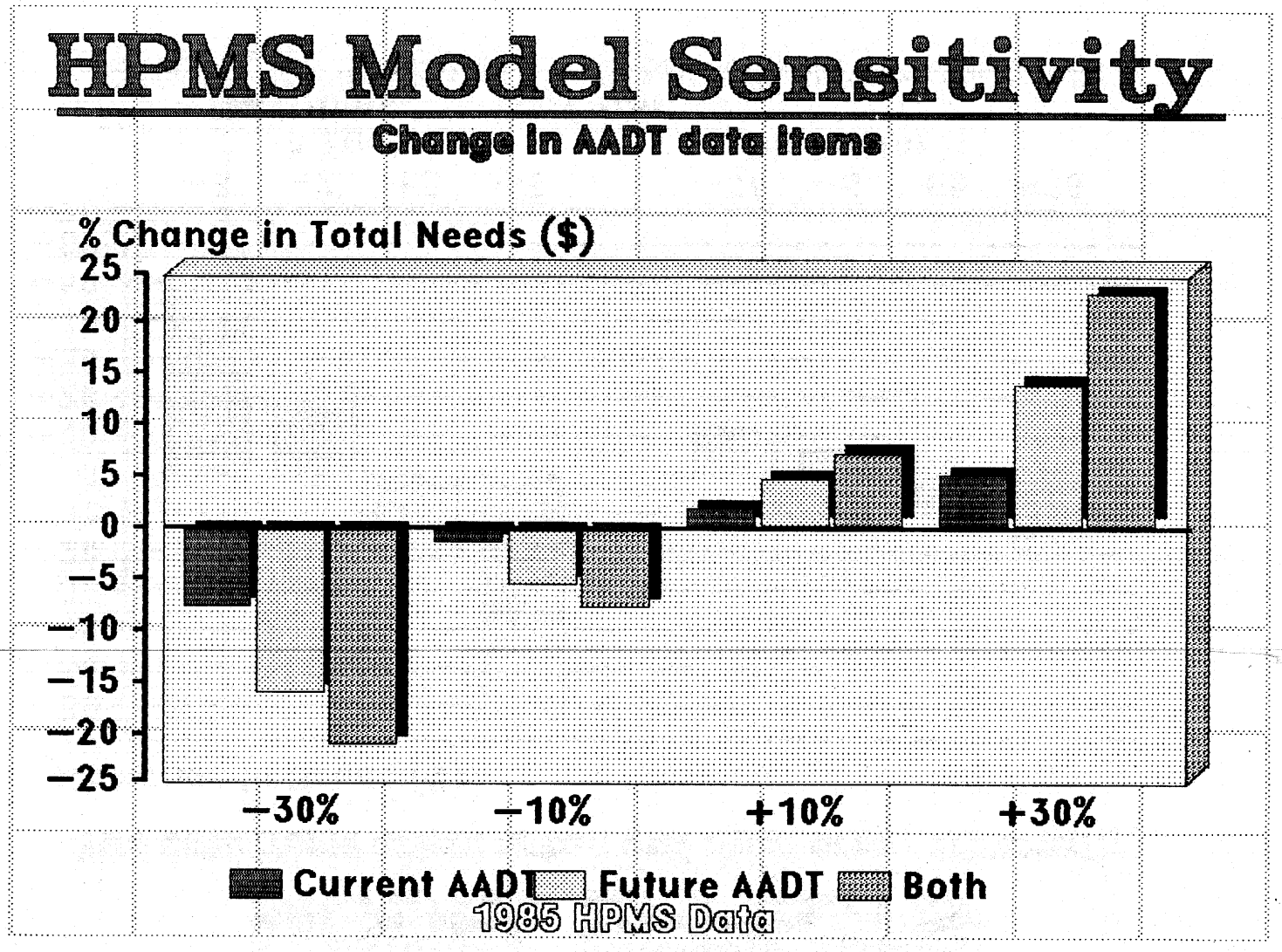
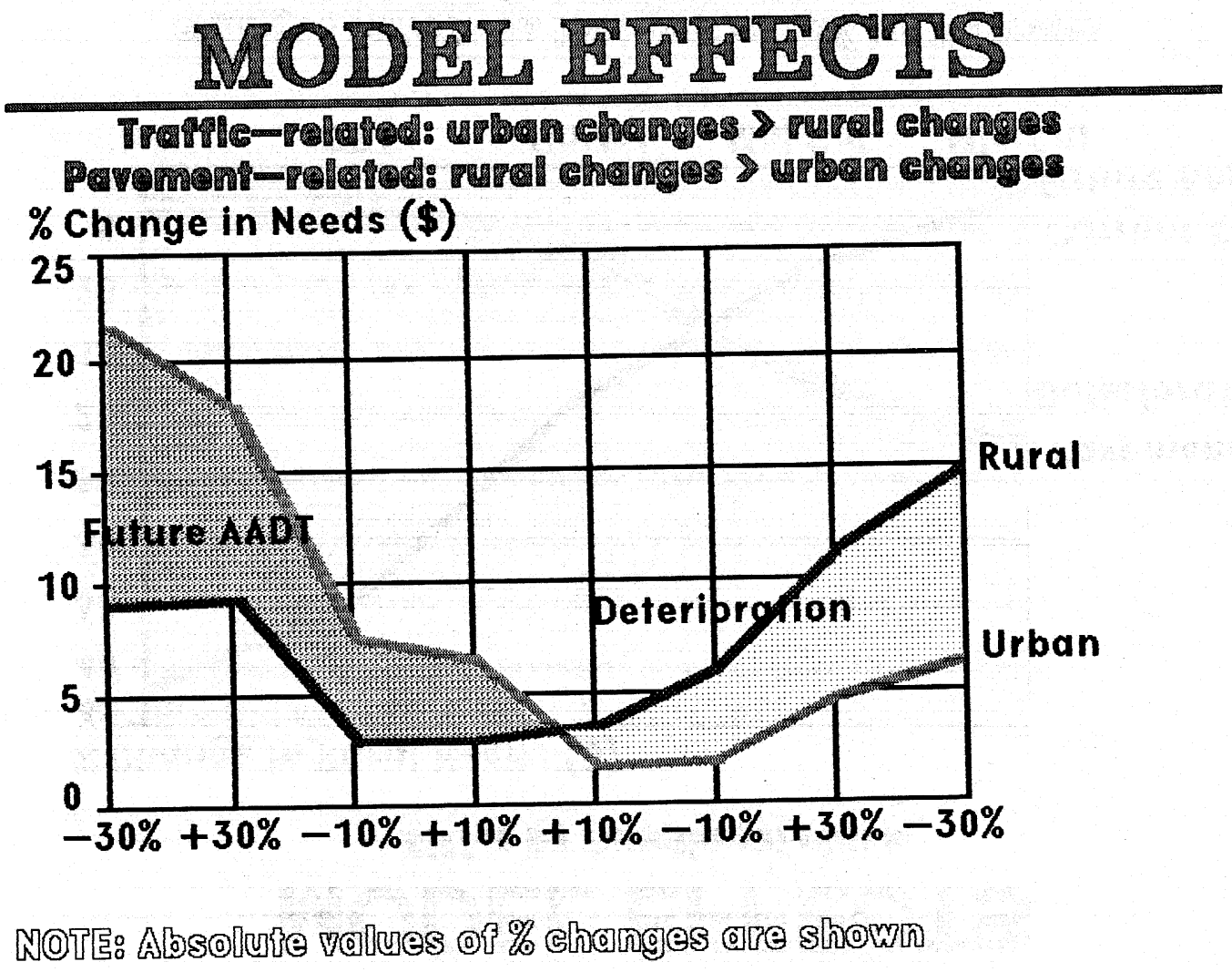

HPMS Model Sensitivity
Change in AADT data items
% Change in Total Needs ($)
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30%
−10%
+10%
+30%
Current AADT
Future AADT
Both
1985 HPMS Data

FIGURE II-15

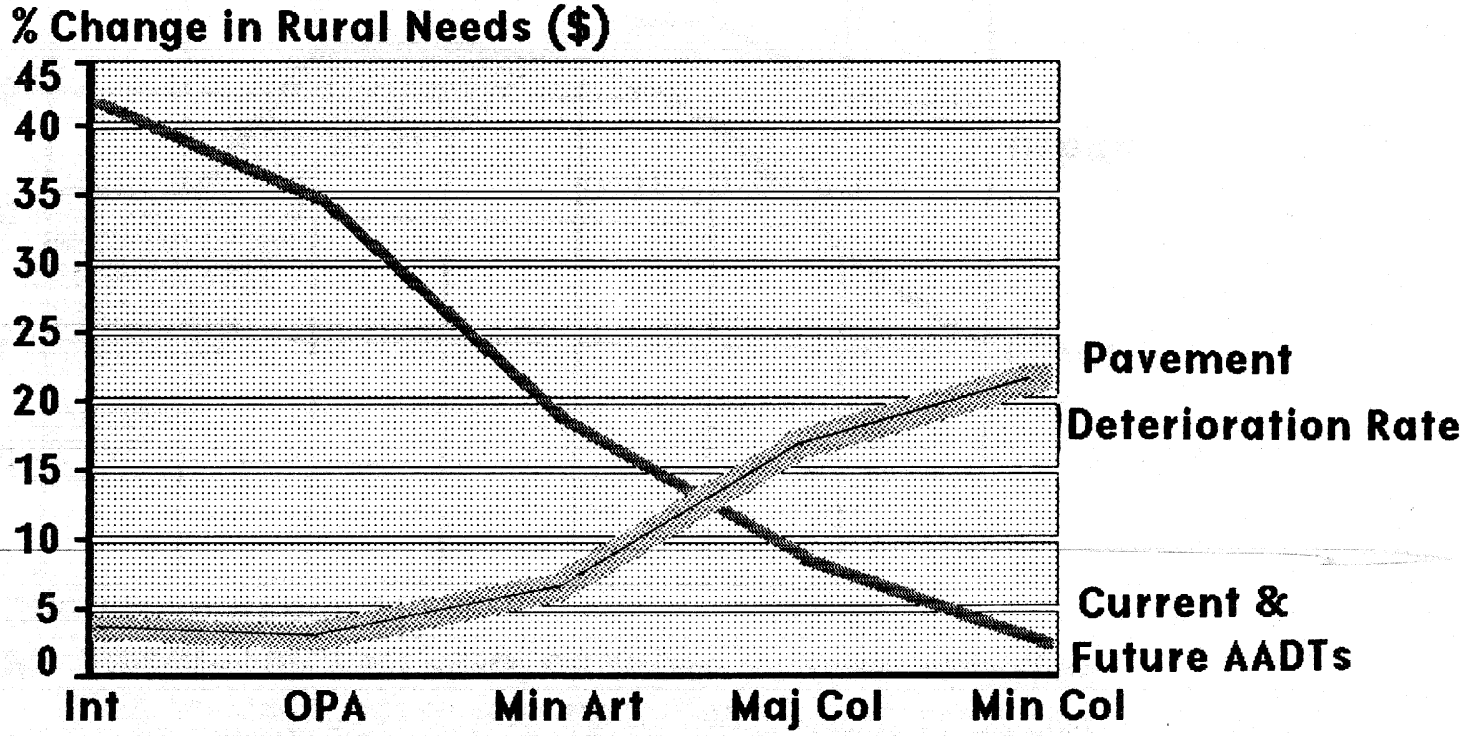


NOTE: Absolute values of % changes are shown

FIGURE II-16

MODEL EFFECTS

differ by functional class



changes reflect an increase of 30% in the items

TABLE II-1

ESAL FACTORS:

EQUIVALENT 18-KIP LOAD APPLICATIONS PER TRUCK

	Rigid Pavement		Flexible Pavement	
	Rural	Urban	Rural	Urban
Interstate & Other Fwy & Expy	1.481	1.392	0.969	0.917
Other Principal Arterial	1.217	1.444	0.798	0.925
Minor Arterial	1.036	0.615	0.699	0.457
Collector	0.451	0.277	0.344	0.234

FUNDING PERIOD ANALYSIS

Additional analyses were done to provide an example of the difference that can be made by the choice of funding period length in the HPMS Analytical Process. The basic analyses for this study were done using a single 10-year period, for the purpose of simplicity, and to keep the variables to a minimum. However, for the analyses that used pavement related items, i.e., pavement deterioration rates, truck growth or percentage, and the SN or D values, the overall needs did not change as much as might have been expected.

The small change in overall needs was thought to be an effect of the use of a single funding period. Some of the highway sections being analyzed needed an additional pavement improvement under some of the analysis scenarios, but a second improvement could not be simulated by the process unless more than one funding period was used. Therefore, analyses were done using two 5-year funding periods. This covers the same time period as the basic analysis, but allows for a second improvement if the process identifies more than one set of deficiencies over the analysis period.

Figures II-17 and II-18 show the changes in improvement miles and needs, respectively, for the two types of analysis. These analyses were done (1) with one 10-year and (2) two 5-year funding periods. In addition to the base data results, analysis results using increased pavement deterioration, accelerated truck growth, and decreased SN or D are shown. The needs and miles of improvements increased for all cases as expected with the use of two funding periods. This shows that for each of the data analyses, some of the highway sections had two improvements when two analysis periods were used.

Figures II-19 and II-20 show the changes in results relative to the base results for each of the same two types of analysis, with each base normalized to 100 percent. That is, the base results for each of the two types of analysis (one 10-year period and two 5-year periods) are shown as 100 percent. These figures show that when the data changes for each analysis are compared with the base data for the same type of analysis, only the increase in pavement deterioration rate increased the improvement miles and needs significantly.

FIGURE II-17

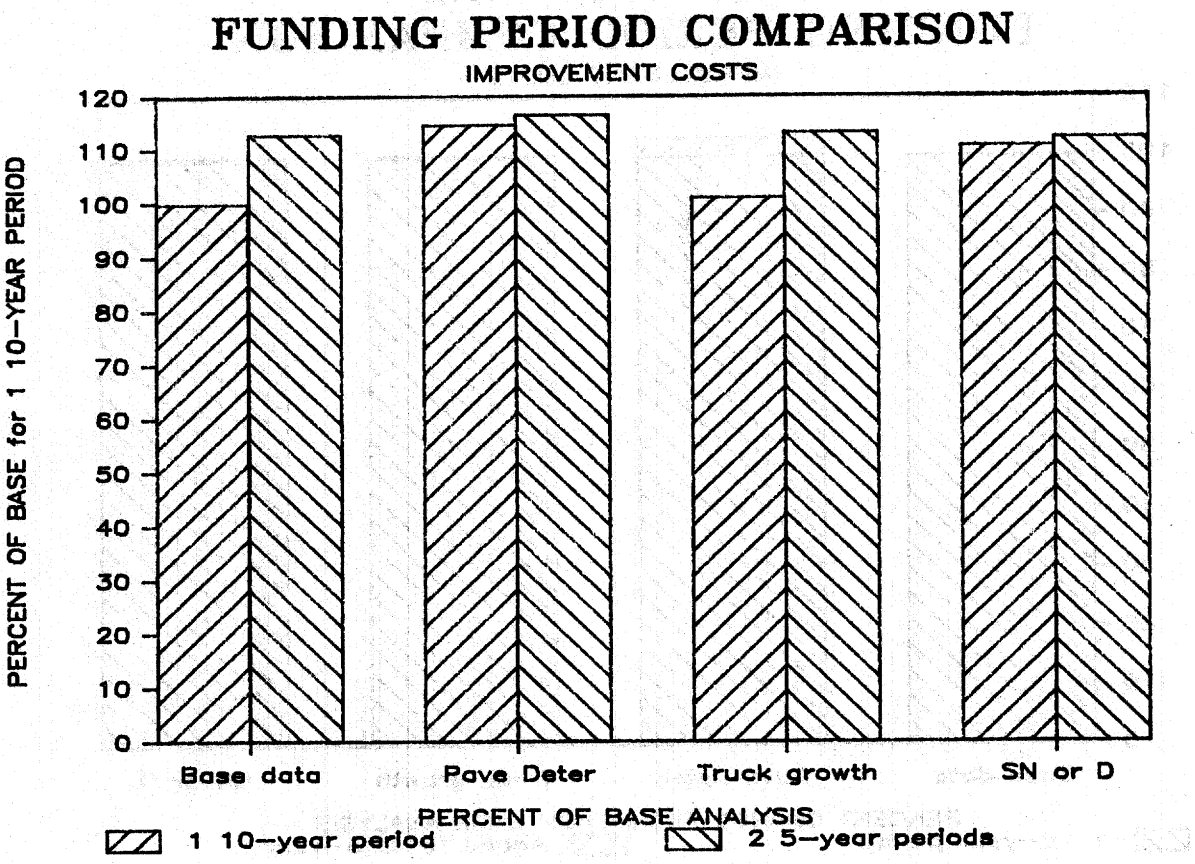


FIGURE II-18

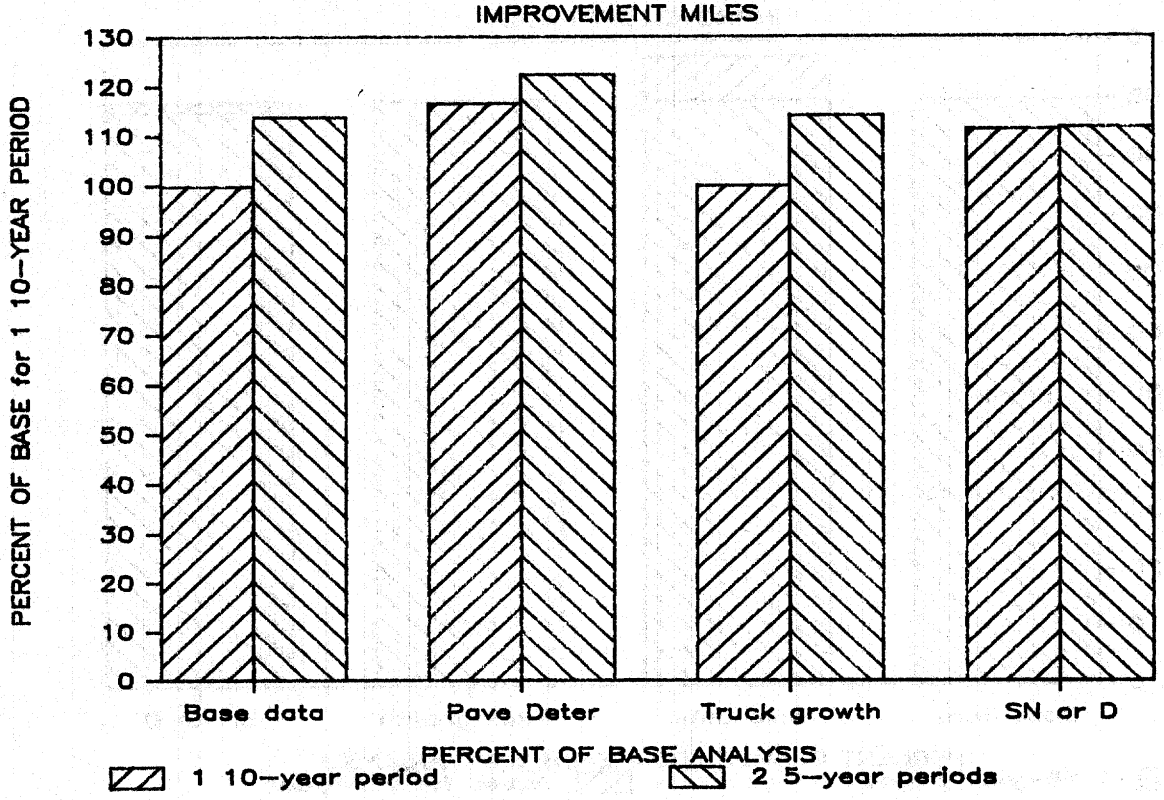


FIGURE II-19

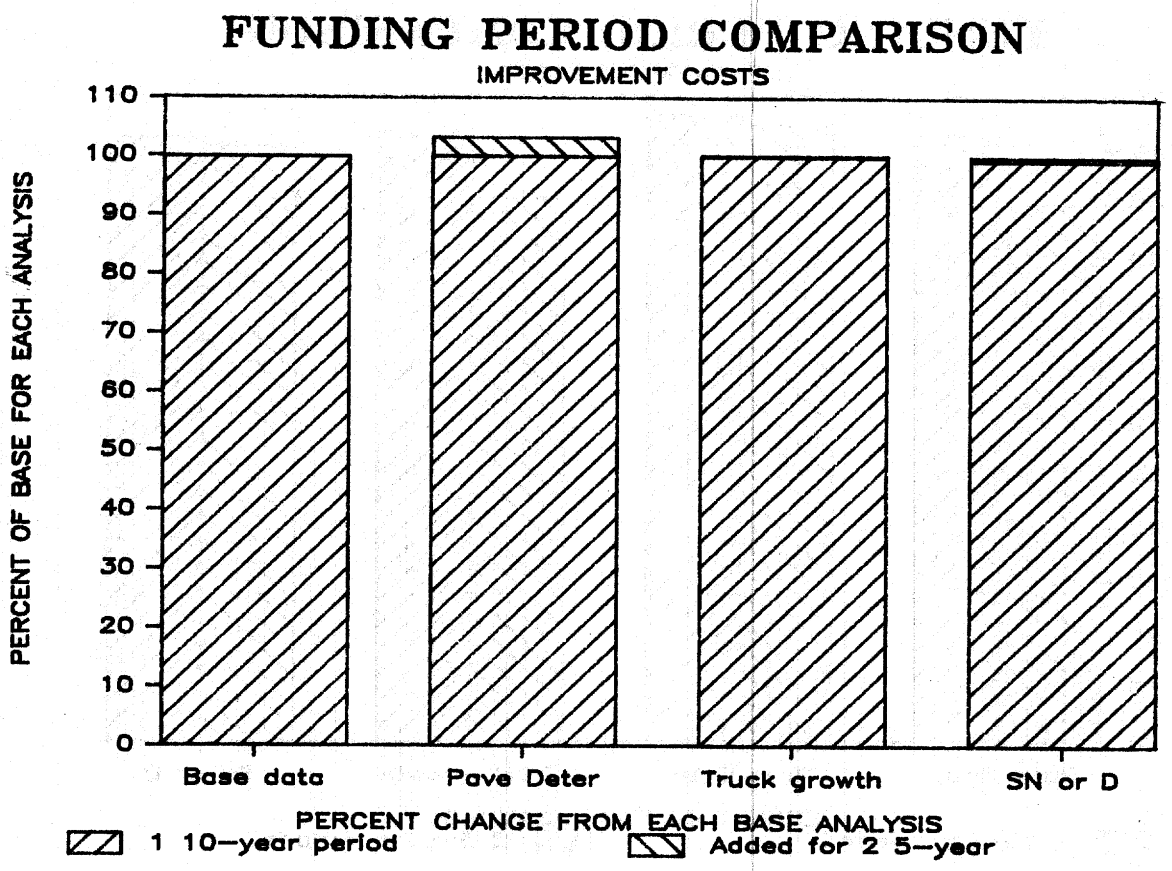
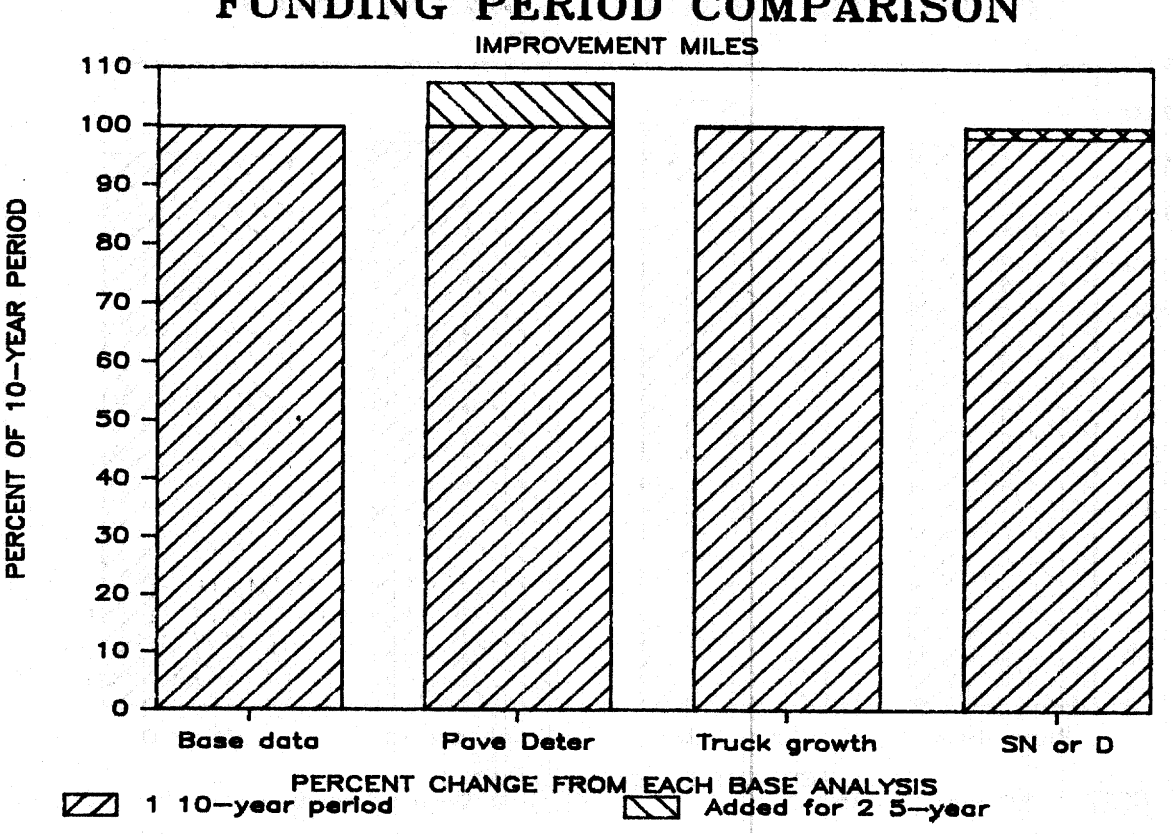


FIGURE II-20



Part 3: SENSITIVITY TO MINIMUM TOLERABLE CONDITIONS

GENERAL COMMENTS

This analysis was done to study the sensitivity of the HPMS Analytical Process to changes in the minimum tolerable conditions (MTCs). The Analytical Process was used to generate needs (costs of improvements) and miles of improvement.

As explained earlier in the report, the analysis has divided the MTCs into two categories, major and minor. The four major MTCs have the greatest influence over the results of the process: volume/capacity ratio, operating speed, lane width, and pavement condition. This is because these MTCs are used to determine when an improvement is required, whereas the minor MTCs are primarily used to determine what type of improvement will then be selected. In general, these expectations are met.

For this analysis the following procedure was used to obtain a broad but reasonable range of values for changing the MTCs. For each of the four major MTCs identified above, each default MTC was changed by an initial increment. That increment was then doubled for each additional run of the model. For example, the pavement condition MTC was initially incremented by 0.2 rating points and additional runs changed the default by 0.4, 0.8, and 1.6 rating points. The initial increment for lane width was one foot, for operating speed, 5 MPH, and volume/capacity ratio, 0.05. The tables in Appendix B contain the changes in miles and costs of improvements after the second increment of change to the MTCs.

Figures are used to illustrated the effects on needs and miles of improvements resulting from changes in the major MTCs. Note that the volume/capacity ratio MTC applies primarily to urban areas, and the operating speed MTC applies to rural areas and urban freeways and expressways.

RURAL -- ANALYSIS OF THE FOUR MAJOR MTCs

Volume/Capacity Ratio

The results were not very sensitive to the volume/capacity ratio MTC (Figures III-1 and III-3). In rural areas this MTC is used principally on sections with dense development. With a 40% decrease in this MTC, there was a 4.3% increase in improvement miles and a 2.5% increase in needs.

Operating Speed

The results were more sensitive to operating speed than to v/c ratio, with an increase in improvement miles occurring when the operating speed MTC was increased (Figures III-1, III-3, and III-5). Changes in needs occurred both with decreases and increases in this MTC; decreasing the value shifts improvement types from adding more lanes and reconstructing freeways to resurfacing. With an increase in the MTC of about 20%, the improvement miles increased by 1% and the needs increased by 14%.

Lane Width

Lane width is also a capacity-oriented MTC. In the analysis, failing the lane width MTC alone will generate minor widening. An additional condition such as a present and future capacity problem or not meeting the shoulder width or shoulder type MTC will generate other types of improvement.

In order to avoid the unrealistic situation of having the MTC larger than the design standard, the lane width MTC was limited to a one foot increase and the Interstate MTC was not increased at all, since it was already 12 feet. This MTC is more sensitive to increases than to decreases, which indicates that many highway sections meet the default lane width MTC, and that most other sections are only one foot less. (See figures III-1, III-3, and III-6). With an 8% increase in the lane with MTC, there was a 5% increase in miles of improvement and an 18% increase in needs.

Pavement Condition

There are two sets of pavement condition MTCs. The first is the threshold for resurfacing, the second is the threshold for pavement reconstruction. These analyses were run in three combinations: (1) changing the resurfacing MTCs alone, (2) changing the reconstruction MTCs alone, and (3) changing the resurfacing and reconstruction MTCs together. No analyses were made with the resurfacing MTC lower than the reconstruction MTC since this would be illogical.

The order of the sensitivity of the rural needs to these three sets of change is generally what would be expected. The needs changed least for the resurfacing MTC change; the next greatest changes were due to the reconstruction MTC change; and changing the resurfacing and reconstruction MTCs together produced the greatest change in rural improvement mileage and needs (Figures III-2 and III-4).

Resurfacing

Both increasing and decreasing the resurfacing MTC substantially affected the miles of improvement. However, the changes in the needs did not always follow a consistent trend. When the resurfacing MTC was decreased without changing the reconstruction MTC, the trends in needs reversed direction. Needs decreased with small changes and then increased with larger changes in the MTC. This occurred when the default reconstruction MTC was close to the resurfacing MTC and some highway sections deteriorated enough in one year to skip the resurfacing and go directly to higher cost reconstruction.

It should be noted that the analysis included only one 10-year funding period, and only one improvement is generated per funding period for each highway section. Therefore, when the pavement condition MTC was increased, more pavement projects were generated early in the funding period, thus precluding possible capacity improvement projects on the same sections late in the period. This shifted the needs from higher cost capacity improvements to lower cost resurfacing improvements, and the resulting needs did not increase at as fast a rate as the miles of improvement.

Also, the 5-year cycle ahead feature would delay pavement resurfacing when a capacity improvement is projected within the next 5 years, in many cases to beyond the analysis period.

Reconstruction

As noted before, the rural improvement miles were more sensitive to changes in the resurfacing MTC than to the reconstruction MTC. This is evident in the higher functional classes and in particular in the Interstate, where the change is zero when the reconstruction MTC was increased by 0.4 of a rating point. However, the dollar needs for Interstate improvements changed by 9.68% with the same 0.4 point increase. Changing the reconstruction MTC alone shifted the improvements from resurfacing to higher cost reconstruction projects without necessarily adding to the number of miles of improvements. With an increase in the reconstruction MTC of about 14%, there was a 3% increase in miles of improvement and a 12% increase in needs.

Resurfacing and Reconstruction

Changing both resurfacing and reconstruction MTCs at the same time by the same increment had the largest effect on improvements. These changes were the greatest in the lower functional classes (Figure III-7). There were large changes in improvement miles in both resurfacing and reconstruction. The largest

change in needs by improvement type was in pavement reconstruction, due to the higher costs. With an increase in both MTCs of about 14%, there was a 12% increase in miles of improvement and a 15% increase in needs.

RURAL -- ANALYSIS OF THE FIVE MINOR MTCs

The five minor MTCs that principally affect the type of improvement are shoulder width, shoulder type, surface type, horizontal alignment, and vertical alignment. These MTCs were changed either by increasing or decreasing one category number or 2 feet in the case of shoulder width.

Shoulder Type

The shoulder type MTC produced more shoulder improvements and needs when the MTC was shifted to better quality (decrease in category number) and vice versa. With an increase in quality by one category number there was a 6% increase in needs.

Right Shoulder Width

The shoulder width MTC also produced more shoulder improvements with a higher MTC and vice versa. With an increase of 2 feet there was a 4.6% increase in needs.

Surface Type

The only significant change in rural improvement miles was a 19% increase produced by increasing the surface type MTC by one category number (increasing the quality). This affected collectors with less than 400 ADT which then required paving. The needs were affected even more (33%) by increasing the surface type MTC because more high cost reconstruction was simulated rather than lower cost resurfacing.

When the surface type MTC was decreased (increasing the coded value), the rural costs of improvements increased. Although needs decreased on minor arterials, and no changes occurred on Interstate and other principal arterials, needs increased on collectors. The MTC for collectors between 400 and 1000 ADT was changed from low type pavement to gravel. This resulted in resurfacing not being simulated on low type pavement in this volume group, and the pavement deteriorated until reconstruction was needed. This increase in reconstruction increased the needs. Also, reconstruction with wider or more lanes decreased with a change of the MTC toward a lower quality surface type.

Horizontal and Vertical Alignment

Horizontal and vertical alignment MTCs produced expected changes with more alignment improvements and needs when the MTC was shifted to better quality and vice versa.

When the MTC for horizontal alignment was increased by one category, there was a 9.7% increase in needs. A similar decrease resulted in 3.7% less needs. When the MTC for vertical alignment was increased by one category, there was a 14.5% increase in needs. A similar decrease resulted in 1.3% less needs.

URBAN -- ANALYSIS OF THE FOUR MAJOR MTCs

Volume/Capacity Ratio

A large decrease in the volume/capacity ratio MTC resulted in an unusual change in improvement mileage. The percent change becomes negative after being positive for the first three incremental changes (Figure III-8). At the point where the urban miles became negative, the volume/capacity ratio on urban arterials and collectors was 0.50 to 0.55. A detailed look at the analysis showed that more widening was being done, but not enough to make up for a large decrease in resurfacing. The 5-year "look-ahead" feature of the Analytical Process delayed resurfacing improvements until a later funding period when a capacity improvement would be made.

The volume/capacity ratio produces an almost linear change in the urban needs; the high cost of widening makes up for the effects seen in the miles of improvements (Figures III-8 and III-10). With a 45% decrease in the MTC for the v/c ratio, there was a reduction of 1% in the improvement miles and an increase of 16% in the needs. The lower (non-freeway) functional classes are the facilities most affected by the V/C MTC, since operating speed is the capacity MTC used for freeways (Figure III-12).

Operating Speed

Operating speed is used only in free-flow conditions, which in urban areas generally occur only on Interstate and other freeways and expressways. On the non-free-flow types of facilities, volume/capacity ratio is used as an MTC. It is interesting to note that the operating speed MTC for freeways and expressways does not produces significant percent changes in miles of improvement. But because of their high cost, these improvements produce significant changes in the needs (Figures III-8 and III-10). With a 50% increase in the operating speed MTC, there was an 8.5% increase in needs; the miles of improvements did not change significantly.

Lane Width

The improvement mileage is somewhat sensitive to increases in the lane width MTC. However, the needs showed a significant increase when the lane width MTC was increased. Little change in the miles or needs was produced with a decrease in this MTC (Figures III-8. III-10, and III-13). With an 8% increase in this MTC, there was a 4% increase in improvement miles and an 3.8% increase in needs.

Pavement Condition

The sensitivity of the urban costs of improvements to the three sets of change is quite logical. These sets of change are (1) changing only the resurfacing MTC, (2) changing only the reconstruction MTC, and (3) changing both MTC values at the same time.

The needs change the least for the resurfacing MTC; the next greatest changes are due to the reconstruction MTC; and changing the resurfacing and reconstruction MTCs together produces the greatest change in improvement mileage and needs. An interesting effect occurred in the urban miles of improvement. The effect of changing the reconstruction MTC was so small that the effects of changing the resurfacing MTC alone or together with the reconstruction MTC were nearly identical (Figures III-9 and III-11).

Resurfacing

The shift to resurfacing on increasing this MTC resulted in less percentage change in costs than improvement mileage. On decreasing this MTC, the needs decreased. However, a slight upturn on the largest change of the MTC shows the effects of reconstruction being selected instead of resurfacing. With a 14% increase in this MTC, there was a 9% increase in improvement miles and a 3% increase in needs.

Reconstruction

Urban improvement miles were not sensitive to this MTC. Unlike the rural analysis, the largest changes in needs were in the higher functional classes, due to changes in the types of improvements. With a 14% increase in this MTC, there was an 11% increase in needs. There was no significant change in improvement miles.

Resurfacing and Reconstruction

In urban areas, the analysis was very sensitive to the resurfacing and reconstruction MTCs combined, whether increased or decreased, generating the most change in miles and costs of improvement (Figure III-14). With a 14% increase in this

MTC, there was a 9% increase in improvement miles and a 13% increase in needs.

URBAN -- ANALYSIS OF THE THREE MINOR MTCs

Urban needs and improvement miles changed very little as a result of changing these MTCs.

Shoulder Type

Shoulder type produced very little change. An increase in quality by one category produced an increase of .67% in needs and no significant change in improvement miles.

Right Shoulder Width

The shoulder width MTC produced more shoulder improvements with a higher MTC and vice versa. A reduction of one category number produced reduction of 1.4% needs and .17% in improvement miles.

Surface Type

A reduced quality surface type MTC (increased numeric value) produced more needs in reconstruction and major widening -- and less reconstruction with more lanes and resurfacing. An increased quality surface type MTC produced more reconstruction of all types except reconstruct to freeway, and less resurfacing. A reduction by one category produced a reduction of 1.12% improvement miles and an increase of 1.06% needs.

FIGURE III-1

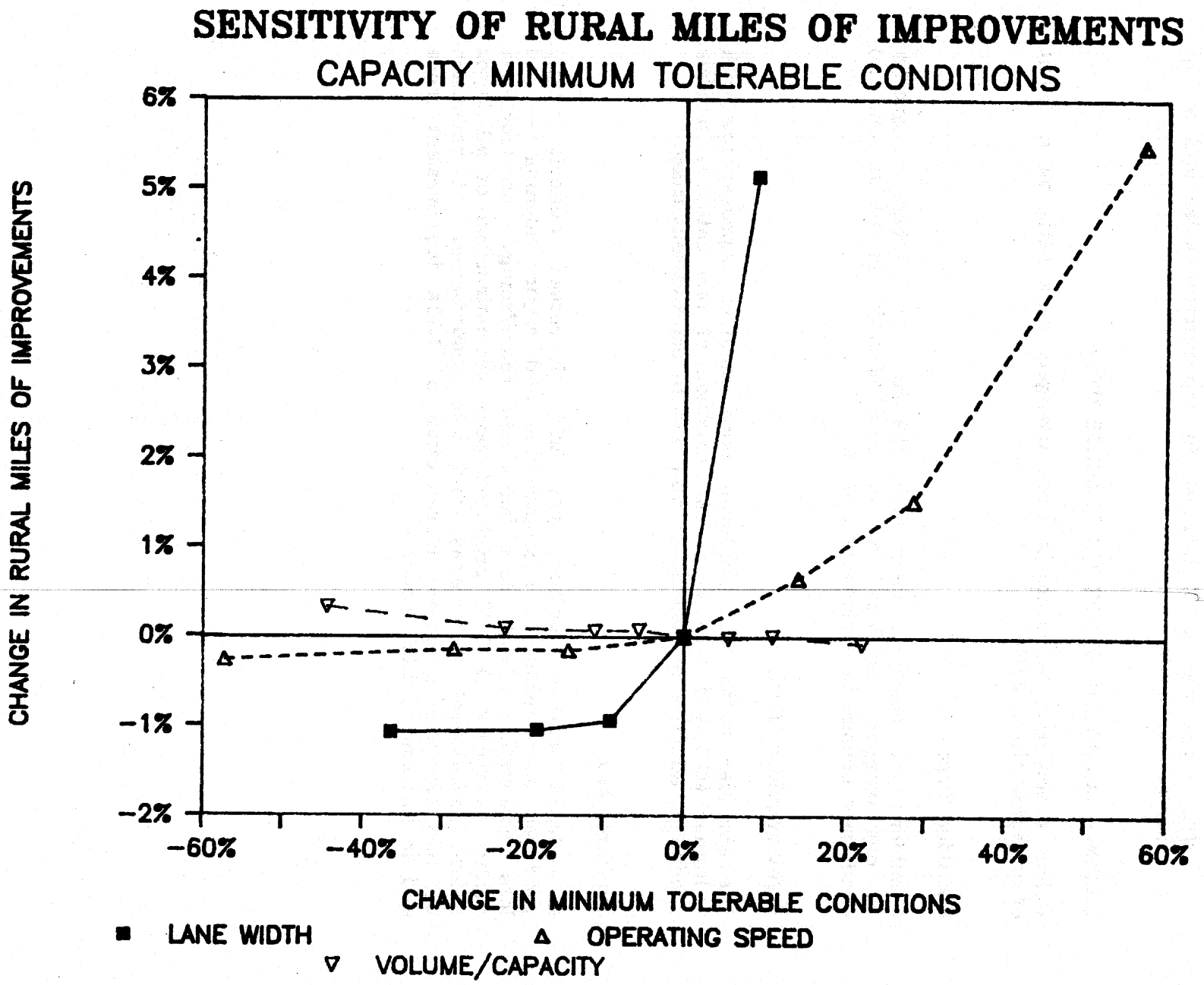

SENSITIVITY OF RURAL MILES OF IMPROVEMENTS
CAPACITY MINIMUM TOLERABLE CONDITIONS
CHANGE IN RURAL MILES OF IMPROVEMENTS
6%
5%
4%
3%
2%
1%
0%
-1%
-2%
-60%
-40%
-20%
0%
20%
40%
60%
CHANGE IN MINIMUM TOLERABLE CONDITIONS
LANE WIDTH
OPERATING SPEED
VOLUME/CAPACITY

FIGURE III-2

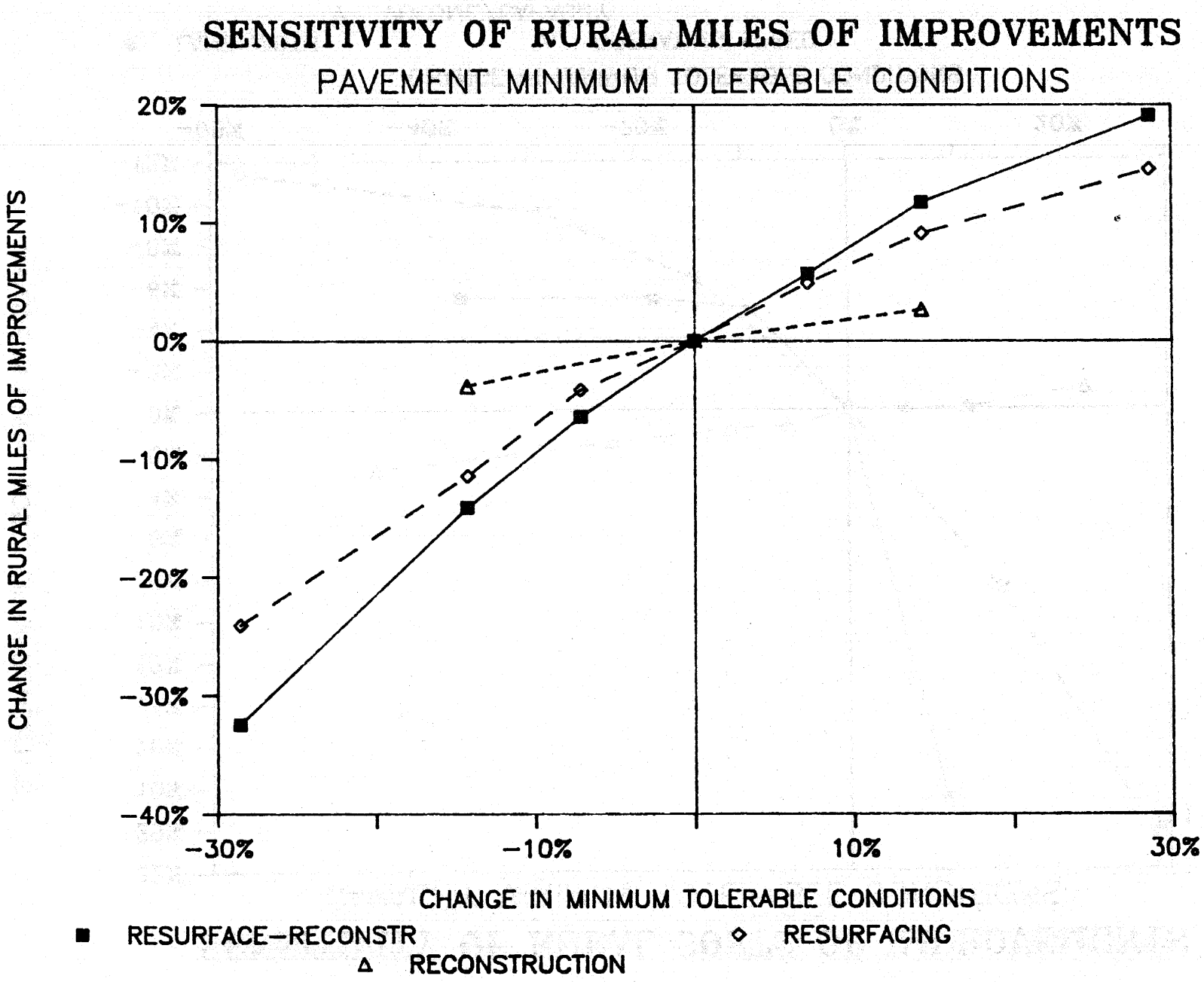

SENSITIVITY OF RURAL MILES OF IMPROVEMENTS
PAVEMENT MINIMUM TOLERABLE CONDITIONS
CHANGE IN RURAL MILES OF IMPROVEMENTS
20%
10%
0%
-10%
-20%
-30%
-40%
-30%
-10%
10%
30%
CHANGE IN MINIMUM TOLERABLE CONDITIONS
RESURFACE-RECONSTR
RESURFACING
RECONSTRUCTION

FIGURE III-3

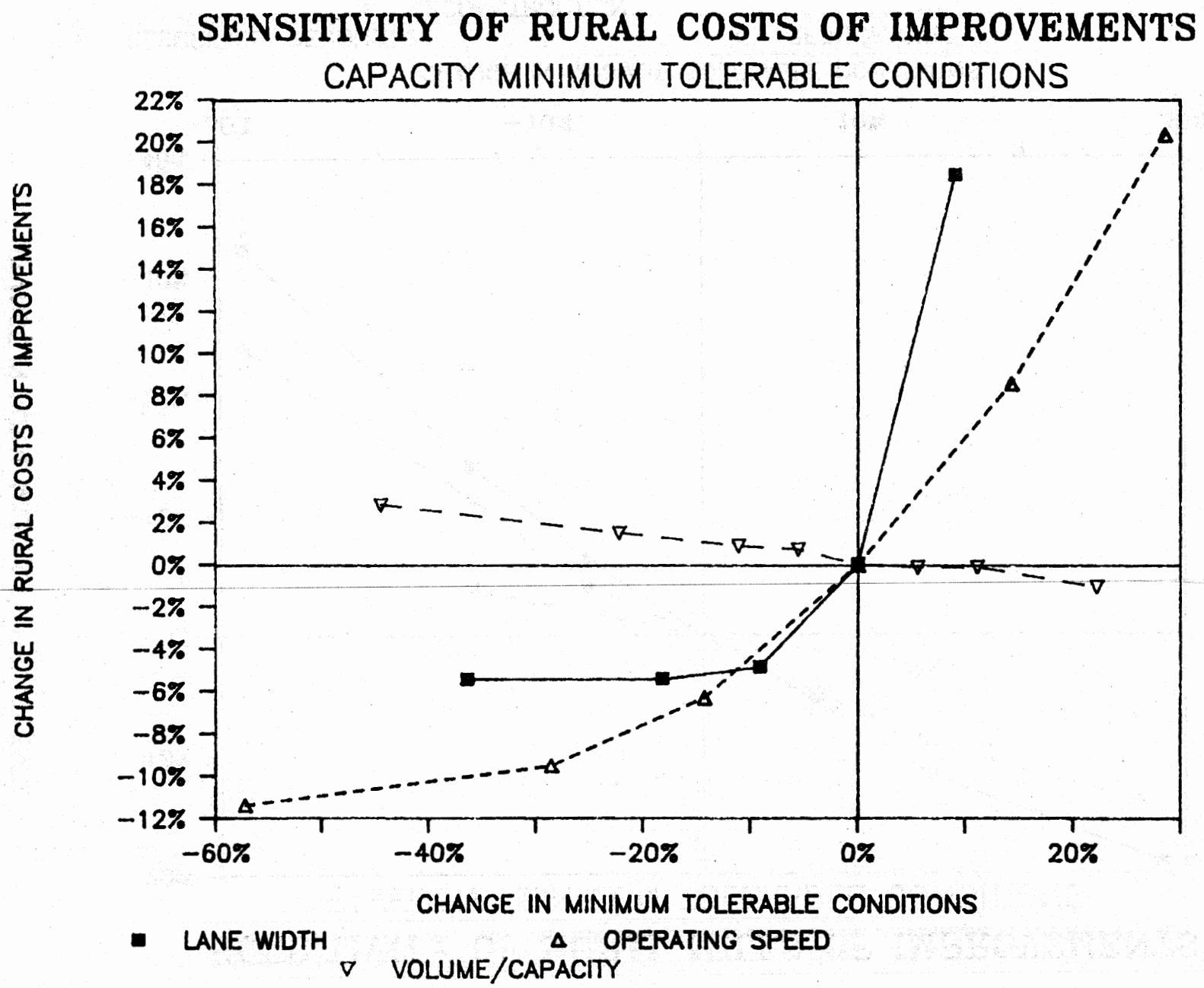

SENSITIVITY OF RURAL COSTS OF IMPROVEMENTS
CAPACITY MINIMUM TOLERABLE CONDITIONS
CHANGE IN RURAL COSTS OF IMPROVEMENTS
22%
20%
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
-2%
-4%
-6%
-8%
-10%
-12%
-60%
-40%
-20%
0%
20%
CHANGE IN MINIMUM TOLERABLE CONDITIONS
LANE WIDTH
OPERATING SPEED
VOLUME/CAPACITY

FIGURE III-4

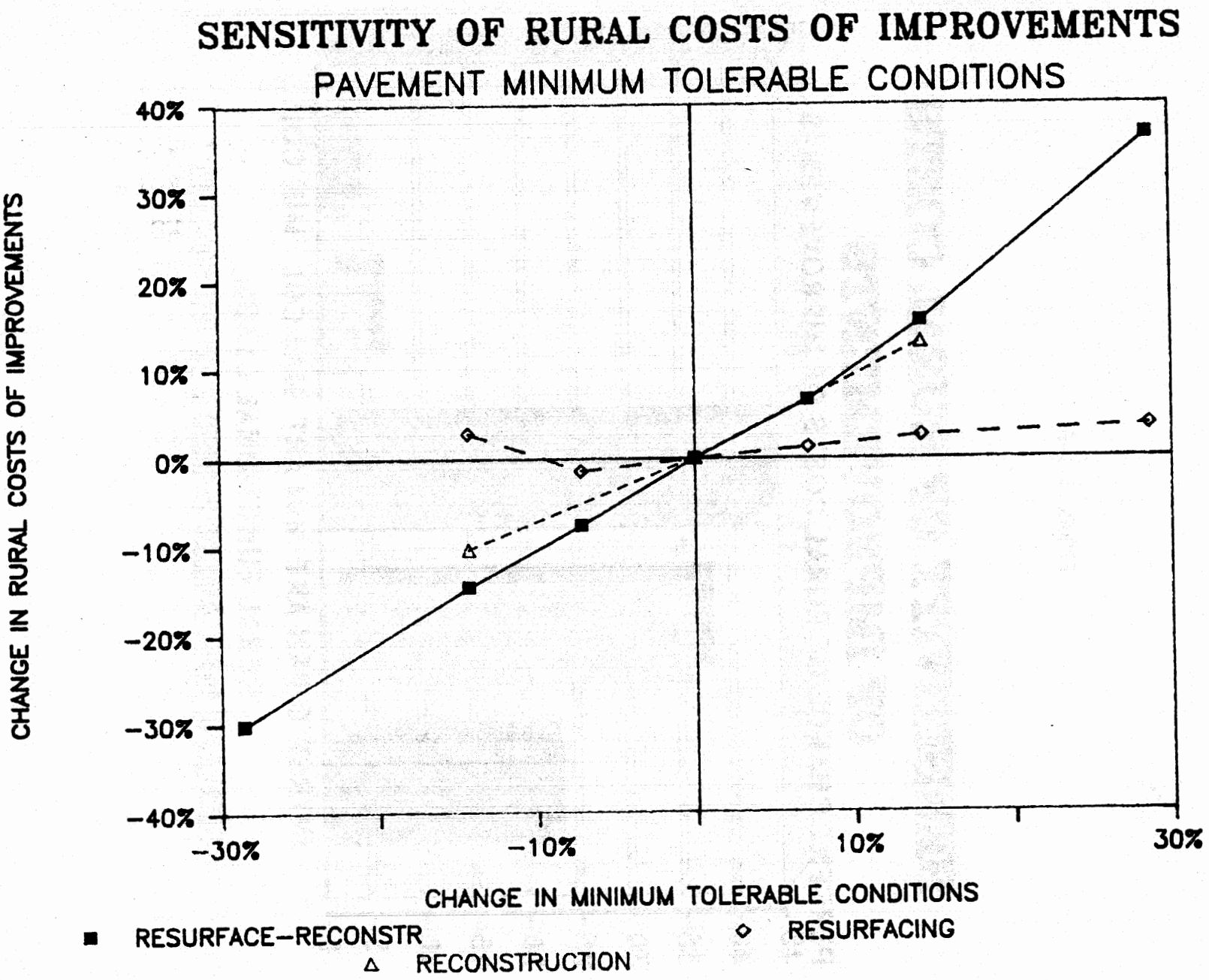

SENSITIVITY OF RURAL COSTS OF IMPROVEMENTS
PAVEMENT MINIMUM TOLERABLE CONDITIONS
CHANGE IN RURAL COSTS OF IMPROVEMENTS
40%
30%
20%
10%
0%
-10%
-20%
-30%
-40%
-30%
-10%
10%
30%
CHANGE IN MINIMUM TOLERABLE CONDITIONS
RESURFACE-RECONSTR
RESURFACING
RECONSTRUCTION

FIGURE III-5

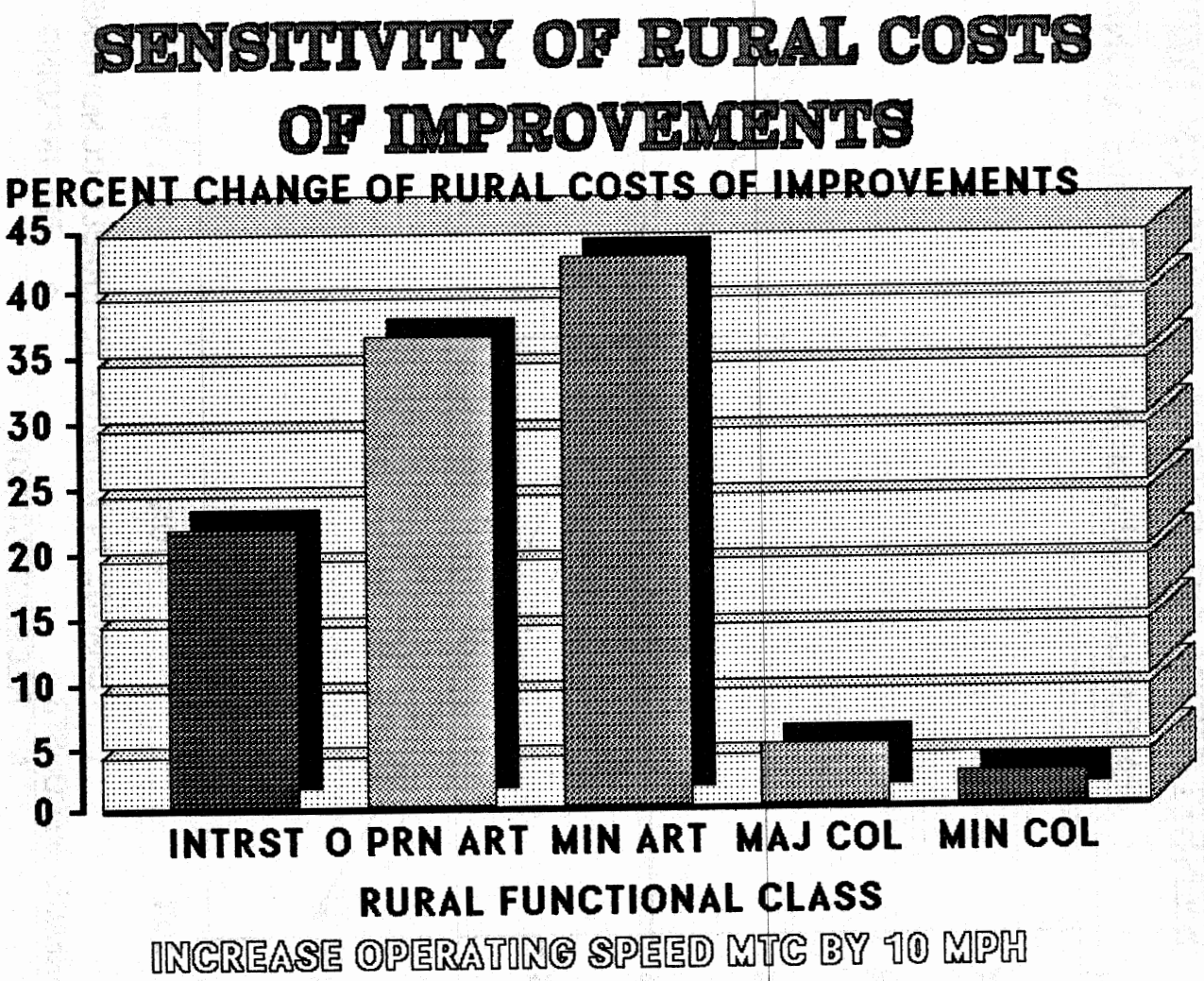

SENSITIVITY OF RURAL COSTS OF IMPROVEMENTS
PERCENT CHANGE OF RURAL COSTS OF IMPROVEMENTS
45
40
35
30
25
20
15
10
5
0
INTRST
O PRN ART
MIN ART
MAJ COL
MIN COL
RURAL FUNCTIONAL CLASS
INCREASE OPERATING SPEED MTC BY 10 MPH

FIGURE III-6

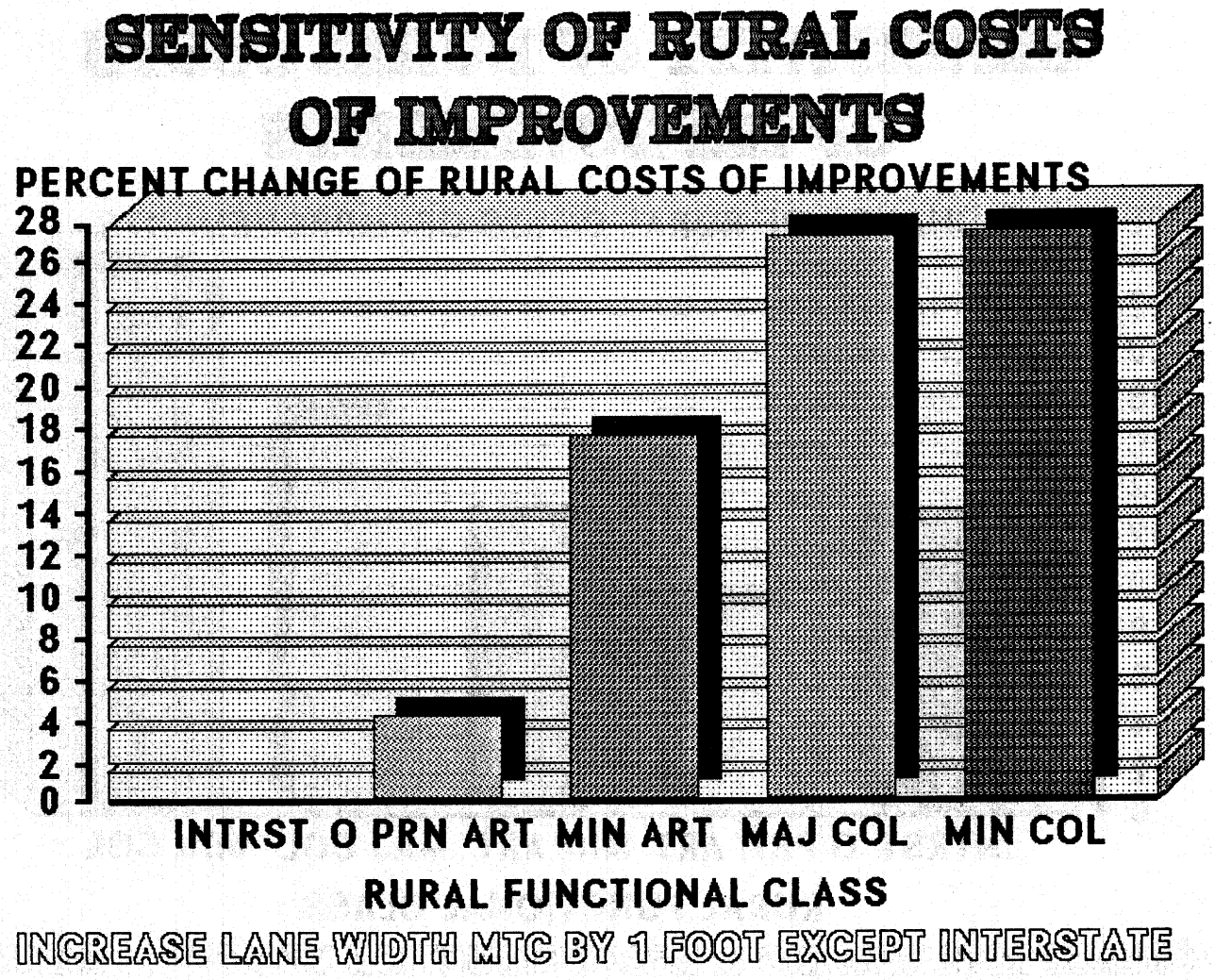

SENSITIVITY OF RURAL COSTS OF IMPROVEMENTS
PERCENT CHANGE OF RURAL COSTS OF IMPROVEMENTS
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
INTRST O PRN ART MIN ART MAJ COL MIN COL
RURAL FUNCTIONAL CLASS
INCREASE LANE WIDTH MTC BY 1 FOOT EXCEPT INTERSTATE

FIGURE III-7

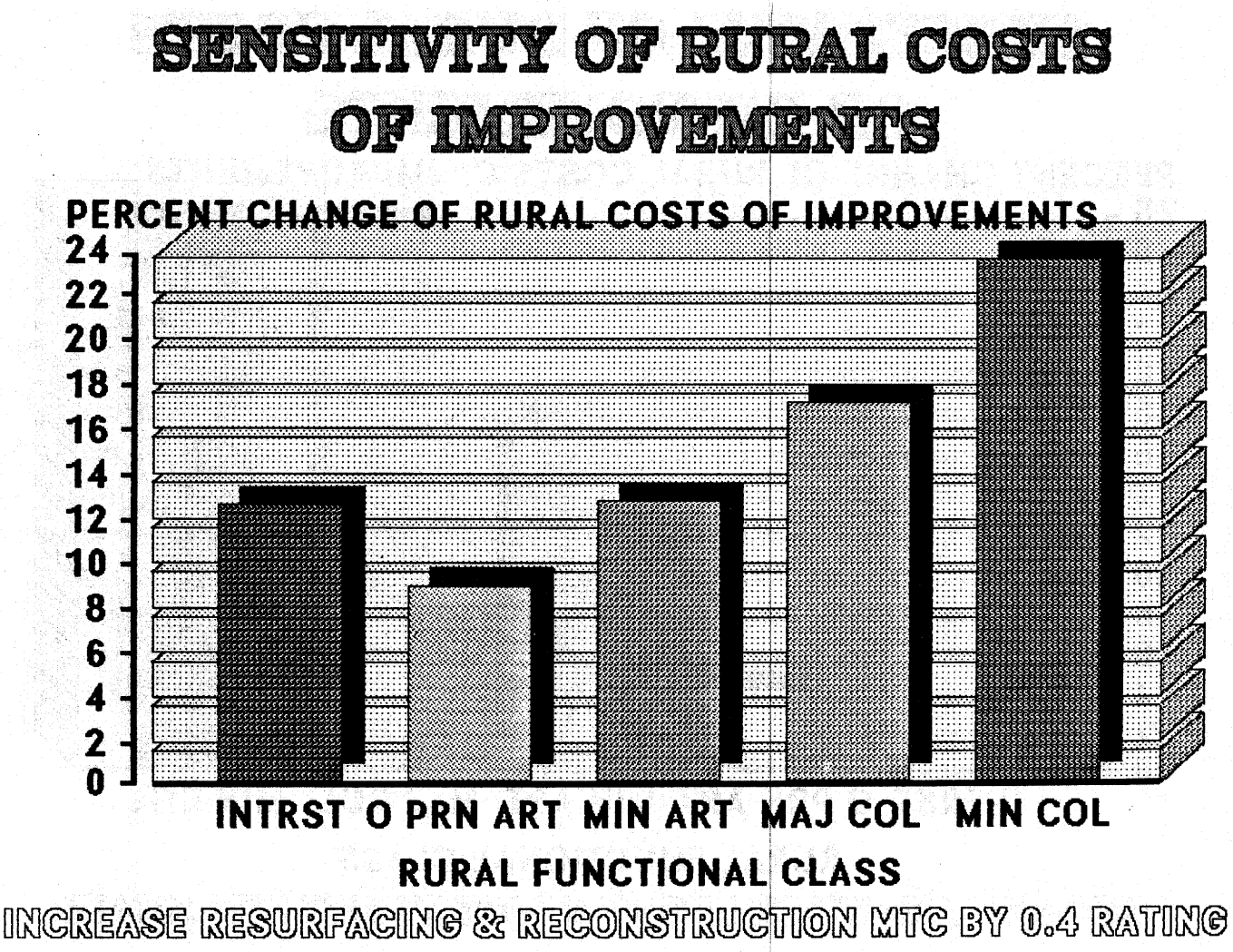

SENSITIVITY OF RURAL COSTS OF IMPROVEMENTS
PERCENT CHANGE OF RURAL COSTS OF IMPROVEMENTS
24
22
20
18
16
14
12
10
8
6
4
2
0
INTRST
O PRN ART
MIN ART
MAJ COL
MIN COL
RURAL FUNCTIONAL CLASS
INCREASE RESURFACING & RECONSTRUCTION MTC BY 0.4 RATING

FIGURE III-8

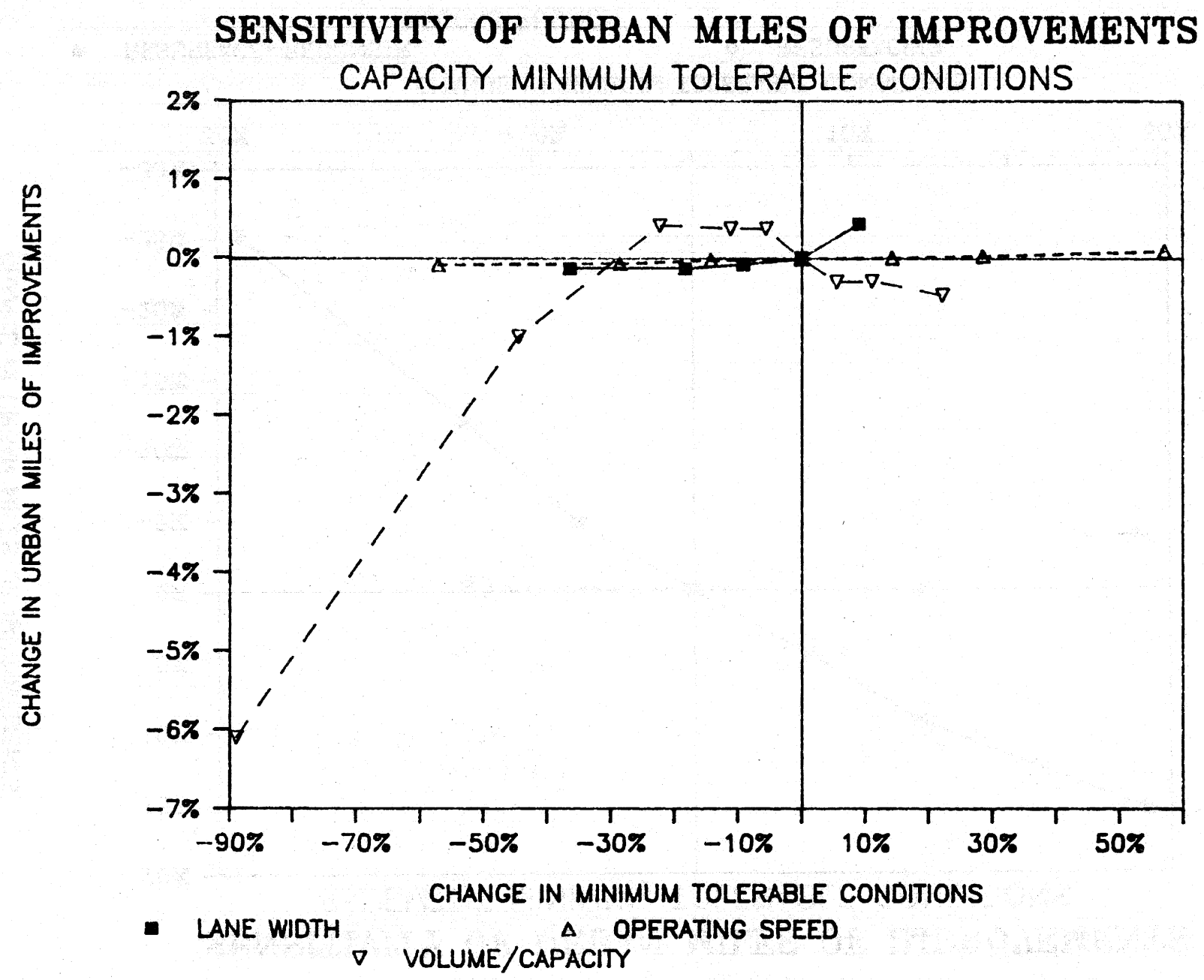

SENSITIVITY OF URBAN MILES OF IMPROVEMENTS
CAPACITY MINIMUM TOLERABLE CONDITIONS
CHANGE IN URBAN MILES OF IMPROVEMENTS
2%
1%
0%
-1%
-2%
-3%
-4%
-5%
-6%
-7%
-90%
-70%
-50%
-30%
-10%
10%
30%
50%
CHANGE IN MINIMUM TOLERABLE CONDITIONS
LANE WIDTH
OPERATING SPEED
VOLUME/CAPACITY

FIGURE III-9

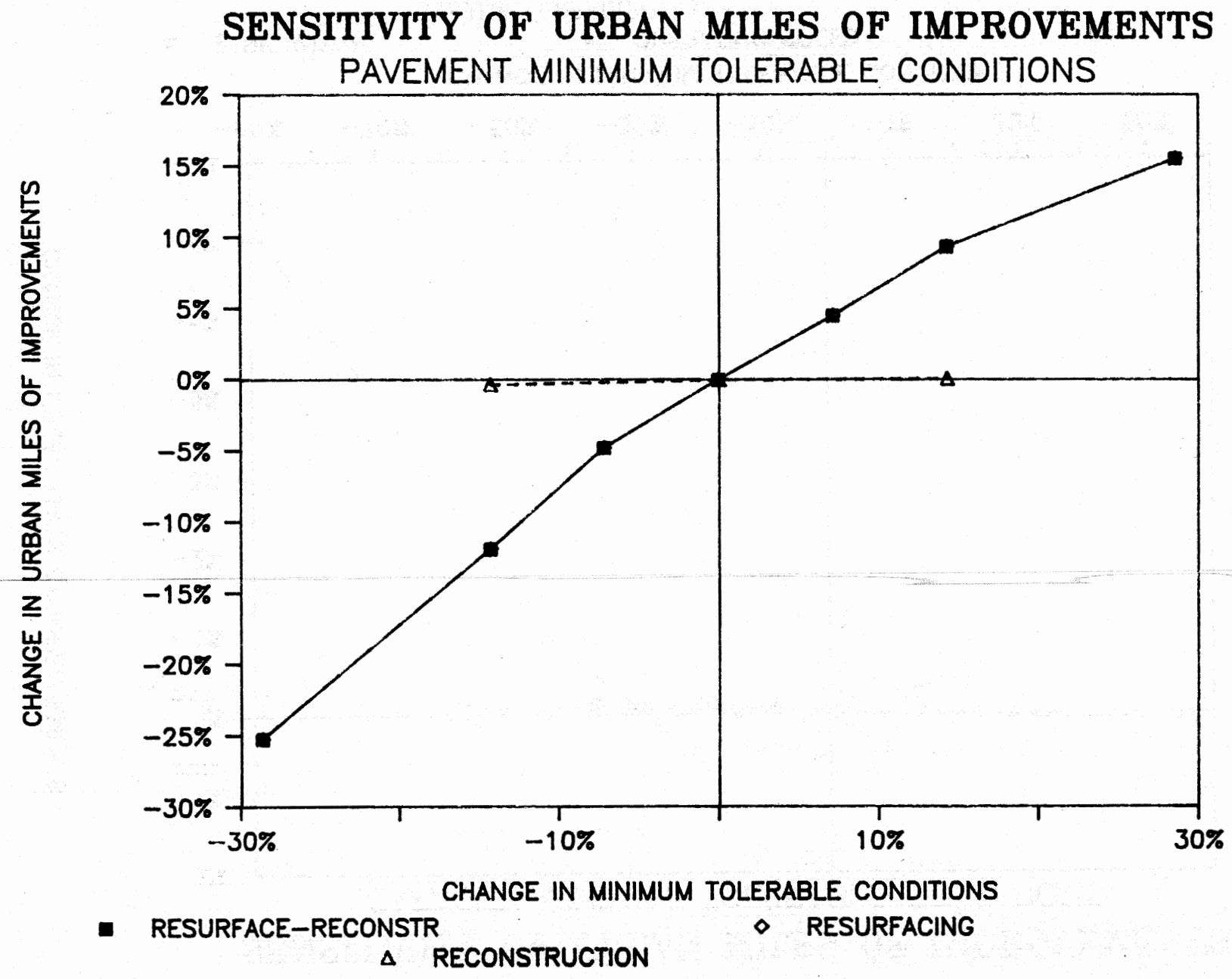

SENSITIVITY OF URBAN MILES OF IMPROVEMENTS
PAVEMENT MINIMUM TOLERABLE CONDITIONS
CHANGE IN URBAN MILES OF IMPROVEMENTS
20%
15%
10%
5%
0%
-5%
-10%
-15%
-20%
-25%
-30%
-30%
-10%
10%
30%
CHANGE IN MINIMUM TOLERABLE CONDITIONS
RESURFACE-RECONSTR
RESURFACING
RECONSTRUCTION

FIGURE III-10

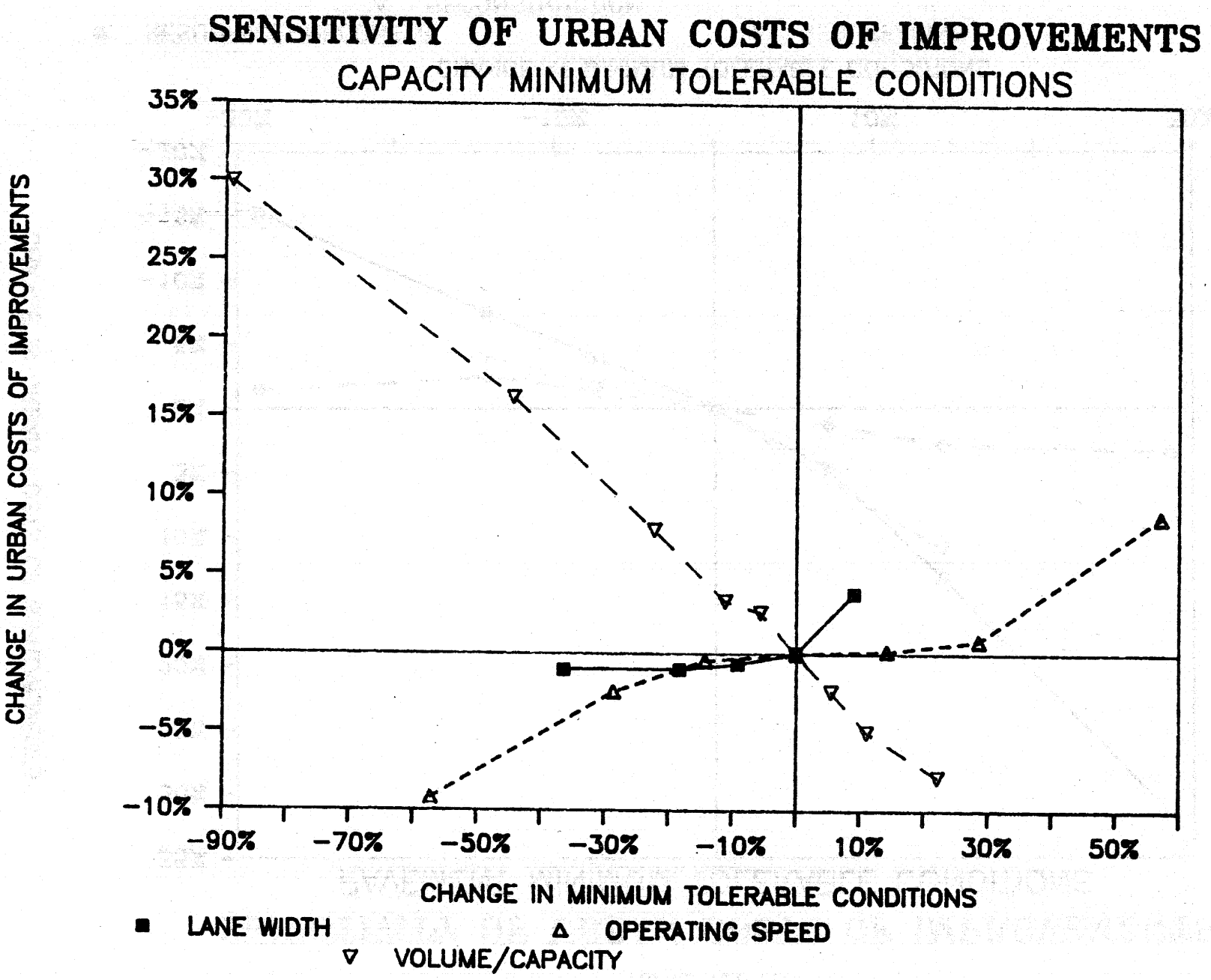


FIGURE III-11

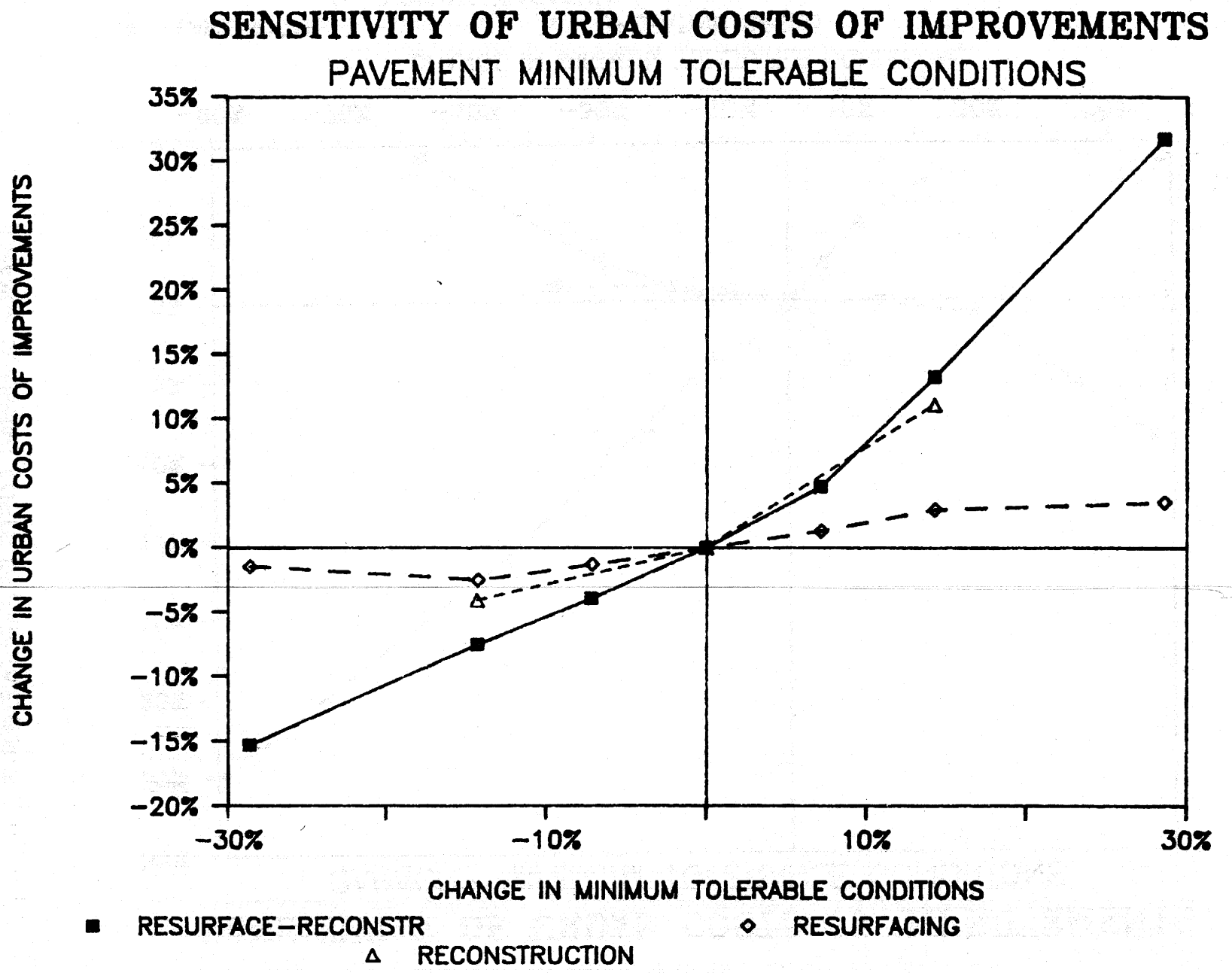


FIGURE III-12

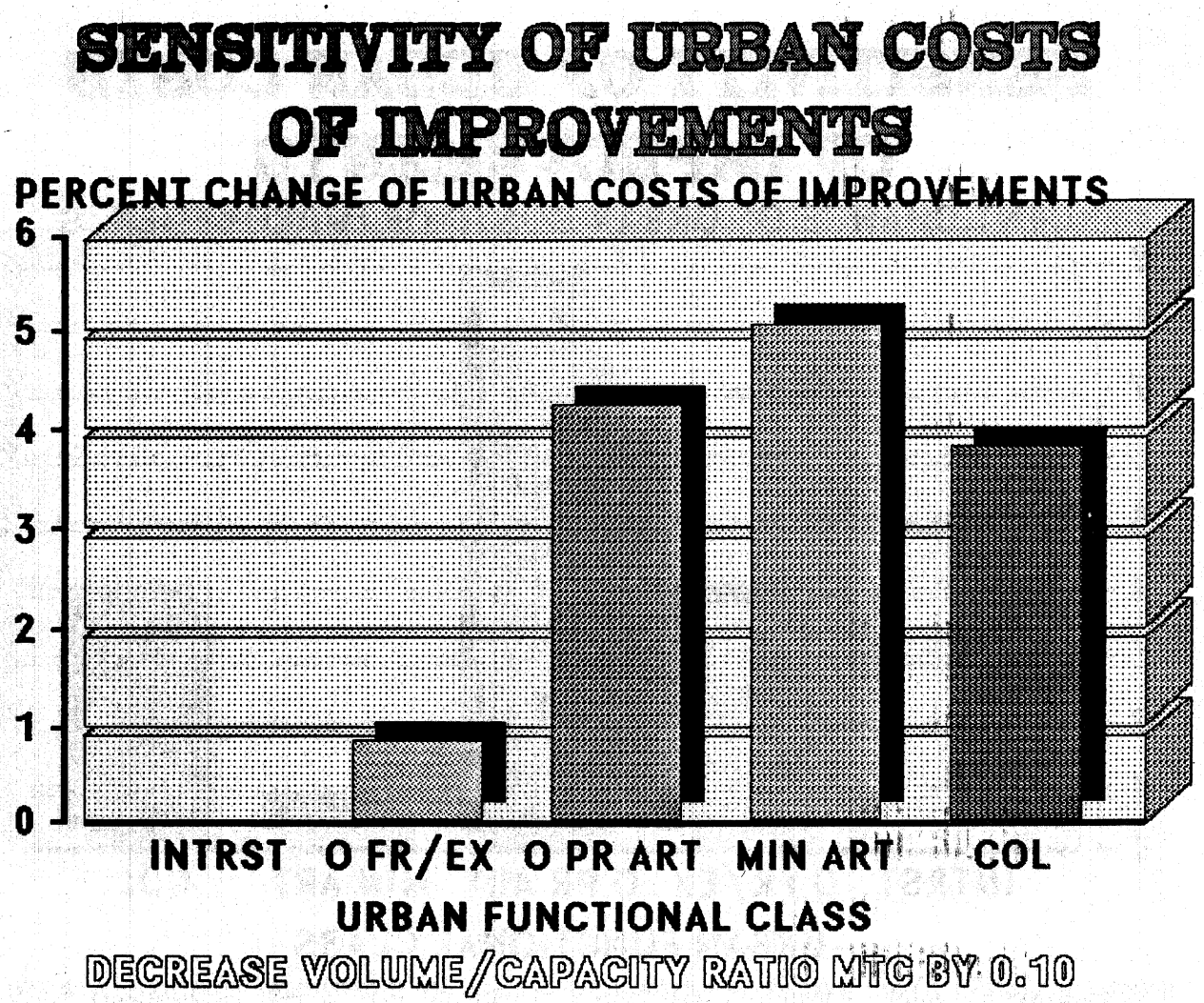


FIGURE III-13

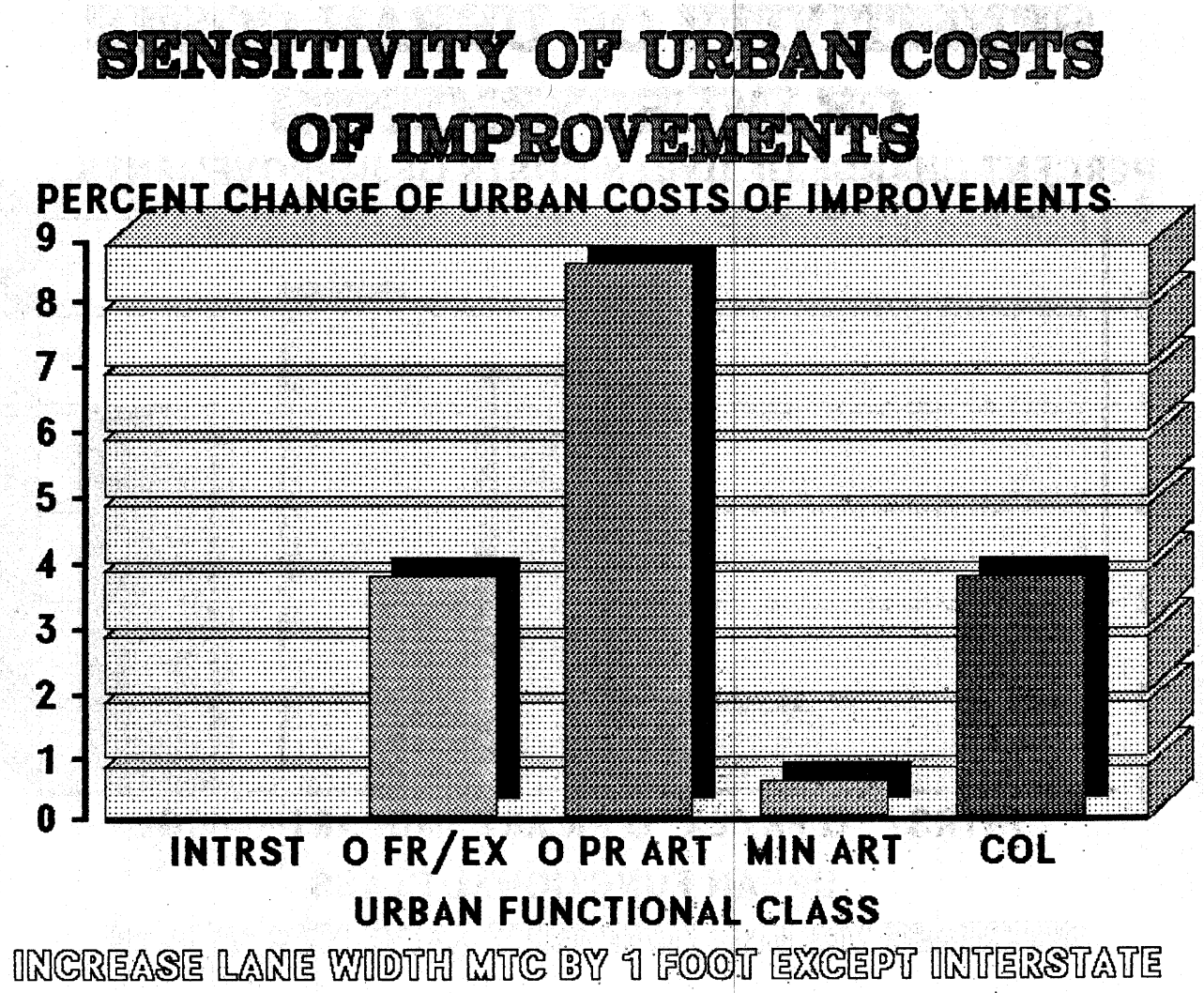


FIGURE III-14

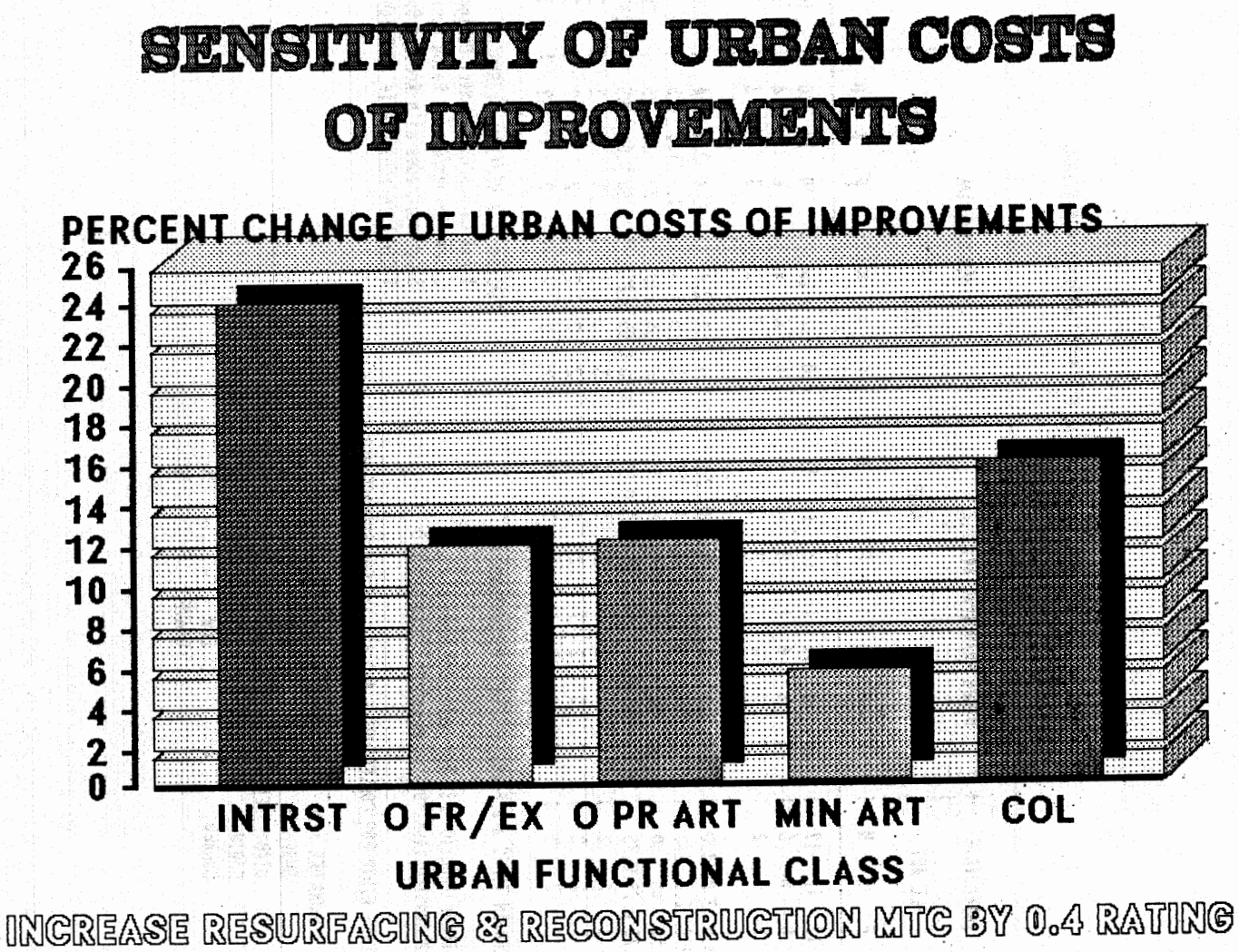


TABLE III-1

RURAL MINIMUM TOLERABLE CONDITIONS

	INTERSTATE			OTHER PRINCIPAL ARTERIAL						MINOR ARTERIAL						MAJOR & MINOR COLLECTOR								
ADT	ALL ADT			) 6000			(= 6000			) 2000			(= 2000			) 1000			400 -- 1000			(400		
TERRAIN	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M
LANE WIDTH	12	12	12	11	11	11	11	11	11	10	10	10	10	10	10	10	10	10	8	8	8	+16	+16	+16
RT SHOULDER WIDTH	8	8	6	8	8	6	8	8	6	6	6	4	6	6	4	4	4	4	2	2	2	0	0	0
SHOULDER TYPE	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
PAVEMENT COND																								
RESURFACING	3.0	3.0	3.0	3.0	3.0	3.0	2.8	2.8	2.8	2.4	2.4	2.4	2.4	2.4	2.4	2.0	2.0	2.0	2.0	2.0	2.0	1.8	1.8	1.8
RECONSTRUCTION	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.5	1.5	1.5	*1.1	*1.1	*1.1	*1.1	*1.1	*1.1	*0.8	*0.8	*0.8
OPERATING SPEED	50	45	40	50	45	35	45	40	35	40	35	30	30	30	25	30	25	20	0	0	0	0	0	0
V/C RATIO	0.75	0.75	0.75	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	1.00	1.00	1.00	1.00	1.00	1.00
SURFACE TYPE	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	4	4	4	5	5	5
HORIZ ALIGNMENT	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3
VERT ALIGNMENT	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3

TERRAIN TYPES are Flat, Rolling, & Mountainous

* RECONSTRUCTION PSR for Major Collectors = 1.1
* RECONSTRUCTION PSR for Minor Collectors = 0.8

+ LANE WIDTH FOR COLLECTORS (400 ADT ARE FOR SURFACE WIDTH

SHOULDER TYPE		SURFACE TYPE	
SURFACED	1	HIGH FLEXIBLE	1
STABILIZED	2	HIGH RIGID	2
EARTH	3	INTERMEDIATE	3
CURBED	4	LOW	4
		GRAVEL	5

HORIZONTAL & VERTICAL ALIGNMENT
1 All Curves/Grades Meet Design Standards
2 Some Curves/Grades Below Design Standards
3 Curves/Grades with Reduced Speed
4 Curves/Grades Unsafe or Siignificant Speed Reduction

TABLE III-2

URBAN MINIMUM TOLERABLE CONDITIONS

		INTERSTATE	OTH FWY, EXPY	OTH PRIN ART	MINOR ART	COLLECTORS
OPERATING SPEED	BUILT-UP	30	30	NA	NA	NA
	OUTLYING	35	30	NA	NA	NA
VOLUME/CAPACITY RATIO		0.90	0.90	0.90	0.95	0.95
LANE WIDTH		12	11	10	8	8
SURFACE TYPE		2	2	2	3	4
PAVEMENT CONDITION	RESURFACING	3.2	3.0	2.8	2.4	2.0
	RECONSTRUCTION	2.2	2.0	1.8	1.1	1.0
SHOULDER TYPE		1	1	2	3	3
RIGHT SHOULDER WIDTH		8	8	6	6	6

SURFACE TYPE CODES	
High Flexible	1
High Rigid	2
Intermediate	3
Low	4
Gravel	5

SHOULDER TYPE CODES	
Surfaced	1
Stabilized	2
Earth	3
Curbed	4

APPENDIX A

Part 2: TABLES FOR THE SENSITIVITY ANALYSIS OF DATA ELEMENTS

TABLE A-1

A CHANGE IN DATA ITEM: SN or D
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change ======>	+2" D, +1 SN			+1" D, +0.5 SN			-1" D, -0.5 SN			-2" D, -1 SN		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX
RURAL												
Interstate	-4.9%	-3.8%	0.2%	-3.2%	-2.5%	0.2%	4.8%	3.4%	-0.2%	8.4%	4.7%	-0.4%
Oth Prin Art	-2.4%	-1.5%	-0.2%	-0.2%	-0.3%	0.1%	1.1%	0.9%	0.0%	6.5%	3.5%	0.2%
Minor Art	-4.0%	-3.7%	-0.2%	-1.3%	-1.3%	-0.2%	0.5%	0.6%	-0.1%	8.1%	4.9%	0.1%
Major Col	-4.5%	-11.3%	0.2%	1.2%	-1.3%	0.1%	1.6%	2.4%	0.4%	10.3%	7.0%	0.6%
Minor Col	-6.5%	-10.4%	0.0%	1.6%	0.7%	0.1%	1.1%	2.9%	0.2%	8.5%	8.1%	0.6%
Total	-4.7%	-6.9%		0.5%	-0.8%		1.4%	1.9%		8.9%	5.8%	
URBAN												
Interstate	-3.7%	-2.3%	0.6%	-2.4%	-1.8%	0.2%	3.2%	5.0%	-0.4%	5.6%	8.3%	-0.6%
Oth Fwy/Expwy	-0.7%	-0.3%	0.1%	-0.4%	-0.2%	0.1%	1.1%	0.7%	-0.2%	4.4%	5.6%	-0.2%
Oth Prin Art	-2.7%	-2.1%	0.3%	-0.5%	-0.4%	0.3%	0.1%	0.8%	-0.8%	5.9%	3.7%	-1.2%
Minor Art	-5.5%	-3.3%	-0.2%	-1.0%	-0.5%	-0.1%	1.9%	1.6%	0.0%	8.3%	5.6%	-0.1%
Collector	-2.2%	-2.7%	0.5%	2.9%	0.8%	0.2%	1.2%	-0.5%	0.1%	10.5%	7.4%	0.2%
Total	-3.4%	-2.4%		0.3%	-0.4%		1.3%	1.5%		8.1%	5.8%	
TOTAL	-4.4%	-4.5%		0.4%	-0.6%		1.3%	1.7%		8.7%	5.8%	
IMPROVEMENT TYPE												
RURAL												
Recon to Fwy	0.0%	0.0%		0.0%	0.0%		.0%	0.1%		-0.9%	-1.1%	
Recon more lanes	-7.6%	-6.2%		-5.7%	-4.4%		6.2%	6.2%		12.9%	9.1%	
Recon wider lanes	0.0%	0.0%		0.1%	0.1%		0.0%	0.0%		0.4%	0.5%	
Pvmt Recon	-17.0%	-15.3%		-2.2%	-2.2%		4.1%	4.4%		7.8%	8.4%	
Pvmt Recon + Algn	-17.6%	-17.4%		0.0%	0.0%		0.9%	1.0%		2.2%	2.3%	
Major Widen	1.5%	1.4%		1.0%	0.9%		-3.0%	-3.3%		-7.0%	-7.2%	
Minor Widen	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		-0.7%	-0.6%	
Resurf + Shldr	-4.4%	-3.8%		0.7%	0.6%		0.1%	0.7%		10.6%	11.7%	
Resurf	-0.7%	-2.6%		1.5%	-0.9%		1.2%	2.4%		11.1%	9.7%	
Resurf+Algn+Shldr	-4.2%	-2.2%		-0.1%	-0.2%		1.5%	1.0%		8.1%	8.0%	
Resurf + Algn	-3.1%	-1.6%		0.3%	.0%		0.8%	0.4%		8.4%	9.1%	
Total	-4.7%	-6.9%		0.5%	-0.8%		1.4%	1.9%		8.9%	5.8%	
URBAN												
Recon to Fwy	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Recon more lanes	-23.2%	-15.3%		-11.5%	-9.9%		9.7%	19.9%		22.9%	39.2%	
Recon wider lanes	-9.0%	-5.2%		1.4%	0.4%		10.4%	5.8%		32.6%	25.3%	
Pvmt Recon	-14.2%	-13.7%		-2.7%	-5.1%		3.8%	8.2%		10.4%	19.3%	
Major Widen	2.2%	1.3%		1.4%	0.9%		-1.2%	-1.4%		-2.6%	-2.9%	
Minor Widen	1.0%	0.6%		0.0%	0.0%		-1.6%	-1.0%		-3.3%	-2.5%	
Resurf + Shldr	-4.2%	-3.4%		1.0%	0.7%		0.9%	1.3%		9.8%	10.6%	
Resurf	-3.5%	-2.9%		0.3%	0.1%		1.8%	1.0%		9.7%	8.6%	
Total	-3.4%	-2.4%		0.3%	-0.4%		1.3%	1.5%		8.1%	5.8%	

TABLE A-2

A CHANGE IN DATA ITEM: Pavement Condition
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change =======>	+0.5 PSR			+0.2 PSR			-0.2 PSR			-0.5 PSR		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX
RURAL												
Interstate	-15.1%	-19.4%	0.3%	-5.0%	-7.0%	0.1%	3.8%	7.3%	-0.4%	8.2%	17.6%	-0.9%
Oth Prin Art	-16.1%	-9.8%	-0.1%	-6.4%	-4.1%	0.0%	4.0%	6.2%	-0.1%	9.0%	12.4%	-0.3%
Minor Art	-19.9%	-18.4%	-0.3%	-4.7%	-4.9%	0.1%	6.0%	5.2%	-0.2%	14.4%	17.5%	-0.2%
Major Col	-26.2%	-24.1%	0.1%	-9.6%	-13.2%	0.1%	9.4%	9.5%	0.1%	19.0%	32.9%	0.2%
Minor Col	-24.9%	-25.5%	-0.1%	-8.5%	-10.1%	0.1%	11.5%	14.9%	0.6%	19.6%	31.7%	0.6%
Total	-23.0%	-19.9%		-7.9%	-8.6%		8.4%	8.7%		16.6%	24.1%	
URBAN												
Interstate	-9.7%	-11.0%	0.6%	-2.0%	-6.2%	0.2%	1.9%	5.3%	-0.5%	3.6%	31.3%	-0.7%
Oth Fwy/Expwy	-15.5%	-9.8%	0.5%	-6.2%	-4.8%	0.2%	3.1%	9.6%	-0.2%	6.8%	15.2%	-0.8%
Oth Prin Art	-14.2%	-9.0%	0.7%	-7.9%	-3.3%	0.1%	3.7%	4.1%	-0.5%	9.5%	15.6%	-1.1%
Minor Art	-19.6%	-8.5%	0.1%	-6.0%	-3.1%	0.0%	5.3%	3.1%	-0.5%	13.5%	12.6%	-0.7%
Collector	-26.3%	-20.5%	0.0%	-6.3%	-7.2%	0.5%	8.2%	8.6%	-0.1%	17.9%	19.2%	-1.0%
Total	-19.7%	-11.2%		-6.3%	-4.5%		5.5%	5.4%		13.1%	18.0%	
TOTAL	-22.2%	-15.3%		-7.5%	-6.4%		7.7%	6.9%		15.8%	20.9%	
IMPROVEMENT TYPE												
RURAL												
Recon to Fwy	6.0%	5.6%		-0.2%	-0.1%		-4.0%	-4.0%		-9.6%	-9.2%	
Recon more lanes	-9.1%	-9.4%		-2.6%	-2.3%		7.0%	5.9%		25.8%	18.2%	
Recon wider lanes	-1.7%	-1.4%		-0.5%	-0.3%		-0.3%	-0.1%		1.5%	1.0%	
Pvmt Recon	-37.5%	-38.0%		-19.4%	-18.6%		17.3%	18.6%		54.3%	60.6%	
Pvmt Recon + Algn	-25.3%	-26.8%		-16.3%	-16.6%		26.2%	27.8%		48.5%	53.8%	
Major Widen	8.6%	8.1%		3.9%	2.8%		-6.3%	-6.2%		-11.3%	-11.3%	
Minor Widen	7.2%	7.0%		2.7%	1.8%		-1.4%	-1.8%		-11.6%	-9.3%	
Resurf + Shldr	-17.4%	-17.1%		-6.6%	-6.9%		5.6%	5.5%		8.4%	8.3%	
Resurf	-24.6%	-20.3%		-6.1%	-5.3%		8.9%	5.5%		11.4%	8.0%	
Resurf+Algn+Shldr	-23.4%	-22.1%		-4.1%	-4.4%		5.5%	4.9%		9.2%	8.5%	
Resurf + Algn	-23.0%	-26.5%		-5.6%	-5.4%		-3.2%	0.3%		.0%	6.6%	
Total	-23.0%	-19.9%		-7.9%	-8.6%		8.4%	8.7%		16.6%	24.1%	
URBAN												
Recon to Fwy	4.0%	0.5%		-0.7%	-1.3%		-6.0%	-2.4%		-7.4%	-3.3%	
Recon more lanes	-55.0%	-53.6%		-29.5%	-30.6%		29.8%	42.8%		87.0%	138.8%	
Recon wider lanes	-12.5%	72.7%		-6.9%	-4.3%		38.9%	47.9%		84.0%	89.7%	
Pvmt Recon	-42.4%	-51.9%		-18.5%	-19.1%		30.0%	33.0%		115.9%	161.9%	
Major Widen	7.9%	5.8%		3.9%	2.8%		-3.3%	-3.4%		-10.1%	-10.6%	
Minor Widen	4.7%	8.1%		1.3%	1.5%		-3.8%	-3.9%		-6.8%	-7.0%	
Resurf + Shldr	-23.0%	-23.2%		-7.0%	-7.7%		5.9%	6.4%		10.4%	11.3%	
Resurf	-23.4%	-20.5%		-7.4%	-7.0%		5.8%	5.3%		12.5%	10.3%	
Total	-19.7%	-11.2%		-6.3%	-4.5%		5.5%	5.4%		13.1%	18.0%	

TABLE A-3

A CHANGE IN DATA ITEM: Pavement Deterioration Rate
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change ======>	-30%			-10%			+10%			+30%		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX
RURAL												
Interstate	-9.9%	-7.0%	0.7%	-1.3%	-1.0%	0.2%	1.7%	1.3%	-0.3%	6.0%	3.5%	-1.1%
Oth Prin Art	-11.4%	-5.6%	0.5%	-2.6%	-1.6%	0.1%	2.3%	2.0%	-0.3%	4.7%	2.5%	-1.2%
Minor Art	-15.5%	-11.9%	-0.1%	-3.6%	-2.7%	0.1%	3.9%	1.3%	-0.3%	11.0%	6.1%	-0.8%
Major Col	-19.7%	-19.8%	0.4%	-6.5%	-11.1%	-0.1%	7.6%	6.0%	0.0%	16.4%	16.6%	-0.5%
Minor Col	-20.0%	-23.6%	0.0%	-6.3%	-8.7%	-0.1%	5.1%	4.6%	-0.4%	17.6%	21.6%	0.0%
Total	-17.6%	-14.9%		-5.2%	-6.2%		5.4%	3.6%		13.8%	11.4%	
URBAN												
Interstate	-5.0%	-2.3%	1.0%	-1.4%	-0.2%	0.2%	0.9%	0.2%	-0.5%	3.0%	1.9%	-1.7%
Oth Fwy/Expwy	-7.5%	-2.6%	1.1%	-0.8%	-0.3%	0.4%	1.4%	1.8%	0.0%	3.8%	2.8%	-1.2%
Oth Prin Art	-10.7%	-5.1%	1.1%	-4.3%	-1.8%	0.1%	2.2%	1.4%	-0.5%	4.2%	3.9%	-1.6%
Minor Art	-15.8%	-8.6%	0.0%	-5.0%	-2.7%	-0.1%	1.9%	1.1%	-0.6%	8.4%	4.8%	-1.0%
Collector	-15.8%	-12.7%	0.7%	-2.7%	-4.5%	0.7%	7.4%	5.6%	0.0%	15.6%	11.4%	-0.9%
Total	-13.5%	-6.5%		-3.7%	-2.1%		3.7%	1.8%		9.2%	4.9%	
TOTAL	-16.6%	-10.5%		-4.8%	-4.0%		5.0%	2.7%		12.7%	8.0%	
IMPROVEMENT TYPE												
RURAL												
Recon to Fwy	0.9%	0.8%		-0.8%	-0.6%		0.0%	0.0%		-1.5%	-1.6%	
Recon more lanes	-9.3%	-8.3%		-1.6%	-1.5%		-2.4%	-2.2%		10.7%	3.9%	
Recon wider lanes	-1.0%	-0.8%		0.0%	0.0%		.0%	.0%		1.1%	1.0%	
Pvmt Recon	-30.1%	-27.0%		-15.3%	-13.6%		4.8%	4.5%		24.2%	22.0%	
Pvmt Recon + Algn	-19.2%	-19.2%		-13.8%	-13.6%		11.3%	10.9%		18.2%	17.0%	
Major Widen	4.3%	4.3%		0.7%	0.6%		-2.0%	-1.8%		-5.8%	-5.6%	
Minor Widen	0.3%	0.3%		0.0%	0.0%		0.0%	0.0%		-2.3%	-1.5%	
Resurf + Shldr	-15.1%	-14.8%		-4.6%	-4.5%		5.2%	5.2%		11.1%	11.4%	
Resurf	-17.7%	-15.3%		-2.8%	-2.4%		7.0%	4.6%		14.7%	10.6%	
Resurf+Algn+Shldr	-16.9%	-16.6%		-2.0%	-2.2%		6.4%	5.8%		11.8%	11.0%	
Resurf + Algn	-15.5%	-17.5%		-4.0%	-3.6%		0.2%	2.9%		8.0%	12.1%	
Total	-17.6%	-14.9%		-5.2%	-6.2%		5.4%	3.6%		13.8%	11.4%	
URBAN												
Recon to Fwy	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Recon more lanes	-24.7%	-19.8%		-19.8%	-12.5%		7.3%	6.1%		14.6%	14.8%	
Recon wider lanes	-7.6%	-4.5%		-9.0%	-5.2%		10.4%	4.7%		9.0%	10.3%	
Pvmt Recon	-12.7%	-7.8%		-6.9%	-3.6%		3.5%	3.8%		10.9%	13.3%	
Major Widen	2.6%	1.6%		1.8%	1.0%		-0.9%	-0.6%		-1.8%	-1.5%	
Minor Widen	1.3%	1.5%		0.8%	0.5%		-1.5%	-0.9%		-1.4%	-1.4%	
Resurf + Shldr	-16.3%	-16.7%		-4.0%	-3.7%		4.8%	5.0%		12.2%	11.7%	
Resurf	-16.4%	-14.2%		-4.4%	-4.1%		4.4%	3.6%		10.6%	9.6%	
Total	-13.5%	-6.5%		-3.7%	-2.1%		3.7%	1.8%		9.2%	4.9%	

TABLE A-4

A CHANGE IN DATA ITEM: Lane Width
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change ======>	+2'			+1'			-1'			-2'		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX
RURAL												
Interstate	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	12.0%	122.9%	-1.6%	12.2%	123.7%	-1.8%
Oth Prin Art	-0.5%	-3.7%	0.5%	-0.6%	-3.2%	0.3%	1.2%	8.5%	-2.8%	11.0%	59.6%	-0.9%
Minor Art	-1.6%	-6.4%	1.4%	-1.3%	-4.5%	0.7%	6.1%	22.9%	-1.0%	11.0%	37.7%	-1.4%
Major Col	-1.1%	-8.9%	2.3%	-1.1%	-7.1%	1.5%	6.3%	27.9%	-1.6%	12.7%	48.8%	-4.4%
Minor Col	-1.1%	-8.8%	4.8%	-0.9%	-7.7%	3.3%	6.1%	27.5%	-3.6%	14.5%	65.5%	-5.8%
Total	-1.1%	-6.6%		-1.0%	-5.3%		6.0%	30.2%		12.6%	57.3%	

IMPROVEMENT TYPE								
RURAL								
Recon to Fwy	-1.5%	-1.5%	-1.5%	-1.5%	-1.8%	-1.7%	-8.6%	-8.5%
Recon more lanes	-4.8%	-2.6%	1.0%	1.6%	34.3%	30.7%	49.0%	40.8%
Recon wider lanes	-88.5%	-89.5%	-76.9%	-78.7%	229.0%	246.4%	422.8%	452.4%
Pvmt Recon	5.8%	6.4%	5.5%	6.2%	-9.7%	-13.2%	-23.1%	-27.4%
Pvmt Recon + Algn	9.5%	8.7%	4.9%	4.3%	-26.3%	-25.2%	-41.7%	-42.2%
Major Widen	-16.0%	-13.4%	-5.7%	-4.3%	37.8%	33.3%	63.7%	55.5%
Minor Widen	-94.3%	-91.5%	-87.7%	-84.2%	700.1%	1124.2%	1721.4%	2351.6%
Resurf + Shldr	4.1%	4.2%	3.7%	3.7%	-17.0%	-17.0%	-46.5%	-51.2%
Resurf	2.3%	1.4%	1.8%	1.2%	-17.2%	-41.2%	-36.8%	-63.1%
Resurf+Algn+Shldr	15.8%	12.6%	15.1%	11.7%	-33.5%	-30.6%	-53.8%	-54.6%
Resurf + Algn	5.2%	5.2%	3.9%	3.9%	-14.1%	-14.7%	-40.4%	-40.8%
Total	-1.1%	-6.6%	-1.0%	-5.3%	6.0%	30.2%	12.6%	57.3%

TABLE A-5

A CHANGE IN DATA ITEM: Directional Factor
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change ======>	-10 percentage points			-5			+5			+10		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX
RURAL												
Interstate	0.4%	-7.8%	0.7%	0.4%	-6.0%	0.3%	0.4%	9.3%	-0.3%	0.9%	19.2%	-0.7%
Oth Prin Art	-0.1%	-1.8%	0.2%	.0%	-1.1%	0.1%	.0%	1.5%	0.0%	-0.1%	2.3%	-0.1%
Minor Art	.0%	-0.2%	0.0%	.0%	-0.1%	0.0%	0.0%	.0%	-0.1%	0.0%	.0%	-0.1%
Major Col	.0%	.0%	0.0%	.0%	.0%	0.0%	.0%	.0%	0.0%	-0.1%	.0%	0.0%
Minor Col	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	.0%	-1.0%		.0%	-0.7%		.0%	1.0%		.0%	2.0%	
URBAN												
Interstate	-0.3%	-14.1%	2.2%	-0.6%	-5.0%	1.3%	0.6%	5.7%	-1.4%	1.0%	14.1%	-2.8%
Oth Fwy/Expwy	-1.1%	-11.6%	1.3%	-0.3%	-5.2%	0.8%	0.7%	9.8%	-0.7%	0.9%	21.4%	-1.4%
Oth Prin Art	-0.6%	-11.8%	1.9%	-0.4%	-7.4%	0.9%	0.5%	5.5%	-1.1%	0.7%	12.9%	-2.0%
Minor Art	-1.2%	-11.6%	1.1%	-0.6%	-7.5%	0.6%	0.8%	9.0%	-0.5%	0.9%	15.0%	-1.1%
Collector	-1.1%	-10.8%	0.3%	-0.5%	-6.6%	0.2%	0.6%	7.0%	-0.2%	0.6%	11.8%	-0.5%
Total	-0.9%	-11.9%		-0.5%	-6.7%		0.6%	7.2%		0.8%	14.4%	
TOTAL	-0.2%	-6.7%		-0.1%	-3.8%		0.2%	4.2%		0.2%	8.4%	
IMPROVEMENT TYPE												
RURAL												
Recon to Fwy	-1.7%	-4.2%		-1.3%	-3.5%		0.5%	1.4%		0.5%	1.5%	
Recon more lanes	0.9%	1.5%		1.3%	1.9%		10.9%	10.5%		8.0%	7.1%	
Recon wider lanes	.0%	-0.1%		.0%	-0.1%		.0%	0.1%		0.1%	0.4%	
Pvmt Recon	-0.1%	-0.1%		.0%	-0.1%		-0.1%	-0.3%		-0.1%	-0.2%	
Pvmt Recon + Algn	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Major Widen	-10.2%	-13.8%		-8.0%	-9.7%		7.8%	10.3%		21.6%	27.3%	
Minor Widen	-0.1%	-0.1%		-0.1%	-0.2%		0.6%	1.5%		1.1%	2.6%	
Resurf + Shldr	0.1%	0.3%		0.1%	0.2%		-0.1%	-0.1%		-0.1%	-0.4%	
Resurf	0.4%	1.3%		0.3%	1.1%		-0.3%	-1.3%		-0.8%	-2.6%	
Resurf+Algn+Shldr	.0%	-0.1%		.0%	-0.1%		.0%	.0%		-0.1%	-0.2%	
Resurf + Algn	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		.0%	-0.1%	
Total	.0%	-1.0%		.0%	-0.7%		.0%	1.0%		.0%	2.0%	
URBAN												
Recon to Fwy	-24.2%	-16.1%		-12.1%	-6.0%		12.1%	6.8%		16.8%	10.6%	
Recon more lanes	-21.8%	-10.3%		-13.7%	13.6%		-8.4%	1.8%		1.0%	17.1%	
Recon wider lanes	-32.6%	-35.8%		-35.4%	-41.6%		15.3%	16.7%		42.4%	28.3%	
Pvmt Recon	6.1%	16.1%		3.5%	7.2%		-1.1%	1.4%		-3.0%	-4.8%	
Major Widen	-28.7%	-28.7%		-17.7%	-19.3%		16.4%	16.0%		30.8%	31.9%	
Minor Widen	-27.7%	-25.3%		-9.8%	-5.4%		16.9%	15.9%		33.5%	28.8%	
Resurf + Shldr	4.4%	5.0%		2.0%	2.2%		-3.1%	-4.6%		-6.1%	-7.4%	
Resurf	4.2%	4.6%		2.7%	2.7%		-1.7%	-1.7%		-4.3%	-4.2%	
Total	-0.9%	-11.9%		-0.5%	-6.7%		0.6%	7.2%		0.8%	14.4%	

TABLE A-6

A CHANGE IN DATA ITEM: K Factor
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change ======>	-5 percentage points			-2			+2			+5		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX
RURAL												
Interstate	-0.1%	-17.5%	2.0%	0.5%	-10.6%	0.8%	0.8%	18.4%	-0.8%	1.2%	55.2%	-1.9%
Oth Prin Art	-0.4%	-31.3%	0.7%	0.2%	-12.4%	0.3%	0.2%	10.8%	-0.3%	1.2%	25.0%	-0.8%
Minor Art	-1.1%	-16.8%	1.1%	-0.6%	-11.4%	0.3%	0.7%	8.5%	-0.5%	2.0%	23.2%	-1.0%
Major Col	-0.3%	-4.2%	0.2%	.0%	-1.8%	0.1%	.0%	1.1%	-0.1%	0.4%	4.9%	-0.2%
Minor Col	0.0%	-0.4%	0.1%	.0%	.0%	0.1%	.0%	0.3%	0.0%	0.2%	1.8%	0.0%
Total	-0.4%	-12.8%		-0.1%	-6.4%		0.2%	5.8%		0.8%	16.2%	
URBAN												
Interstate	-0.8%	-49.6%	7.1%	-0.2%	-20.0%	3.4%	1.0%	14.3%	-3.2%	0.7%	55.0%	-6.4%
Oth Fwy/Expwy	-1.4%	-48.8%	4.9%	-0.8%	-19.2%	2.1%	0.9%	22.2%	-1.8%	1.1%	54.5%	-4.5%
Oth Prin Art	-1.0%	-39.0%	7.5%	-1.0%	-18.4%	2.8%	1.2%	16.0%	-2.3%	2.1%	45.8%	-4.4%
Minor Art	-2.8%	-36.8%	3.9%	-1.2%	-15.8%	1.6%	1.6%	18.1%	-1.2%	3.5%	45.8%	-3.1%
Collector	-1.5%	-30.4%	1.1%	-0.9%	-14.3%	0.3%	0.7%	12.4%	-0.6%	1.2%	29.8%	-1.5%
Total	-1.7%	-39.8%		-1.0%	-17.4%		1.1%	16.3%		2.1%	45.6%	
TOTAL	-0.7%	-26.9%		-0.3%	-12.2%		0.4%	11.3%		1.1%	31.6%	
IMPROVEMENT TYPE												
RURAL												
Recon to Fwy	-68.6%	-68.4%		-22.4%	-22.7%		3.2%	4.6%		10.3%	14.3%	
Recon more lanes	-80.8%	-81.7%		-50.5%	-54.1%		71.5%	68.8%		171.3%	155.2%	
Recon wider lanes	-1.6%	-1.4%		0.2%	1.5%		1.0%	0.8%		-1.7%	-1.1%	
Pvmt Recon	0.5%	0.4%		0.2%	0.2%		-0.8%	-1.0%		-1.1%	-1.3%	
Pvmt Recon + Algn	0.3%	0.3%		-0.1%	-0.2%		-0.6%	-0.7%		-1.4%	-1.9%	
Major Widen	-91.0%	-91.9%		-51.6%	-52.5%		53.5%	54.0%		156.1%	161.6%	
Minor Widen	-4.1%	-5.7%		-0.9%	-1.1%		2.5%	3.7%		12.4%	13.4%	
Resurf + Shldr	3.2%	4.0%		1.6%	2.0%		-1.2%	-1.5%		-3.2%	-3.8%	
Resurf	2.6%	4.5%		1.4%	2.7%		-1.1%	-3.1%		-3.2%	-8.6%	
Resurf+Algn+Shldr	5.1%	6.8%		2.6%	2.9%		-2.6%	-3.7%		-6.4%	-7.9%	
Resurf + Algn	2.0%	3.9%		1.8%	3.5%		-2.0%	-3.0%		-2.4%	-3.8%	
Total	-0.4%	-12.8%		-0.1%	-6.4%		0.2%	5.8%		0.8%	16.2%	
URBAN												
Recon to Fwy	-67.8%	-76.6%		-34.9%	-23.3%		24.2%	19.2%		34.2%	30.1%	
Recon more lanes	-86.9%	-80.6%		-25.6%	-13.2%		4.2%	14.0%		34.6%	83.3%	
Recon wider lanes	-74.3%	-76.4%		-31.9%	-38.4%		31.9%	17.8%		53.5%	25.1%	
Pvmt Recon	15.1%	18.6%		7.0%	13.4%		0.7%	0.7%		-10.7%	-15.1%	
Major Widen	-84.1%	-85.8%		-42.8%	-42.0%		35.3%	35.8%		91.8%	99.7%	
Minor Widen	-75.1%	-72.9%		-30.4%	-30.0%		36.2%	37.6%		61.3%	71.9%	
Resurf + Shldr	12.5%	16.7%		6.1%	7.8%		-6.4%	-8.0%		-12.8%	-17.6%	
Resurf	14.7%	16.5%		6.5%	7.1%		-4.9%	-5.6%		-13.5%	-14.7%	
Total	-1.7%	-39.8%		-1.0%	-17.4%		1.1%	16.3%		2.1%	45.6%	

TABLE A-7

A CHANGE IN DATA ITEM: Right Shoulder Width
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change ======>	+3'			+1'			-1'			-3'		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX
RURAL												
Interstate	0.0%	-0.1%	0.4%	0.0%	0.0%	0.0%	0.0%	0.5%	-0.9%	0.0%	41.4%	-1.2%
Oth Prin Art	.0%	-2.2%	0.6%	.0%	-0.6%	0.1%	.0%	3.5%	-0.3%	0.5%	11.6%	-0.3%
Minor Art	-0.3%	-10.4%	0.5%	.0%	-2.3%	0.1%	.0%	2.5%	-0.3%	.0%	6.3%	-0.8%
Major Col	-0.1%	-3.4%	0.9%	-0.1%	-2.5%	0.4%	.0%	3.8%	-0.4%	0.4%	10.7%	-1.1%
Minor Col	-0.5%	-3.1%	0.9%	-0.2%	-2.0%	0.4%	0.1%	3.5%	-0.4%	0.8%	9.6%	-1.0%
Total	-0.2%	-4.3%		-0.1%	-1.8%		.0%	3.1%		0.4%	12.1%	

IMPROVEMENT TYPE								
RURAL								
Recon to Fwy	-1.3%	-1.1%	-0.6%	-0.6%	0.9%	1.2%	3.8%	4.6%
Recon more lanes	-6.2%	-8.2%	5.2%	4.6%	2.3%	2.5%	17.9%	15.5%
Recon wider lanes	-13.0%	-12.9%	-8.9%	-9.6%	8.8%	8.1%	18.6%	17.3%
Pvmt Recon	1.1%	1.3%	1.0%	1.2%	-0.4%	-0.5%	-1.3%	-1.4%
Pvmt Recon + Algn	1.9%	1.3%	1.4%	0.8%	-7.4%	-7.1%	-7.6%	-7.1%
Major Widen	-6.4%	-7.2%	-2.6%	-3.3%	1.5%	1.1%	6.1%	5.4%
Minor Widen	-4.3%	-5.3%	-1.2%	-0.9%	5.2%	7.5%	23.7%	31.8%
Resurf + Shldr	-36.8%	-37.4%	-16.9%	-14.8%	43.0%	41.7%	132.8%	179.1%
Resurf	14.3%	13.5%	6.5%	4.5%	-16.7%	-13.8%	-51.6%	-65.2%
Resurf+Algn+Shldr	-57.2%	-51.7%	-27.0%	-20.9%	32.6%	24.9%	67.2%	50.0%
Resurf + Algn	46.4%	65.1%	21.7%	24.3%	-25.9%	-29.0%	-54.1%	-59.5%
Total	-0.2%	-4.3%	-0.1%	-1.8%	.0%	3.1%	0.4%	12.1%

TABLE A-8

A CHANGE IN DATA ITEM: Left Shoulder Width
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change ======>	+3'			+1'			-1'			-3'		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX
RURAL												
Interstate	.0%	-0.6%	0.0%	.0%	-0.7%	0.0%	0.2%	0.8%	-0.1%	0.3%	1.2%	-0.2%
Oth Prin Art	0.0%	0.5%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%
Minor Art	0.0%	.0%	0.0%	0.0%	.0%	0.0%	0.0%	0.0%	0.0%	0.0%	.0%	-0.1%
Major Col	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Minor Col	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	.0%	0.1%		.0%	.0%		.0%	0.1%		.0%	0.2%	

IMPROVEMENT TYPE												
RURAL												
Recon to Fwy	0.0%	0.9%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Recon more lanes	0.8%	1.2%		0.9%	1.3%		0.1%	0.1%		-2.0%	-1.8%	
Recon wider lanes	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Pvmt Recon	.0%	.0%		0.0%	.0%		0.0%	0.0%		.0%	.0%	
Pvmt Recon + Algn	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Major Widen	-1.3%	-1.1%		-1.2%	-1.4%		0.6%	0.8%		2.8%	3.4%	
Minor Widen	0.3%	1.3%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Resurf + Shldr	.0%	-0.1%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Resurf	.0%	0.1%		.0%	0.1%		.0%	.0%		.0%	-0.1%	
Resurf+Algn+Shldr	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Resurf + Algn	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Total	.0%	0.1%		.0%	.0%		.0%	0.1%		.0%	0.2%	

TABLE A-9

A CHANGE IN DATA ITEM: Current AADT
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change =======>	-30%			-10%			+10%			+30%		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX
RURAL												
Interstate	-0.9%	-9.2%	1.1%	-0.2%	-3.0%	0.3%	1.1%	2.9%	-0.4%	1.9%	10.2%	-1.2%
Oth Prin Art	-0.9%	-12.7%	0.5%	-0.4%	-4.5%	0.1%	0.6%	3.4%	-0.1%	1.8%	10.2%	-0.2%
Minor Art	-1.3%	-10.1%	0.5%	-0.6%	-3.3%	0.1%	0.4%	2.2%	-0.2%	0.5%	5.3%	-0.7%
Major Col	-1.5%	-2.7%	0.5%	-0.5%	-0.8%	0.1%	0.5%	2.0%	0.0%	2.5%	4.3%	0.0%
Minor Col	-0.4%	4.5%	0.5%	.0%	0.6%	0.1%	0.5%	-0.2%	0.0%	1.6%	0.1%	-0.1%
Total	-1.1%	-5.6%		-0.4%	-2.0%		0.5%	2.0%		1.8%	5.4%	
URBAN												
Interstate	-2.6%	-13.2%	3.4%	-0.6%	2.7%	1.2%	0.7%	1.1%	-1.3%	1.4%	3.5%	-3.7%
Oth Fwy/Expwy	-1.9%	-18.0%	1.9%	-0.3%	0.4%	0.8%	0.5%	2.3%	-0.8%	1.3%	13.3%	-1.8%
Oth Prin Art	-1.2%	-8.2%	3.6%	0.1%	-1.4%	1.2%	0.4%	1.7%	-1.1%	0.7%	5.5%	-3.2%
Minor Art	-1.5%	-10.1%	1.7%	-0.9%	-3.5%	0.5%	0.3%	1.4%	-0.6%	1.2%	4.8%	-1.8%
Collector	-0.5%	-5.4%	0.7%	-0.3%	-3.0%	0.2%	0.5%	1.9%	-0.1%	0.8%	2.9%	-0.7%
Total	-1.2%	-10.1%		-0.4%	-1.3%		0.4%	1.6%		0.9%	5.3%	
TOTAL	-1.1%	-7.9%		-0.4%	-1.6%		0.5%	1.8%		1.6%	5.4%	
IMPROVEMENT TYPE												
RURAL												
Recon to Fwy	-17.7%	-17.6%		-5.7%	-3.9%		0.6%	0.6%		-1.9%	-2.4%	
Recon more lanes	-14.8%	-20.8%		-5.2%	-2.5%		9.3%	8.5%		35.1%	35.3%	
Recon wider lanes	-20.0%	-20.0%		-6.6%	-7.1%		12.1%	11.2%		20.8%	20.2%	
Pvmt Recon	5.1%	4.2%		-0.3%	-0.5%		-1.4%	-1.7%		-7.5%	-7.2%	
Pvmt Recon + Algn	16.0%	17.4%		11.8%	11.4%		-4.7%	-3.4%		4.5%	5.6%	
Major Widen	-58.1%	-53.1%		-22.7%	-19.8%		21.9%	16.9%		57.6%	45.6%	
Minor Widen	-17.3%	-14.6%		-8.7%	-6.9%		6.5%	6.1%		18.9%	17.7%	
Resurf + Shldr	-4.3%	-2.2%		-0.9%	-0.5%		0.9%	0.6%		6.6%	5.1%	
Resurf	2.9%	2.4%		1.7%	1.2%		-0.6%	-0.5%		-2.5%	-2.8%	
Resurf+Algn+Shldr	-1.7%	-0.3%		-1.4%	-1.0%		1.8%	1.1%		4.8%	1.7%	
Resurf + Algn	-12.6%	-6.4%		-7.8%	-4.0%		-0.1%	-0.7%		6.8%	3.7%	
Total	-1.1%	-5.6%		-0.4%	-2.0%		0.5%	2.0%		1.8%	5.4%	
URBAN												
Recon to Fwy	-30.9%	-19.7%		-10.1%	-4.7%		11.4%	4.6%		19.5%	13.0%	
Recon more lanes	-15.0%	13.3%		1.4%	37.9%		-20.3%	-16.2%		-16.1%	-16.4%	
Recon wider lanes	-18.8%	2.4%		13.9%	17.8%		10.4%	13.7%		16.0%	17.8%	
Pvmt Recon	4.6%	14.4%		1.7%	5.7%		-0.5%	0.4%		-0.3%	-0.3%	
Major Widen	-26.8%	-26.1%		-8.9%	-8.9%		6.6%	3.3%		14.2%	11.4%	
Minor Widen	-47.3%	-45.1%		-12.8%	-11.7%		25.5%	33.6%		47.8%	49.7%	
Resurf + Shldr	4.9%	5.9%		1.4%	1.2%		-2.0%	-2.8%		-4.8%	-5.9%	
Resurf	4.4%	5.1%		1.1%	1.0%		-1.0%	-1.4%		-1.8%	-2.6%	
Total	-1.2%	-10.1%		-0.4%	-1.3%		0.4%	1.6%		0.9%	5.3%	

TABLE A-10

A CHANGE IN DATA ITEM: Future AADT
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change ======>	-30%			-10%			+10%			+30%		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX
RURAL												
Interstate	0.4%	-12.3%	0.8%	0.3%	-5.0%	0.2%	0.1%	3.7%	-0.3%	1.0%	19.9%	-0.4%
Oth Prin Art	0.2%	-19.5%	0.2%	.0%	-7.6%	0.0%	0.1%	6.8%	0.1%	0.5%	20.4%	0.1%
Minor Art	-0.7%	-12.3%	0.3%	-0.3%	-5.4%	0.1%	0.4%	2.7%	-0.1%	0.2%	11.0%	-0.5%
Major Col	-1.4%	-5.2%	0.4%	-0.4%	0.4%	0.1%	0.4%	1.9%	0.0%	1.5%	3.2%	-0.1%
Minor Col	-0.2%	0.4%	0.2%	.0%	-0.1%	0.1%	0.5%	0.5%	0.0%	1.5%	1.7%	0.0%
Total	-0.7%	-9.2%		-0.2%	-3.0%		0.4%	3.0%		1.1%	9.4%	
URBAN												
Interstate	-0.7%	-24.4%	2.3%	-0.2%	-7.7%	0.8%	0.6%	5.2%	-0.7%	0.9%	23.1%	-2.3%
Oth Fwy/Expwy	-0.4%	-24.6%	1.5%	-0.4%	-5.4%	0.5%	0.4%	4.4%	-0.6%	0.4%	19.8%	-1.2%
Oth Prin Art	-1.5%	-21.6%	1.3%	-0.8%	-7.3%	0.3%	0.9%	6.9%	-0.3%	0.8%	16.2%	-1.1%
Minor Art	-2.2%	-19.4%	0.7%	-0.8%	-9.6%	0.0%	0.6%	8.3%	-0.1%	1.0%	18.8%	-0.5%
Collector	-1.9%	-21.0%	0.0%	-0.7%	-7.1%	0.0%	0.7%	6.6%	0.0%	0.5%	14.4%	-0.2%
Total	-1.7%	-21.7%		-0.7%	-7.7%		0.7%	6.7%		0.8%	18.1%	
TOTAL	-1.0%	-15.7%		-0.3%	-5.5%		0.5%	4.9%		1.0%	14.0%	
IMPROVEMENT TYPE												
RURAL												
Recon to Fwy	-58.4%	-60.6%		-24.5%	-25.8%		27.9%	28.3%		74.2%	75.9%	
Recon more lanes	-58.6%	-60.7%		-16.5%	-20.8%		15.4%	12.3%		81.2%	86.3%	
Recon wider lanes	-10.5%	-10.3%		-4.1%	-2.8%		6.9%	6.6%		8.4%	7.9%	
Pvmt Recon	0.1%	-0.6%		0.4%	0.3%		-0.4%	-0.5%		-4.3%	-4.2%	
Pvmt Recon + Algn	12.5%	13.5%		9.5%	9.1%		-3.3%	-3.4%		-5.1%	-5.7%	
Major Widen	-35.1%	-43.7%		-12.9%	-16.1%		4.3%	6.3%		15.1%	28.1%	
Minor Widen	-10.3%	-6.7%		-0.6%	0.6%		5.6%	3.7%		15.8%	12.2%	
Resurf + Shldr	0.7%	1.3%		0.6%	0.9%		0.1%	.0%		2.3%	1.3%	
Resurf	2.5%	3.1%		0.5%	0.9%		-0.5%	-0.7%		-1.0%	-2.6%	
Resurf+Algn+Shldr	2.3%	4.0%		0.8%	0.9%		0.4%	0.3%		-0.2%	-1.9%	
Resurf + Algn	-8.6%	-4.0%		-4.2%	-1.5%		-0.2%	-0.6%		.0%	-1.9%	
Total	-0.7%	-9.2%		-0.2%	-3.0%		0.4%	3.0%		1.1%	9.4%	
URBAN												
Recon to Fwy	-22.1%	-16.9%		-10.1%	-4.8%		10.1%	6.2%		18.8%	13.3%	
Recon more lanes	-61.8%	-55.2%		-26.2%	-21.7%		-5.7%	2.9%		20.7%	54.4%	
Recon wider lanes	-66.0%	-66.5%		-25.7%	-41.0%		63.2%	146.1%		73.6%	155.6%	
Pvmt Recon	8.4%	12.8%		1.9%	4.0%		-2.0%	0.7%		-3.2%	1.5%	
Major Widen	-46.7%	-47.3%		-16.3%	-17.2%		14.2%	14.3%		31.5%	35.0%	
Minor Widen	-18.1%	-16.9%		5.2%	6.5%		5.1%	2.1%		13.4%	14.5%	
Resurf + Shldr	5.6%	7.4%		1.3%	1.6%		-1.7%	-2.6%		-5.6%	-9.1%	
Resurf	6.1%	7.3%		1.7%	2.1%		-1.2%	-1.6%		-3.9%	-4.3%	
Total	-1.7%	-21.7%		-0.7%	-7.7%		0.7%	6.7%		0.8%	18.1%	

TABLE A-11

A CHANGE IN DATA ITEM: Both Current & Future AADT
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change ======>	-30%			-10%			+10%			+30%		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX
RURAL												
Interstate	-2.2%	-16.2%	1.6%	-0.1%	-7.1%	0.7%	1.3%	13.0%	-0.5%	2.9%	42.1%	-1.6%
Oth Prin Art	-1.5%	-28.8%	0.5%	-0.2%	-11.3%	0.1%	0.7%	11.9%	0.0%	2.9%	34.8%	0.0%
Minor Art	-1.5%	-15.6%	1.0%	-0.6%	-8.0%	0.2%	0.3%	5.5%	-0.3%	1.6%	18.7%	-0.9%
Major Col	-2.0%	-5.8%	0.7%	-1.0%	-2.4%	0.2%	1.9%	1.2%	-0.1%	3.8%	8.6%	-0.2%
Minor Col	-2.1%	-0.5%	0.2%	-0.1%	0.7%	0.1%	1.1%	1.0%	0.0%	3.4%	2.7%	-0.1%
Total	-1.9%	-12.5%		-0.6%	-5.3%		1.2%	5.2%		3.1%	17.7%	
URBAN												
Interstate	-3.1%	-35.2%	5.4%	-1.6%	-8.2%	1.8%	1.1%	8.6%	-2.0%	1.6%	26.9%	-5.8%
Oth Fwy/Expwy	-2.6%	-32.8%	3.8%	-0.4%	-6.7%	1.4%	1.0%	12.0%	-0.9%	1.1%	32.4%	-3.4%
Oth Prin Art	-1.8%	-26.9%	5.4%	-0.6%	-9.9%	1.5%	0.7%	6.8%	-1.5%	2.1%	29.8%	-3.9%
Minor Art	-1.9%	-25.3%	2.5%	-1.1%	-9.1%	0.7%	0.8%	11.1%	-0.7%	2.2%	26.0%	-2.2%
Collector	-2.4%	-25.4%	0.6%	-1.0%	-12.7%	0.0%	0.5%	7.6%	-0.3%	1.9%	19.4%	-0.9%
Total	-2.1%	-28.3%		-0.9%	-9.5%		0.7%	8.9%		2.0%	26.9%	
TOTAL	-2.0%	-20.7%		-0.7%	-7.5%		1.1%	7.1%		2.9%	22.5%	
IMPROVEMENT TYPE												
RURAL												
Recon to Fwy	-67.0%	-67.5%		-28.4%	-29.0%		29.9%	30.1%		92.3%	92.8%	
Recon more lanes	-68.7%	-71.8%		-33.2%	-37.2%		42.3%	41.1%		105.3%	99.9%	
Recon wider lanes	-37.9%	-36.0%		-8.7%	-7.7%		15.5%	14.2%		29.5%	28.2%	
Pvmt Recon	9.7%	8.4%		.0%	-0.2%		-4.9%	-4.9%		-10.6%	-9.6%	
Pvmt Recon + Algn	21.7%	23.5%		13.4%	13.0%		-4.9%	-3.5%		3.3%	4.3%	
Major Widen	-73.2%	-75.3%		-26.1%	-27.8%		25.7%	26.1%		95.3%	102.9%	
Minor Widen	-32.5%	-27.6%		-10.6%	-7.9%		12.4%	10.9%		32.5%	27.1%	
Resurf + Shldr	-6.8%	-3.5%		-0.9%	-0.2%		2.3%	1.1%		8.7%	5.5%	
Resurf	5.0%	4.1%		2.1%	2.0%		.0%	-1.7%		-4.3%	-7.6%	
Resurf+Algn+Shldr	-2.1%	1.3%		0.3%	0.8%		1.8%	-0.1%		2.8%	-1.1%	
Resurf + Algn	-16.6%	-8.8%		-7.9%	-3.4%		-0.1%	-0.9%		7.5%	3.6%	
Total	-1.9%	-12.5%		-0.6%	-5.3%		1.2%	5.2%		3.1%	17.7%	
URBAN												
Recon to Fwy	-39.6%	-30.2%		-12.1%	-6.4%		18.8%	10.4%		26.2%	21.8%	
Recon more lanes	-53.9%	-40.2%		-29.8%	-0.6%		-5.2%	4.5%		19.0%	45.9%	
Recon wider lanes	-62.5%	-68.5%		-31.9%	-35.0%		29.2%	24.2%		23.6%	22.5%	
Pvmt Recon	6.8%	12.1%		4.0%	7.5%		2.2%	3.3%		-4.0%	-4.1%	
Major Widen	-61.1%	-62.9%		-24.1%	-24.5%		20.1%	19.6%		54.8%	57.0%	
Minor Widen	-56.2%	-55.4%		-10.2%	-7.8%		17.6%	21.6%		51.2%	56.4%	
Resurf + Shldr	8.5%	11.5%		2.6%	3.2%		-4.1%	-5.8%		-8.6%	-12.6%	
Resurf	9.5%	11.2%		3.3%	3.7%		-2.2%	-2.8%		-7.2%	-8.4%	
Total	-2.1%	-28.3%		-0.9%	-9.5%		0.7%	8.9%		2.0%	26.9%	

TABLE A-12

A CHANGE IN DATA ITEM: Widening Feasibility
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change =======>	None feasible			Feasible, all 2 lanes or more		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX
RURAL						
Interstate	.0%	-17.1%	-0.7%	0.0%	1.0%	0.0%
Oth Prin Art	-1.4%	-43.6%	-2.9%	0.1%	9.1%	0.6%
Minor Art	-3.0%	-24.1%	-1.1%	0.1%	4.3%	0.1%
Major Col	-1.2%	-10.9%	-0.7%	.0%	1.3%	0.0%
Minor Col	-0.7%	-8.1%	-0.5%	0.6%	3.6%	0.2%
Total	-1.4%	-20.4%		0.2%	3.9%	
URBAN						
Interstate	-0.4%	-55.7%	-3.6%	0.8%	28.2%	1.7%
Oth Fwy/Expwy	-1.6%	-58.4%	-3.9%	0.4%	40.9%	1.9%
Oth Prin Art	-0.8%	-44.7%	-3.9%	0.6%	56.6%	2.7%
Minor Art	-2.8%	-47.2%	-2.8%	1.5%	50.8%	1.3%
Collector	-1.6%	-34.2%	-1.1%	0.6%	28.2%	0.5%
Total	-1.7%	-47.0%		0.9%	44.0%	
TOTAL	-1.5%	-34.3%		0.4%	24.8%	
IMPROVEMENT TYPE						
RURAL						
Recon to Fwy	-100.0%	-100.0%		16.5%	22.6%	
Recon more lanes	-100.0%	-100.0%		35.0%	32.8%	
Recon wider lanes	-88.6%	-89.9%		3.1%	4.7%	
Pvmt Recon	7.1%	7.9%		-0.5%	-0.7%	
Pvmt Recon + Algn	16.5%	16.4%		-2.0%	-2.7%	
Major Widen	-100.0%	-100.0%		14.4%	19.1%	
Minor Widen	-100.0%	-100.0%		-2.3%	-3.2%	
Resurf + Shldr	7.9%	9.1%		-0.5%	-0.5%	
Resurf	4.2%	5.5%		-0.3%	-0.6%	
Resurf+Algn+Shldr	25.2%	25.3%		-0.8%	-1.4%	
Resurf + Algn	6.5%	7.3%		-0.3%	-0.7%	
Total	-1.4%	-20.4%		0.2%	3.9%	
URBAN						
Recon to Fwy	-100.0%	-100.0%		10.7%	24.7%	
Recon more lanes	-100.0%	-100.0%		30.2%	52.3%	
Recon wider lanes	-92.4%	-96.6%		2.8%	44.6%	
Pvmt Recon	35.2%	41.5%		-10.6%	-16.7%	
Major Widen	-100.0%	-100.0%		61.0%	99.0%	
Minor Widen	-100.0%	-100.0%		-2.3%	38.6%	
Resurf + Shldr	16.6%	19.5%		-3.5%	-6.1%	
Resurf	16.9%	17.4%		-9.2%	-10.9%	
Total	-1.7%	-47.0%		0.9%	44.0%	

TABLE A-13

A CHANGE IN DATA ITEM: % Trucks
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change ======>	-5 percentage points			-2			+2			+5		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX
RURAL												
Interstate	-1.1%	-4.0%	0.8%	-0.1%	-2.1%	0.3%	0.9%	2.1%	-0.3%	2.3%	9.4%	-0.8%
Oth Prin Art	-1.3%	-8.9%	0.1%	-0.6%	-3.7%	0.1%	0.7%	3.4%	0.0%	1.7%	7.7%	-0.2%
Minor Art	-1.4%	-7.7%	0.2%	-1.0%	-5.9%	0.0%	0.1%	1.5%	-0.2%	1.1%	7.9%	-0.3%
Major Col	-0.6%	-2.3%	0.1%	-0.5%	-1.9%	0.0%	0.2%	0.5%	0.0%	1.7%	5.0%	0.0%
Minor Col	.0%	.0%	0.1%	.0%	.0%	0.1%	0.2%	0.4%	0.0%	1.0%	3.4%	0.1%
Total	-0.7%	-4.5%		-0.5%	-2.8%		0.3%	1.4%		1.4%	6.2%	

IMPROVEMENT TYPE												
RURAL												
Recon to Fwy	-11.7%	-12.9%		-7.5%	-7.0%		1.7%	2.9%		2.6%	3.1%	
Recon more lanes	-33.9%	-39.8%		-30.6%	-34.0%		11.7%	10.1%		68.1%	63.5%	
Recon wider lanes	-1.1%	-0.8%		0.3%	1.5%		0.3%	0.4%		-2.0%	-1.0%	
Pvmt Recon	-2.2%	-2.4%		-2.0%	-2.2%		0.4%	0.4%		2.7%	3.1%	
Pvmt Recon + Algn	-0.2%	-0.2%		0.0%	0.0%		0.0%	-0.1%		9.7%	9.3%	
Major Widen	-22.3%	-23.0%		-5.5%	-7.6%		7.2%	10.3%		25.1%	27.5%	
Minor Widen	-0.9%	-1.9%		-0.7%	-1.0%		0.2%	-0.1%		0.9%	1.1%	
Resurf + Shldr	0.5%	0.9%		-0.1%	.0%		.0%	-0.2%		0.1%	-0.1%	
Resurf	0.2%	-0.2%		0.3%	0.2%		0.1%	0.2%		0.2%	.0%	
Resurf+Algn+Shldr	2.6%	4.2%		.0%	0.4%		.0%	-0.4%		3.0%	0.9%	
Resurf + Algn	0.5%	1.3%		0.5%	1.4%		-0.5%	-1.0%		-4.3%	-3.6%	
Total	-0.7%	-4.5%		-0.5%	-2.8%		0.3%	1.4%		1.4%	6.2%	

TABLE A-14

A CHANGE IN DATA ITEM: Relative Truck Growth (change in truck percent each year)
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change ======>	-10%			-5%			+5%			+10%		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX
RURAL												
Interstate	-1.7%	-6.4%	1.3%	-0.4%	-4.6%	0.8%	2.9%	19.8%	-1.1%	3.0%	44.2%	-3.3%
Oth Prin Art	-0.7%	-5.4%	0.6%	-0.3%	-4.4%	0.3%	1.0%	7.8%	-0.5%	2.2%	21.6%	-0.8%
Minor Art	-1.2%	-5.4%	0.3%	-0.9%	-4.5%	0.1%	0.5%	7.6%	-0.5%	2.5%	22.3%	-0.7%
Major Col	-0.5%	-2.1%	0.1%	-0.5%	-1.9%	0.0%	0.7%	1.4%	-0.1%	2.4%	8.3%	-0.1%
Minor Col	.0%	.0%	0.1%	.0%	.0%	0.1%	.0%	0.5%	-0.1%	1.1%	3.6%	0.0%
Total	-0.6%	-3.4%		-0.4%	-2.9%		0.6%	5.3%		2.1%	15.9%	
URBAN												
Interstate	-1.7%	-1.1%	1.9%	-1.1%	1.1%	1.3%	0.7%	6.4%	-1.8%	1.7%	31.2%	-4.3%
Oth Fwy/Expwy	-0.4%	-0.5%	0.8%	-0.2%	.0%	0.5%	0.4%	1.6%	-0.9%	-0.6%	26.9%	-1.9%
Oth Prin Art	-1.2%	-1.4%	1.1%	-0.7%	-1.1%	0.7%	1.3%	3.8%	-1.2%	0.5%	16.7%	-2.8%
Minor Art	-0.9%	-1.6%	0.4%	-0.4%	-1.2%	0.2%	1.5%	4.2%	-0.1%	0.6%	20.6%	-1.0%
Collector	-0.2%	-2.3%	0.1%	-0.2%	-2.2%	0.1%	0.6%	3.5%	-0.2%	1.6%	11.2%	-0.3%
Total	-0.8%	-1.5%		-0.5%	-0.8%		1.1%	4.1%		0.9%	20.4%	
TOTAL	-0.7%	-2.4%		-0.4%	-1.8%		0.7%	4.7%		1.8%	18.3%	
IMPROVEMENT TYPE												
RURAL												
Recon to Fwy	-8.5%	-9.8%		-8.9%	-10.2%		6.1%	7.1%		13.3%	13.1%	
Recon more lanes	-20.9%	-22.2%		-14.6%	-15.7%		67.5%	65.4%		191.9%	178.3%	
Recon wider lanes	-2.0%	-2.5%		-2.0%	-2.5%		1.4%	1.6%		2.0%	2.5%	
Pvmt Recon	-2.1%	-2.3%		-2.0%	-2.3%		0.2%	0.5%		1.0%	2.1%	
Pvmt Recon + Algn	0.0%	0.0%		0.0%	0.0%		-0.5%	-0.6%		9.7%	9.4%	
Major Widen	-14.7%	-17.1%		-11.1%	-13.8%		28.4%	31.2%		104.1%	102.9%	
Minor Widen	-0.5%	-0.6%		-0.5%	-0.5%		4.0%	4.9%		12.4%	19.6%	
Resurf + Shldr	0.1%	0.4%		0.1%	0.4%		-0.4%	-0.3%		-2.6%	-3.2%	
Resurf	0.2%	-0.1%		0.4%	0.5%		-0.5%	-1.1%		-1.2%	-5.0%	
Resurf+Algn+Shldr	1.4%	2.3%		1.3%	2.2%		-0.3%	-2.8%		-2.7%	-6.0%	
Resurf + Algn	0.6%	1.3%		0.5%	1.4%		-1.4%	-2.7%		-4.6%	-4.5%	
Total	-0.6%	-3.4%		-0.4%	-2.9%		0.6%	5.3%		2.1%	15.9%	
URBAN												
Recon to Fwy	-8.1%	-3.3%		-8.1%	-3.3%		2.0%	1.4%		5.4%	4.2%	
Recon more lanes	-15.2%	-9.1%		-14.2%	-6.0%		-1.7%	8.8%		39.0%	100.1%	
Recon wider lanes	-4.9%	-2.6%		-1.4%	-1.3%		40.3%	48.3%		92.4%	163.5%	
Pvmt Recon	-2.8%	-3.3%		-1.4%	0.3%		4.0%	7.3%		14.5%	47.6%	
Major Widen	-0.4%	-0.8%		-0.1%	-0.5%		6.1%	5.5%		24.6%	25.1%	
Minor Widen	-3.8%	-2.9%		-3.7%	-2.8%		8.2%	11.1%		39.6%	41.4%	
Resurf + Shldr	-0.2%	0.1%		-0.2%	0.1%		-1.6%	-1.6%		-6.7%	-8.7%	
Resurf	-0.4%	-0.5%		-0.1%	-0.3%		0.6%	0.2%		-4.9%	-6.2%	
Total	-0.8%	-1.5%		-0.5%	-0.8%		1.1%	4.1%		0.9%	20.4%	

TABLE A-15

A CHANGE IN DATA ITEM: Truck Factors
CAUSES THESE PERCENT CHANGES IN NEEDS & THE COMPOSITE INDEX (end of period, weighted by miles)

Change =======>	-30%			-10%			+10%			+30%		
FUNCTIONAL CLASS	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX	MILES	COST	INDEX
RURAL												
Interstate	-1.7%	-1.4%	0.3%	-0.4%	-0.3%	0.1%	0.8%	0.5%	-0.1%	1.6%	1.1%	-0.4%
Oth Prin Art	-0.8%	-0.7%	0.0%	-0.2%	-0.2%	0.0%	0.3%	0.1%	0.0%	1.2%	0.7%	0.1%
Minor Art	-0.5%	-0.3%	0.0%	-0.1%	-0.1%	0.0%	.0%	.0%	-0.1%	0.3%	0.3%	-0.1%
Major Col	-0.5%	-1.9%	0.0%	-0.5%	-1.8%	0.0%	.0%	.0%	0.0%	0.3%	0.3%	0.0%
Minor Col	.0%	.0%	0.0%	.0%	.0%	0.0%	.0%	.0%	0.0%	0.8%	2.5%	0.1%
Total	-0.5%	-0.9%		-0.3%	-0.7%		0.1%	0.1%		0.6%	0.8%	
URBAN												
Interstate	-2.2%	-1.2%	0.8%	-0.9%	-0.2%	0.2%	0.6%	1.0%	-0.4%	1.2%	2.9%	-1.1%
Oth Fwy/Expwy	-0.4%	-0.1%	0.4%	-0.1%	.0%	0.1%	0.3%	0.1%	-0.1%	0.4%	0.2%	-0.5%
Oth Prin Art	-1.0%	-0.5%	0.5%	-0.3%	-0.1%	0.3%	0.4%	0.3%	-0.3%	1.1%	0.7%	-0.8%
Minor Art	-0.5%	-0.3%	0.0%	-0.3%	-0.1%	0.0%	.0%	.0%	-0.1%	0.8%	1.2%	0.0%
Collector	-0.2%	-1.6%	0.0%	-0.1%	-0.1%	0.0%	.0%	.0%	0.0%	0.7%	0.4%	0.0%
Total	-0.6%	-0.7%		-0.3%	-0.1%		0.2%	0.3%		0.9%	1.1%	
TOTAL	-0.5%	-0.8%		-0.3%	-0.4%		0.1%	0.2%		0.7%	1.0%	
IMPROVEMENT TYPE												
RURAL												
Recon to Fwy	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Recon more lanes	-3.2%	-2.9%		-0.1%	-0.2%		0.5%	0.5%		0.5%	0.5%	
Recon wider lanes	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Pvmt Recon	-2.1%	-2.3%		-2.0%	-2.1%		.0%	.0%		1.6%	1.9%	
Pvmt Recon + Algn	0.0%	0.0%		0.0%	0.0%		0.1%	0.1%		0.3%	0.3%	
Major Widen	1.4%	1.2%		0.1%	0.1%		-0.2%	-0.3%		-0.2%	-0.3%	
Minor Widen	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Resurf + Shldr	-0.4%	-0.3%		-0.3%	-0.3%		0.1%	0.2%		0.3%	0.3%	
Resurf	-0.1%	-1.1%		0.3%	-0.1%		0.2%	0.4%		0.5%	1.2%	
Resurf+Algn+Shldr	-0.4%	-0.3%		-0.2%	-0.2%		0.0%	0.0%		1.2%	0.9%	
Resurf + Algn	-0.4%	-0.5%		-0.2%	-0.2%		0.0%	0.0%		0.0%	0.0%	
Total	-0.5%	-0.9%		-0.3%	-0.7%		0.1%	0.1%		0.6%	0.8%	
URBAN												
Recon to Fwy	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
Recon more lanes	-10.8%	-9.3%		-0.3%	-1.0%		3.6%	5.1%		6.1%	12.5%	
Recon wider lanes	0.0%	0.0%		1.4%	0.4%		0.0%	0.0%		20.1%	10.9%	
Pvmt Recon	-1.8%	-3.0%		-0.1%	0.5%		0.2%	0.8%		2.6%	4.2%	
Major Widen	1.2%	0.7%		.0%	0.1%		-0.4%	-0.3%		-0.6%	-0.7%	
Minor Widen	0.1%	.0%		0.0%	0.0%		0.0%	0.0%		-1.0%	-0.6%	
Resurf + Shldr	-0.6%	-0.7%		-0.1%	-0.2%		.0%	.0%		0.2%	0.4%	
Resurf	-0.8%	-0.8%		-0.4%	-0.4%		0.3%	0.3%		1.3%	1.2%	
Total	-0.6%	-0.7%		-0.3%	-0.1%		0.2%	0.3%		0.9%	1.1%	

APPENDIX B

Part 3: TABLES FOR THE SENSITIVITY ANALYSIS OF MINIMUM TOLERABLE CONDITIONS

TABLE B-1
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: VOLUME/CAPACITY RATIO BY 0.10 PERCENT CHANGE		INCREASE MTC: VOLUME/CAPACITY RATIO BY 0.10 PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Function Class				
Interstate	0.00%	0.00%	0.00%	0.00%
Other Principal Arterial	0.14%	0.48%	0.15%	0.13%
Minor Arterial	-0.05%	2.18%	-0.08%	-0.66%
Major Collector	0.11%	0.90%	0.00%	-0.07%
Minor Collector	0.00%	0.01%	0.00%	0.04%
TOTAL	0.05%	0.86%	0.00%	-0.13%
U R B A N				
Function Class				
Interstate	0.00%	0.00%	0.00%	0.00%
Other Freeway & Expressway	0.03%	0.90%	-0.03%	-0.59%
Other Principal Arterial	-0.03%	4.25%	0.10%	-6.76%
Minor Arterial	0.59%	5.07%	-0.56%	-5.69%
Collector	0.58%	3.85%	-0.40%	-8.49%
TOTAL	0.37%	3.33%	-0.29%	-4.97%
	PERCENT CHANGE		PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	12.82%	13.74%	7.22%	7.01%
Reconstruct w/wider lanes	0.08%	0.14%	-0.01%	-0.04%
Pavement Reconstruction	-0.05%	-0.08%	-0.06%	-0.15%
Pavement Reconst w/align imp	0.00%	0.00%	0.00%	0.00%
Major widening(add lanes)	8.70%	6.51%	-7.30%	-5.70%
Minor Widening	1.80%	2.75%	-0.09%	-0.20%
Resurfacing w/shldr imp	-0.36%	-0.39%	0.08%	0.09%
Resurfacing	-0.08%	-0.05%	0.14%	0.13%
Resurf w/align & shldr imp	-1.42%	-2.18%	-0.04%	-0.06%
Resurfacing w/align imp	-0.04%	-0.04%	0.00%	0.00%
TOTAL	0.05%	0.86%	0.00%	-0.13%
U R B A N				
Improvement Type				
Reconstruct to Freeway	18.79%	8.85%	-12.08%	-5.35%
Reconstruct w/more Lanes	-9.11%	-7.32%	-32.75%	-18.59%
Reconstruct w/wider lanes	29.66%	25.19%	-21.38%	-11.09%
Pavement Reconstruction	1.28%	1.56%	1.83%	3.95%
Major widening(add lanes)	11.02%	5.73%	-12.10%	-9.55%
Minor Widening	39.03%	43.15%	-20.58%	-16.39%
Resurfacing w/shldr imp	-4.38%	-5.50%	2.46%	2.73%
Resurfacing	-2.12%	-2.34%	2.86%	2.70%
TOTAL	0.37%	3.33%	-0.29%	-4.97%

TABLE B-2

SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT OF TOTAL RURAL OR URBAN CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: VOLUME/CAPACITY RATIO BY 0.10 PERCENT OF TOTAL CHANGE		INCREASE MTC: VOLUME/CAPACITY RATIO BY 0.10 PERCENT OF TOTAL CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Function Class				
Interstate	0.00%	0.00%	0.00%	0.00%
Other Principal Arterial	29.46%	11.43%	600.00%	21.10%
Minor Arterial	-19.38%	53.71%	-528.57%	-107.17%
Major Collector	88.37%	34.76%	0.00%	-19.07%
Minor Collector	1.55%	0.11%	28.57%	5.13%
TOTAL	100.00%	100.00%	100.00%	-100.00%
U R B A N				
Function Class				
Interstate	0.00%	0.00%	0.00%	0.00%
Other Freeway & Expressway	0.34%	2.77%	-0.43%	-1.22%
Other Principal Arterial	-1.68%	38.16%	8.23%	-40.69%
Minor Arterial	50.84%	40.16%	-62.77%	-30.16%
Collector	50.51%	18.91%	-45.02%	-27.93%
TOTAL	100.00%	100.00%	-100.00%	-100.00%
	PERCENT OF TOTAL CHANGE		PERCENT OF TOTAL CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	147.29%	68.11%	1528.57%	230.65%
Reconstruct w/wider lanes	5.43%	1.52%	-14.29%	-2.62%
Pavement Reconstruction	-13.95%	-2.64%	-342.86%	-33.65%
Pavement Reconst w/align imp	0.00%	0.00%	0.00%	0.00%
Major widening(add lanes)	231.01%	52.65%	-3571.43%	-306.25%
Minor Widening	62.02%	5.46%	-57.14%	-2.68%
Resurfacing w/shldr imp	-117.05%	-4.19%	471.43%	6.56%
Resurfacing	-72.09%	-0.71%	2142.86%	11.64%
Resurf w/align & shldr imp	-137.21%	-19.98%	-71.43%	-3.65%
Resurfacing w/align imp	-5.43%	-0.23%	0.00%	0.00%
TOTAL	100.00%	100.00%	100.00%	-100.00%
U R B A N				
Improvement Type				
Reconstruct to Freeway	9.43%	3.56%	-7.79%	-1.44%
Reconstruct w/more Lanes	-28.28%	-13.50%	-130.74%	-22.95%
Reconstruct w/wider lanes	14.48%	3.95%	-13.42%	-1.16%
Pavement Reconstruction	11.11%	2.92%	20.35%	4.95%
Major widening(add lanes)	330.64%	74.46%	-466.67%	-83.14%
Minor Widening	374.75%	65.51%	-254.11%	-16.67%
Resurfacing w/shldr imp	-304.04%	-18.41%	219.91%	6.11%
Resurfacing	-307.41%	-18.50%	533.33%	14.31%
TOTAL	100.00%	100.00%	-100.00%	-100.00%

TABLE B-3
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: OPERATING SPEED BY 10 MPH PERCENT CHANGE		INCREASE MTC: OPERATING SPEED BY 10 MPH PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Function Class				
Interstate	0.14%	-9.42%	0.61%	22.06%
Other Principal Arterial	-0.41%	-29.73%	2.46%	36.51%
Minor Arterial	-0.53%	-11.78%	4.36%	42.48%
Major Collector	-0.07%	-0.57%	0.63%	5.03%
Minor Collector	-0.00%	-0.04%	0.60%	2.89%
TOTAL	-0.17%	-9.49%	1.52%	20.35%
U R B A N				
Function Class				
Interstate	-0.41%	-12.60%	0.33%	1.63%
Other Freeway & Expressway	-0.74%	-4.22%	0.71%	5.08%
Other Principal Arterial	-0.03%	0.51%	-0.09%	-0.02%
Minor Arterial	0.00%	-0.01%	0.00%	0.13%
Collector	0.00%	0.00%	0.00%	0.00%
TOTAL	-0.06%	-2.44%	0.03%	0.83%
	PERCENT CHANGE		PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	-66.29%	-64.80%	6.70%	5.79%
Reconstruct w/more Lanes	-65.59%	-69.80%	235.83%	197.78%
Reconstruct w/wider lanes	-4.79%	-5.39%	19.42%	25.85%
Pavement Reconstruction	0.30%	0.30%	-1.01%	-0.41%
Pavement Reconst w/align imp	0.12%	0.13%	-1.19%	-1.30%
Major widening(add lanes)	-49.78%	-49.75%	213.26%	178.48%
Minor Widening	-0.83%	-0.08%	34.58%	32.10%
Resurfacing w/shldr imp	2.73%	3.35%	-7.55%	-8.50%
Resurfacing	1.70%	3.14%	-3.42%	-6.38%
Resurf w/align & shldr imp	6.63%	8.65%	-18.85%	-22.33%
Resurfacing w/align imp	1.92%	3.75%	-4.50%	-6.77%
TOTAL	-0.17%	-9.49%	1.52%	20.35%
U R B A N				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	1.74%	4.96%	0.76%	3.41%
Reconstruct w/wider lanes	-13.79%	-33.52%	0.00%	0.35%
Pavement Reconstruction	2.80%	10.28%	-0.19%	-1.37%
Major widening(add lanes)	-5.08%	-8.21%	1.62%	2.32%
Minor Widening	-0.35%	-1.27%	-0.84%	-3.10%
Resurfacing w/shldr imp	0.19%	0.65%	-0.12%	-0.62%
Resurfacing	0.71%	1.26%	-0.18%	-0.28%
TOTAL	-0.06%	-2.44%	0.03%	0.83%

TABLE B-4
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT OF TOTAL RURAL OR URBAN CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: OPERATING SPEED BY 10 MPH PERCENT OF TOTAL CHANGE in Miles	DECREASE MTC: OPERATING SPEED BY 10 MPH PERCENT OF TOTAL CHANGE in Cost	INCREASE MTC: OPERATING SPEED BY 10 MPH PERCENT OF TOTAL CHANGE in Miles	INCREASE MTC: OPERATING SPEED BY 10 MPH PERCENT OF TOTAL CHANGE in Cost
R U R A L				
Function Class				
Interstate	4.12%	-7.68%	2.03%	8.39%
Other Principal Arterial	-27.36%	-63.92%	18.26%	36.61%
Minor Arterial	-58.35%	-26.35%	53.15%	44.32%
Major Collector	-18.16%	-1.99%	17.03%	8.22%
Minor Collector	-0.24%	-0.07%	9.53%	2.47%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
U R B A N				
Function Class				
Interstate	-39.22%	-88.33%	72.73%	33.56%
Other Freeway & Expressway	-49.02%	-17.79%	109.09%	62.74%
Other Principal Arterial	-11.76%	6.26%	-81.82%	-0.56%
Minor Arterial	0.00%	-0.15%	0.00%	4.26%
Collector	0.00%	0.00%	0.00%	0.00%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
	PERCENT OF TOTAL CHANGE in Miles	PERCENT OF TOTAL CHANGE in Cost	PERCENT OF TOTAL CHANGE in Miles	PERCENT OF TOTAL CHANGE in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	-373.85%	-44.20%	4.18%	1.84%
Reconstruct w/more Lanes	-235.35%	-31.43%	93.57%	41.54%
Reconstruct w/wider lanes	-101.94%	-5.27%	45.73%	11.78%
Pavement Reconstruction	27.60%	0.94%	-10.23%	-0.60%
Pavement Reconst w/align imp	2.42%	0.10%	-2.60%	-0.47%
Major widening(add lanes)	-412.83%	-36.58%	195.56%	61.20%
Minor Widening	-8.96%	-0.01%	41.07%	2.70%
Resurfacing w/shldr imp	278.21%	3.25%	-84.98%	-3.84%
Resurfacing	451.09%	3.96%	-100.40%	-3.76%
Resurf w/align & shldr imp	199.52%	7.21%	-62.76%	-8.69%
Resurfacing w/align imp	73.85%	2.02%	-19.20%	-1.70%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
U R B A N				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	31.37%	12.45%	31.82%	25.10%
Reconstruct w/wider lanes	-39.22%	-7.16%	0.00%	0.22%
Pavement Reconstruction	141.18%	26.18%	-22.73%	-10.23%
Major widening(add lanes)	-888.24%	-145.36%	654.55%	120.69%
Minor Widening	-19.61%	-2.63%	-109.09%	-18.79%
Resurfacing w/shldr imp	76.47%	2.94%	-109.09%	-8.25%
Resurfacing	598.04%	13.58%	-345.45%	-8.73%
TOTAL	-100.00%	-100.00%	100.00%	100.00%

TABLE B-5
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: LANE WIDTH BY 2 FEET PERCENT CHANGE		INCREASE MTC: LANE WIDTH BY 1 FOOT EXCEPT INTERSTATE PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Function Class				
Interstate	0.00%	-0.02%	0.00%	0.00%
Other Principal Arterial	-0.49%	-2.23%	0.75%	4.38%
Minor Arterial	-1.19%	-3.57%	5.60%	17.56%
Major Collector	-1.09%	-7.73%	6.19%	27.23%
Minor Collector	-1.32%	-9.32%	6.12%	27.38%
TOTAL	-1.04%	-5.41%	5.14%	18.44%
U R B A N				
Function Class				
Interstate	0.00%	-0.02%	0.00%	0.00%
Other Freeway & Expressway	-0.24%	-1.27%	0.24%	3.81%
Other Principal Arterial	-0.41%	-2.67%	1.22%	8.61%
Minor Arterial	-0.04%	-0.11%	0.02%	0.68%
Collector	-0.02%	-0.31%	0.37%	4.23%
TOTAL	-0.13%	-1.01%	0.44%	3.84%
	PERCENT CHANGE		PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	0.17%	0.16%	-1.80%	-1.76%
Reconstruct w/more Lanes	0.00%	-0.08%	8.16%	3.68%
Reconstruct w/wider lanes	-88.38%	-87.86%	220.53%	227.16%
Pavement Reconstruction	5.88%	6.52%	-8.17%	-8.98%
Pavement Reconst w/align imp	9.51%	8.70%	-26.00%	-24.74%
Major widening(add lanes)	-0.44%	-0.16%	2.54%	1.61%
Minor Widening	-90.35%	-84.86%	427.55%	376.68%
Resurfacing w/shldr imp	3.73%	3.73%	-16.09%	-15.43%
Resurfacing	1.88%	1.10%	-7.12%	-3.83%
Resurf w/align & shldr imp	15.23%	11.94%	-31.48%	-27.26%
Resurfacing w/align imp	4.43%	3.94%	-13.76%	-14.01%
TOTAL	-1.04%	-5.41%	5.14%	18.44%
U R B A N				
Improvement Type				
Reconstruct to Freeway	-8.05%	-4.33%	22.15%	13.06%
Reconstruct w/more Lanes	-6.29%	-5.58%	0.22%	-0.28%
Reconstruct w/wider lanes	-18.62%	-11.85%	59.31%	31.71%
Pavement Reconstruction	3.46%	4.50%	-3.66%	-2.13%
Major widening(add lanes)	-1.58%	-1.62%	2.90%	3.25%
Minor Widening	-4.00%	-4.53%	61.22%	64.88%
Resurfacing w/shldr imp	0.48%	0.55%	-3.48%	-4.03%
Resurfacing	0.14%	0.14%	-2.25%	-2.24%
TOTAL	-0.13%	-1.01%	0.44%	3.84%

TABLE B-6

SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT OF TOTAL RURAL OR URBAN CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: LANE WIDTH BY 2 FEET PERCENT OF TOTAL CHANGE in Miles	in Cost	INCREASE MTC: LANE WIDTH BY 1 FOOT EXCEPT INTERSTATE PERCENT OF TOTAL CHANGE in Miles	in Cost
R U R A L				
Function Class				
Interstate	0.00%	-0.03%	0.00%	0.00%
Other Principal Arterial	-5.33%	-8.42%	1.64%	4.85%
Minor Arterial	-21.10%	-14.02%	20.15%	20.21%
Major Collector	-42.86%	-47.52%	49.37%	49.11%
Minor Collector	-30.71%	-30.01%	28.93%	25.83%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
U R B A N				
Function Class				
Interstate	0.00%	-0.41%	0.00%	0.00%
Other Freeway & Expressway	-7.77%	-12.88%	2.30%	10.21%
Other Principal Arterial	-77.67%	-78.81%	68.68%	67.10%
Minor Arterial	-9.71%	-2.97%	1.72%	4.69%
Collector	-4.85%	-4.93%	27.30%	18.00%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
	PERCENT OF TOTAL CHANGE in Miles	in Cost	PERCENT OF TOTAL CHANGE in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	0.16%	0.20%	-0.33%	-0.62%
Reconstruct w/more Lanes	0.00%	-0.06%	0.96%	0.85%
Reconstruct w/wider lanes	-302.57%	-150.75%	153.26%	114.27%
Pavement Reconstruction	86.57%	35.99%	-24.39%	-14.53%
Pavement Reconst w/align imp	30.13%	11.71%	-16.71%	-9.77%
Major widening(add lanes)	-0.58%	-0.21%	0.69%	0.61%
Minor Widening	-156.01%	-26.86%	149.86%	34.95%
Resurfacing w/shldr imp	61.04%	6.35%	-53.44%	-7.70%
Resurfacing	80.15%	2.44%	-61.65%	-2.49%
Resurf w/align & shldr imp	73.73%	17.48%	-30.93%	-11.70%
Resurfacing w/align imp	27.48%	3.72%	-17.30%	ERR
TOTAL	-100.00%	-100.00%	100.00%	100.00%
U R B A N				
Improvement Type				
Reconstruct to Freeway	-11.65%	-5.73%	9.48%	4.56%
Reconstruct w/more Lanes	-56.31%	-33.82%	0.57%	-0.45%
Reconstruct w/wider lanes	-26.21%	-6.11%	24.71%	4.31%
Pavement Reconstruction	86.41%	27.65%	-27.01%	-3.45%
Major widening(add lanes)	-136.89%	-69.15%	74.14%	36.68%
Minor Widening	-110.68%	-22.64%	501.72%	85.44%
Resurfacing w/shldr imp	96.12%	6.03%	-206.32%	-11.70%
Resurfacing	58.25%	3.77%	-277.59%	-15.39%
TOTAL	-100.00%	-100.00%	100.00%	100.00%

TABLE B-7
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: RESURFACING BY 0.4 RATING POINT PERCENT CHANGE		INCREASE MTC: RESURFACING BY 0.4 RATING POINT PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Function Class				
Interstate	-13.29%	-8.70%	7.53%	3.32%
Other Principal Arterial	-10.17%	-0.93%	5.51%	-0.18%
Minor Arterial	-12.29%	-7.87%	9.39%	4.40%
Major Collector	-10.54%	-3.21%	10.77%	2.75%
Minor Collector	-7.42%	-2.81%	8.03%	2.62%
TOTAL	-10.20%	-4.09%	9.09%	2.52%
U R B A N				
Function Class				
Interstate	-7.58%	-0.19%	3.81%	-1.90%
Other Freeway & Expressway	-9.12%	-1.19%	4.77%	-0.06%
Other Principal Arterial	-11.29%	-0.01%	5.29%	1.85%
Minor Arterial	-14.10%	-3.92%	7.94%	3.46%
Collector	-11.34%	-8.06%	15.53%	11.32%
TOTAL	-11.90%	-2.51%	9.36%	2.98%
	PERCENT CHANGE		PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	5.84%	5.48%	-7.94%	-7.43%
Reconstruct w/more Lanes	10.59%	8.59%	-4.45%	-5.56%
Reconstruct w/wider lanes	1.07%	1.14%	-1.32%	-1.22%
Pavement Reconstruction	0.24%	0.33%	-0.55%	-0.85%
Pavement Reconst w/align imp	0.06%	0.11%	0.00%	0.00%
Major widening(add lanes)	0.00%	0.00%	-4.79%	-4.67%
Minor Widening	0.32%	0.27%	0.00%	-0.01%
Resurfacing w/shldr imp	-12.24%	-12.92%	11.36%	11.75%
Resurfacing	-15.05%	-15.50%	13.97%	11.24%
Resurf w/align & shldr imp	-16.18%	-15.64%	12.03%	11.21%
Resurfacing w/align imp	-12.40%	-14.58%	9.80%	12.12%
TOTAL	-10.20%	-4.09%	9.09%	2.52%
U R B A N				
Improvement Type				
Reconstruct to Freeway	5.37%	1.73%	-7.38%	-2.84%
Reconstruct w/more Lanes	16.49%	19.17%	-5.53%	-6.38%
Reconstruct w/wider lanes	73.79%	218.78%	-8.28%	-4.35%
Pavement Reconstruction	7.08%	11.26%	-2.06%	-2.43%
Major widening(add lanes)	0.85%	0.55%	-1.66%	-1.71%
Minor Widening	0.67%	1.11%	-2.24%	-1.80%
Resurfacing w/shldr imp	-15.07%	-17.65%	12.49%	12.98%
Resurfacing	-15.94%	-14.74%	12.03%	11.28%
TOTAL	-11.90%	-2.51%	9.36%	2.98%

TABLE B-8

SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT OF TOTAL RURAL OR URBAN CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: RESURFACING BY 0.4 RATING POINT PERCENT OF TOTAL CHANGE in Miles	in Cost	INCREASE MTC: RESURFACING BY 0.4 RATING POINT PERCENT OF TOTAL CHANGE in Miles	in Cost
R U R A L				
Function Class				
Interstate	-6.57%	-16.44%	4.18%	10.17%
Other Principal Arterial	-11.21%	-4.62%	6.81%	-1.43%
Minor Arterial	-22.26%	-40.85%	19.08%	36.96%
Major Collector	-42.32%	-26.13%	48.51%	36.28%
Minor Collector	-17.64%	-11.96%	21.42%	18.02%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
U R B A N				
Function Class				
Interstate	-3.93%	-1.32%	2.51%	-10.90%
Other Freeway & Expressway	-3.29%	-4.89%	2.19%	-0.20%
Other Principal Arterial	-23.38%	-0.10%	13.93%	18.50%
Minor Arterial	-38.47%	-41.20%	27.53%	30.60%
Collector	-30.93%	-52.49%	53.84%	62.00%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
	PERCENT OF TOTAL CHANGE in Miles	in Cost	PERCENT OF TOTAL CHANGE in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	0.54%	8.68%	-0.83%	-19.04%
Reconstruct w/more Lanes	0.62%	8.98%	-0.29%	-9.40%
Reconstruct w/wider lanes	0.37%	2.58%	-0.52%	-4.46%
Pavement Reconstruction	0.36%	2.39%	-0.93%	-10.00%
Pavement Reconst w/align imp	0.02%	0.20%	0.00%	0.00%
Major widening(add lanes)	0.00%	0.00%	-0.73%	-12.90%
Minor Widening	0.06%	0.11%	0.00%	-0.00%
Resurfacing w/shldr imp	-20.47%	-29.06%	21.30%	42.81%
Resurfacing	-65.65%	-45.42%	68.36%	53.35%
Resurf w/align & shldr imp	-8.00%	-30.27%	6.68%	35.16%
Resurfacing w/align imp	-7.86%	-18.19%	6.96%	24.49%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
U R B A N				
Improvement Type				
Reconstruct to Freeway	0.08%	0.92%	-0.15%	-1.28%
Reconstruct w/more Lanes	1.61%	46.84%	-0.69%	-13.11%
Reconstruct w/wider lanes	1.14%	45.48%	-0.16%	-0.76%
Pavement Reconstruction	1.93%	27.92%	-0.71%	-5.06%
Major widening(add lanes)	0.81%	9.52%	-2.00%	-24.84%
Minor Widening	0.20%	2.24%	-0.86%	-3.05%
Resurfacing w/shldr imp	-32.99%	-78.28%	34.76%	48.46%
Resurfacing	-72.77%	-154.65%	69.83%	99.64%
TOTAL	-100.00%	-100.00%	100.00%	100.00%

TABLE B-9
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: RECONSTRUCTION BY 0.4 RATING POINT PERCENT CHANGE		INCREASE MTC: RECONSTRUCTION BY 0.4 RATING POINT PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Function Class				
Interstate	0.00%	-6.46%	0.00%	9.68%
Other Principal Arterial	-0.54%	-5.54%	0.35%	9.76%
Minor Arterial	-0.94%	-3.37%	0.46%	8.61%
Major Collector	-4.65%	-15.34%	1.85%	14.59%
Minor Collector	-6.97%	-16.26%	7.27%	21.05%
TOTAL	-3.85%	-10.28%	2.65%	13.08%
U R B A N				
Function Class				
Interstate	0.00%	-8.72%	-0.02%	27.15%
Other Freeway & Expressway	0.00%	-3.05%	0.00%	12.99%
Other Principal Arterial	-0.17%	-4.72%	-0.04%	11.99%
Minor Arterial	-0.90%	-1.61%	0.31%	2.66%
Collector	0.00%	-2.60%	-0.04%	5.15%
TOTAL	-0.33%	-4.07%	0.08%	11.11%
	PERCENT CHANGE		PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	-1.42%	-1.15%	0.39%	0.32%
Reconstruct w/more Lanes	-12.55%	-13.49%	36.03%	29.22%
Reconstruct w/wider lanes	-3.22%	-2.84%	1.02%	1.09%
Pavement Reconstruction	-29.37%	-29.36%	33.97%	38.29%
Pavement Reconst w/align imp	-21.57%	-22.45%	39.61%	42.41%
Major widening(add lanes)	5.05%	4.65%	-9.87%	-9.36%
Minor Widening	4.35%	3.17%	-2.16%	-2.72%
Resurfacing w/shldr imp	2.10%	2.30%	-6.02%	-7.14%
Resurfacing	2.07%	1.96%	-4.00%	-3.89%
Resurf w/align & shldr imp	1.16%	1.27%	-4.76%	-5.23%
Resurfacing w/align imp	1.76%	2.02%	-14.01%	-11.01%
TOTAL	-3.85%	-10.28%	2.65%	13.08%
U R B A N				
Improvement Type				
Reconstruct to Freeway	-0.67%	-1.24%	1.34%	0.44%
Reconstruct w/more Lanes	-48.16%	-49.39%	75.38%	117.66%
Reconstruct w/wider lanes	-24.83%	-25.83%	107.59%	94.57%
Pavement Reconstruction	-37.34%	-46.26%	97.01%	132.01%
Major widening(add lanes)	4.25%	3.19%	-6.15%	-6.62%
Minor Widening	0.91%	0.79%	-5.05%	-4.97%
Resurfacing w/shldr imp	1.30%	2.03%	-4.75%	-4.24%
Resurfacing	1.17%	1.31%	-3.76%	-4.67%
TOTAL	-0.33%	-4.07%	0.08%	11.11%

TABLE B-10

SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT OF TOTAL RURAL OR URBAN CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: RECONSTRUCTION BY 0.4 RATING POINT PERCENT OF TOTAL CHANGE in Miles	DECREASE MTC: RECONSTRUCTION BY 0.4 RATING POINT PERCENT OF TOTAL CHANGE in Cost	INCREASE MTC: RECONSTRUCTION BY 0.4 RATING POINT PERCENT OF TOTAL CHANGE in Miles	INCREASE MTC: RECONSTRUCTION BY 0.4 RATING POINT PERCENT OF TOTAL CHANGE in Cost
R U R A L				
Function Class				
Interstate	0.00%	-4.87%	0.00%	5.72%
Other Principal Arterial	-1.57%	-11.00%	1.47%	15.22%
Minor Arterial	-4.49%	-6.97%	3.22%	13.97%
Major Collector	-49.50%	-49.64%	28.60%	37.09%
Minor Collector	-43.91%	-27.53%	66.70%	27.99%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
U R B A N				
Function Class				
Interstate	0.00%	-36.70%	-1.64%	41.83%
Other Freeway & Expressway	0.00%	-7.70%	0.00%	12.02%
Other Principal Arterial	-12.50%	-34.70%	-13.11%	32.26%
Minor Arterial	-87.50%	-10.44%	131.15%	6.31%
Collector	0.00%	-10.46%	-16.39%	7.58%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
	PERCENT OF TOTAL CHANGE in Miles	PERCENT OF TOTAL CHANGE in Cost	PERCENT OF TOTAL CHANGE in Miles	PERCENT OF TOTAL CHANGE in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	-0.35%	-0.72%	0.14%	0.16%
Reconstruct w/more Lanes	-1.96%	-5.61%	8.19%	9.55%
Reconstruct w/wider lanes	-2.98%	-2.56%	1.38%	0.77%
Pavement Reconstruction	-117.00%	-85.21%	196.96%	87.31%
Pavement Reconst w/align imp	-18.50%	-15.90%	49.42%	23.60%
Major widening(add lanes)	1.82%	3.15%	-5.18%	-4.99%
Minor Widening	2.03%	0.53%	-1.47%	-0.36%
Resurfacing w/shldr imp	9.29%	2.06%	-38.77%	-5.02%
Resurfacing	23.95%	2.29%	-67.35%	-3.56%
Resurf w/align & shldr imp	1.52%	0.98%	-9.08%	-3.17%
Resurfacing w/align imp	2.95%	1.00%	-34.22%	-4.29%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
U R B A N				
Improvement Type				
Reconstruct to Freeway	-0.38%	-0.41%	3.28%	0.05%
Reconstruct w/more Lanes	-168.18%	-74.47%	1139.34%	64.94%
Reconstruct w/wider lanes	-13.64%	-3.31%	255.74%	4.44%
Pavement Reconstruction	-363.64%	-70.74%	4088.52%	73.90%
Major widening(add lanes)	143.56%	33.93%	-898.36%	-25.75%
Minor Widening	9.85%	0.98%	-236.07%	-2.26%
Resurfacing w/shldr imp	101.52%	5.54%	-1604.92%	-4.25%
Resurfacing	190.53%	8.47%	-2649.18%	-11.07%
TOTAL	-100.00%	-100.00%	100.00%	100.00%

TABLE B-11
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: RESURFACE-RECONSTRUCT BY 0.4 RATING POINT PERCENT CHANGE		INCREASE MTC: RESURFACE-RECONSTRUCT BY 0.4 RATING POINT PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Function Class				
Interstate	-13.29%	-15.17%	7.53%	12.59%
Other Principal Arterial	-10.63%	-6.78%	5.85%	9.11%
Minor Arterial	-13.22%	-11.31%	9.86%	12.91%
Major Collector	-15.18%	-18.60%	12.61%	17.35%
Minor Collector	-14.65%	-19.31%	15.25%	23.65%
TOTAL	-14.08%	-14.50%	11.73%	15.45%
U R B A N				
Function Class				
Interstate	-7.26%	-10.08%	3.81%	24.12%
Other Freeway & Expressway	-9.03%	-5.28%	4.77%	12.10%
Other Principal Arterial	-11.36%	-6.67%	5.39%	12.36%
Minor Arterial	-14.97%	-5.58%	8.26%	5.98%
Collector	-11.34%	-10.87%	15.53%	16.02%
TOTAL	-12.17%	-7.51%	9.49%	13.26%
	PERCENT CHANGE		PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	4.42%	4.34%	-7.56%	-7.11%
Reconstruct w/more Lanes	-7.42%	-8.16%	21.05%	14.09%
Reconstruct w/wider lanes	-3.08%	-2.64%	-0.32%	-0.13%
Pavement Reconstruction	-29.21%	-29.17%	33.35%	37.31%
Pavement Reconst w/align imp	-21.51%	-22.34%	39.61%	42.41%
Major widening(add lanes)	6.60%	6.04%	-10.13%	-9.81%
Minor Widening	6.49%	5.66%	-2.16%	-2.72%
Resurfacing w/shldr imp	-10.49%	-10.73%	5.28%	4.58%
Resurfacing	-12.93%	-13.49%	9.99%	7.42%
Resurf w/align & shldr imp	-15.03%	-14.37%	7.26%	5.98%
Resurfacing w/align imp	-10.64%	-12.55%	-4.22%	1.11%
TOTAL	-14.08%	-14.50%	11.73%	15.45%
U R B A N				
Improvement Type				
Reconstruct to Freeway	4.70%	0.49%	-7.38%	-2.84%
Reconstruct w/more Lanes	-45.12%	-47.27%	-5.53%	-6.38%
Reconstruct w/wider lanes	42.07%	188.45%	-8.28%	-4.35%
Pavement Reconstruction	-35.24%	-43.00%	-2.06%	-2.43%
Major widening(add lanes)	6.53%	4.87%	-1.66%	-1.71%
Minor Widening	1.96%	2.18%	-2.24%	-1.80%
Resurfacing w/shldr imp	-13.75%	-15.58%	12.49%	12.98%
Resurfacing	-15.94%	-14.74%	12.03%	11.28%
TOTAL	-12.17%	-7.51%	9.49%	13.26%

TABLE B-12

SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT OF TOTAL RURAL OR URBAN CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: RESURFACE-RECONSTRUCT BY 0.4 RATING POINT PERCENT OF TOTAL CHANGE in Miles	DECREASE MTC: RESURFACE-RECONSTRUCT BY 0.4 RATING POINT PERCENT OF TOTAL CHANGE in Cost	INCREASE MTC: RESURFACE-RECONSTRUCT BY 0.4 RATING POINT PERCENT OF TOTAL CHANGE in Miles	INCREASE MTC: RESURFACE-RECONSTRUCT BY 0.4 RATING POINT PERCENT OF TOTAL CHANGE in Cost
R U R A L				
Function Class				
Interstate	-4.76%	-8.09%	3.24%	6.30%
Other Principal Arterial	-8.49%	-9.54%	5.61%	12.02%
Minor Arterial	-17.35%	-16.56%	15.54%	17.73%
Major Collector	-44.15%	-42.65%	44.05%	37.33%
Minor Collector	-25.25%	-23.16%	31.56%	26.62%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
U R B A N				
Function Class				
Interstate	-3.67%	-22.98%	2.48%	31.15%
Other Freeway & Expressway	-3.18%	-7.22%	2.16%	9.38%
Other Principal Arterial	-22.99%	-26.55%	14.00%	27.86%
Minor Arterial	-39.94%	-19.59%	28.25%	11.88%
Collector	-30.22%	-23.66%	53.13%	19.73%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
	PERCENT OF TOTAL CHANGE in Miles	PERCENT OF TOTAL CHANGE in Cost	PERCENT OF TOTAL CHANGE in Miles	PERCENT OF TOTAL CHANGE in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	0.30%	1.94%	-0.61%	-2.98%
Reconstruct w/more Lanes	-0.32%	-2.40%	1.08%	3.89%
Reconstruct w/wider lanes	-0.78%	-1.69%	-0.10%	-0.08%
Pavement Reconstruction	-31.82%	-59.99%	43.61%	72.00%
Pavement Reconst w/align imp	-5.04%	-11.21%	11.15%	19.98%
Major widening(add lanes)	0.65%	2.90%	-1.20%	-4.43%
Minor Widening	0.83%	0.67%	-0.33%	-0.30%
Resurfacing w/shldr imp	-12.70%	-6.81%	7.68%	2.73%
Resurfacing	-40.85%	-11.14%	37.91%	5.75%
Resurf w/align & shldr imp	-5.39%	-7.84%	3.12%	3.06%
Resurfacing w/align imp	-4.88%	-4.42%	-2.33%	0.37%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
U R B A N				
Improvement Type				
Reconstruct to Freeway	0.07%	0.09%	-0.15%	-0.29%
Reconstruct w/more Lanes	-4.32%	-38.60%	-0.68%	-2.95%
Reconstruct w/wider lanes	0.63%	13.09%	-0.16%	-0.17%
Pavement Reconstruction	-9.40%	-35.62%	-0.71%	-1.14%
Major widening(add lanes)	6.04%	28.03%	-1.97%	-5.59%
Minor Widening	0.58%	1.47%	-0.85%	-0.69%
Resurfacing w/shldr imp	-29.41%	-23.09%	34.30%	10.90%
Resurfacing	-71.13%	-51.68%	68.90%	22.41%
TOTAL	-100.00%	-100.00%	100.00%	100.00%

TABLE B-13
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: SHOULDER TYPE BY ONE CATEGORY NUMBER PERCENT CHANGE		INCREASE MTC: SHOULDER TYPE BY ONE CATEGORY NUMBER PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Function Class				
Interstate	0.00%	0.68%	0.00%	-0.06%
Other Principal Arterial	0.00%	1.46%	0.00%	-1.64%
Minor Arterial	0.00%	3.81%	0.00%	-1.29%
Major Collector	0.00%	10.09%	0.00%	0.00%
Minor Collector	0.00%	8.95%	0.00%	0.00%
TOTAL	0.00%	6.07%	0.00%	-0.61%
U R B A N				
Function Class				
Interstate	0.00%	0.00%	0.00%	-0.41%
Other Freeway & Expressway	0.00%	0.00%	0.00%	-0.87%
Other Principal Arterial	0.00%	0.48%	0.00%	-1.06%
Minor Arterial	0.00%	0.99%	0.00%	-0.01%
Collector	0.00%	1.62%	0.00%	-0.02%
TOTAL	0.00%	0.67%	0.00%	-0.48%
	PERCENT CHANGE		PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	0.00%	0.00%	0.00%	0.00%
Reconstruct w/wider lanes	0.00%	0.00%	0.00%	0.00%
Pavement Reconstruction	0.00%	0.00%	0.00%	0.00%
Pavement Reconst w/align imp	0.00%	0.00%	0.00%	0.00%
Major widening(add lanes)	0.00%	0.00%	0.00%	0.00%
Minor Widening	0.00%	0.00%	0.00%	0.00%
Resurfacing w/shldr imp	104.02%	83.98%	-10.59%	-13.63%
Resurfacing	-39.87%	-22.58%	4.06%	5.75%
Resurf w/align & shldr imp	69.95%	44.47%	-3.39%	-3.74%
Resurfacing w/align imp	-54.63%	-48.38%	2.65%	4.86%
TOTAL	0.00%	6.07%	0.00%	-0.61%
U R B A N				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	0.00%	0.00%	0.00%	0.00%
Reconstruct w/wider lanes	0.00%	0.00%	0.00%	0.00%
Pavement Reconstruction	0.00%	0.00%	0.00%	0.00%
Major widening(add lanes)	0.00%	0.00%	0.00%	0.00%
Minor Widening	0.00%	0.00%	0.00%	0.00%
Resurfacing w/shldr imp	19.98%	17.54%	-6.37%	-10.40%
Resurfacing	-9.58%	-4.87%	3.05%	2.57%
TOTAL	0.00%	0.67%	0.00%	-0.48%

TABLE B-14

SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT OF TOTAL RURAL OR URBAN CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: SHOULDER TYPE BY ONE CATEGORY NUMBER PERCENT OF TOTAL CHANGE in Miles	DECREASE MTC: SHOULDER TYPE BY ONE CATEGORY NUMBER PERCENT OF TOTAL CHANGE in Cost	INCREASE MTC: SHOULDER TYPE BY ONE CATEGORY NUMBER PERCENT OF TOTAL CHANGE in Miles	INCREASE MTC: SHOULDER TYPE BY ONE CATEGORY NUMBER PERCENT OF TOTAL CHANGE in Cost
R U R A L				
Function Class				
Interstate	NA	0.87%	NA	-0.73%
Other Principal Arterial	NA	4.89%	NA	-54.72%
Minor Arterial	NA	13.33%	NA	-44.55%
Major Collector	NA	55.27%	NA	0.00%
Minor Collector	NA	25.65%	NA	0.00%
TOTAL	NA	100.00%	NA	-100.00%
U R B A N				
Function Class				
Interstate	NA	0.00%	NA	-14.47%
Other Freeway & Expressway	NA	0.00%	NA	-18.58%
Other Principal Arterial	NA	21.35%	NA	-66.01%
Minor Arterial	NA	39.04%	NA	-0.40%
Collector	NA	39.61%	NA	-0.54%
TOTAL	NA	100.00%	NA	-100.00%
	PERCENT OF TOTAL CHANGE in Miles	PERCENT OF TOTAL CHANGE in Cost	PERCENT OF TOTAL CHANGE in Miles	PERCENT OF TOTAL CHANGE in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	NA	0.00%	NA	0.00%
Reconstruct w/more Lanes	NA	0.00%	NA	0.00%
Reconstruct w/wider lanes	NA	0.00%	NA	0.00%
Pavement Reconstruction	NA	0.00%	NA	0.00%
Pavement Reconst w/align imp	NA	0.00%	NA	0.00%
Major widening(add lanes)	NA	0.00%	NA	0.00%
Minor Widening	NA	0.00%	NA	0.00%
Resurfacing w/shldr imp	NA	127.25%	NA	-204.40%
Resurfacing	NA	-44.57%	NA	112.28%
Resurf w/align & shldr imp	NA	57.99%	NA	-48.32%
Resurfacing w/align imp	NA	-40.67%	NA	40.44%
TOTAL	NA	100.00%	NA	-100.00%
U R B A N				
Improvement Type				
Reconstruct to Freeway	NA	0.00%	NA	0.00%
Reconstruct w/more Lanes	NA	0.00%	NA	0.00%
Reconstruct w/wider lanes	NA	0.00%	NA	0.00%
Pavement Reconstruction	NA	0.00%	NA	0.00%
Major widening(add lanes)	NA	0.00%	NA	0.00%
Minor Widening	NA	0.00%	NA	0.00%
Resurfacing w/shldr imp	NA	291.18%	NA	-240.77%
Resurfacing	NA	-191.18%	NA	140.77%
TOTAL	NA	100.00%	NA	-100.00%

TABLE B-15
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: SHOULDER WIDTH BY 2 FEET PERCENT CHANGE		INCREASE MTC: SHOULDER WIDTH BY 2 FEET PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Function Class				
Interstate	0.00%	-0.11%	0.00%	1.13%
Other Principal Arterial	-0.01%	-1.01%	0.01%	3.33%
Minor Arterial	-0.11%	-5.32%	0.00%	2.53%
Major Collector	-0.02%	-2.72%	0.02%	7.10%
Minor Collector	0.00%	-1.38%	0.00%	5.05%
TOTAL	-0.03%	-2.49%	0.01%	4.55%
U R B A N				
Function Class				
Interstate	0.00%	-0.03%	0.00%	3.90%
Other Freeway & Expressway	0.00%	-0.74%	0.03%	8.90%
Other Principal Arterial	-0.25%	-1.30%	0.47%	3.48%
Minor Arterial	-0.11%	-1.72%	0.90%	2.86%
Collector	-0.23%	-2.75%	0.12%	2.16%
TOTAL	-0.17%	-1.37%	0.45%	3.73%
	PERCENT CHANGE		PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	0.00%	0.00%	0.00%	0.00%
Reconstruct w/wider lanes	-1.86%	-2.22%	0.33%	0.49%
Pavement Reconstruction	0.01%	0.02%	-0.07%	-0.12%
Pavement Reconst w/align imp	0.81%	0.89%	0.00%	0.00%
Major widening(add lanes)	0.00%	0.00%	0.00%	0.00%
Minor Widening	-2.21%	-3.30%	2.84%	5.69%
Resurfacing w/shldr imp	-30.60%	-30.38%	72.15%	64.71%
Resurfacing	11.81%	10.59%	-27.75%	-19.78%
Resurf w/align & shldr imp	-46.80%	-40.57%	55.03%	38.87%
Resurfacing w/align imp	36.71%	47.86%	-42.98%	-43.50%
TOTAL	-0.03%	-2.49%	0.01%	4.55%
U R B A N				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	0.00%	0.00%	0.00%	0.00%
Reconstruct w/wider lanes	-2.76%	-1.40%	12.41%	32.70%
Pavement Reconstruction	0.08%	0.06%	-0.70%	-2.04%
Major widening(add lanes)	0.00%	0.00%	0.00%	0.00%
Minor Widening	-8.73%	-6.62%	21.74%	35.66%
Resurfacing w/shldr imp	-31.64%	-28.86%	28.06%	45.53%
Resurfacing	15.44%	8.27%	-14.07%	-12.08%
TOTAL	-0.17%	-1.37%	0.45%	3.73%

TABLE B-16
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT OF TOTAL RURAL OR URBAN CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: SHOULDER WIDTH BY 2 FEET PERCENT OF TOTAL CHANGE in Miles	DECREASE MTC: SHOULDER WIDTH BY 2 FEET PERCENT OF TOTAL CHANGE in Cost	INCREASE MTC: SHOULDER WIDTH BY 2 FEET PERCENT OF TOTAL CHANGE in Miles	INCREASE MTC: SHOULDER WIDTH BY 2 FEET PERCENT OF TOTAL CHANGE in Cost
R U R A L				
Function Class				
Interstate	0.00%	-0.35%	0.00%	1.93%
Other Principal Arterial	-2.70%	-8.26%	14.29%	14.95%
Minor Arterial	-66.22%	-45.44%	0.00%	11.83%
Major Collector	-31.08%	-36.32%	85.71%	51.96%
Minor Collector	0.00%	-9.63%	0.00%	19.33%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
U R B A N				
Function Class				
Interstate	0.00%	-0.42%	0.00%	17.92%
Other Freeway & Expressway	0.00%	-5.56%	0.28%	24.52%
Other Principal Arterial	-35.82%	-28.33%	25.71%	27.85%
Minor Arterial	-20.90%	-32.95%	65.25%	20.23%
Collector	-43.28%	-32.74%	8.76%	9.48%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
	PERCENT OF TOTAL CHANGE in Miles	PERCENT OF TOTAL CHANGE in Cost	PERCENT OF TOTAL CHANGE in Miles	PERCENT OF TOTAL CHANGE in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	0.00%	0.00%	0.00%	0.00%
Reconstruct w/wider lanes	-221.62%	-8.28%	138.10%	1.00%
Pavement Reconstruction	5.41%	0.21%	-128.57%	-0.80%
Pavement Reconst w/align imp	89.19%	2.61%	0.00%	0.00%
Major widening(add lanes)	0.00%	0.00%	0.00%	0.00%
Minor Widening	-132.43%	-2.27%	600.00%	2.14%
Resurfacing w/shldr imp	-17374.32%	-112.35%	144371.43%	130.93%
Resurfacing	17494.59%	51.00%	-144880.95%	-52.13%
Resurf w/align & shldr imp	-7863.51%	-129.11%	32585.71%	67.69%
Resurfacing w/align imp	7898.65%	98.20%	-32585.71%	-48.83%
TOTAL	-100.00%	-100.00%	100.00%	100.00%
U R B A N				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	0.00%	0.00%	0.00%	0.00%
Reconstruct w/wider lanes	-2.99%	-0.53%	5.08%	4.57%
Pavement Reconstruction	1.49%	0.26%	-5.08%	-3.40%
Major widening(add lanes)	0.00%	0.00%	0.00%	0.00%
Minor Widening	-185.82%	-24.34%	175.14%	48.29%
Resurfacing w/shldr imp	-4869.40%	-233.93%	1634.75%	135.86%
Resurfacing	4956.72%	158.55%	-1709.60%	-85.33%
TOTAL	-100.00%	-100.00%	100.00%	100.00%

TABLE B-17
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: SURFACE TYPE BY ONE CATEGORY NUMBER PERCENT CHANGE		INCREASE MTC: SURFACE TYPE BY ONE CATEGORY NUMBER PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Function Class				
Interstate	0.00%	0.00%	0.00%	0.00%
Other Principal Arterial	0.00%	0.00%	0.00%	0.00%
Minor Arterial	0.00%	0.00%	0.73%	-7.53%
Major Collector	19.55%	56.35%	-0.55%	11.10%
Minor Collector	45.34%	82.77%	-2.28%	10.35%
TOTAL	19.01%	33.13%	-0.64%	3.89%
U R B A N				
Function Class				
Interstate	0.00%	0.00%	0.00%	0.00%
Other Freeway & Expressway	0.00%	0.00%	0.00%	0.00%
Other Principal Arterial	0.00%	0.00%	0.00%	0.00%
Minor Arterial	0.00%	0.00%	1.12%	-2.89%
Collector	-3.46%	6.48%	-4.16%	4.85%
TOTAL	-1.12%	1.06%	-0.99%	0.03%
	PERCENT CHANGE		PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	0.00%	0.00%	-14.84%	-9.49%
Reconstruct w/wider lanes	-1.68%	-1.72%	-23.07%	-21.29%
Pavement Reconstruction	86.04%	108.55%	16.95%	14.92%
Pavement Reconst w/align imp	-3.72%	-1.16%	25.43%	25.78%
Major widening(add lanes)	0.00%	0.00%	2.16%	1.41%
Minor Widening	0.00%	0.00%	40.40%	26.40%
Resurfacing w/shldr imp	10.70%	6.16%	-5.61%	-1.93%
Resurfacing	8.26%	2.69%	-5.19%	-1.38%
Resurf w/align & shldr imp	-2.26%	-2.31%	5.50%	2.73%
Resurfacing w/align imp	9.41%	5.86%	-14.51%	-9.33%
TOTAL	19.01%	33.13%	-0.64%	3.89%
U R B A N				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	2.82%	1.35%	-24.40%	-12.31%
Reconstruct w/wider lanes	12.41%	5.88%	-8.97%	-4.47%
Pavement Reconstruction	51.50%	28.75%	14.66%	9.27%
Major widening(add lanes)	-0.24%	-0.14%	1.85%	1.38%
Minor Widening	-0.63%	-0.36%	0.42%	0.24%
Resurfacing w/shldr imp	-7.66%	-5.38%	-4.30%	-3.13%
Resurfacing	-1.48%	-0.64%	-0.49%	-0.11%
TOTAL	-1.12%	1.06%	-0.99%	0.03%

TABLE B-18
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT OF TOTAL RURAL OR URBAN CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: SURFACE TYPE BY ONE CATEGORY NUMBER PERCENT OF TOTAL CHANGE in Miles	in Cost	INCREASE MTC: SURFACE TYPE BY ONE CATEGORY NUMBER PERCENT OF TOTAL CHANGE in Miles	in Cost
R U R A L				
Function Class				
Interstate	0.00%	0.00%	0.00%	0.00%
Other Principal Arterial	0.00%	0.00%	0.00%	0.00%
Minor Arterial	0.00%	0.00%	20.93%	-41.05%
Major Collector	42.13%	56.55%	-34.99%	94.80%
Minor Collector	57.87%	43.45%	-85.94%	46.25%
TOTAL	100.00%	100.00%	-100.00%	100.00%
U R B A N				
Function Class				
Interstate	0.00%	0.00%	0.00%	0.00%
Other Freeway & Expressway	0.00%	0.00%	0.00%	0.00%
Other Principal Arterial	0.00%	0.00%	0.00%	0.00%
Minor Arterial	0.00%	0.00%	36.70%	-2348.69%
Collector	-100.00%	100.00%	-136.70%	2448.69%
TOTAL	-100.00%	100.00%	-100.00%	100.00%
	PERCENT OF TOTAL CHANGE in Miles	in Cost	PERCENT OF TOTAL CHANGE in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	0.00%	0.00%	-13.87%	-10.42%
Reconstruct w/wider lanes	-0.32%	-0.48%	-127.93%	-50.73%
Pavement Reconstruction	69.42%	97.70%	403.97%	114.31%
Pavement Reconst w/align imp	-0.65%	-0.25%	130.45%	48.22%
Major widening(add lanes)	0.00%	0.00%	4.67%	2.52%
Minor Widening	0.00%	0.00%	112.99%	11.61%
Resurfacing w/shldr imp	9.60%	1.71%	-148.61%	-4.57%
Resurfacing	19.34%	0.97%	-359.08%	-4.26%
Resurf w/align & shldr imp	-0.60%	-0.55%	43.13%	5.56%
Resurfacing w/align imp	3.20%	0.90%	-145.65%	-12.23%
TOTAL	100.00%	100.00%	-100.00%	100.00%
U R B A N				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	2.93%	7.85%	-28.77%	-2332.27%
Reconstruct w/wider lanes	2.03%	2.90%	-1.66%	-71.98%
Pavement Reconstruction	149.10%	168.99%	48.21%	1781.09%
Major widening(add lanes)	-2.36%	-5.55%	21.10%	1848.45%
Minor Widening	-2.03%	-1.71%	1.53%	37.98%
Resurfacing w/shldr imp	-177.93%	-56.61%	-113.43%	-1074.75%
Resurfacing	-71.85%	-15.87%	-26.98%	-88.51%
TOTAL	-100.00%	100.00%	-100.00%	100.00%

TABLE B-19
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: HORIZONTAL ALIGNMENT BY ONE CATEGORY NUMBER PERCENT CHANGE		INCREASE MTC: HORIZONTAL ALIGNMENT BY ONE CATEGORY NUMBER PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Function Class				
Interstate	0.00%	2.96%	0.00%	-0.40%
Other Principal Arterial	0.00%	11.04%	0.00%	-2.91%
Minor Arterial	0.00%	7.02%	0.00%	-4.64%
Major Collector	0.00%	10.96%	0.00%	-4.91%
Minor Collector	0.00%	11.77%	0.00%	-2.48%
TOTAL	0.00%	9.66%	0.00%	-3.67%

	PERCENT CHANGE		PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	37.18%	33.28%	-13.29%	-12.30%
Reconstruct w/wider lanes	17.61%	19.91%	-10.39%	-11.48%
Pavement Reconstruction	-21.36%	-19.67%	5.09%	5.10%
Pavement Reconst w/align imp	99.25%	90.31%	-23.69%	-23.07%
Major widening(add lanes)	-16.06%	-14.52%	5.78%	5.75%
Minor Widening	-34.94%	-32.57%	20.60%	19.74%
Resurfacing w/shldr imp	-19.50%	-17.88%	9.07%	9.36%
Resurfacing	-16.81%	-10.07%	5.26%	2.82%
Resurf w/align & shldr imp	65.87%	54.33%	-30.64%	-27.12%
Resurfacing w/align imp	115.75%	113.85%	-36.22%	-33.57%
TOTAL	0.00%	9.66%	0.00%	-3.67%

TABLE B-20
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT OF TOTAL RURAL OR URBAN CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: HORIZONTAL ALIGNMENT BY ONE CATEGORY NUMBER PERCENT OF TOTAL CHANGE in Miles	in Cost	INCREASE MTC: HORIZONTAL ALIGNMENT BY ONE CATEGORY NUMBER PERCENT OF TOTAL CHANGE in Miles	in Cost
R U R A L				
Function Class				
Interstate	NA	2.37%	NA	-0.84%
Other Principal Arterial	NA	23.31%	NA	-16.17%
Minor Arterial	NA	15.43%	NA	-26.80%
Major Collector	NA	37.71%	NA	-44.45%
Minor Collector	NA	21.18%	NA	-11.74%
TOTAL	NA	100.00%	NA	-100.00%

	PERCENT OF TOTAL CHANGE in Miles	in Cost	PERCENT OF TOTAL CHANGE in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	NA	0.00%	NA	0.00%
Reconstruct w/more Lanes	NA	14.72%	NA	-14.32%
Reconstruct w/wider lanes	NA	19.11%	NA	-28.99%
Pavement Reconstruction	NA	-60.71%	NA	41.39%
Pavement Reconst w/align imp	NA	68.02%	NA	-45.73%
Major widening(add lanes)	NA	-10.48%	NA	10.93%
Minor Widening	NA	-5.77%	NA	9.20%
Resurfacing w/shldr imp	NA	-17.02%	NA	23.44%
Resurfacing	NA	-12.49%	NA	9.21%
Resurf w/align & shldr imp	NA	44.50%	NA	-58.46%
Resurfacing w/align imp	NA	60.11%	NA	-46.66%
TOTAL	NA	100.00%	NA	-100.00%

TABLE B-21
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: VERTICAL ALIGNMENT BY ONE CATEGORY NUMBER PERCENT CHANGE		INCREASE MTC: VERTICAL ALIGNMENT BY ONE CATEGORY NUMBER PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Function Class				
Interstate	0.00%	8.99%	0.00%	0.00%
Other Principal Arterial	0.00%	19.08%	0.00%	-0.56%
Minor Arterial	0.00%	19.05%	0.00%	-1.50%
Major Collector	0.00%	12.47%	0.00%	-1.81%
Minor Collector	0.00%	9.91%	0.00%	-1.76%
TOTAL	0.00%	14.50%	0.00%	-1.34%

	PERCENT CHANGE		PERCENT CHANGE	
	in Miles	in Cost	in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	0.00%	0.00%	0.00%	0.00%
Reconstruct w/more Lanes	46.69%	44.21%	-4.32%	-3.42%
Reconstruct w/wider lanes	22.99%	26.81%	-1.85%	-1.71%
Pavement Reconstruction	-23.65%	-24.58%	5.25%	5.13%
Pavement Reconst w/align imp	109.87%	111.52%	-24.38%	-22.85%
Major widening(add lanes)	-20.23%	-20.81%	1.87%	1.70%
Minor Widening	-45.58%	-46.18%	3.63%	2.73%
Resurfacing w/shldr imp	-31.11%	-32.83%	2.58%	2.57%
Resurfacing	-19.74%	-15.35%	2.80%	1.45%
Resurf w/align & shldr imp	105.14%	101.62%	-8.73%	-7.59%
Resurfacing w/align imp	135.97%	164.56%	-19.30%	-17.17%
TOTAL	0.00%	14.50%	0.00%	-1.34%

TABLE B-22
SENSITIVITY OF
THE HIGHWAY PERFORMANCE MONITORING SYSTEM ANALYTICAL PROCESS
TO CHANGES IN THE MINIMUM TOLERABLE CONDITIONS (MTC)
PERCENT OF TOTAL RURAL OR URBAN CHANGE BY FUNCTIONAL CLASS & IMPROVEMENT TYPE

	DECREASE MTC: VERTICAL ALIGNMENT BY ONE CATEGORY NUMBER PERCENT OF TOTAL CHANGE in Miles	in Cost	INCREASE MTC: VERTICAL ALIGNMENT BY ONE CATEGORY NUMBER PERCENT OF TOTAL CHANGE in Miles	in Cost
R U R A L				
Function Class				
Interstate	NA	4.79%	NA	0.00%
Other Principal Arterial	NA	26.85%	NA	-8.50%
Minor Arterial	NA	27.89%	NA	-23.76%
Major Collector	NA	28.59%	NA	-44.86%
Minor Collector	NA	11.89%	NA	-22.88%
TOTAL	NA	100.00%	NA	-100.00%

	PERCENT OF TOTAL CHANGE in Miles	in Cost	PERCENT OF TOTAL CHANGE in Miles	in Cost
R U R A L				
Improvement Type				
Reconstruct to Freeway	NA	0.00%	NA	0.00%
Reconstruct w/more Lanes	NA	13.03%	NA	-10.90%
Reconstruct w/wider lanes	NA	17.14%	NA	-11.84%
Pavement Reconstruction	NA	-50.54%	NA	114.06%
Pavement Reconst w/align imp	NA	55.98%	NA	-124.11%
Major widening(add lanes)	NA	-10.01%	NA	8.88%
Minor Widening	NA	-5.45%	NA	3.49%
Resurfacing w/shldr imp	NA	-20.82%	NA	17.63%
Resurfacing	NA	-12.68%	NA	12.97%
Resurf w/align & shldr imp	NA	55.46%	NA	-44.81%
Resurfacing w/align imp	NA	57.90%	NA	-65.36%
TOTAL	NA	100.00%	NA	-100.00%