THE IMPACT OF RAISING THE SPEED LIMIT ON FREEWAYS IN MICHIGAN

EXECUTIVE SUMMARY

BY

WILLIAM C. TAYLOR

AUGUST 2000

MICHIGAN STATE UNIVERSITY
1855

COLLEGE OF ENGINEERING
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EAST LANSING, MICHIGAN 48824

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INTRODUCTION

In 1995 the US Congress determined that it was no longer necessary for the federal government to be involved in setting speed limits on the nations roads and streets, including the Interstate Highway System. In response to this change in the national policy, the Michigan Legislature passed a bill directing the Michigan Department of Transportation (MDOT) and the Michigan State Police (MSP) to designate 500 miles of rural freeway where the speed limit would be increased from 65 MPH to 70 MPH. These departments were to study the impact of this change on vehicle speeds and traffic crashes over a six-month period and report back to the legislature.

Michigan State University conducted the required impact study and concluded that there was a small increase in speed (1-2 MPH) at some locations but less than 1 MPH at most reporting stations. There was insufficient data to determine the impact on traffic crashes given the lag time in obtaining and processing traffic crash reports. The legislature then authorized the MDOT to raise the speed limit on an additional 1000 miles of rural freeways on January 1, 1997. Truck speeds remained at 55 MPH throughout the study period.

The study of the impact of the change in the speed limit was expanded to include these additional freeway segments. The results of this study after one year were presented to MDOT and the MSP in the summer of 1998 and the results after two years were presented in an interim report dated December 1999. This final report covers the results for the three years following the increase (January 1, 1997 through December 31, 1999), and it compares crashes for the three years before and three years after the change in the speed limit.

The 1500 miles of rural freeway included in this study is shown in Figure 1. The locations of the permanent count stations used to obtain speed and vehicle classification data are shown in Figure 2. Data from these counters are provided by the Transportation Planning division in a format designed for this study. Unfortunately, not all stations collect and transmit data every day. However, because of the very large data set, the missing data does not affect the results reported later in this report. For reference, Table1 shows the data availability for each station by month.

Because this executive summary is intended for the general public as well as the sponsor, the results are presented in a question and answer format. We have tried to anticipate the questions of concern to the sponsors of the study and the general public.

Table1 - Data Available from the Permanent Count Stations

Station Number	Location	1997											
		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
SPD-17	I-94	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	C	C
SPD-18	I-96	NR	NR	NR	NR	NR	NR	C	C	C	C	C	C
SPD-19	I-69	NR	NR	NR	NR	NR	NR	C	C	C	C	C	C
SPD-24	US-31	NR	NR	NR	NR	NR	NR	P	C	C	C	C	C
SPD-26	I-75	NR	NR	NR	NR	NR	NR	C	C	C	C	C	C
SPD-40	US-27	NR	NR	NR	NR	NR	NR	C	C	C	C	C	C
SPD-43	I-69	NR	NR	NR	NR	NR	NR	C	C	C	C	C	C
SPD-70	I-75	NR	NR	NR	NR	NR	NR	C	C	C	C	C	C
SPD-77	US-131	NR	NR	NR	NR	NR	NR	P	C	C	C	C	C
Station Number	Location	1998											
		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
SPD-17	I-94	C	C	C	C	C	C	C	C	C	C	C	C
SPD-18	I-96	C	C	C	C	C	C	C	C	C	C	C	C
SPD-19	I-69	C	C	C	C	C	P	C	C	C	C	C	C
SPD-24	US-31	C	C	P	C	C	C	C	C	C	C	C	C
SPD-26	I-75	C	C	C	NR	C	C	C	C	C	C	C	C
SPD-40	US-27	C	C	C	C	C	P	NR	NR	NR	NR	NR	NR
SPD-43	I-69	C	NR	NR	P	C	C	C	C	C	C	C	C
SPD-70	I-75	C	C	C	C	C	C	C	C	C	C	C	C
SPD-77	US-131	C	C	C	C	C	C	C	C	C	C	C	C
Station Number	Location	1999											
		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
SPD-17	I-94	C	C	C	C	C	C	P	C	C	C	C	C
SPD-18	I-96	C	C	C	C	C	C	C	C	C	C	C	C
SPD-19	I-69	C	NR	NR	NR	NR	NR	C	C	C	C	P	C
SPD-24	US-31	C	NR	NR	NR	NR	NR	P	C	C	C	C	C
SPD-26	I-75	C	NR	NR	NR	NR	NR	C	C	C	C	C	C
SPD-40	US-27	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	C	C
SPD-43	I-69	C	NR	NR	NR	NR	NR	C	C	C	C	C	C
SPD-70	I-75	C	NR	NR	NR	NR	NR	C	C	C	C	C	C
SPD-77	US-131	C	NR	NR	NR	NR	NR	C	C	C	C	C	P

C (for complete, data is available for at least 20 days)
P (for partial, data is available for at least 5 days but less than 20 days)
NR (for not reporting, data is available for 4 days or less)

FIGURE 1: Freeways Included in the Study

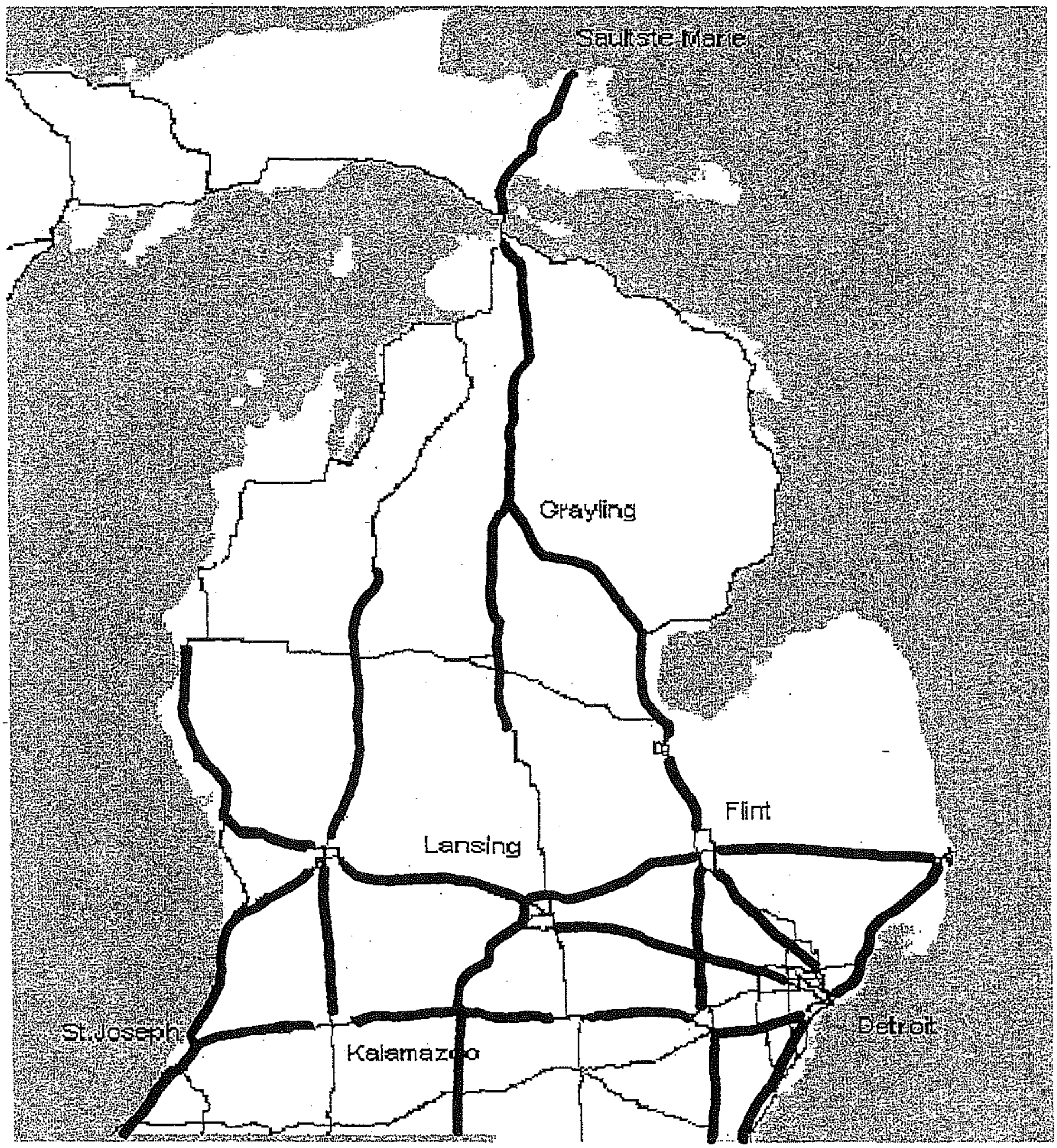
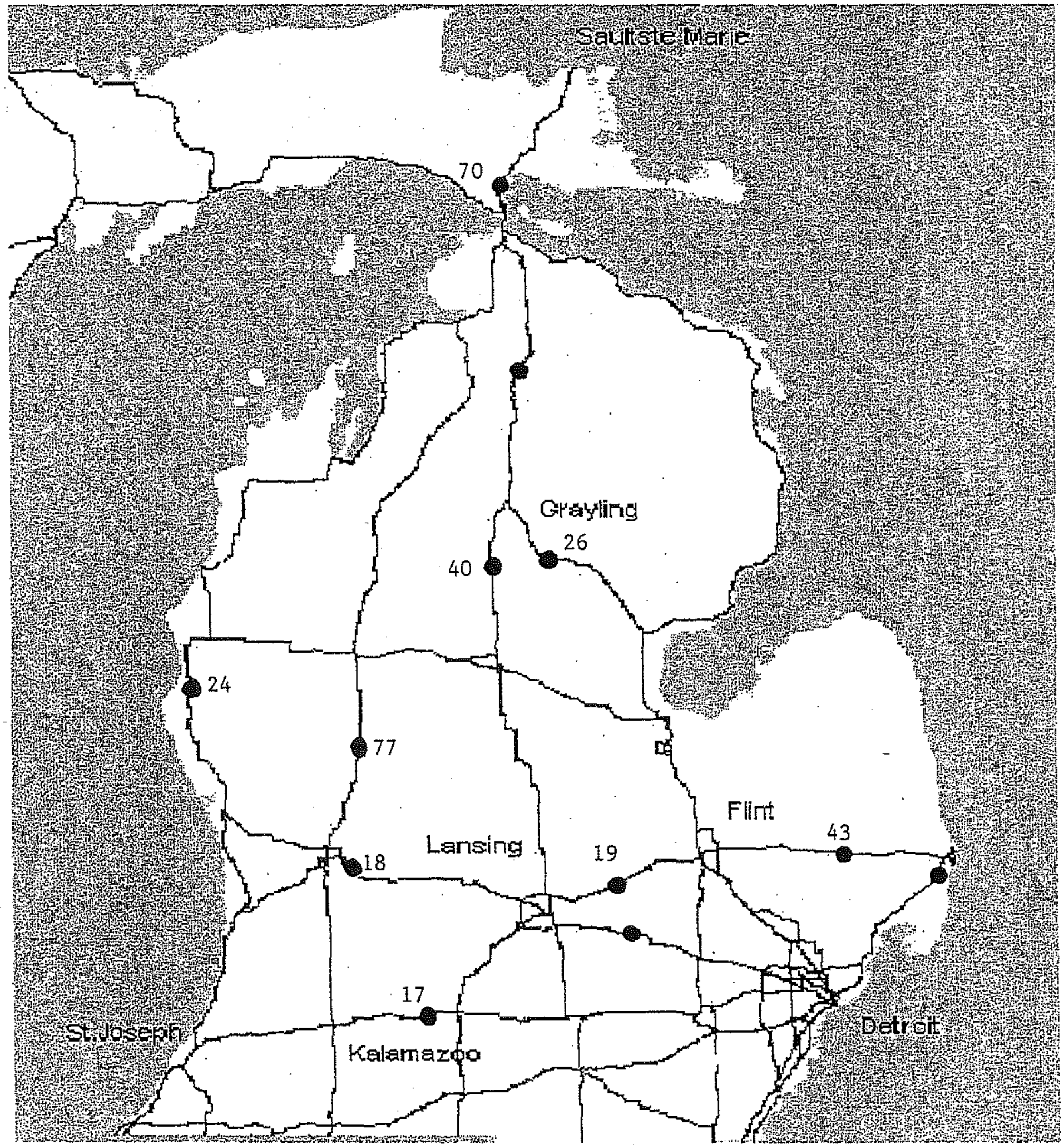


FIGURE 2: Location of Speed and Volume Detectors



QUESTION 1

DID TRAFFIC CRASHES INCREASE ON THE FREEWAYS WHERE THE SPEED LIMIT WAS INCREASED FROM 65 MPH TO 70 MPH IN JANUARY 1997.

1a) DID THE FREQUENCY OF SEVERE TRAFFIC CRASHES INCREASE WITH THE CHANGE IN THE SPEED LIMIT?

Yes for fatal crashes, but only slightly, as shown in Table 2. There were 311 fatal crashes on these freeway sections in the three years before the change and 325 fatal crashes in the three years after the change in the speed limit. This is a 4.5 percent increase.

The reverse was true for crashes resulting in an incapacitating injury, but no fatality. There were 2389 incapacitating injury crashes in the three years before the change and 2165 crashes in the three years after the change in the speed limit. This is a 9.3% decrease.

Table 2: 70 MPH Freeway Severe Crashes

YEAR	1994	1995	1996	1997	1998	1999	Difference
FATAL	98	100	113	110	101	114	14
A INJURY	750	775	864	737	668	760	-224

1b) DID THE FREQUENCY OF ALL CRASHES INCREASE WITH THE INCREASE IN THE SPEED LIMIT?

Yes, as shown in Table 3, there were 66,523 total crashes in the three years before the change and 73,492 total crashes after the change. This is a 10.5% increase in crashes.

Since we do not have volume counts for each segment of the freeway system, we do not know if the crash rate increased after the change in the speed limit. The Transportation Planning Bureau of MDOT estimates that the vehicle miles of travel (VMT) on rural freeways increased by an average of 3.95% per year over this period. Thus, the average VMT in the after period (1997-99) is approximately 11.9% higher than the average in the before period (1994-96). This means that the total number of crashes increased slower than the growth in vehicle miles of travel on these freeway segments.

Table 3: 70 MPH Freeway Total Crashes

1994	1995	1996	1997	1998	1999	Difference
20,167	22,310	24,046	24,691	22,461	26,340	6.969

1c) WAS THE CHANGE IN SEVERE CRASHES AND/OR TOTAL CRASHES DIFFERENT THAN THE CHANGE EXPERIENCED ON THE OTHER ROADS IN MICHIGAN?

Yes, as shown in Table 4, the decrease in fatal, A injury and total crashes were greater on the rest of the road system than it was on the freeway segments. This results in the percentage of statewide crashes occurring on the freeways being higher in the three years after the speed limit was changed than it was in the three years before the change. Since we do not know the change in VMT for the entire road system, it is not possible to determine what percent of this increase would be due to a different rate of growth in traffic volume between the two categories.

Table 4: Percent Of Crashes Occurring On 70 MPH Freeways

	Statewide		70 MPH Freeways		Percentage	
	1994-1996	1997-1999	1994-1996	1997-1999	1994-1996	1997-1999
FATAL CRASHES	4,087	3,849	311	325	7.6	8.4
A INJURY CRASHES	41,668	34,762	2,389	2,165	5.7	6.2
TOTAL CRASHES	1,257,765	1,249,696	66,523	73,492	5.3	5.9

QUESTION 2

DID TRAFFIC CRASHES INVOLVING HEAVY TRUCKS INCREASE WHEN THE SPEED LIMIT FOR AUTOMOBILES WAS INCREASED FROM 65 MPH TO 70 MPH AND THE SPEED LIMIT FOR TRUCKS REMAINED AT 55 MPH?

2a) DID THE FREQUENCY OF TRUCK INVOLVED SEVERE CRASHES INCREASE WITH THE CHANGE IN THE AUTOMOBILE SPEED LIMIT?

No, as shown in Table 5, there were 69 fatal crashes in the three years before the change and 59 fatal crashes in the three years after the change in the speed limit. This is a reduction of 14.5% in fatal crashes.

For incapacitating injury crashes, there was a decrease from 326 in the three years before the change in the speed limit to 247 in the three years after the change in the speed limit. For incapacitating injury crashes, the reduction was 24.2%.

Table 5: 70 MPH Freeway Truck Involved Severe Crashes

YEAR	1994	1995	1996	1997	1998	1999	Difference
FATAL	25	22	22	20	22	17	-10
A INJURY	100	93	133	76	86	85	-79

2b.) DID THE FREQUENCY OF ALL TRUCK INVOLVED CRASHES INCREASE WITH THE CHANGE IN THE AUTOMOBILE SPEED LIMIT?

Yes, as shown in Table 6, there were 6896 crashes involving heavy trucks in the three years before the change and 7327 in the three years after the change. This is a 7.0 percent increase in the number of crashes.

Since we do not have volume counts for each segment of the freeway system, we do not know if the crash rate increased after the change in the speed limit.

To estimate the change in VMT for trucks, the percentage of trucks in the traffic stream at seven permanent count stations in 1996 and 1998 were obtained. The average annual growth rate for all vehicles was 4.06 percent (which compares closely with the MDOT estimates of 3.95 percent from the Department of Transportation), while the annual growth rate for Truck VMT was 6.4 percent. Thus, it appears that the truck involved crash rate remained nearly constant on these road segments where the speed limit differential was increased from 10 MPH to 15 MPH.

Table 6: 70 MPH Freeway Total Truck Involved Crashes

1994	1995	1996	1997	1998	1999	Difference
2,206	2,252	2,438	2,416	2,235	2,726	481

2c) WAS THE CHANGE IN TRUCK INVOLVED SEVERE CRASHES AND/OR TOTAL CRASHES DIFFERENT THAN THE CHANGE EXPERIENCED ON OTHER ROADS IN MICHIGAN?

No, as shown in Table 7, the percentage of all truck involved crashes on the freeway segments where the automobile speed limit was increased remained nearly constant (15.6 to 15.7 percent). During the same time period, the percentage of severe crashes (fatal and incapacitating injury combined) involving trucks decreased from 18.2 to 16.3. Since we do not know the changes in VMT for the entire road system, it is not possible to determine what percentage of this decrease would be due to a different rate of growth in traffic volume between these two road categories.

Table 7: Percent Of Truck Involved Crashes Occurring On 70 MPH Freeways

	Statewide		70 MPH Freeways		Percentage	
	1994-1996	1997-1999	1994-1996	1997-1999	1994-1996	1997-1999
FATAL CRASHES	384	365	69	59	18.0	16.2
A INJURY CRASHES	1,781	1,506	326	247	18.3	16.4
TOTAL CRASHES	44,257	46,909	6,896	7,377	15.6	15.7

QUESTION 3

DID THE SPEED AT WHICH VEHICLES TRAVEL INCREASE ON THE FREEWAYS WHERE THE SPEED LIMIT WAS INCREASED FROM 65 MPH TO 70 MPH IN JANUARY 1997?

3a) Was there an increase in the speed when considering all vehicles?

Overall, there was a small increase in the speed of traffic when the speed limit was changed. However, this increase was not experienced at all monitoring locations, and was not greater than 2 mph at any location.

Table 8 summarizes the difference in speed between July 1996 (six months before the change) and July 1997 (six months after the change).

Table 8 – The Difference in Speed – 50th and 85th Percentile Speeds (MPH)

Station	Location	July 1996		July 1997		Difference	
		50th	*85th*	*50th*	*85th*	*50th*	*85th*
18 SPD	I-96	70.0	75.0	70.1	75.1	+0.1	+0.1
19 SPD	I-69	71.2	76.9	71.9	77.5	+0.7	+0.6
24 SPD	US-31	68.7	73.8	69.6	75.1	+0.9	+1.3
26 SPD	I-75	70.7	76.1	71.5	76.5	+0.8	+0.4
40 SPD	US-27	69.0	73.9	69.3	74.7	+0.3	+0.8
43 SPD	I-69	68.5	74.4	68.7	75.0	+0.2	+0.6
70 SPD	I-75	70.1	76.5	70.3	76.5	+0.2	0

Table 9 shows similar data for July 1997 and July 1999.

3b) HAVE DRIVERS INCREASED THEIR SPEED OVER TIME AS THEY BECOME MORE ACCUSTOMED TO THE 70-MPH SPEED LIMIT?

There is no evidence of the phenomenon (often referred to as speed creep), for the time period of January 1997 through December 1999. Figures 3 through 6 show the 50th percentile and the 85th percentile speed at two locations.

Table 9 shows this increase or decrease in speed between July 1997 and July 1999 for the six permanent count stations for which data are available. In only one location was the increase in speed greater than 2 mph on this two-year period. The average increase was 0.8 MPH for the 50th percentile speed and 0.9 MPH for the 25th percentile speed.

Table 9 – The Difference in Speed – 50th and 85th Percentile Speeds (MPH)

Station	Location	July 1997		July 1999		Difference	
		50th	85th	50th	85th	50th	85th
18SPD	I-96	70.1	75.1	71.1	76.3	+1.0	+1.2
19SPD	I-69	71.9	77.5	74.5	79.7	+2.6	+2.2
24SPD	US-31	69.6	75.1	70.3	75.1	+0.7	+0.0
26SPD	I-75	71.5	76.5	71.9	77.1	+0.4	+0.6
43SPD	I-69	68.7	75.0	67.6	75.2	-1.1	+0.2
70SPD	I-75	70.3	76.5	71.3	77.9	+1.0	+1.4

Summary

Raising the speed limit from 65 mph to 70 mph appears to have had little effect on either the speed of traffic or traffic crashes. The average increase in the 50th percentile speed between July 1996 (the last month before the speed limit was increased) and July 1999 was 1.3 mph. The increase averaged 0.5 mph in the first year, and 0.8-mph over the next two years.

There was an increase in traffic crashes in the three years following the change in the speed limit, but this increase was less than the increase in traffic volume in the same time period. The number of crashes resulting in a fatality or an incapacitating injury decreased over the three-year period, presumably due to increased seat belt use and air bags. Crashes involving heavy trucks showed the same pattern, with an increase in total crashes and a decrease in severe crashes over this three-year period.

Figure 3: 50th Percentile Speed on US-31 in Oceana County

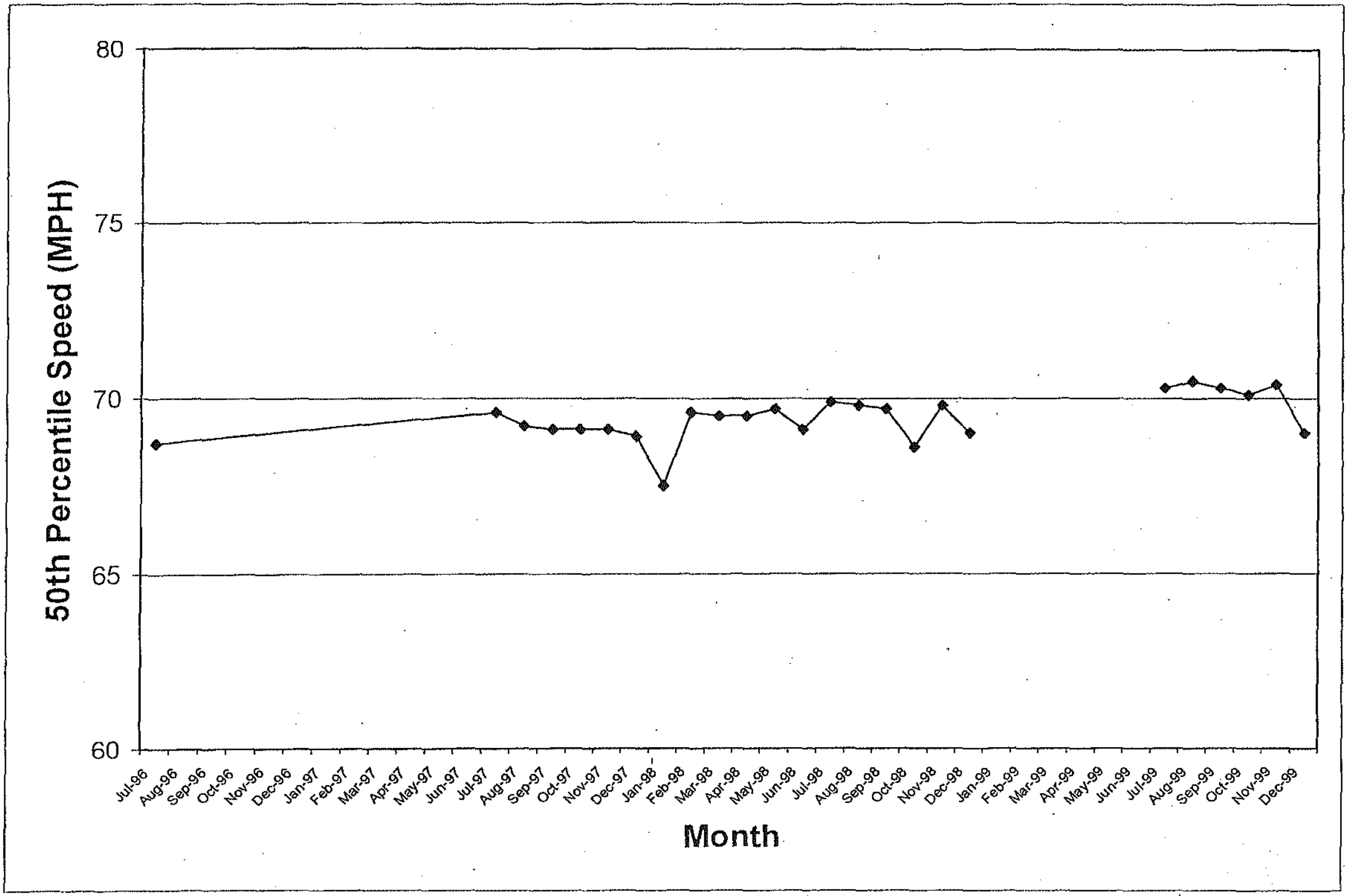


Figure 4: 85th Percentile Speed on US-31 in Oceana County

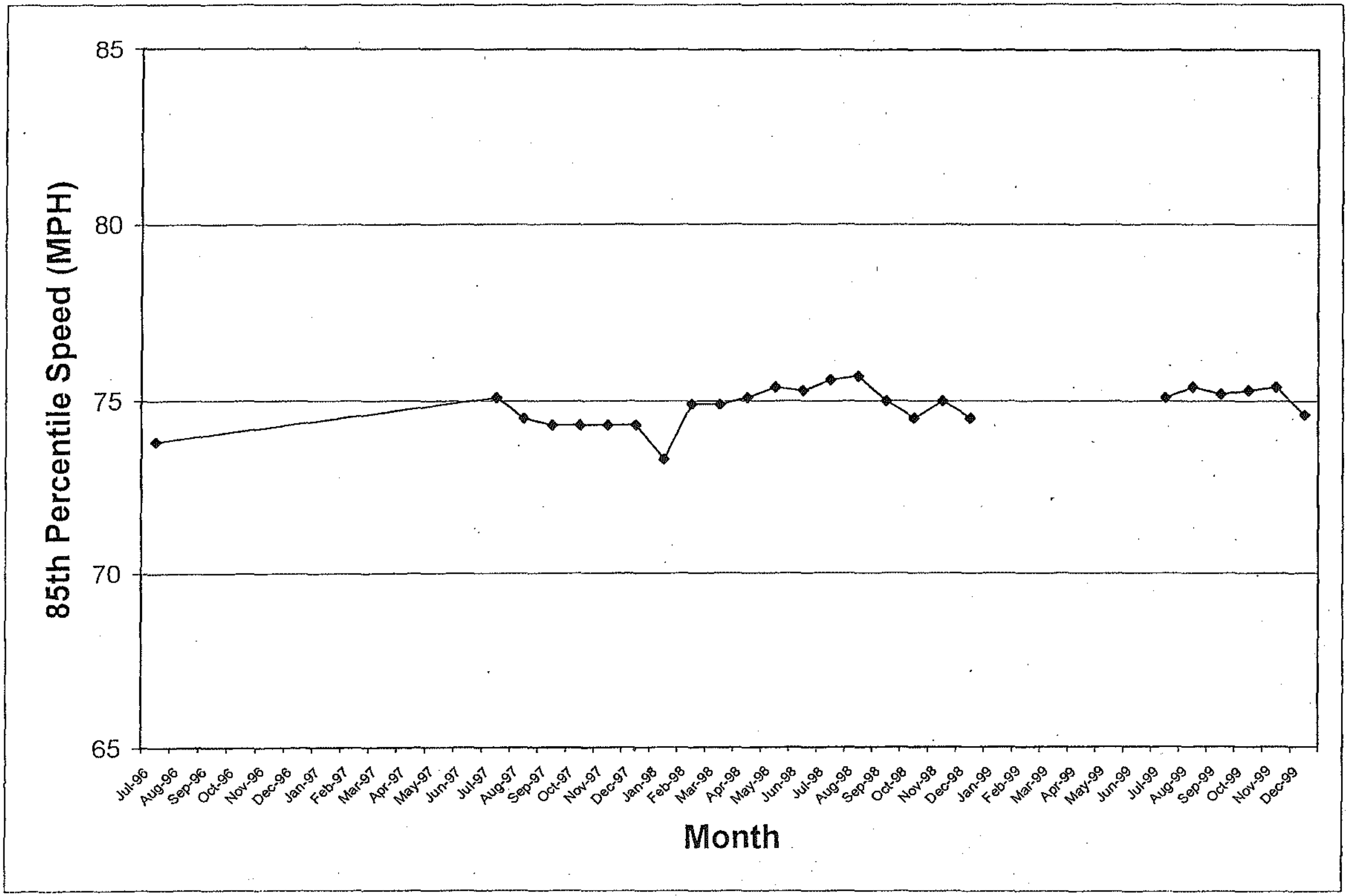


Figure 5: 50th Percentile Speed on I-75 in Roscommon County

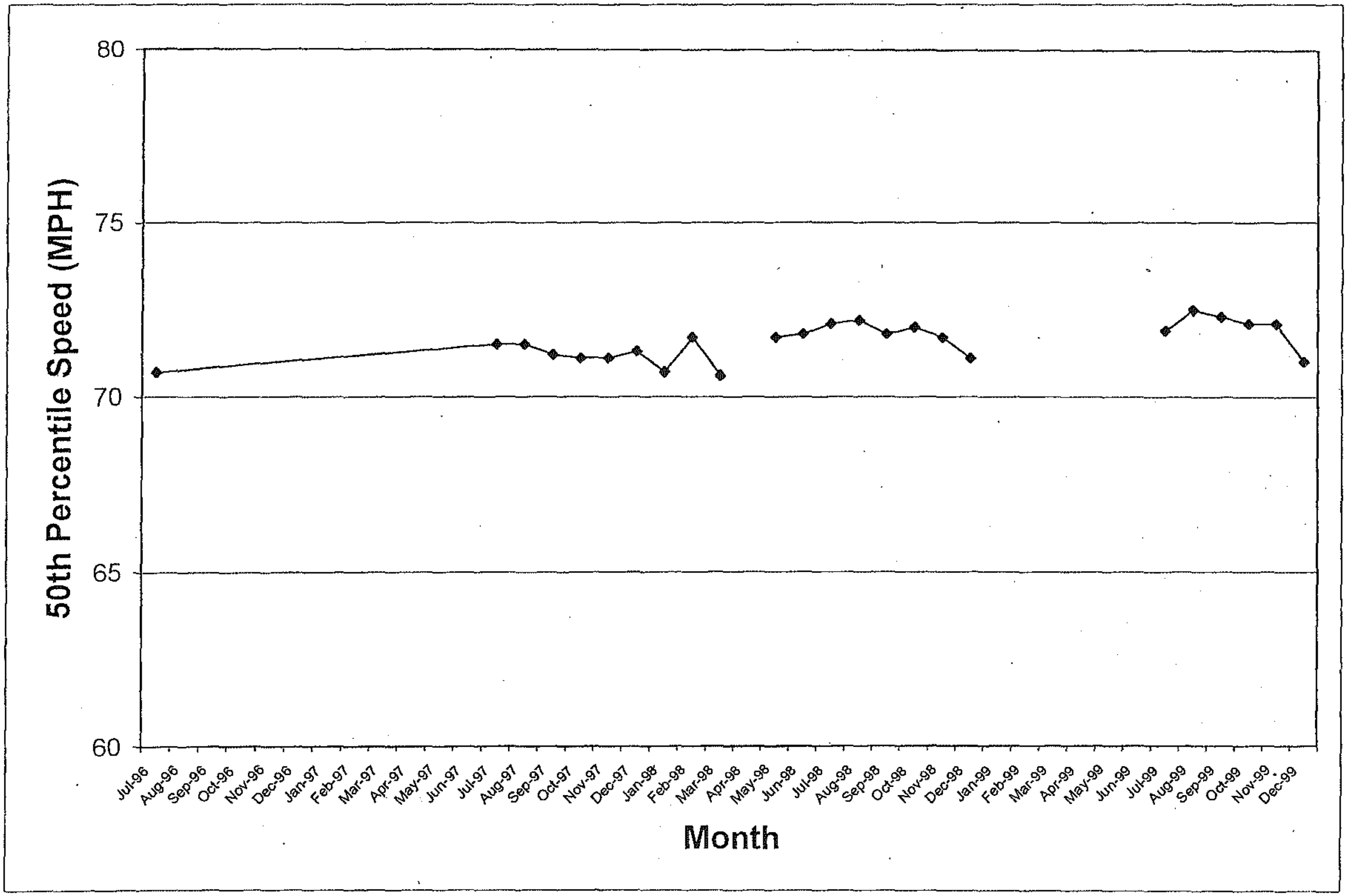
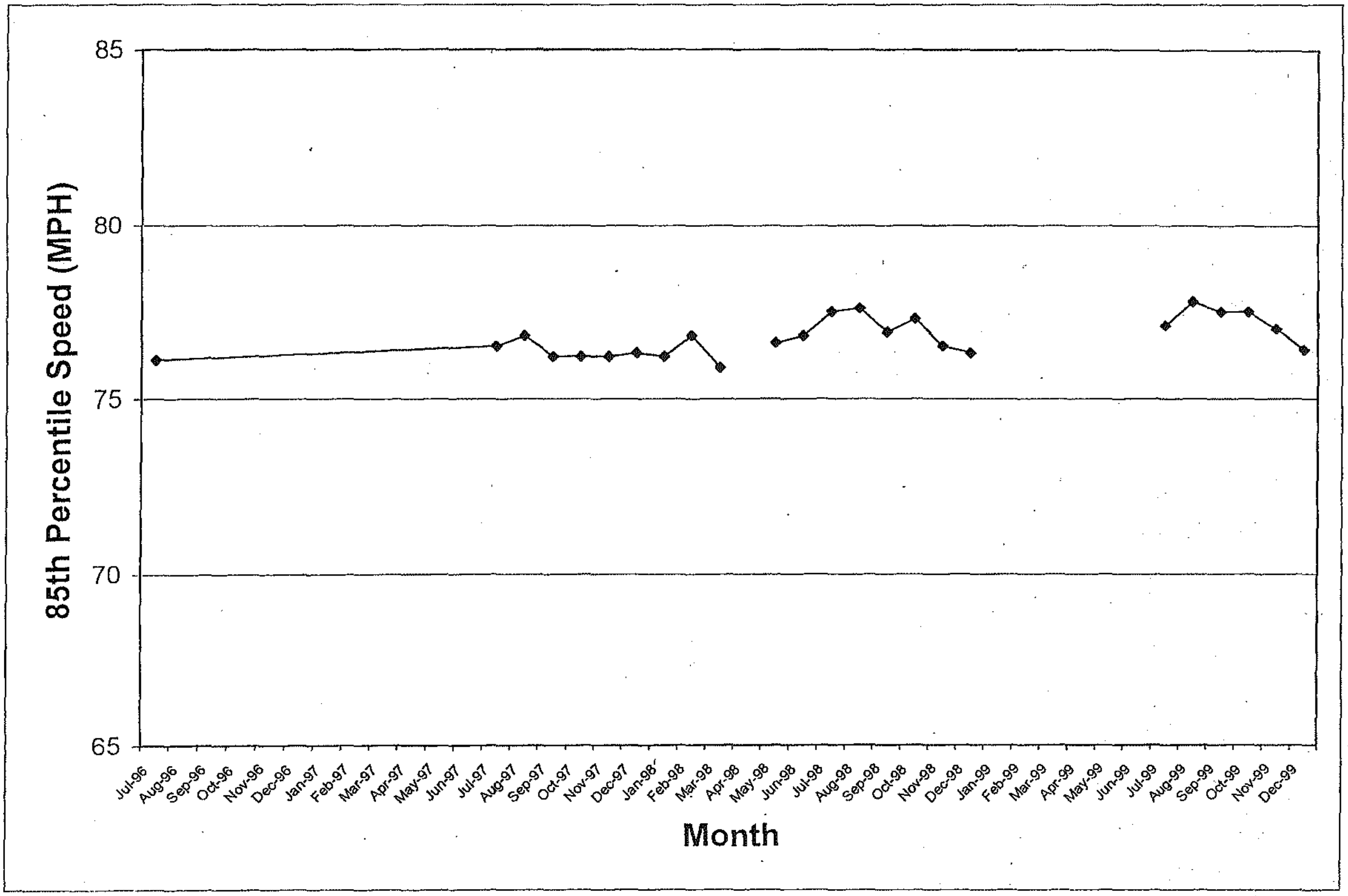


Figure 6: 85th Percentile Speed on I-75 in Roscommon County



THE IMPACT OF RAISING THE SPEED LIMIT ON FREEWAYS IN MICHIGAN

FINAL REPORT

VOLUME 1

By:

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The Impact of Raising the Speed Limit on Freeways in Michigan
Final Report

INTRODUCTION

In 1995 the US Congress determined that it was no longer necessary for the federal government to be involved in setting speed limits on the nations roads and streets, including the Interstate Highway System. In response to this change in the national policy, the Michigan Legislature passed a bill directing the Michigan Department of Transportation (MDOT) and the Michigan State Police (MSP) to designate 500 miles of rural freeway where the speed limit would be increased from 65 MPH to 70 MPH. These departments were to study the impact of this change on vehicle speeds and traffic crashes over a six-month period and report back to the legislature.

Michigan State University conducted the required impact study and concluded that there was a small increase in speed (1-2 MPH) at some locations but less than 1 MPH at most reporting stations. There was insufficient data to determine the impact on traffic crashes given the lag time in obtaining and processing traffic crash reports. The legislature then authorized the MDOT to raise the speed limit on an additional 1000 miles of rural freeways on January 1, 1997. Truck speeds remained at 55 MPH throughout the study period.

The study of the impact of the change in the speed limit was expanded to include these additional freeway segments. The results of this study after one year were presented to MDOT and the MSP in the summer of 1998 and the results after two years were presented in an interim report dated December 1999. This final report covers the results for the three years following the increase (January 1, 1997 through December 31, 1999), and it compares crashes for the three years before and three years after the change in the speed limit.

The 1500 miles of rural freeway included in this study is shown in Figure 1. The locations of the permanent count stations used to obtain speed and vehicle classification data are shown in Figure 2. Data from these counters are provided by the Transportation Planning division in a format designed for this study. Unfortunately, not all stations collect and transmit data every day. However, because of the very large data set, the missing data does not affect the results reported later in this report.

This report consists of four parts. The first is an analysis of speed changes between July 1996 and March 2000. The second is an analysis of traffic crashes for the three years immediately preceding the change in the speed limit and the three years immediately following the change. The third is a very brief discussion of the work conducted on freeway sections where the speed limit was raised to 65 MPH. The forth covers the model developed to predict the crash frequency at interchanges, and to identify interchanges that experience a greater frequency of crashes than predicted.

FIGURE 1: Freeways Included in the Study

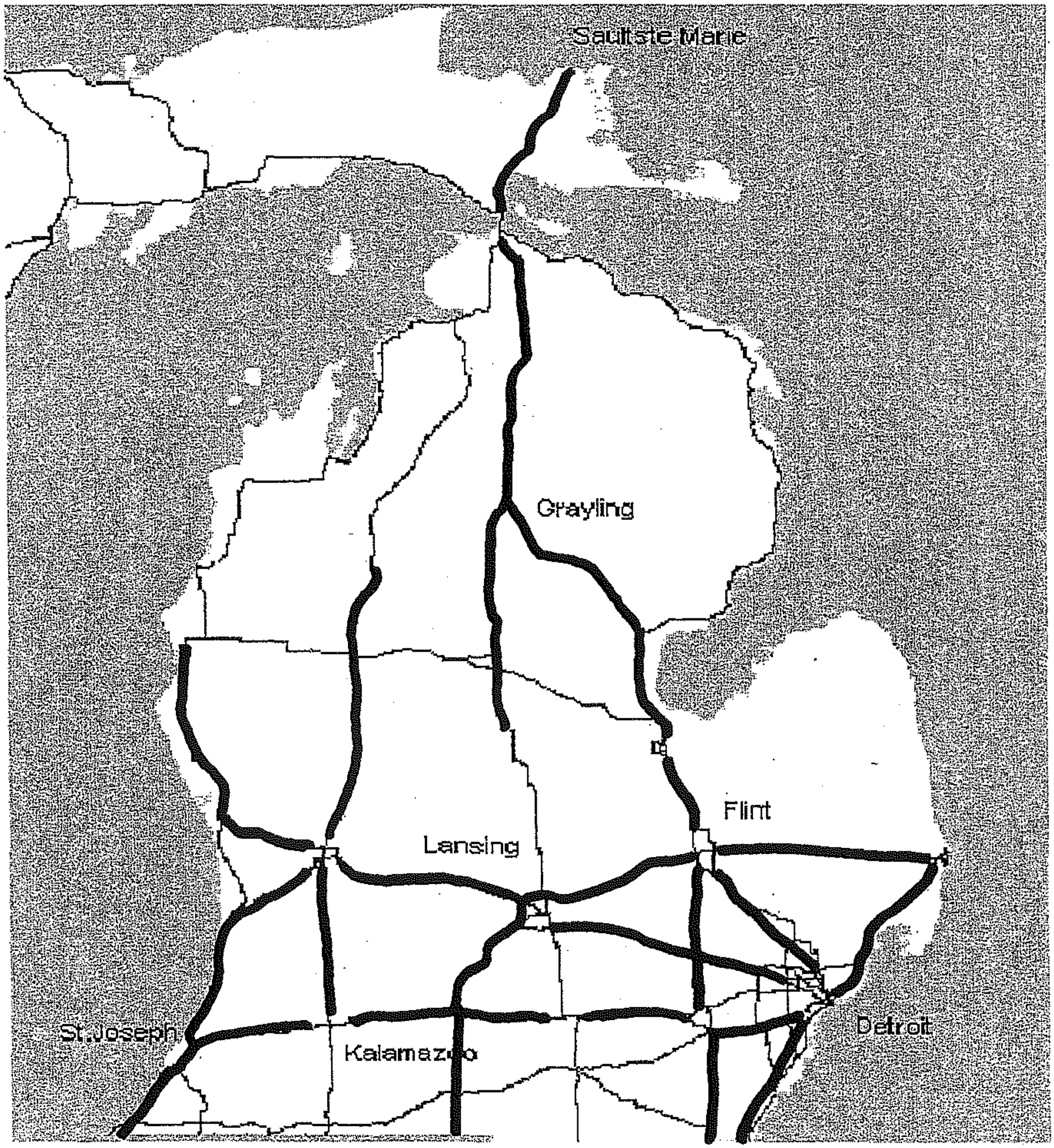
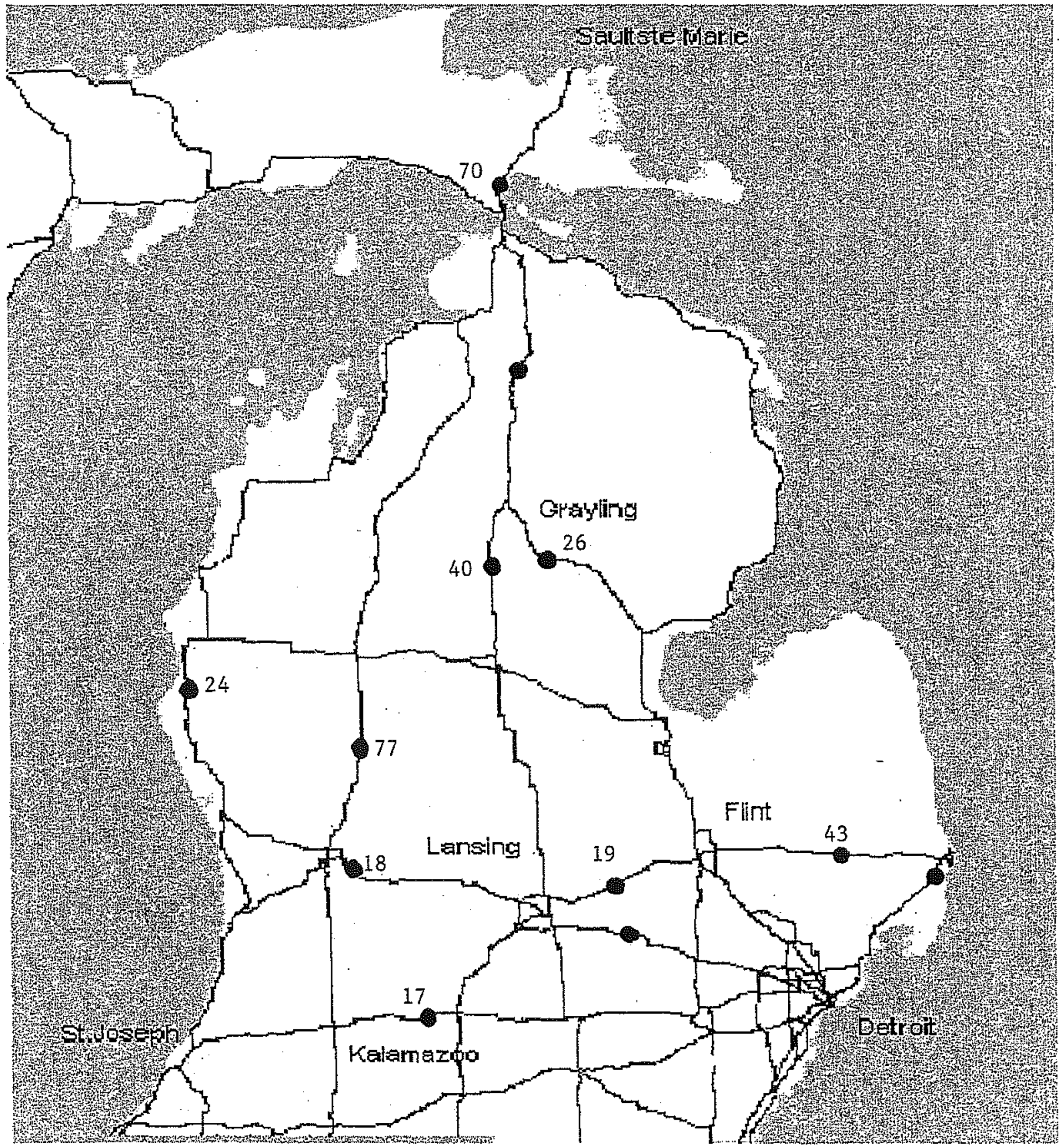


FIGURE 2: Location of Speed and Volume Detectors



SECTION 1 – ANALYSIS OF SPEED CHANGES

There were two concerns about the potential impact of raising the speed limit from 65 MPH to 70 MPH. The first concern was that this would result in an immediate increase in the speed that drivers chose to drive on the freeways. The second concern was that speeds would gradually increase over time (a phenomenon often referred to as speed creep).

The report that was submitted to the Department in December 1996 (1) addressed the first concern. Table 1.1, taken from the report, compares the 50th percentile and 85th percentile speeds for nine locations on the rural freeway systems. The before data represents the speed at these locations over 17 days in July 1996, before the speed limit was increased. The after data represents the speed at these same locations observed in August, September, and October of 1996.

Table 1.1: Test Sites Before and After – 50th and 85th Percentile Speeds

	Speed Limit		Volume		50th Percentile Speeds			85th Percentile Speeds		
	Before	After	Before	After	Before	After	Change	Before	After	Change
Intercity										
I-96 Cascades	65	70	428,940	2,355,659	70.0	70.7	0.7	75.0	75.6	0.6
I-94 Port Huron	65	70	54,378	1,354,147	65.4	68.4	3.0	73.3	74.9	1.6
I-69 Looking Glass River	65	70	431,714	2,447,888	71.2	72.3	1.1	76.9	76.7	-0.2
I-69 Capac	65	70	204,253	973,371	68.5	69.7	1.2	74.4	75.5	1.1
I-69 Swartz Creek	65	70	543,475	3,015,242	70.1	71.1	1.0	76.5	76.9	0.4
Recreational										
US-131 Morley	65	70	210,643	1,313,529	68.4	69.6	1.2	73.7	74.2	0.5
I-75 Prudenville	65	70	313,398	1,399,936	70.7	71.9	1.2	76.1	77.0	0.9
I-75 St. Ignace	65	70	135,403	291,718	70.1	70.2	0.1	76.5	76.7	0.2
I-75 Vanderbilt	65	70	284,448	1,387,627	67.0	68.2	1.2	72.8	73.6	0.8

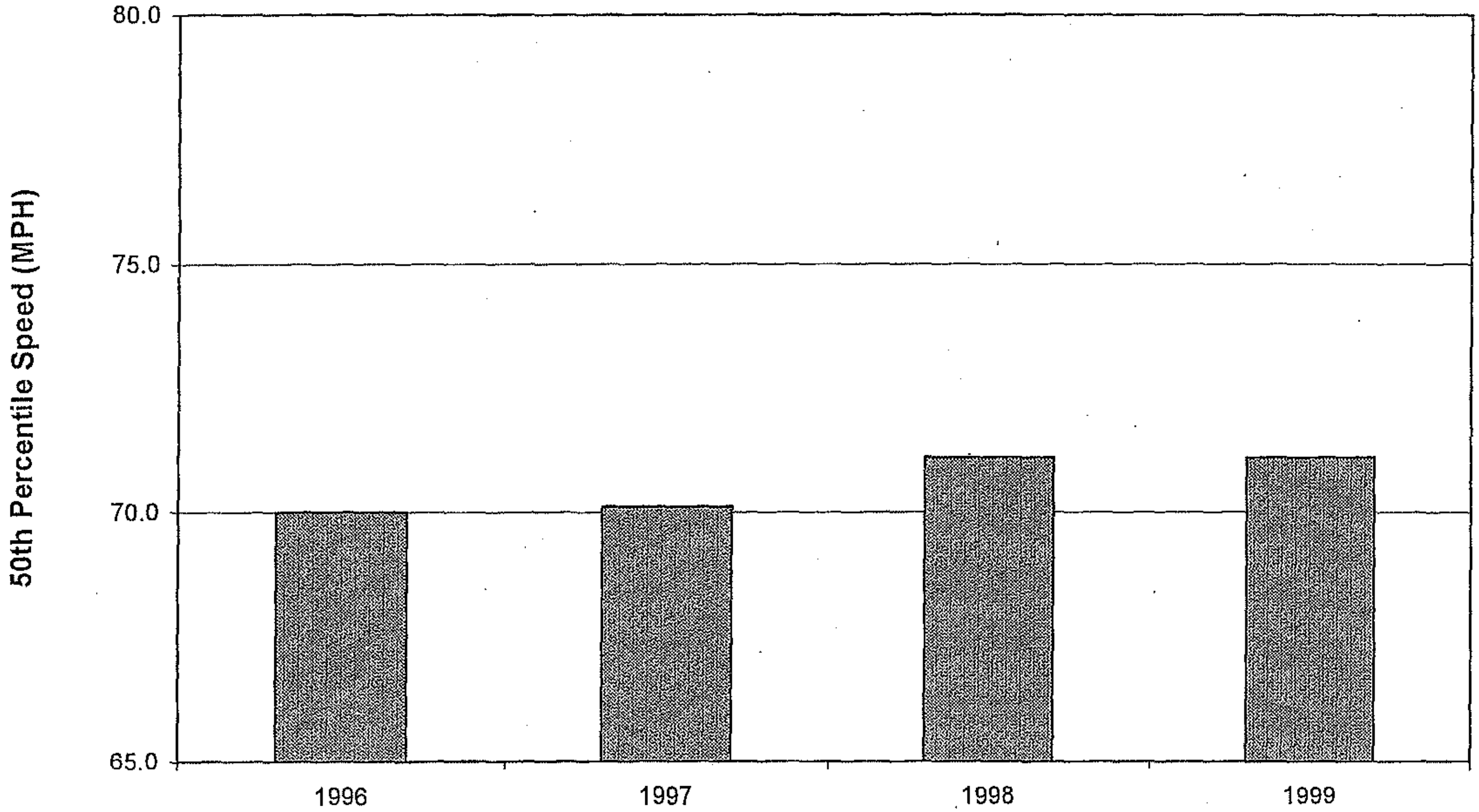
The average increase in the 50th percentile speed at these nine locations was 1.2 MPH. The average increase in the 85th percentile speed was only 0.7 MPH. The average increase in the 50th and 85th percentile speeds between July 1996 and July 1997, as shown in Figure 1.1, was 0.5 MPH. Thus, there is no evidence that the higher speed limit resulted in drivers choosing significantly higher speeds. In fact, this can not even be interpreted as an increase because, as shown in Appendix A, month to month differences of this magnitude occur at each of the locations included in this study.

Figures 1.2 to 1.13 show the 50th and 85th percentile speed at each of the permanent counter stations for July 1996, July 1997, July 1998 and July 1999. These figures show that there has been a slight increase in speed at each of the study locations, but it does not appear that this represents the phenomenon known as speed creep.

Figures 1.14 to 1.27 are plots of the 50th and 85th percentile speed for each month between July 1997 and March 2000. While there are month to month variations, there is no discernable trend toward increased speeds shown in these figures.

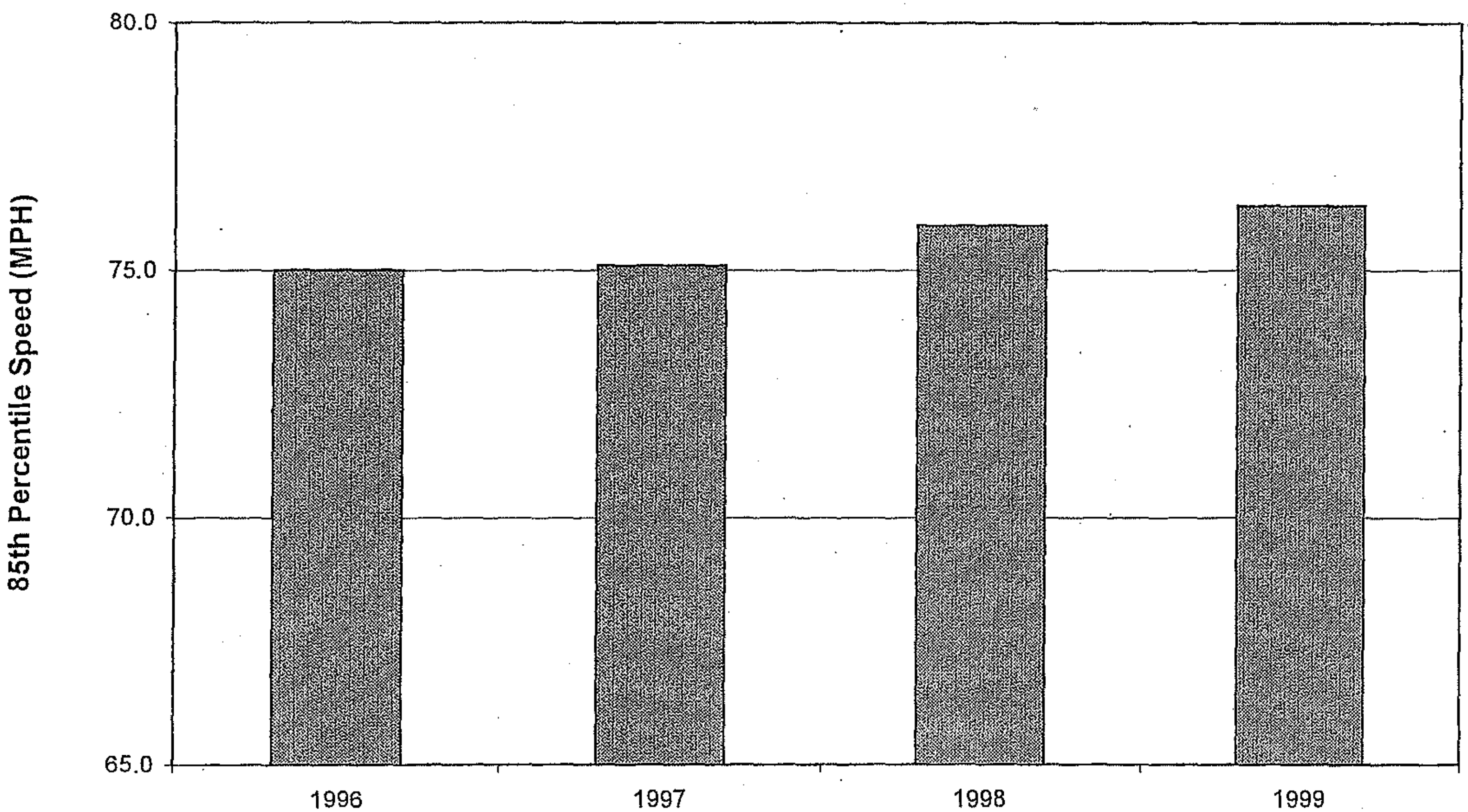
The distribution of speeds as represented by the 5th, 15th, 50th, 85th and 95th percentile speeds are shown in tabular form in Appendix A. These tables separate the vehicles into automobiles and light trucks (vehicle type 101), heavy trucks (vehicle type 103) and recreational vehicles and medium trucks (vehicle type 102). The speeds for heavy trucks and recreational vehicles reported by counter number 70 spd are not correct. An accuracy check was made at all counter locations, and it was determined that the conversion from time between axle detections to speeds for the large vehicles at this station is not correct. All other counters were found to be calibrated correctly.

Figure 1.2 : 50th Percentile Speed in July of Each Year on I-96



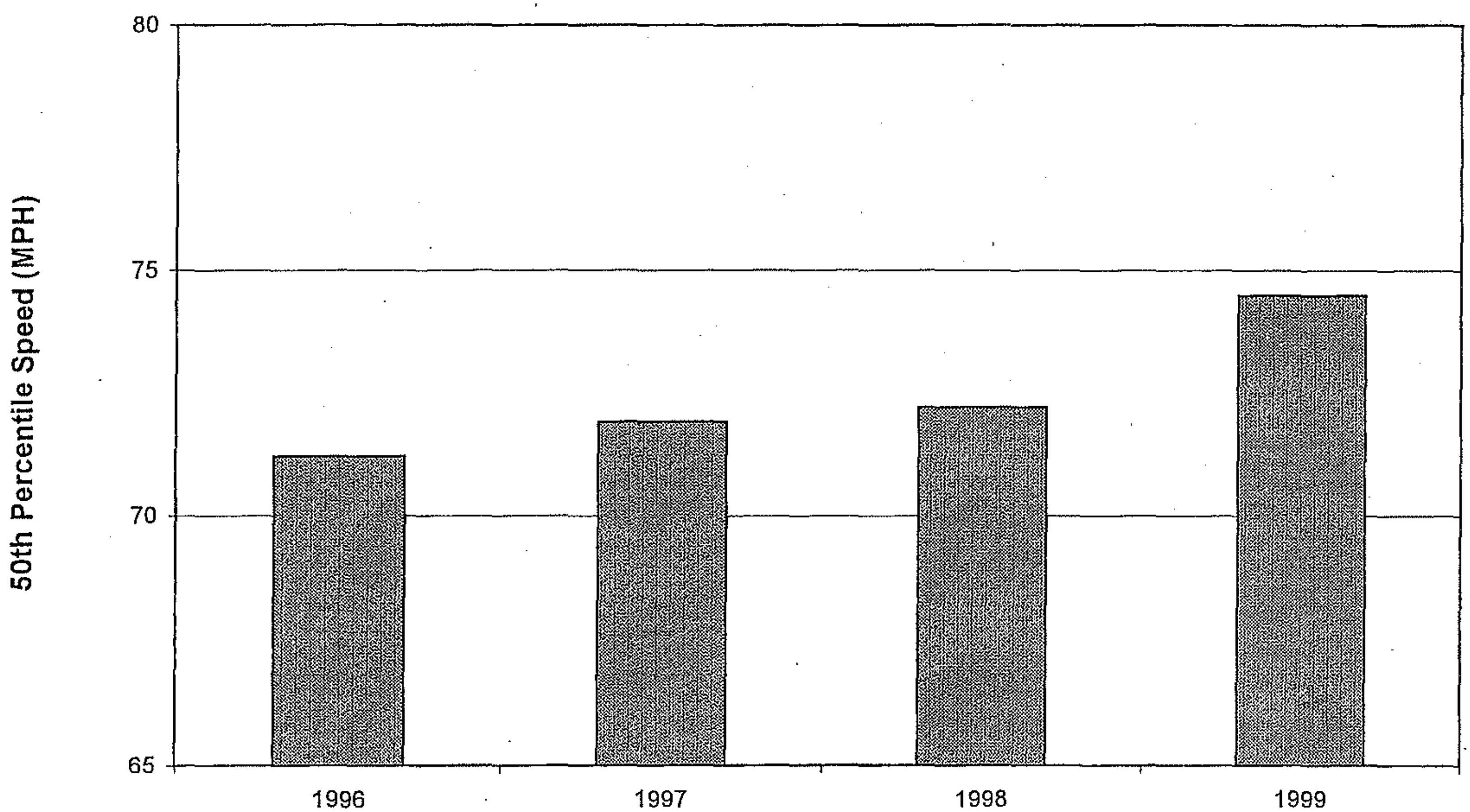
	Jul-96	Jul-97	Jul-98	Jul-99
18spd	70.0	70.1	71.1	71.1

Figure 1.3 : 85th Percentile Speed in July of Each Year on I-96



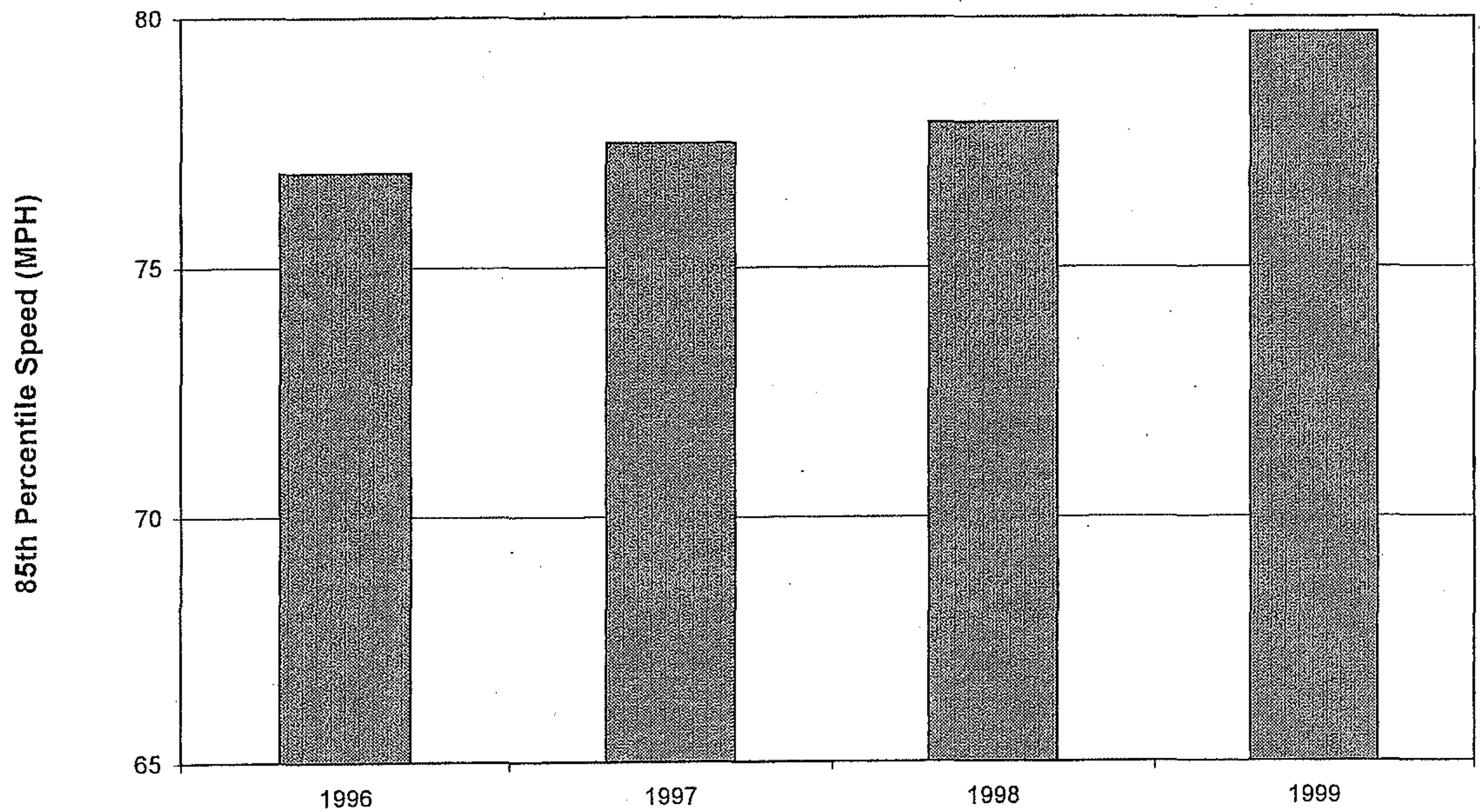
	Jul-96	Jul-97	Jul-98	Jul-99
18spd	75.0	75.1	75.9	76.3

Figure 1.4 : 50th Percentile Speed in July of Each Year on I-69



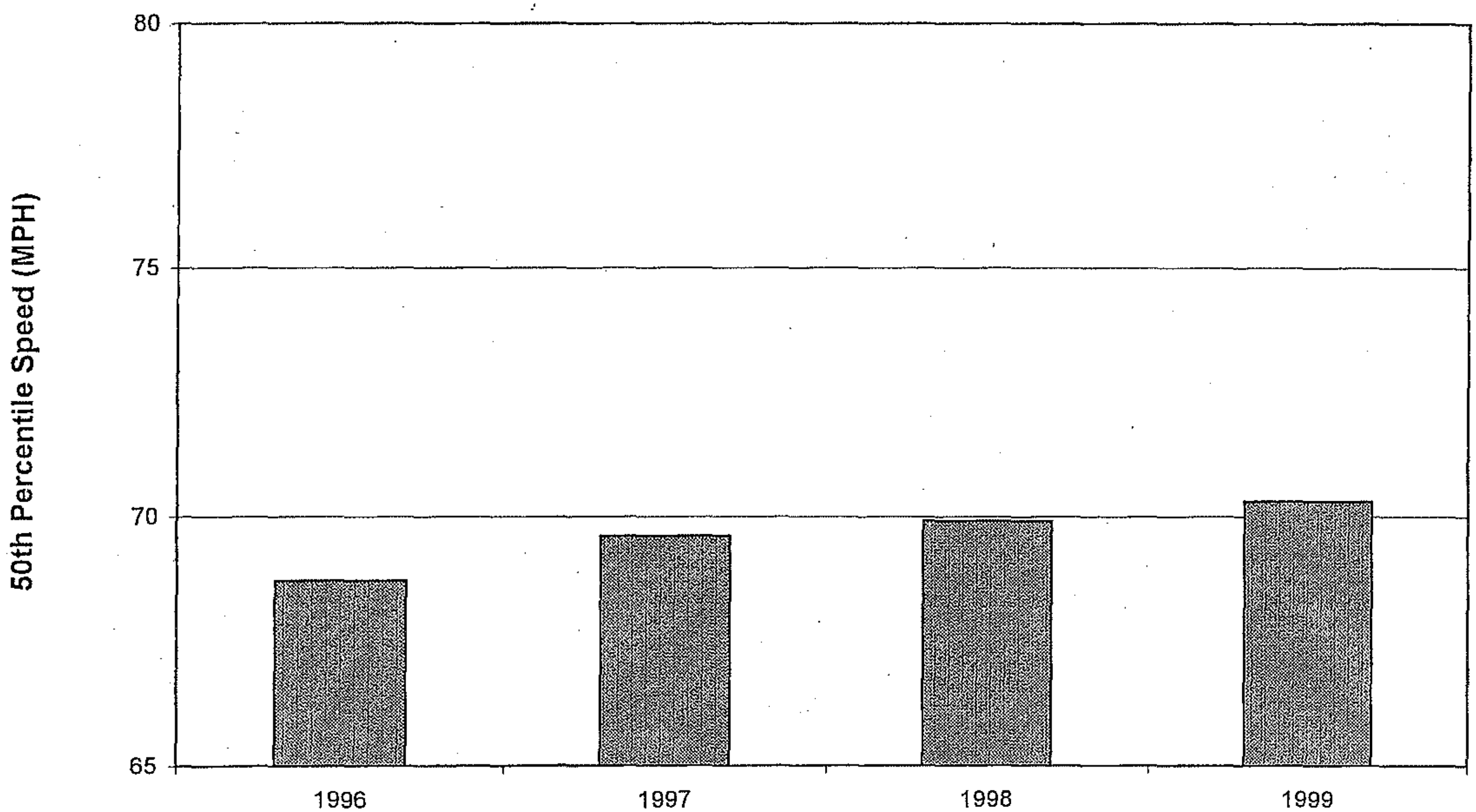
	Jul-96	Jul-97	Jul-98	Jul-99
19spd	71.2	71.9	72.2	74.5

Figure 1.5 : 85th Percentile Speed in July of Each Year on I-69



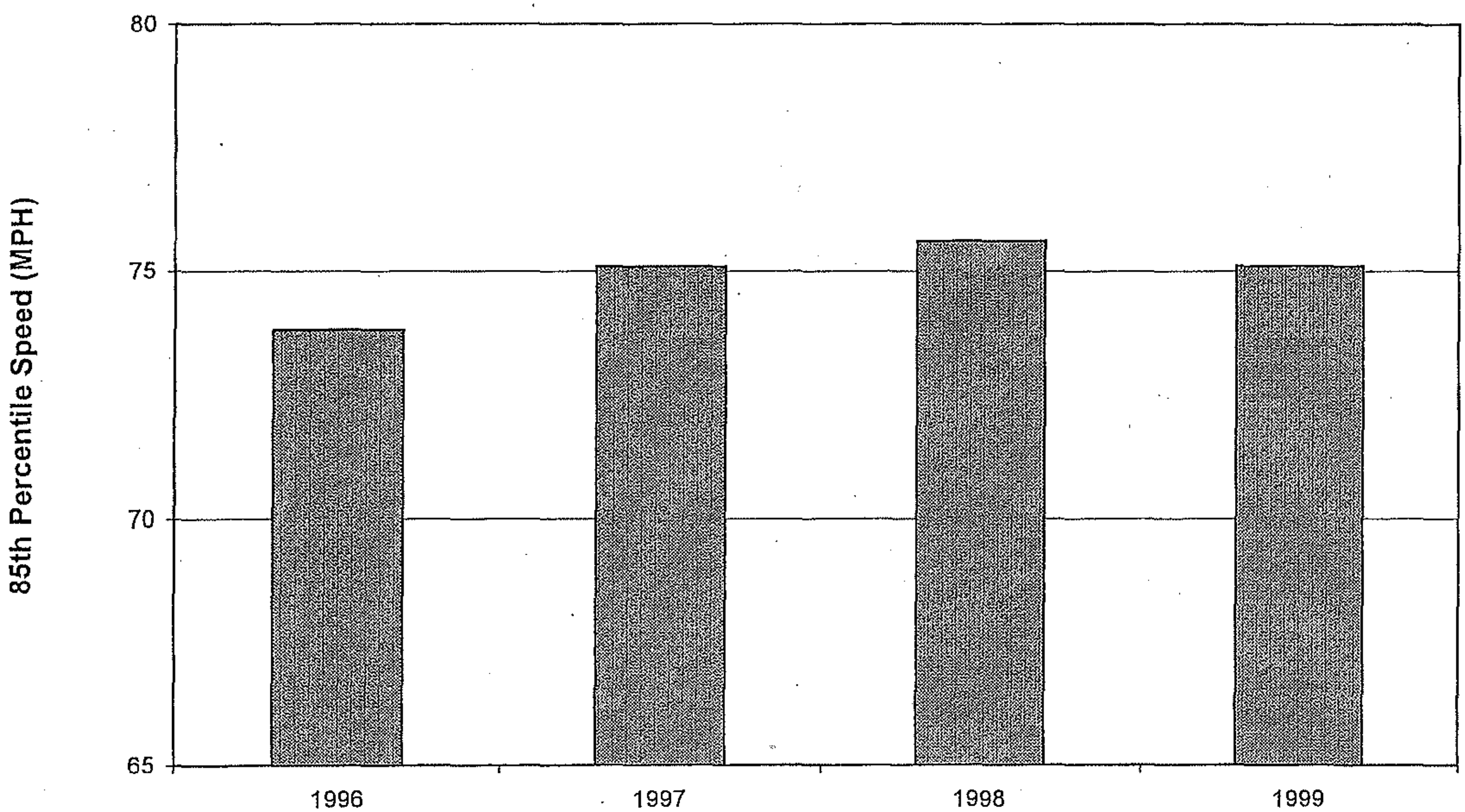
	Jul-96	Jul-97	Jul-98	Jul-99
19spd	76.9	77.5	77.9	79.7

Figure 1.6 : 50th Percentile Speed in July of Each Year on US-31



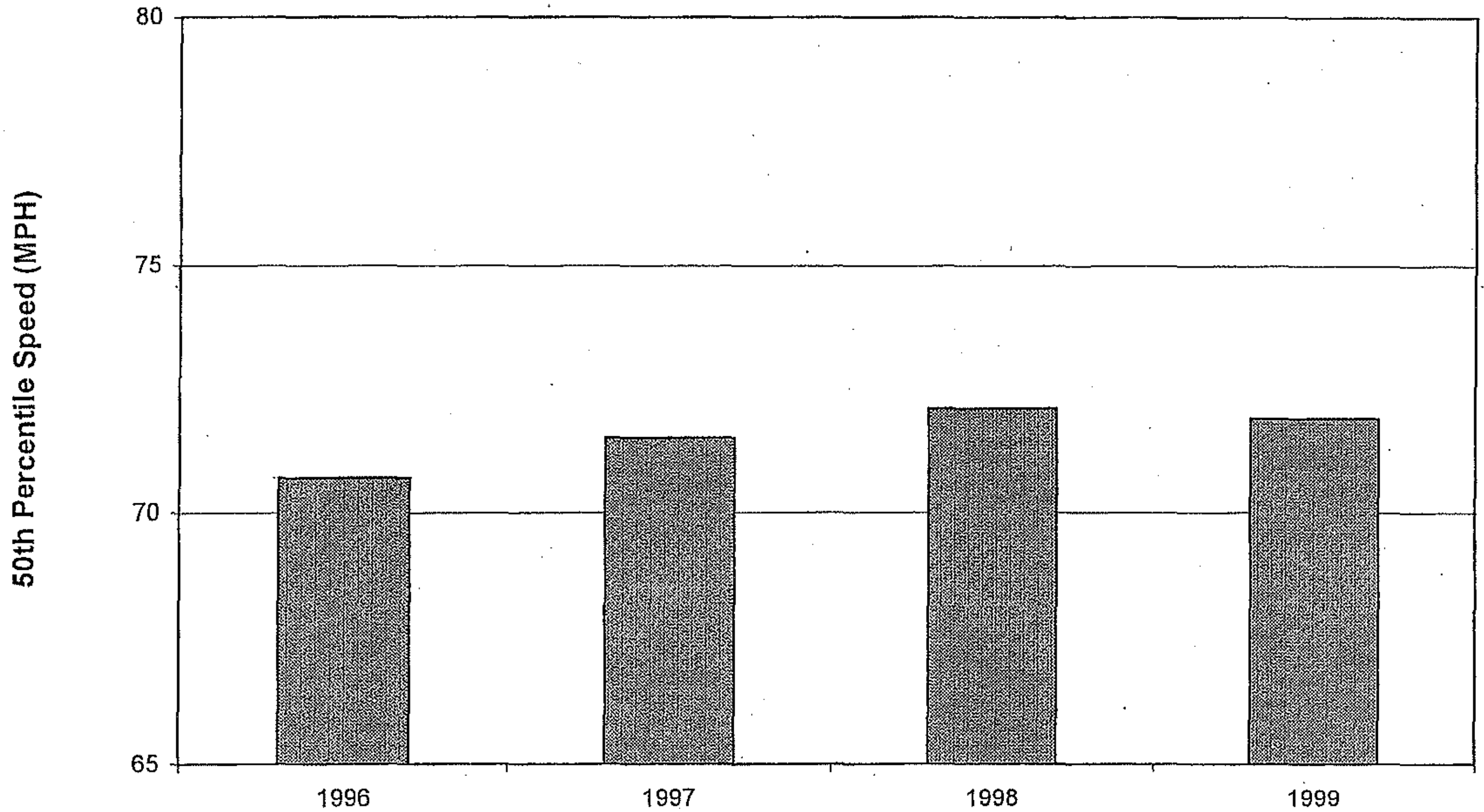
	Jul-96	Jul-97	Jul-98	Jul-99
24spd	68.7	69.6	69.9	70.3

Figure 1.7 : 85th Percentile Speed in July of Each Year on US-31



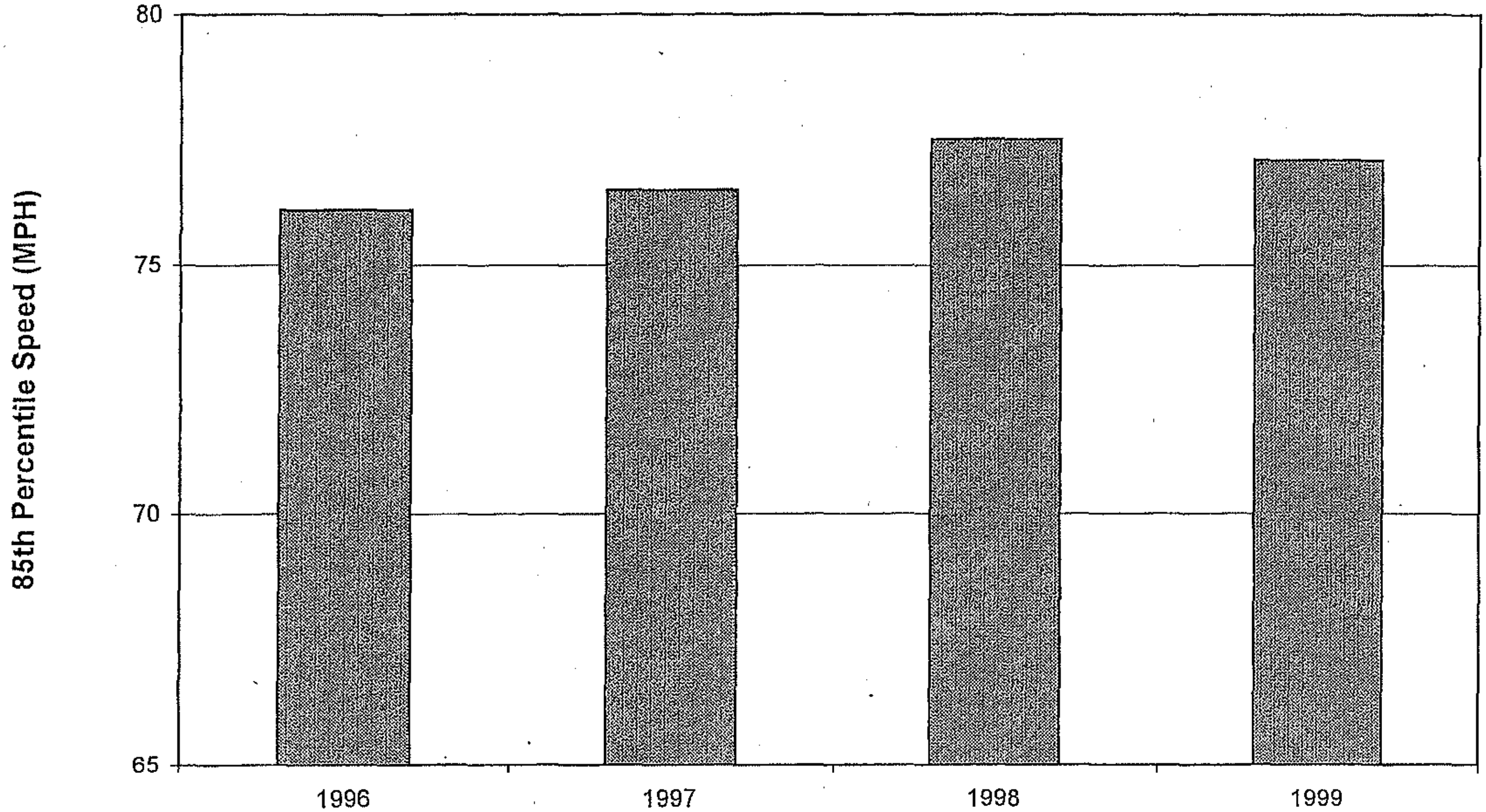
	Jul-96	Jul-97	Jul-98	Jul-99
24spd	73.8	75.1	75.6	75.1

Figure 1.8 : 50th Percentile Speed in July of Each Year on I-75



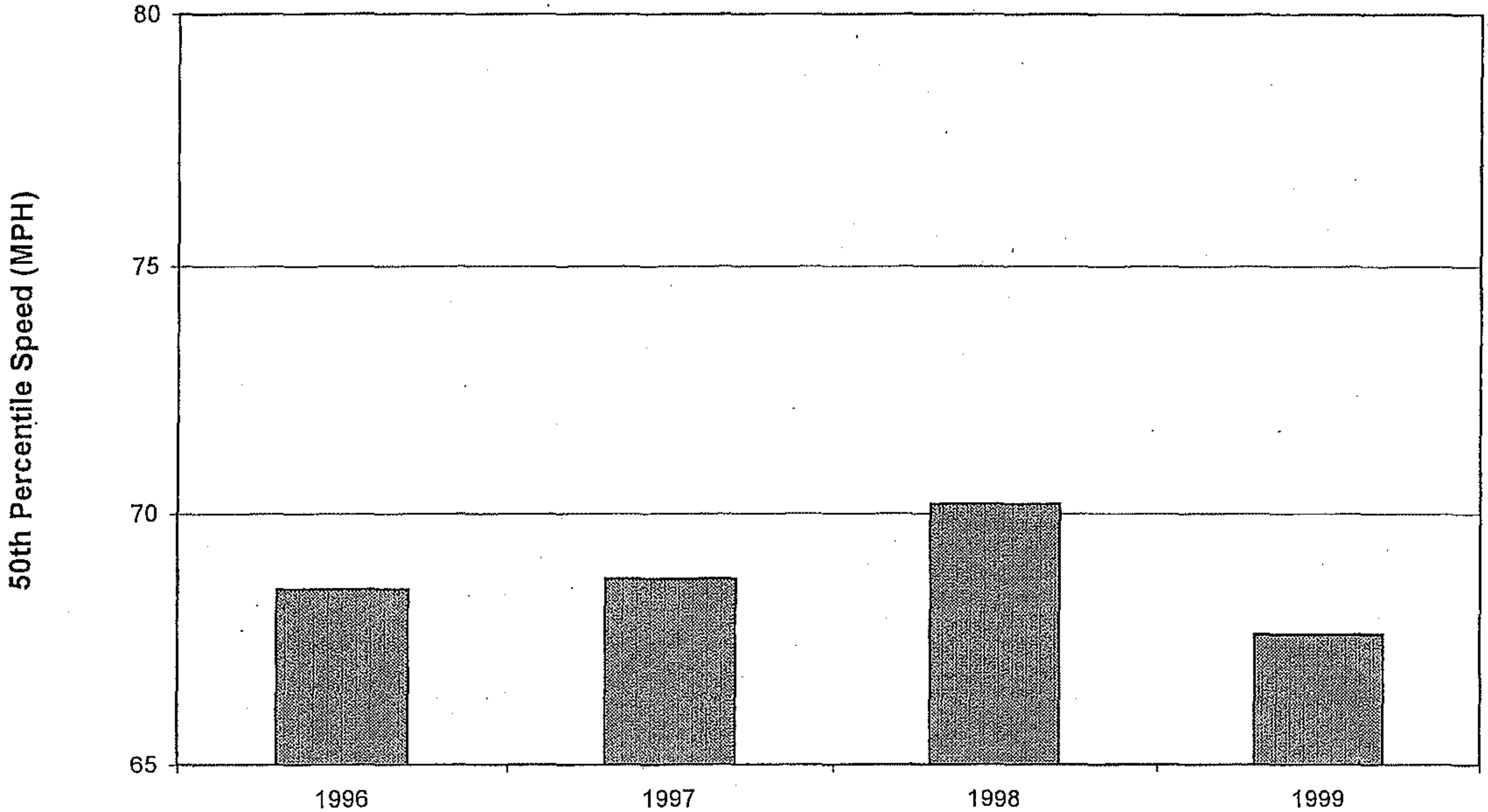
	Jul-96	Jul-97	Jul-98	Jul-99
26spd	70.7	71.5	72.1	71.9

Figure 1.9 : 85th Percentile Speed in July of Each Year on I-75



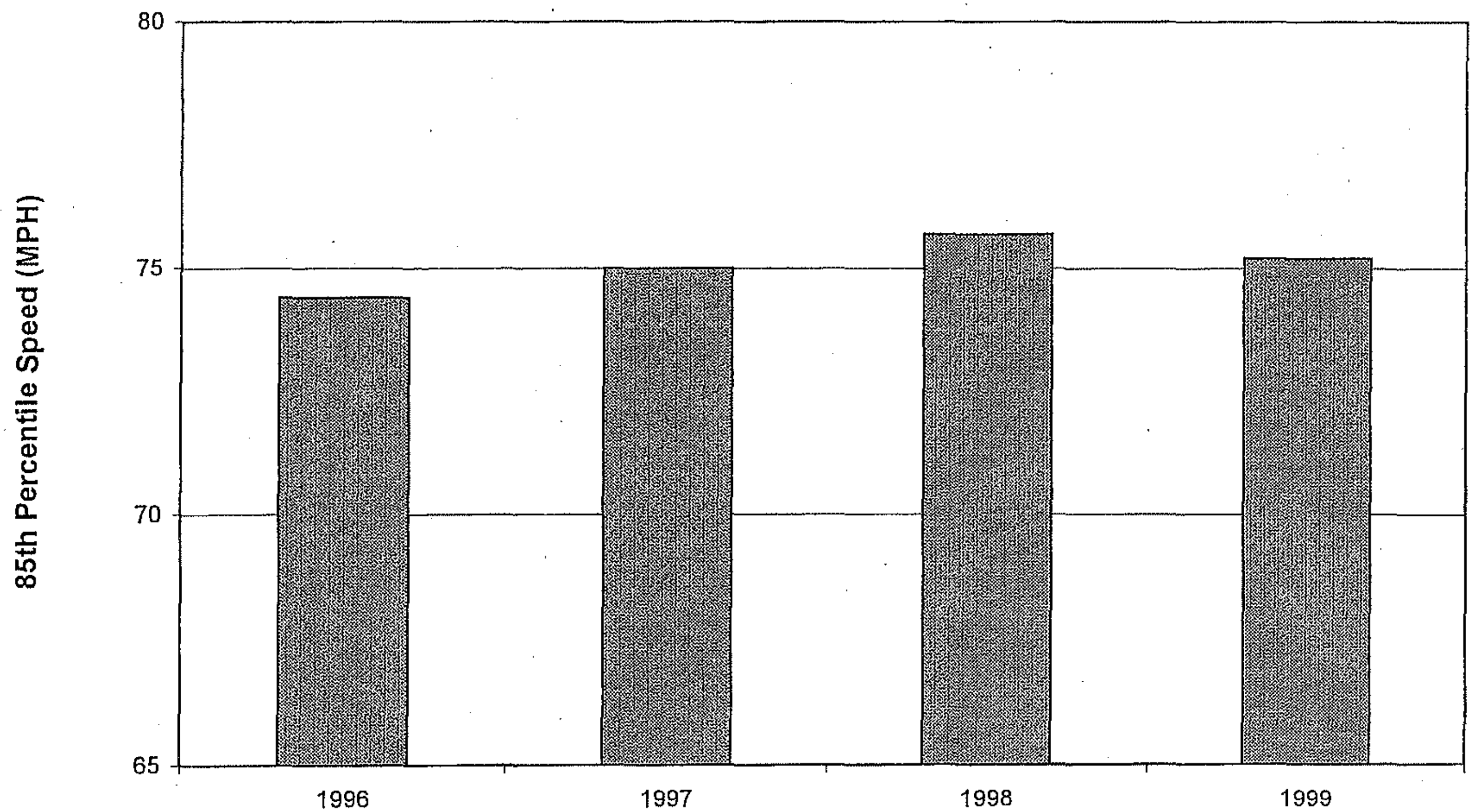
	Jul-96	Jul-97	Jul-98	Jul-99
26spd	76.1	76.5	77.5	77.1

Figure 1.10 : 50th Percentile Speed in July of Each Year on I-69



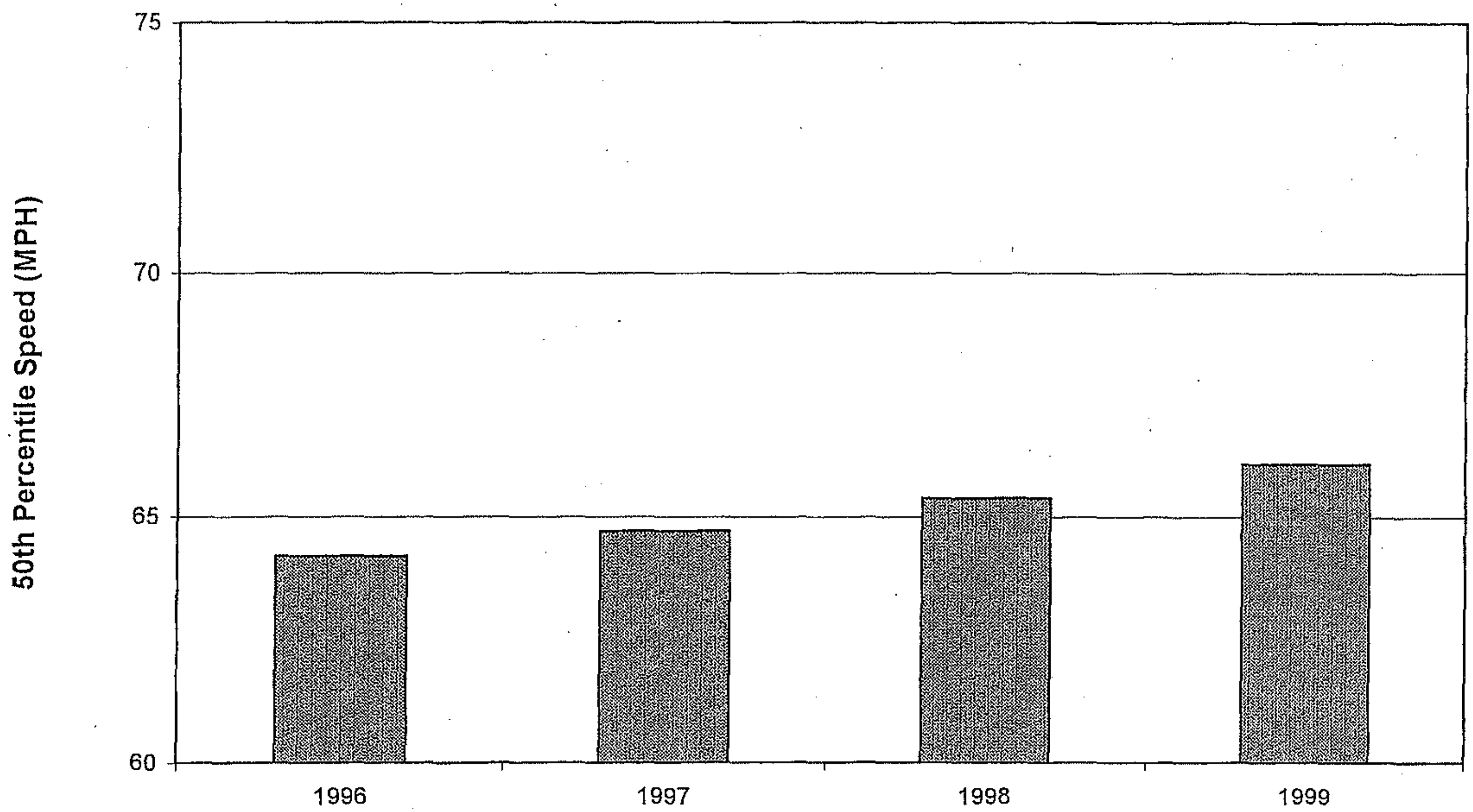
	Jul-96	Jul-97	Jul-98	Jul-99
43spd	68.5	68.7	70.2	67.6

Figure 1.11 : 85th Percentile Speed in July of Each Year on I-69



	Jul-96	Jul-97	Jul-98	Jul-99
43spd	74.4	75.0	75.7	75.2

Figure 1.12 : 50th Percentile Speed in July of Each Year on US-131



	Jul-96	Jul-97	Jul-98	Jul-99
77spd	64.2	64.7	65.4	66.1

Figure 1.13 : 85th Percentile Speed in July of Each Year on US-131

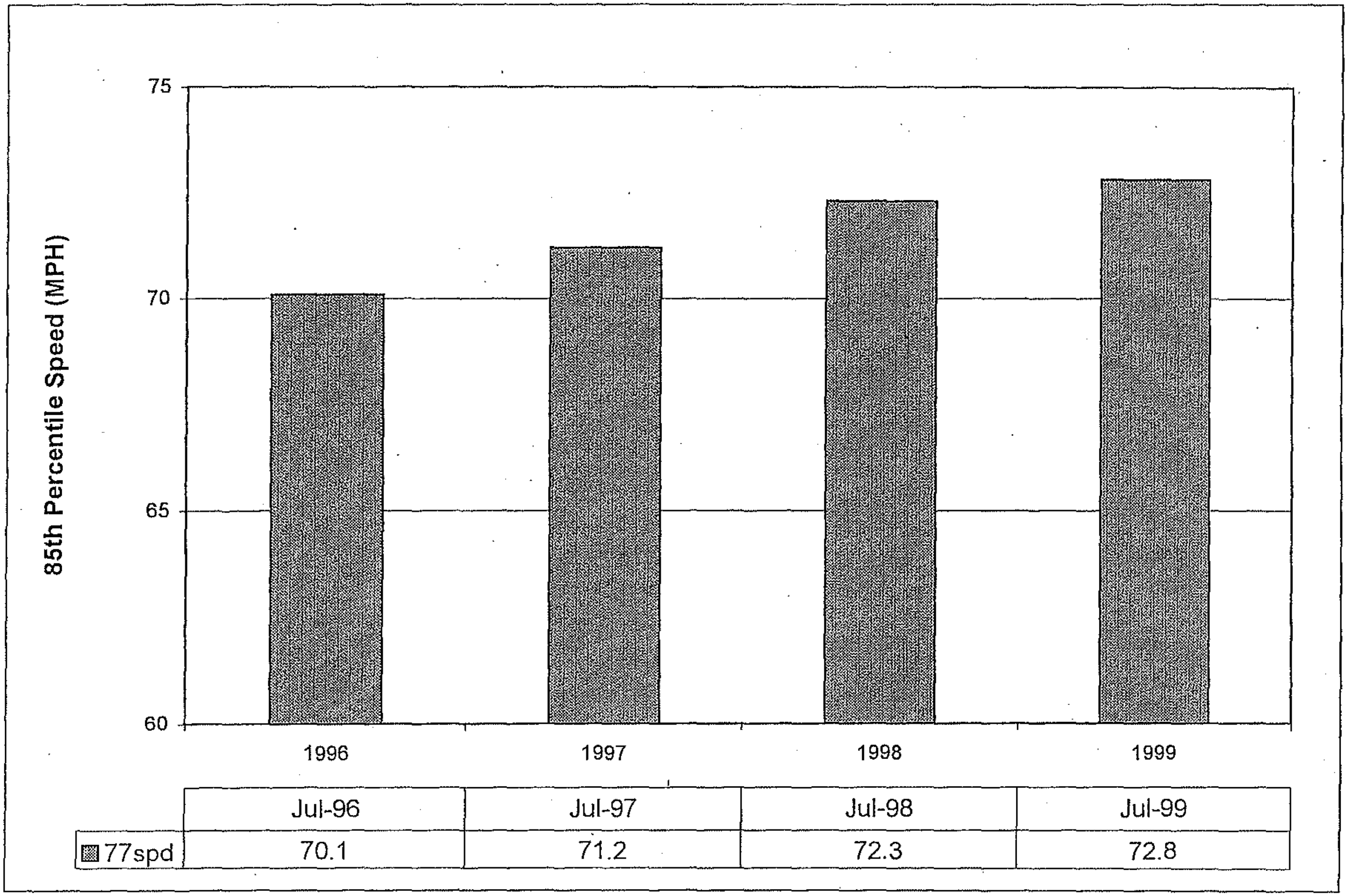


Figure 1.14 : Speed Data on I-94 in Calhoun County (50th Percentile)

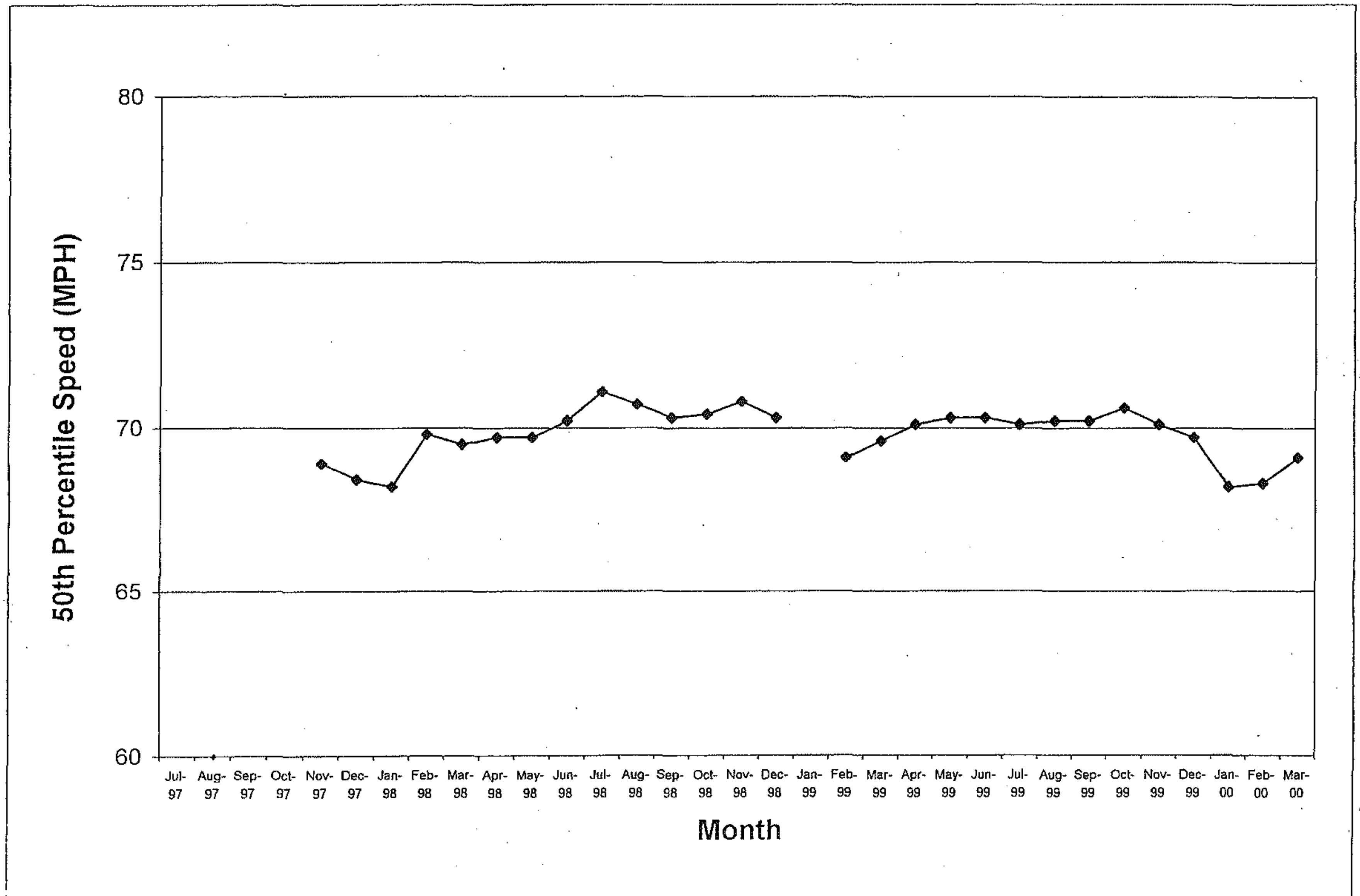


Figure 1.15 : Speed Data on I-94 in Calhoun County (85th Percentile)

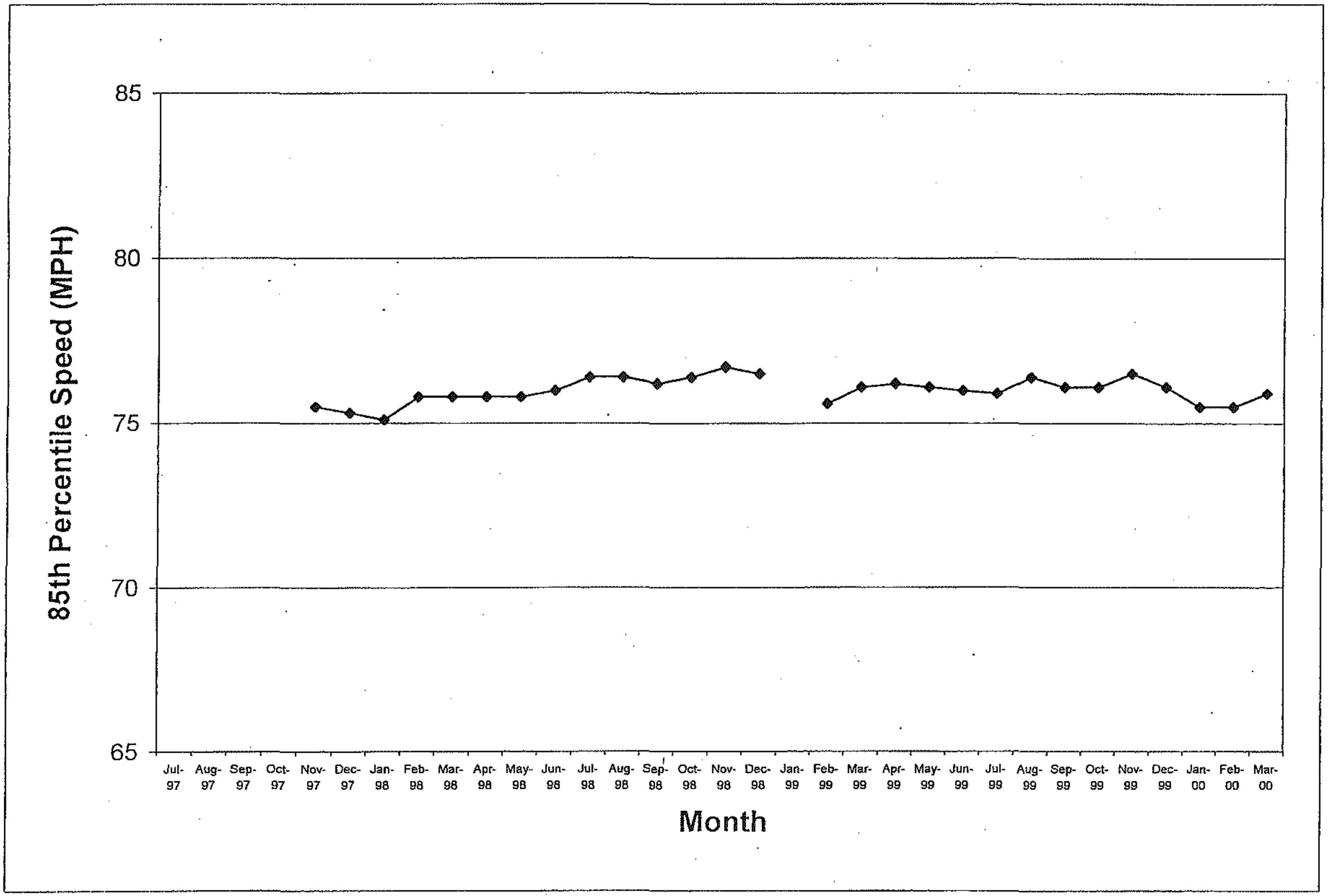


Figure 1.16 : Speed Data on I-96 in Kent County (50th Percentile)

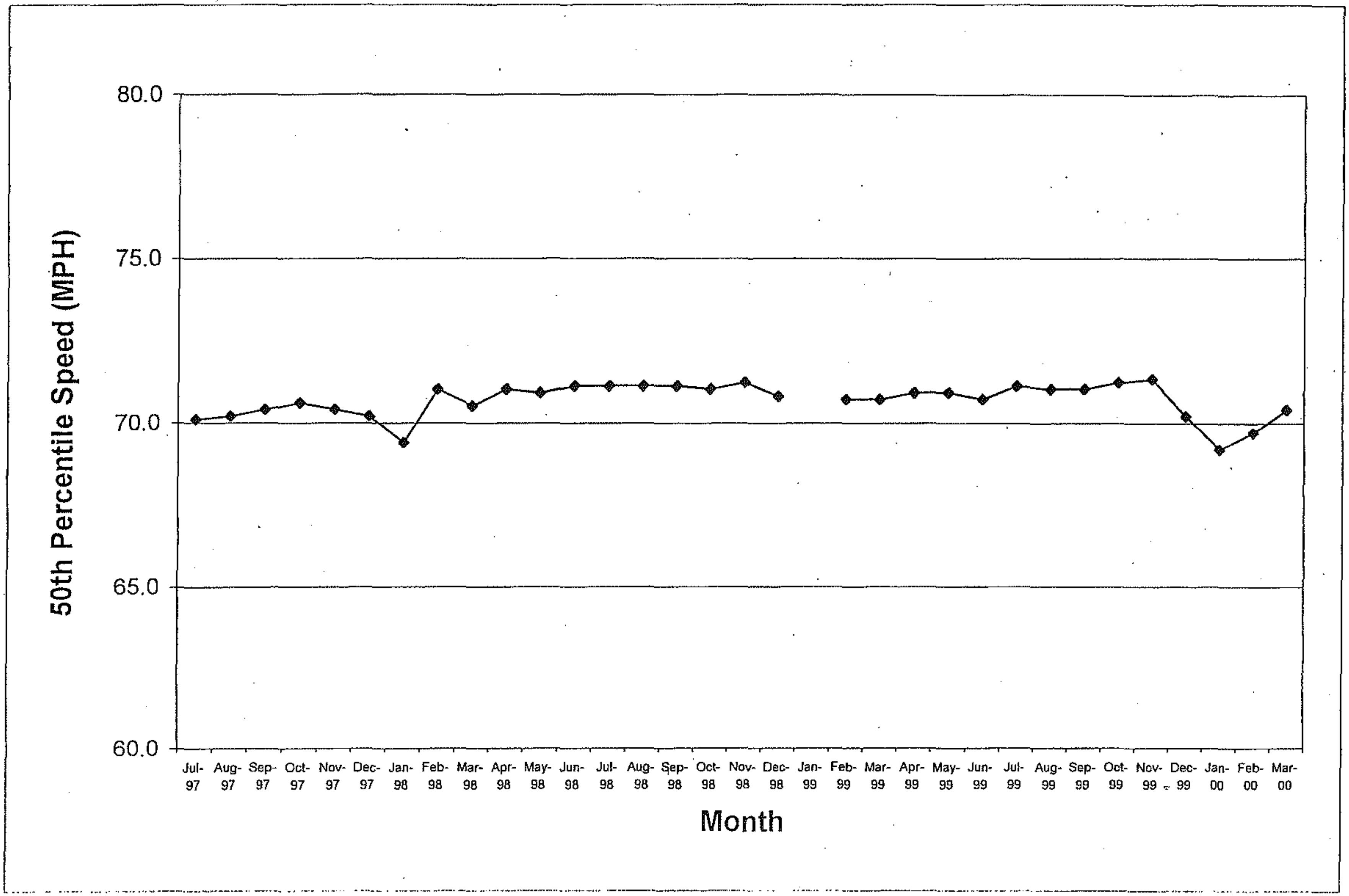


Figure 1.17 : Speed Data on I-96 in Kent County (85th Percentile)

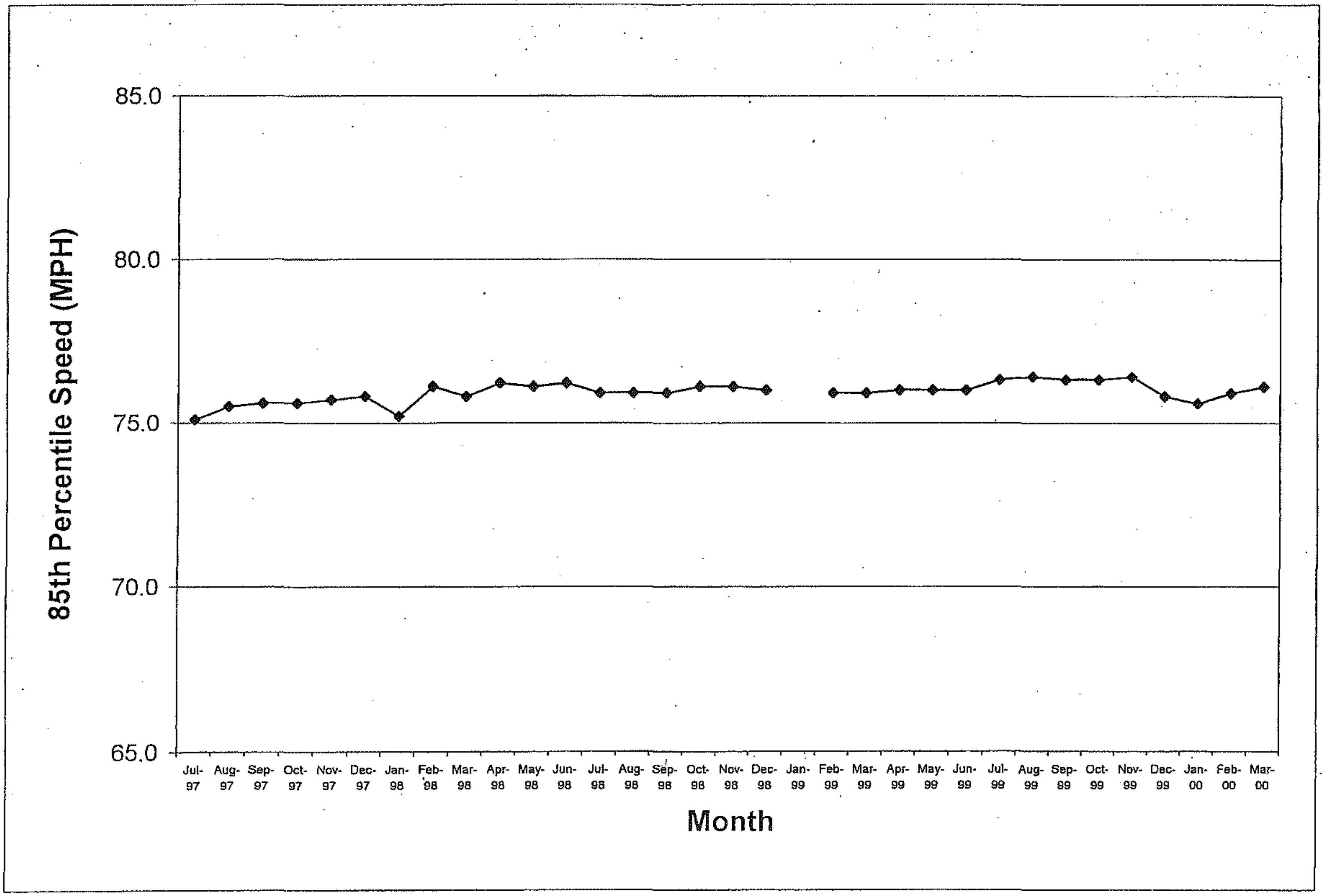


Figure 1.18 : Speed Data on I-69 in Shiawassee County (50th Percentile)

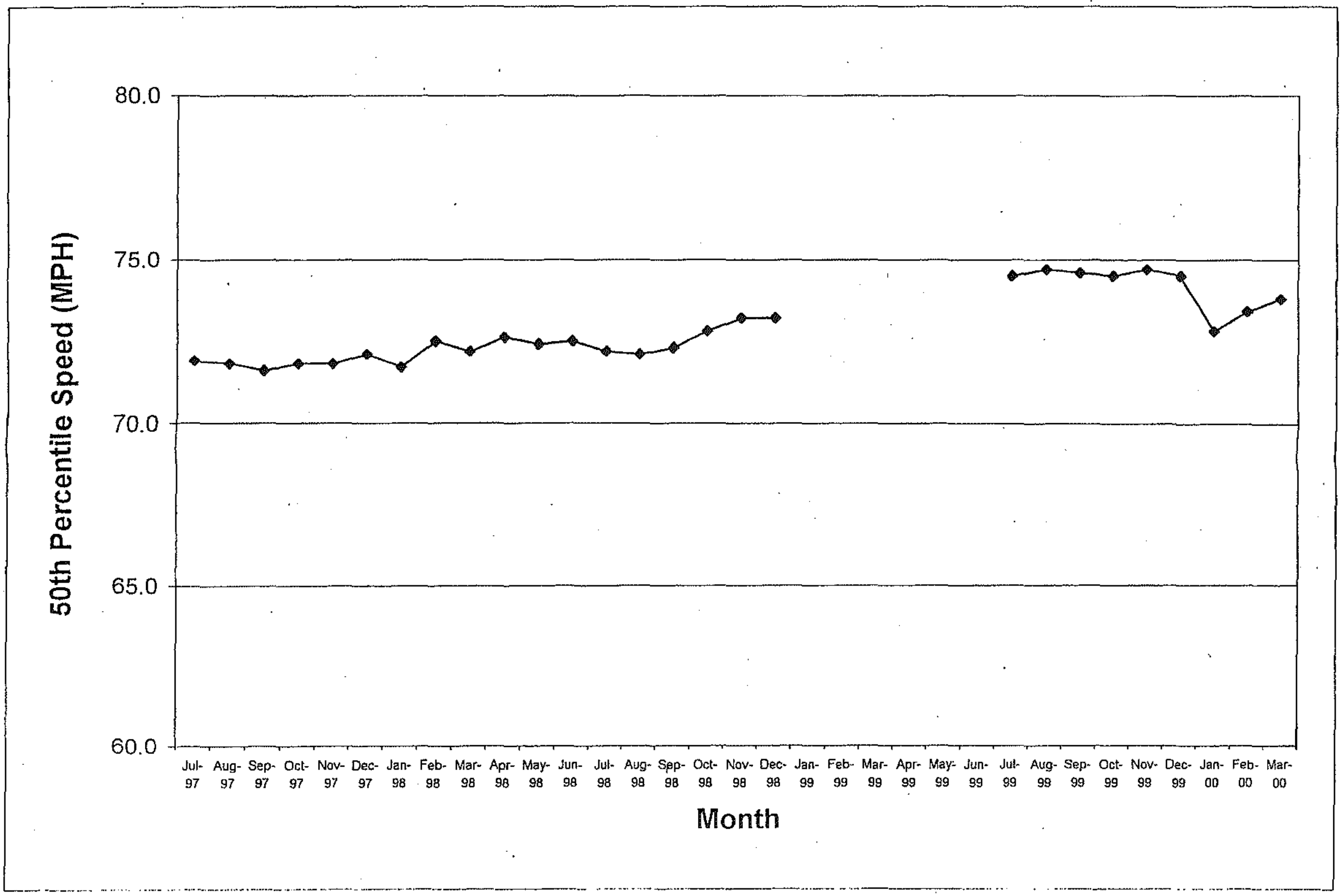


Figure 1.19 : Speed Data on I-69 in Shiawassee County (85th Percentile)

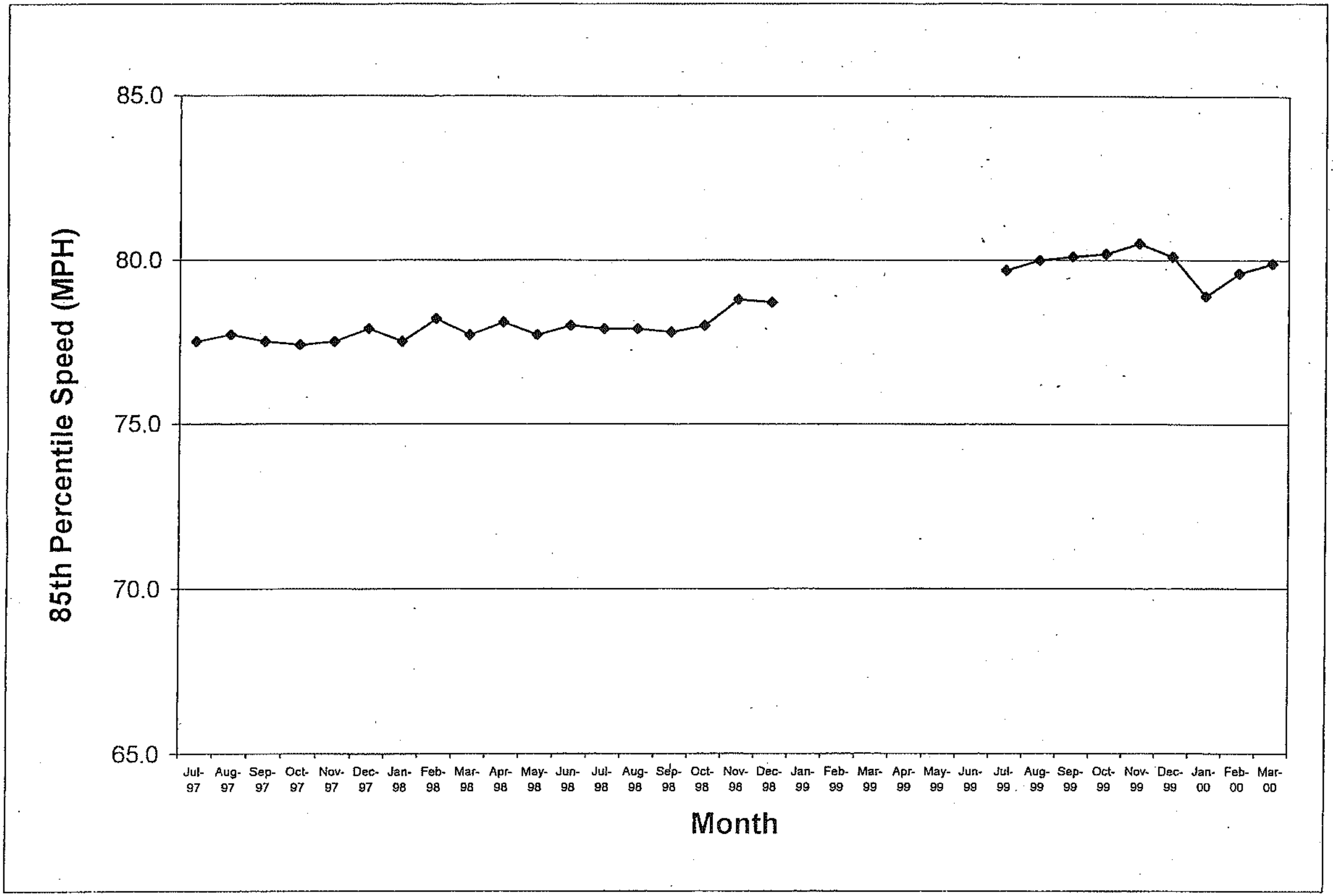


Figure 1.20 : Speed Data on US-31 in Oceana County (50th Percentile)

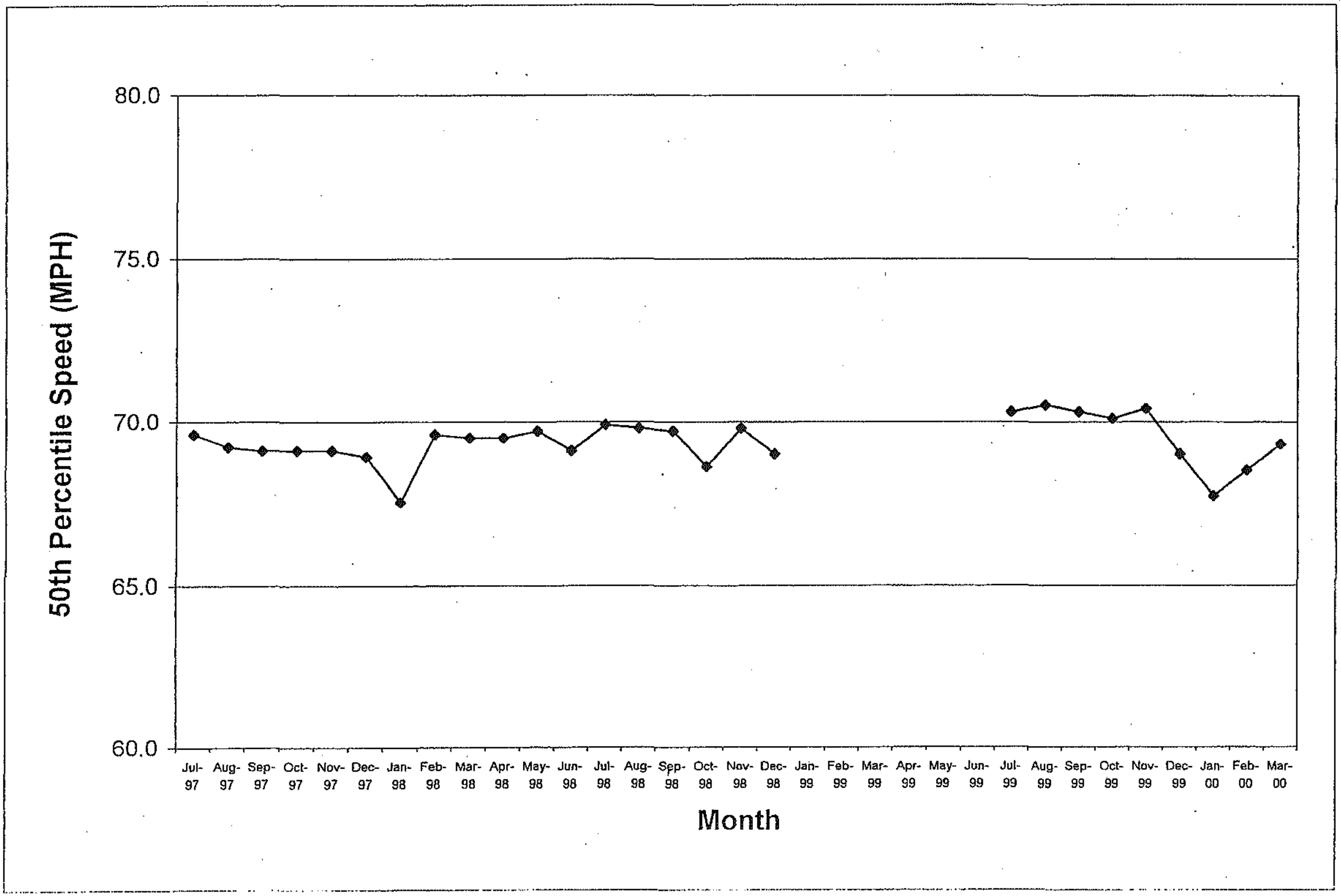


Figure 1.21 : Speed Data on US-31 in Oceana County (85th Percentile)

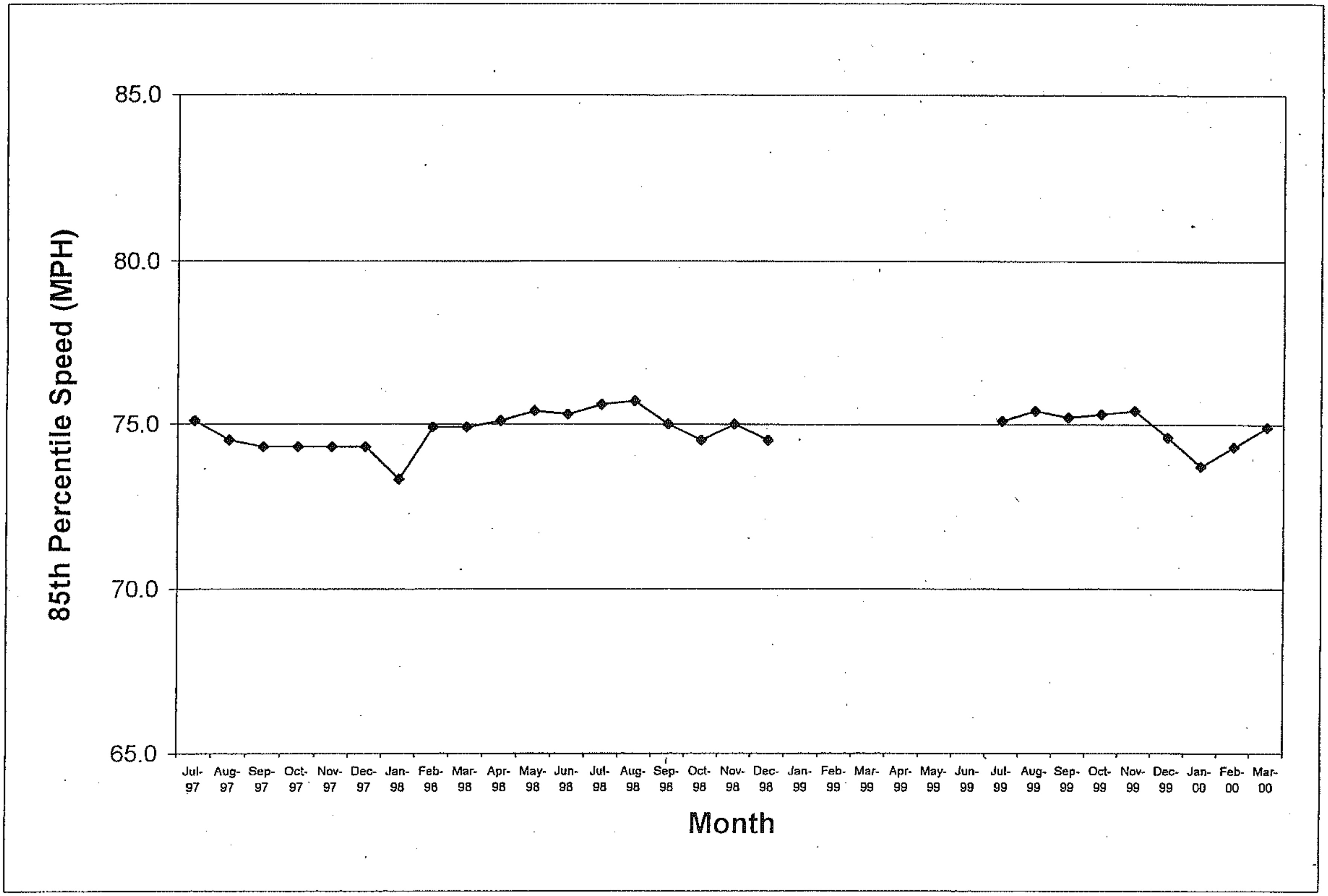


Figure 1.22 : Speed Data on I-75 in Roscommon County (50th Percentile)

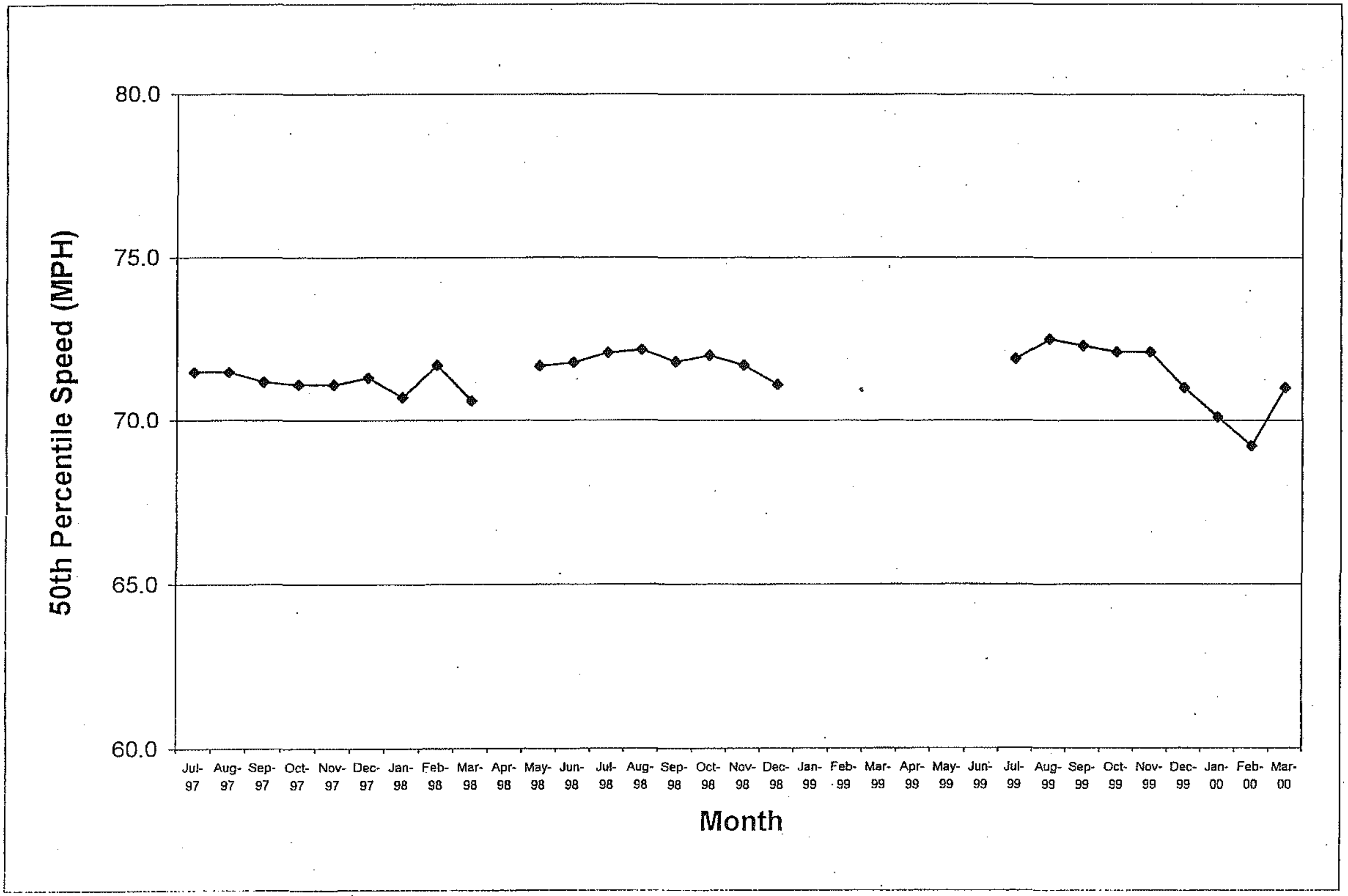


Figure 1.23 : Speed Data on I-75 in Roscommon County (85th Percentile)

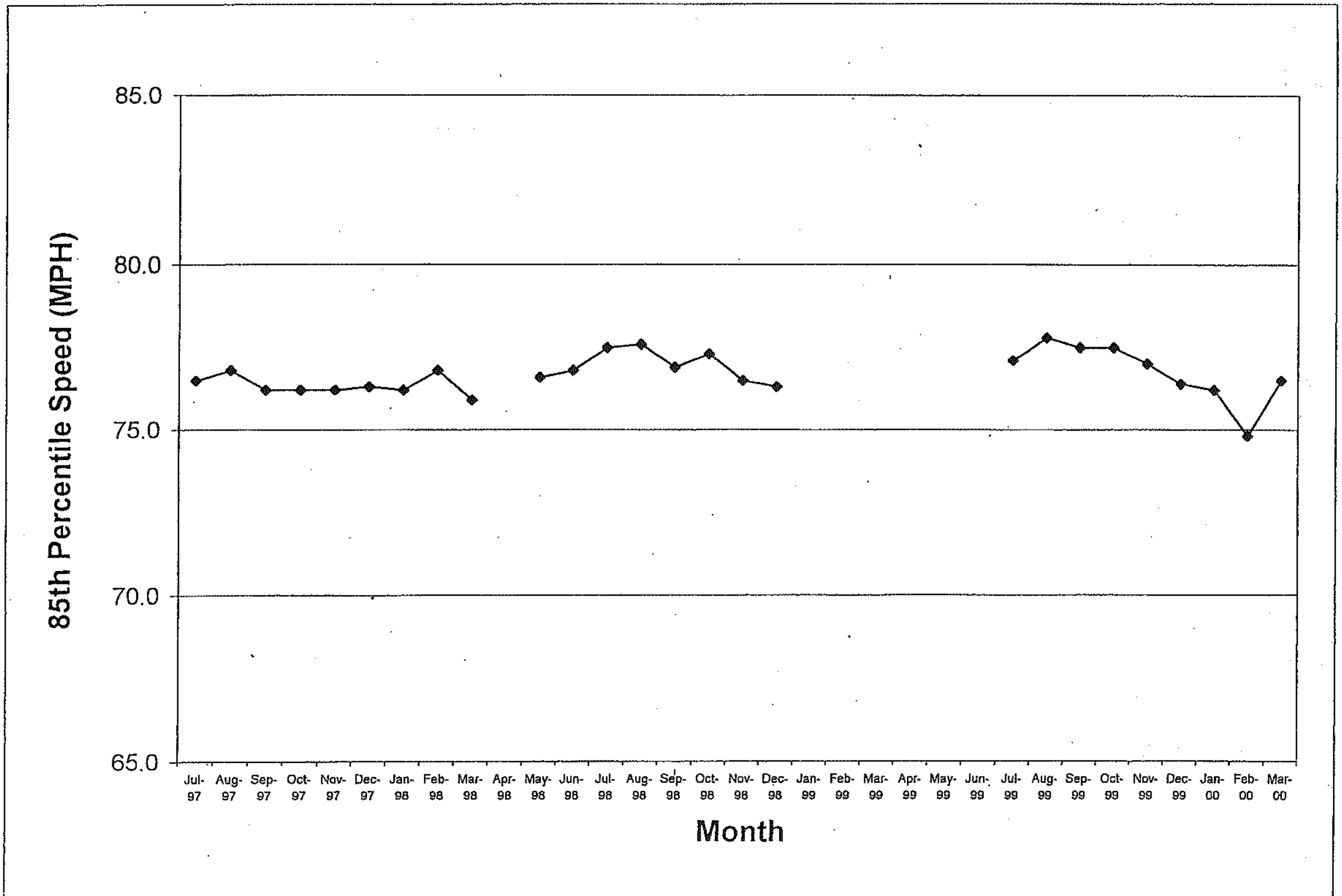


Figure 1.24 : Speed Data on I-69 in St. Clare County (50th Percentile)

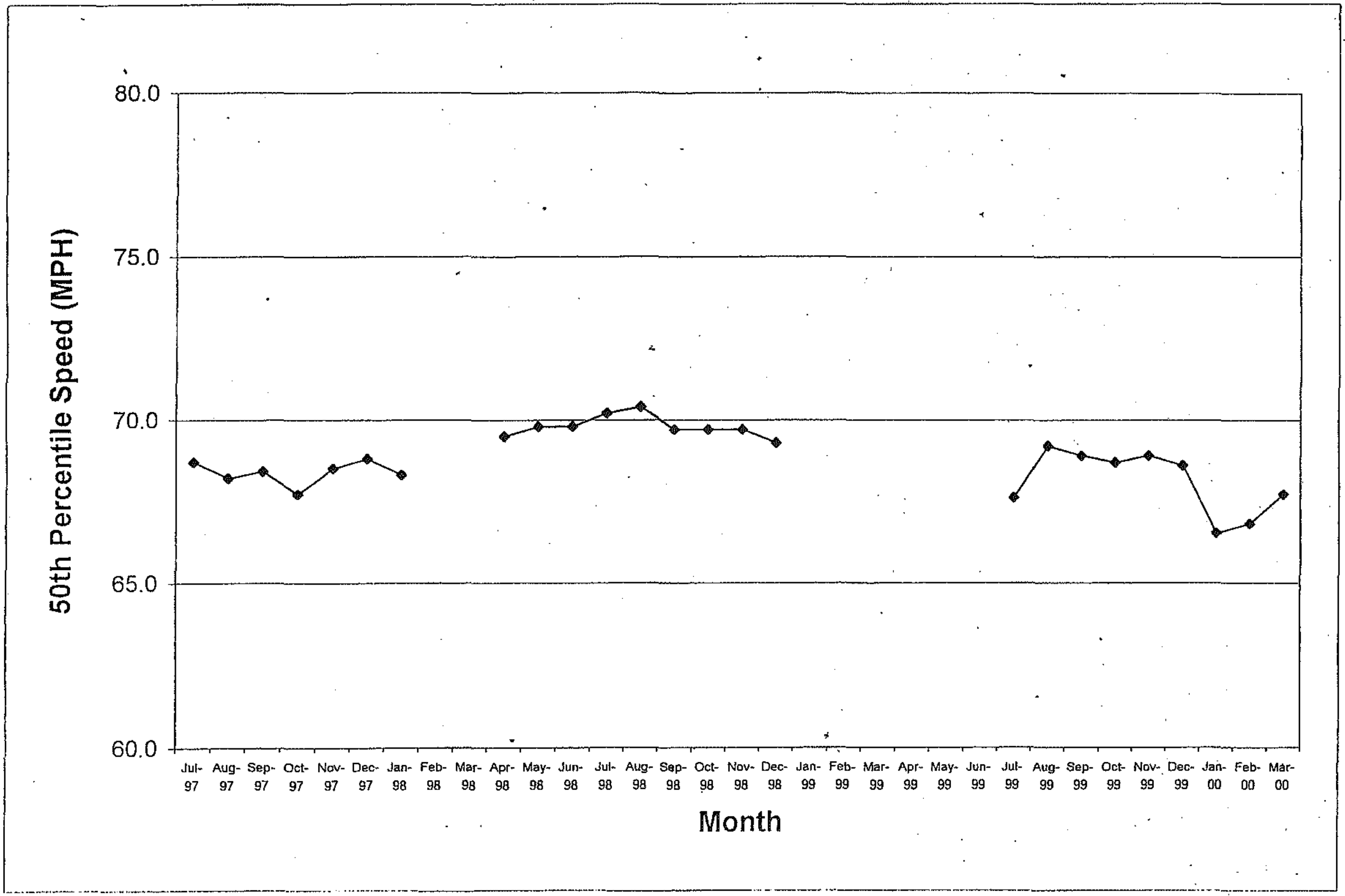


Figure 1.25 : Speed Data on I-69 in St.Clare County (85th Percentile)

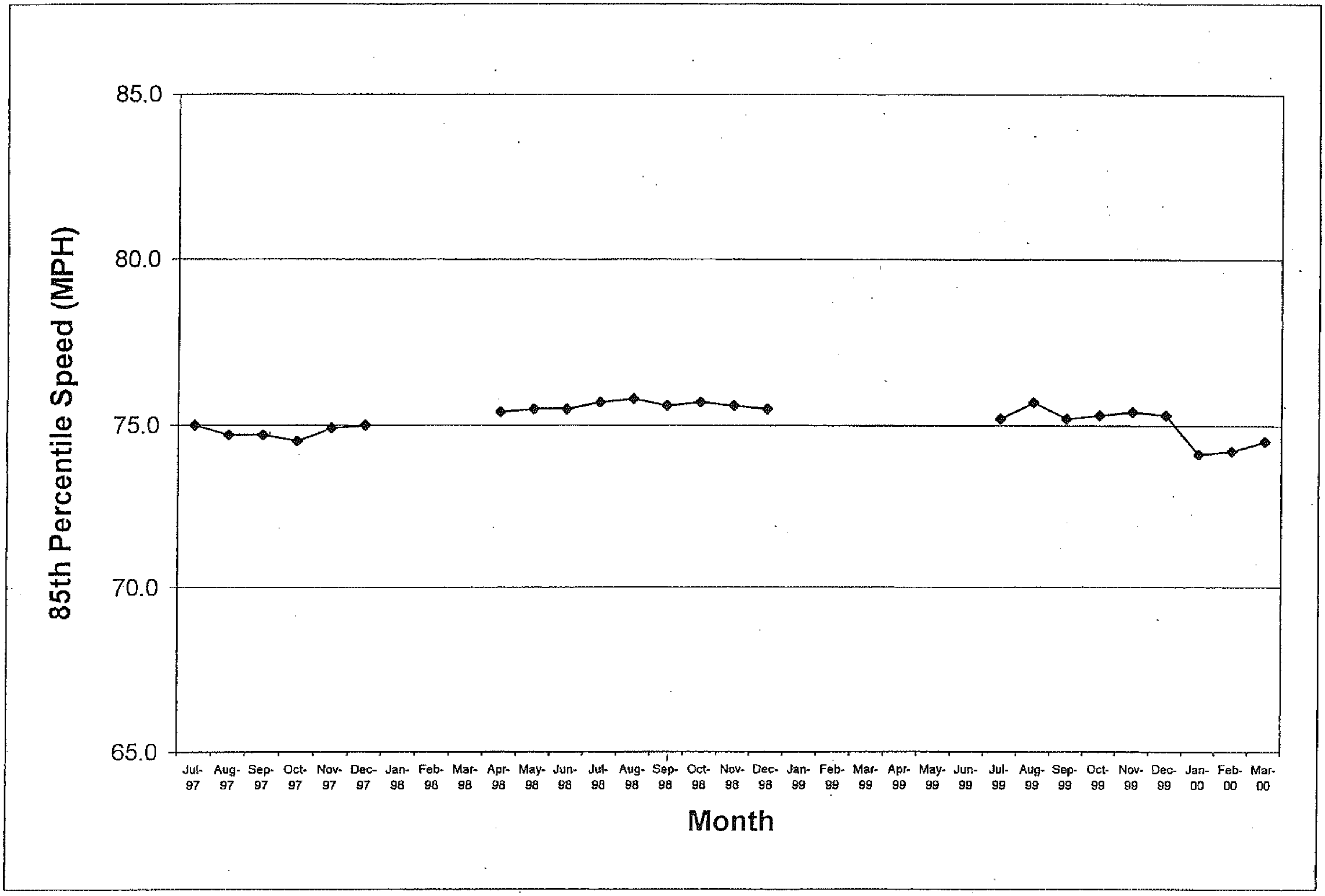


Figure 1.26 : Speed Data on I-75 in Mackinac County (50th Percentile)

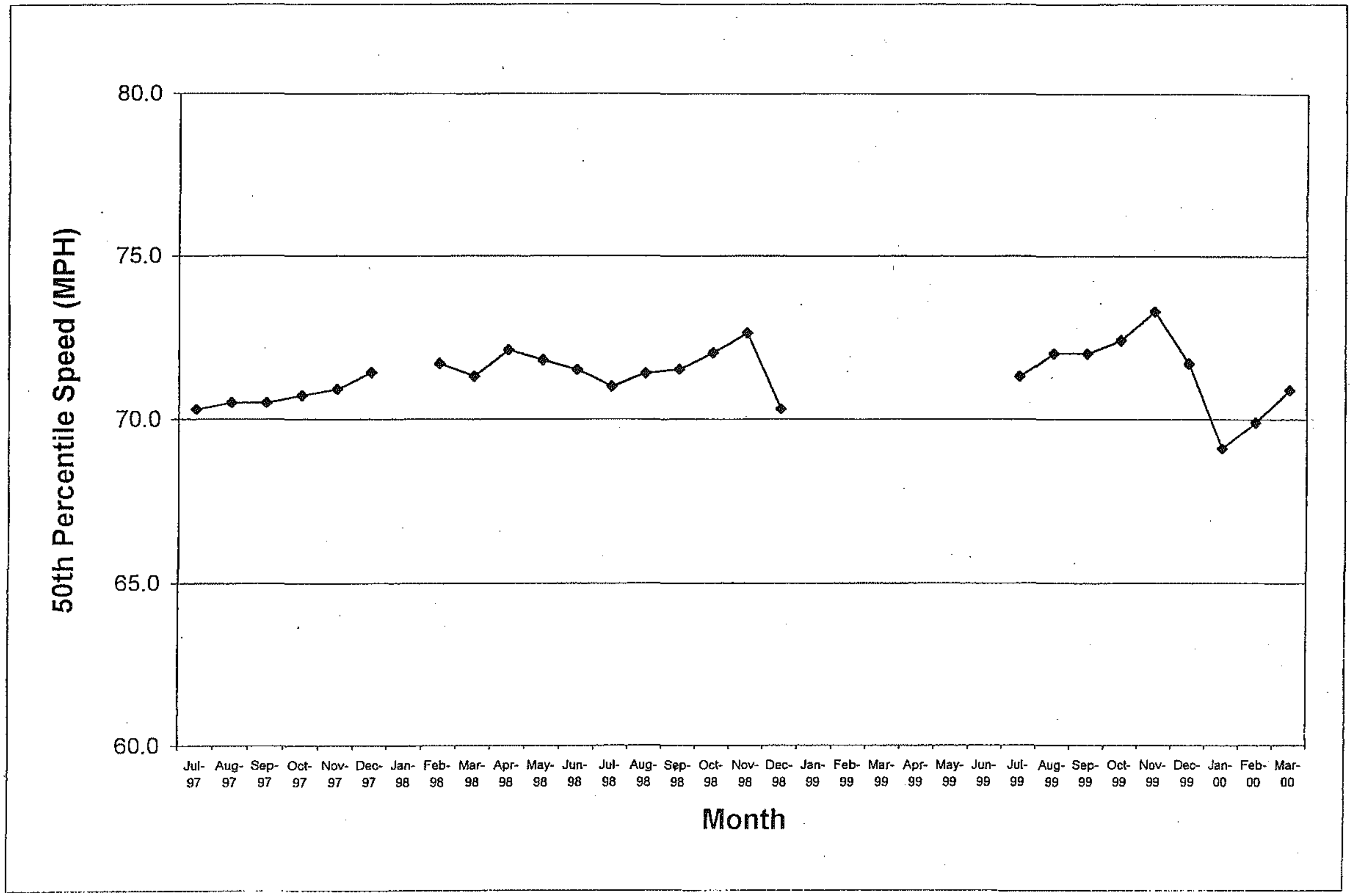
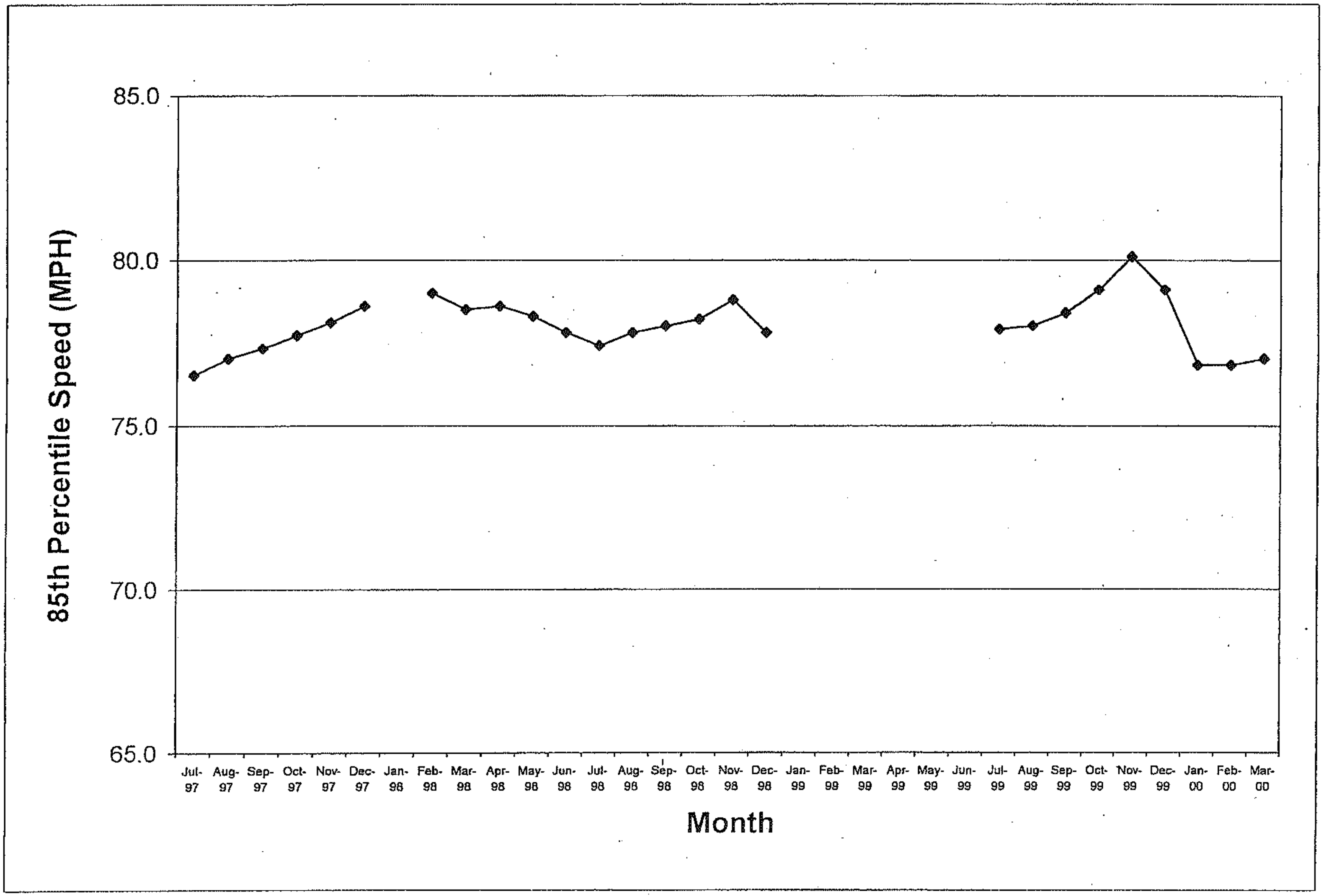


Figure 1.27 : Speed Data on I-75 in Mackinac County (85th Percentile)



SECTION 2 – CRASH DATA

The results of the crash analysis were reported in several stages. The 1997 crash experience on the freeways where the speed limit was raised to 70 MPH was reported in 1998. The interim report in 1999[1], compared the crash experience for two years before (1995 and 1996) and two years after (1997 and 1998) the change in the speed limit. This report compares three year before and after the changes, by adding 1994 and 1999 data to the before and after period respectively.

The results were similar in each of these reports. There was a slight increase in total crashes, but a decrease in severe crashes reported on the freeways following the increase in the speed limit.

The change in severe traffic crashes is shown in Table 2.1. There were 311 fatal crashes on these freeway sections in the three years before the change and 325 fatal crashes in the three years after the change in the speed limit. This is a 4.5 percent increase.

The reverse was true for crashes resulting in an incapacitating injury, but no fatality. There were 2389 incapacitating injury crashes in the three years before the change and 2165 crashes in the three years after the change in the speed limit. This is a 9.3% decrease.

Table 2.1: 70 MPH Freeway Severe Crashes

YEAR	1994	1995	1996	1997	1998	1999	Difference
FATAL	98	100	113	110	101	114	14
A INJURY	750	775	864	737	668	760	-224

As shown in Table 2.2, there were 66,523 total crashes in the three years before the change and 73,492 total crashes after the change. This is a 10.5% increase in crashes.

Since we do not have volume counts for each segment of the freeway system, we do not know if the crash rate increased after the change in the speed limit. The Transportation Planning Bureau of MDOT estimates that the vehicle miles of travel (VMT) on rural freeways increased by an average of 3.95% per year over this period.

Thus, the average VMT in the after period (1997-99) is approximately 11.9% higher than the average in the before period (1994-96). This means that the total number of crashes increased slower than the growth in vehicle miles of travel on these freeway segments, and the crash rate decreased.

Table 2.2: 70 MPH Freeway Total Crashes

1994	1995	1996	1997	1998	1999	Difference
20,167	22,310	24,046	24,691	22,461	26,340	6.969

As shown in Table 2.3 the decrease in fatal and injury crashes were greater on the rest of the road system than it was on the freeway segments and there was a decrease in total crashes as well. This results in the percentage of statewide crashes occurring on the freeways being higher in the three years after the speed limit was changed than it was in the three years before the change. Since we do not know the change in VMT for the entire road system, it is not possible to determine what percent of this increase would be explained by a different rate of growth in traffic volume between the two categories.

Table 2.3: Percent Of Crashes Occurring On 70 MPH Freeways

	Statewide		70 MPH Freeways		Percentage	
	1994-1996	1997-1999	1994-1996	1997-1999	1994-1996	1997-1999
FATAL CRASHES	4,087	3,849	311	325	7.6	8.4
A INJURY CRASHES	41,668	34,762	2,389	2,165	5.7	6.2
TOTAL CRASHES	1,257,765	1,249,696	66,523	73,492	5.3	5.9

A separate analyses was conducted on crashes involving heavy trucks. As shown in Table 2.4, there were 69 fatal crashes in the three years before the change and 59 fatal crashes in the three years after the change in the speed limit. This is a reduction of 14.5% in fatal crashes.

For incapacitating injury crashes, there was a decrease from 326 in the three years before the change in the speed limit to 247 in the three years after the change in the speed limit. For incapacitating injury crashes, the reduction was 24.2%.

Table 2.4: 70 MPH Freeway Truck Involved Severe Crashes

YEAR	1994	1995	1996	1997	1998	1999	Difference
FATAL	25	22	22	20	22	17	-10
A INJURY	100	93	133	76	86	85	-79

There were 6896 crashes involving heavy trucks in the three years before the change and 7327 in the three years after the change as shown in Tables 2.5. This is a 7.0 percent increase in the number of crashes.

Since we do not have truck volume counts for each segment of the freeway system, we do not know if the crash rate increased after the change in the speed limit.

To estimate the change in VMT for trucks, the percentage of trucks in the traffic stream at seven permanent count stations in 1996 and 1998 were obtained. The average annual growth rate for all vehicles was 4.06 percent (which compares closely with the estimates of 3.95 percent from the Department of Transportation), while the annual growth rate for Truck VMT was 6.4 percent. Thus, it appears that the truck involved crash rate decreased on these road segments where the speed limit differential was increased from 10 MPH to 15 MPH.

Table 2.5: 70 MPH Freeway Total Truck Involved Crashes

1994	1995	1996	1997	1998	1999	Difference
2,206	2,252	2,438	2,416	2,235	2,726	481

Unlike the finding for all vehicles the percentage of all truck involved crashes on the freeway segments where the automobile speed limit was increased remained nearly constant (15.6 to 15.7 percent). As shown in Table 2.6 during the same time period, the percentage of severe crashes (fatal and incapacitating injury combined) involving trucks decreased from 18.2 to 16.3. Since we do not know the changes in VMT for the entire road system, it is not possible to determine what percentage of this decrease would be due to a different rate of growth in traffic volume between these two road categories.

Table 2.6: Percent Of Truck Involved Crashes Occurring On 70 MPH Freeways

	Statewide		70 MPH Freeways		Percentage	
	1994-1996	1997-1999	1994-1996	1997-1999	1994-1996	1997-1999
FATAL CRASHES	384	365	69	59	18.0	16.2
A INJURY CRASHES	1,781	1,506	326	247	18.3	16.4
TOTAL CRASHES	44,257	46,909	6,896	7,377	15.6	15.7

SUMMARY AND CONCLUSIONS

The crash data indicate that increasing the speed limit from 65 mph to 70 mph on the rural freeway system did not cause an increase in the frequency of crashes, nor in the severity of crashes when they do occur.

The increase in total crashes reported in Table 2.2 is lower than the increase in traffic volume experienced over the three years between the midpoint of the before period and the midpoint of the after period. The Bureau of Transportation Planning estimates that the traffic growth on the freeway system is 3.95 percent per year. Using the data from the permanent counters on the freeway system, the growth rate was 4.06 percent per year. Thus, the growth in traffic volume was between 11.8 percent and 12.2 percent over the three-year period, while traffic crashes increased by only 9.5 percent.

The total number of crashes resulting in a fatality or an incapacitating injury decreased by 6.3 percent only over this time, as noted in Table 2.1. Since there was very little change in the speed of traffic, this reduction is most likely the result of changes in the vehicle fleet (more vehicles with air bags) and driver awareness (increased seat belt usage).

The data for crashes involving heavy trucks was also analyzed. As shown in Tables 2.4 and 2.5, the results were similar to that for all vehicles, an increase in the frequency of total crashes and a reduction in the number of high severity crashes.

The number of total crashes and the number of fatal crashes that occurred on each of the Interstate Highways and other freeways where the speed limit was increased are shown in Tables 2.7 and 2.8, and plotted in Figures 2.1 through 2.5. The data includes three years before and three years after the speed limit changes in January 1997.

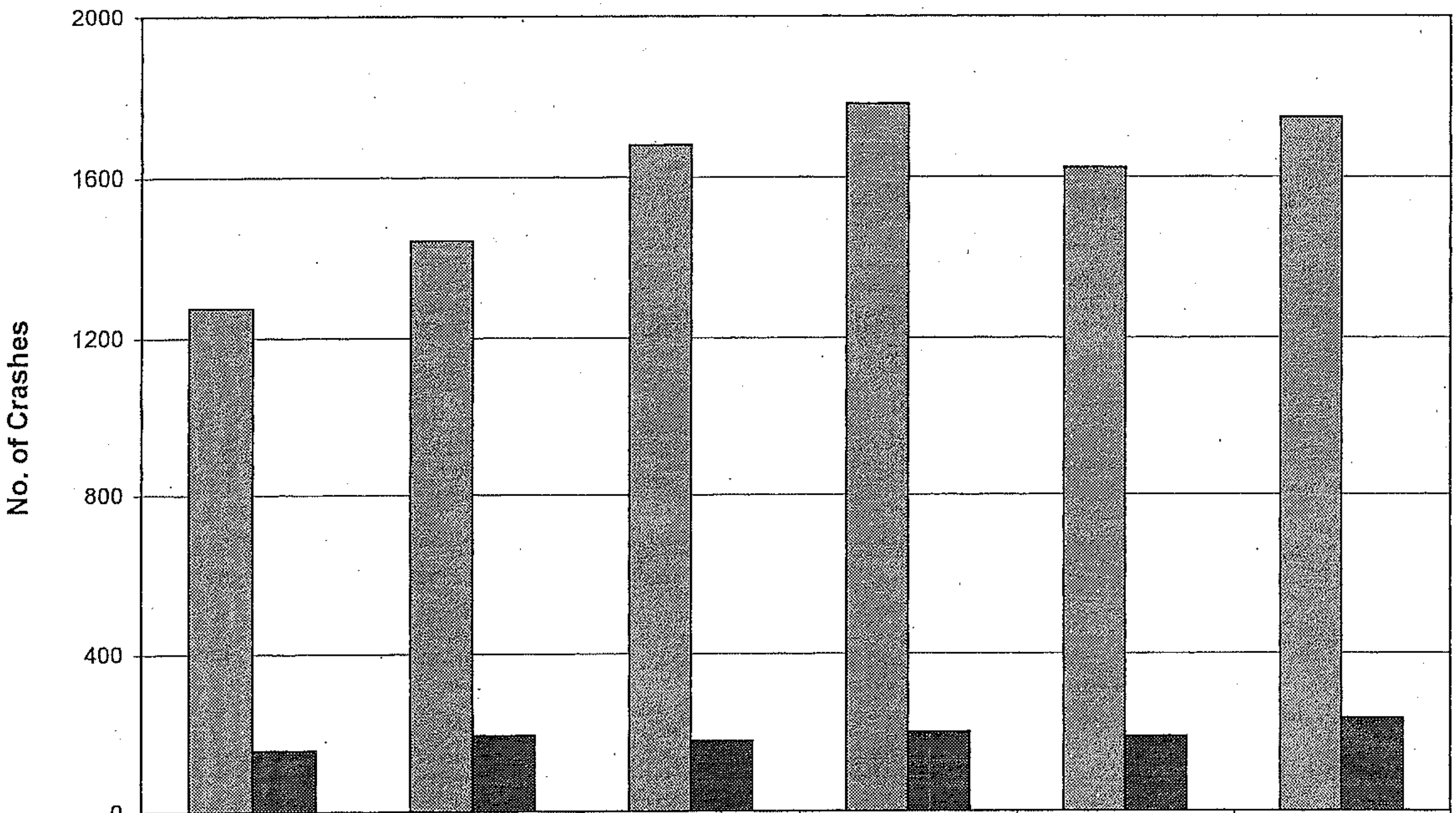
Table 2.7 : Total Crashes on Freeways when the Speed Limit was increased to 70 MPH in January 1997

Route	1994		1995		1996		1997		1998		1999	
	Total	*Fatal*	*Total*	*Fatal*	*Total*	*Fatal*	*Total*	*Fatal*	*Total*	*Fatal*	*Total*	*Fatal*
I-69	1,276	6	1,446	6	1,680	12	1,781	2	1,623	8	1,747	7
I-75	3,359	15	3,767	23	4,018	24	4,337	29	3,966	24	4,903	25
I-94	3,999	26	3,994	22	4,477	26	4,666	24	3,924	24	4,913	28
I-96	4,083	10	4,337	18	4,265	17	4,572	16	4,489	14	5,117	10
Other	7,450	41	8,766	31	9,606	34	9,335	39	8,459	31	9,660	44
Total	20,167	98	22,310	100	24,046	113	24,691	110	22,461	101	26,340	114

Table 2.8 :Truck-Involved Crashes on Freeways when the Automobile Speed Limit was increased to 70 MPH in January 1997

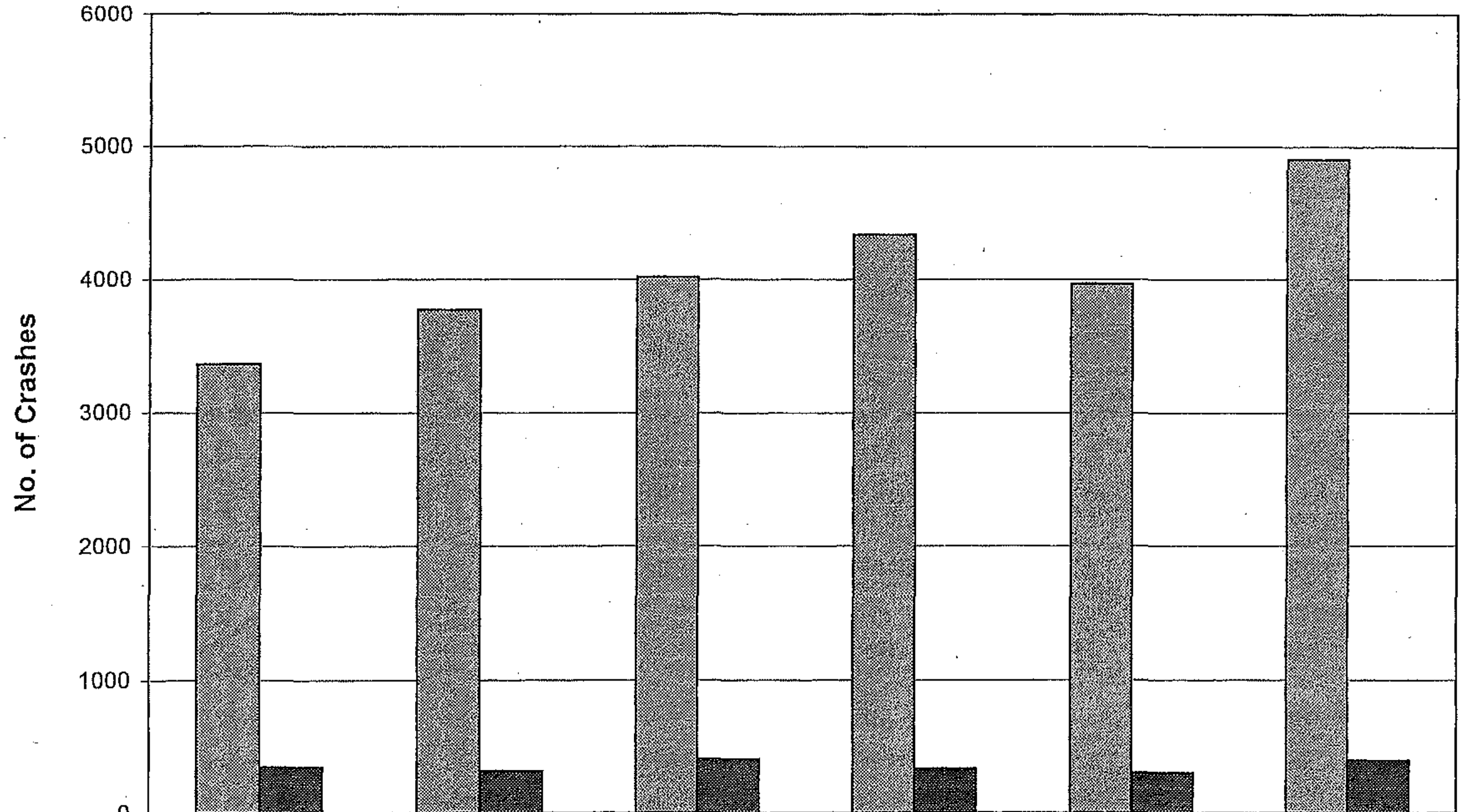
Route	1994		1995		1996		1997		1998		1999	
	Total	*Fatal*	*Total*	*Fatal*	*Total*	*Fatal*	*Total*	*Fatal*	*Total*	*Fatal*	*Total*	*Fatal*
I-69	157	2	195	1	180	3	202	0	191	5	237	1
I-75	340	5	310	5	404	2	327	3	297	2	394	2
I-94	707	7	729	9	788	7	809	7	704	9	837	8
I-96	392	3	403	5	398	3	397	3	411	2	483	0
Other	610	8	615	2	668	7	681	7	632	4	775	6
Total	2,206	25	2,252	22	2,438	22	2,416	20	2,235	22	2,726	17

Figure 2.1 : Total Crashes and Truck Involved Crashes on I-69



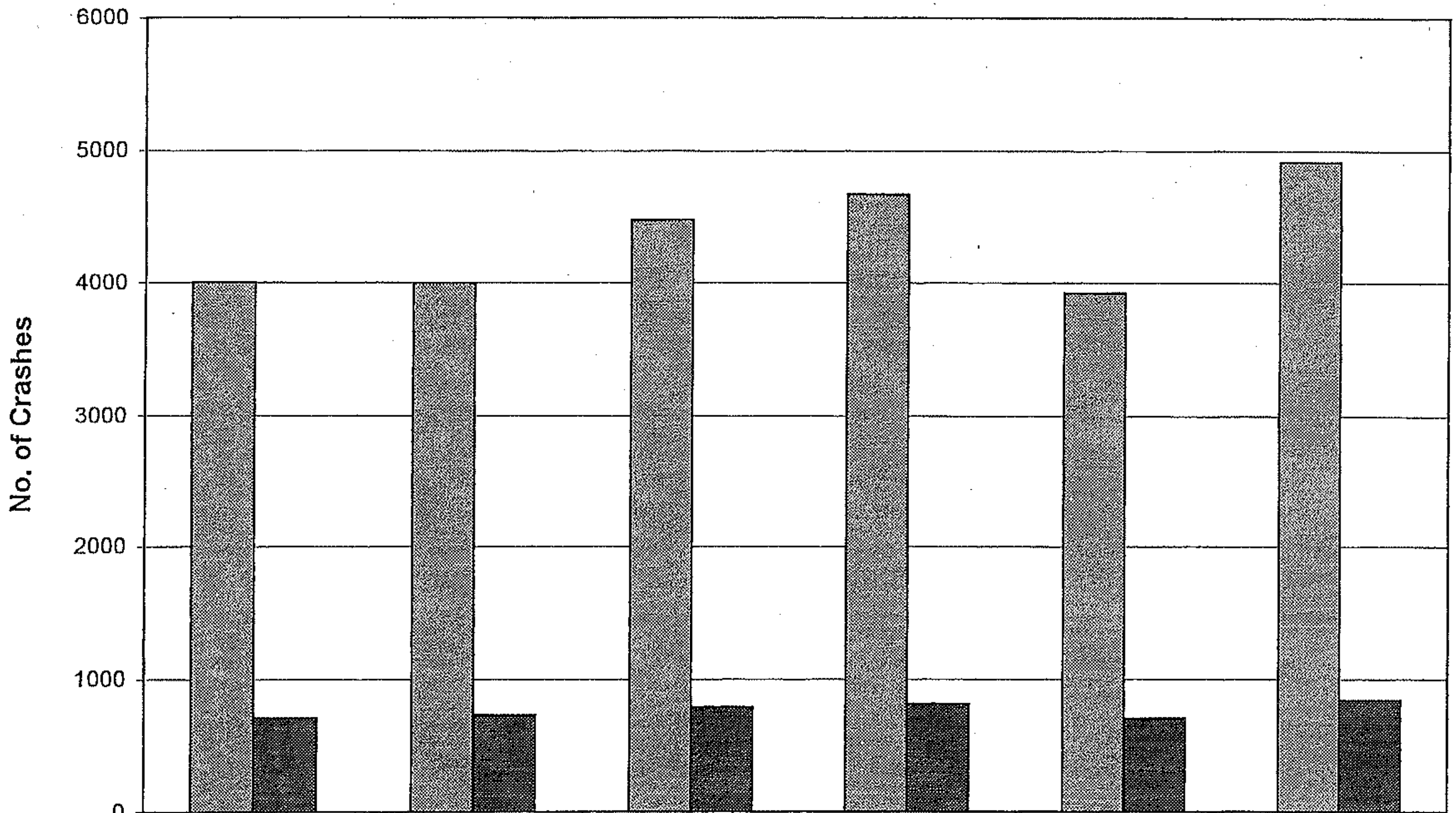
	1994	1995	1996	1997	1998	1999
Total	1276	1446	1680	1781	1623	1747
Truck	157	195	180	202	191	237

Figure 2.2 : Total Crashes and Truck Involved Crashes on I-75



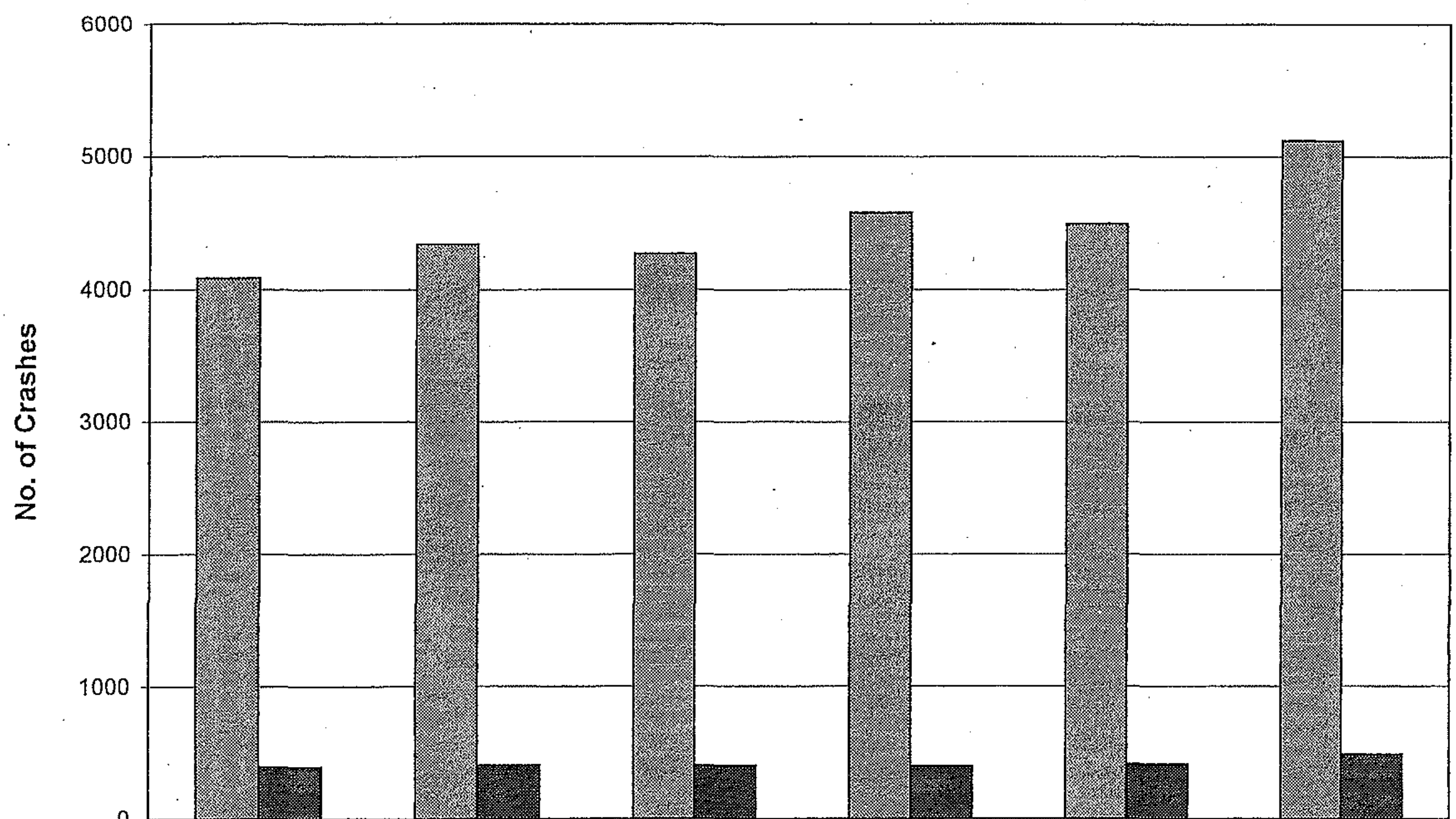
	1994	1995	1996	1997	1998	1999
Total	3359	3767	4018	4337	3966	4903
Truck	340	310	404	327	297	394

Figure 2.3 : Total Crashes and Truck Involved Crashes on I-94



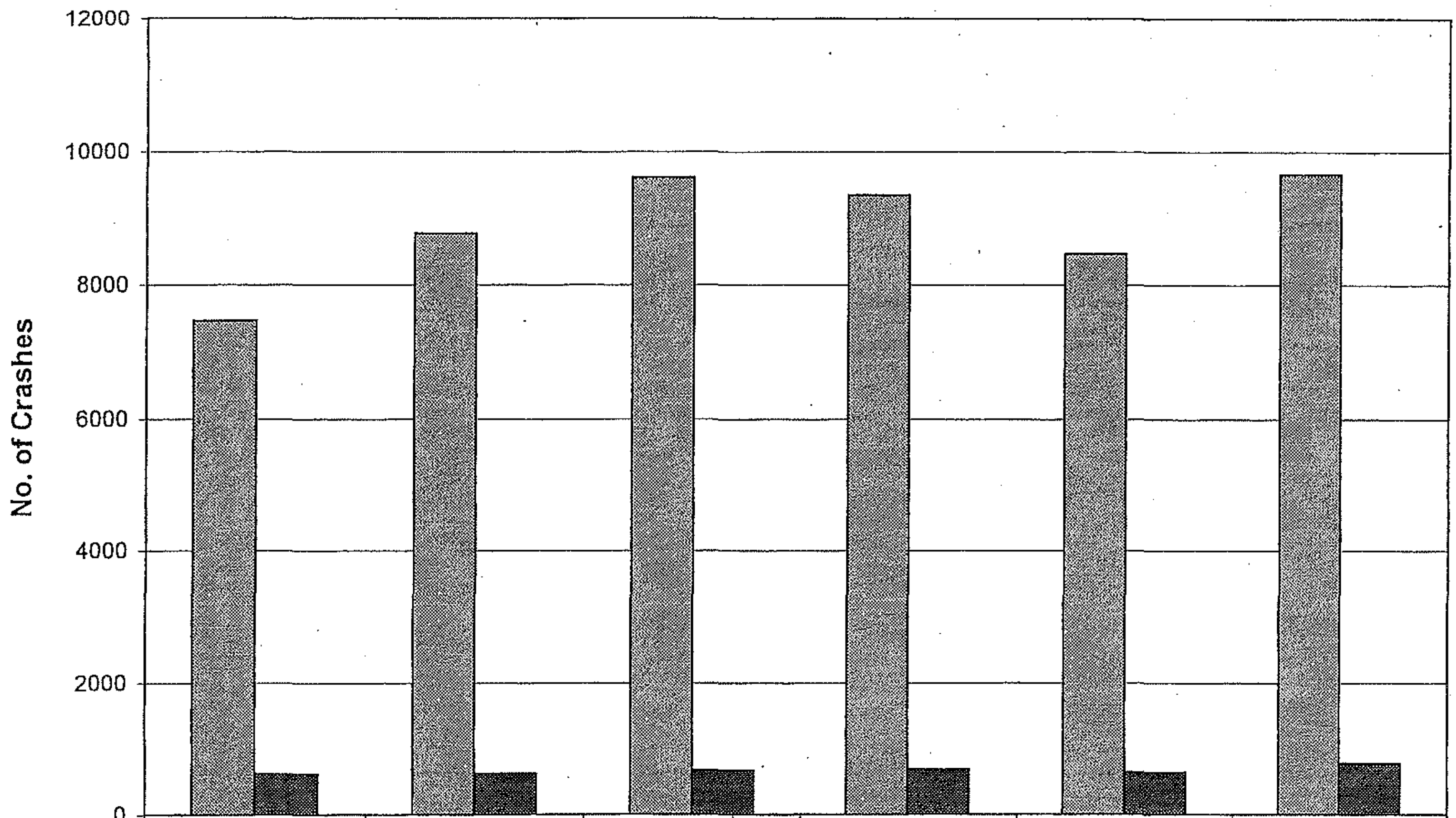
	1994	1995	1996	1997	1998	1999
Total	3999	3994	4477	4666	3924	4913
Truck	707	729	788	809	704	837

Figure 2.4 : Total Crashes and Truck Involved Crashes on I-96



	1994	1995	1996	1997	1998	1999
Total	4083	4337	4265	4572	4489	5117
Truck	392	403	398	397	411	483

Figure 2.5 : Total Crashes and Truck Involved Crashes on all other Freeways



	1994	1995	1996	1997	1998	1999
Total	7450	8766	9606	9335	8459	9660
Truck	610	615	668	681	632	775

APPENDIX A

a) Monthly speed data showing the mean speed and the 5th, 15th, 50th, 85th and 95th percentile speed at each permanent count location.

b) Monthly speed data for each of three vehicle classifications at each permanent count location.

* Speed Analysis in July, 1997 *

1) Total

(Unit :mph)

Site	*Location*	*Volume*	*Mean Speed*	*Percentile*				
				5th	*15th*	*50th*	*85th*	*95th*
24spd	US-31	179,129	70.5	56.9	62.5	69.6	75.1	79.1
40spd	US-27	300,415	70.3	57.4	62.6	69.3	74.7	77.6
69spd	US-2	157,475	60.3	50.4	53.9	58.8	63.8	67.3
77spd	US-131	1,184,420	65.5	51.2	56.2	64.7	71.2	74.9
18spd	I-96	689,945	70.8	57.6	63.0	70.1	75.1	77.9
19spd	I-69	727,070	73.0	59.8	65.1	71.9	77.5	81.3
26spd	I-75	398,343	72.5	59.8	65.0	71.5	76.5	80.2
43spd	I-69	287,622	69.2	54.4	59.5	68.7	75.0	78.7
70spd	I-75	253,309	71.2	56.4	62.1	70.3	76.5	80.7

* Speed Analysis in August, 1997 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	259,244	69.9	56.5	61.6	69.2	74.5	78.4
40spd	US-27	343,587	70.5	57.6	62.8	69.5	75.0	78.0
69spd	US-2	186,116	60.4	50.0	53.8	58.9	63.9	67.5
77spd	US-131	1,883,978	65.7	51.8	56.6	64.9	71.3	75.0
18spd	I-96	1,086,769	70.9	57.7	62.7	70.2	75.5	78.5
19spd	I-69	887,202	73.0	59.8	65.0	71.8	77.7	81.5
26spd	I-75	464,117	72.3	58.0	64.3	71.5	76.8	80.9
43spd	I-69	453,921	68.6	53.1	58.8	68.2	74.7	78.4
70spd	I-75	295,597	71.4	56.4	62.0	70.5	77.0	81.2

* Speed Analysis in September, 1997 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	175,145	70.0	57.4	62.0	69.1	74.3	77.9
40spd	US-27	259,746	70.2	57.3	62.4	69.3	74.6	77.6
69spd	US-2	86,531	60.9	49.7	54.0	59.3	64.3	69.4
77spd	US-131	1,560,163	65.3	51.0	56.2	64.6	71.0	74.7
18spd	I-96	760,674	71.1	57.8	62.7	70.4	75.6	78.6
19spd	I-69	736,973	72.5	58.8	64.2	71.6	77.5	81.3
26spd	I-75	340,185	72.1	59.4	64.5	71.2	76.2	79.4
43spd	I-69	233,438	68.9	54.7	59.2	68.4	74.7	78.2
70spd	I-75	199,398	71.4	56.0	61.9	70.5	77.3	81.5

* Speed Analysis in October, 1997 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	212,109	69.9	57.0	61.8	69.1	74.3	77.9
40spd	US-27	253,299	70.2	57.2	62.2	69.4	74.8	77.9
69spd	US-2	55,388	61.9	42.9	51.8	59.7	68.3	81.4
77spd	US-131	1,996,331	65.4	51.0	56.2	64.7	71.1	74.8
18spd	I-96	656,930	71.1	57.8	62.7	70.6	75.6	78.7
19spd	I-69	785,823	72.7	59.1	64.5	71.8	77.4	81.2
26spd	I-75	370,595	72.0	59.1	64.2	71.1	76.2	79.5
43spd	I-69	381,408	68.3	53.7	58.6	67.7	74.5	78.4
70spd	I-75	125,543	71.8	56.7	62.4	70.7	77.7	82.0

* Speed Analysis in November, 1997 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	147,959	69.9	56.8	61.6	69.1	74.3	77.8
40spd	US-27	194,200	70.1	56.6	61.9	69.4	74.8	78.1
69spd	US-2	87,823	61.8	52.4	55.8	60.2	65.1	69.2
77spd	US-131	1,376,339	65.3	50.0	55.7	64.8	71.3	75.2
18spd	I-96	709,602	70.8	56.7	62.2	70.4	75.7	78.8
19spd	I-69	747,990	72.6	58.9	64.2	71.8	77.5	81.2
26spd	I-75	294,410	71.9	58.7	64.1	71.1	76.2	79.5
43spd	I-69	252,545	69.2	55.7	59.6	68.5	74.9	78.7
70spd	I-75	127,669	71.9	56.1	62.2	70.9	78.1	82.3
17spd	I-94	712,874	69.2	53.4	59.2	68.9	75.5	79.0

* Speed Analysis in December, 1997 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	170,407	69.5	55.8	59.6	68.9	74.3	77.6
40spd	US-27	197,800	70.3	56.6	62.0	69.6	75.0	78.3
69spd	US-2	88,725	61.6	51.6	55.7	60.1	64.7	68.5
77spd	US-131	1,868,185	65.0	49.5	55.4	64.6	71.3	75.3
18spd	I-96	977,139	70.7	56.1	61.8	70.2	75.8	78.8
19spd	I-69	723,670	72.7	58.5	64.5	72.1	77.9	81.6
26spd	I-75	312,697	72.2	58.9	64.5	71.3	76.3	79.7
43spd	I-69	356,971	69.3	54.8	59.5	68.8	75.0	78.9
70spd	I-75	149,300	72.4	56.3	62.8	71.4	78.6	83.0
17spd	I-94	810,308	68.6	52.3	58.2	68.4	75.3	78.9

* Speed Analysis in January, 1998 *

1) Total

(Unit :mph)

Site	*Location*	*Volume*	*Mean Speed*	*Percentile*				
				5th	*15th*	*50th*	*85th*	*95th*
24spd	US-31	132,067	67.7	51.8	56.5	67.5	73.3	76.7
40spd	US-27	178,572	69.0	54.1	60.0	68.6	74.3	77.8
69spd	US-2	51,916	59.9	47.6	53.1	58.9	63.8	67.2
77spd	US-131	1,514,382	63.2	45.9	52.8	62.8	70.2	74.4
18spd	I-96	872,495	69.5	53.7	59.9	69.4	75.2	78.5
19spd	I-69	691,118	72.2	57.6	63.5	71.7	77.5	81.3
26spd	I-75	301,406	71.2	56.5	62.3	70.7	76.2	79.8
43spd	I-69	291,779	69.0	54.8	59.3	68.3	74.8	78.7
70spd	I-75	109,327	69.0	51.4	58.0	68.1	76.5	81.6
17spd	I-94	698,635	68.5	52.2	58.3	68.2	75.1	78.8

* Speed Analysis in February, 1998 *

1) Total

(Unit :mph)

Site	*Location*	*Volume*	*Mean Speed*	*Percentile*				
				5th	*15th*	*50th*	*85th*	*95th*
24spd	US-31	136,614	70.5	57.6	61.9	69.6	74.9	78.4
40spd	US-27	171,449	70.8	57.9	62.8	70.0	75.3	78.4
69spd	US-2	61,723	62.0	53.2	56.1	60.3	64.9	68.6
77spd	US-131	1,609,204	66.2	51.7	56.8	65.5	72.2	75.7
18spd	I-96	821,028	71.6	58.1	63.1	71.0	76.1	79.2
19spd	I-69	681,739	73.6	60.6	65.6	72.5	78.2	82.0
26spd	I-75	267,213	72.6	59.3	64.8	71.7	76.8	80.5
43spd	I-69	-	-	-	-	-	-	-
70spd	I-75	118,195	72.9	57.6	63.6	71.7	79.0	83.5
17spd	I-94	656,481	70.4	56.6	61.2	69.8	75.8	79.3

* Speed Analysis in March, 1998 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	98,277	70.4	57.6	62.2	69.5	74.9	78.4
40spd	US-27	179,010	69.5	54.2	60.7	69.2	74.9	77.9
69spd	US-2	48,184	61.3	50.5	55.3	60.0	64.4	68.4
77spd	US-131	1,711,473	65.2	48.8	55.6	64.9	71.8	75.4
18spd	I-96	950,363	70.5	55.0	61.4	70.5	75.8	79.0
19spd	I-69	698,772	73.1	59.8	65.0	72.2	77.7	81.4
26spd	I-75	258,215	70.6	54.3	61.6	70.6	75.9	79.4
43spd	I-69	-	-	-	-	-	-	-
70spd	I-75	104,068	72.2	55.6	62.3	71.3	78.5	83.0
17spd	I-94	741,754	69.8	55.0	60.4	69.5	75.8	79.3

* Speed Analysis in April, 1998 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	167,187	70.5	57.5	62.2	69.5	75.1	78.6
40spd	US-27	196,396	70.5	57.6	62.5	69.7	75.0	78.1
69spd	US-2	-	-	-	-	-	-	-
77spd	US-131	1,824,029	66.0	51.5	56.6	65.2	72.1	75.6
18spd	I-96	917,233	71.6	58.2	63.1	71.0	76.2	79.3
19spd	I-69	768,229	73.7	61.0	65.8	72.6	78.1	81.8
26spd	I-75	-	-	-	-	-	-	-
43spd	I-69	119,519	70.1	56.3	60.5	69.5	75.4	79.1
70spd	I-75	148,653	73.1	58.0	63.9	72.1	78.6	83.1
17spd	I-94	845,246	70.3	56.8	60.9	69.7	75.8	79.4

* Speed Analysis in May, 1998 *

1) Total

(Unit :mph)

Site	*Location*	*Volume*	*Mean Speed*	*Percentile*				
				5th	*15th*	*50th*	*85th*	*95th*
24spd	US-31	226,028	70.8	58.2	62.7	69.7	75.4	78.7
40spd	US-27	295,260	70.6	57.9	62.8	69.8	75.0	78.1
69spd	US-2	125,057	61.4	52.7	55.7	59.8	64.0	67.4
77spd	US-131	2,086,091	66.1	51.7	56.7	65.2	72.1	75.5
18spd	I-96	1,011,052	71.7	58.6	63.4	70.9	76.1	79.2
19spd	I-69	758,304	73.5	61.0	65.7	72.4	77.7	81.4
26spd	I-75	364,620	72.7	59.8	64.9	71.7	76.6	80.3
43spd	I-69	424,326	70.3	56.5	61.1	69.8	75.5	79.2
70spd	I-75	227,737	72.7	57.5	63.4	71.8	78.3	82.5
17spd	I-94	930,901	70.4	56.7	61.0	69.7	75.8	79.3

* Speed Analysis in June, 1998 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	192,640	68.4	37.6	59.5	69.1	75.3	79.3
40spd	US-27	139,835	66.7	49.8	55.6	66.7	73.6	77.0
69spd	US-2	-	-	-	-	-	-	-
77spd	US-131	1,706,258	66.2	51.8	56.9	65.4	72.3	75.6
18spd	I-96	1,111,268	71.8	58.7	63.6	71.1	76.2	79.3
19spd	I-69	569,013	73.6	61.4	66.0	72.5	78.0	81.6
26spd	I-75	463,400	72.7	59.8	65.0	71.8	76.8	80.4
43spd	I-69	401,124	70.4	56.6	61.2	69.8	75.5	79.2
70spd	I-75	232,815	72.4	57.6	63.1	71.5	77.8	82.1
17spd	I-94	853,600	70.7	56.9	61.5	70.2	76.0	79.5

* Speed Analysis in July, 1998 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	323,179	71.1	58.7	63.2	69.9	75.6	79.0
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	-	-	-	-	-	-	-
77spd	US-131	1,822,092	66.3	52.0	57.1	65.4	72.3	75.5
18spd	I-96	1,118,735	71.6	58.6	63.6	71.1	75.9	79.2
19spd	I-69	654,641	73.5	61.2	65.9	72.2	77.9	81.6
26spd	I-75	619,756	73.2	60.4	65.5	72.1	77.5	81.0
43spd	I-69	348,957	70.8	56.7	61.8	70.2	75.7	79.4
70spd	I-75	318,061	71.8	56.6	62.2	71.0	77.4	81.7
17spd	I-94	987,242	71.8	58.9	63.1	71.1	76.4	80.3

* Speed Analysis in August, 1998 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	154,931	70.7	56.7	62.4	69.8	75.7	79.4
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	68,783	60.9	49.7	54.0	59.3	64.5	69.2
77spd	US-131	1,948,692	66.3	52.1	57.1	65.4	72.3	75.5
18spd	I-96	1,227,336	71.6	58.6	63.5	71.1	75.9	79.1
19spd	I-69	935,735	73.3	60.9	65.4	72.1	77.9	81.5
26spd	I-75	656,034	73.3	60.7	65.8	72.2	77.6	81.0
43spd	I-69	450,215	71.0	57.2	62.1	70.4	75.8	79.4
70spd	I-75	328,639	72.3	57.7	63.1	71.4	77.8	82.0
17spd	I-94	843,581	71.5	58.3	62.6	70.7	76.4	79.9

* Speed Analysis in September, 1998 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	154,389	70.5	57.4	62.1	69.7	75.0	78.6
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	158,039	60.7	51.1	54.5	59.2	64.0	67.4
77spd	US-131	1,893,653	66.2	51.4	56.7	65.4	72.2	75.5
18spd	I-96	1,114,294	71.6	58.1	63.3	71.1	75.9	79.0
19spd	I-69	880,326	73.4	60.8	65.4	72.3	77.8	81.4
26spd	I-75	449,644	72.8	59.9	65.0	71.8	76.9	80.5
43spd	I-69	347,830	70.4	56.6	61.1	69.7	75.6	79.3
70spd	I-75	281,771	72.5	57.6	63.2	71.5	78.0	82.2
17spd	I-94	923,605	71.0	57.4	62.0	70.3	76.2	79.5

* Speed Analysis in October, 1998 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	161,215	68.7	52.0	58.6	68.6	74.5	78.3
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	129,545	61.4	52.2	55.5	59.9	64.5	68.4
77spd	US-131	1,818,960	66.2	51.1	56.6	65.6	72.3	75.7
18spd	I-96	1,067,052	71.6	58.2	63.0	71.0	76.1	79.1
19spd	I-69	832,352	73.8	61.4	66.0	72.8	78.0	81.6
26spd	I-75	418,464	73.0	59.9	65.1	72.0	77.3	81.0
43spd	I-69	385,179	70.4	56.6	61.0	69.7	75.7	79.3
70spd	I-75	214,663	72.9	58.2	63.6	72.0	78.2	82.4
17spd	I-94	763,752	71.1	57.4	61.8	70.4	76.4	80.0

* Speed Analysis in November, 1998 *

1) Total

(Unit :mph)

Site	*Location*	*Volume*	*Mean Speed*	*Percentile*				
				5th	*15th*	*50th*	*85th*	*95th*
24spd	US-31	168,912	70.4	56.9	62.2	69.8	75.0	78.5
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	83,628	62.0	53.0	55.9	60.2	65.1	68.8
77spd	US-131	1,721,543	66.4	51.3	56.8	65.8	72.4	76.1
18spd	I-96	1,002,422	71.7	58.1	63.4	71.2	76.1	79.2
19spd	I-69	742,245	74.6	62.5	67.1	73.2	78.8	82.3
26spd	I-75	331,527	72.4	59.0	64.5	71.7	76.5	80.0
43spd	I-69	315,131	70.3	56.4	60.8	69.7	75.6	79.1
70spd	I-75	153,140	73.6	58.8	64.8	72.6	78.8	83.9
17spd	I-94	824,945	71.5	57.6	62.2	70.8	76.7	80.3

* Speed Analysis in December, 1998 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	173,002	69.5	55.6	60.6	69.0	74.5	78.1
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	66,228	60.7	48.9	54.2	59.6	64.4	68.0
77spd	US-131	1,830,232	65.6	49.5	55.7	65.2	72.2	75.9
18spd	I-96	1,041,980	71.1	56.8	62.3	70.8	76.0	79.0
19spd	I-69	802,805	74.3	61.8	66.6	73.2	78.7	82.3
26spd	I-75	314,744	71.7	57.6	63.1	71.1	76.3	79.7
43spd	I-69	359,569	69.8	55.5	60.1	69.3	75.5	79.1
70spd	I-75	112,749	71.1	53.7	60.6	70.3	77.8	82.7
17spd	I-94	864,749	71.0	56.8	61.6	70.3	76.5	80.1

* Speed Analysis in January, 1999 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	121,352	65.9	49.8	55.9	65.2	72.6	76.1
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	47,941	59.1	46.4	51.8	58.3	63.3	66.8
77spd	US-131	1,304,542	59.1	39.0	46.5	58.5	68.3	72.6
18spd	I-96	809,437	66.9	46.9	55.1	67.6	74.5	77.8
19spd	I-69	427,936	71.9	55.8	62.3	71.4	77.9	82.2
26spd	I-75	259,220	69.0	51.4	58.9	68.9	75.5	78.9
43spd	I-69	249,968	67.4	51.4	57.2	66.7	74.1	78.1
70spd	I-75	100,167	68.2	49.8	56.6	67.3	75.9	81.4
17spd	I-94	548,553	68.0	51.8	58.0	67.4	74.9	78.8

* Speed Analysis in February, 1999 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	-	-	-	-	-	-	-
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	-	-	-	-	-	-	-
77spd	US-131	-	-	-	-	-	-	-
18spd	I-96	895,360	70.9	56.4	61.8	70.7	75.9	79.0
19spd	I-69	-	-	-	-	-	-	-
26spd	I-75	-	-	-	-	-	-	-
43spd	I-69	-	-	-	-	-	-	-
70spd	I-75	-	-	-	-	-	-	-
17spd	I-94	671,328	69.5	54.7	59.6	69.1	75.6	79.1

* Speed Analysis in March, 1999 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	-	-	-	-	-	-	-
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	-	-	-	-	-	-	-
77spd	US-131	-	-	-	-	-	-	-
18spd	I-96	959,708	70.7	55.7	61.4	70.7	75.9	79.0
19spd	I-69	-	-	-	-	-	-	-
26spd	I-75	-	-	-	-	-	-	-
43spd	I-69	-	-	-	-	-	-	-
70spd	I-75	-	-	-	-	-	-	-
17spd	I-94	839,815	70.0	55.6	60.2	69.6	76.1	79.5

* Speed Analysis in April, 1999 *

1) Total

(Unit :mph)

Site	*Location*	*Volume*	*Mean Speed*	*Percentile*				
				5th	*15th*	*50th*	*85th*	*95th*
24spd	US-31	-	-	-	-	-	-	-
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	-	-	-	-	-	-	-
77spd	US-131	-	-	-	-	-	-	-
18spd	I-96	914,038	71.4	57.6	62.7	70.9	76.0	79.1
19spd	I-69	-	-	-	-	-	-	-
26spd	I-75	-	-	-	-	-	-	-
43spd	I-69	-	-	-	-	-	-	-
70spd	I-75	-	-	-	-	-	-	-
17spd	I-94	820,140	70.7	57.0	61.2	70.1	76.2	79.6

* Speed Analysis in May, 1999 *

1) Total

(Unit :mph)

Site	*Location*	*Volume*	*Mean Speed*	*Percentile*				
				5th	*15th*	*50th*	*85th*	*95th*
24spd	US-31	-	-	-	-	-	-	-
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	-	-	-	-	-	-	-
77spd	US-131	-	-	-	-	-	-	-
18spd	I-96	1,201,630	71.5	58.1	63.2	70.9	76.0	79.1
19spd	I-69	-	-	-	-	-	-	-
26spd	I-75	-	-	-	-	-	-	-
43spd	I-69	-	-	-	-	-	-	-
70spd	I-75	-	-	-	-	-	-	-
17spd	I-94	952,549	70.9	57.1	61.6	70.3	76.1	79.5

* Speed Analysis in June, 1999 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	-	-	-	-	-	-	-
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	-	-	-	-	-	-	-
77spd	US-131	-	-	-	-	-	-	-
18spd	I-96	1,074,655	71.4	58.0	62.9	70.7	76.0	78.9
19spd	I-69	-	-	-	-	-	-	-
26spd	I-75	-	-	-	-	-	-	-
43spd	I-69	-	-	-	-	-	-	-
70spd	I-75	-	-	-	-	-	-	-
17spd	I-94	1,050,794	70.8	57.2	61.6	70.3	76.0	79.4

* Speed Analysis in July, 1999 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	129,008	71.1	58.5	63.3	70.3	75.1	78.7
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	81,164	60.5	50.8	54.3	59.1	63.6	66.9
77spd	US-131	1,558,028	66.9	52.6	57.6	66.1	72.8	76.0
18spd	I-96	1,187,716	71.8	58.6	63.5	71.1	76.3	79.4
19spd	I-69	696,329	75.5	62.5	68.1	74.5	79.7	84.4
26spd	I-75	446,422	72.8	60.0	65.3	71.9	77.1	80.5
43spd	I-69	319,088	67.3	49.6	54.6	67.6	75.2	78.8
70spd	I-75	296,563	72.3	57.7	63.0	71.3	77.9	82.1
17spd	I-94	594,907	70.8	57.1	61.7	70.1	75.9	79.2

<u>* Speed Analysis in August, 1999 *</u>

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	354,306	71.3	58.8	63.6	70.5	75.4	78.8
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	193,403	60.6	50.6	54.4	59.2	63.8	67.3
77spd	US-131	1,961,739	67.0	52.6	57.6	66.3	73.0	76.2
18spd	I-96	1,008,135	71.9	58.7	63.6	71.0	76.4	79.4
19spd	I-69	847,341	76.0	63.5	68.6	74.7	80.0	84.4
26spd	I-75	409,309	73.5	60.7	66.0	72.5	77.8	81.2
43spd	I-69	533,575	69.9	55.3	60.2	69.2	75.7	79.0
70spd	I-75	283,753	72.9	58.7	63.9	72.0	78.0	82.0
17spd	I-94	1,095,458	71.1	57.4	61.7	70.2	76.4	80.1

* Speed Analysis in September, 1999 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	279,732	71.0	58.4	63.0	70.3	75.2	78.7
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	135,661	60.7	51.0	54.6	59.3	63.9	67.3
77spd	US-131	1,926,038	66.8	52.1	57.2	66.2	72.8	76.3
18spd	I-96	1,156,765	71.7	58.1	63.3	71.0	76.3	79.3
19spd	I-69	763,196	75.9	63.0	68.4	74.6	80.1	84.4
26spd	I-75	390,606	73.3	60.5	65.8	72.3	77.5	80.9
43spd	I-69	423,748	69.4	54.6	59.4	68.9	75.2	78.8
70spd	I-75	268,197	73.0	58.2	63.9	72.0	78.4	82.4
17spd	I-94	1,019,670	70.7	57.2	61.3	70.2	76.1	79.5

* Speed Analysis in October, 1999 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	246,503	70.9	58.1	62.7	70.1	75.3	78.8
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	100,830	61.3	51.3	55.1	59.8	64.3	68.3
77spd	US-131	1,785,985	67.0	52.2	57.4	66.4	72.9	76.5
18spd	I-96	1,107,286	71.8	58.2	63.4	71.2	76.3	79.3
19spd	I-69	730,831	75.7	62.4	68.0	74.5	80.2	84.2
26spd	I-75	342,313	72.9	59.6	65.2	72.1	77.5	81.0
43spd	I-69	478,872	69.3	54.3	59.2	68.7	75.3	78.9
70spd	I-75	200,272	73.5	58.8	64.6	72.4	79.1	83.6
17spd	I-94	991,210	70.8	57.3	61.3	70.6	76.1	79.7

* Speed Analysis in November, 1999 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	198,210	71.1	58.3	63.0	70.4	75.4	78.8
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	112,350	62.0	53.2	56.1	60.3	64.8	68.7
77spd	US-131	1,687,983	66.8	51.9	57.2	66.2	72.8	76.3
18spd	I-96	1,014,313	71.9	58.2	63.4	71.3	76.4	79.4
19spd	I-69	531,830	76.0	62.7	68.3	74.7	80.5	84.6
26spd	I-75	333,957	73.0	60.0	65.5	72.1	77.0	80.3
43spd	I-69	385,953	69.4	54.4	59.3	68.9	75.4	79.0
70spd	I-75	159,415	74.5	60.0	65.6	73.3	80.1	84.6
17spd	I-94	628,456	70.8	57.0	61.0	70.1	76.5	80.3

* Speed Analysis in December, 1999 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	186,929	69.5	55.5	60.6	69.0	74.6	78.0
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	82,430	61.1	50.7	54.9	59.8	64.3	67.9
77spd	US-131	1,130,543	65.8	50.4	55.9	65.2	72.2	76.0
18spd	I-96	1,067,793	70.2	54.1	60.4	70.2	75.8	79.0
19spd	I-69	690,802	75.6	62.1	67.6	74.5	80.1	84.5
26spd	I-75	268,902	71.8	58.5	63.3	71.0	76.4	79.5
43spd	I-69	371,923	69.1	54.0	59.0	68.6	75.3	78.9
70spd	I-75	140,230	72.6	56.2	62.6	71.7	79.1	83.8
17spd	I-94	851,452	70.2	56.1	60.3	69.7	76.1	79.7

* Speed Analysis in January, 2000 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	127,960	68.9	52.7	58.5	67.7	73.7	77.1
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	51,986	60.2	45.9	52.6	58.3	63.3	67.0
77spd	US-131	1,125,085	65.8	49.1	54.8	64.0	71.5	75.7
18spd	I-96	851,659	70.6	54.2	60.0	69.2	75.6	78.9
19spd	I-69	424,667	74.1	57.6	63.8	72.8	78.9	82.4
26spd	I-75	290,307	71.8	56.4	62.1	70.1	76.2	79.8
43spd	I-69	294,180	68.1	51.4	56.5	66.5	74.1	77.2
70spd	I-75	95,885	70.4	51.0	58.5	69.1	76.8	81.2
17spd	I-94	694,224	69.8	53.9	58.8	68.2	75.5	78.9

* Speed Analysis in February, 2000 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	167,470	70.0	54.9	60.2	68.5	74.3	77.2
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	67,589	61.6	50.8	54.0	59.3	64.2	67.3
77spd	US-131	697,106	67.1	51.2	56.5	65.1	72.2	76.3
18spd	I-96	902,156	71.0	54.4	60.3	69.7	75.9	78.8
19spd	I-69	701,583	75.2	59.7	65.7	73.4	79.6	82.8
26spd	I-75	256,037	72.0	54.9	60.3	69.2	74.8	79.1
43spd	I-69	307,572	68.2	52.2	56.6	66.8	74.2	77.3
70spd	I-75	119,149	71.5	54.1	60.7	69.9	76.8	81.0
17spd	I-94	698,795	69.9	54.2	58.9	68.3	75.5	78.9

* Speed Analysis in March, 2000 *

1) Total

(Unit :mph)

Site	Location	Volume	Mean Speed	Percentile				
				5th	15th	50th	85th	95th
24spd	US-31	183,116	71.1	57.5	62.3	69.3	74.9	77.5
40spd	US-27	-	-	-	-	-	-	-
69spd	US-2	64,001	61.7	51.5	54.3	59.4	64.1	67.3
77spd	US-131	1,013,036	68.0	52.7	57.8	66.2	73.0	76.8
18spd	I-96	1,035,438	72.0	57.1	62.1	70.4	76.1	78.9
19spd	I-69	710,635	75.8	61.2	67.3	73.8	79.9	83.0
26spd	I-75	250,491	72.9	58.5	63.6	71.0	76.5	80.1
43spd	I-69	371,604	68.9	52.8	57.6	67.7	74.5	77.4
70spd	I-75	139,465	72.6	56.9	62.9	70.9	77.0	81.2
17spd	I-94	761,391	70.8	55.7	59.8	69.1	75.9	79.6

* Speed Analysis in July, 1997 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile 5th	15th	50th	85th	95th
24spd	US-31	101	159,404	71.2	58.6	64.4	70.2	75.4	79.4
		102	13,374	64.9	53.5	57.2	63.4	69.7	73.1
		103	6,358	62.7	54.3	56.9	61.1	65.1	68.6
40spd	US-27	101	259,324	71.2	59.4	64.7	69.9	75.1	78.0
		102	31,731	65.2	53.4	57.1	64.1	69.8	73.2
		103	9,360	62.5	53.3	56.7	61.4	65.4	68.0
69spd	US-2	101	130,732	60.7	50.6	54.1	59.2	64.1	67.7
		102	19,005	58.4	49.2	52.7	57.0	61.5	64.4
		103	7,738	59.7	52.0	54.3	58.2	62.3	64.4
77spd	US-131	101	1,091,808	65.9	52.2	56.9	65.1	71.5	75.0
		102	49,863	59.5	46.3	50.1	57.8	66.0	70.1
		103	42,749	60.1	48.3	52.4	58.5	64.9	68.7
18spd	I-96	101	624,466	71.7	60.1	65.2	70.7	75.4	78.2
		102	48,202	62.5	52.6	55.5	60.7	66.9	70.4
		103	17,277	62.1	53.3	56.0	60.4	64.8	68.4
19spd	I-69	101	664,538	73.7	61.9	66.7	72.4	77.8	81.5
		102	40,741	65.8	54.7	58.0	63.8	70.3	75.3
		103	21,791	64.8	55.4	58.0	62.4	68.4	74.3
26spd	I-75	101	352,543	73.4	62.5	66.8	72.0	77.0	80.6
		102	33,969	66.6	54.9	58.6	65.2	71.7	75.2
		103	11,831	62.6	54.1	56.8	61.1	64.9	67.8
43spd	I-69	101	240,313	70.7	56.3	62.5	69.8	75.6	79.1
		102	28,999	61.4	50.4	54.0	59.8	65.8	69.8
		103	18,310	62.0	53.6	56.3	60.3	64.4	67.5
70spd	I-75	101	226,905	71.4	56.6	62.5	70.6	76.5	80.4
		102	21,703	68.3	54.0	58.8	66.7	74.8	79.7
		103	4,701	75.6	59.0	63.4	72.1	86.1	95.6

* Speed Analysis in August, 1997 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	Location	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	228,184	70.7	58.2	63.6	69.9	74.9	78.8
		102	19,944	64.4	53.0	56.7	62.9	63.9	72.8
		103	11,116	62.6	54.1	56.7	60.9	65.1	68.3
40spd	US-27	101	298,236	71.4	59.5	64.7	70.1	75.3	78.3
		102	34,588	65.5	53.5	57.3	64.4	70.1	73.5
		103	10,763	62.6	53.5	56.8	61.3	65.4	68.1
69spd	US-2	101	156,433	60.7	50.1	54.0	59.1	64.2	68.2
		102	21,489	58.8	49.1	52.7	56.9	62.1	64.7
		103	8,194	59.8	51.6	54.4	58.4	62.4	64.4
77spd	US-131	101	1,740,758	66.2	52.7	57.3	65.4	71.5	75.2
		102	77,585	59.6	46.6	50.3	57.7	66.1	70.1
		103	65,635	60.5	49.2	52.8	58.8	65.3	69.0
18spd	I-96	101	979,688	71.9	60.0	65.0	70.8	75.7	78.7
		102	77,165	62.2	51.9	55.4	60.4	66.5	70.3
		103	29,916	62.1	53.7	56.4	60.4	64.5	67.7
19spd	I-69	101	808,573	73.7	61.8	66.6	72.3	78.0	81.7
		102	48,596	65.7	54.7	58.1	63.8	70.2	75.1
		103	30,033	64.8	55.7	58.4	62.5	68.0	73.4
26spd	I-75	101	414,579	73.1	59.6	65.9	72.0	77.3	81.3
		102	35,973	67.1	55.4	58.9	65.8	72.1	75.4
		103	13,565	62.9	54.4	57.0	61.4	65.4	68.6
43spd	I-69	101	376,578	70.0	54.1	61.2	69.5	75.4	78.9
		102	45,287	61.3	50.1	54.0	59.8	65.8	69.8
		103	32,056	61.9	53.1	56.1	60.3	64.4	67.5
70spd	I-75	101	253,452	71.4	56.5	62.3	70.7	76.9	80.8
		102	35,667	70.2	55.5	60.3	68.7	76.9	81.5
		103	6,478	75.0	58.3	63.0	71.7	85.2	94.0

* Speed Analysis in September, 1997 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	152,016	71.0	59.5	62.9	69.9	74.8	78.3
		102	13,098	64.0	52.8	56.4	62.4	68.9	72.4
		103	10,031	62.3	54.2	56.6	60.7	64.4	67.4
40spd	US-27	101	226,483	71.1	59.2	64.6	69.9	75.0	78.0
		102	22,994	65.1	53.1	56.8	63.9	69.9	73.2
		103	10,269	62.3	53.5	56.6	61.0	64.7	67.4
69spd	US-2	101	72,321	61.3	49.8	54.3	59.6	64.7	70.2
		102	8,513	58.3	46.6	52.4	57.3	61.6	64.4
		103	5,697	59.6	50.6	54.5	58.6	62.1	64.4
77spd	US-131	101	1,442,629	65.8	51.9	56.9	65.1	71.3	74.9
		102	61,231	59.0	46.0	49.9	57.2	65.4	69.7
		103	56,303	59.9	48.2	52.4	58.4	64.7	68.4
18spd	I-96	101	681,424	72.1	60.2	65.3	71.1	75.8	78.8
		102	54,834	62.3	52.6	55.7	60.5	66.2	70.2
		103	24,416	62.3	53.6	56.4	60.5	64.7	68.1
19spd	I-69	101	672,049	73.3	60.3	65.9	72.1	77.8	81.5
		102	39,785	65.2	54.0	57.5	63.3	69.8	74.5
		103	25,139	64.4	55.3	57.8	62.1	67.6	73.1
26spd	I-75	101	300,002	73.0	62.2	66.3	71.7	76.4	79.7
		102	25,195	66.4	54.5	58.3	64.9	71.7	75.0
		103	14,988	62.5	54.3	57.0	61.0	64.6	67.4
43spd	I-69	101	189,429	70.7	56.6	62.7	69.7	75.3	78.8
		102	25,202	61.1	50.6	54.1	59.5	65.0	69.3
		103	18,807	61.9	53.9	56.3	60.2	64.3	67.2
70spd	I-75	101	169,059	71.4	56.0	62.1	70.7	77.1	81.0
		102	24,985	70.4	55.6	60.4	69.0	77.1	81.8
		103	5,354	75.4	58.9	63.5	71.9	85.9	94.0

* Speed Analysis in October, 1997 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile 5th	15th	50th	85th	95th
24spd	US-31	101	184,551	71.0	59.2	62.8	69.9	74.8	78.3
		102	12,477	63.5	52.8	56.0	61.8	68.5	72.3
		103	15,081	62.2	54.0	56.5	60.7	64.5	67.6
40spd	US-27	101	223,561	71.1	58.9	64.2	70.0	75.1	78.3
		102	17,327	64.9	52.8	56.5	63.6	70.0	73.5
		103	12,411	62.3	53.4	56.8	61.1	64.7	67.4
69spd	US-2	101	48,373	62.4	43.9	52.2	60.0	69.3	82.7
		102	3,854	57.4	35.7	45.2	57.4	63.6	69.4
		103	3,161	59.1	40.5	53.3	58.7	62.7	65.6
77spd	US-131	101	1,845,384	65.9	52.0	57.0	65.2	71.4	75.0
		102	75,274	58.8	45.9	49.8	56.8	65.1	69.6
		103	75,673	60.0	48.3	52.4	58.5	64.7	68.5
18spd	I-96	101	586,716	72.2	60.3	65.3	71.2	75.9	78.9
		102	45,694	62.1	52.5	55.7	61.4	65.6	69.9
		103	24,520	62.4	53.8	56.5	60.7	64.8	68.6
19spd	I-69	101	711,734	73.5	61.1	66.3	72.3	77.8	81.4
		102	43,688	65.3	54.1	57.6	63.3	69.9	74.7
		103	30,401	64.5	54.9	57.7	62.3	68.0	73.1
26spd	I-75	101	325,068	73.0	62.1	66.4	71.7	76.5	80.0
		102	24,674	66.5	54.3	58.0	65.1	71.8	75.0
		103	20,853	62.6	54.2	56.8	61.2	64.8	67.9
43spd	I-69	101	300,844	70.1	55.3	61.1	69.5	75.4	79.0
		102	43,821	61.0	50.2	54.1	59.6	64.7	69.0
		103	36,743	62.1	53.4	56.4	60.4	64.4	67.4
70spd	I-75	101	110,932	71.6	56.6	62.4	70.7	77.4	81.3
		102	10,015	70.9	56.1	61.0	69.3	77.8	82.8
		103	4,596	77.1	60.7	65.2	74.1	86.4	95.5

* Speed Analysis in November, 1997 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	131,351	70.8	58.8	63.8	69.8	74.7	78.2
		102	6,161	63.3	52.5	55.8	61.6	68.7	76.4
		103	10,447	61.9	53.8	56.3	60.4	64.2	67.3
40spd	US-27	101	171,862	71.0	58.2	63.7	70.0	75.2	78.4
		102	11,704	65.0	52.3	56.5	63.9	70.1	73.5
		103	10,634	62.1	52.3	56.5	61.1	65.0	67.6
69spd	US-2	101	72,107	62.2	52.6	56.0	60.5	65.5	69.7
		102	8,745	60.5	50.4	54.3	59.2	63.8	67.0
		103	6,971	60.2	52.6	55.4	59.0	62.2	64.5
77spd	US-131	101	1,281,541	65.8	50.7	56.4	65.3	71.6	75.4
		102	45,196	58.2	44.5	48.9	56.3	65.0	69.6
		103	49,602	59.4	47.0	51.4	57.9	64.5	68.2
18spd	I-96	101	638,266	71.9	59.1	64.8	71.1	75.9	79.0
		102	45,042	61.6	51.3	55.0	60.0	65.0	69.3
		103	26,294	62.1	53.0	56.1	60.6	64.6	68.3
19spd	I-69	101	676,752	73.4	60.6	66.0	72.3	77.8	81.5
		102	40,107	65.1	54.1	57.6	63.1	69.8	74.4
		103	31,131	64.3	55.3	57.9	62.0	67.3	72.8
26spd	I-75	101	260,151	72.9	61.5	66.2	71.7	76.4	80.0
		102	16,949	67.0	54.3	58.5	65.9	72.3	75.6
		103	17,310	62.6	53.9	56.6	61.1	65.1	68.3
43spd	I-69	101	196,569	71.3	58.3	63.5	70.5	75.7	79.3
		102	28,431	61.2	51.0	54.7	59.8	64.4	68.5
		103	27,545	62.5	54.7	56.9	60.7	64.7	67.7
70spd	I-75	101	116,249	71.7	55.9	62.1	70.9	77.8	81.7
		102	6,508	71.0	56.2	61.5	69.2	77.7	83.3
		103	4,912	77.9	61.6	65.7	75.5	86.9	95.2
17spd	I-94	101	560,013	71.6	58.2	64.1	70.6	76.1	79.5
		102	61,171	58.7	44.8	50.2	57.1	64.3	69.2
		103	91,690	62.1	52.4	55.9	60.7	65.6	69.1

* Speed Analysis in December, 1997 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	Location	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	151,687	70.4	57.0	63.0	69.6	74.7	78.0
		102	5,853	62.5	50.4	55.3	61.0	67.4	72.1
		103	12,867	61.7	53.1	56.0	60.3	64.2	67.1
40spd	US-27	101	178,205	71.0	57.9	63.6	70.2	75.3	78.5
		102	9,360	65.8	52.7	57.4	64.9	71.1	74.4
		103	10,235	62.1	52.9	56.3	60.9	64.7	67.3
69spd	US-2	101	73,965	61.8	51.8	55.9	60.3	65.1	69.0
		102	6,486	60.6	50.1	54.3	59.3	64.0	67.3
		103	8,274	60.3	52.3	55.2	59.1	62.6	65.0
77spd	US-131	101	1,750,759	65.5	50.0	56.0	65.1	71.5	75.4
		102	54,412	58.0	44.2	48.6	56.0	64.8	69.6
		103	63,014	59.1	46.7	51.1	57.6	64.3	67.9
18spd	I-96	101	880,146	71.7	58.4	64.7	70.9	76.0	79.0
		102	60,022	61.4	51.2	54.9	60.0	64.9	68.9
		103	36,971	61.9	52.8	56.1	60.4	64.7	68.0
19spd	I-69	101	661,108	73.4	59.5	65.9	72.5	78.1	81.8
		102	32,219	65.8	54.1	58.4	63.9	70.5	75.7
		103	30,343	65.7	55.1	58.7	63.4	70.2	76.7
26spd	I-75	101	278,262	73.1	61.7	66.5	71.9	76.5	80.1
		102	15,652	67.6	54.7	58.8	66.7	72.8	76.0
		103	18,783	62.4	53.7	56.5	61.0	64.9	67.9
43spd	I-69	101	283,742	71.2	56.9	63.2	70.6	75.8	79.4
		102	34,461	61.1	50.2	54.2	59.6	64.8	69.1
		103	38,768	62.7	53.6	56.6	60.9	65.7	69.7
70spd	I-75	101	135,915	72.1	56.1	62.6	71.3	78.3	82.1
		102	7,717	72.2	58.0	62.8	70.1	78.9	85.0
		103	5,668	78.3	61.8	66.1	75.8	87.6	96.0
17spd	I-94	101	632,654	71.1	56.7	63.3	70.2	76.0	79.4
		102	75,715	57.9	44.1	49.8	56.4	63.4	68.0
		103	101,939	61.5	50.4	55.4	60.2	65.3	68.8

* Speed Analysis in January, 1998 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	114,609	68.7	52.6	59.7	68.5	73.8	77.3
		102	5,889	61.6	46.3	53.3	60.5	67.7	71.9
		103	11,569	60.6	50.0	54.6	59.6	63.9	66.8
40spd	US-27	101	149,284	69.8	54.7	61.4	69.3	74.8	78.2
		102	19,368	66.9	53.3	58.6	66.2	72.0	75.2
		103	9,920	61.5	51.0	55.6	60.5	64.3	67.1
69spd	US-2	101	36,699	60.2	47.6	53.2	59.2	64.1	67.5
		102	9,044	59.8	47.8	53.0	58.7	63.7	67.1
		103	6,173	58.6	47.5	52.7	57.8	61.5	64.0
77spd	US-131	101	1,409,235	63.7	46.4	53.3	63.3	70.4	74.6
		102	49,096	56.9	42.0	47.0	55.0	64.2	69.2
		103	56,051	57.9	44.0	49.6	56.7	63.6	67.2
18spd	I-96	101	776,479	70.6	55.3	62.4	70.2	75.6	78.8
		102	58,398	60.5	48.8	53.5	59.4	64.3	68.3
		103	37,618	61.1	50.4	55.1	60.0	64.2	67.3
19spd	I-69	101	619,908	73.0	58.8	65.3	72.2	77.8	81.5
		102	34,419	65.6	53.5	58.2	63.8	70.3	75.5
		103	36,786	65.5	54.3	58.6	63.4	69.8	75.7
26spd	I-75	101	246,080	72.3	58.5	64.7	71.5	76.7	80.5
		102	36,323	69.0	55.1	60.4	68.4	74.0	77.4
		103	19,003	61.7	52.7	55.8	60.5	64.4	67.4
43spd	I-69	101	221,127	70.9	56.6	62.6	70.2	75.6	79.3
		102	31,666	61.9	50.5	54.5	60.1	66.4	71.4
		103	38,986	63.8	54.3	57.0	61.6	67.1	72.8
70spd	I-75	101	93,248	68.5	50.9	57.5	67.8	76.0	80.5
		102	11,155	69.8	53.4	59.6	68.4	76.8	82.3
		103	4,924	76.6	58.9	63.9	74.1	86.8	96.4
17spd	I-94	101	515,416	71.1	56.6	63.2	70.4	76.0	79.4
		102	62,820	58.7	44.6	49.9	57.3	64.5	69.4
		103	120,399	62.1	50.4	55.6	60.8	66.1	70.0

* Speed Analysis in February, 1998 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	121,961	71.5	60.0	64.7	70.4	75.3	78.7
		102	4,614	63.0	52.3	55.7	61.1	67.8	72.0
		103	10,039	62.2	54.1	56.5	60.5	64.3	67.4
40spd	US-27	101	150,543	71.6	59.4	64.8	70.6	75.6	78.7
		102	10,828	67.2	54.2	58.8	66.4	72.2	75.4
		103	10,078	62.5	53.8	57.0	61.1	64.8	67.6
69spd	US-2	101	44,985	62.3	53.3	56.3	60.6	65.4	69.1
		102	9,314	61.9	53.1	56.0	60.2	65.0	68.5
		103	7,424	60.6	53.1	55.5	59.2	62.8	65.0
77spd	US-131	101	1,504,658	66.7	52.7	57.6	66.0	72.4	75.8
		102	47,994	58.2	44.8	48.9	56.2	64.8	69.7
		103	56,552	59.7	48.1	52.0	58.1	64.3	68.1
18spd	I-96	101	730,426	72.8	61.1	65.9	71.7	76.4	79.4
		102	55,065	62.0	52.6	55.6	60.3	65.4	69.4
		103	35,537	62.5	53.9	56.6	60.8	65.0	68.2
19spd	I-69	101	612,113	74.5	62.7	67.6	73.1	78.5	82.2
		102	32,652	66.8	55.9	59.2	64.4	71.5	77.1
		103	36,974	66.2	56.6	59.3	63.8	69.8	76.1
26spd	I-75	101	231,359	73.7	62.6	67.5	72.3	77.3	81.0
		102	18,195	69.3	56.1	60.8	68.6	74.0	77.6
		103	17,659	62.4	54.0	56.6	61.0	64.5	67.8
43spd	I-69	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
70spd	I-75	101	102,550	72.6	57.1	63.3	71.6	78.6	82.4
		102	10,773	73.1	59.5	64.5	71.4	78.9	83.9
		103	4,872	78.9	62.3	66.5	76.7	88.0	96.7
17spd	I-94	101	484,562	72.8	60.8	65.7	71.7	76.4	80.1
		102	46,173	63.1	51.5	55.8	61.8	67.4	71.9
		103	125,746	63.9	54.4	57.5	62.2	67.3	72.0

* Speed Analysis in March, 1998 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	87,350	71.4	59.8	64.6	70.3	75.3	78.8
		102	3,535	63.3	52.5	55.9	61.4	68.4	72.4
		103	7,392	62.1	54.0	56.5	60.5	64.3	67.3
40spd	US-27	101	156,950	70.3	55.2	62.4	69.9	75.1	78.3
		102	10,676	65.7	51.0	56.6	65.1	71.6	74.9
		103	11,384	61.9	51.3	56.1	60.9	64.8	67.6
69spd	US-2	101	38,449	61.5	50.4	55.6	60.2	64.9	69.1
		102	2,735	60.1	48.7	53.5	59.0	63.8	67.3
		103	7,000	60.2	51.7	55.0	59.0	62.8	64.9
77spd	US-131	101	1,593,080	65.7	49.7	56.3	65.4	72.1	75.5
		102	53,126	57.7	43.6	48.1	55.9	64.6	69.5
		103	65,267	59.0	45.4	50.9	57.9	64.3	67.9
18spd	I-96	101	850,601	71.6	57.4	64.6	71.2	76.1	79.2
		102	61,362	60.7	49.5	53.9	59.5	64.5	68.9
		103	38,400	61.2	50.9	55.7	60.2	64.3	67.4
19spd	I-69	101	626,169	73.8	61.6	66.8	72.8	78.0	81.6
		102	35,950	66.5	55.7	59.1	64.3	71.0	76.2
		103	36,653	66.5	56.3	59.4	64.2	70.4	76.6
26spd	I-75	101	221,225	71.6	55.6	64.3	71.3	76.2	79.8
		102	17,566	66.9	51.3	57.3	66.6	72.9	76.2
		103	19,424	61.7	52.2	56.0	60.8	64.4	67.5
43spd	I-69	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
70spd	I-75	101	95,683	71.8	55.3	62.1	71.2	78.1	82.1
		102	4,737	73.1	58.2	63.2	71.3	79.6	86.5
		103	3,648	79.4	62.3	66.8	77.0	88.9	98.4
17spd	I-94	101	556,706	72.1	57.9	64.8	71.5	76.4	80.1
		102	43,575	62.6	47.9	54.7	61.7	67.5	72.0
		103	141,473	63.3	53.2	57.0	61.9	66.8	70.3

* Speed Analysis in April, 1998 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	Location	Vehicle Type	Volume	Mean Speed	Percentile 5th	15th	50th	85th	95th
24spd	US-31	101	146,981	71.5	61.0	64.7	70.3	75.5	78.9
		102	8,082	63.8	52.9	56.3	61.9	68.7	72.6
		103	12,124	62.3	54.5	56.7	60.6	64.5	67.8
40spd	US-27	101	173,842	71.4	59.2	64.6	70.4	75.3	78.4
		102	11,087	65.1	53.2	58.6	63.8	70.2	73.4
		103	11,467	62.6	53.8	51.5	61.2	65.0	67.5
69spd	US-2	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
77spd	US-131	101	1,694,138	66.6	52.6	57.5	65.7	72.4	75.7
		102	63,999	58.6	45.1	49.2	56.7	65.1	70.0
		103	65,892	59.9	48.1	52.1	58.5	64.4	68.4
18spd	I-96	101	819,504	72.7	60.9	65.7	71.6	76.5	79.5
		102	62,203	62.2	52.6	55.7	60.5	65.9	69.9
		103	35,526	62.4	53.9	56.6	60.7	64.8	68.3
19spd	I-69	101	684,844	74.5	62.9	67.7	73.2	78.4	82.0
		102	39,729	66.8	56.3	59.4	64.6	71.0	76.0
		103	43,656	67.1	57.1	59.8	64.7	70.8	77.4
26spd	I-75	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
43spd	I-69	101	91,582	72.1	59.1	64.7	71.2	76.1	79.7
		102	12,778	62.7	51.6	55.6	60.8	67.0	71.4
		103	15,159	64.4	55.5	57.8	62.2	67.5	72.7
70spd	I-75	101	136,957	72.8	57.9	63.9	72.0	78.2	82.1
		102	7,211	72.8	57.5	62.5	70.7	80.1	87.0
		103	4,485	81.0	63.5	67.8	78.7	91.1	100.4
17spd	I-94	101	630,899	72.8	61.1	65.6	71.6	76.7	80.4
		102	58,281	62.9	51.5	55.8	61.2	67.2	71.4
		103	156,066	63.1	53.9	57.2	61.5	66.2	69.8

* Speed Analysis in May, 1998 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	Location	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	197,771	71.8	60.2	65.0	70.4	75.7	79.0
		102	15,137	64.8	53.3	57.0	63.3	69.8	73.3
		103	13,120	62.7	54.8	57.0	60.9	65.3	68.6
40spd	US-27	101	256,704	71.5	59.5	64.8	70.4	75.4	78.4
		102	26,344	65.9	53.7	57.8	64.9	70.6	73.9
		103	12,212	62.6	53.8	57.0	61.3	65.2	67.8
69spd	US-2	101	102,627	61.6	52.8	55.8	60.1	64.2	68.0
		102	11,605	59.7	50.8	54.0	58.3	62.5	64.7
		103	10,825	60.5	53.0	55.6	59.1	62.8	64.5
77spd	US-131	101	1,928,833	66.6	52.7	57.6	65.7	72.4	75.6
		102	81,875	59.5	46.2	50.1	57.7	66.0	70.6
		103	75,383	60.2	48.5	52.6	58.9	64.7	68.8
18spd	I-96	101	904,262	72.7	61.1	65.8	71.5	76.4	79.4
		102	68,920	63.0	53.1	56.3	61.1	66.9	70.9
		103	37,870	63.0	54.6	57.1	61.1	65.6	69.2
19spd	I-69	101	676,805	74.2	62.8	67.6	73.0	78.0	81.6
		102	41,005	66.9	56.4	59.5	64.7	71.2	75.8
		103	40,494	67.3	57.0	59.9	64.9	71.2	77.6
26spd	I-75	101	320,346	73.6	62.6	67.3	72.3	77.1	80.7
		102	26,312	67.4	55.2	59.1	66.2	72.5	75.7
		103	17,962	62.9	54.9	57.4	61.5	65.1	68.3
43spd	I-69	101	336,426	72.1	59.2	64.8	71.2	76.1	79.8
		102	43,090	63.1	51.8	55.8	61.2	67.8	72.0
		103	44,810	64.3	55.5	57.6	62.2	67.5	72.4
70spd	I-75	101	208,382	72.6	57.5	63.5	71.9	78.0	81.9
		102	14,216	71.6	56.5	61.6	69.7	78.4	85.6
		103	5,139	80.6	62.5	67.1	78.4	91.0	99.7
17spd	I-94	101	712,042	72.6	60.5	65.4	71.5	76.5	80.2
		102	64,559	63.0	51.0	55.5	61.3	67.6	72.0
		103	154,300	63.1	53.8	57.2	61.5	66.3	69.9

* Speed Analysis in June, 1998 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	Location	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	169,363	69.3	37.3	61.6	69.9	75.7	79.7
		102	12,247	63.0	37.4	55.5	62.7	69.4	73.1
		103	11,030	61.8	50.1	56.1	60.8	65.4	68.9
40spd	US-27	101	122,104	67.4	50.0	56.2	67.6	74.1	77.4
		102	13,121	63.0	48.7	53.6	62.0	69.2	72.7
		103	4,610	60.0	46.7	51.7	59.1	64.7	68.3
69spd	US-2	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
77spd	US-131	101	1,577,592	66.7	52.7	57.7	65.9	72.5	75.7
		102	67,452	59.8	46.1	50.3	58.0	66.4	71.0
		103	61,214	60.5	48.7	52.7	59.0	65.2	69.2
18spd	I-96	101	1,000,252	72.8	61.0	65.8	71.7	76.5	79.5
		102	75,530	63.3	53.3	56.5	61.5	67.2	71.3
		103	35,486	63.1	54.4	57.0	61.3	65.8	69.5
19spd	I-69	101	510,302	74.4	63.1	67.7	73.1	78.3	81.8
		102	32,004	67.0	56.4	59.6	65.0	71.0	75.8
		103	26,707	67.4	57.3	60.0	64.9	71.1	78.3
26spd	I-75	101	408,980	73.7	62.7	67.4	72.4	77.3	80.8
		102	34,439	66.7	54.6	58.5	65.3	72.0	75.2
		103	19,981	63.0	55.0	57.5	61.6	65.2	68.3
43spd	I-69	101	320,825	72.1	59.2	64.7	71.1	76.1	79.7
		102	40,559	63.2	52.0	55.8	61.5	68.0	72.1
		103	39,740	64.1	55.5	57.5	62.2	67.2	71.9
70spd	I-75	101	212,429	72.3	57.7	63.3	71.6	77.6	81.6
		102	15,678	70.5	55.8	60.3	68.7	77.0	83.7
		103	4,708	79.8	62.1	66.6	77.5	90.0	98.4
17spd	I-94	101	650,928	72.9	60.6	65.6	71.8	76.9	80.5
		102	61,927	63.0	50.3	55.4	61.6	68.1	72.4
		103	140,745	63.9	54.1	57.6	62.2	67.3	71.5

* Speed Analysis in July, 1998 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	283,953	72.0	60.6	65.2	70.6	75.9	79.2
		102	24,086	65.2	53.9	57.5	63.6	69.8	73.4
		103	15,140	62.7	55.1	57.2	61.0	65.1	68.2
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
77spd	US-131	101	1,683,293	66.8	52.9	57.9	66.0	72.5	75.7
		102	74,877	60.0	46.6	50.6	58.4	66.4	71.1
		103	63,922	60.4	49.0	52.8	59.0	64.6	68.8
18spd	I-96	101	1,013,050	72.6	61.0	65.6	71.5	76.2	79.3
		102	75,303	62.9	52.7	56.0	61.0	67.0	71.4
		103	30,382	62.6	54.0	56.7	60.9	65.3	68.9
19spd	I-69	101	590,701	74.2	63.0	67.6	72.8	78.2	81.8
		102	36,041	66.7	56.1	59.3	64.9	70.6	75.5
		103	27,899	67.0	56.9	59.6	64.5	70.6	77.7
26spd	I-75	101	544,882	74.1	63.2	67.7	72.7	77.9	81.3
		102	56,027	67.4	55.7	59.3	66.0	72.4	75.8
		103	18,847	63.1	55.0	57.6	61.5	65.6	68.7
43spd	I-69	101	293,262	72.1	59.0	64.8	71.2	76.2	80.0
		102	31,575	63.5	52.1	56.0	61.8	68.5	72.5
		103	24,120	64.2	55.5	57.6	62.2	67.4	71.9
70spd	I-75	101	290,518	71.9	56.9	62.6	71.2	77.4	81.4
		102	22,885	68.9	54.2	59.0	67.1	75.5	81.6
		103	4,658	79.1	61.2	65.7	76.7	90.9	99.1
17spd	I-94	101	795,276	73.4	61.7	66.4	72.1	77.3	80.9
		102	53,360	65.4	54.0	58.3	63.7	70.1	73.6
		103	138,606	65.0	55.8	58.9	63.2	68.5	72.6

* Speed Analysis in August, 1998 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	136,862	71.5	58.7	64.6	70.4	76.0	79.7
		102	12,619	65.0	50.1	56.7	63.8	70.2	74.9
		103	5,450	62.7	54.2	56.8	60.9	65.2	68.9
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	59,279	61.2	49.5	54.0	59.5	65.0	69.7
		102	6,090	59.1	50.0	53.2	57.7	62.3	65.4
		103	3,414	60.2	52.6	55.0	58.7	62.9	65.4
77spd	US-131	101	1,798,350	66.8	52.9	57.9	65.9	72.5	75.6
		102	79,342	60.0	46.7	50.6	58.2	66.5	71.2
		103	71,000	60.2	48.8	52.7	58.9	64.5	68.7
18spd	I-96	101	1,107,126	72.5	61.0	65.6	71.6	76.2	79.3
		102	82,777	63.0	52.7	56.0	61.2	67.2	71.5
		103	37,433	62.7	54.1	56.8	61.0	65.2	68.9
19spd	I-69	101	834,394	74.1	62.6	67.2	72.6	78.2	81.7
		102	51,690	66.8	56.3	57.5	64.8	71.0	75.7
		103	49,651	67.5	57.5	60.1	64.9	72.0	78.4
26spd	I-75	101	580,373	74.2	63.3	67.8	72.8	78.0	81.3
		102	55,646	67.6	55.7	59.4	66.2	72.6	75.9
		103	20,015	63.1	55.1	57.6	61.5	65.6	68.9
43spd	I-69	101	370,424	72.5	60.1	65.4	71.4	76.3	80.1
		102	41,193	63.6	52.3	56.0	61.9	68.5	72.4
		103	38,598	64.3	55.6	57.9	62.4	67.5	71.9
70spd	I-75	101	300,792	72.4	58.1	63.5	71.6	77.8	81.7
		102	23,145	69.4	55.4	59.7	67.5	75.8	81.8
		103	4,702	79.2	61.7	65.7	76.8	89.6	98.5
17spd	I-94	101	655,216	73.4	62.0	66.6	72.2	77.3	80.7
		102	49,838	64.9	53.2	57.2	63.2	69.6	73.5
		103	138,527	64.6	55.2	58.4	62.9	68.1	72.0

* Speed Analysis in September, 1998 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	133,556	71.6	59.6	64.5	70.7	75.5	79.0
		102	11,593	63.9	52.7	56.3	62.1	69.0	72.6
		103	9,240	62.5	54.7	56.9	60.9	64.4	67.6
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	130,530	61.0	51.3	54.7	59.5	64.3	67.9
		102	17,276	59.0	49.9	53.0	57.5	62.0	65.1
		103	10,233	60.3	52.7	55.3	58.8	62.7	65.2
77spd	US-131	101	1,739,305	66.7	52.5	57.6	66.0	72.5	75.6
		102	78,820	59.5	46.4	50.2	57.7	66.0	70.5
		103	75,528	60.2	48.8	52.6	58.9	64.6	68.7
18spd	I-96	101	994,489	72.7	61.2	65.9	71.7	76.2	79.2
		102	78,402	62.5	52.5	55.7	60.8	66.6	70.9
		103	41,404	62.7	54.1	56.7	61.0	65.2	68.8
19spd	I-69	101	777,201	74.2	62.7	67.6	72.8	78.1	81.6
		102	49,359	66.6	56.3	59.3	64.4	70.9	75.3
		103	53,766	67.4	57.4	60.1	64.8	71.7	77.9
26spd	I-75	101	394,185	73.8	63.0	67.5	72.4	77.4	80.9
		102	34,596	67.1	55.5	58.9	65.6	72.3	75.6
		103	20,863	62.9	54.9	57.4	61.4	64.9	67.8
43spd	I-69	101	281,519	72.0	59.0	64.6	71.0	76.2	79.9
		102	37,457	63.0	52.4	55.9	61.2	67.2	71.5
		103	28,854	64.1	55.5	57.7	62.2	67.2	71.5
70spd	I-75	101	255,622	72.5	57.9	63.5	71.7	77.9	81.9
		102	20,679	69.9	55.7	59.9	68.1	76.3	82.6
		103	5,470	79.4	61.9	66.0	77.1	90.0	98.4
17spd	I-94	101	698,124	73.3	61.7	66.4	72.1	77.1	80.6
		102	55,463	64.2	52.8	56.6	62.6	68.9	72.8
		103	169,762	64.1	54.4	57.8	62.6	67.5	71.0

* Speed Analysis in October, 1998 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	141,070	69.6	52.5	60.1	69.6	75.0	78.7
		102	9,956	62.7	49.2	54.1	61.2	68.6	72.4
		103	10,189	61.6	50.9	55.6	60.4	64.3	67.6
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	107,562	61.7	52.4	55.6	60.1	64.9	68.8
		102	12,532	59.9	50.2	53.7	58.4	63.3	66.2
		103	9,451	60.6	52.9	55.6	59.2	63.2	65.2
77spd	US-131	101	1,680,646	66.7	52.1	57.4	66.1	72.6	75.9
		102	68,105	59.2	45.8	50.0	57.2	66.0	70.3
		103	70,271	60.0	48.3	52.2	58.4	64.7	68.6
18spd	I-96	101	952,328	72.7	60.7	65.8	71.7	76.3	79.3
		102	72,307	62.3	52.7	55.8	60.5	66.0	70.1
		103	42,417	62.6	54.2	56.9	60.8	65.0	68.3
19spd	I-69	101	733,865	74.6	63.3	67.9	73.4	78.3	81.8
		102	43,878	66.9	56.5	59.6	64.8	71.0	75.6
		103	54,609	68.1	57.8	60.6	65.6	72.6	79.0
26spd	I-75	101	370,709	74.0	62.8	67.5	72.5	77.8	81.3
		102	27,317	67.3	55.4	58.9	65.9	72.6	76.0
		103	20,438	62.9	54.7	57.5	61.4	64.9	68.1
43spd	I-69	101	314,881	71.9	58.7	64.2	71.0	76.2	79.9
		102	39,345	63.0	52.4	56.0	61.2	67.2	71.5
		103	30,953	64.2	55.6	57.7	62.2	67.2	71.5
70spd	I-75	101	196,953	72.8	58.2	63.8	72.0	78.0	82.0
		102	12,846	71.1	56.2	61.5	69.4	77.6	83.9
		103	4,864	80.1	62.4	66.8	77.8	90.4	99.1
17spd	I-94	101	564,799	73.6	61.9	66.7	72.4	77.5	81.1
		102	46,983	64.0	52.6	56.4	62.4	68.8	72.9
		103	151,970	64.1	54.3	57.8	62.5	67.5	71.0

* Speed Analysis in November, 1998 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	Location	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	150,347	71.3	59.0	64.5	70.5	75.4	78.8
		102	7,573	63.7	51.3	56.1	62.0	69.2	72.8
		103	10,992	61.9	53.2	56.3	60.6	64.3	67.5
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	70,235	62.2	53.1	56.0	60.4	65.4	69.2
		102	8,075	60.9	51.9	54.9	59.3	64.1	67.3
		103	5,318	60.7	53.0	55.6	59.3	63.2	65.7
77spd	US-131	101	1,606,461	66.9	52.4	57.6	66.3	72.7	76.2
		102	54,710	59.0	45.3	49.6	57.1	65.9	70.3
		103	60,372	59.7	47.7	51.7	58.2	64.6	68.2
18spd	I-96	101	907,738	72.7	61.0	65.8	71.7	76.3	79.3
		102	58,842	61.8	51.9	55.3	60.2	65.4	69.7
		103	35,842	62.3	53.8	56.5	60.7	64.5	67.6
19spd	I-69	101	653,272	75.2	64.2	68.5	73.6	79.0	82.3
		102	35,066	68.3	58.0	60.8	66.0	72.8	78.1
		103	53,907	71.7	59.8	62.8	68.9	77.6	85.0
26spd	I-75	101	294,059	73.3	61.8	66.8	72.2	76.9	80.4
		102	19,408	67.6	54.9	59.0	66.5	72.8	76.0
		103	18,060	62.6	54.1	56.9	61.3	64.7	68.1
43spd	I-69	101	252,301	72.0	58.8	64.3	71.1	76.2	79.6
		102	33,398	62.7	51.9	55.8	61.0	66.8	71.5
		103	29,432	64.0	55.6	57.7	62.1	67.0	71.7
70spd	I-75	101	141,269	73.5	58.7	64.8	72.6	78.6	83.0
		102	7,635	72.6	58.1	63.0	70.8	78.8	85.6
		103	4,236	80.1	63.1	67.3	77.4	90.4	98.5
17spd	I-94	101	640,574	73.7	62.0	66.8	72.5	77.7	81.1
		102	40,840	63.7	52.2	56.1	62.1	68.6	72.7
		103	143,531	64.0	54.2	57.5	62.5	67.5	70.9

* Speed Analysis in December, 1998 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	153,795	70.5	56.6	62.6	69.8	75.0	78.5
		102	6,489	62.5	50.8	55.3	60.8	67.7	71.9
		103	12,718	61.6	52.6	56.0	60.3	64.1	67.1
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	54,043	61.0	48.7	54.4	59.9	64.7	68.5
		102	5,476	59.2	47.9	52.8	58.0	63.1	66.2
		103	6,709	60.1	51.0	54.6	59.0	63.0	65.3
77spd	US-131	101	1,710,775	66.1	50.1	56.4	65.7	72.4	76.0
		102	54,178	58.5	44.1	48.8	56.6	65.7	70.3
		103	65,279	59.0	45.8	50.7	57.7	64.3	67.9
18spd	I-96	101	935,556	72.2	59.2	65.1	71.5	76.2	79.2
		102	62,918	61.6	51.3	55.1	60.1	65.1	69.3
		103	43,506	62.2	52.9	56.2	60.7	65.1	68.5
19spd	I-69	101	710,040	74.8	62.9	68.0	73.6	78.8	82.2
		102	36,335	68.0	57.1	60.4	65.7	72.7	78.3
		103	56,433	71.5	59.4	62.5	68.8	77.4	85.5
26spd	I-75	101	273,246	72.7	59.6	65.4	71.8	76.6	80.3
		102	21,782	67.4	52.9	58.5	66.7	73.1	76.4
		103	19,716	62.5	53.7	56.8	61.2	64.6	67.9
43spd	I-69	101	293,195	71.3	56.9	63.0	70.8	76.0	79.5
		102	35,265	62.4	50.9	55.5	60.8	66.7	71.2
		103	31,109	63.6	54.1	57.2	61.8	66.9	71.4
70spd	I-75	101	102,976	70.8	53.5	60.4	70.2	77.5	81.9
		102	6,297	71.0	54.3	60.3	69.2	78.4	85.4
		103	3,476	79.5	62.4	66.6	77.3	89.7	98.5
17spd	I-94	101	652,963	73.4	61.5	66.4	72.3	77.6	81.1
		102	45,037	63.3	51.5	55.8	61.8	68.2	72.5
		103	166,749	63.6	53.5	57.2	62.2	67.2	70.5

* Speed Analysis in January, 1999 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	Location	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	102,649	66.9	50.3	56.8	66.6	73.1	76.5
		102	5,423	60.1	45.9	51.6	59.1	65.7	70.3
		103	13,280	60.1	48.1	53.3	59.3	63.8	66.7
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	33,392	59.4	46.3	52.0	58.6	63.6	67.1
		102	8,727	58.4	45.8	50.8	57.4	62.8	66.4
		103	5,822	58.7	47.7	52.6	57.8	61.9	64.4
77spd	US-131	101	1,208,955	59.5	39.3	46.9	59.0	68.6	72.8
		102	41,898	53.6	36.1	42.3	52.1	61.7	67.3
		103	53,687	54.1	36.8	43.2	53.4	61.2	65.5
18spd	I-96	101	716,395	67.9	47.4	56.3	68.6	74.9	78.1
		102	53,748	59.0	44.3	50.8	58.3	63.8	67.5
		103	39,294	59.3	44.2	51.6	58.9	63.8	67.0
19spd	I-69	101	373,907	72.2	55.9	62.9	71.8	77.9	81.8
		102	21,991	66.9	53.3	54.4	64.7	72.8	79.5
		103	32,038	72.3	56.5	61.4	69.4	81.0	90.5
26spd	I-75	101	212,933	70.0	52.3	60.4	69.9	75.9	79.3
		102	29,548	65.8	47.7	55.7	65.7	72.6	76.0
		103	16,739	61.5	51.0	55.3	60.5	64.4	67.5
43spd	I-69	101	95,136	67.5	49.6	56.6	67.5	74.2	78.3
		102	14,849	60.7	47.5	52.8	59.5	65.5	70.1
		103	12,759	61.9	50.0	54.8	60.4	65.8	70.1
70spd	I-75	101	87,796	67.7	49.5	56.3	67.1	75.6	80.3
		102	9,059	68.9	51.8	58.1	67.4	76.3	82.9
		103	3,312	77.2	58.9	64.1	74.5	87.9	97.8
17spd	I-94	101	454,516	69.8	52.2	60.0	69.7	75.8	79.2
		102	42,127	61.0	46.2	52.5	60.0	66.5	70.6
		103	160,432	61.6	46.8	54.0	60.7	66.3	69.9

* Speed Analysis in February, 1999 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	Location	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
77spd	US-131	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
18spd	I-96	101	795,113	72.1	59.0	65.0	71.4	76.2	79.2
		102	57,580	61.4	51.4	55.0	59.9	64.5	68.8
		103	42,667	61.9	53.2	56.1	60.4	64.3	67.4
19spd	I-69	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
26spd	I-75	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
43spd	I-69	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
70spd	I-75	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
17spd	I-94	101	480,886	72.1	58.1	64.7	71.6	76.5	80.0
		102	43,637	62.4	50.5	55.0	60.9	67.0	71.6
		103	146,805	62.7	52.8	56.4	61.2	66.3	69.9

* Speed Analysis in March, 1999 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
77spd	US-131	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
18spd	I-96	101	856,227	71.9	57.8	64.6	71.4	76.2	79.2
		102	60,334	61.2	50.4	54.5	59.9	64.4	68.9
		103	43,147	61.5	51.7	55.8	60.2	64.2	67.3
19spd	I-69	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
26spd	I-75	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
43spd	I-69	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
70spd	I-75	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
17spd	I-94	101	598,479	72.9	59.6	65.6	72.0	77.2	80.7
		102	50,996	62.8	50.5	55.3	61.3	67.4	71.8
		103	190,340	62.9	52.5	56.6	61.6	66.6	70.0

* Speed Analysis in April, 1999 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	Location	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
77spd	US-131	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
18spd	I-96	101	81,355	72.6	60.5	65.6	71.6	76.3	79.3
		102	60,098	61.8	51.9	55.2	60.0	65.4	69.9
		103	40,387	62.1	53.7	56.4	60.4	64.3	67.4
19spd	I-69	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
26spd	I-75	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
43spd	I-69	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
70spd	I-75	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
17spd	I-94	101	594,538	73.4	61.7	66.3	72.1	77.3	80.8
		102	50,926	63.6	52.4	56.2	62.0	68.4	72.5
		103	174,676	63.6	54.2	57.4	62.1	67.0	70.3

* Speed Analysis in May, 1999 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
77spd	US-131	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
18spd	I-96	101	1,071,922	72.7	61.1	65.9	71.6	76.3	79.3
		102	80,864	62.2	52.1	55.5	60.4	66.3	70.4
		103	48,848	62.4	53.9	56.6	60.7	64.7	68.1
19spd	I-69	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
26spd	I-75	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
43spd	I-69	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
70spd	I-75	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
17spd	I-94	101	710,492	73.3	61.6	66.2	72.1	77.1	80.7
		102	58,599	63.8	52.5	56.2	62.2	68.7	72.8
		103	183,202	63.7	54.2	57.4	62.2	67.1	70.5

* Speed Analysis in June, 1999 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	Location	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
77spd	US-131	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
18spd	I-96	101	962,365	72.4	60.5	65.5	71.4	76.2	79.1
		102	71,859	62.4	52.4	55.8	60.6	66.5	70.4
		103	40,431	62.3	53.9	56.6	60.6	64.5	67.7
19spd	I-69	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
26spd	I-75	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
43spd	I-69	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
70spd	I-75	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
17spd	I-94	101	791,204	73.1	61.6	66.2	72.0	76.7	80.3
		102	66,023	63.9	52.6	56.3	62.2	68.9	72.9
		103	193,567	63.6	54.2	57.4	62.1	67.0	70.4

* Speed Analysis in July, 1999 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	Location	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	113,942	72.0	61.1	65.4	70.9	75.5	79.0
		102	8,845	65.1	54.0	57.3	63.5	70.0	73.0
		103	6,221	62.6	54.6	56.8	61.0	64.5	68.3
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	66,177	60.7	51.0	54.5	59.3	63.9	67.3
		102	10,345	58.8	49.6	53.0	57.5	61.5	64.2
		103	4,642	60.2	52.5	55.0	59.0	62.5	64.4
77spd	US-131	101	1,431,944	67.5	53.4	58.6	66.7	73.0	76.1
		102	65,536	60.3	46.8	50.8	58.5	66.9	71.5
		103	60,496	60.2	48.6	52.6	58.8	64.7	68.6
18spd	I-96	101	1,067,853	72.8	61.1	65.9	71.7	76.5	79.6
		102	79,977	63.1	52.9	56.2	61.2	67.4	71.6
		103	39,886	62.6	53.9	56.7	60.9	65.1	68.7
19spd	I-69	101	599,988	76.0	64.7	69.1	74.8	79.7	84.1
		102	37,404	70.0	56.8	57.7	67.8	76.8	82.0
		103	58,937	74.2	59.7	63.7	72.3	80.8	88.7
26spd	I-75	101	389,131	73.8	62.9	67.4	72.5	77.6	80.9
		102	42,703	67.3	55.5	59.3	66.0	72.3	75.7
		103	14,588	63.1	54.6	57.6	61.5	65.6	68.8
43spd	I-69	101	266,572	68.5	49.7	55.2	69.1	75.8	79.2
		102	26,519	61.0	48.2	52.1	59.4	67.0	71.3
		103	25,997	61.4	50.4	54.3	60.1	64.8	68.4
70spd	I-75	101	269,449	72.4	58.0	63.4	71.5	77.8	81.8
		102	22,176	69.5	55.5	59.8	67.5	76.0	82.0
		103	4,938	79.7	60.9	65.6	77.5	90.9	99.9
17spd	I-94	101	356,734	72.7	61.0	65.8	71.6	76.4	79.5
		102	27,660	63.8	52.7	56.2	62.2	68.8	72.8
		103	78,977	63.6	54.0	57.2	62.0	67.0	70.4

<u>* Speed Analysis in August, 1999 *</u>

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	314,816	72.1	61.2	65.4	71.0	75.7	79.1
		102	25,311	65.4	54.2	57.7	63.9	70.3	73.2
		103	14,179	62.6	54.8	56.9	61.0	64.6	68.2
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	160,505	60.9	50.7	54.6	59.4	64.1	67.8
		102	23,167	59.0	49.7	53.2	57.7	61.9	64.4
		103	9,731	60.1	52.2	55.0	58.9	62.4	64.5
77spd	US-131	101	1,807,898	67.6	53.5	58.6	66.9	73.2	76.4
		102	80,615	60.4	46.6	50.6	58.5	67.2	71.6
		103	73,226	60.4	48.9	52.5	58.7	65.3	68.9
18spd	I-96	101	907,908	72.9	61.3	66.1	71.7	76.7	79.6
		102	66,605	63.2	52.8	56.2	61.3	67.7	71.5
		103	33,622	62.6	54.0	56.8	61.0	64.7	68.5
19spd	I-69	101	731,985	76.4	65.6	69.7	75.0	80.0	84.1
		102	40,186	70.6	57.9	59.8	68.4	77.0	82.1
		103	75,170	74.5	60.2	63.9	72.5	81.2	89.2
26spd	I-75	101	360,366	74.5	63.7	68.0	73.1	78.2	81.5
		102	34,519	67.7	55.9	59.6	66.5	72.8	76.1
		103	14,424	63.0	54.6	57.8	61.4	65.4	68.8
43spd	I-69	101	434,232	71.8	58.8	64.6	70.5	76.3	79.3
		102	50,182	61.5	49.8	53.3	59.7	67.0	71.0
		103	49,161	62.2	53.5	56.2	60.5	65.0	68.1
70spd	I-75	101	254,748	73.0	59.0	64.3	72.2	78.0	81.7
		102	22,476	69.9	56.1	60.7	68.5	75.8	80.7
		103	6,529	77.8	61.1	65.0	75.1	88.0	96.5
17spd	I-94	101	843,830	73.3	61.5	66.2	72.0	77.5	81.0
		102	64,911	64.3	52.9	56.6	62.6	69.2	73.1
		103	186,717	63.6	54.1	57.4	61.9	66.9	70.1

* Speed Analysis in September, 1999 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	245,185	72.0	60.9	65.1	70.9	75.6	79.0
		102	20,092	64.9	53.4	56.9	63.3	70.0	73.2
		103	14,455	62.5	54.9	57.0	60.9	64.4	67.8
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	111,557	60.9	51.1	54.8	59.5	64.2	67.6
		102	15,048	59.2	50.1	53.4	57.8	62.0	64.8
		103	9,056	60.4	52.8	55.3	59.0	62.8	65.1
77spd	US-131	101	1,773,378	67.4	53.1	58.3	66.8	73.1	76.4
		102	77,256	60.0	46.3	50.3	58.1	67.0	71.3
		103	75,404	60.1	48.6	52.3	58.5	65.0	68.7
18spd	I-96	101	1,031,458	72.8	61.1	66.1	71.7	76.6	79.4
		102	81,698	62.7	52.8	56.0	60.9	66.8	70.6
		103	43,609	62.5	54.1	56.7	60.9	64.7	68.1
19spd	I-69	101	653,284	76.4	65.3	69.7	74.9	80.1	84.1
		102	35,431	70.1	57.7	58.2	67.7	76.7	82.2
		103	74,481	74.1	59.7	63.2	72.0	61.0	69.0
26spd	I-75	101	342,042	74.3	63.8	68.0	72.9	77.9	81.2
		102	31,958	67.9	55.9	59.7	66.7	72.9	76.2
		103	16,606	63.1	55.0	57.8	61.5	65.5	68.9
43spd	I-69	101	333,413	71.5	57.8	63.9	70.6	76.0	79.3
		102	42,604	61.0	49.6	53.0	59.3	66.2	70.5
		103	47,731	62.1	53.5	56.2	60.5	64.7	68.1
70spd	I-75	101	239,557	73.1	58.4	64.3	72.2	78.4	82.1
		102	21,279	70.3	56.0	60.8	68.7	76.5	81.7
		103	7,361	78.1	61.5	65.5	75.7	87.9	96.5
17spd	I-94	101	764,170	73.1	61.5	66.1	71.9	77.1	80.6
		102	62,330	63.8	52.8	56.3	62.0	68.5	72.7
		103	193,171	63.5	54.1	57.4	61.7	66.8	70.4

* Speed Analysis in October, 1999 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	Location	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	216,819	71.9	60.4	65.1	70.9	75.7	79.0
		102	14,046	64.3	53.0	56.6	62.5	69.6	73.1
		103	15,638	62.6	54.9	57.0	60.9	64.8	68.3
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	83,643	61.5	51.2	55.3	59.9	64.6	68.9
		102	9,459	60.1	50.5	53.9	58.7	63.2	66.5
		103	7,728	60.5	53.0	55.5	59.2	62.7	64.9
77spd	US-131	101	1,648,860	67.6	53.2	58.5	66.9	73.2	76.7
		102	66,299	59.8	46.1	50.2	57.8	66.7	71.0
		103	70,756	60.2	48.7	52.4	58.6	65.1	68.7
18spd	I-96	101	991,860	72.9	61.2	66.1	71.9	76.6	79.5
		102	73,375	62.4	52.7	55.9	60.7	66.2	70.2
		103	42,051	62.5	54.1	56.7	60.8	64.8	68.0
19spd	I-69	101	625,229	76.3	64.9	69.6	74.8	80.3	84.0
		102	34,909	69.0	57.0	57.9	66.1	75.8	81.5
		103	70,693	73.6	59.3	62.5	71.7	80.9	89.1
26spd	I-75	101	301,975	73.9	62.7	67.6	72.7	77.9	81.3
		102	22,885	67.4	54.5	58.9	66.3	72.9	76.3
		103	17,453	62.9	54.6	57.6	61.4	65.0	68.1
43spd	I-69	101	374,780	71.4	57.5	63.7	70.5	76.0	79.4
		102	47,281	60.5	49.2	52.7	58.8	65.4	70.1
		103	56,811	62.1	53.5	56.3	60.5	64.5	67.6
70spd	I-75	101	190,732	73.5	58.8	64.7	72.5	79.0	82.8
		102	12,725	71.6	56.9	61.9	69.7	78.3	83.9
		103	6,815	79.2	62.2	66.3	76.9	89.0	98.2
17spd	I-94	101	732,619	73.3	61.6	66.1	72.1	77.2	80.8
		102	58,450	63.7	52.7	56.4	62.0	68.4	72.6
		103	200,141	63.7	54.5	57.7	62.0	66.9	71.1

* Speed Analysis in November, 1999 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	*Location*	Vehicle Type	Volume	Mean Speed	Percentile 5th	15th	50th	85th	95th
24spd	US-31	101	176,102	72.1	60.6	65.3	71.0	75.7	79.1
		102	8,547	64.3	53.0	56.6	62.4	69.8	73.3
		103	13,561	62.6	54.5	56.9	60.9	64.7	68.0
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	91,941	62.3	53.4	56.3	60.6	65.3	69.1
		102	11,745	60.8	52.4	55.2	59.5	63.7	66.8
		103	8,664	60.6	53.0	55.6	59.3	62.9	65.2
77spd	US-131	101	1,559,251	67.4	53.0	58.3	66.7	73.0	76.5
		102	60,354	59.6	45.7	49.9	57.6	66.5	70.9
		103	68,378	60.0	48.4	52.2	58.5	64.8	68.4
18spd	I-96	101	911,825	73.0	61.2	66.1	71.9	76.7	79.6
		102	63,470	62.2	52.5	55.8	60.5	65.7	69.9
		103	39,018	62.3	53.9	56.5	60.7	64.4	67.6
19spd	I-69	101	454,561	76.6	65.2	69.8	75.1	80.6	84.4
		102	24,332	69.5	57.3	58.1	66.5	76.4	82.2
		103	52,937	74.1	59.5	63.0	72.1	81.4	88.9
26spd	I-75	101	294,501	74.0	63.2	67.7	72.8	77.5	80.8
		102	20,710	68.3	55.9	59.9	67.3	73.4	76.3
		103	18,746	62.8	54.4	57.4	61.3	65.1	68.1
43spd	I-69	101	302,608	71.6	57.6	63.9	70.6	76.1	79.5
		102	35,430	60.4	49.0	52.6	58.7	65.0	69.8
		103	47,915	62.1	53.5	56.2	60.5	64.6	67.9
70spd	I-75	101	143,765	74.4	59.9	65.7	73.3	79.6	83.8
		102	8,564	73.2	58.9	63.6	71.2	79.7	85.0
		103	7,086	79.8	62.7	66.7	77.9	89.3	98.7
17spd	I-94	101	457,558	73.5	61.5	66.3	72.2	77.7	81.3
		102	36,463	63.5	52.6	56.1	61.6	68.2	72.7
		103	134,435	63.4	54.0	57.4	61.8	66.7	70.1

* Speed Analysis in December, 1999 *

2) Vehicle Classification (101, 102, 103)

(Unit : mph)

Site	Location	Vehicle Type	Volume	Mean Speed	Percentile				
					5th	15th	50th	85th	95th
24spd	US-31	101	166,403	70.4	56.5	62.5	69.8	75.0	78.4
		102	6,801	62.4	50.3	55.1	60.7	67.7	72.1
		103	13,725	61.6	52.5	55.9	60.3	64.2	67.2
40spd	US-27	101	-	-	-	-	-	-	-
		102	-	-	-	-	-	-	-
		103	-	-	-	-	-	-	-
69spd	US-2	101	66,636	61.4	50.9	55.2	60.1	64.5	68.6
		102	6,995	59.3	48.4	52.7	58.2	63.0	66.2
		103	8,799	60.3	52.4	55.0	59.2	62.5	64.4
77spd	US-131	101	1,042,098	66.4	51.2	56.7	65.7	72.4	76.1
		102	40,266	58.8	44.7	49.0	56.6	65.8	70.6
		103	48,179	59.3	47.4	51.3	57.8	64.3	67.8
18spd	I-96	101	955,405	71.3	55.8	63.0	71.0	76.1	79.2
		102	67,738	60.9	49.5	53.9	59.7	64.5	68.9
		103	44,650	61.1	50.3	55.0	60.0	64.2	67.2
19spd	I-69	101	588,080	76.1	64.2	68.9	74.8	80.2	84.3
		102	31,348	69.1	57.3	58.1	66.2	75.9	81.5
		103	71,374	73.9	59.4	63.0	72.0	80.9	88.6
26spd	I-75	101	232,597	72.8	60.4	65.6	71.8	76.8	80.0
		102	19,167	67.8	55.2	59.3	66.7	73.2	76.4
		103	17,138	62.4	53.7	56.7	61.0	64.5	67.3
43spd	I-69	101	294,338	71.2	56.9	63.2	70.3	76.0	79.4
		102	32,567	60.0	48.5	52.2	58.4	64.4	69.2
		103	45,018	62.1	53.3	56.2	60.5	64.7	68.1
70spd	I-75	101	126,193	72.4	56.0	62.5	71.7	78.8	82.8
		102	8,103	71.6	55.7	61.4	69.9	78.7	84.4
		103	5,934	78.6	61.9	65.9	76.2	88.2	97.8
17spd	I-94	101	623,030	72.9	59.9	65.4	71.9	77.3	80.8
		102	40,890	63.0	52.1	55.9	61.3	67.4	72.0
		103	187,532	62.7	53.1	56.7	61.2	65.9	69.3

SECTION 3 – ANALYZE SPEED DATA ON FREEWAYS WHERE THE SPEED LIMIT WAS RAISED TO 65 MPH

In January 1997, when the speed limit was raised to 70 MPH on rural freeways, some of the urban freeway speed limits were also changed from 55 or 60 MPH to 65 MPH. Since these road segments were not included in the pilot project, no data was collected prior to the speed limit change. Therefore, when the results of the first year were presented in the summer of 1998, these road segments were not included. The project extension approved in 1998 requested that a study be made to determine if data existed which would make it possible to document any change in speed on these urban freeways.

Unfortunately, the data to compare speeds prior to and subsequent to January 1997 does not exist. There are no permanent count stations located on these freeway segments, and thus no archived data. The only detectors located on the Southeast Michigan freeway system capable of measuring speeds were part of the SCANDI project. None of those freeways were included in the segments where the speed limit was increased. Some of the new detectors installed as part of the ATMS deployment system are located on freeway segments where the speed limit was increased, but these detectors were not operational prior to January 1997.

Thus, there is no data available on prevailing speeds before the speed limit was changed on these urban freeways, and no comparisons could be conducted.

THE IMPACT OF RAISING THE SPEED LIMIT ON FREEWAYS IN MICHIGAN

FINAL REPORT

VOLUME 2

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16. Abstract

This report includes an analysis of the change in vehicle speeds and traffic crashes which occurred on Michigan Freeways following an increase in the speed limit. The speed limit was raised to 70 mph (from 65 mph) in January 1997, and the speed characteristics and traffic crash statistics for the years 1997-1999 were compared with data from the three years immediately preceding the change in the speed limit.

The speed characteristics, as defined by the 50^{th} and 85^{th} percentile speeds, showed a small increase in the after period. The total traffic crashes increased, but this increase was lower than the increase in vehicle miles of travel. There was a decrease in fatal and serious injury crashes following the speed limit increase. Similar results were found for truck involved crashes. The speed limit for trucks was 55 mph over the entire six years included in the study.

A mathematical model to predict traffic crashes at interchanges on the freeway system was constructed. This model is based on fitting a negative exponential distribution to traffic crash frequency over time, which was determined to be more accurate than the Poisson distribution.

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DISCLAIMER

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SECTION 4 - INTERCHANGE CRASH MODELS

Background and Problem Identification

In response to limited budgets, it has become very important to ensure that funding available for road improvements is efficiently utilized. A typical safety program includes identification, diagnosis, and remediation of hazardous locations, and hence the success of the safety program can be enhanced by efficiently identifying hazardous locations. A hazardous location is defined as a site where the observed number of crashes is larger than a specific norm (a record of crashes at locations with similar characteristics). That is, a site is deemed hazardous if its crash history over a given period exceeds a predetermined level which is based on the concept of confidence levels within the context of classical statistics (Witkowski 1988).

The observed number of crashes over a specific period at a specific site can usually be obtained from a database related to traffic crashes. However, several difficulties arise in determining a base for comparing this number to an expected number of crashes at reference sites that are defined as sites with similar geometric and traffic characteristics. Hauer (92) recognized that the identification of hazardous sites using reference sites causes conceptual and practical problem.

The main conceptual problem is that of choosing suitable reference sites, which is a matter of judgement. The practical problem is that if we choose very similar sites to reduce the variations caused from the conceptual difficulties, the number of reference sites will usually be too small to allow for an accurate estimate of the hazard at a given site. These same questions were also raised by Mahalel (1982), Hauer and Persaud (1987), and Mountain and Fawaz (1989).

There are 397 interchanges along the four main Interstates (I-69, I-75, I-94 and I-96) in Michigan. In order to define reference sites for the evaluation of a given interchange in Michigan, the interchanges were first classified according to their geometry; such as interchange type, the number of ramps, shoulder width, the number of lanes, ramp length et al., and second according to traffic conditions. However, with this level of stratification, it was not possible to obtain enough reference sites to guarantee a significant level of accuracy for each type of interchange. To overcome these difficulties, a crash prediction model to estimate crash frequencies at interchanges was developed in this study.

The basic concept of the prediction model method is that the expected value of crashes at the reference sites $E(\theta)$ can be obtained by developing a crash prediction model rather than on the basis of reference sites. A specific site is deemed to be abnormal if the number of observed crashes occurring at the site is larger than or smaller than expected at some predetermined values (i.e.,0.05). That is, a location in which the deviation from the expected crash frequency $E(\theta)$ is large. However, if this method is to be accurate, it is important to develop the traffic crash prediction models under the appropriate rationale.

There are generally two kinds of crash prediction models which differ according to the assumption of the error structures. One is the conventional linear regression model with a constant normal error structure, the other is a regression model with a non-normal and heterogeneous error structure (i.e., Poisson and Negative Binomial distribution). In this research, we have examined the error structures of crash occurrences in various respects on the basis of the observed data, and verified that crashes on freeway interchanges follow the Negative Binomial distribution rather than a Normal or Poisson distribution. Accordingly, the model parameters were calibrated under the assumption of the Negative Binomial error structure.

Probability Distributions

The Poisson distribution frequently appears in articles using control limit charts, because of its simplicity resulting from the assumption that the variance is the same as the mean (Norden et.al 1956, Hauer 1996). It has also been recognized that the Poisson distribution provides a better fit to traffic crash data than the Normal distribution (Miaou et al 1992, Jovanis and Chang 1993).

However, in studying the injury severity to the front seat occupants of vehicles in crashes, Hutchinson and Mayne (1977) realized that there appeared to be more variability of different severity levels occurring in different years than would be expected on the hypothesis of the Poisson distribution. When there is greater variability than expected by Poisson' law, we call this phenomenon over-dispersion. Issues related to this over-dispersion are also implicit in the works of earlier researchers (Benneson and McCoy 1997, Vogt and Bared 1999).

Consequently, two distributions (Poisson and Negative Binomial) have been assumed for traffic crash occurrences. However, no researcher has yet provided a full discussion of the issue, even though the assumption of the probability distribution for crash occurrence is very important in the identification of hazardous sites and for the calibration of crash prediction models.

For example, with the rate quality control method, a site is identified as abnormal if its observed crash rate exceeds the upper control limit, which is the mean crash rate of reference sites plus a multiple of the standard deviation of the site crash rates (Stokes and Mutabazi 1996). Herein, the standard deviation is equal to the square root of the mean for a Poisson distribution and the square root of the (mean + mean ^{2}/k) for the Negative Binomial distribution, respectively (Rice 1997).

Three distributions have generally been assumed for the calibration of traffic crash prediction models (i.e., constant normal, Poisson and Negative Binomial). However, recently there is an implicit agreement among traffic engineers that the Poisson or Negative Binomial distributions are more desirable assumptions than the constant normal distribution. Crash prediction models with a heterogeneous error structure such as the Poisson or Negative Binomial distribution, are generally calibrated using weighted least squares (Seber and Wild 1989). In weighted least square regression, data points are weighted by the reciprocal of their variances. Thus, in calibrating traffic crash models, the assumption of error structures is a very critical issue in determining the accuracy of coefficients.

The Poisson distribution is often the first option considered for random counts; it has the property that the mean of the distribution is equal to the variance (Rice 1997) and the following frequency function:

$$p(X = x) = \frac{\exp(-m)(m)^x}{x!}$$

where,
m = mean

However, when the variance of the counts is substantially larger than the mean, consideration is given to the Negative Binomial distribution, which is a discrete distribution with the following frequency function (Rice 1997):

$$f(x/m,k) = \left(1+\frac{m}{k}\right)^{-k} \frac{\Gamma(k+x)}{x!\Gamma(k)} \left(\frac{m}{m+k}\right)^x$$

where,
m = mean
k = negative binomial parameter

In examing the freeway interchange crash data over time, there appeared to be more variability than would be expected under the hypothesis of the Poisson distribution. Two data sets are utilized to test for this over-dispersion. One is the number of crashes classified by type, the other is the number of crashes per interchange across 84 interchanges. Analyses of the over-dispersion were performed for the crashes during the 5 year-period 1994-1998.

Analysis by Crash Types

To test over-dispersion of the crashes which occurred at freeway interchanges, crash frequencies of each of 24 types of crashes were obtained separately for each of 5 years from 1994 to 1998. The variance and the mean annual number of crashes of each type were calculated on the basis of the crashes that occurred over the 5 years.

To test whether the crash occurrences follow the Poisson distribution, the observed variances of the annual number of crashes were plotted against the annual mean value. **In Figure 4.1**, the solid line is the variance that would be expected on the hypothesis of the Poisson distribution. If the Poisson distribution is a good fit, the observed variances should lie along the solid line. However, the figure shows that there is larger variability than would be expected under the Poisson distribution.

There is a much larger variability in the most common types of crashes (rear end, sideswipe) than for the less common types of crashes (backing, fixed object). This phenomenon was discussed in previous research (Hutchinson and Mayne 1977).

Noting that the Negative Binomial distribution is an alternative to reflect the phenomena of over-dispersion, the maximum likelihood estimate of k was determined to be about 71 by fitting the data to the Negative Binomial distribution. In **Figure 4.2**, the solid line is the variance that would be expected on the hypothesis of the Negative Binomial distribution. This figure shows that the Negative Binomial distribution fits the data much better than the Poisson distribution shown in **Figure 4.1**.

Analysis of Annual Crash Frequency Per Interchange (Diamond Interchanges)

To see how widely this relationship applies, a similar approach was used to test the distribution of the annual number of crashes occurring at Diamond interchanges, which is the most common type of freeway interchange in Michigan.

The variance and the mean annual number of crashes were calculated from the total number of crashes that occurred on the same 84 interchanges from 1994 through 1998. The observed variances in the annual numbers of crashes were also plotted against the mean annual numbers, with a data point corresponding to each of the 84 interchanges.

In **Figure 4.3**, the solid line is the variance that would be expected on the hypothesis of the Poisson distribution, and we see that there is also greater variability than expected by the Poisson distribution, as in the previous case. When the data were fit to the Negative Binomial distribution, it was found that the maximum likelihood estimate for k is about 21. **Figure 4.4** shows that the Negative Binomial distribution fits the data much better than the Poisson distribution.

For theoretical support of these graphical results, correlation coefficients and squared residuals were calculated for the data in **Figure 4.1** through **Figure 4.4**. As shown in **Table 4.1**, the correlation coefficients between the observed and the expected variances increased from 0.91 to 0.97 and from 0.84 to 0.90 in the analysis of 24 crash types and annual total crashes, respectively, when the Negative Binomial distribution was assumed. Squared residuals were calculated using the observed variances and expected variances.

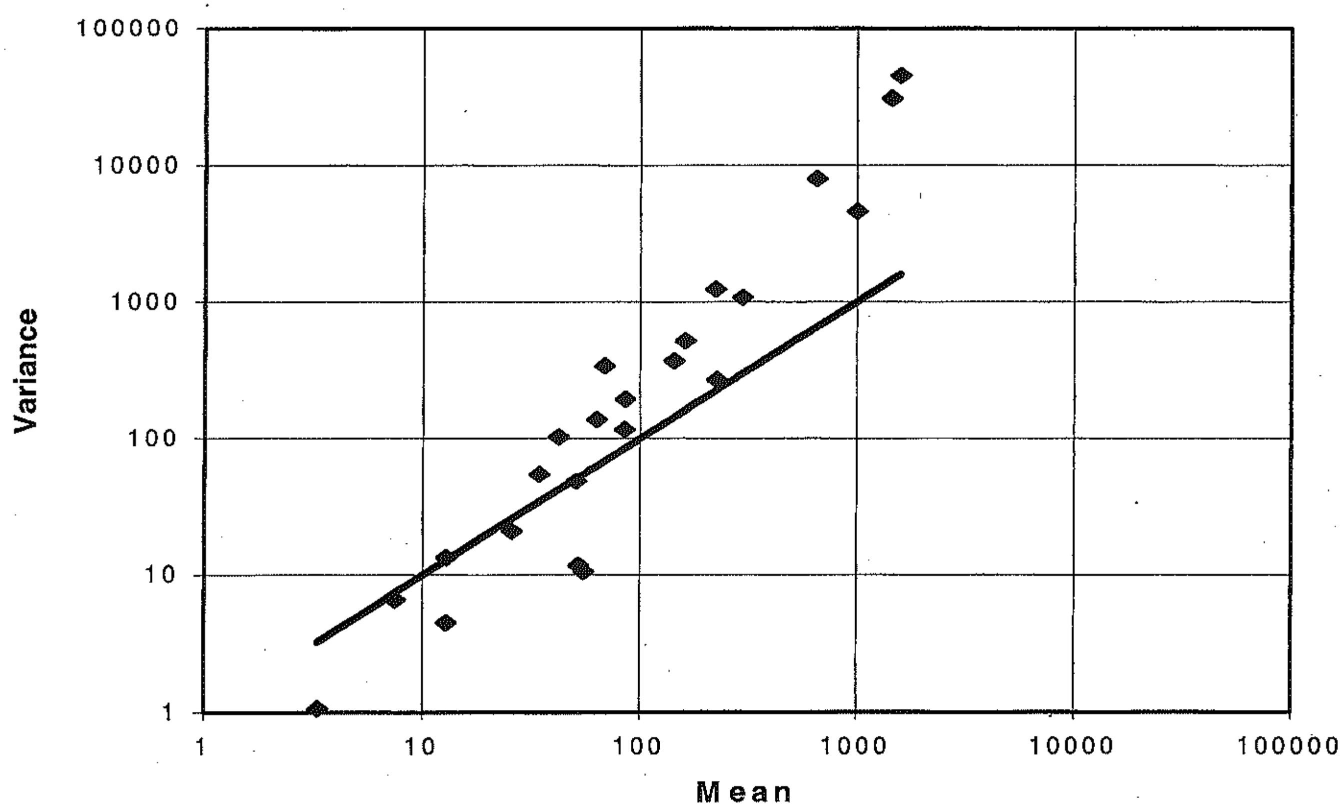

Figure 4.1 Observed and theory variances by crash types (Poisson distribution)

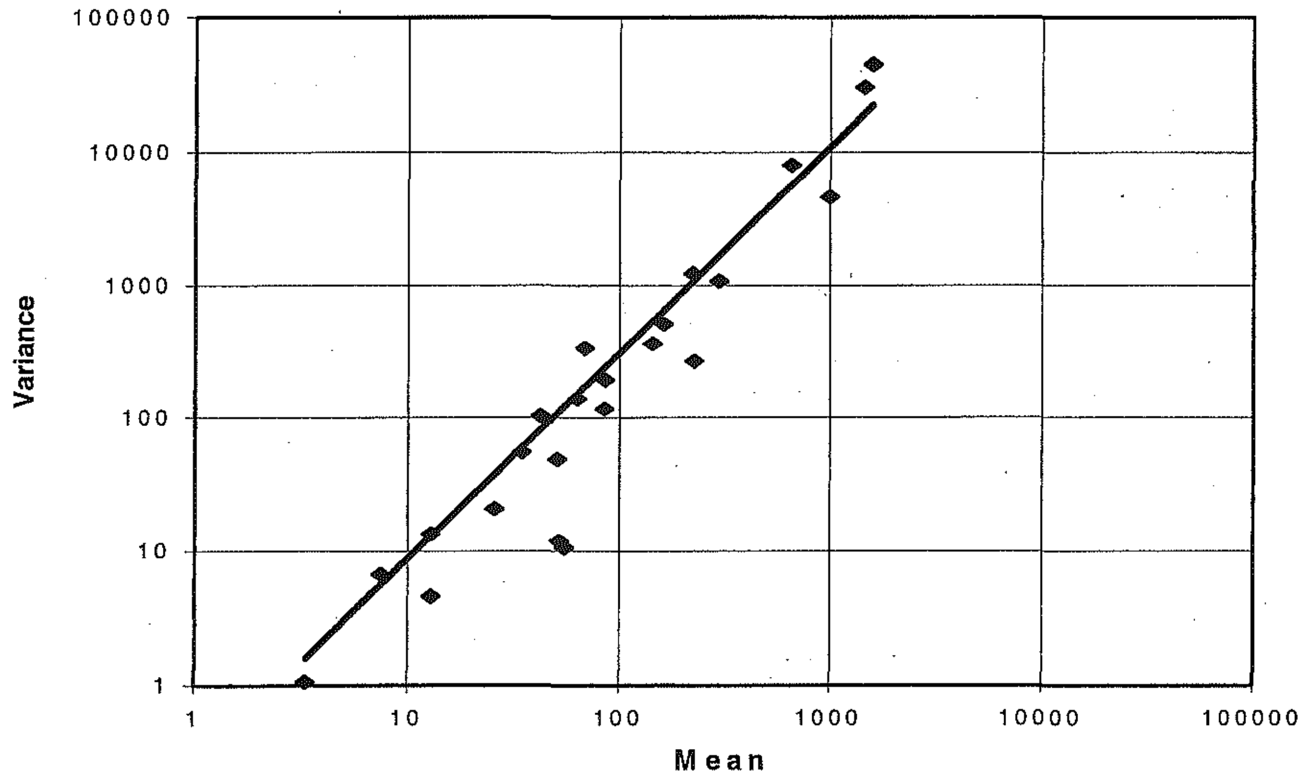

Figure 4.2 Observed and Theory Variances by Crash Types (Negative Binomial Distribution)

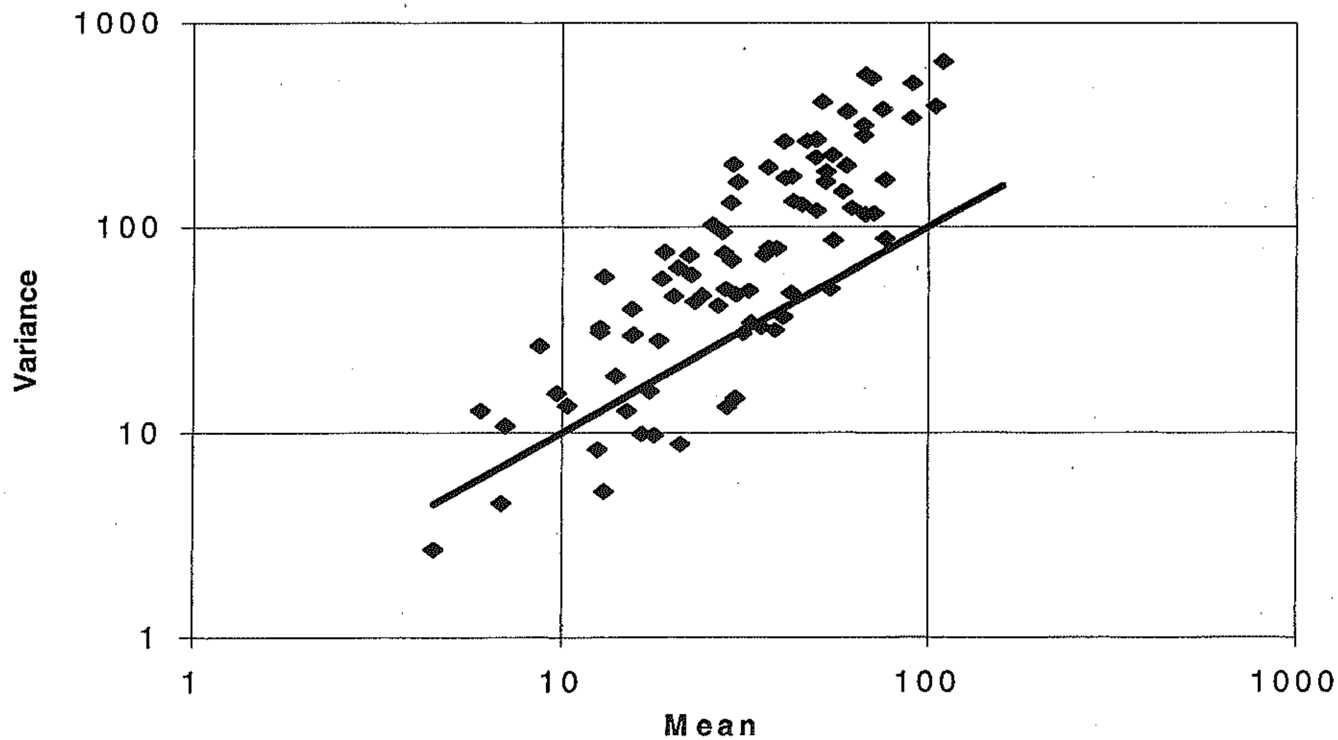

Figure 4.3 Observed and Theory Variances of Annual Crash Frequency (Poisson Distribution)

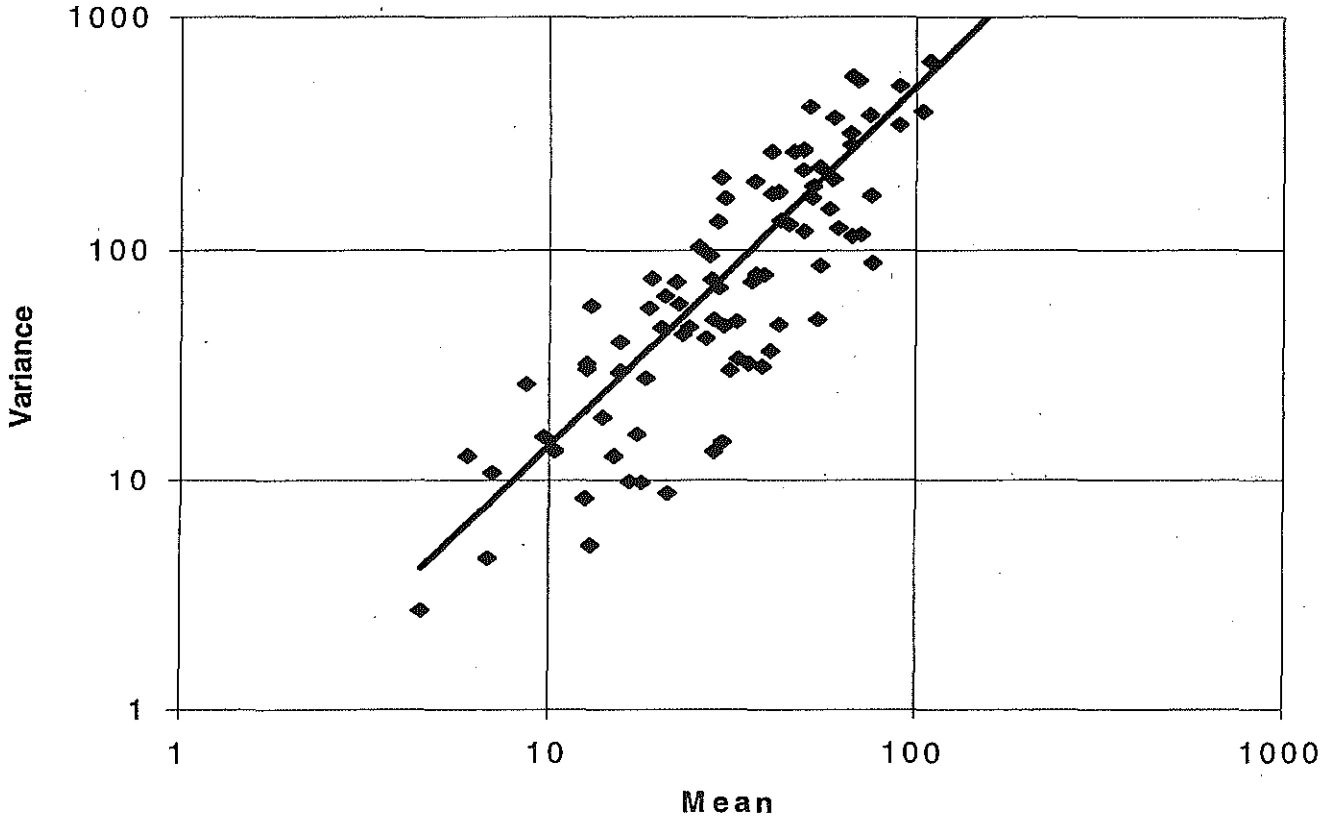

Figure 4.4 Observed and Theory Variances of Annual Crash Frequency (Negative Binomial Distribution)

The residuals were reduced by more than 80 % when the Negative Binomial distribution was assumed as shown in **Table 4.1.**

Thus, we can conclude that the Negative Binomial distribution is a more reasonable assumption for the distribution of freeway interchange crashes than the Poisson distribution.

Table 4.1 The correlation and residual values according to the distribution

	Poisson	Negative Binomial	
	Correlation coefficient	Correlation coefficient	Squared Residual
Accident type	0.91	0.97	87%⇓
Annual crash Frequency	0.84	0.90	84%⇓

Traffic Crash Prediction Model Development

There have been several studies whose purpose was to develop crash prediction models using the relationship between traffic crashes and various independent variables.
In all such studies, the first issue is selection of the independent variables. Using characteristics of a county, Maleck (1980) and Tarko et al (1996) developed models for predicting the expected annual crashes for a county. Independent variables in these models consist of a subset of the following factors: the number of licensed drivers, the number of registered vehicles, population, median family income, road mileage, and percentage of state roads.

Mcguigan (1981), Maher and Summersgill (1996), Persaud and Nguyen (1998), Rodriguez and Sayed (1999), Bonneson and McCoy (1997), Lau and May (1988), and Belanger (1994) developed crash prediction models for signalized or unsignalized intersections. These models include one or more of the following independent variables; major road traffic volume, minor road traffic volume, pedestrian volume and channelization on the main road. The main road traffic and minor road traffic have been found to be the most significant variables.

Hauer and Griffith (1994), Vogt and Bared (1999), Seder and Livneh (1981), and Moutain et al (1996) developed crash prediction models for road sections using only the traffic volume. In addition, Hauer and Persaud (1987) used traffic volume and train volume for crash models of rail-highway grade crossings, and Miaou et al (1992) modeled truck crashes using geometric characteristics and truck ADT. A few researchers modeled the effects of independent variables on traffic crashes on freeways. Kim (1989) used interchange types, traffic volume, population and the number of ramps to develop a crash prediction model for freeway interchanges. All of these models would be classified as macroscopic models because they use average daily traffic (ADT), rather than the traffic volume at the time of the crash.

Persaud and Dzbik (1993) developed a microscopic model to estimate crashes on freeway sections. Microscopic models relate crash occurrences to the specific flow at the time of the crash rather than to the average daily traffic (ADT). Hence a freeway with intense flow during rush hour periods would have a higher crash potential than a freeway with the same ADT, but with flow more evenly distributed during the day.

As noted above, traffic volume is considered the main contributing factor in predicting traffic crashes in most of the models, with additional geometric variables chosen based on the objective of modeling.

The second issue in the development of an crash prediction model is how to calibrate the model parameters, which usually depend on the error structure. There are two approaches that are often used when calibrating model parameters. One is a conventional linear regression approach, with its assumption of a normally distributed and homogeneous error structure. The linear regression approach has been recognized to be lacking the distribution properties to adequately describe the discrete, nonnegative, and sporadic traffic crash events with a low mean value (Mahalel 1986, Miaou and Lum1993). Before the Poisson approach was introduced, most models were developed on the basis of multi linear regression, with the assumption of a normal distribution. For example, McGuigan (1981), Kim (1989), and Lau and May (1988) used the normal error structure to calibrate their crash prediction models.

The other approach is the use of a regression model, with a non -normal and heterogeneous error structure. These include the Poisson, Negative Binomial and Gamma distributions. It has been generally recognized that crash frequencies better fit a model using the assumption of a Poisson distribution rather than a Normal distribution. For example, Miaou et al. (1992, 1994) proposed the Poisson model to develop the relationship between truck crashes and geometric design. Jovanis and Chang (1993) also used the Poisson model to relate crashes to mileage and environmental variables.

However, the Poisson model also has its weakness. For example, The Poisson model assumes that the variance is the same as the expected number, and hence it can not reflect the phenomenon of "over-dispersion" which often occurs in traffic crashes.

The phenomenon of over-dispersion on freeway crashes has been verified and discussed earlier so a crash prediction model for freeway interchanges was developed under the assumption of a Negative Binomial error structure.

Dependent Variable Description

The focus on freeway interchange crashes requires a working definition of the boundary of an interchange. In this study, the interchange is composed of ramps and mainlines. The ramps include on- ramps and off-ramps, and the mainlines are defined as the section within 500 feet from the beginning of the off- ramp to 500 feet from the end of the on-ramp as shown in **Figure 4.5**. This definition is the same as that of the Michigan DOT interchange inventory file. The crashes on cross roads are not included in this study because of the practical barrier that traffic volume for the cross road is not available, and the engineering intuition that the crashes on the cross road may have very different characteristics (i.e., low severity, high percentage of angle crashes).

The crash rate will not be used as the dependent variable since accurate volume data for each element of the interchange is not available. The original source of the crash data is the "Official Michigan Traffic Accident Report' (form UD-10). The crash data are summarized in **Table 4.3**.

Classification by Interchange Type

A lack of homogeneity refers to the understanding that different relationships may hold between variables on the basis of the values of various characteristics (i.e., geometry, control, traffic, and so on). In many cases, tree structures which are easily understood and interpreted, are built describing the main factors and interactions between factors (Lau and May 1988). However, the tree structures can be used only in the case of large samples, and hence this method may be inadequate in developing crash prediction models for freeway interchanges, even though it is a conceptually powerful and systematic tool.

In this study, a total of 199 interchanges are grouped into 10 categories as shown in **Table 4.2**. We can not classify the interchanges more specifically because of the limitation of sample sizes, even though the Michigan interchange inspection file includes 22 categories of interchanges. In the approach to grouping interchanges, the independent variables (i.e., traffic volume, ramp length, et al) were explicitly excluded from the features which were used in the classification of interchange types.

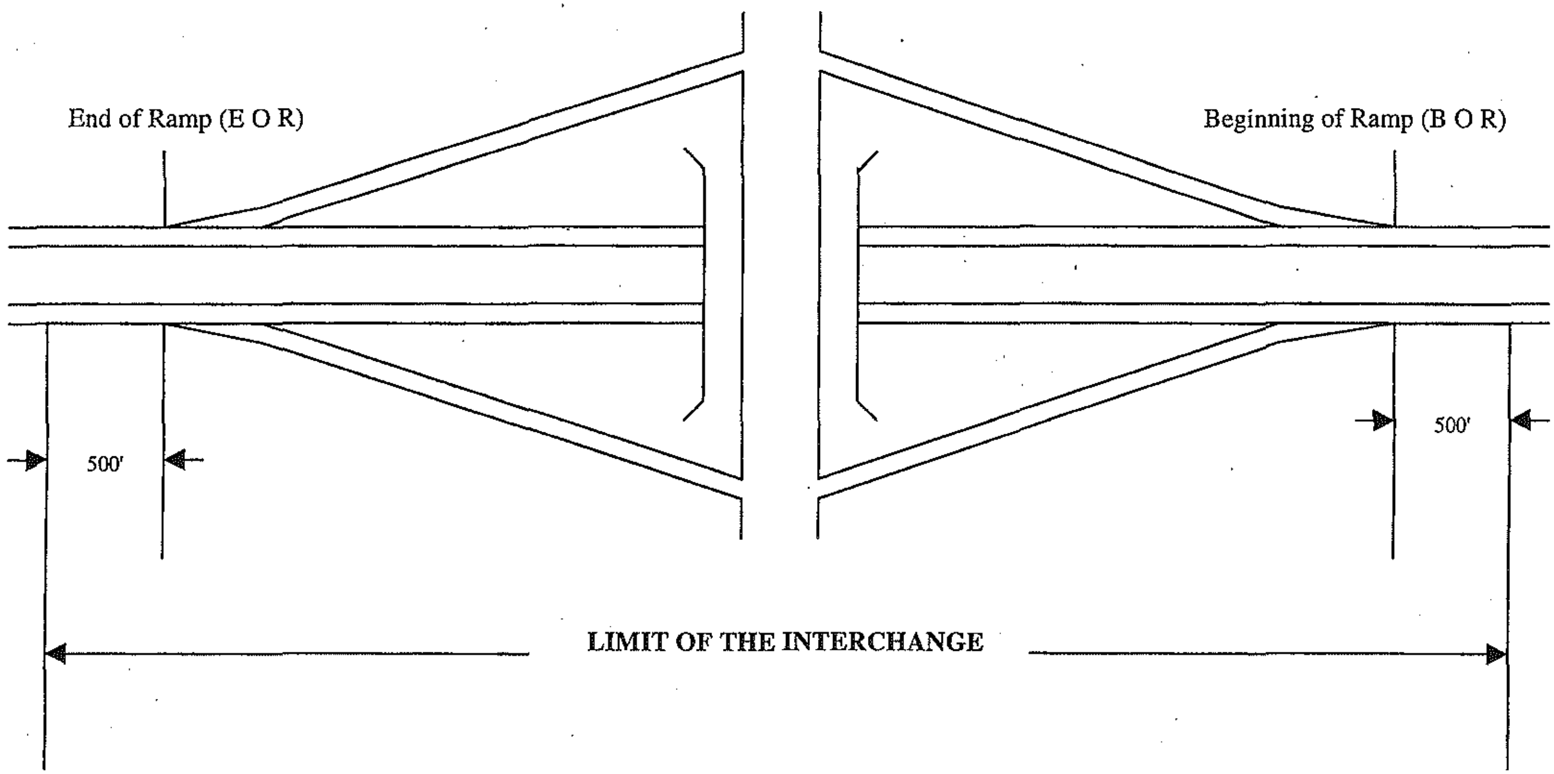

Figure 4.5 Boundary of The Interchange

As shown in **Table 4.2**, the number of type 11 and type 31 interchanges is relatively large compared with those of other types.

Table 4.2 Interchange Classification

CLASSIFICATION		INTERCHANGE TYPE	SAMPLE SIZE
1. DIAMOND INTERCHANGE	Type 11	• Diamond	34
	Type 12	• Tight Diamond • Modified Tight Diamond	19
	Type 13	• Partial Diamond • Partial Tight Diamond	24
	Type 14	• Split Diamond • Modified Diamond	14
2. T-INTERCHANGES	Type 21	• Trumpet – A • Trumpet – B	9
3. CLOVER LEAFS	Type 31	• Partial Clover A • Partial Clover B • Partial Clover A 4 Quadrant • Partial Clover B 4 Quadrant	41
	Type 33	• Partial Clover AB • Partial Clover AB 4 Quadrant	21
	Type 35	• Clover • Clover with CD	8
4. DIRECTIONAL	Type 41	• Full Directional • Partial Directional • Directional Y • Partial Directional Y	21
5. OTHERS	Type 51	• Others	8
TOTAL			199

Crash Data Summary

The summary statistics describing the crashes that have occurred over 3 years in each interchange are provided in **Table 4.3**. As listed in the table, an average of 126 crashes is highest in Directional interchanges, and lowest in T-interchanges.

Table 4.3 Summary of Crashes Per Interchange (1996~1998)

Interchange type		Total crashes			Injury crashes		
		Max	Min	Average	Max	Min	Average
Diamond	Type 11	321	24	132	93	6	39
	Type 12	492	42	123	156	6	33
	Type 13	252	18	120	84	3	33
	Type 14	393	24	99	135	3	27
T-interchange	Type 21	156	21	75	69	6	24
Clover-leaf	Type 31	402	33	135	99	6	33
	Type 33	237	24	84	54	3	21
	Type 35	405	51	168	138	12	48
Directional	Type 41	408	21	186	111	3	54
Others	Type 51	408	21	180	45	6	21
Total		492	18	126	156	3	36

Table 4.4 contains summary statistics of injury crashes that occurred in the past 3 years. It is not surprising that the percent of injury crashes is relatively high for T-interchanges and Directional interchanges (30.8 % and 29.2 % respectively), considering that the vehicle operating speeds on these types of interchanges are high compared with those on other types of interchanges.

Table 4.4 Summary of Injury Percent By Interchange Type (1996~1998)

Interchange type		Total crashes	Injury crashes	Injury (%)
Diamond	Type 11	4479	1272	28.4
	Type 12	2211	600	27.1
	Type 13	2886	822	28.5
	Type 14	1380	393	28.5
T-interchange	Type 21	681	210	30.8
Clover-leaf	Type 31	5388	1380	25.6
	Type 33	1779	453	25.5
	Type 35	1347	381	28.3
Directional	Type 41	4074	1188	29.2
Others	Type 51	699	177	25.3
Total		24924	6876	27.6
V(x)		-	-	10.8

The coefficient of variation V(x) is a stable measure of the variability of a random variable x, which is defined as (Harr 1996):

$$V(x) = \frac{\sigma(x)}{E(x)} \times 100 \quad (\%)$$

By the previous equation, the higher the coefficient of variation V(x), the greater will be the scatter. As a rule of thumb, coefficients of variation below 15 % are thought to be low, between 15 and 30 % moderate, and greater than 30 % high (Harr 1996).

As shown in the last row of the **Table 4.4**, the coefficient of variation of injury percent across the interchange types is 10. 8 %, which is low. This implies that interchange types are related to the number of crashes, but not the severity of the crashes. Thus, for this study, the total number of crashes is used as the dependent variable for the development of traffic crash prediction models.

Table 4.5 presents a statistical summary of mainline and ramp crashes that occurred from 1996 to 1998. Ramp accidents are about 4300 of the total 25000 crashes, or about 17 %. There is a large variability in the percent of ramp crashes across the interchange type, as shown in the table. That is, the coefficient of variation is 344 %, which is extremely high. This implies that we need different explanatory variables when developing crash prediction models by interchange type.

Table 4.5 Summary of Mainline and Ramp Crashes (1996~1998)

Interchange type		Total crashes	Mainline		Ramp	
			Crashes	%	Crashes	%
Diamond	Type 11	4479	3780	84.4	699	15.6
	Type 12	2211	1872	84.7	339	15.3
	Type 13	2886	2634	91.3	252	8.7
	Type 14	1380	1329	96.3	51	3.7
T-interchange	Type 21	681	486	71.4	195	28.6
Clover-leaf	Type 31	5388	4323	80.2	1065	19.8
	Type 33	1779	1470	82.6	309	17.4
	Type 35	1347	960	71.3	387	28.7
Directional	Type 41	4074	3135	77.0	939	23.0
Others	Type 51	699	642	91.8	57	8.2
Total		24924	20631	82.8	4293	17.2
V(x)		-	-	-	-	344

Table 4.6 presents data on the crash type according to the interchange type. Rear end crashes account for 39.7 % of total crashes. Rear end crashes are especially high in Type 11 (Diamond) and Type 35 (Cloverleaf) interchanges, and low in Type 33 (Partial Clover AB or Partial Clover AB 4 Q). Fixed object and sideswipe crashes are 20.9 % and 14.1 %, respectively, as shown in the table. The coefficients of variance of a special type of crash percent across interchange types range from 53 % to 172 %, which are high. Accordingly, one recognizes that the different types of interchanges are associated with different types of crashes.

Table 4.6 Summary of the crash types (1996~1998)

Interchange type		Total Crashes	Rear end		Fixed object (over turn)		Sideswipe		Others	
			#	%	#	%	#	%	#	%
Diamond	Type 11	4479	2247	50.2	908	20.3	463	10.3	861	19.2
	Type 12	2211	910	41.2	450	20.3	360	16.3	492	22.2
	Type 13	2886	963	33.4	615	21.3	467	16.2	842	29.2
	Type 14	1380	604	43.7	321	23.3	102	7.4	353	25.6
T-interchange	Type 21	681	205	30.0	184	27.1	88	12.9	205	30.0
Cloverleaf	Type 31	5388	2122	39.4	1275	23.7	816	15.1	1175	21.8
	Type 33	1779	400	22.5	434	24.4	374	21.0	571	32.1
	Type 35	1347	694)	51.5	234	17.4	130	9.7	289	21.5
Directional	Type 41	4074	1527	37.5	625	15.3	590	14.5	1332	32.7
Others	Type 51	699	233	33.3	153	21.9	117	16.8	196	28.0
Total		24924	9905	39.7	5199	20.9	3509	14.1	6314	25.3
V(x)				172		53		118		85

Independent Variables

Independent variables used for this study consist of traffic data and geometric data. The traffic data are:

1) Mainline traffic volume,

2) Ramp traffic volume, and

Truck traffic volume and truck percent.

Geometric data were obtained from the sufficiency rating files (1994) and freeway interchange inventory files (1997), which are maintained by the Michigan DOT. **Table 4.7** presents all variables that are intuitively thought to effect crash frequency, and are possible to obtain. An analysis of variance (ANOVA) of all independent variables was performed to determine which variables have a significant effect on the dependent variable (i.e., crash frequency).

Table 4.7 Classification of independent variables

	Independent variables	
	Variable type 1	Variable type 2
Traffic effects	• Mainline traffic(ADT) • On ramp traffic(ADT) • On and off ramp traffic(ADT) • Truck percent (%)	
Geometric effects	• Interchange length (miles) • Average spread - ramp length (miles) • Average loop- ramp length (miles)	• The number of lanes • The number of on ramps • The number of on and off ramps • Shoulder width(feet) • Lighting condition

There is an implicit assumption in statistical model development that the independent variables are mutually independent. It is generally accepted that multicollinearity exists when a linear combination of independent variables is highly correlated, and that it is difficult to identify independent variable effects on the dependent variable (Neter et al. 1992, Sever and Wild 1989). Therefore, explanatory variables with low collinearity should be selected in the process of modeling.

To evaluate the mutual independence between variables, a correlation table was produced. As shown in **Table 4.8**, some of the independent variables are identified as relatively highly correlated. For example, the correlation between the ramp traffic volume and the interchange size, and the correlation between the mainline traffic volume and shoulder width are 0.454 and - 0.411 respectively. Those are not high enough to be excluded in the first stage of model developments. However, these variables are carefully dealt with in the detailed process of modeling.

Table 4.8 Correlations Between Independent Variables

	Mainline Traffic (per lane)	Ramp Traffic Volume	Truck Traffic Volume	Truck percent	Interchange length	Average loop-ramp length	Average spread- ramp length	Number of lanes	Number of ramps	Lights	Shoulder width
Mainline traffic volume (per lane)	1.00										
Ramp traffic Volume	0.375	1.00									
Truck traffic Volume	0.028	0.003	1.00								
Truck Percent	-0.404	-0.384	0.438	1.00							
Interchange Length	-0.011	0.454	0.052	-0.040	1.00						
Average loop – ramp Length	-0.104	-0.122	0.076	-0.054	0.067	1.00					
Average spread – ramp Length	-0.282	0.080	0.194	-0.105	0.226	0.160	1.00				
Number of lanes	0.200	0.131	-0.434	0.077	-0.121	-0.206	-0.197	1.000			
Number of ramps	0.078	0.409	0.045	0.047	0.384	-0.093	0.127	-0.133	1.000		
Lights	0.422	0.102	-414	-0.060	-0.158	-0.212	-0.298	0.248	-0.172	1.00	
Shoulder Width	-0.411	-0.245	0.079	0.052	-0.058	0.000	0.238	-0.094	-0.046	-0.320	1.00

Analysis of Variance (ANOVA)

Analysis of variance (ANOVA) techniques are a useful tool for analyzing the statistical relationship between a dependent variable and independent variables. In fact, these may be considered as a special case of linear regression. However, ANOVA models allow analyses of statistical relations from a different perspective than with linear regression, and therefore are widely used. In this section we use the ANOVA for the preliminary analyses of the relations between the independent variables and a dependent variable. The independent variables are categorized into several groups before the ANOVA models are applied (i.e., for mainline ADT, 1: under 10000, 2:10000~15000, 3: 15000~20000, 4: over 20000).

We are now in a position to carry out a test of whether or not the category means μ_j are equal. The hypothesis for this test is the following (Neter et al. 1992)

$$H_0 : \mu_1 = \mu_2 = \mu_3 \ldots\ldots = \mu_r$$

$$H_1 : \text{Not all } \mu_j \text{ are equal}$$

Here, H_0 implies that all of the probability distributions have the same mean, and thus there are no factor effects. Alternative H_1 implies that the means are not equal, and hence that there are factor effects. The F- test statistic and p-value are used as a decision rule for this test, and statistical package SPSS (9.0 version) is used to investigate the ANOVA.

For mainline ADT the F- test statisitic=17.578>2.65, this we conclude that the mean crash frequency is not the same for the different mainline ADT categories. Similarly, ANOVA of ramp ADT and truck percent result in the same interpretion as that of mainline ADT. However, for truck ADT, the F-test statistic 0.244 is less than the critical value of 3.04, and hence we conclude that the mean crash frequencies are the same for different truck ADT. The large p-value of the test provides strong evidence that the sample data are in accord with equal mean frequencies for the different truck ADT. Mainline ADT, ramp ADT, and truck percent are thus expected to be contributing factors in the crash prediction models.

Table 4.9 presents the results of ANOVA for geometric effects. For the variables of interchange size and average spread ramp length, the F-test statistics are 6.760 and 3.901, respectively, which exceed the critical value of 3.04. This implies that the mean accidents are not the same for the different length of interchange, or the different length of spread ramps. However, for average loop ramp length, the F-test statistic 0.146 is very small, compared to the critical value of 3.11, and hence we conclude that the mean crashes are the same for the different length of loop ramps. The small P-value of the test in this table provides strong evidence of this conclusion.

On the other hand, the number of lanes and shoulder width are expected to be important independent variables for the prediction models based on F-test statistics that exceed critical values at χ=0.05. However, for lighting, the F-test statistic (1.953) is less than the critical value of 3.04, and hence we can not conclude that mean crash frequencies are not the same for the different lighting conditions. In addition, the F- test statistic for the number of on-off ramps is 1.818, which is close to the critical value of 1.93.

Thus, the number of on and off ramps, the number of lanes, shoulder width, interchange length and average spread ramp length are expected to be contributing factors. However, there are no factor effects caused by lighting condition and average loop ramp length, and thus no further analyses which include these variables is required.

Model Structure

Model structure is another issue in building a crash prediction model. However it is very difficult to choose the form of model equations because modeling remains, partly at least, an art (McCullagh and Nelder 1989). There are, however, some principles related to model structures which are summarized as follows. (McCullagh and Nelder 1989):

- A good model is one that fits the observed data very well.
- Simplicity is a desirable feature of any model; we should not include parameters that we do not need.
- Models should make sense physically.

If main effects are found from several studies bearing on the same phenomenon, the main effects should usually be included whether significant or not.

Table 4.9 ANOVA for geometric effects

Source of variance		d.o.f	Mean square	F-test		P-value
				Statistic	Critical value (α=0.05)	
A. Variable type 1						
Interchange length	Hypothesis	2	5860	6.760	3.04	0.001
	Error	196	866			
Average Loop ramp Length	Hypothesis	2	115	**0.146**	**3.11**	**0.703**
	Error	83	782			
Average Spread ramp Length	Hypothesis	2	3565	3.901	3.04	0.021
	Error	193	902			
B. Variable type 2						
The number of On and off ramps	Hypothesis	9	1608	**1.818**	**1.93**	**0.067**
	Error	189	884			
The number of Lanes	Hypothesis	4	2206	2.477	2.42	0.046
	Error	194	890			
Shoulder width	Hypothesis	1	17458	20.950	3.89	0.000
	Error	197	833			
Lighting	Hypothesis	2	1703	**1.953**	**3.04**	**0.144**
	Error	196	872			

Several studies (Maher and Summersgill 1996, Persaud and Nguyen 1998, Bonneson and McCoy 1997, Vogt and Bared 1999) found that a nonlinear relation is generally true, and traffic volume belongs in the main effect group among the various variables.

To confirm the model structure, the cross tabulation between crash frequency and traffic volume were produced as shown in **Table 4.10.** This approach was performed in a similar manner by Bonneson and McCoy (1993), and Hauer et al.(1988). In **Table 4.10**, the traffic ranges were selected such that the same traffic ranges are located in each row, or each column, in order to obtain equal weight in calculating the average number of crashes per interchange. Therefore, 52 interchanges with traffic volumes that exceed these ranges were excluded in building the table.

The cells give the average number of crashes that have occurred for 3 years at interchanges with mainline volume and ramp volume given in the left-most column and the upper row. The brief examination of the row and column summaries indicates a positive relation between crashes and both mainline volume and ramp volume as shown in **Figure 4.6** and **Figure 4.7**. However, the rate of increase may be different, depending on the traffic volume.

For example, while crashes are always increasing over all ranges of mainline ADT, the increase is very small between mainline ADT 10000~15000 and 15000 ~20000, compared with other ranges of mainline ADT. This implies that the increase of crashes with mainline ADT is nonlinear, and the increase can be captured by a function such as V^B, where V is mainline ADT and B is a coefficient larger than 0.0.

We can also determine from **Table 4.10** that there is a nonlinear relationship between crash frequency and traffic volume. For example, in the first column, crash frequencies increase sharply from 57 to 116 when the mainline volumes are changed from 15000~20000 to 20000 ~25000, whereas the crash frequencies increase only slightly (from 50 to 57) when the mainline volumes are changed from 5000~10000 to 15000~20000. These combinations can be found in other cells in **Table 4.10**, which is conceptually consistent with the nonlinear product of flows to power formulation as follows:

$$E(\theta) = A \times V_1^{B_1} \times V_2^{B_2}$$

where,

$E(\theta)$: Expected number of crashes
V_1 : Mainline volume
V_2 : Ramp volume
A, B_1, B_2 : Parameters

In principle, one should seek a model structure that best fits each interchange type. However, in this case, the model structure would be based on too small of a sample size to allow for finesse. Therefore, we regard this equation as the basic model structure describing the main effects of traffic variables on the interchange crash frequency.

The range of geometric variables is also an issue in choosing the appropriate model structure. The previous research found that the expected number of crashes can be represented by a product of geometric variables raised to various powers (Mountain et al. 1996), or by an exponential applied to a linear function of the geometric variables (Vogt and Bared 1999, Mahel and Summersgill 1996).

Table 4.10 Cross Tabulation of Crashes by Mainline Volume and Ramp Volume

Ramp volume / Mainline volume	5000 ~ 15000	5000 ~ 15000	5000 ~ 15000	5000 ~ 15000	Summary Row
5000 ~ 10000	50[1)] 903[2)]/18[3)]	88 1233/14	66 132/2	62 186/3	66 2454/37
10000 ~ 15000	55 721/13	100 2091/21	108 1624/15	148 1038/7	98 5474/56
15000 ~ 20000	57 454/8	122 1095/9	90 270/3	133 1065/8	103 2884/28
20000 ~ 25000	116 815/7	170 851/5	178 1420/8	175 1049/6	159 4135/26
Summary Column	63 2893/46	108 5270/49	123 3446/28	139 3338/24	102 14947/147

1): Average number of crashes per interchange
2): Total crashes
3): The number of interchanges

The effect of the range of possible geometric variables can not be evaluated efficiently, and hence, iterative tests of the model structures were performed. The results showed that a product of variables raised to various powers is appropriate for variables of type 1 (such as the size of interchanges), whereas an exponential applied to a linear function is appropriate for variables of type 2 (such as the number of on and off ramps).

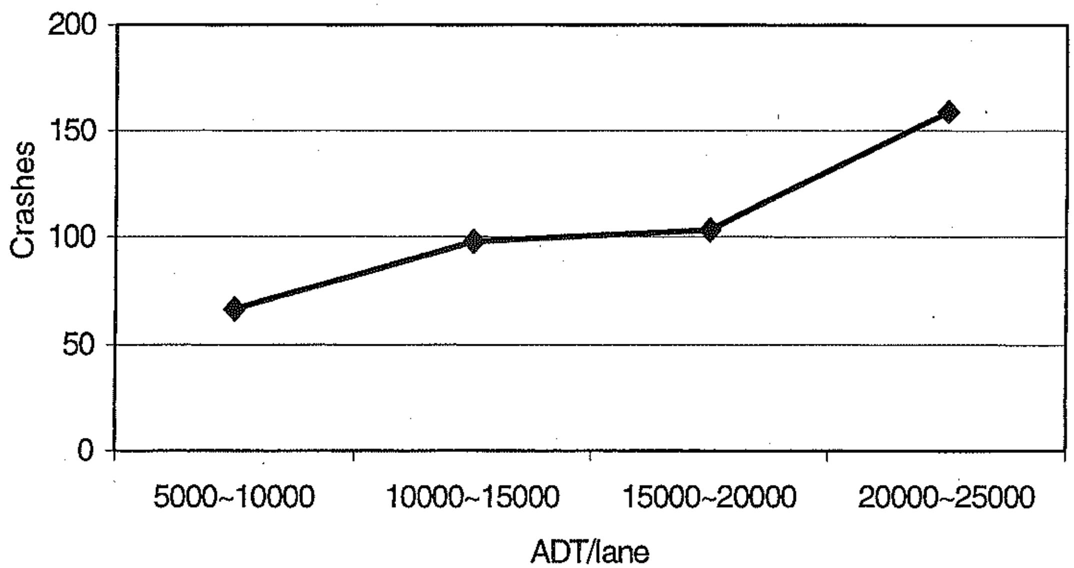

Figure 4.6 Mainline Traffic Volume and Crashes

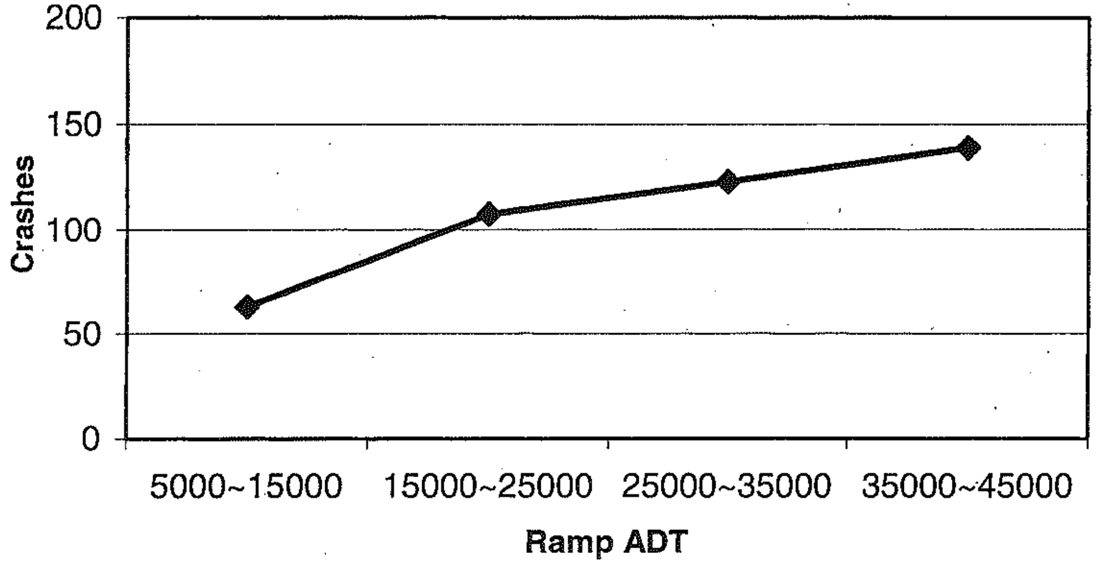

Figure 4.7 Ramp Traffic Volume and Crashes

On the basis of the literature review, the principles of model structures, and the results of the analyses, the general model structure for this study was finally determined to be of the following form:

$$E(\theta) = A \times V_i^{B_i} \times G_j^{C_j} \times \exp \sum (C_k \times G_k)$$

where,

$E(\theta)$: Expected number of crashes
V_i : Traffic variables
G_j : Geometric variables
G_k : Geometric variables
A, B_i, C_j, C_k : Parameters

Model Calibration and Analysis

Simplicity is a desirable feature of any model as noted by McCullagh and Nelder (1989). This means that we should not include insignificant parameters in a model, noting that not only does a simple model enable the researchers to think about their data, but the model that involves only the correct variables gives better predictions than one that includes unnecessary variables. In this stage, the irrelevant terms from the general model structure are excluded, and the models are calibrated through checks on the fit of a model to the data, for example by residuals and other statistics.

A nonlinear regression model was proposed, and it has been shown that the crash occurrences follow a Negative Binomial distribution. Therefore, we have to calibrate the coefficients of the crash prediction models and the Negative Binomial distribution parameter k simultaneously. There are two methods used to calibrate nonlinear regression models with a heterogeneous error structure (such as the Negative Binomial distribution): transformation of the model and generalized linear models (GLIM).

The transformation of models causes a change of scale in the data (Sever and Wild 1987, and McCullagh and Nelder 1989), which results in a violation of the Negative Binomial error assumption. Therefore, the analyses were performed on the original scale of the data using generalized linear models (McCullagh and Nelder 1989). Previous researchers have suggested that the generalized linear models can be a technique to overcome the shortcomings of the conventional normally distributed error assumption in describing random, discrete and non-negative events which often occur in the traffic crash field (Rodriguez and Sayed 1999).

Recognizing that traffic crashes follow the Negative Binomial distribution the GLIM approach is utilized for model calibration. The GLIM approach used herein is based on the work of McCullagh and Nelder (1989), and Lawless (1987). The generalized linear modeling technique introduces a link function η that relates the linear equation to the expected value of an observation. This link function equates the non- linear relationship to a linear one.

At the same time, there is a specific link function that is associated with the error structure of a distribution. This is defined as the natural link function. For example, natural link functions for the Negative Binomial distribution is as follows (McCullagh and Nelder 1989):

$$Negative\ Binomial : \eta = \left[\frac{E(\theta)}{K + E(\theta)} \right]$$

It is not algebraically possible to derive the linear predictor using the natural link function for the Negative Binomial distribution (Bonneson and Macoy 1997). Therefore, the Poisson link function is utilized instead, recognizing that the use of a natural link function is not a requirement for the GLIM approach (McCullagh and Nelder 1989).

In order to calibrate the prediction model, a dispersion parameter (D_p) will be utilized. That is, if D_p is greater than 1.0, then the data has a greater dispersion than is explained by the Poisson error assumption, and further analysis using the Negative Binomial error structure is required. In this case, the parameters are estimated in the iterative process using the maximum likelihood method.

Assessing the Goodness of Fit of the Model

This section describes a basis of measuring the model significance. To make understanding easier, the following notations are used:

y_i : the observed number of crashes at a site i

$E(\theta)_i$: the expected number of crashes at a site i

$\overline{E}(\theta)$: the average expected number of crashes

$Var(y_i)$: estimated variance in crashes at a site i

n: sample size

p: the number of parameters

Several measures can be used to assess the model fit and the significance of the model parameters. One such measure is the generalized Pearson χ^2 statistic, which is calculated as:

$$Pearson\ \chi^2 = \sum_{i=1}^{n} \frac{(y_i - E(\theta)_i)^2}{\mathrm{var}(y_i)}$$

where var(y_i) is estimated from the variance equation of the Negative Binomial distribution. McCullagh and Nelder(1989) indicate that the generalized Pearson χ^2 statistic has the exact χ^2 distribution for a Normal linear model, while asymptotic results are available for other distributions. The asymptotic results may not be relevant to statistics calculated from a small sample size. Therefore this statistic sometimes can not be used as an absolute measure for assessing the fit of a model.

A second measure of model fit is the Dispersion parameter (D_P), which can be calculated as:

$$Dispersion\ parameter(D_P) = \frac{Pearson\ \chi^2}{n-p}$$

As shown in the above formula, D_P can be obtained by dividing the Pearson χ^2 by n - p. McCullagh and Nelder (1989) indicated that it is a useful measure for assessing the fit of a model. A D_P value near 1.0 means that the error assumption of the model is equivalent to that found in observed data. If D_P is greater than 1.0, then the observed data has greater dispersion than is assumed in the model. This concept will be utilized in estimating the " k parameter " in the Negative Binomial distribution and the coefficients of the accident prediction models.

The third measure of model fit is the coefficient of determination R^2, which can be calculated as:

$$R^2 = 1 - \frac{SSE}{SST}$$

where

$$SSE = \sum_{i=1}^{n} [E(\theta)_i - y_i]^2$$

$$SST = \sum_{i=1}^{n} [y_i - \overline{E}(\theta)]^2$$

This measure is commonly used for measuring a linear regression model based on the normally distributed error assumption. Nevertheless, this statistic can still be useful in assessing the model fit, recognizing the findings that the coefficient of determination R^2 is still efficient in assessing a model calibrated under a non normal error structure (Kvalseth 1985).

The fourth measure of model fit is the Pearson Residual, which can be calculated as:

$$Pearson\ Residual(PR_i) = \frac{E(\theta)_i - y_i}{\sqrt{\text{var}(y_i)}}$$

As shown in this formula, this is defined as the difference between the predicted and observed data divided by the standard deviation. The Pearson Residual will be discussed again later.

In addition to these measures, the standard error and t-value are used for assessing the significance of variable coefficients. The t-value is the ratio between the variable coefficient and its standard error. The detailed descriptions of these statistics are not presented here since the concepts are commonly applied in measuring the fit of linear regression models.

The calibration of model parameters was performed based on the works of Lawless (1987). The calibration for this research is a multi-step process as shown in **Figure 4.8**.

First, the model parameters are estimated based on the Poisson error structure that the variance equals the expected value. Using the expected number being calculated in the first step, the second step is to estimate the "k" parameter. If 1/k is not greater than 0.0, then there is no over-dispersion in the observed data and the procedure stops. If 1/k is greater than 0.0, then a third step is to calculate new model coefficients under the Negative Binomial error structure using the k from the second step. In this step, the maximum likelihood estimates of the model coefficients are obtained by iterative weighted least squares. The final step is to calculate the Dispersion parameter (D_P). If D_P does not equal 1.0, the k parameter is increased (or decreased) and then a feedback loop is performed to the third step. The analysis is repeated in an iterative manner until the Dispersion parameter (D_P) converges to 1.0.

Models with Negative Binomial errors can not be calibrated using conventional statistical packages (i.e., SPSS, SYSTAT), and thus a statistical package for Generalized Linear

Interactive Modeling (GLIM), which is specially designed to calibrate models with special types of errors (i.e., Negative Binomial, Poisson and Gamma), was used. Rodriguez and Sayed (1999) used a similar process in calibrating the traffic crash prediction models for urban unsignalized intersections.

Results of the Model Calibration

On the basis of the procedures for assessing the model fit, the crash prediction models have been calibrated. The logarithmic link function has the following basic form.

$$\ln[E(\theta)] = \ln A + B_i \ln V_i + C_j G_j + \sum (C_k \times G_k) \quad (3.3)$$

This equation can be rewritten in a more useful form as:

$$E(\theta) = A \times V_i^{B_i} \times G_j^{C_j} \times \exp \sum (C_k \times G_k)$$

where,

$E(\theta)$: Expected number of crashes
V_i : Traffic variables
G_j : Geometric variables
G_k : Geometric variables
A, B_i, C_j, C_k : Parameters

The model calibration process starts with individual models according to the interchange types. **Table 4.11** presents several statistics relating to the calibrated crash prediction model for interchange type 11. In determining the significance of the variable coefficients, the 95 percent confidence level is used with a few exceptions. In the second row of the table, the statistic for the constant terms does not have any meaning since the logarithm results in a change of scale.

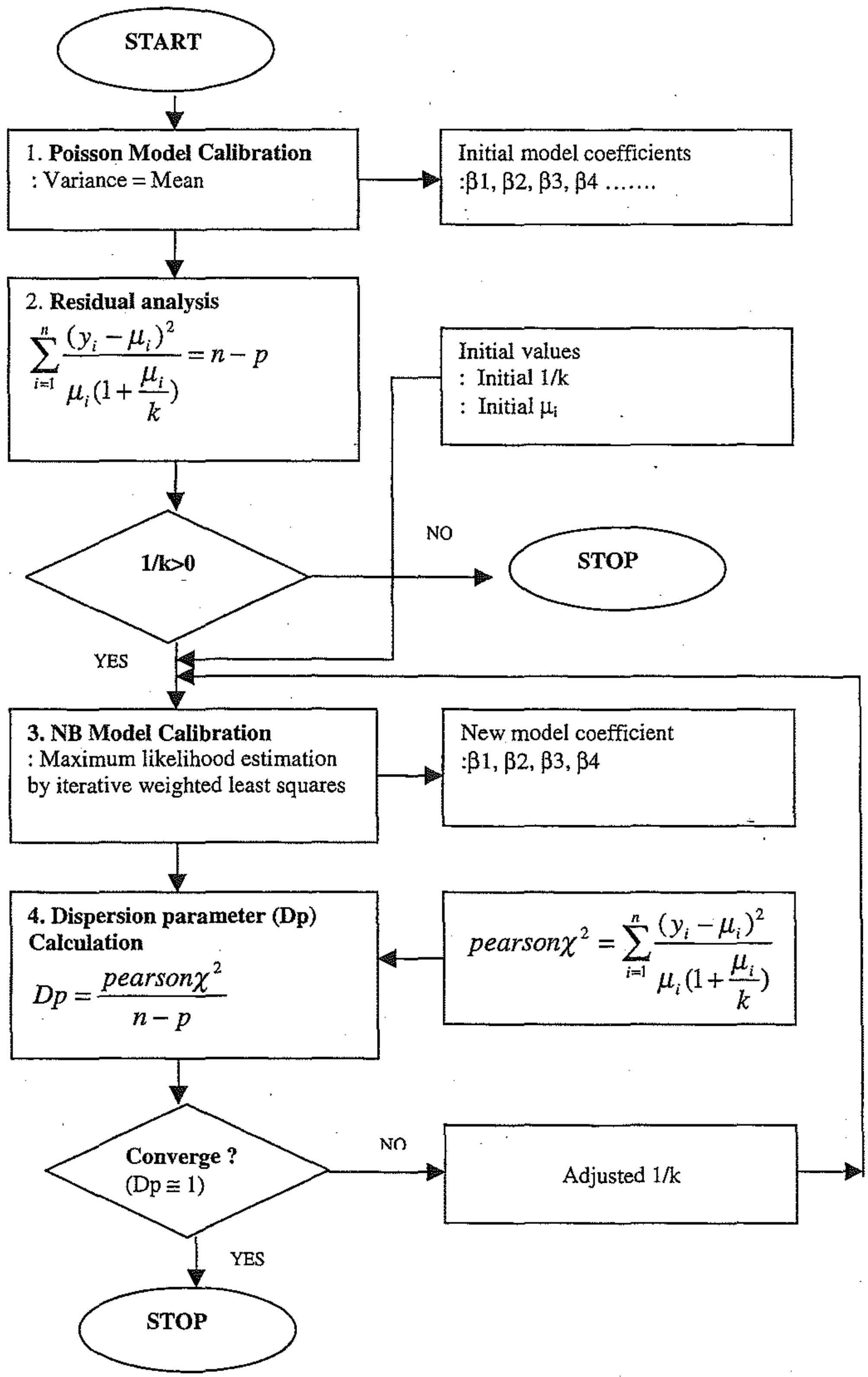

Figure 4.8 The Process To Calibrate Coefficients & K Parameter

The table indicates that several variables have a significant effect on the frequency of interchange crashes. These variables are mainline traffic, ramp traffic, truck percent, interchange size, spread ramp length, and shoulder width. However, the number

Table 4.11 The Results of Crash Prediction Model Calibration

(Interchange type 11)

Coefficient	Variable definition	Unit	Estimate	Std error	t - statistic
A Log(A)	Constant	-	3.448 (1.238)	(0.67)	(1.85)
B_1	V_1: Mainline traffic volume per lane	(ADT/1000)	1.401	0.30	4.66
B_2	V_2 : Ramp traffic volume	(ADT/1000)	0.186	0.12	1.55
B_3	V_3 :Truck percent	(%)	0.620	0.19	3.26
C_1	G_1 : Interchange length	(Mile)	0.738	0.15	4.92
C_2	G_2 : Average spread- ramp length	(Mile)	-1.267	0.97	-1.31
C_3	G_3 : The number of lanes	-			
C_4	G_4 : The number of total ramps	-			
C_5	G_5 : Shoulder width	(Feet)	-0.156	0.12	-1.30
Model statistic					
D_p	Dispersion parameter	1.0			
X^2	Pearson chi -square	28.84 ($\chi^2_{0.05,\ 27}$ = 40.11)			
R^2	Coefficient of determination	0.60			
K	Negative Binomial parameter	8.05			

of lanes and the number of total ramps are not included in this model because the effect of these variables is not significant. The calibrated coefficients can be applied to the basic model structure, in order to predict the number of traffic crashes that would be expected over 3 years at interchange type 11. The resulting model can be written as follow:

$$E(\theta) = 3.448\, V_1^{1.401}\, V_2^{0.186}\, V_3^{0.620}\, G_1^{0.738} \exp(-1.267\, G_2 - 0.156\, G_5)$$

where,

V_1 : Mainline traffic volume per lane
V_2 : Ramp traffic volume
V_3 : Truck percent
G_1 : Interchange length
G_2 : Average spread - ramp length
G_5 : Shoulder width

A k parameter of 8.05 is found to yield a dispersion parameter of 1.0. The Pearson χ^2 is 28.84, and the degree of freedom is 27(n-p-1=34-6-1). This statistic is less than $\chi^2_{0.05,\,27}$ = 40.11, and hence we can not reject the hypothesis that the model fits the data. It implies that the model is consistent with the observed data.

The calibrated crash prediction models for other interchange types are included as Appendix 1.

Pearson Residuals

A useful subjective measure of the model fit is the Pearson Residuals (PR), which are normalized residuals in the context that Pearson Residuals are the difference between the predicted and observed data divided by the standard. One can visually assess the goodness of model fit by plotting the Pearson Residuals versus the estimates of the expected number of crashes. A good model will have the Pearson Residuals centered around 0.0.

Pearson Residuals are plotted against the expected crash frequency in **Figure 4.9**. As shown in the figure, Pearson Residuals are centered around 0.0 for the entire range of expected frequency, which indicates that the calibrated models fit the observed data well.

Sensitivity Analysis

There are two objectives associated with a sensitivity analysis: One is to examine the possibility that the crash prediction model violates conceptual rules. For example, if a model were designed such that its predicted crashes would decrease with an increase in ramp volume, the model should be rejected because it violates a conceptual rule. The other objective is to determine the effects of individual variables on the crash frequency at freeway interchanges.

The sensitivity analyses were performed for the major geometric variables, but not for the traffic variables because it is possible to change the geometry, but changing traffic is difficult. During the sensitivity analysis of a specific variable, other design parameters are assumed to be a constant. For this analysis, an experimental matrix was established, which includes 3 experiments (A: 0.1 mile shorter than mean, B: mean, C: 0.1 mile longer than mean) for interchange length, 3 experiments (A: 0.1 mile longer than mean,

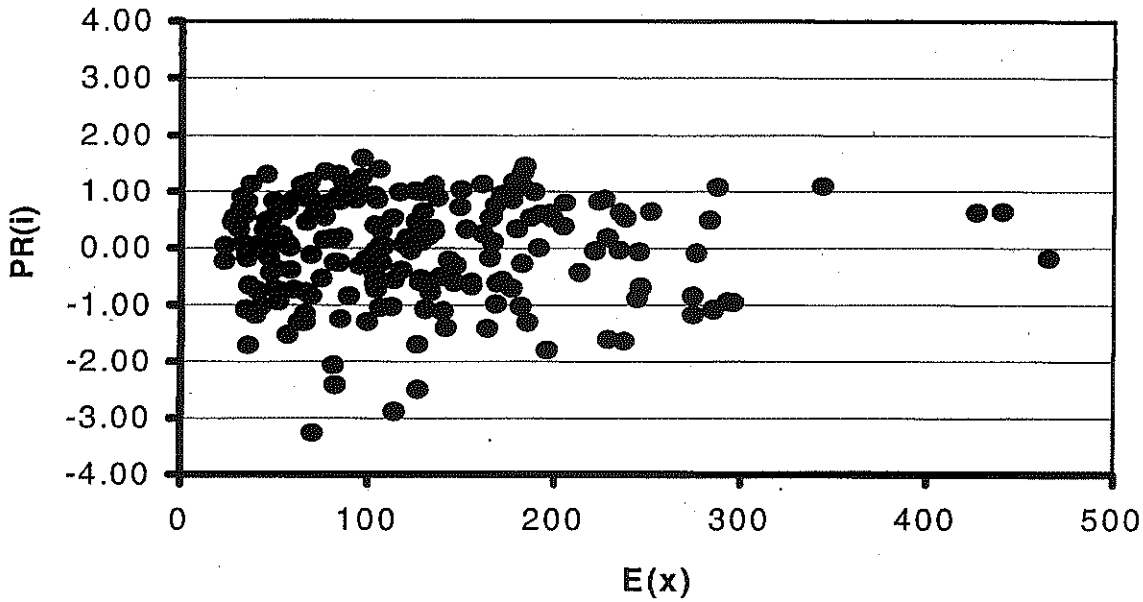

Figure 4.9 Pearson Residuals and E(x)

B: mean, C: 0.1 mile shorter than mean) for spread -ramp length, and 2 experiments (A: 12 feet and B: 10 feet) for shoulder width.

Table 4.13 illustrates the results of the sensitivity analyses. In the sensitivity analysis of interchange size, when the interchange size is increased by 0.1 mile, traffic crashes increase in all interchange types which use this variable as a model component. The average increase is 14 %.

In the sensitivity analysis of the spread- ramp length, traffic crashes increase by an average of 26 % when the spread- ramp length is decreased by 0.1 mile. The traffic crashes increase most rapidly for interchange type 12 (Tight diamond interchanges), which increases by 47 %. The crash frequency is very sensitive to shoulder width for both interchange types that include this variable, and especially for type 41(Directional interchanges). In the sensitivity analyses, no violation of conceptual rules of traffic crashes were found.

Identification of Potential Study Sites Using the Traffic Crash Prediction Models

Previous researchers (Jorgensen 1972, Flak and Barbaresso 1982) have recommended that hazardous sites be estimated by the difference between the observed accident frequency (B) of a site and the expected frequency (A) as predicted by an accident prediction model as shown in **Figure 4.10**. McGuian (1981) noted that this difference represents the size of the potential crash reduction when we perform a safety improvement project for the site. These ideas can be updated to solve both the conceptual problem and the practical problem, which have been identified.

Table 4.13 Sensitivity Analysis (Effect of Main Geometric Variables)

Parameter	Interchange type	Experiment (A)	Experiment (B)	Experiment (C)	Effects
Interchange Length	Length	0.534 mile	0.634 mile	0.734 mile	0.1 Mile (↑)
	Type 11	0.629	0.714	0.796	1.12
	Type 12	0.557	0.654	0.749	1.16
	Type 13	0.599	0.689	0.777	1.14
	Type 14	0.438	0.549	0.666	1.23
	Type 31	0.819	0.865	0.906	1.05
	Type 33	0.549	0.647	0.744	1.16
	Mean	0.599	0.686	0.773	1.14
Spread-ramp Length	Length	0.33 mile	0.23 mile	0.13 mile	0.1 mile (↓)
	Type 11	0.658	0.747	0.848	1.14
	Type 12	0.281	0.413	0.607	1.47
	Type 14	0.472	0.592	0.744	1.26
	Type 33	0.438	0.563	0.723	1.28
	Mean	0.462	0.579	0.730	1.26
Shoulder Width	Width	12 ft	10 ft		2.0 feet(↓)
	Type 11	0.154	0.211		1.37
	Type 41	0.057	0.093		1.63
	Mean	0.106	0.152		1.50

Suppose that the goal is to estimate the over representation of crashes at site i using a statistical concept like the rate quality control method. In order to evaluate site i using the rate quality control method, we should choose reference sites with similar properties, and compare the accident rate of the site i with that of the reference sites. However, in the strict sense, there are no reference sites which exactly reflect site i. Thus, the idea of the prediction model method is that we can use E(θ) obtained from the crash prediction model instead of the average crashes of the reference sites to which the site i belongs

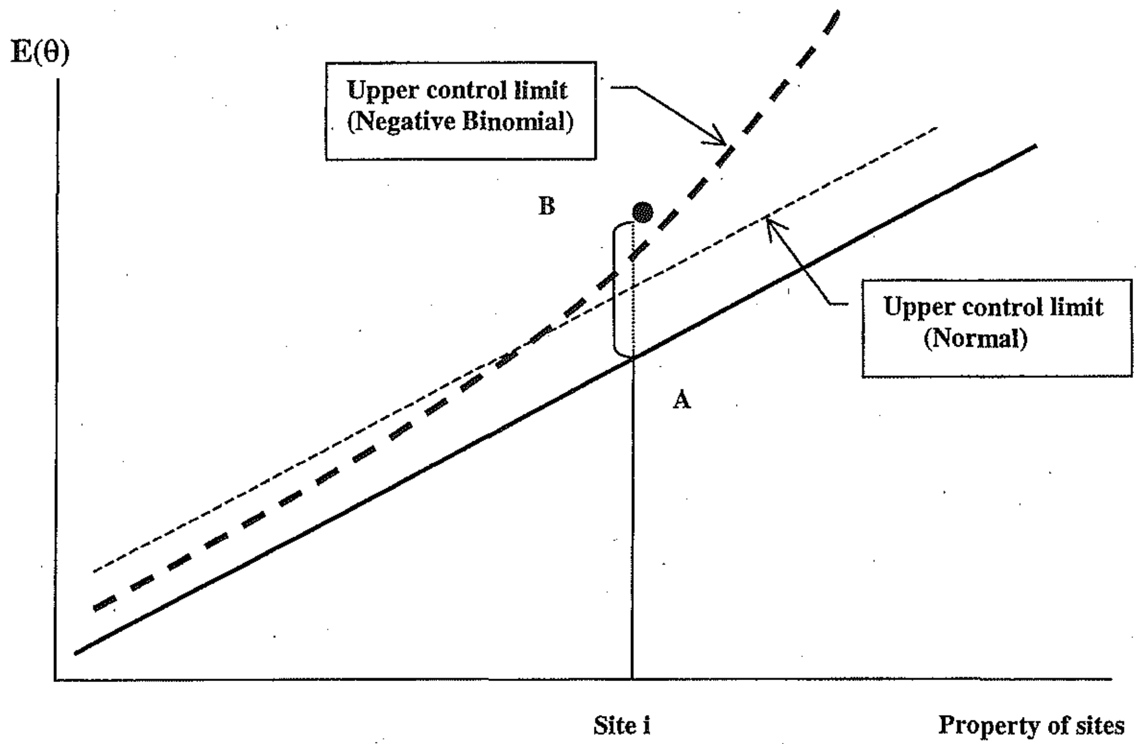

Figure 4.10 Concept of Prediction Model Method

Using this approach, the reference sites match exactly the traits of the site i (these are imaginary reference sites as denoted by Hauer (1992).

This approach is similar to the rate quality control method in the sense that both use the mean and standard deviation for identification of study sites. However, the difference is that the mean is the expected value E(θ), based on a calibrated model for the prediction model method, whereas the mean is the average of the reference sites for the rate quality control method. This is why "E(θ)" instead of "m" is used. Therefore, the calibration of the crash prediction model based on the correct error structure is extremely important to the identification of these sites.

It has already been shown that the desirable assumption for freeway crash models is the Negative Binomial rather than the Normal or Poisson error structure. In order to illustrate the prediction model method for the identification of sites above the upper control limit,

$$P = \sum_{x=0}^{U-1} \left(1 + \frac{E(\theta)}{k}\right)^{-k} \frac{\Gamma(k+x)}{x!\,\Gamma(k)} \left(\frac{E(\theta)}{E(\theta)+k}\right)^{x}$$

where,

U : the true upper control limit
$E(\theta)$: expected values
k : parameter

the Negative Binomial distribution function is shown again.

In this equation E(θ) would be obtained from the crash prediction model and the parameter k would be estimated in the process of calibrating coefficients of the crash prediction model, which were discussed in detail earlier. From this equation, the upper control limit at a desired probability level can be computed.

Illustration of the Prediction Model Method

Suppose that we are going to estimate the safety of a specific site using a crash prediction model that has been calibrated under the Negative Binomial error structure.

As shown, k can be estimated by the parameter calibration procedure described, and E(θ) can be computed from the crash prediction model. Thus, the true upper control limit 'U' can be found from the previous equation for a given site under the desired probability level.

For example, consider site 1 in **Table 4.14**. Using the crash prediction model the expected value at site 1,E (θ)

$$= 3.448\, V_1^{1.401}\, V_2^{0.186}\, V_3^{0.620}\, G_1^{0.738}\, \exp(-1.267\, G_2 - 0.156\, G_5) \qquad (6.2)$$

$$= 141.6 \text{ accidents/3years}$$

The standard deviation at site 1

$$= \sqrt{\mathrm{E}(\theta) + \mathrm{E}(\theta)^2 / k}$$

$$= 51.3 \text{ accidents/ 3years}$$

The parameter k was found to be 8.05. The upper control limit ' U ' is 233 crashes for 3 years under the 95 percent probability level as follows:

$$P = \sum_{x=0}^{U-1} \left(1 + \frac{141.6}{8.05}\right)^{-8.05} \frac{\Gamma(8.05 + x)}{x!\,\Gamma(8.05)} \left(\frac{141.6}{141.6 + 8.05}\right)^{x}$$

However, there were only 213 crashes over 3 years at the given site. Thus this site is not identified as being beyond the 95 percent significance level as shown in **Figure 4.11.**

Validation of the Prediction Model Method

Despite its advantages, the prediction model method can cause unreasonable results since there may be significant errors in choosing the model structure and calibrating the model parameters. For these reasons, it is important to illustrate empirically that the prediction model method and reference method produce similar results. However, we can not expect that the results of both approaches will be coincident, because in the strict sense, the imaginary reference sites for the prediction model method is a subset of the reference sites for the rate quality control method.

To demonstrate the results of both the prediction model and the rate quality control method, the data for Diamond and Par Clo 4Q interchanges were analyzed. The results are shown in Table 4.14. In this table, the 5th column presents the probability that observed crashes exceed the expected crashes at a given site under the prediction model method. The 6th column represents the probability that the observed accident rate exceeds the reference accident rate under the rate quality control method. There is some disagreement between the methods as expected. When sites are identified at a high

Table 4.14 A comparison of results

Site (i)	Interchange type	The number of crashes (3 years)		Probability	
		Observed	Estimated	By upper control limit	By prediction model
1	Diamond	213	141.6	0.91 ♦ v	0.91 ♦ v
2	Diamond	322	204.2	0.99 * ♦ v	0.93 ♦ v
3	Diamond	137	113.8	0.72	0.75
4	Diamond	196	139.9	0.95 * ♦ v	0.87 v
5	Diamond	193	237.7	0.36	0.34
6	Diamond	194	251.5	0.42	0.29
7	Diamond	247	163.7	0.92 ♦ v	0.92 ♦ v
8	Diamond	164	138.7	0.79	0.73
9	Diamond	207	169.3	0.85	0.76
10	Diamond	160	166.5	0.45	0.51
11	Diamond	242	157.8	0.90 ♦ v	0.92 ♦ v
12	Diamond	102	177.7	0.05	0.10
13	Diamond	111	182.7	0.09	0.13
14	Diamond	158	179.5	0.31	0.42
15	Diamond	161	198.5	0.28	0.34
16	Diamond	121	188.4	0.11	0.16
1	Par Clo A 4 Q	39	44.8	0.43	0.43
2	Par Clo A 4 Q	45	69.1	0.12	0.20
3	Par Clo B 4 Q	53	87.1	0.07	0.15
4	Par Clo A 4 Q	62	93.3	0.09	0.21
5	Par Clo A 4 Q	127	85.4	0.77 v	0.89 v
6	Par Clo B 4 Q	120	135.1	0.59	0.44
7	Par Clo B 4 Q	157	127.8	0.83 v	0.76 v
8	Par Clo A 4 Q	111	102.5	0.55	
9	Par Clo A 4 Q	103	125.7	0.33	0.64 v
10	Par Clo B 4 Q	117	134.8	0.33	0.36
					0.42
11	Par Clo A 4 Q	131	166.1	0.39	0.33
12	Par Clo A 4 Q	226	221.5	0.75 v	0.58
13	Par Clo A 4 Q	286	275.9	0.81 v	0.59 v
14	Par Clo B 4 Q	403	285.3	0.95 * ♦ v	0.86 v

*: Hazardous sites under 95 percent significance level

♦ :Hazardous sites undet 90 percent significance level

v: Top 10 hazardous rankings (5 for Diamond, and 5 for Par Clo 4 Q)

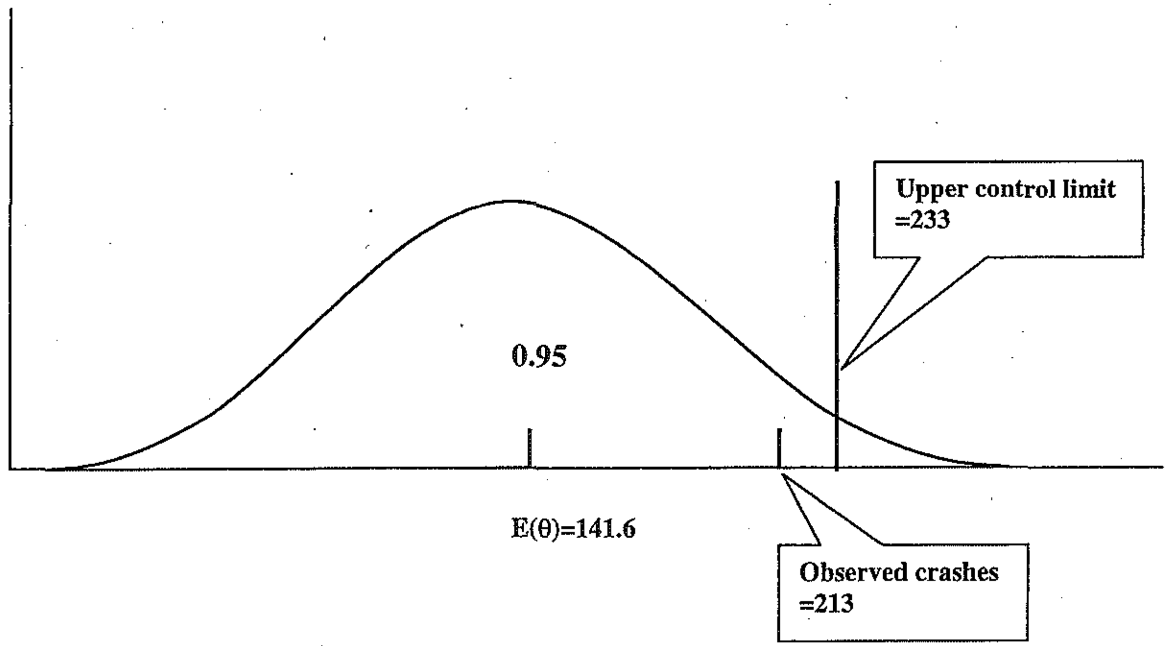

Figure 4.11 An example of application of prediction model method (95%)

significance level (i.e., 0.95), 3 sites out of 30 are identified by the rate quality control method (marked by a "*" in the table), whereas there are no sites identified when using the prediction model method. At a lower significance level (i.e., 0.90), 6 and 4 sites out of 30 are identified using the rate quality control method and prediction model method respectively (noted by a "♦" in the table).

In the prediction model method, the model parameters are calibrated through a minimization of the sum of squared residuals, and hence there may be underestimates of the variances for the special sites which have a larger value than the average sites as shown in the table. Moreover, not all geometric elements (i.e., interchange size, ramp length, et al) and traffic elements (mainline traffic, on and off ramp traffic, truck traffic, et al) were used in classifying the reference sites to design the upper control limit, whereas the imaginary reference sites for the prediction model method match exactly the characteristics of a special site.

If we rank all the sites by the probability, and choose the top 10 sites from the two data sets (5 sites at Diamond interchanges, and 5 sites at Par-Clo A or B 4 Q interchanges), the results are shown in Table 4.14 (noted by a "∨" in the table). As shown in the table, the prediction model method identifies the same sites as the rate quality control method for the Diamond interchanges. It also identifies 4 sites out of the 5 identified by the rate quality control method for the Par-Clo A or B 4 Q interchanges.

A practical application of the above results is that if the goal is to prioritize several sites for a highway safety program, the prediction model method can be used as a tool to produce very similar ranks as the rate quality control method. If the goal is to evaluate a specific site, the expected frequency of crashes at that site under the desired significance level can be evaluated through the prediction model method. These advantages imply that we can overcome the conceptual and practical problem associated with the identification of candidate sites for further study through the use of the prediction model method. The accuracy of this method depends on having the crash prediction model calibrated under the appropriate error structure.

Evaluation of Michigan Freeway Interchanges on the Basis of the Prediction Model

As noted the prediction model method can be used to identify sites beyond the control limits without the use of reference sites. Using this approach, the 199 interchanges which were utilized in the crash prediction model development were assessed using the coefficients and k parameters estimated according to the interchange type.

The sites which exceed the upper control limit are summarized in **Table 4.15**. Under the 95 % upper control limit, there is one site out of the 10 interchanges on I-69, 4 sites out of 65 on I-75, 6 sites out of 90 on I-94, and 1 site out of 34 on I-96, respectively. Therefore, a total 12 sites out of 199 were identified. These results are approximately consistent with the statistical concept that there may be 10 abnormal sites out of 200 random sites using the 95 % upper control limit. Under the 90 % upper control limit, 22 sites are chosen as hazardous, which also supports the preceding conclusion. The results of evaluating all interchanges are presented in detail **in the Appendix**.

These sites are candidates for improvement under a highway safety improvement program for freeway interchanges. These results could not be obtained through the existing rate quality method because there are not enough reference sites to allow the accurate identification of the control limits.

Table 4.15 The Out-of-Control Sites Using The Prediction Model Method

Route	Interchange ID	Interchange type	Cross road	Observed	Fitted	Probability	Control Limits	
							90 %	95%
I-69 (10)	69137	Full Direct	M-54 BR	165	83	0.98	*	*
I-75	75018	Diamond	Nadeau Rd	60	36	0.95	*	*
I-75	75026	Mod Tight Diamond	Huron River Rd	48	35	0.90	*	
I-75	75044	Part Diamond	Dearborn Rd	96	57	0.96	*	*
I-75	75074	Parclo AB	Adams Rd	208	114	0.99	*	*
I-75 (65)	75069	Clover w/C-D	Big Beaver Rd	406	229	0.95	*	*
I-94	94220 A	Diamond	French Rd	213	142	0.91	*	
I-94	94218	Diamond	Van Dyke Ave	247	164	0.91	*	
I-94	94230	Diamond	12 mile Rd	242	127	0.98	*	*
I-94		Tight Diamond	Pipestone Rd	142	106	0.90	*	
I-94	94217 B	Tight Diamond	Mt Elliott Ave	306	196	0.97	*	*
I-94	94214 A	Part Tight Daimond	Grand River Blvd	103	65	0.93	*	
I-94	94214 C	Part Tight Daimond	14th St	220	126	0.96	*	*
I-94	94214 B	Part Tight Daimond	Trumbull Ave	156	100	0.93	*	
I-94	94127	Mod Diamond	I-94 BL	98	66	0.91	*	
I-94	94215 C	Split Diamond	John R Rd	392	237	0.95	*	*
I-94	94034	Trumpet A	SB I-196	96	63	0.94	*	
I-94	94235	Trumpet B	Shook Rd	59	40	0.92	*	
I-94	94027	Parclo A	M-63	162	71	0.99	*	*
I-94	94028	Parclo B	Scottdale Rd	148	82	0.97	*	*
I-94 (90)	94219	Parclo B	Gratiot Ave	278	185	0.90	*	
I-96 (34)	96160	Other	Grand River Ave	107	66	0.95	*	*
Total (199)							22 sites	12 sites

( ): the number of sites which were assessed

APPENDIX

Appendix 1 The Results of Accident Prediction Model Calibration

(Interchange type 11)

Coefficient	Variable definition	Unit	Estimate	Std error	T - statistic
A Log(A)	Constant	-	3.448 (1.238)	(0.67)	(1.85)
B_1	V_1: Mainline traffic volume per lane	(ADT/1000)	1.401	0.30	4.66
B_2	V_2: Ramp traffic volume	(ADT/1000)	0.186	0.12	1.55
B_3	V_3 :Truck percent	(%)	0.620	0.19	3.26
C_1	G_1 : Interchange length	(Mile)	0.738	0.15	4.92
C_2	G_2 : Average spread ramp length	(Mile)	-1.267	0.97	-1.31
C_3	G_3 : The number of lanes	-			
C_4	G_4 : The number of total ramps	-			
C_5	G_5 : Shoulder width	(Feet)	-0.156	0.12	-1.30
Model statistic					
D_p	Dispersion parameter	1.0			
X^2	Pearson chi –square	28.84 ($\chi^2_{0.05,\ 27} = 40.11$)			
R^2	Coefficient of determination	0.60			
K	Negative Binomial parameter	8.05			

Appendix 1 The Results of Accident Prediction Model Calibration (Continued)

(Interchange type 12)

Coefficient	Variable definition	Unit	Estimate	Std error	t - statistic
A Log(A)	Constant	-	31.343 (3.445)	(0.73)	(4.72)
B_1	V_1: Mainline traffic volume per lane	(ADT/1000)	0.946	0.24	3.94
B_2	V_2: Ramp traffic volume	(ADT/1000)			
B_3	V_3: Truck percent	(%)			
C_1	G_1: Interchange length	(Mile)	0.933	0.36	2.59
C_2	G_2: Average spread ramp length	(Mile)	-3.842	1.31	-2.93
C_3	G_3: The number of lanes	-			
C_4	G_4: The number of total ramps	-			
C_5	G_5: Shoulder width	(Feet)			
Model statistic					
D_p	Dispersion parameter	1.0			
X^2	Pearson chi -square	14.66 ($\chi^2_{0.05,\ 14}$ = 23.68)			
R^2	Coefficient of determination	0.88			
K	Negative Binomial parameter	10.74			

Appendix 1 The Results of Accident Prediction Model Calibration (Continued)

(Interchange type 13)

Coefficient	Variable definition	Unit	Estimate	Std error	t - statistic
A Log(A)	Constant	-	3.614 (1.285)	(1.07)	(1.20)
B_1	V_1: Mainline traffic volume per lane	(ADT/1000)	0.947	0.47	2.01
B_2	V_2 : Ramp traffic volume	(ADT/1000)	0.187	0.16	1.17
B_3	V_3 :Truck percent	(%)			
C_1	G_1 : Interchange length	(Mile)	0.816	0.22	3.71
C_2	G_2 : Average spread ramp length	(Mile)			
C_3	G_3 : The number of lanes	-	0.136	0.10	1.36
C_4	G_4 : The number of total ramps	-			
C_5	G_5 : Shoulder width	(Feet)			
Model statistic					
D_p	Dispersion parameter	1.0			
X^2	Pearson chi -square	19.82 ($\chi^2_{0.05,\ 19}$ = 30.14)			
R^2	Coefficient of determination	0.47			
K	Negative Binomial parameter	5.48			

Appendix 1 The Results of Accident Prediction Model Calibration (Continued)

(Interchange type 14)

Coefficient	Variable definition	Unit	Estimate	Std error	t - statistic
A Log(A)	Constant	-	17.531 (2.864)	(1.25)	(2.29)
B_1	V_1: Mainline traffic volume per lane	(ADT/1000)	0.911	0.43	2.12
B_2	V_2 : Ramp traffic volume	(ADT/1000)	0.142	0.14	1.00
B_3	V_3 :Truck percent	(%)			
C_1	G_1 : Interchange length	(Mile)	1.315	0.33	3.98
C_2	G_2 : Average spread ramp length	(Mile)	-2.278	1.984	-1.15
C_3	G_3 : The number of lanes	-			
C_4	G_4 : The number of total ramps	-			
C_5	G_5 : Shoulder width	(Feet)			
Model statistic					
D_p	Dispersion parameter	1.0			
X^2	Pearson chi -square	9.07 ($\chi^2_{0.05, 9} = 16.92$)			
R^2	Coefficient of determination	0.65			
K	Negative Binomial parameter	6.38			

Appendix 1 The Results of Accident Prediction Model Calibration (Continued)

(Interchange type 21)

Coefficient	Variable definition	Unit	Estimate	Std error	t - statistic
A Log(A)	Constant	-	5.479 (1.701)	 (1.02)	 (1.67)
B_1	V_1: Mainline traffic volume per lane	(ADT/1000)	0.467	0.43	1.09
B_2	V_2 : Ramp traffic volume	(ADT/1000)	0.470	0.18	2.61
B_3	V_3 :Truck percent	(%)			
C_1	G_1 : Interchange length	(Mile)			
C_2	G_2 : Average spread ramp length	(Mile)			
C_3	G_3 : The number of lanes	-			
C_4	G_4 : The number of total ramps	-			
C_5	G_5 : Shoulder width	(Feet)			
Model statistic					
D_p	Dispersion parameter	1.0			
X^2	Pearson chi -square	6.35 ($\chi^2_{0.05,6}$ = 12.19)			
R^2	Coefficient of determination	0.68			
K	Negative Binomial parameter	6.73			

Appendix 1 The Results Of Accident Prediction Model Calibration (Continued)

(Interchange type 31)

Coefficient	Variable definition	Unit	Estimate	Std error	t - statistic
A Log(A)	Constant	-	3.494 (1.251)	(0.83)	(1.52)
B_1	V_1: Mainline traffic volume per lane	(ADT/1000)	1.144	0.24	4.77
B_2	V_2: Ramp traffic volume	(ADT/1000)	0.128	0.11	1.16
B_3	V_3: Truck percent	(%)	0.138	0.12	1.15
C_1	G_1: Interchange length	(Mile)	0.319	0.19	1.68
C_2	G_2: Average spread ramp length	(Mile)			
C_3	G_3: The number of lanes	-			
C_4	G_4: The number of total ramps	-			
C_5	G_5: Shoulder width	(Feet)			
Model statistic					
D_p	Dispersion parameter	1.0			
X^2	Pearson chi -square	37.68 ($\chi^2_{0.05,\ 35}$ = 51.00)			
R^2	Coefficient of determination	0.72			
K	Negative Binomial parameter	7.02			

Appendix 1 The Results of Accident Prediction Model Calibration (Continued)

(Interchange type 33)

Coefficient	Variable definition	Unit	Estimate	Std error	t - statistic
A Log(A)	Constant	-	44.124 (3.787)	(0.87)	(1.20)
B_1	V_1: Mainline traffic volume per lane	(ADT/1000)	0.515	0.24	2.15
B_2	V_2: Ramp traffic volume	(ADT/1000)	0.244	0.12	2.03
B_3	V_3: Truck percent	(%)			
C_1	G_1: Interchange length	(Mile)	0.956	0.24	3.98
C_2	G_2: Average spread ramp length	(Mile)	-2.500	0.98	-2.55
C_3	G_3: The number of lanes	-			
C_4	G_4: The number of total ramps	-			
C_5	G_5: Shoulder width	(Feet)			
Model statistic					
D_p	Dispersion parameter	1.0			
X^2	Pearson chi -square	16.23 ($\chi^2_{0.05, 16} = 26.30$)			
R^2	Coefficient of determination	0.82			
K	Negative Binomial parameter	13.85			

Appendix 1 The Results of Accident Prediction Model Calibration (Continued)

(Interchange type 35)

Coefficient	Variable definition	Unit	Estimate	Std error	t - statistic
A Log(A)	Constant	-	8.619 (2.154)	(1.19)	(1.81)
B_1	V_1: Mainline traffic volume per lane	(ADT/1000)	0.736	0.82	0.90
B_2	V_2: Ramp traffic volume	(ADT/1000)	0.270	0.41	0.66
B_3	V_3: Truck percent	(%)			
C_1	G_1: Interchange length	(Mile)			
C_2	G_2: Average spread ramp length	(Mile)			
C_3	G_3: The number of lanes	-			
C_4	G_4: The number of total ramps	-			
C_5	G_5: Shoulder width	(Feet)			
Model statistic					
D_p	Dispersion parameter	1.0			
X^2	Pearson chi -square	5.36 ($\chi^2_{0.05,5} = 11.07$)			
R^2	Coefficient of determination	0.37			
K	Negative Binomial parameter	4.35			

Appendix 1 The Results of Accident Prediction Model Calibration (Continued)

(Interchange type 41)

Coefficient	Variable definition	Unit	Estimate	Std error	t - statistic
A Log(A)	Constant	-	28.247 (3.341)	(2.344)	(1.43)
B_1	V_1: Mainline traffic volume per lane	(ADT/1000)	0.839	0.29	2.89
B_2	V_2: Ramp traffic volume	(ADT/1000)	0.215	0.15	1.43
B_3	V_3: Truck percent	(%)			
C_1	G_1: Interchange length	(Mile)			
C_2	G_2: Average spread ramp length	(Mile)			
C_3	G_3: The number of lanes	-			
C_4	G_4: The number of total ramps	-	0.182	0.06	3.03
C_5	G_5: Shoulder width	(Feet)	-0.238	0.18	-1.32
Model statistic					
D_p	Dispersion parameter	1.0			
X^2	Pearson chi -square	17.99 ($\chi^2_{0.05, 17} = 27.59$)			
R^2	Coefficient of determination	0.64			
K	Negative Binomial parameter	6.37			

Appendix 1 The Results Of Accident Prediction Model Calibration (Continued)

(Interchange type 51)

Coefficient	Variable definition	Unit	Estimate	Std error	t - statistic
A Log(A)	Constant	-	3.658 (1.297)	(1.23)	(1.05)
B_1	V_1: Mainline traffic volume per lane	(ADT/1000)	0.478	0.65	0.73
B_2	V_2 : Ramp traffic volume	(ADT/1000)	0.506	0.33	1.53
B_3	V_3 :Truck percent	(%)			
C_1	G_1 : Interchange length	(Mile)			
C_2	G_2 : Average spread ramp length	(Mile)			
C_3	G_3 : The number of lanes	-			
C_4	G_4 : The number of total ramps	-			
C_5	G_5 : Shoulder width	(Feet)			
Model statistic					
D_p	Dispersion parameter	1.0			
X^2	Pearson chi -square	5.19 ($\chi^2_{0.05,\ 5}$ = 11.07)			
R^2	Coefficient of determination	0.47			
K	Negative Binomial parameter	4.86			

Appendix 2 The Results Of Evaluating Freeway Interchanges By The Prediction Model Method

Route	Interchange ID	Type	Interchange type	Cross road	Observed	Fitted	Probability	Control limits	
								90 %	95 %
I-69	69136	Type11	Diamond	Church St	76	81	0.49		
I-69	69128	Type31	Parclo B	Morrish Rd	41	57	0.27		
I-69	69129	Type31	Parclo B	Miller Rd	93	84	0.66		
I-69	69143	Type31	Parclo A 4 Q	Irish Rd	80	85	0.49		
I-69	69131	Type31	Parclo A 4 Q	Bristol Rd	48	106	0.05		
I-69	69141	Type31	Parclo A 4 Q	Belsay Rd	45	69	0.20		
I-69	69138	Type31	Parclo A 4 Q	M-54 dort Hwy	103	126	0.36		
I-69	69139	Type31	Parclo A 4 Q	Center Rd	62	93	0.21		
I-69	69135	Type31	Parclo B 4 Q	Hammerburg Rd	117	135	0.42		
I-69	69137	Type41	Full Direct	M-54 Br	165	83	0.98	*	*
I-75	75005	Type11	Diamond	Erie Rd	39	48	0.36		
I-75	75006	Type11	Diamond	Luna pier Rd	48	49	0.54		
I-75	75042	Type11	Diamond	Outer Dr	57	84	0.21		
I-75	75018	Type11	Diamond	Nadeau Rd	60	36	0.95	*	*
I-75	75045	Type11	Diamond	Springwells Ave	137	114	0.75		
I-75	75049A	Type11	Diamond	12th Ave	178	146	0.76		
I-75		Type11	Daimond	Clay Ave	36	35	0.59		
I-75	75052A	Type11	Diamond	Warren Ave	95	107	0.43		
I-75	75047	Type11	Diamond	M-3 Clark Ave	196	140	0.87		
I-75	75054	Type11	Diamond	Clay Ave	201	182	0.66		
I-75	75058	Type11	Diamond	7 mile Rd	194	251	0.29		
I-75	75057	Type11	Diamond	Mcnichols Rd	193	238	0.34		
I-75		Type11	Diamond	I-94	80	135	0.12		
I-75	75026	Type12	Mod Tight Diamond	Huron River Rd	48	35	0.90	*	
I-75	75036	Type12	Mod Tight Diamond	Eureka Rd	75	60	0.84		
I-75		Type12	Tight Diamond	M-50	47	97	0.05		

Appendix 2 The Results Of Evaluating Freeway Interchanges By The Prediction Model Method (Continued)

Route	Interchange ID	Type	Interchange type	Cross road	Observed	Fitted	Probability	Control limits	
								90 %	95 %
I-75	75062	Type12	Tight Diamond	11 mile Rd	492	465	0.69		
I-75	75044	Type13	Part Diamond	Dearborn Rd	96	57	0.96	*	*
I-75	75051A	Type13	Part Tight Diamond	John St	240	168	0.89		
I-75	75047B	Type13	Part Tight Diamond	Lafayette Ave	109	96	0.74		
I-75	75052	Type13	Part Tight Diamond	Mack Ave	252	245	0.66		
I-75	75055	Type13	Part Tight Diamond	Holbrook Ave	51	85	0.25		
I-75	75055A	Type13	Part Tight Diamond	Caniff Ave	49	94	0.18		
I-75	75011	Type14	Diamond + loop	La plaisance Rd	23	23	0.62		
I-75	75040	Type14	Split Diamond	Northline Rd	148	226	0.25		
I-75	75060	Type14	Split Diamond	9 mile Rd	38	35	0.69		
I-75	75046	Type14	Split Diamond	Livernois Rd	77	129	0.20		
I-75	75020	Type21	Trumpet A	I-275	36	69	0.17		
I-75	75072	Type21	Trumpet A	Crooks Rd	69	105	0.30		
I-75	75081	Type21	Trumpet A	M-24	125	123	0.68		
I-75	75032	Type31	Parclo B	West Rd	60	77	0.33		
I-75	75067	Type31	Parclo A	Rochester Rd	311	246	0.78		
I-75	75084	Type31	Parclo B 4 Q	Baldwin Rd	120	135	0.44		
I-75	75089	Type31	Parclo A 4 Q	Sashabaw Rd	112	121	0.48		
I-75	75122	Type31	Parclo A 4 Q	Pierson Rd	127	85	0.89		
I-75	75041	Type31	Parclo A 4 Q	M-39 Soufield Rd	131	166	0.33		
I-75	75079	Type31	Parclo A 4 Q	University Dr	133	152	0.42		
I-75	75065	Type31	Parclo B 4 Q	14 mile Rd	403	285	0.86		
I-75	75063	Type31	Parclo A 4 Q	12 mile Rd	286	276	0.59		
I-75		Type33	Parclo AB	Bay city Rd	57	51	0.75		
I-75	75027	Type33	Parclo AB	Huron River Dr	25	23	0.72		
I-75	75021	Type33	Parclo AB	Newport Rd	39	40	0.60		
I-75	75029	Type33	Parclo AB 4 Q	Gibraltar Rd	47	48	0.60		
I-75	75009	Type33	Parclo AB	Otter Creek Rd	26	35	0.30		

Appendix 2 The Results Of Evaluating Freeway Interchanges By The Prediction Model Method (Continued)

Route	Interchange ID	Type	Interchange type	Cross road	Observed	Fitted	Probability	Control limits	
								90 %	95 %
I-75	75013	Type33	Palclo AB	M-50 Front Rd	28	34	0.40		
I-75	75014	Type33	Palclo AB	Elm Rd	44	36	0.84		
I-75	75074	Type33	Parclo AB	Adams Rd	208	114	0.99	*	*
I-75	75118	Type33	Parclo AB	M-56	105	107	0.60		
I-75	75083	Type33	Parclo AB 4 Q	Joslyn Rd	117	119	0.60		
I-75	75043	Type33	Parclo AB 4 Q	Schaefer Hwy	195	235	0.37		
I-75	75116	Type35	Clover –loop	M-121 Bristol Rd	220	172	0.81		
I-75	75069	Type35	Clover w/C-D	16 mile Rd	406	229	0.95	*	*
I-75	75077	Type35	Cloverleaf	M-59	135	223	0.28		
I-75	75048	Type41	Directional Y	Michigan Ave	106	104	0.63		
I-75	75051	Type41	Full Direct	Madison Ave	197	155	0.82		
I-75	75040A	Type41	Part Direct	Dix Hwy	123	129	0.57		
I-75	75125	Type41	Directional Y	I-475	64	103	0.22		
I-75	75034	Type41	Part Direct	Ext to Dix Hwy	57	48	0.76		
I-75	75117	Type41	Gen Directional	Miller Rd	193	155	0.80		
I-75	75075	Type41	Directional Y	Ext to WB I-75	118	107	0.70		
I-75	75059	Type41	Part Direct	Chrysler Rd	321	427	0.35		
I-75	75056	Type41	Full Direct	Davison to SB I-75	367	274	0.85		
I-75	75061	Type41	Full Direct	Ext to NB I-75	329	441	0.34		
I-75	75002	Type51	Other	Sumit Rd	21	29	0.49		
I-75		Type51	Other	Oakland Center Dr	35	52	0.43		
I-94	94157	Type11	Diamond	Jackson Rd	49	54	0.46		
I-94	94156	Type11	Diamond	Kalmback Rd	154	197	0.31		
I-94	94220A	Type11	Diamond	French Rd	213	142	0.91	*	
I-94	94218	Type11	Diamond	Van dyke Ave	247	164	0.91	*	
I-94	94230	Type11	Diamond	12 mile Rd	242	127	0.98	*	*
I-94	94228	Type11	Diamond	10 mile Rd	160	166	0.52		

Appendix 2 The Results Of Evaluating Freeway Interchanges By The Prediction Model Method (Continued)

Route	Interchange ID	Type	Interchange type	Cross road	Observed	Fitted	Probability	Control limits	
								90 %	95 %
I-94	94223	Type11	Diamond	Cadieux Ave	164	139	0.73		
I-94	94225	Type11	Diamond	Vernier Rd	322	244	0.83		
I-94	94224	Type11	Diamond	Moross Rd	207	169	0.77		
I-94	94227	Type11	Diamond	9 mile Rd	222	177	0.79		
I-94	94022	Type12	Tight Diamond	John Beers Rd	52	41	0.85		
I-94	94128	Type12	Tight Diamond	Michigan Ave	58	58	0.63		
I-94	94141	Type12	Tight Diamond	Elm Rd	59	84	0.25		
I-94	94085	Type12	Tight Diamond	Shafter 35th St	89	82	0.72		
I-94	94137	Type12	Tight Diamond	Airport Rd	43	67	0.19		
I-94	94030	Type12	Tight Diamond	Napier Ave	62	85	0.29		
I-94	94072	Type12	Tight Diamond	9th St	105	99	0.69		
I-94	94139	Type12	Mod Tight Diamond	M-106	58	78	0.31		
I-94		Type12	Tight Diamond	Pipestone Rd	142	106	0.90	*	
I-94	94075	Type12	Tight Diamond	Oakland Dr	115	149	0.33		
I-94	94217B	Type12	Tight Diamond	Mt Elliott Ave	306	196	0.97	*	*
I-94	94212B	Type13	Part Tight Daimond	30th St	132	103	0.83		
I-94	94211	Type13	Part Tight Daimond	Lonyo Ave	41	67	0.27		
I-94	94214A	Type13	Part Tight Daimond	Grand River Blvd	103	65	0.93	*	
I-94	94211C	Type13	Part Tight Daimond	Addison Ave	55	57	0.61		
I-94	94217	Type13	Part Tight Daimond	Chene Rd	112	177	0.28		
I-94	94213	Type13	Part Diamond	W Grand Blvd	163	112	0.90		
I-94	94222B	Type13	Part Diamond	Harper Ave	120	132	0.56		
I-94	94221	Type13	Part Tight Diamond	Outer Dr	39	55	0.37		
I-94	94214C	Type13	Part Tight Daimond	14th St	220	126	0.96	*	*
I-94	94211B	Type13	Part Tight Daimond	Cecil Ave	138	118	0.77		
I-94	94211A	Type13	Part Tight Daimond	Weir St	93	129	0.37		
I-94	94214B	Type13	Part Tight Daimond	Trumbull Ave	156	100	0.93	*	
I-94	94127	Type14	Mod Diamond	Concord Rd	68	59	0.74		
I-94	94023	Type14	Diamond+loop	Red Arrow Hwy	72	77	0.55		

Appendix 2 The Results Of Evaluating Freeway Interchanges By The Prediction Model Method (Continued)

Route	Interchange ID	Type	Interchange type	Cross road	Observed	Fitted	Probability	Control limits	
								90 %	95 %
I-94	94127	Type14	Mod Diamond	I-94 BL	98	66	0.91	*	
I-94	94175	Type14	Diamond+loop	Saline Rd	54	71	0.37		
I-94	94241	Type14	Mod Diamond	21 mile Rd	89	67	0.84		
I-94	94169	Type14	Mod Diamond	Zeeb Rd	87	104	0.45		
I-94	94199	Type14	Mod Diamond	Middlebelt Rd	122	103	0.76		
I-94	94222A	Type14	Split Diamond	Chalmers Ave	79	86	0.53		
I-94	94215C	Type14	Split Diamond	John Rd	392	237	0.95	*	*
I-94	94136	Type21	Trumpet A	M-60	46	51	0.58		
I-94	94034	Type21	Trumpet A	SB I-196	96	63	0.94	*	
I-94	94235	Type21	Trumpet B	Shook Rd	59	40	0.92	*	
I-94	94033	Type21	Trumpet B	I-94 BL	20	33	0.27		
I-94	94240	Type21	Trumpet B	Hall Rd	73	70	0.69		
I-94	94006	Type31	Parclo B	Union Pier Rd	32	33	0.54		
I-94	94012	Type31	Parclo B	Sawyer Rd	61	43	0.86		
I-94	94124	Type31	Parclo B	M-99	93	70	0.82		
I-94	94027	Type31	Parclo A	M-63	162	71	0.99	*	*
I-94	94028	Type31	Parclo B	Scottdale Rd	148	82	0.97	*	*
I-94	94232	Type31	Parclo B	Little Mack Ave	121	128	0.50		
I-94	94159	Type31	Parclo B	M-52	107	108	0.55		
I-94	94219	Type31	Parclo B	Gratiot Ave	278	185	0.90	*	
I-94	94001	Type31	Parclo A 4 Q	US-12	39	45	0.43		
I-94		Type31	Parclo A 4 Q	US-127	72	117	0.16		
I-94	94080	Type31	Parclo A 4 Q	Sprinkle Rd	116	120	0.52		
I-94	94234	Type31	Parclo B 4 Q	Harper Rd	157	128	0.75		
I-94	94078	Type31	Parclo A 4 Q	Kilgore Rd	90	137	0.20		
I-94	94076	Type31	Parclo B 4 Q	Westnedge Ave	90	150	0.14		
I-94	94236	Type31	Parclo A 4 Q	Metro Beach Rd	111	102	0.64		
I-94	94183	Type31	Parclo A 4 Q	Hamilton Rd	212	228	0.48		
I-94	94177	Type31	Parclo A 4 Q	State St	146	161	0.46		

Appendix 2 The Results Of Evaluating Freeway Interchanges By The Prediction Model Method (Continued)

Route	Interchange ID	Type	Interchange type	Cross road	Observed	Fitted	Probability	Control limits	
								90 %	95 %
I-94	94196	Type31	Parclo A 4 Q	Wayne Rd	226	222	0.57		
I-94	94243	Type31	Parclo A 4 Q	M-29	81	184	0.04		
I-94	94104B	Type33	Parclo AB	11 mile Rd	37	50	0.28		
I-94	94052	Type33	Parclo AB	Paw Paw Rd	67	52	0.88		
I-94	94237	Type33	Parclo AB	North River Rd	112	90	0.87		
I-94		Type33	Parclo AB 4 Q	Ford Plant Rd	39	46	0.43		
I-94	94181	Type33	Parclo AB 4 Q	US-12	43	64	0.19		
I-94	94208	Type33	Parclo AB 4 Q	Greenfield Rd	58	67	0.44		
I-94	94206	Type33	Parclo AB 4 Q	Oakwood Blvd	141	165	0.42		
I-94		Type33	Parclo AB 4 Q	Michigan Ave	94	134	0.20		
I-94	94004	Type35	Cloverleaf	US-12	51	47	0.69		
I-94	94180	Type35	Clover w/C-D	US-23&BL-94	169	147	0.73		
I-94	94074	Type35	Clover w/C-D	US-131	158	166	0.60		
I-94		Type35	Clover w/C-D	Pittsfield tw	72	161	0.14		
I-94	94198	Type35	Clover w/C-D	Merriman Rd	136	192	0.38		
I-94	94144	Type41	Part Direct Y	I-94	39	84	0.10		
I-94	94185	Type41	Part Direct Y	US-12	22	27	0.45		
I-94	94210	Type41	Part Direct	Michigan Ave	191	191	0.61		
I-94	94200	Type41	Part Direct	Ecorse Rd	74	125	0.19		
I-94	94220	Type41	Full Direct	Conner Ave	256	182	0.88		
I-94	94231	Type41	Part Direct Y	Gratiot Ave	44	86	0.13		
I-94	94202	Type41	Direct.w/loops	Telegraph Rd	228	283	0.41		
I-94	94214	Type41	Full Direct	Ext to I - 96	403	293	0.87		
I-94		Type41	Full Direct	M-10	409	296	0.87		
I-94		Type41	Full Direct	Dubois St	173	204	0.46		
I-94	94229	Type41	Full Direct	11 mile Rd	194	344	0.16		
I-94	94209	Type51	Other	Rotunda Dr	73	54	0.88		
I-94	94204	Type51	Other	Pelham Rd	157	143	0.78		
I-96	96187	Type11	Diamond	Grand River Ave	90	75	0.74		

Appendix 2 The Results Of Evaluating Freeway Interchanges By The Prediction Model Method (Continued)

Route	Interchange ID	Type	Interchange type	Cross road	Observed	Fitted	Probability	Control limits	
								90 %	95 %
I-96	96186	Type11	Diamond	Wyoming Ave	23	46	0.08		
I-96	96185	Type11	Diamond	Grand River Ave	27	31	0.44		
I-96		Type11	Diamond	Schaefer Rd	23	32	0.28		
I-96	96180	Type11	Diamond	Outer Dr	94	183	0.07		
I-96	96178	Type11	Diamond	Beach Daly	121	188	0.16		
I-96	96176	Type11	Diamond	Middlebelt Rd	158	180	0.42		
I-96	96175	Type11	Diamond	Merriman Rd	111	183	0.13		
I-96	96177	Type11	Diamond	Inkster Rd	161	199	0.34		
I-96	96174	Type11	Diamond	Farmington Rd	102	178	0.11		
I-96	96159	Type12	Mod Tight Diamond	Wixom Rd	120	171	0.24		
I-96	96188A	Type12	Tight Diamond	Livernois	174	165	0.69		
I-96	96184	Type12	Tight Diamond	Greenfield Rd	166	133	0.85		
I-96	96150	Type13	Part Diamond	Pleasant Valley Rd	18	37	0.17		
I-96	96191	Type13	Part Diamond	Myrtle Ave	113	168	0.32		
I-96	96190	Type13	Part Diamond	Warren Ave	253	213	0.78		
I-96	96188B	Type13	Part Tight Diamond	Joy Rd	37	61	0.26		
I-96	96189	Type13	Part Tight Diamond	W Grand Blvd	143	187	0.41		
I-96	96173B	Type13	Part Diamond	Levan Rd	154	287	0.18		
I-96	96182	Type14	Diamond+loop	Evergreen Rd	34	77	0.08		
I-96	96186B	Type21	Trumpet A	Davison Rd	156	128	0.82		
I-96	96151	Type31	Parclo B	Kensington Rd	90	113	0.34		
I-96	96155	Type31	Parclo A	Milford Rd	185	131	0.86		
I-96	96153	Type31	Parclo B 4 Q	Kent Lake Rd	53	87	0.16		
I-96	96162	Type31	Parclo A 4 Q	Novi Rd	49	96	0.09		
I-96	96170	Type31	Parclo A 4 Q	6 mile Rd	397	275	0.88		
I-96		Type33	Palclo AB	Holly Rd	61	50	0.84		
I-96	96169	Type33	Parclo AB 4 Q	7 mile Rd	237	234	0.64		
I-96	96160	Type51	Other	Grand River Ave	107	66	0.95	*	*

Appendix 2 The Results Of Evaluating Freeway Interchanges By The Prediction Model Method (Continued)

Route	Interchange ID	Type	Interchange type	Cross road	Observed	Fitted	Probability	Control limits	
								90 %	95 %
I-96	96179	Type51	Other	Telegraph Rd	36	67	0.29		
I-96		Type51	Other	To M-102	130	205	0.38		
I-96		Type51	Other	8 mile Rd	139	104	0.89		