Wayne State University

COLLEGE OF ENGINEERING

TRAFFIC SIGNAL INSTALLATION & SAFETY

FINAL REPORT

by

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16. Abstract

A study of various accident characteristics for 155 intersections where traffic signals were installed between 1978 and 1983. The study included evaluation of "before" and "after" accidents at signalized intersections, ramps and crossovers.

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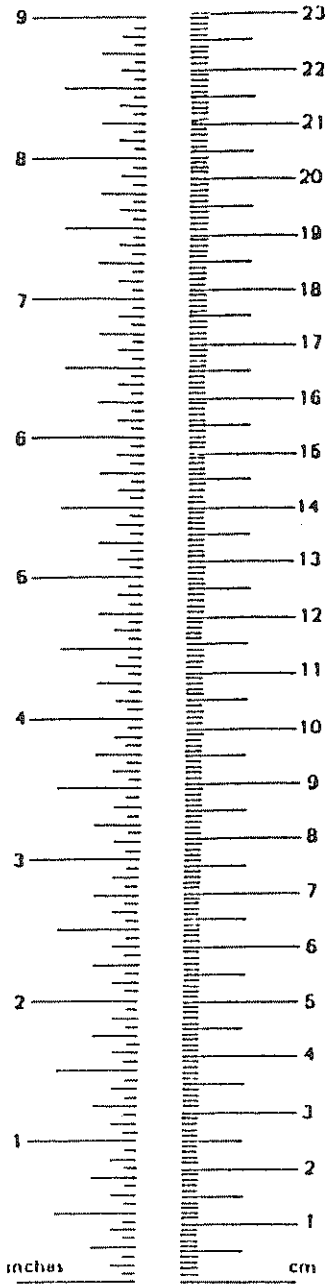
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
VOLUME				
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.96	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in. = 2.54 cm (exactly). For other exact conversions and more detail tables see NBS Misc. Publ. 286, Units of Weight and Measures. Price $2.25 SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
AREA				
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
MASS (weight)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
TEMPERATURE (exact)				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

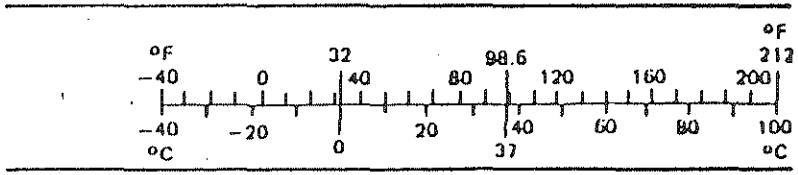


Table of Contents

List of Figures

List of Tables

List of Tables (Continued)

List of Tables (Continued)

EXECUTIVE SUMMARY

INTRODUCTION AND BACKGROUND

Traffic signals at intersections are often installed to alleviate traffic operational problems. However, such installations are often associated with changes in accident characteristics.

Past studies at newly signalized intersections have concluded that:

a) Accident frequency increases, as well as decreases, have been reported after traffic signal installation.
b) Accident severity is generally reduced.
c) "Right-angle" accident frequency decreases.
d) "Rear-end" accidents generally increase.
e) "Head-on left-turn" accidents generally increase.

These generalized conclusions have been used by Engineers in predicting the impact on accident characteristics due to the installation of traffic signals.

In October of 1986, the Michigan Department of Transportation sponsored a study of 155 traffic signals which were installed during the period of 1978 to 1983. The objective of this study was to evaluate the change in accident characteristics at these newly signalized locations.

Wayne State University's Department of Civil Engineering was awarded the contract for this research. The project included collection of all available data regarding the candidate traffic signal locations from MDOT files, plans and diagrams. The data consisted of:

- Intersection names, locations, milepoints, etc.
- Intersection geometry.
- Traffic volumes.
- Signal equipment.
- Signal timing and phasing.
- Traffic accidents.

ANALYSIS

Data analysis consisted of testing the significance of changes in accident measures of effectiveness (MOE) between the "before" and the "after" conditions for all sites and various categories of the intersections.

The following analyses were performed:

- A "before" and "after" study of all sites and various geometric categories, such as:
  - Intersections (Appendix 2)
  - Crossovers (Appendix 3)
  - Ramps (Appendix 4)
- Test of means of various accident MOE's, such as, "total", "right-angle", "injury", "rear-end", "head-on left-turn", and "other type" accidents of all sites, as well as geometric groupings.

COMPARISON FOR ALL INTERSECTIONS

Tests of differences in mean accident rates were performed using paired "t" tests at a significance level (α) of 0.05. The comparison of mean accident rates for all intersections (102) indicated that for various MOE's (e.g. "total", "injury", "rear-end", "head-on left-turn", "right-angle" and "other type" accidents) there were significant differences between "before" and "after" signal installations. The significant findings are summarized as follows:

- Mean "total" accident rate in the "after" situation was 19.2 percent lower than the "before" signal installation.
- Mean "injury" accident rate in the "after" situation was 17 percent lower than the "before" condition.
- Mean "rear-end" accident rate was 53 percent higher in the "after" condition as compared to the "before" condition.

- Mean "right-angle" accident rate in the "after" situation was 57 percent lower than the "before" condition.
- Mean "head-on left-turn" accident rate in the "after" situation was 50 percent higher than the "before" condition.
- Mean "other type" accident rate in the "after" situation was 33.8 percent lower than the "before" condition.

INTERSECTIONS WITH NO GEOMETRIC CHANGES

There were 67 locations out of 102 that did not have any geometric improvement "during" or "after" signal installation. A comparison of the "before" and "after" mean accident rates of these 67 locations yielded the following:

- The mean "injury" accident rate decreased 7 percent but did not exhibit significant differences between the "before" and the "after" conditions.

The significant changes in the mean accident rates in the "after" condition as compared to the "before" are similar to the comparison for all intersections and are summarized as follows:

- The "total" accident rate decreased 15.5 percent.
- The "right-angle" accident rate decreased 52.5 percent.
- The "rear-end" accident rate increased 64.5 percent.
- The "head-on left-turn" accident rate increased 75 percent.
- The "other type" accident rate decreased 31.8 percent.

"HEAD-ON LEFT-TURN" ACCIDENTS

A study of "head-on left-turn" accident rates at intersections with and without left-turn lane and, also, locations where a left-turn lane was installed coincident to signal installation resulted in the following observations:

- Intersections with and without left-turn lane in the "before" period:
  - The mean "head-on left-turn" accident rate was significantly different only for intersections with left-turn lanes in the "before" period.
  - The mean "head-on left-turn" accident rate at intersections with left-turn lanes increased 80 percent as compared to 58.3 percent for locations without left-turn lanes.
- Intersections where left-turn lane was added coincident to signal installation:
  - The "head-on left-turn" accident rate increased by 7 percent.
  - A 31.7 percent significant reduction in "total" accident rate.
  - "Right-angle" and "injury" accident rates were significantly reduced 63.5 percent and 44.2 percent, respectively.
  - "Rear-end" accident rate was not significantly increased as it was for intersections with and without left-turn lanes in the "before" period.
  - "Other type" accident rate was reduced significantly (by 33.1 percent) as it was for locations with and without left-turn lane.

CROSSOVERS

A "before" and "after" mean accident rate study at 27 crossover locations rendered the following:

- The "total" accident rate showed an increase of only 3.6 percent. This change was not statistically significant.
- The "rear-end" accident rate increased 36.1 percent, however, this was not statistically significant.
- The "injury" accident rate increased 27.3 percent, however, this change was not statistically significant.

- The "right-angle" accident rate decreased 10.4 percent and it was not statistically significant.
- The "other type" accident rate was significantly reduced by 21.6 percent.

RAMPS

Traffic volumes were not available in the "after" period for the ramp locations in this study.

A "before" and "after" average accident frequency at 26 ramp locations yielded the following:

- The "total" average accident frequency decreased 26.2 percent and the change was statistically significant.
- The "right-angle" average accident frequency decreased by 37.8 percent, but was not statistically significant.
- The "rear-end" average accident frequency increased by 12.7 percent and this change was not statistically significant.
- The "injury" average accident frequency reduced by 12.7 percent and this change was not statistically significant.
- The "other type" average accident frequency reduced by 34.3 percent and was statistically significant.

FINDINGS

The findings presented here are based on the results of statistical tests conducted in this study and the authors' interpretations of the results. Others mentioned, herein, refer to some data gathering and record keeping items which will certainly facilitate future studies and evaluations. The specific findings are as follows:

A. Safety Related

1. Properly installed traffic signals reduces "total", "injury" and "other type" accident rates.

2. "Right-angle" accidents can be expected to be reduced after installation of traffic signal.
3. "Rear-end" accidents can be expected to increase after installation of traffic signal.
4. The installation of traffic signals will result in an increase of "head-on left-turn" accident rate.
5. Similar to intersections, installation of traffic signals at major ramp locations can be expected to reduce "total" accident frequency.

B. Record-Keeping Related

For future signal installations the following data should be kept in intersection record files:

- "Before" ADT.
- "After" ADT.
- "Before" and "after" left-turn counts.
- Three years "before" accidents in summary form.
- Three years "after" accidents in summary form.
- Record of any geometric changes with dates.

I. INTRODUCTION

The installation of traffic signals along with various phasing and timing options has been found to influence accident patterns at intersections. In some instances, the overall accident rate and severity of accidents has also been affected. However, many geometric, operational and environmental factors combined with traffic signal options are also known to influence accidents.

Several previous research studies have been conducted using Michigan data, as well as data from other States, to study the effects of traffic signals and signal improvements on accidents. A 1959 study by Solomon was conducted on 29 Michigan intersections in urban and rural areas which have been signalized.[1] Overall, total accidents increased 23 percent, injuries decreased 20 percent and fatalities dropped by 50 percent. In terms of accident types, increases were found in "rear-end" accidents (200 percent), "head-on left-turn" (157 percent) and "sideswipes" (74 percent), while decreases in "angle" accidents (51 percent) and "other type" accidents (39 percent). It was also observed that signals were most effective at multi-leg and divided intersections. However, at T-intersections and cross-undivided intersections, signals accelerated the frequency of accidents (see Table 1).[1]

A 1964 Michigan study by Clyde analyzed 52 urban and suburban signalized intersections.[2] Although "right-angle" accidents decreased by 45 percent, increases were observed in "rear-end" accidents (98 percent), "left-turn" accidents (66 percent), and "other type" accidents (46 percent). Overall, accidents increased by 33 percent.[2]

Table 1. Change in accident rate after installation of traffic signals.

Intersection Type	ADT Average	Change in Number of Accidents	Per Million Vehicles Entering at Intersection		Net Change in Rate
			Before	After	
T	11,800	+78%	1.7	3.0	+73%
Cross Undivided	20,000	+61%	1.3	2.0	+53%
Cross Divided	27,200	+4%	1.3	1.3	-16%
Multi-leg	16,900	-47%	4.1	1.3	-69%
Overall	20,200	+23%	1.5	1.8	+19%

[Source: Reference 1]

Another Michigan study, relative to the effects of signal modernization, was conducted in 1967 by Malo for 20 intersections in Detroit.[3] These signals had been improved by installing two overhead signals on major roadways, as well as one or more signals facing each minor street approach. The average number of accidents was reduced from 20 per year (per site) to 10 per year. "Right-angle" accidents were reduced from 169 to 43, a 75 percent reduction.[3]

A study by King and Goldblatt in 1975, involving a statistical analysis of a nationwide data base, resulted in the following conclusions.[4]

1. Signalization leads to a reduction in "right-angle" accidents and an increase in "rear-end" accidents.

2. Signalized intersections have higher accident rates, but this is usually offset by less severity per accident, which leads to no significant change in "total" accident-related economic losses.
3. There appears to be no clear-cut evidence that the installation of signals will reduce the adverse effects of accidents. This appears to hold true especially in those cases where signals would not be warranted.
4. As far as accident patterns are concerned, there is no clear-cut justification for lowering numerical warrant minimums for rural conditions. In fact, the effect of unwarranted signals is more adverse for rural conditions.
5. The number of "right-angle" accidents appears to be an insensitive indication of any expected improvement in accident patterns as the result of signalization. The "right-angle" ratio seems to be better suited to that purpose.

Similar findings were found in a 1976 Virginia study of 2,301 intersection accidents.[5] In that study, "rear-end" and "total" accidents increased as a result of traffic signals, as shown in Table 2.[5] A comparison study of accident rates by type of intersection (i.e., Cross, T, and Y), as shown in Table 3, further concluded that there were no difference in accident rates between signalized intersections which meet MUTCD signal warrants, compared to those which do not meet the warrants.[5]

A 1975 study was conducted of urban intersection control in Philadelphia for various accident types, as shown in Table 4.[6] The percent of "rear-end" accidents was the greatest at traffic signal controlled inter-

Table 2. Variation in accident type and rates with type of control -- rural municipalities.

Type of Control	Accident Type - Percent of Total				Accident Rate*
	Rear-End	Angle	Sideswipe	Other	
Traffic Signal	43	37	12	8	1.26
Yield or Stop Sign	29	49	10	12	1.08

[Source: Reference 5]

Table 3. Variation of accident type and rate with intersection geometry and traffic control -- rural municipalities.

Type of Control	Accident Type - Percent of Total				Accident Rate*
	Rear-End	Angle	Sideswipe	Other	
Cross					
Signals	40	40	11	9	1.47
Stop Sign	22	59	10	9	1.27
T					
Signals	58	25	11	6	0.82
Stop Sign	28	43	12	17	0.79
Y					
Signals	42	29	25	4	1.40
Stop Sign	66	23	4	7	1.04
Offset					
Stop Sign	34	30	13	23	0.76

[Source: Reference 5]

* Accidents per million entering vehicles

Table 4. Variation in accident type and rate with traffic control type -- urban municipalities.

Type of Control	Accident Type - Percent of Total					Accident Rate*
	Rear-End	Angle	Sideswipe	Fixed Object	Pedestrian	
Two-Way Stop	11	51	5	21	12	1.5
Four-Way Stop	17	20	9	42	12	0.8
Traffic Signals	23	30	8	27	12	1.2

* Accidents per million entering vehicles.

[Source: Reference 6]

sections (23 percent), compared to two-way stop (11 percent) or four-way stop (17 percent). Percentages of "angle" accidents were the greatest for two-way stop locations (51 percent), compared to intersections with traffic signals (30 percent) or four-way stop control (20 percent). Overall, accident rates were the greatest for two-way stop locations (1.5 accs/mv), compared to traffic signals (1.2 accs/mv) and four-way stops (0.8 accs/mv).[6]

In terms of signal phasing, studies conducted in San Francisco and Kentucky both found reduced accident severity for multiphase signals, compared to two-phase signals.[7,8] In the Kentucky study use of multiphase signals resulted in up to 13 percent reduction in severe accidents, along with an 85 percent reduction in "left-turn" accidents, and a 33 percent increase in "rear-end" accidents.[8]

In summary, previous studies in Michigan and other States strongly indicated that adding new traffic signals resulted in reduced "right-angle" accidents, but increase in "rear-end" and "left-turn" accident types. Accident rates have both increased and decreased as a result of adding traffic signals, and multiphase signals usually are associated with lower accident rates than two-phase signals (i.e., often due to the protected left-turn and other movements).

The Department of Civil Engineering at Wayne State University was selected by MDOT to perform an evaluation of accident characteristics at 155 newly installed signalized intersections in Michigan. The purpose of this study was to examine the effects of new traffic signal installations on accident patterns and severity at various intersections, crossovers and ramp locations. The following major tasks were conducted as a part of the study:

- Obtaining the site data from existing files, plans and other sources for newly installed traffic signals on the State trunkline system between 1978 and 1983.
- Determining the characteristics which have significant impact on accident occurrence at newly installed signal locations.
- Documenting the findings of the study.

This report presents a description of the activities performed in the research, along with the findings and conclusions.

II. DATA COLLECTION

1. Selection of Candidate Traffic Signal Location for the Study

A list of 235 candidate locations, where traffic signals were installed during the years 197[illegible] through 1983, was selected as a part of this study. The reason for selecting this time period was to allow for two to three years of accident data to be available for both the "before" and the "after" conditions of the proposed study sites.

During the course of the study a number of locations had to be eliminated from the candidate site list either because they were of temporary nature due to construction or because they were not judged to be of interest (such as, traffic signals at shopping center entrance, etc.). Also, several sites were eliminated from the study due to lack of traffic volume information. A total of 155 locations were studied and the breakdown is as follows:

Intersections	102
Crossovers	27
Ramps	26
Total	155

2. Data Collection and Coding

In this context, an attempt was made to collect as much information as possible that is pertinent to the study and that adequately describes each study location. Such information includes:

- Traffic signal equipment and operations.
- "Before" and "after" accident data.
- "Before" and "after" geometric and traffic characteristics.

The following is a list of the different data variables collected:

Site #

District #

Location

Control Section #

Milepoint

Date of Installation

Type of Control (signal)

No. of Phases

Cycle Length

Other Operations

"Before" Installation Control

"Before" ADT

"After" ADT

Intersection Configuration

No. of Lanes on Each Leg

One Way

Comments

Appendix 1 provides a comprehensive listing of all data collected.

The information regarding all candidate sites was obtained by going thoroughly through each signalized intersection's records and files. Copies of signal timing permits were used to obtain the traffic signal equipment and operations data. The geometric information was obtained by examining copies of "before" and "after" installation intersection diagrams, where available. Average daily traffic estimates on the State trunkline for all locations were provided by the MDOT Planning Division. Accident history of all locations during the period 1976 to 1985 was obtained from MDOT. Average daily traffic volume information, when not available, was estimated by using a calculated growth factor.

III. DATA ANALYSIS

Data Analysis

The "before" and "after" accident rates were studied to evaluate the impact of signal installation. In this analysis, the accident rate is defined as the number of accidents per million entering vehicles.

The effect of signal installations was determined on the following accident types:

Accident Types	MOE (Measures of Effectiveness)
"Total" Accidents	"Total" Accidents/MV
"Right-Angle" Accidents	"Right-Angle" Accidents /MV
"Rear-End" Accidents	"Rear-End" Accidents/MV
"Injury" Accidents	"Injury" Accidents/MV
"Head-On Left-Turn" Accidents	"Head-On Left-Turn" Accidents/MV
"Other Type" Accidents	"Other Type" Accidents/MV

Accident Rate Calculation Procedures

This procedure consisted of three distinct efforts, namely:

- Determination of "before"/"after" accident frequency.
- Determination of "before"/"after" average daily traffic.
- Determination of accident rate.

"Before"/"After" Accident Frequency

The total number of accidents for a three-year period "before" installation of the signal and the three-year period "after" installation was identified. For signals installed after 1982 or before 1979, a two or one-year study period was selected depending on the date of signal installation and availability of data.

"Before"/"After" Average Daily Traffic

The average (total ADT of all approaches) traffic volume for a three-year period "before" and "after" the installation of the traffic signal at each location was calculated.

Total ADT of all approaches = Approach ADT on Trunkline + Approach ADT on minor streets

In the case only "after" or only "before" minor street ADT was available, the missing information was calculated using a growth factor (G.F.).

$$\text{Growth Factor} = \frac{\text{Average ADT on Trunkline "after" signal}}{\text{Average ADT on Trunkline "before" signal}}$$

Minor ("before") street ADT = Minor ("after") street ADT/G.F.

Accident Rate

The accident rate for each location "before" and "after" signal installation was calculated using the following formula:

$$\text{Acc. Rate} = A(10^6)/365(T)V$$

Where,

A = Accident frequency (total for the study period) (output of Phase I)

T = Time period of the study

V = Average Daily Traffic (output of Phase II)

The "before" and "after" accident frequencies of "total" and various accident types is presented in Figure 1. It shows a reduction in "total", "PDO", and "right-angle" accidents, and an increase in the frequency of "rear-end" and "left-turn" accidents. The magnitude of "injury" accidents remained approximately the same.

Figure 2 represents the accident rates of 102 intersections under investigation. It shows a reduction in "total", "injury", "PDO" and "right-angle" accident rates. "Rear-end" and "left-turn" accident rates increased in the "after" period.

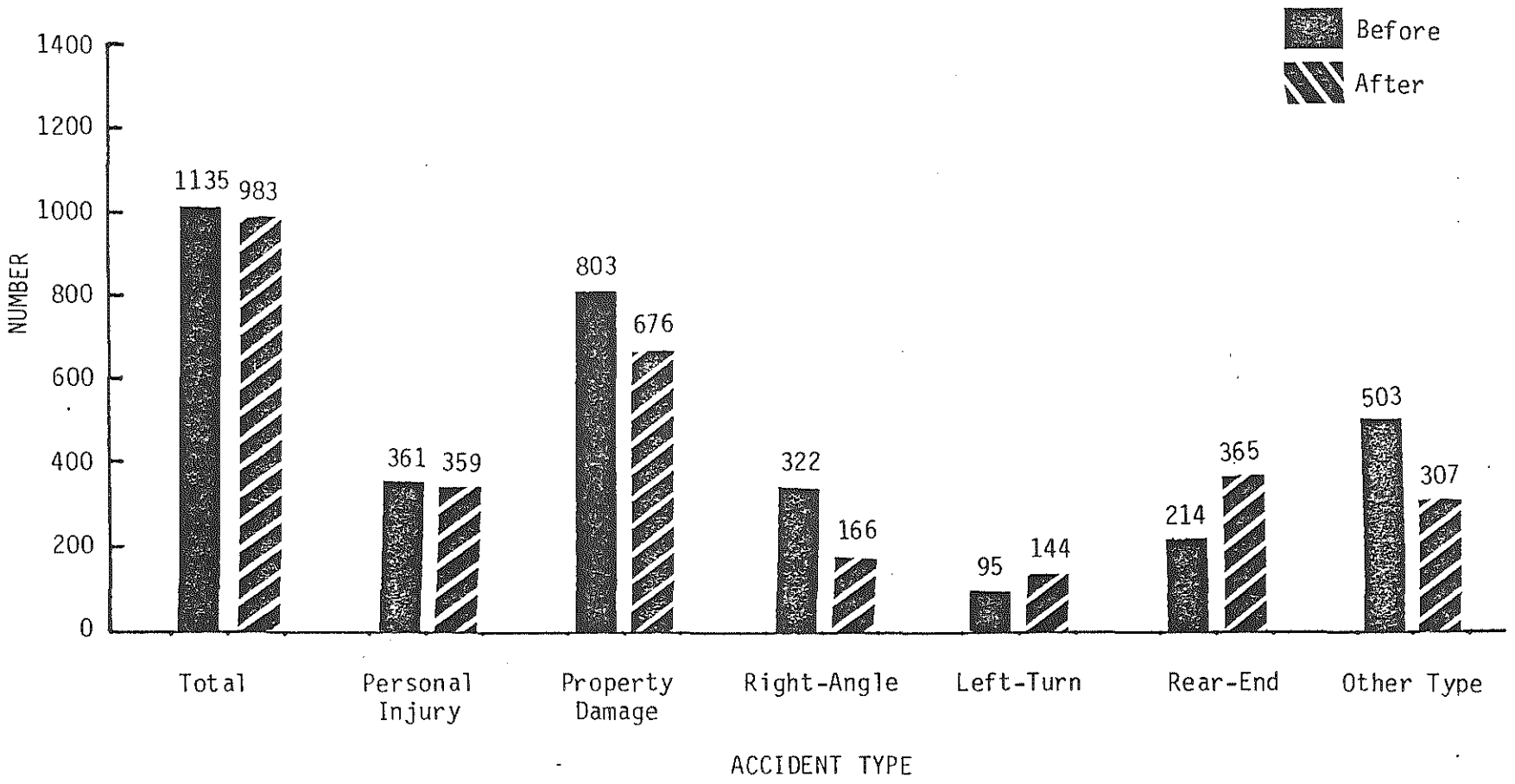


Figure 1. "Before" and "after" average annual accidents for 102 signalized intersections (new).

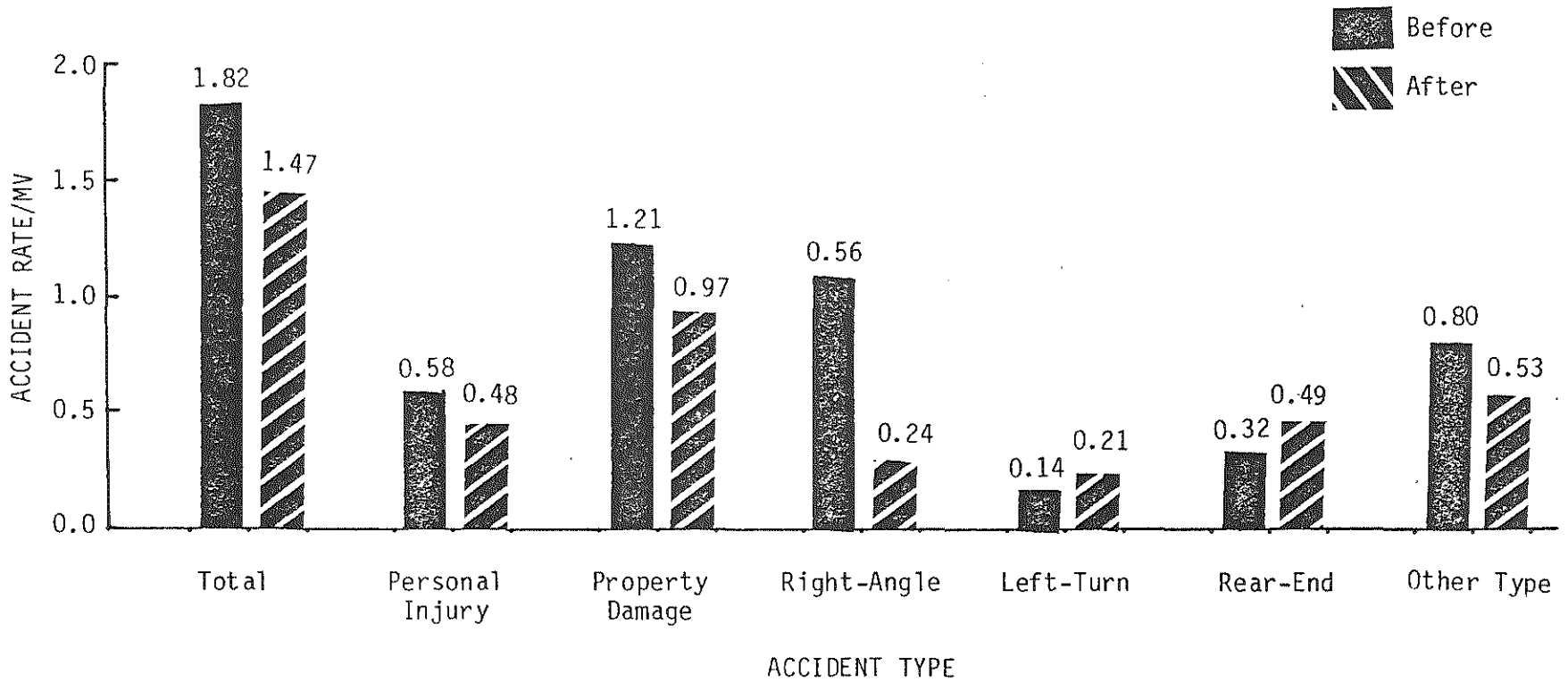


Figure 2. "Before" and "after" accident rate at 102 newly installed traffic signals.

Statewide Accident History

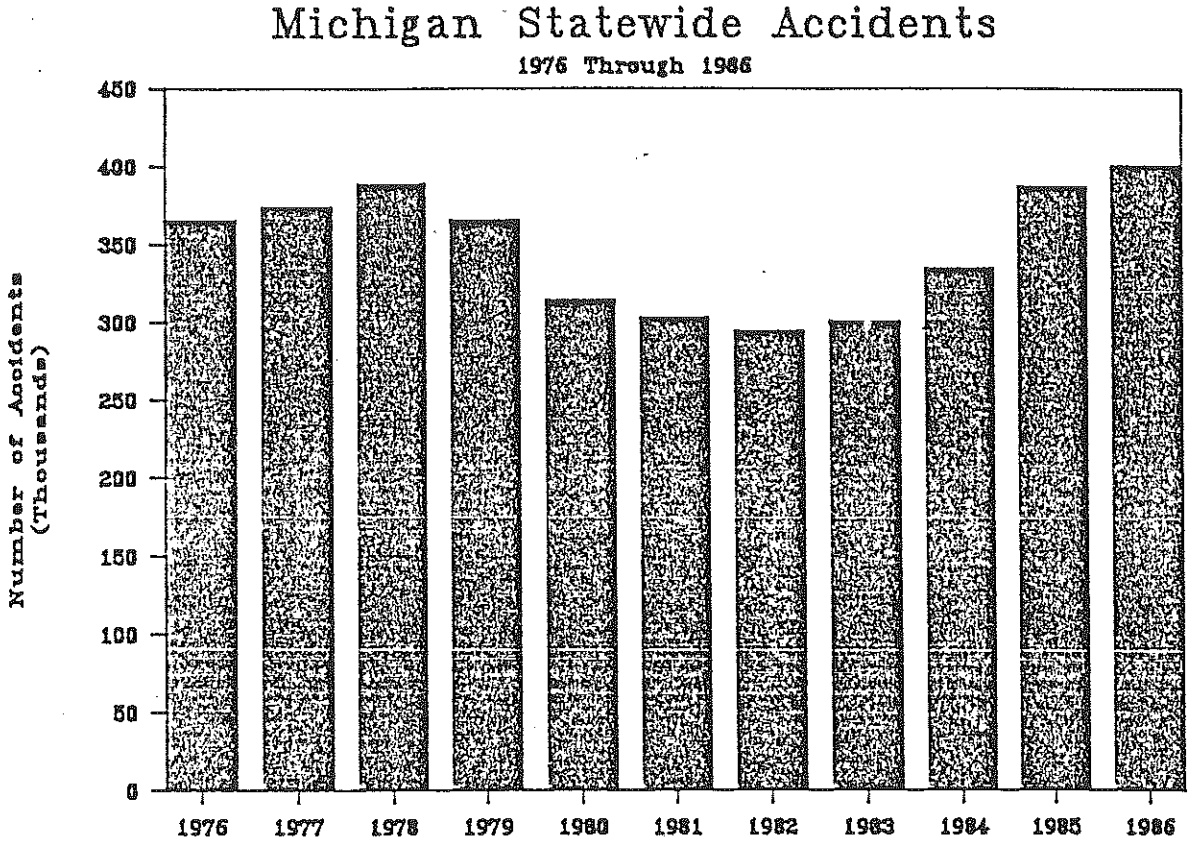
Statewide accident data during the period 1976 to 1986 was obtained from MDOT to investigate if any adjustments to the accident history of the study sites were necessary. Figure 3 represents the statewide accident history for 1976 to 1986. Figures 4 and 5 represent the accident history for the same time period for Michigan Trunkline and Michigan Trunkline signalized intersection, respectively. The statewide accident frequencies show some fluctuations year-by-year, however, these fluctuations are meaningless, unless accurate exposure data is used to determine year-by-year accident rates.

Vehicle registration and statewide vehicle miles of travel data were obtained from the "Accident Facts" booklet, published by the State Police. These data and rates determined from them are presented in Table 5. Linear regression analysis was performed on the statewide rate data with extremely low correlation. Thus, it can be concluded that there exists no trend for the statewide accidents.

The trunkline signalized intersections' accident history (Figure 5) is most pertinent to this study. The time period for the study ranged between 1978 and 1983. During the same time period (1978 to 1983) the following was observed for the Statewide Trunkline signalized intersection accident history (total yearly accidents for 2,100 signalized intersections), review of Figure 5:

- Total accidents by year:

  1978 - 29,033
  1979 - 27,416
  1980 - 24,742
  1981 - 24,939
  1982 - 24,360
  1983 - 24,989

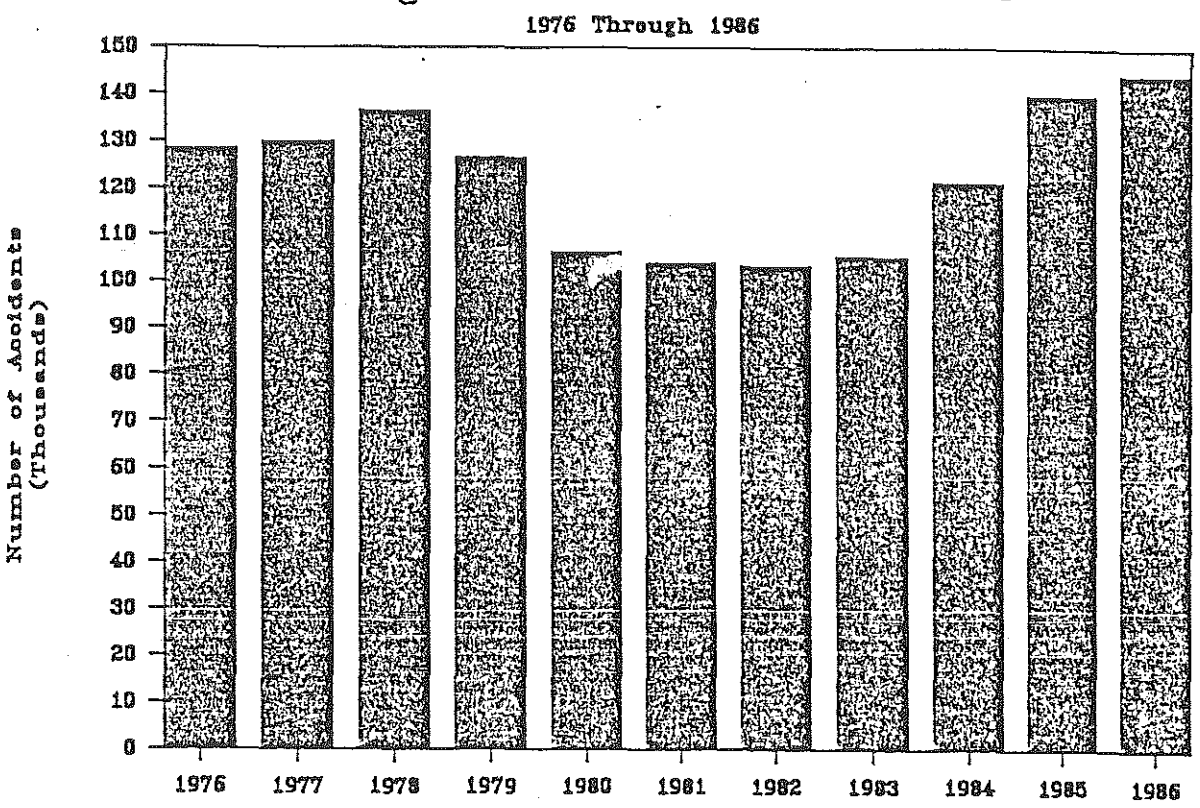


Michigan Statewide Traffic Accident Trends, 1976 through 1986

Year	Accidents	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1976	365,600	2.5	6.5	0.2	-14.0	-17.2	-19.3	-17.7	-8.3	5.9	9.6
1977	374,571	--	3.9	-2.2	-16.0	-19.2	-21.3	-19.7	-10.5	3.3	7.0
1978	389,193	--	--	-5.8	-19.2	-22.2	-24.2	-22.7	-13.9	-0.5	3.0
1979	366,435	--	--	--	-14.1	-17.4	-19.5	-17.9	-8.5	5.6	9.4
1980	314,594	--	--	--	--	-3.7	-6.2	-4.4	6.5	23.0	27.4
1981	302,831	--	--	--	--	--	-2.6	-0.7	10.7	27.8	32.4
1982	294,971	--	--	--	--	--	--	2.0	13.6	31.2	35.9
1983	300,797	--	--	--	--	--	--	--	11.4	28.7	33.3
1984	335,193	--	--	--	--	--	--	--	--	15.5	19.6
1985	387,069	--	--	--	--	--	--	--	--	--	3.6
1986	400,825	--	--	--	--	--	--	--	--	--	--

How to read table: The value in each cell is the total percent change in accident counts between the year shown at the front of the row and the year shown at the top of the column.
EXAMPLE: The change from 1976 to 1978 was +6.5 percent, and the change from 1976 to 1979 was +0.2 percent.

Figure 3. Michigan statewide accidents (1976 through 1985).

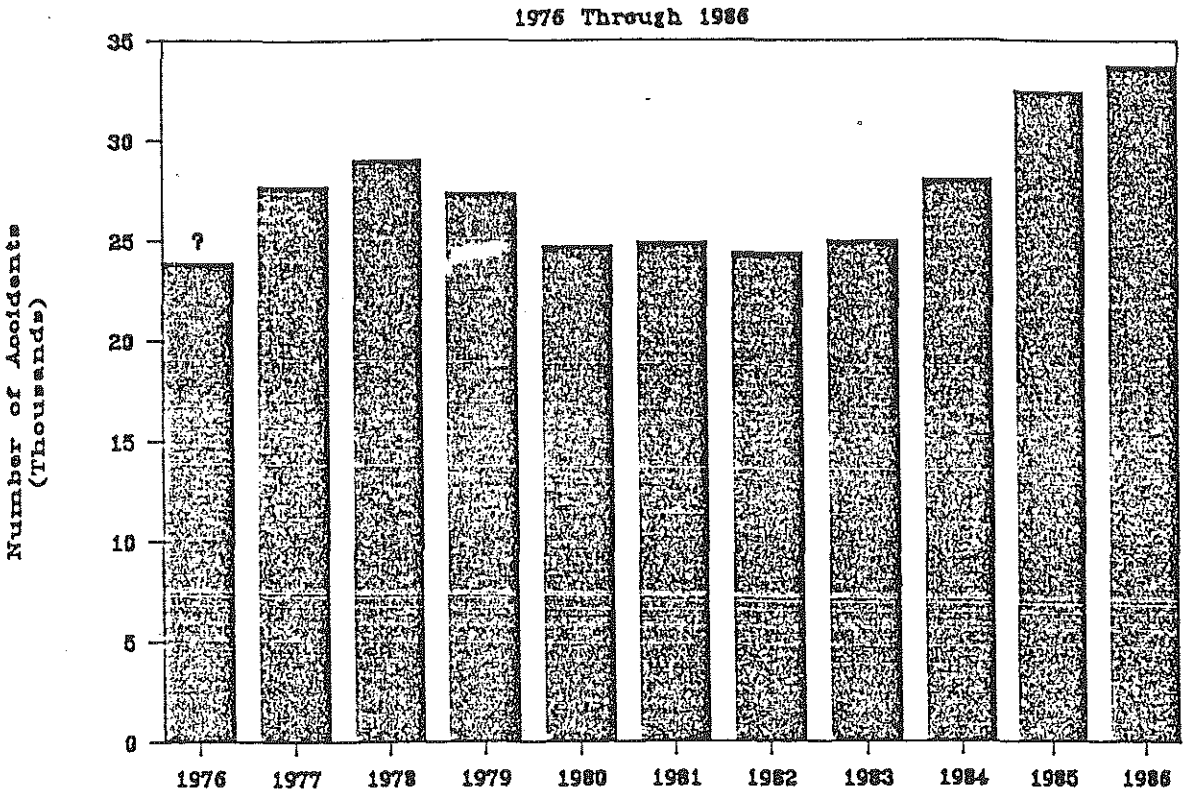


Percentage Change in Michigan Trunkline Accidents, 1976 through 1986

Year	Accidents	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1976	128,445	1.2	6.2	-1.4	-17.3	-19.2	-19.5	-18.1	-5.4	9.0	12.4
1977	130,014	--	4.9	-2.6	-18.3	-20.1	-20.5	-19.1	-6.5	7.6	11.1
1978	136,427	--	--	-7.2	-22.2	-23.9	-24.2	-22.9	-10.9	2.6	5.8
1979	126,657	--	--	--	-16.2	-18.0	-18.4	-16.9	-4.0	10.5	14.0
1980	106,184	--	--	--	--	-2.2	-2.6	-0.9	14.5	31.8	36.0
1981	103,817	--	--	--	--	--	-0.4	1.4	17.1	34.8	39.1
1982	103,391	--	--	--	--	--	--	1.8	17.6	35.4	39.7
1983	105,246	--	--	--	--	--	--	--	15.5	33.0	37.2
1984	121,556	--	--	--	--	--	--	--	--	15.1	18.8
1985	139,947	--	--	--	--	--	--	--	--	--	3.2
1986	144,407	--	--	--	--	--	--	--	--	--	--

How to read table: The value in each cell is the total percent change in accident counts between the year shown at the front of the row and the year shown at the top of the column.
EXAMPLE: The change from 1976 to 1978 was +6.2 percent, and the change from 1976 to 1979 was -1.4 percent.

Figure 4. Michigan trunkline accidents (1976 through 1985).



Michigan Trunkline SIGNALIZED INTERSECTION Traffic Accident Trends, 1976 through 1986

Year	Accidents	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1976	23,898 ?	15.9	21.5	14.7	3.5	4.4	1.9	4.6	17.5	35.8	41.1
1977	27,701	--	4.8	-1.0	-10.7	-10.0	-12.1	-9.8	1.3	17.2	21.8
1978	29,033	--	--	-5.6	-14.8	-14.1	-16.1	-13.9	-3.3	11.8	16.2
1979	27,416	--	--	--	-9.8	-9.0	-11.1	-8.9	2.4	18.4	23.0
1980	24,742	--	--	--	--	0.8	-1.5	1.0	13.5	31.2	36.3
1981	24,939	--	--	--	--	--	-2.3	0.2	12.6	30.1	35.3
1982	24,360	--	--	--	--	--	--	2.6	15.2	33.2	38.5
1983	24,989	--	--	--	--	--	--	--	12.3	29.9	35.0
1984	28,072	--	--	--	--	--	--	--	--	15.6	20.2
1985	32,457	--	--	--	--	--	--	--	--	--	3.9
1986	33,732	--	--	--	--	--	--	--	--	--	--

How to read table: The value in each cell is the total percent change in signalized accident counts between the year shown at the front of the row and the year shown at the top of the column.
EXAMPLE: The change from 1976 to 1980 was +3.5 percent, and the change from 1978 to 1980 was -14.8 percent.

Figure 5. Michigan trunkline signalized accidents (1976 through 1985).

Table 5. Statewide Accident Trend (Source: Accident Facts)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Accidents in Thousands	374.7	389.2	366.4	314.6	302.8	295.0	300.8	335.2	386.9	400.7
VMT in Billions	64.85	67.38	64.88	61.19	62.00	61.32	63.56	65.73	68.41	70.62
Vehicle Registration in Millions	6.13	6.45	6.54	6.57	6.14	6.40	6.44	6.51	6.86	6.95
Accidents/100 Millions Vehicle Miles of Travel	0.578	0.578	0.565	0.514	0.488	0.481	0.473	0.510	0.566	0.567
Accidents/Million Registered Vehicles	61.13	60.34	56.02	47.88	49.32	46.09	46.71	51.49	56.40	57.65

- There were 81,191 accidents in the first three years (1978-1980) and 74,288 accidents between 1981 and 1983.
- The accident frequency was reduced by 8.5 percent during the last three years in comparison to the first three years. In absence of rate data this cannot be used for any correction.
- The statewide frequency has been declining during the "after" period of our study. Thus, it can be assumed that, if any of our study sites had signals installed in 1980 or 1981, and we use 1978, 1979 and 1980 data as the "before" period, and 1981, 1982 and 1983 as the "after" period, then we would have expected a possible natural drop in accident frequency of 8.5 percent provided the traffic volumes remained constant over the entire period (1976-1986).

The available data for statewide accident history was not considered for making any adjustments due to the following reasons:

- The ten-year trend lines for the "total" accident frequencies or rates show extremely low correlation, as such, use of any trend correction will be inappropriate.
- Having just overall "total" accident frequency/rate does not allow for making any adjustments without the possibility of making an erroneous correction to various types of accidents.
- Many sites' "before" accident data did not include 1978, which had a very high frequency compared to 1982 or 1983 data. Thus, any correction may not have been appropriate.
- Some sites' "before" accident data did not include 1978 and 1979. Thus, trend correction was not necessary for these sites, because the overall accident picture was almost flat during 1980, 1981, 1982 and 1983.

- The drop in accident frequency could have been due to other safety programs and, as such, cannot be attributed to the trend above.
- Year-by-year increase or decrease in accident frequency or rate may be true only for "total" accidents at signalized intersections. It cannot be applied for other MOE's like "rear-end", "right-angle", "injury", "head-on left-turn" accidents, etc., since we don't have the history of all types of accidents. As such, any corrections made using statewide total accident history will be inappropriate.
- Analysis of the statewide historical data did not indicate any discernable trend. However, it is conceivable that the intersections signalized at various years within the study period (signals installed between 1978 to 1983) may indicate different accident characteristics.

In order to further test the statewide background effect of signal installation during specific years within the study period of 1978 to 1983, a study was performed isolating the locations where signals were installed in the following time periods:

Group 1 - Signals installed 1979 and 1980, with a declining statewide accident frequency during the "after" period of study.

Group 2 - Signals installed 1982 and 1983, with an increasing statewide accident frequency during the "after" period of study.

The following were the number of sites in each of the groups:

Group 1 - 45 locations.

Group 2 - 27 locations.

Table 6 shows the results of the "t" tests of both groups (Group 1 and 2) along with the total intersection samples (102 sites) to allow comparison.

Table 6. Results of paired t-tests for Group 1 and 2.

Accident Type	Signals Installed in													
	1978-1983					Group 1 - 1979-1980					Group 2 - 1982-1983			
	Mean Acc. Rate		Percent + Increase - Decrease	"t" Statistics	Sample Size & (t_{cr})	Mean Acc. Rate		Percent + Increase - Decrease	"t" Statistics	Sample Size & (t_{cr})	Mean Acc. Rate		Percent + Increase - Decrease	"t" Statistics	Sample Size & (t_{cr})
	Before	After				Before	After				Before	After			
Total	1.82	1.47	-19.2%	+3.47*	102 (2.00)	1.90	1.21	-36.3%	+4.12*	(45) (2.015)	1.86	1.79	- 3.8%	+0.35	27 (2.056)
Right-Angle	0.56	0.24	-57.1%	+5.77*		0.58	0.20	-65.5%	+4.37*		0.59	0.31	-47.5%	+2.79*	
Injury	0.58	0.48	-17.24%	+2.41*		0.54	0.37	-31.5%	+2.64*		0.69	0.60	-13.1%	+1.14	
Rear-End	0.32	0.49	+53.0%	-4.84*		0.34	0.40	+15.0%	-1.24		0.31	0.68	+119.4%	-4.27*	
Head-On Left-Turn	0.14	0.21	+50.0%	-2.56*		0.14	0.12	-14.3%	+0.49		0.15	0.25	+66.7%	-1.70	
Other	0.80	0.53	-33.8%	+5.67*		0.84	0.49	-41.7%	+4.31*		0.81	0.56	-30.1%	+3.47*	

*Means significantly different.

For Group No. 1 (Signals installed in 1979 and 1980)

- "Total" accident rate reduced 36 percent after signal installation and was statistically significant.
- "Right-angle" accident rate reduced 65 percent and was statistically significant.
- "Rear-end" accident rate increased 15 percent, but it was not statistically significant.
- "Injury" accident rate reduced 32 percent and was statistically significant.
- "Head-on left-turn" accident rate decreased 14.3 percent, but it was not statistically significant.
- "Other type" accident rate reduced 42 percent and was significant.

For Group No. 2 (Signals installed in 1982 and 1983)

- No significant change in "total" accident rate (3.8 percent reduction), "injury" accident rate (13 percent decrease), or "head-on left-turn" accident rate (67 percent increase).
- "Right-angle" accident rate reduced 47 percent and was statistically significant.
- "Rear-end" accident rate increased 119 percent and was statistically significant.
- "Other type" accident rate reduced 30 percent and was statistically significant.

The results of this group analysis when compared to the 102 site sample is presented in Table 6 for comparative purposes. Examination of Table 6 reveals the following:

- Mean "total", "right-angle", "injury", "rear-end" and "other type" accident rate of all 102 study sites, Group 1 sites and Group 2 sites followed similar rate trends.
- Mean "left-turn head-on" accident rate of 102 sites increased significantly after signal installation. A similar trend was also noticed for Group 2 sites, however, 14.3 percent reduction in "left-turn head-on" accident rate was observed in the case of Group 1 sites. The rate change was not statistically significant for Group 1 or Group 2 sites.
- While the three groups exhibited similar rate trends, the reported safety benefits defined by the percent change in mean accident rate for each accident type category were larger for Group 1 than Group 2 sites. The safety benefits were thought to be overstated for Group 1 since there was a natural drop in accidents statewide during the "after" period. The benefits reported for Group 2 may in turn be understated since they experienced accident reductions despite the statewide trend of increasing accidents in the "after" period. While no statistical relationship could be established, it would appear that year-to-year fluctuations in the statewide accident experience were an influence in this study.
- Although this study could not address the influence of statewide accident experience, the accident experience reported for the 102 sites which includes the Group 1 and Group 2 sites, is a valid statistical estimate of the safety benefits attributed to the new signal installations at these sites.

TEST OF SIGNIFICANCE

In order to determine the effect of signal installation on accident experience, the paired t-tests were conducted. Accident rates both "before" and "after" signal installation for all locations were compared to determine if there was a statistically significant difference between the "before" and "after" periods. The formula used in calculating the "t" statistic are shown below:

$$t = \frac{\overline{X}_B - \overline{X}_A}{S_D/\sqrt{N}}$$

where: $\overline{X}_B$ = "Before" Sample Mean

$\overline{X}_A$ = "After" Sample Mean

$$S_D^2 = S_B^2 + S_A^2 - 2\left[\frac{1}{N-1}\sum_{i=1}^{N}(X_{Bi} - \overline{X}_B)(X_{Ai} - \overline{X}_A)\right]$$

S_B = "Before" Sample Standard Deviation

S_A = "After" Sample Standard Deviation

N = Sample Size

If $t > t_C$ (t critical from standard statistical tables) the difference in means is statistically significant for assumed level of significance "α" where degrees of freedom is equal to the number of locations minus 1. Therefore, the null hypothesis is rejected. The null hypothesis is that there is no significant difference between the means of the "before" and "after" distribution rates. A significance level (α) of 0.05 was used.

There are two types of paired t-tests that can be conducted; one-tail or two-tail. The one-tail test is used to test whether one mean is significantly greater than another. The two-tailed test is used to test whether the means are significantly different. The one-tail test involves making some initial assumptions about whether the "after" accident rate is higher or lower than the "before" accident rate. In this study only two-tailed tests were conducted.

INTERSECTION ANALYSIS

The results of "before"/"after" mean accident rate analysis of 102 signalized intersection are presented in Table 7. Examination of Table 7 reveals the following:

- In all cases, mean accident rates are significantly different before and after signal installations for all locations (102 intersections) combined.
- The "total" accident rate after signal installation was 19 percent lower than before signal installation. This result compares favorably to past research in other states.
- The "injury" accident rate was 17.24 percent lower after signal installation. This result compares favorably with past research.
- The "rear-end" accident rate was 53 percent higher after signal installation when compared to "before" condition. This result compares favorably with past research.
- The "right-angle" accident rate was reduced by 57 percent after signal installation when compared to "before" accident rate. This result compares favorably with all past research.
- The "head-on left-turn" accident rate was 50 percent higher after signal installation. This result compares favorably with all past research.
- The "other type" accident rate was reduced by 33 percent after installation when compared to "before" accident rate. This result compared favorably with past research.

The results based on all locations do not take into consideration the different geometrics of the intersections. The details of the intersection data, mainstreet traffic volumes, "before" and "after" accident frequencies and rates are included in Appendix 2.

Table 7. Results of paired t-tests for all locations combined.

Accident Type	Mean Accident Rate		Percent Increase (+) Decrease (-)	"t" statis-tics -	Two Tail
	Before $\overline{X}_B$	After $\overline{X}_A$		t	α = 0.05 t_c
Total	1.82	1.47	-19.2%	3.47*	2
Injury	0.58	0.48	-17.24	2.41*	2
Rear-End	0.32	0.49	+53.0%	-4.84*	2
Right-Angle	0.56	0.24	-57.1%	5.77*	2
Head-On Left-Turn	0.14	0.21	+50.0%	-2.56*	2
Other	0.80	0.53	-33.8%	5.67*	2

* Means significantly different.

Comparison of "Before" and "After" Accidents at Intersections With No Geometric Changes

A review of the data base indicated that there were only 67 intersection sites, out of 102 sites, where no geometric change (refer to Appendix 5) has been made either during or after signal installations. A paired "t" test of mean "before" and "after" accident rates was performed at $\alpha = 0.5$ to evaluate whether or not there was any change attributable to the installation of traffic signal. The results of this analysis are presented in Table 8 and Figure 6.

Table 8. Results of paired t-tests for locations with no geometric changes.

Accident Type	Mean Accident Rate		Percent Increase (+) Decrease (-)	"t" statistics - t	Two Tail t_C
	Before $\overline{X}_B$	After $\overline{X}_A$			
Total	1.87	1.58	-15.5%	2.09*	2.00
Right-Angle	0.59	0.28	-52.5%	4.31*	2.00
Injury	0.57	0.53	-7.0%	0.86	2.00
Head-On Left-Turn	0.12	0.21	+75.0%	-2.78*	2.00
Rear-End	0.31	0.51	+64.5%	-4.07*	2.00
Other	0.85	0.58	-31.8%	+4.59*	2.00

*Means significantly different.

A review of Table 8 demonstrates the following:

- The "total" accident rate was reduced by 15.1 percent and the difference between "before" and "after" was statistically significant.
- The "right-angle" accident rate was reduced 52.5 percent and the change was statistically significant.

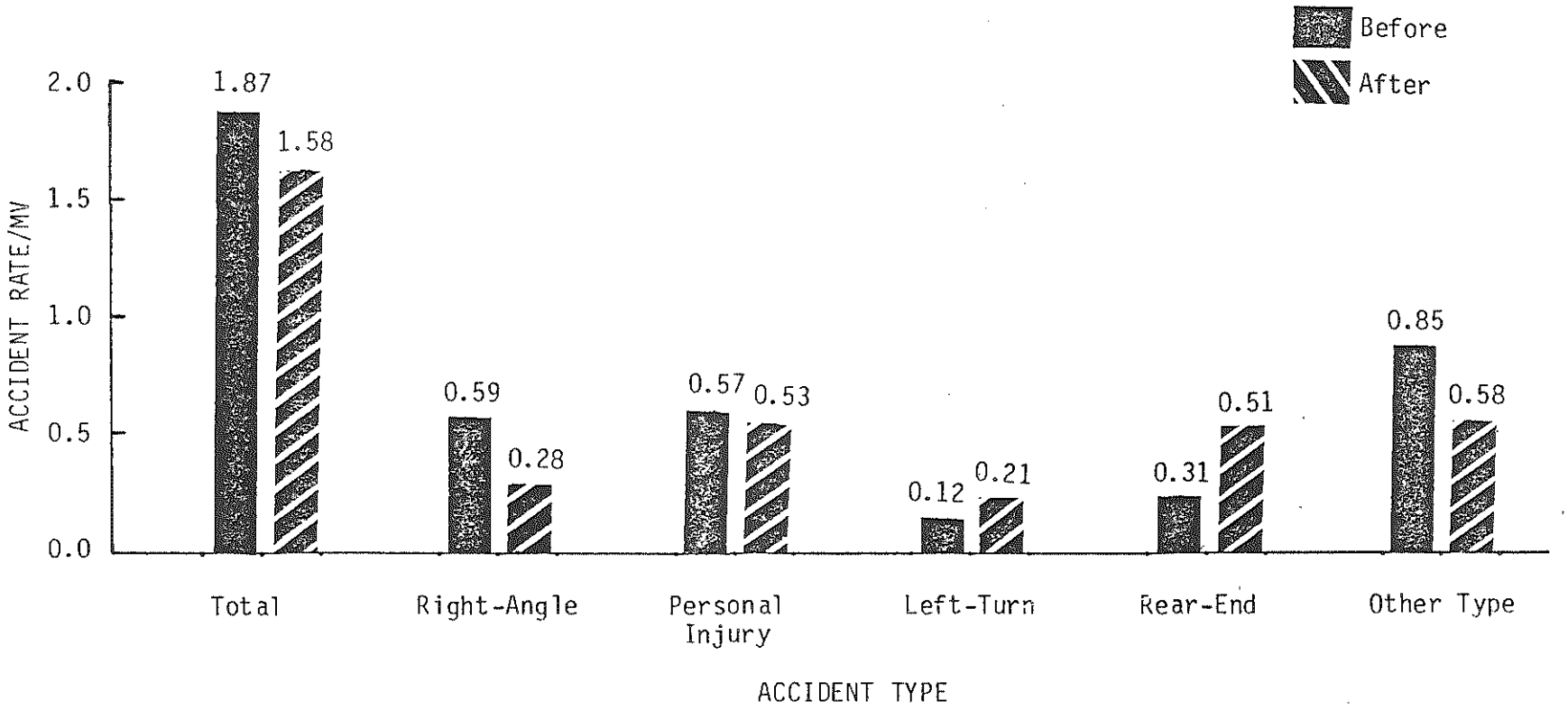


Figure 6. "Before" and "after" accident rates for 67 intersections with no geometric changes.

- The "injury" accident rate was reduced 7.0 percent, however, the change was not statistically significant.
- The "head-on left-turn" accident rate was increased significantly (75.0 percent).
- The "rear-end" accident rate increased 64.5 percent and this was statistically significant.
- The "other type" accident rate was reduced by 31.8 percent and the change was statistically significant.

Evaluation of "Head-On Left-Turn" Accident Rates

The "head-on left-turn" type accidents at intersections are of great concern to Traffic Engineers. Past studies have generally concluded that this type of accident increases with the installation of traffic signals. Intersections where left-turn lanes existed both "before" and "after" signal installation; and locations where left-turn did not exist "before" and "after" period were analyzed by comparing mean accident rates. Also, locations where a left-turn lane was installed coincident to signal installation were analyzed as part of this effort. The results of this mean accident rate analysis are presented in Table 9 and Figure 7.

The statistical test of mean rate of "head-on left-turn" accidents showed significant differences at locations with left-turn lanes. In fact, the accident rate went up from 0.15 to 0.27. However, at locations without left-turn lane and locations where left-turn lane installed coincident to signal installation the changes were not statistically significant. Please refer to Appendices 6 and 7 for the "before" and "after" accident rate data.

Table 9. Results of paired t-tests for "head-on left-turn" accident rate.

Intersection Type	No. of Sites	Mean Accident Rate		Percent Increase (+) Decrease (-)	"t" statistics	Two Tail t_C $\alpha = .05$
		Before $\bar{X}_B$	After $\bar{X}_A$			
Locations With Left-Turn Lane	29	0.15	0.27	+80.0%	-2.25*	2.048
Locations Without Left-Turn Lane	35	0.12	0.19	+58.3%	-1.58	2.030
Locations Where Left-Turn Lane Was Installed Coincident to Signal Installation	14	0.27	0.29	+7.4%	-0.22	2.160

*Means significantly different.

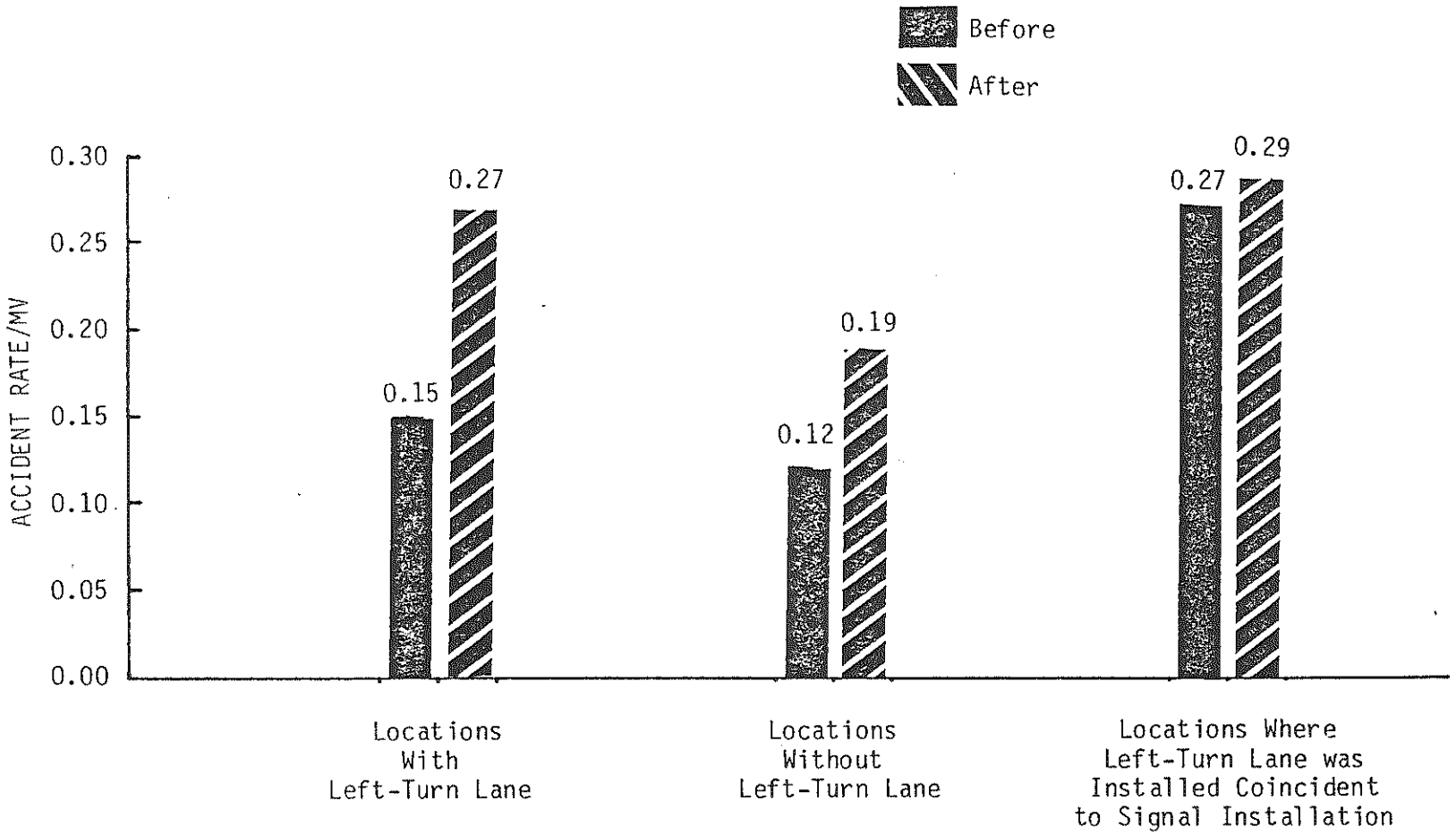


Figure 7. "Before" and "after" "head-on left-turn" accident rate for locations with and without left-turn lane.

Analysis of Intersections With and Without Left-Turn Lane

As a part of this analysis, comparisons of the "before" and "after" mean accident rates by "total", "rear-end", right-angle", "injury", "head-on left-turn" and "other type" were performed and the results are presented in Tables 10, 11 and 12, and Figures 8, 9 and 10.

Table 10 shows the results of the paired "t" tests for locations with left-turn lanes. For this group of 29 intersections the following is observed:

- The "total" accident rate was reduced 10.1 percent, but the difference between "before" and "after" was not statistically significant.
- The "right-angle" accident rate was reduced 60.0 percent and the change was statistically significant.
- The "injury" accident rate was reduced 18.2 percent, however, the change was not statistically significant.
- The "rear-end" accident rate increased 78.1 percent and this was statistically significant.
- The "head-on left-turn" accident rate increased 80.0 percent and this change was statistically significant.
- The "other type" accident rate was reduced by 23 percent and the change was statistically significant.

Table 10. Results of paired t-tests for locations with left-turn lane.

Accident Type	Mean Accident Rate		Percent Increase (+) Decrease (-)	"t" Statistics	Two Tail t_c @ $\alpha = 0.05$ d.f. 28
	Before $\bar{X}_B$	After $\bar{X}_A$			
Total	1.98	1.78	-10.1%	0.87	2.048
Right-Angle	0.60	0.24	-60.0%	4.06*	2.048
Injury	0.66	0.54	-18.2%	1.34	2.048
Rear-End	0.32	0.57	+78.1%	-2.46*	2.048
Head-On Left-Turn	0.15	0.27	+80.0%	-2.25*	2.048
Other	0.91	0.70	-23.1%	+2.08*	2.048

*Means significantly different.

Table 11. Results of paired t-tests for locations without left-turn lane.

Accident Type	Mean Accident Rate		Percent Increase (+) Decrease (-)	"t" Statistics	Two Tail t_c @ $\alpha = 0.05$ d.f. 34
	Before $\bar{X}_B$	After $\bar{X}_A$			
Total	1.74	1.33	-23.6%	2.35*	2.03
Right-Angle	0.58	0.28	-51.7%	2.53*	2.03
Injury	0.51	0.45	-11.8%	0.78	2.03
Rear-End	0.31	0.46	+48.3%	-3.09*	2.03
Head-On Left-Turn	0.12	0.19	+58.3%	-1.58	2.03
Other	0.74	0.41	-44.6%	+4.58*	2.03

*Means significantly different.

Table 12. Results of paired t-tests for locations where left-turn lane was added coincident to signalized installation.

Accident Type	Mean Accident Rate		Percent Increase (+) Decrease (-)	"t" Statistics	Two Tail t_c @ $\alpha = 0.05$
	Before $\bar{X}_B$	After $\bar{X}_A$			
Total	2.08	1.42	-31.7%	3.98*	2.16
Right-Angle	0.74	0.27	-63.5%	3.23*	2.16
Injury	0.77	0.43	-44.2%	4.07*	2.16
Rear-End	0.31	0.39	+25.8%	-1.59	2.16
Head-On Left-Turn	0.27	0.29	+7.4%	-0.22	2.16
Other	0.76	0.47	-38.2%	3.31*	2.16

*Means significantly different.

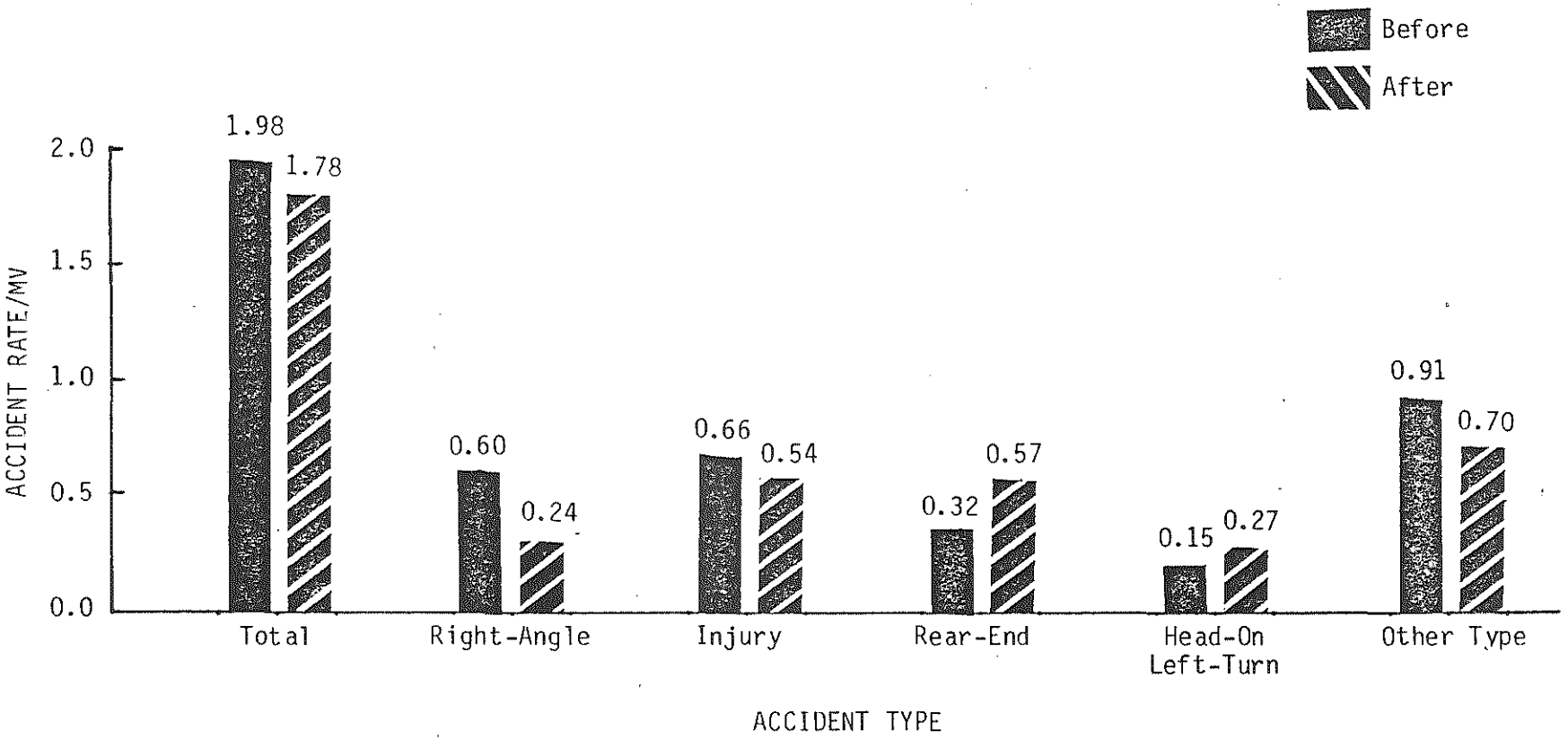


Figure 8. "Before" and "after" accident rates for locations with left-turn lane.

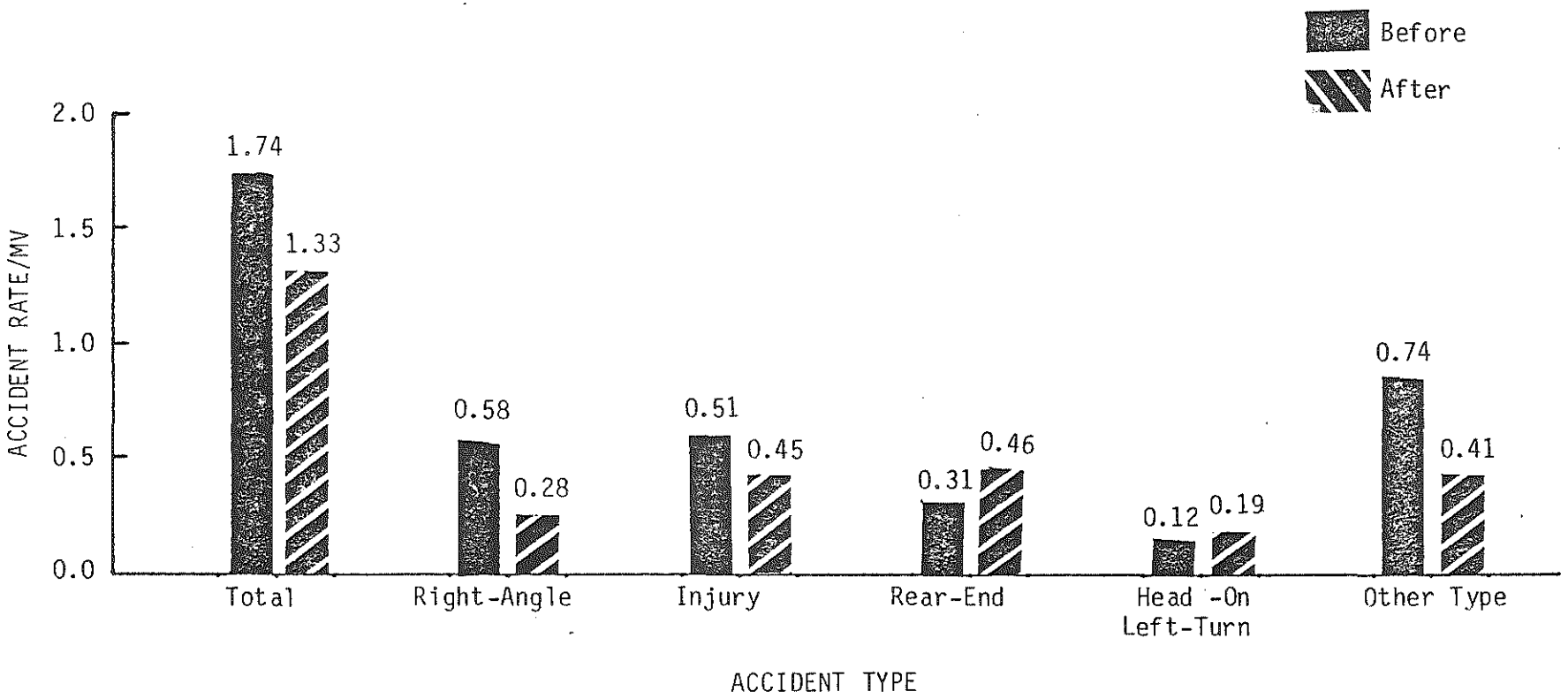


Figure 9. "Before" and "after" accident rates for locations without left-turn lane.

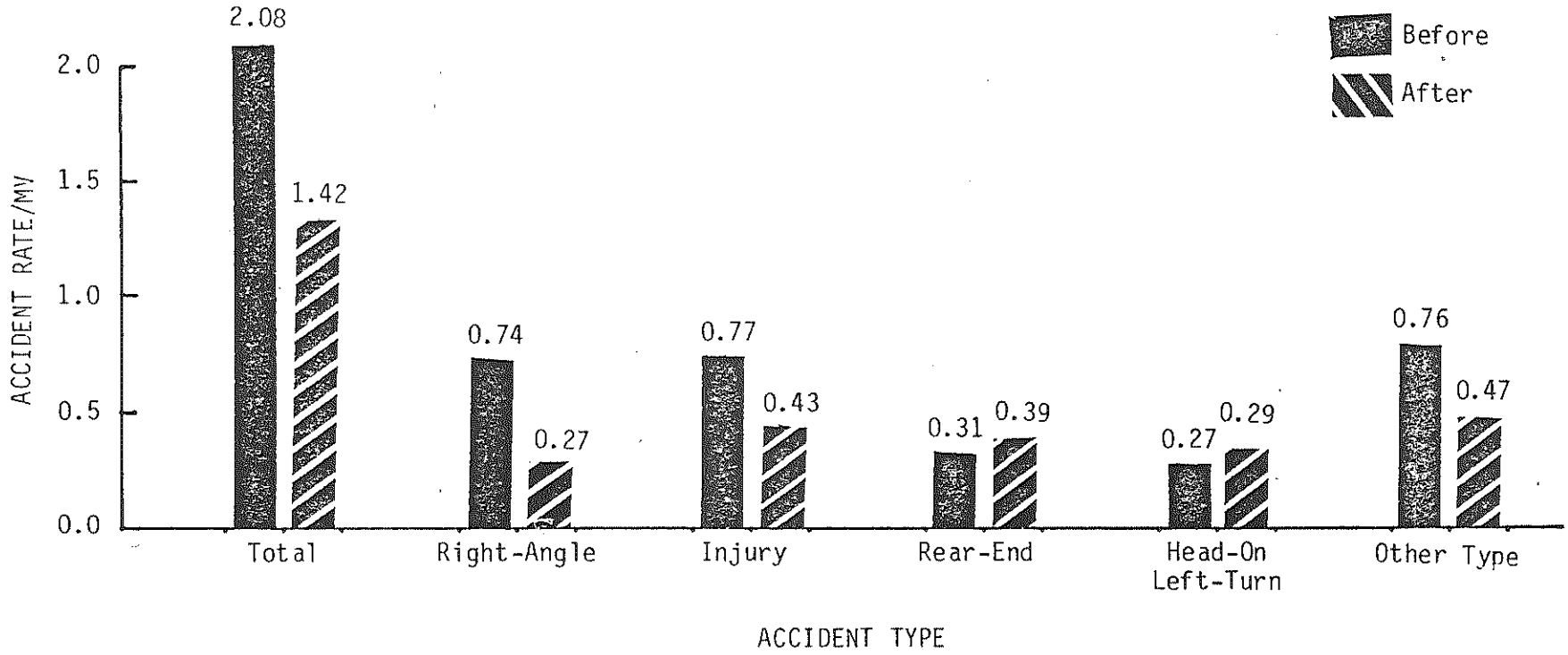


Figure 10. "Before" and "after" accident rates for locations where left-turn lane was installed coincident to traffic signal.

Table 11 shows the results of the paired "t" tests for locations without left-turn lanes. For this group of 35 intersections the following is observed:

- The "total" accident rate was reduced 23.6 percent and this change was statistically significant.
- The "right-angle" accident rate was reduced 51.7 percent and was statistically significant.
- The "injury" accident rate was reduced only 11.8 percent and it was not statistically significant.
- The "rear-end" accident rate was reduced 48.3 percent and this change was statistically significant.
- The "head-on left-turn" accident rate increased 58.3 percent, however, this change was not statistically significant.
- The "other type" accident rate was reduced by 44.6 percent and this change was statistically significant.

Table 12 shows the results of the paired "t" tests for 14 locations where left-turn lane was constructed just before installing the traffic signals. The following are observed from the analysis of this group of locations:

- The "total" accident rate was reduced 31.7 percent and was statistically significant.
- The "right-angle" and "injury" accident rates were reduced 63.5 percent and 44.2 percent, respectively. Both of these changes were statistically significant.
- The "rear-end" and "head-on left-turn" accident rates were increased 25.8 percent and 7.4 percent, respectively. However, neither of these changes were statistically significant.
- The "other type" accident rate was reduced by 38.2 percent and was statistically significant.

IV. TRAFFIC SIGNALS AT CROSSOVERS

There were 42 crossover locations in the initial candidate list. However, accident and/or traffic volume data were not available for 15 locations. Thus, the analysis was performed with 27 sites. The details of traffic volumes, "before" and "after" accident frequencies and rates, etc. is presented in Appendix 3.

A paired "t" test was performed to investigate the mean accident rate changes in "total", "angle", "rear-end", "injury" and "other type" accidents. The results of this analysis are presented in Table 13 and Figure 11.

Table 13. Results of paired t-tests for locations at crossovers.

Accident Type	Mean Accident Rate		Percent Increase (+) Decrease (-)	"t" Statistics - t	Two Tail $\alpha = 0.05$ t_C
	Before $\overline{X}_B$	After $\overline{X}_A$			
Total	0.78	0.81	+3.6%	-1.58	2.056
Right-Angle	0.10	0.09	-10.4%	+0.72	2.056
Rear-End	0.32	0.43	+36.1%	-1.44	2.056
Injury	0.22	0.28	+27.3%	-1.39	2.056
Other	0.37	0.29	-21.6%	+2.41*	2.056

*Means significantly different.

The above data shows that "t" statistics were never greater than the "t_C", except for other types of accident rate. Thus, it can be concluded that the accidents at crossover locations did not show any significant change at $\alpha = 0.05$ level. However, the "after" "other type" accident rate was significantly reduced from the "before" rate.

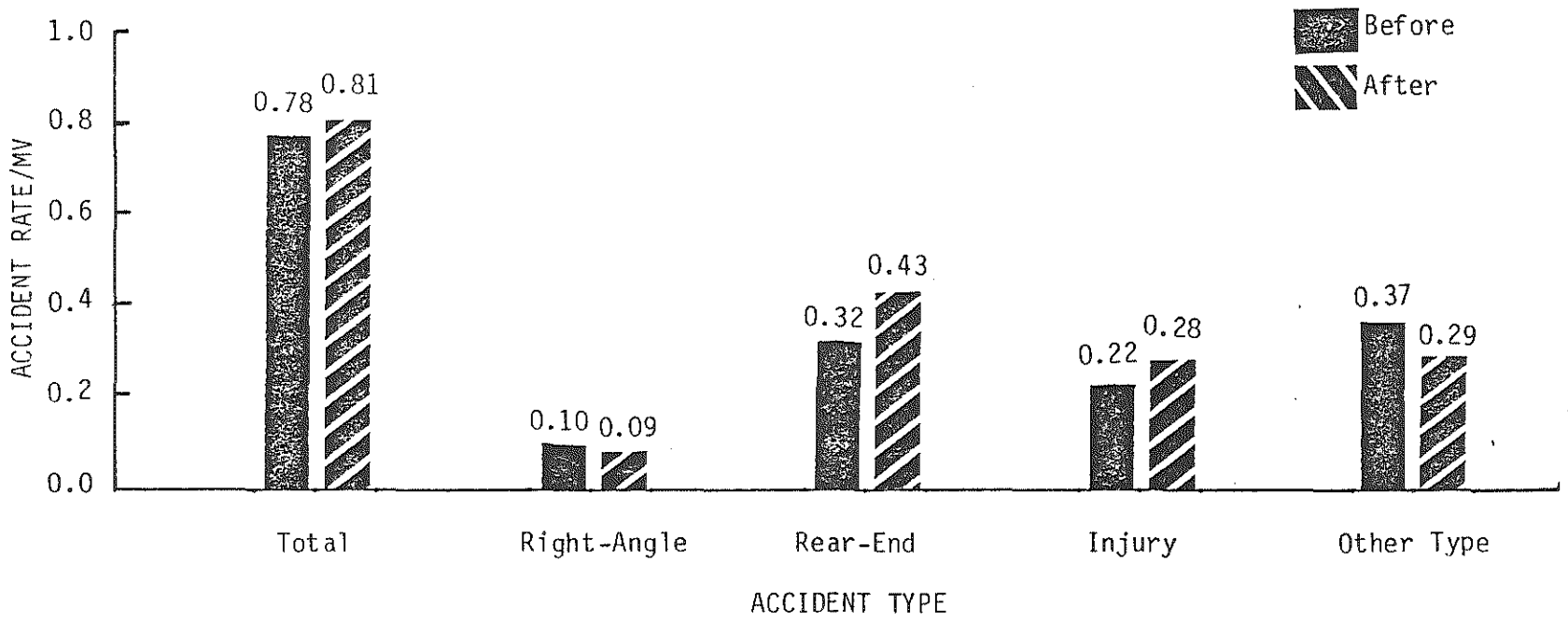


Figure 11. "Before" and "after" accident rates at crossovers.

V. TRAFFIC SIGNALS AT RAMPS

The study of safety impacts at newly installed traffic signals included 26 ramp locations. The details of the "before" and "after" accidents is included in Appendix 4.

The accident data for two or three years was available at only 19 ramp locations. The remaining seven locations had one year's accident data only. The "before" traffic volumes were available for 16 sites, whereas, "after" traffic volume was available for only three sites. Therefore, the average accident frequency per year was used as measures of effectiveness instead of accident rates. The results of this analysis are presented in Table 14 and Figure 12. A review of Table 14 shows that the "total" and "other type" accident frequency per year were reduced significantly after signal installation, as compared to the "before" condition. Whereas, "right-angle", "rear-end" and "injury" accidents did not show any significant change.

Table 14. Results of paired t-tests for ramps.

Accident Type	Avg. Accident Frequency/ Year		Percent Increase (+) Decrease (-)	"t" statistics - t	Two Tail t_C
	Before $\bar{X}_B$	After $\bar{X}_A$			
Total	12.76	9.42	-26.2%	+2.13*	2.06
Right-Angle	0.98	0.61	-37.8%	+1.53	2.06
Rear-End	2.28	2.57	+12.7%	-0.54	2.06
Injury	3.53	3.11	-11.9%	+0.84	2.06
Other	9.50	6.24	-34.3%	+2.40*	2.06

*Means significantly different.

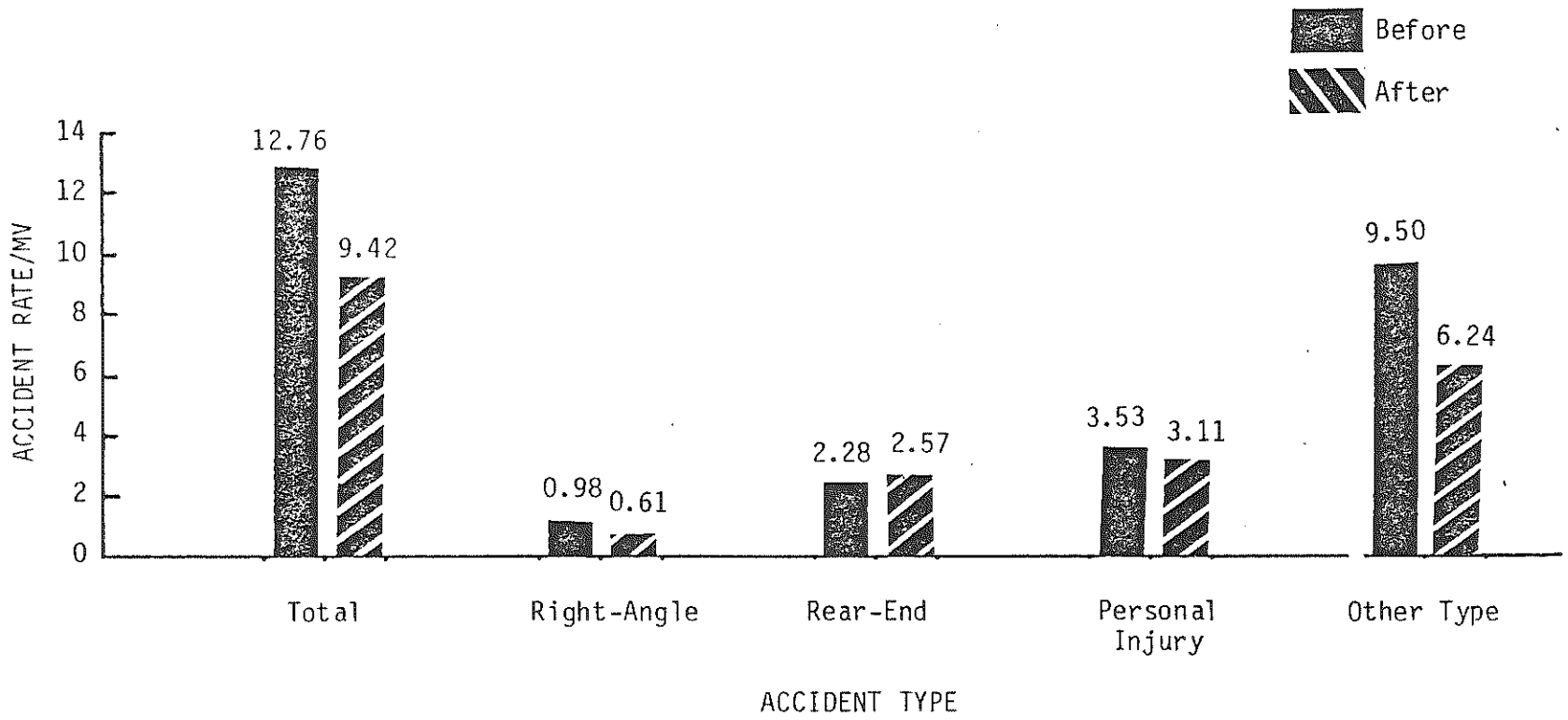


Figure 12. "Before" and "after" accident rates at ramps.

VI. FINDINGS

This study investigated a number of signalized locations, namely: intersections, crossovers and ramps, to determine the effectiveness of signalization on accident frequency, rate and severity. The following are the findings of the study:

A. Intersections

- The mean "total" accident rate of all intersections (102 locations) combined decreased 19.2 percent in the "after" period and was statistically significant.
- Accident "injury" rates were reduced ("after" 17 percent less than "before" period) significantly after the installation of signal.
- Installation of traffic signals were very effective in cutting down the "right-angle" accident rates significantly. This reduction was 57 percent.
- The "rear-end" and "head-on left-turn" accident rates were increased as a result of traffic signal installation. "Rear-end" and "head-on left-turn" rates increased 53 percent and 50 percent, respectively.
- The "other type" accident rate was reduced significantly as a result of traffic signal installation. This is true for all intersection groups studied.
- Intersections with and without left-turn lane in the "before" period:
  - The mean "head-on left-turn" accident rate was significantly different only for intersections with left-turn lanes in the "before" period.

- The mean "head-on left-turn" accident rate at intersections with left-turn lanes increased 80 percent as compared to 58.3 percent for locations without left-turn lanes.

- Intersections where left-turn lane was added coincident to signal installation:
  - The "head-on left-turn" accident rate increased by 7 percent.
  - A 31.7 percent significant reduction in "total" accident rate.
  - "Right-angle" and "injury" accident rates were significantly reduced 63.5 percent and 44.2 percent, respectively.
  - "Rear-end" accident rate was not significantly increased as it was for intersections with and without left-turn lanes in the "before" period.
  - "Other type" accident rate was reduced significantly (by 33.1 percent) as it was for locations with and without left-turn lane.
- Intersections without any geometric changes:
  - A 15.5 percent decrease in "total" accident rates.
  - "Right-angle" accident rates decreased 52.5 percent.
  - "Injury" accident rates were reduced 7 percent.
  - "Head-on left-turn" accident rates increased 75 percent.
  - "Rear-end" accident rates increased 64 percent.
  - "Other type" accident rates decreased 31.8 percent.

B. Crossovers

- There was no significant difference between "before" and "after" accident rates, except for the "other type" accident.
- The "total", "injury" and "rear-end" accident rates were increased 3.6 percent, 27 percent and 36 percent, respectively.
- The "right-angle" accident rate was reduced 10 percent.
- The "other type" accident rate was reduced by 21.6 percent.

C. Ramps

- The "total" and "other type" average accident frequency were reduced significantly after the installation of traffic signals at ramps.
- "Right-angle", "rear-end" and "injury" accident frequency did not show any significiant change due to installation of signals at ramps.

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APPENDIX 1 - SIGNAL PROJECT DATA

SIGNAL PROJECT DATA FORM | TRAFFIC DATA | GEOMETRIC DATA

DIST NO. N S	LOCATION	CONTROL SECTION NO.	MILE PT.	DATE OF SIGNAL INSTALL.	TYPE OF CTRL.	NO. PHASES	CYCLE LENGTH (SEC.)	OTHER OPERATION	BIC #1	BEFORE INSTALL. APPROACH ADT NB	SB	EB	WB	AFTER INSTALL. APPROACH ADT NB	SB	EB	WB	IC #2	ONE WAY LEG	# LANES ON LEG N S E W	LEGS WITH EXCLUSIVE TURN LANE LT	RT
3	US-131,M55;MITCHELL AT SOUTH ST.	83031-004	6.26	02-19-82	2	3	60	2,3 FLASH;12-6 A.M.	2	10575	9558	2315						3		4 4 3	W	
7	M-43 AT BLUE STAR HIGHWAY	80041-4	0.36	03-31-80	2	2	70	2;6 AM-9 PM	2	2062	2185	2136	2245					2		4 4 3 4		EW
26																						
M(9)	M-25 (GRATIOT) AT HURON	77031-10	1.11	03-08-78	2	2	80	2,3 FLASH;12-6 A.M.	2	1992	4741	1936	4949	4600	4600			2		4 4 4 4		
5	M-40 (STATE) @ M-40 (LINCOLN) @ 32ND (CALINE RD)	70031-1	0.00	03-16-78	4	2	60	1	2	1476	3505	3464	3500			3500	3500	6		2 3 3 3	WES	
6	M-21 (GENESSEE);SAGINAW ST. LAPEER	44042-2	0.65	11-21-78	2	2	80	2	2									2		2 3 4 4		
8	M-59 HIGHLAND, OLD US-23	47082-01	12.56	12-12-78	1	2	80	2	1	2800	8750	4168	5478			4950	4950	1		4 3 6 4	NSEW	EW
5	M-20 (MAPLE ST.) @ M-20 (3RD ST.)	54022-002	0.60	12-12-78	2	4	60,100	2,3	2	5203	3420	2618	1910					1		2 4 2 3		EW
7	M-37 (ANGELL) @ M-37 (JACKSON)	13061-046	5.80	03-14-79	2	2	60	1	2	3716	6121	6756	6121			2000	2000	1		2 2 2 2		
3	US-31, M-37 @ TOWN HALL RD.	28012-012	3.61	10-18-78	1	2	70	1	2					10282	9889	2961	8171	1		5 5 5 3	NSEW	
6	M-46 (GRATIOT) @ FROST	73062-023	5.16	10-28-80	2	2	80	1	2	5580	2930	11303	11015			9250	9250	1		3 3 5 5	NE	
6	M-47 @ M-58 (STATE RD)	73032-002	1.55	01-20-81	1	3	60	1	2	6341	2704	3451	7749			5600	5600	2		4 4 3 3	NSEW	NS
1	US-41 BR (MAIN) @ FIFTH ST.	52044-10	1.39	06-09-79	2	2	60	2,3	1&2					2589	5220	7359	5282	1		2 2 2 2		
6	M-58 (5TH ST.) @ CHURCH ST.	25081-029	72.30	08-26-80	2	2	60	1	1&2									1	N,S,E,W	4 4 4 4		
9	M-24 @ SILVER BELL RD.	63112-13	2.96	09-18-80	1	2	70	2;6 A.M.-9 P.M.	1&2	12981	13821	1810	1534	13318	15764	2130	2763	1		4 4 2 2		
38																						
M(9)	M-59 (HIGHLAND RD.) @ S. WILLIAMS LAKE RD.	63041-021	12.77	04-08-80	2	2	80	2;12:01 A.M.-6 A.M.	2			11800	11800			17300	17300	4		3 5 5	EWS	
1	M-95 (CARPENTER) AT E. BLVD. NELSON	22011-6		10-17-79	2	2	70	2;6:30 AM-10 PM	2									1		3 3 3 3		
8	US-24 (TELEGRAPH) @ STEWART ST.	58052-5	10.65	04-18-80	2	2	70	2;12:01 A-6:00 A	2	8457	5756	5487	5293			5800	5800	2		5 5 3 4	EWS	
5	M-46 @ M-91	59043-1		11-20-79	5	2		1	1	2079	2146	2476	2553					4		2 2 2		
3	US-10 NELSON RD	53021-9		10-03-79	2	2	70	2;6:30 A-11:00 P	2					1246	1970	10750	10957	3		4 5 5	NEW	N
9	M-53 (VAN DYKE) @ BROUGHAM ST.	50011-55	7.47	03-20-81	2	2	60	2;6:00 A-10:00 P	2					27350	27350			3		4 4 2		
8	M-50 (W. CHICAGO BLVD) OCCIDENTAL HWY.	46082-10		05-15-79	2	2	60	2;6:00 A-10:00 P	2	2265	4350	6409	6877					1		3 3 3 3	NSEW	
M(9)	M-102 (8 MILE) & BRIDGE ST.	82141-11	1.71	05-07-80	2	2	80	2;6:00 A-10:00 P	2													
5	BL-96 (GD. RIVER) WAVERLY RD. & AIRPORT RD.	19021-6	3.80	04-08-80	2	2	70	2;6:00 A-10:00 P	2													
5	US-27 @ CLARK RD.	19031-2	3.00	04-07-80	3	2		2;6:00 A-10:00 P	2					8187	8636	1410	1957	1		6 6 4 2	NS	NS
M(9)	M-59 (HIGHLAND RD) @ ORMOND RD.	63041-01-13		12-21-78	2	2	80	2;6:00 A-10:00 P	1	2424	2523	8441	8981	3095	3178			3		2 2 3	W	
5	I-69 @ MARSH ROAD	19041-01-2	0.45	09-07-78	1	2	80	2;7:00 A-11:00 P	1							9000	9000	2		3 3 5 4	E	NS
6	M-15, M-25, BL-75 (SEVENTH) @ WATER ST/	09042-01-26	3.26	09-02-80	2	2	55,80	2;7:00 A-11:00 P	1						5630	6250	6250	2	N,S,E,W	2 2 3 3		
7	M-51 FRONT ST @ PRAIRIE AVRDE ST.	14011-01-12	10.52	04-17-79	1	2	70	2;6:00 A-10:00 P	2							3750	3750	1		2 2 2 2		
4	M-27 (MAIN ST.) @ LINCOLN ST.	16032-01-7	15.77	11-01-78	2	2	60	2;6:00 A-10:00 P	2									2		3 4 3 3	NSEW	S
8	BL-96 (GRAND RIVER) @ HIGHLANDER WAY	47061-01-12	1.56	12-19-78	1	2	70	2;7:00 A-11:00 P	2	9940	2502	5486	5118	11500	11500			2		2 2 3 4	WE	E
8	TEMP I-69 @ LAKE LANSING RD.	33043-01-15	3.51	08-15-79	2	3	80,50	2;12:01 A-6:00 A	1	10170	10903	1801	2249	17950	17950			6		4 4 4 4	NS	NS
3	US-31,M-72 (MUNSON) @ AIRPORT ACCESS RD.	28013-01-19	3.19	07-14-83	2	2	60	2;12:01 A-6:00 A	2					1651		9842	8107	3		3 5 5	WES	
8	US-24 (TELEGRAPH) @ NEWPORT RD.	58053-01-002	2.10	01-12-79	3	2	55,39	2;6:00 A-10:00 A	1	6433	4578	3420	1690	4200	4200			2		5 5 3 3	EWNS	
3	US-131 (MITCHELL ST.) @ BELL AVE.	83032-01-13	1.76	10-21-81	2	2	80	2;9:00 A-10:00 P	2	7797	7316	7506	5820					1		4 4 2 2		
M(9)	M-29 (PARKER ST.) @ CHARTIER ST.	77052-01-9	0.77	10-06-83	2	2	60	2;7:00 A-11:00 P	2	4661	3768	1867	1580	4900	4900			1		2 2 3 3	EW	
4																						
5	BL-196, US-31 BR (9TH ST.) @ COLLEGE AVE.	70012-01-21	0.67	06-02-81	2	2	60,80	2&3;6:00 A-11:00 P	2	1743	2692	6256	7973	5950	5950			1	EW	2 2 3 3		
5	BL-196 (CHICAGO DR.) @ 112TH AVE.	70023-01-20	1.29	01-13-82	1	3	70	2;6 A-10 P; 4 LTGA	1	9540	1633	6979	5960			6500	8500	2		2 2 4 4		
6	US-12 (MICHIGAN) @ PLATT ROAD	81031-01-05	16.64	12-13-83	1	1	60	2:1:00 A -5:00 P	2	1385	1558	6947	7287			7700	7700	2		3 3 4 4	NSEW	
6	M-84 (SAGINAW) @ DELTA RD. & 3 MILE RD.	09011-01-01		01-04-84	1	2	70	2:8:00 A-11:00 P	2			5150	5150			5450	5450	2		3 3 3 3	NSE	
8	US-27 @ HOPE	23012-01-03	15.55	04-21-81	2	3	65	2:6:00 A-10:00 P	2							8650	8850	2		5 5 2 4	S	N 26
24																						
M(9)	M-24 (LAPEER RD) @ BROWN RD.	63112-01-25	1.97	05-06-81	5			2:6:00 A-10:00 P	2	13848	14961	1492		14600	14600			3		5 6 5	S	N 45
24																						
8	M-50 @ RAISINVILLE RD.	58042-0011	4.92	05-12-82	1	3	0	1:6:00 A-10:00 P	2	2230	2086	3710	3790			4850	4850	6		2 2 3 3	NE	
5	M-45 (LAKE MICH. DR.) @ KINNEY AVE.	41081-0012	0.93	08-19-82	1	2	80	1:6:00 A-10:00 P	2	1074	1518	6711	7135			9180	9180	1		3 3 5 5	NSEW	
5	BL-196 (CHICAGO DR.) @ 120TH AVE WAVERLY RD.	70023-0012	0.20	06-23-81	1	4	70	1;12:01 A-6:00 A	2	1655	1655	6554	9323			8150	8150	6		3 3 4 4	EWNS	EW
8	US-23 @ SAND CREEK & WOLF CREEK	46061-0018	0.00	07-07-82	1	2	70	1;6:30 A-9:00 P	2	1476	1386	3704	4518	2299	1827	5705	5428	1		4 3 4 4	NSEW	EW
										1251	2315			2385	2358							
6	M-84 (SAGINAW RD) @ SALZBURG RD.	09011-01-003	2.23	11-02-82	2	2	80	2:FLASH 12:01 A-6:30 A	2	4300	4300			5150	5150							
5	M-15 (MAPLE ST.) @ M-20 (THIRD ST.)	54022-01-002	0.60	12-12-78	2	2	80	2,3;10:30 P-6:00 A	2		4580	2618	5205		4708	8815	3307	1	N	2 2 2 3		W

1

#1 E #SIGNAL CONFIG

SIGNAL PROJECT DATA FORM

TRAFFIC DATA

GEOMETRIC DATA

DIST NO.	LOCATION	CONTROL SECTION NO.	MILE PT.	DATE OF SIGNAL INSTALL.	TYPE OF CTRL.	NO. PHASES	CYCLE LENGTH (SEC.)	OTHER OPERATION	BIC #1	BEFORE INSTALL. APPROACH ADT NB	SB	EB	WB	AFTER INSTALL. APPROACH ADT NB	SB	EB	WB	IC #2	ONE WAY LEG	# LANES ON LEG N S E W	LEGS WITH EXCLUSIVE TURN LANE LT: RT:
N : S																					
6	M-21 (MAIN ST.) @ GOULD RD.	76062-01-011	0.96	08-04-81	2	2	55	2:FLASH 9:00 P-7:00 A	2					3097	2926	9163	10123	1		4 2 4 4	
5	M-44 (BELDING RD.) @ OLD US-131	41101-01-005	0.00	03-08-76	1	2	70	2:11:00 P-8:00 A	2	5090		7317	7201			7000	7000	2	N,S	3 2 2 2	N
6	M-24 (MAIN ST.) @ EAST AND BALDWIN STS.	44011-01-007	10.93	01-04-78	1	2	80	2:9:00 P-8:00 A	2	7340	6944	4823	7260					2	N,S	5 5 2 3	NS
M(9)	M-97 (GROESBECK) @ CARLIER	50051-033	9.01	02-25-81	2	2	90	1:6:00 A TO 11:00 P	2	20699	17731	3037				18850	18850			5 5 2	NS
7	BL-94 (DICKMAN) @ MELMER RD.	13121-007	5.07	03-08-78	2	2	70		2							5250	5250	3		4 3 3	NW EW
7	BL-94 @ RIVER RD.	39121-002	2.35	03-23-78	2	2	65,80		2	1372	1378	1986	1872			2800	2800	1		2 2 3 3	EW
8	US-12 (MICHIGAN) @ RELOC. STATE RD. & MOON RD.	81031-006	14.88	10-29-81	3	2	50	1:6:00 A- 10:00 P	2	2176	1246	9229	7449	2596	1364	8195	8399	2		3 3 3 3	NS EW
8	US-12 (MICHIGAN AVE.) @ AUSTIN RD.	81031-011	10.44	02-26-82	2	2	70	1:6:00 A-8:00 P	2	1560		6369	6952			10600	10600	4		3 4 4	EW NEW
5	M-11 (28TH ST.) @ LAKE EASTGROOVE BLVD.	41063-019	4.63	06-02-83	2	2	90	1:9:30 A-10:30 P	2							16500	16500	1		4 4 4 4	NEWS EW
M(9)	US-10 BR (SUGARE LAKE RD.) @ LASHER RD.	63052-022	6.79	02-15-82	2	2	80				1898	17532	21571			19750	19750				
5	US-31 @ JAMES ST.	70013-001	1.10	11-06-80	2	3	70	1(LT);2,12:01A-5:30 A	2	6985	6736	3165	3110	8000	8000			2		3 3 4 4	NEWS NEWS
YES																					
M(9)	US-24 (TELEGRAPH) @ VREELAND RD.	82051-007	1.12	10-31-80	1	2	50	2	2	9444	9813	1710		10350	10350			4		5 5 4	NS
M(9)	M-4 (NORTHWESTERN HWY) @ INKSTER RD.	63082-009		08-28-80						1114	1342	19326	19210			18800	18800				
8	B2-94, US-23 BR (HURON ST.) @ GLEN AVE.	81072-015	0.66	07-24-80	3	3	70	1:12:01 A-6:30 A	2	7330		11859	12908	12632		11000	11000	3		3 5 5	
6	M-247 (EUCLID AVE.) @ OLD KAWKAWLIN RD.	09012-005	0.06	10-30-80	2	2	70	1:7:00 A-9:00 P	2					3350	3350			2		3 3 3 3	NSEW
6	M-13 @ FIFTH ST.	09033-006	16.49	04-01-83	1	2	70	1:12:01 A-6:30 A	2					5250	5250			1		5 5 2 2	NS
8	M-43 (SAGINAW ST.) @ WEST MALL DRIVE	23042-008	5.47	07-13-79	2	2	80	1:6:30 A-11:00 P	2					3155	3114	14301	12667	1		5 5 5 5	NSEW
6	TEMP I-69, US-27 @ CHEYS RD.	23012-007	12.95	08-02-79	2	2	80	1:6:00 A-10:00 P						2016	1974	9294	8748	2		3 3 5 5	EW
M(9)	M-150 (ROCHESTER RD.) @ CHARRINGTON ST.	63131-01-028	0.65	10-01-80	2	3	80	1:6:00 A-11:00 P;3	2	18327	17639	2490	2499	19150	19150			3		5 5 4	NS
8	US-12 BR (MICHIGAN AVE.) @ HARRIS RD.	81032-010	3.99	10-10-79	2	2	80	1:6:00 A-11:00 P	2	3047	2755	8364	8872	7420	9730	10684	10698	2		3 5 5	EW
1	US-41 BR (FRONT) @ SPRING	52044-011		10-30-79	2	3	60	1:12:30 A-7:00 A);3	2	14087	5377	1950	4510	7831	3544	1087	5560	1		3 3 2 3	NSW W
1	US-41, M-28 (FRONT ST.) @ GENESSEE ST.	52042-014		06-13-79	2	2	70	1:(6:00 A-11:00 P);3	2	12011	11201	1634		10225	8535	3211		4		5 5 3	NSW W
5	BL-196, US-31 BR (8TH ST.) & LINCOLN	70012-014		02-25-81	2	2	60	1:16:00 A-11:00 P	2	1260	1215	9544	7903			5950	5950	1		3 3 4 4	NS
M(9)	M-153 (FORD RD.) @ BRANDT ST.	82081-038	10.80	01-26-82	2	2	60	1:(10:00 A-6:00 P)	2			16650	16650	8160	9720	16700	16700	1		3 3 5 5	NSEW
7	US-12 @ THIRD ST.	11101-001	2.55	09-28-82	3	2			2	1564	1416	4466	4096			4250	4250	1		3 3 6 5	NSEW E
3	US-27 BR @ TOWNLINE RD.	18032-006	0.91	02-25-82	2	2	60	1:(7:00 A-10:00 P)	2									2		3 4 3 3	EWNS S
M(9)	M-97 (GROESBECK) @ KELLEY RD.	50031-028	7.65	10-08-82	2	2	90	1:(6:00 A-10:00 P)	2			17850	17850			18850	18850	2		4 4 6 6	EW EW
M(9)	M-150 (MAIN) @ SECOND ST.	63131-009	2.92	09-23-82	2	2	60	1:(6:00 A-11:00 P)	2	14542	15641	1551	1245	16700	16700			1		5 5 3 3	NEWS
6	M 16, M-61 (CEDAR) @ BOWCAY ST.	26011-002	12.57	06-16-82	2	2	70	1:(7:00 A-9:00 P)	2	6280	4820	1674	2053	4850	4460	1729	2369	1		3 3 5 3	NEWS
M(9)	US-12 (MICHIGAN AVE.) @ SHELDON RD.	82061-047	3.77	03-30-82	2	3	80	1:(1:00 A-6:00 A)	2			15450	15450			16200	16200	6	EW	2 2 2 2	
5	M-21 (FULTON) @ EAST DR TO AMWAY CORP.	41043-19		09-07-83	5			1	2									4		2 4 5	NW
4'																					
3	US-31, M-72 @ FOUR MILE RD.	28013-26	5.18	07-12-83	2	2	60	2;(6:00 A-10:00 P)	2	9780	1096	13334	13601					2		3 3 5 5	NEWS
5	BL-96, US-31 BR (SEAWAY DR.) @ SEMINOLE AVE.	61151-008	3.46	11-10-83	2	3	80	1:12:01 A-6:00 A)	2	6320	6580	10521	12230	9950	9950			2	E,W	3 3 3 3	EW NS
6	BL-94, US-23 BR (WASHTENAW) @ BROCKMAN	81072-012	2.14	10-29-82	2	2	40,70	3	2			7850	7850	1100		11609	4798	4		2 4 4	
7	M-66 @ 6. DRIVE N. (BECKLEY RD.)	13031-008	13.60	07-29-82	5			FLASHER (6 A-10 P)	2	4699	4807	1695	1702	3245	3293	2060	2590	2	N,S	4 4 4 6	NW NW
4	US-31, M-68 (PENT ST.) @ LAKE ST.	24011-009	7.15	09-14-83	2	2	70	3	2	9363	9641	1317	1355					2		5 5 2 2	NS
7	BL-196,US-31 BR(WASHINGTON)AT 40TH STREET	03051-003	-	08-19-83	3	3	80	1;(6A-10P)	1									1		5 5 3 3	EW
5	M-45(LAKE MICH)AT 68TH AVE.	70041-005	-	08-10-83	1	2	8	2;(6A-10P)	-	2339	2487	3075	3154	3267	3277	3544	4517	1		3 3 3 3	NSEW
5	NS M-44(E.BELTLINE)AT EW KNAPP	41051-9	-	07-6-78	2	2	80	2	1					8273	8153	1371	2234	1		4 4 4 4	
4	NB M-31(BROADWAY) AT EW INDIANOLIS	50051-61	9.84	07-7-78						17670		1880	1880	8050				2	NE	3 3 2 2	
7	EW M43(GULL) AT N.BROOK ST.	39082-16	2.010	03-10-78	2	2	65	2	2	2420	1443	7217	7267			7300	7300	2		3 2 3 2	WE N
7	NS US-131(GRAND ST) AT EW ELIZA	39011-12	2.930	03-22-78	1	2	70	2,3	2	8005	7228	1258	1693	8739	8061	1560	1924	2		4 4 3 3	EW

SIGNAL PROJECT DATA FORM | TRAFFIC DATA | GEOMETRIC DATA

DIST NO.	LOCATION	CONTROL SECTION NO.	MILE PT.	DATE OF SIGNAL INSTALL.	TYPE OF CTRL.	NO. PHASES	CYCLE LENGTH (SEC.)	OTHER OPERATION	BIC #1	BEFORE INSTALL. APPROACH ADT NB	SB	EB	WB	AFTER INSTALL. APPROACH ADT NB	SB	EB	WB	TC #2	ONE WAY LEG	# LANES ON LEG N S E W	LEGS WITH EXCLUSIVE TURN LANE LT; RT:
N ; S																					
7	NS US-31(NILES) AT EW BOTHAM ST	11052-17	22.39	11-30-79	2	2	55 2		2					9500	9500	1519	1587	1		5 5 3 3	NSEW
8	NS US-24(TELEGRAPH) AT EW S. HURON RIVER	82031-4		02-14-80	2	2	80 2		1	6463	9052	2358	7360	5850	5850			2		4 4 2 4	
9	EW US-12(MICHIGAN)AT NS RAGGERTY	82061-46	5.244	03-15-79	2	2	70 2		2	1737	1086	19576	19932	2567	6900	15107	15024	2	EW	6 5 2 2	84
9	EW M-29(23 MILE)AT N.SEAVON DR.	50072-10	2.340	06-28-79	1	2	70 2		2		1067	10750	10776			9450	9450	3		2 - 6 5	EW E
5	EW M-46(APPLE AVE) AT NS GULF LAKE RD.	61023-2	4.66	08-13-80	1	2	80 2		1	9200	1992	6365	5556			5300	5300	1		2 2 5 5	EW
6	NS M-84 (BAY RD) AT EW ENTERPRISE DR.	73032-4	1.440	04-18-79	2	2	90 2		2	11267	10329	1001	2300	10173	10882	1942	410	2		6 6 3 3	NS NSEW
9	EW US-10(BIXIE HWY) AT NS WHITE LAKE RD.	63054-3	1.770	01-14-80	2	2	80 2		2	2191	1758	7791	7468			7300	7300	2		3 3 5 5	NSEW
5	EW M-45(LAKE MICH. DR) AT NS CULLENDALE	41081-15	2.420	08-19-76	1	2	60 2		2							9000	9000	1		3 3 5 5	NSEW
7	EW US-131 BR,M-60(INDIANA) DOUGLAS ST.	78042-8		05-09-79	2	2	65 2,3		2	8410	5790	4698	5428					1		5 5 4 4	NS
6	EW M-20(INDIANA) AT NS JEROME	58023-27		04-2-79	2	2	50 2,3		2	4780	4780	1903	4451					2	WE	4 4 3 3	
3	EW US-31,M-74(MUNSON) AT 3 MILE RD.	28013-6		07-19-79	2	2	60 2		2					4611		8600	11050	4		- 4 5 5	EW
6	NS, M-25 (MADISON) @ WB M-25 (7TH ST.)	09042-19		08-10-79	2	2	55 2,3		2					7950	7950			1	E,W	4 4 3 3	
8	M-155 (MICHIGAN) @ M-155 (MASON)	47121-3	0.50	04-22-81	2	2	70 2		2	7227	6954	3831	3158			2550	2550	1		3 3 3 3	NS EW
1	US-41, M-28 @ CHERRY CREEK RD.	52061-1		12-04-80	1	2	80 2		2	1545	1854	7671	3829					2		4 2 5 5	EW
6	M-71 (CORUNNA) @ GOULD ST (OAKDALE)	78041-14		03-20-80	1	2	70 2,3		2		3214	6889	7769					4		4 2 2	
9	M-25 (PIKE GROVE-LYNBURNER) @ M-13a	77132-1		04-10-80	2	3	70 2		2	9373	9261	3715		7100	7100			4		5 5 4	NS
7	M-60 (STATE ST) @ M-60, M-62 (BROADWAY)	14032-1		01-25-80	1	2	60 2,3		2					4128	2335	1396	4487	1		4 4 5 5	EW
9	US-10 (DIXIE HWY) @ GRAYTON PLAINS SHP. CENTER	63053-11	2.39	09-11-79	2	2	80,90 2;BET. 11:00 P-8:00 A		2	18882	18624	3300	4211	16970	18149	2916	4004	3		6 6 2	NS NS
5	M-44 & M-91 (STATE) @ (BRIDGE ST. OR JOHN RD).	34081-7		01-17-80	1	2	70 3,ALL LEGS;2,10P-6:30A		1									1		3 3 3 3	NEWS
9	M-19 (MAIN ST.) @ PARK AVE. & N. ST. (YALE RD.)	77012-2		07-31-79	1	2	60 3,ALL LEGS;2,11P-7A		1	3757	3830	1315	1378	3750	3750			1		3 3 3 3	NEWS
20																					
9	M-53 (VAN DYKE) @ GATE 8B CHRYSLER TANK PLANT	50011-30	3.69	06-17-82	2	2	60 2;5:00P-2:30P WEEKDAYS		2	3200	3200	1000						3		7 7 4	NS W
3	US-31, M-72 (FRONT) @ FAIR ST.	28013-21	2.32	11-18-81	2	2	60 2;BET. 12 MID & 6 A		2	1000	2000	1000	8000	1267	2138	9640	8688	1		3 2 5 5	NW
3	US-31, M-72 @ BUNKER HILL RD.	28013-24	7.33	07-13 83	2	2	70 2;10:00 P-6:00 A		2	1100	1100		1000					3		3 2 3	NE

SIGNAL PROJECT DATA FORM

TRAFFIC DATA

GEOMETRIC DATA

DIST NO.	LOCATION	CONTROL SECTION NO.	MILE PT.	DATE OF SIGNAL INSTALL.	TYPE OF CONT.	NO. PHASES	CYCLE LENGTH (SEC.)	OTHER OPERATION	BIC #1	BEFORE INSTALL. APPROACH ADT NB	SB	EB	WB	AFTER INSTALL. APPROACH ADT NB	SB	EB	WB	IC #2	ONE WAY LEG	% LANES ON LEG N S E W	LEGS WITH EXCLUSIVE TURN LANE LT	RT
N I S																						
9	M-102 EXIT RAMP AT GRAND RIVER AVE.	63021-006	13.61	05-17-82	3	4	60/90	2(1A-5A)	2	9220	6931	8687	11704					2	N	2 2 2 2		
7	I-94 EB EXIT RAMP AT SPRINGLE RD	39022-004		03-12-81	2	2	70	2(1AM-6AM)	2	15432	11857	8947		16506	12586	7452		3	W	6 6 - 3	SW	
M19)	I-94 SB OFF RAMP AT OLD 8 MILE RD.	82025-001		04-07-81	2	2	70	1	2		11357	4608	7881		13000	5044	7710	2	NS	1 2 4 5	N	NW
M15)	SB US-10 EXIT RAMP AT LAHSER RD	63081-202		11-20-80	3	2	80	1(5A-7P)	2									4	W	2 - 2 2		
8	I-75 NB OFF RAMP AT M-57(VIENNA)	25032-006		08-11-80	2	3	60	1(12A-6A)	2									2	NS	1 2 2 2	S	S
9	SB I-96 AND I-275 OFF RAMP AT 6 MI RD.	82125-001		03-20-81	1	2			2		3500	6400	7500					2	NS	2 1 4 5	N	NW
5	US-31 SB ON RAMP AT LAKETON AVE(EW)	61072-109		08-25-80	1	3	70	2(10P-6A)	2	2400		10700	11600					3		- 3 5 6	EWS	WS
5	I-96 EEBD OFF RAMP(W) AT M-37,M-44	41051-011		05-27-81	2	2	70	2(12A-6A)	2	11000	6600	8500						5		6 5 - 4	NSW	NW
6	M-21 ED OFF RAMP AT M-15(STATE ROADS	25084-004		04-16-80	2	2	70	2(12A-6A)	2									3	W	4 4 - 2	W	W
16																						
5	I-75 SB OFF RAMP AT WB OUTER DRIVE	82194-003		07-31-80	1	2			2		6700		14700					4	NEW	2 - 3 3		W
8	NB US-23 EXIT RAMP AT PLYMOUTH RD EW	81074-002		02-14-80	1	2	70	2(12A-6A)	2	4300		6000	5200					3	S	- 1 4 4		
6	M-24(LAPEER RD.) AT M-21 EB OFF RAMP	44011-003	9.500	04-20-79	1	2	80	2(12A-6A)	2	5933	5884	5247		7368	8343	6619		4	W	4 4 - 2		
12																						
5	NB I-75 OFF RAMP AT EW 14 MILE RD.	63174-003	6.145	11-12-80	2	2	60	5	2	11063		25240	24614	12994				2	NS	2 2 4 4		
4	NB I-75 RAMP AT EW 12 MILE RD.	63174-001	4.128	03-30-80	2	2	60	5	2	8465		12046	17417					4	S	5 4 4	S	S
7	I-94 WB RAMPS AT NB 7TH STREET	39024-003		10-25-79	1	2	70	2(10P-7A)	2									2	EW	2 3 2 1	S	
4	WB I-96,I-275 OFF RAMP AT EW 8 MILE RD	82125-003	0.1	03-05-79	2	2	80	2(1A-6A)	2	8193		12007	11023					4	S	- 2 4 4		
6	US-23 SB OFF RAMP (NS) AT HILL RD EW	25031-005		11-12-79	2	2	80	2(12A-6A)	2									2	NS	2 1 4 4	W	N
4	U-696 SERVICE DR EW AT BONEAT ST NS	50061-016		09-05-79				3	2									1		4 4 6 6		
8	U-696 WB OFF RAMP AT CHEYIS ROAD	23081-002	1.360	10-07-81	3	2		1	2	5702	5356		7280					1	EW	4 4 2 2		
5	I-196 WB OFF RAMP EW AT FULLER AVE NS	41027-007		08-17-83	5	3		3	2	1300	11700		1400					1	EW	4 5 2 2	S	
10																						
5	I-196 EB OFF RAMP EW AT COLLEGE RD NS	41027-006	8.630	01-19-81	1	2	60	2(12A-6A)	2									2	EW	5 4 2 3	N	
7	I 94 EB OFF RAMP EW AT AIRPORT RD NS	38101-008		10-17-83	1	2	60	2(10P-6A)	2									1	WE	6 5 2 2	N	S
4																						
6	I-75 SB OFF RAMP NS AT M-59 EW	58152-005		10-11-83	1	2	70	2(1A-5A)	2		5709	8000	8200					1	NS	2 2 4 5		W
9	NB I-275 EXIT RAMP AT M-153(FORD) EW	82242-103	7.030	04-07-8.	2	2	80	2(1A-6A)	2	4700		9500	8400					3	S	- 2 5 3		

APPENDIX 2 - "BEFORE" AND "AFTER" ACCIDENT DATA AT 102 SIGNALIZED INTERSECTIONS

NOTE: Study period is the number of years of "before" or "after" accident data considered in the analysis. For example, study period 2 years means, 2 years of "before" accident data and 2 years of "after" accident data were considered.

Table 2-1. Intersection Locations - "Total" Accidents

Intersections-Individual Locations "Before"/"After"

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	14	25	2	11,550	14,000	1.212	1.660	2.446
09011-0101	12	15	1	21,600	20,829	0.964	1.522	1.973
09011-01003	16	25	3	22,500	27,200	1.209	0.649	0.839
09012-0005	24	6	2	7,050	7,633	1.083	4.663	1.077
09033-0006	28	23	2	11,050	12,900	1.167	3.471	2.442
09042-0019	25	28	3	24,000	16,200	0.675	0.951	1.578
09042-0126	25	17	3	20,000	15,000	0.750	1.142	1.035
11052-0017	8	19	3	18,046	22,106	1.220	0.405	0.785
11101-0001	41	21	3	11,313	12,121	1.071	3.310	1.582
13031-0008	15	7	3	9,063	8,460	0.933	1.522	0.756
13061-0046	39	20	3	22,714	11,770	0.518	1.568	1.552
13121-0007	48	54	2	11,449	12,600	0.000	5.743	5.871
14011-0112	53	24	3	7,200	7,500	1.042	6.722	2.922
14032-0001	33	16	3	8,450	7,733	0.915	3.567	1.890
18032-0006	18	23	3	3,633	2,733	0.752	4.525	7.686
19021-0006	37	11	3	12,950	11,200	0.865	2.609	0.897
19031-0002	30	17	3	17,510	19,267	1.100	1.565	0.806
22011-0008	21	26	3	10,000	12,000	1.200	1.918	1.979
23012-0003	56	30	3	33,113	37,000	1.117	1.544	0.740
23012-0007	39	35	3	20,771	22,032	1.061	1.715	1.451
24011-0009	25	18	2	18,972	17,685	0.932	1.805	1.394
26011-0002	17	16	3	12,143	13,164	1.084	1.279	1.110
28013-0006	70	43	3	17,600	22,320	1.268	3.632	1.759
28013-0119	19	21	2	19,200	21,750	1.133	1.356	1.323
28013-0021	20	21	3	26,733	23,860	0.890	0.683	0.804
28013-0024	8	11	2	16,800	16,317	0.970	0.652	0.923

Table 2-1. Intersection Locations - "Total" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
28013-0026	34	16	2	22,124	21,241	0.960	2.105	1.032
33043-0115	51	43	3	21,073	38,965	1.849	2.210	1.008
34081-0001	10	5	3	5,855	6,200	1.058	1.560	0.736
39011-0012	6	24	2	18,184	22,317	1.227	0.452	1.473
39081-0015	13	43	2	23,500	25,650		0.758	2.296
39082-0016	15	7	2	16,169	19,422	1.200	1.271	0.494
39121-0002	11	10	2	6,608	13,301	2.013	2.280	1.030
41063-0019	33	55	2	29,000	33,750	1.164	1.559	2.232
41081-0012	36	34	3	16,975	22,135	1.300	1.937	1.403
41081-0015	35	29	2	16,860	18,000	1.068	2.844	2.207
41101-0005	31	20	2	15,027	14,684	0.977	2.826	1.866
44011-0007	18	28	2	19,833	35,377	1.784	1.243	1.084
46061-0018	26	21	3	14,528	13,075	0.900	1.634	1.467
46082-0010	23	22	3	18,400	15,855	0.862	1.142	1.267
47082-0013	16	14	2	13,121	11,692	0.891	1.670	1.640
47121-0003	23	23	3	6,700	5,100	0.760	3.135	4.119
50011-0055	5	15	1	60,433	54,700	0.905	0.227	0.751
50031-0028	51	100	3	36,400	34,600	0.951	1.280	2.639
50031-0033	35	45	3	37,637	39,118	1.039	0.849	1.051
50072-0010	0	31	3	22,593	19,837	0.878	0.000	1.427
52042-0014	42	45	3	23,634	21,470	0.908	1.623	1.914
52044-0010	33	19	3	18,988	15,752	0.830	1.587	1.102
52044-0011	52	15	3	17,495	18,303	1.046	2.714	0.748
52061-0001	28	36	3	16,899	19,508	1.150	1.513	1.685
53021-0009	33	40	3	20,653	19,816	0.959	1.459	1.843
54022-0002	12	12	2	13,151	14,994	1.140	1.250	1.096
56023-0027	31	19	3	10,166	11,600	1.141	2.785	1.496
58042-0011	18	28	3	12,582	15,541	1.230	1.306	1.645

Table 2-1. Intersection Locations - "Total" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
58052-0005	89	37	3	29,030	36,341	1.252	2.800	0.930
58053-01002	54	15	3	13,043	10,412	0.798	3.781	1.316
59043-0001	7	1	1	9,254	8,767	0.947	2.072	0.313
61023-0002	30	25	3	14,833	13,192	0.889	1.847	1.731
61151-0008	26	44	2	19,440	22,646	1.165	1.832	2.662
62011-0005	20	38	2	9,200	16,250		2.978	3.203
63041-0113	40	34	2	22,369	25,539	1.142	2.450	1.824
63041-0021	47	72	3	28,650	25,200	0.880	1.498	2.609
63052-0022	56	66	3	40,118	51,141	1.275	1.275	1.179
63053-0011	15	13	3	36,611	36,385	0.990	0.374	0.326
63054-0003	68	34	3	19,208	18,391	0.957	3.233	1.688
63082-0009	53	24	3	40,992	42,868	1.046	1.181	0.511
63112-0013	43	39	3	28,518	33,843	1.187	1.377	1.052
63112-0125	16	30	3	30,301	30,329	1.001	0.482	0.903
63131-01028	22	28	3	36,463	41,135	1.128	0.551	0.622
63132-0009	63	61	3	31,629	37,432	1.183	1.819	1.488
70012-0014	31	25	3	21,308	16,280	0.764	1.329	1.402
70012-0121	59	29	3	18,664	16,682	0.894	2.887	1.588
70013-0001	45	25	3	23,075	23,208	1.006	1.781	0.984
70023-0012	57	27	3	20,277	21,937	1.300	2.567	1.124
70023-0120	46	32	3	16,843	19,100	1.134	2.494	1.530
70031-0001	12	11	2	11,945	12,121	1.015	1.376	1.243
70041-0005	28	25	2	10,350	11,100	1.070	3.706	3.085
73032-0002	16	20	3	20,245	25,657	1.267	0.722	0.712
73033-0009	16	30	3	29,031	35,819	1.234	0.503	0.765
73062-0023	18	13	3	23,170	21,905	0.945	0.709	0.542
76041-0014	11	14	3	17,214	17,214	1.000	0.584	0.743
76062-01011	78	68	3	27,474	26,356	0.959	2.593	2.356
77012-0002	34	19	3	9,693	8,443	0.870	3.203	2.055

Table 2-1. Intersection Locations - "Total" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
77031-0010	16	6	2	13,618	14,475	1.063	1.609	0.568
77052-0109	23	12	2	11,874	12,909	1.087	2.653	1.273
77132-0001	20	15	3	16,915	17,340	1.025	1.080	0.790
78042-0008	15	16	3	10,025	20,000	1.995	1.366	0.731
80041-0004	28	9	3	9,797	8,356	0.853	2.610	0.994
81031-0005	18	27	2	17,177	18,574	1.081	1.435	1.991
81031-0006	19	25	3	20,455	18,480	0.903	0.848	1.235
81031-0011	33	31	3	22,260	25,378	1.140	1.354	1.116
81032-0010	52	27	3	21,022	16,815	0.800	2.259	1.466
81072-0012	16	16	3	17,567	17,200	0.979	0.832	0.850
81072-0015	17	17	3	32,097	23,632	0.736	0.484	0.657
82051-0004	55	14	3	15,644	14,872	0.950	3.211	0.860
82051-0007	23	17	3	21,860	22,594	1.034	0.961	0.687
82061-0046	45	46	3	42,331	34,188	0.808	0.971	1.229
82061-0047	39	30	3	29,800	34,333	1.152	1.195	0.798
82131-0066	11	14	2	25,500	20,350		0.591	0.942
82141-0011	20	19	3	44,925	46,866	1.043	0.407	0.370
83031-0004	37	39	3	21,981	22,724	1.034	1.537	1.567
83032-0113	16	25	3	15,770	17,310	1.098	0.927	1.319

Table 2-2. Intersection Locations - "Right-Angle" Accidents

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	4	4	2	11,550	14,000	1.212	0.474	0.391
09011-0101	2	2	1	21,600	20,829	0.964	0.254	0.263
09011-01003	0	0	3	22,500	27,200	1.209	0.000	0.000
09012-0005	10	1	2	7,050	7,633	1.083	1.943	0.179
09033-0006	0	6	2	11,050	12,900	1.167	0.000	0.637
09042-0019	16	20	3	24,000	16,200	0.675	0.609	1.127
09042-0126	7	1	3	20,000	15,000	0.750	0.320	0.061
11052-0017	1	10	3	18,046	22,106	1.220	0.051	0.413
11101-0001	29	12	3	11,313	12,121	1.071	2.341	0.904
13031-0008	12	3	3	9,063	8,460	0.933	1.209	0.324
13061-0046	21	7	3	22,714	11,770	0.518	0.844	0.543
13121-0007	21	15	2	11,449	12,600	0.000	2.512	1.631
14011-0112	28	7	3	7,200	7,500	1.042	3.551	0.852
14032-0001	5	2	3	8,450	7,733	0.915	0.540	0.236
18032-0006	6	2	3	3,633	2,733	0.752	1.508	0.668
19021-0006	3	0	3	12,950	11,200	0.865	0.212	0.000
19031-0002	11	5	3	17,510	19,267	1.100	0.574	0.237
22011-0008	5	4	3	10,000	12,000	1.200	0.457	0.304
23012-0003	38	15	3	33,113	37,000	1.117	1.048	0.370
23012-0007	19	8	3	20,771	22,032	1.061	0.835	0.332
24011-0009	12	6	2	18,972	17,685	0.932	0.866	0.465
26011-0002	4	1	3	12,143	13,164	1.084	0.301	0.069
28013-0006	3	2	3	17,600	22,320	1.268	0.156	0.082
28013-0119	1	1	2	19,200	21,750	1.133	0.071	0.063
28013-0021	1	6	3	26,733	23,860	0.890	0.034	0.230
28013-0024	0	1	2	16,800	16,317	0.970	0.000	0.084

Table 2-2. Intersection Locations - "Right-Angle" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
28013-0026	4	0	2	22,124	21,241	0.960	0.248	0.000
33043-0115	38	15	3	21,073	38,965	1.849	1.647	0.352
34081-0001	2	1	3	5,855	6,200	1.058	0.312	0.147
39011-0012	1	2	2	18,184	22,317	1.227	0.075	0.123
39081-0015	0	9	2	23,500	25,650		0.000	0.481
39082-0016	2	0	2	16,169	19,422	1.200	0.169	0.000
39121-0002	9	2	2	6,608	13,301	2.013	1.866	0.206
41063-0019	10	10	2	29,000	33,750	1.164	0.472	0.406
41081-0012	7	4	3	16,975	22,135	1.300	0.377	0.165
41081-0015	3	1	2	16,860	18,000	1.068	0.244	0.076
41101-0005	12	4	2	15,027	14,684	0.977	1.094	0.373
44011-0007	3	1	2	19,833	35,377	1.784	0.207	0.039
46061-0018	6	7	3	14,528	13,075	0.900	0.377	0.489
46082-0010	7	3	3	18,400	15,855	0.862	0.347	0.173
47082-0013	5	3	2	13,121	11,692	0.891	0.522	0.351
47121-0003	7	0	3	6,700	5,100	0.760	0.954	0.000
50011-0055	0	0	1	60,433	54,700	0.905	0.000	0.000
50031-0028	5	6	3	36,400	34,600	0.951	0.125	0.158
50031-0033	0	1	3	37,637	39,118	1.039	0.000	0.023
50072-0010	0	1		22,593	19,837	0.878	0.000	0.046
52042-0014	4	0	3	23,634	21,470	0.908	0.155	0.000
52044-0010	4	2	3	18,988	15,752	0.830	0.192	0.116
52044-0011	8	1	3	17,495	18,303	1.046	0.418	0.050
52061-0001	8	6	3	16,899	19,508	1.150	0.432	0.281
53021-0009	1	3	3	20,653	19,816	0.959	0.044	0.138
54022-0002	0	1	2	13,151	14,994	1.140	0.000	0.091
56023-0027	13	2	3	10,166	11,600	1.141	1.168	0.157
58042-0011	6	9	3	12,582	15,541	1.230	0.435	0.529

Table 2-2. Intersection Locations - "Right-Angle" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
58052-0005	19	5	3	29,030	36,341	1.252	0.598	0.126
58053-01002	14	3	3	13,043	10,412	0.798	0.980	0.263
59043-0001	5	0	1	9,254	8,767	0.947	1.480	0.000
61023-0002	11	1	3	14,833	13,192	0.889	0.677	0.069
61151-0008	4	12	2	19,440	22,646	1.165	0.282	0.726
62011-0005	4	8	2	9,200	16,250		0.596	0.674
63041-0113	2	4	2	22,369	25,539	1.142	0.122	0.215
63041-0021	3	4	3	28,650	25,200	0.880	0.096	0.145
63052-0022	21	11	3	40,118	51,141	1.275	0.478	0.196
63053-0011	0	1	3	36,611	36,385	0.990	0.000	0.025
63054-0003	20	10	3	19,208	18,391	0.957	0.951	0.497
63082-0009	39	13	3	40,992	42,868	1.046	0.869	0.277
63112-0013	14	7	3	28,518	33,843	1.187	0.448	0.189
63112-0125	1	3	3	30,301	30,329	1.001	0.030	0.090
63131-01028	0	0	3	36,463	41,135	1.128	0.000	0.000
63132-0009	8	10	3	31,629	37,432	1.183	0.231	0.244
70012-0014	4	3	3	21,308	16,280	0.764	0.171	0.168
70012-0121	41	9	3	18,664	16,682	0.894	2.006	0.493
70013-0001	21	4	3	23,075	23,208	1.006	0.831	0.157
70023-0012	22	6	3	20,277	21,937	1.300	0.991	0.250
70023-0120	34	7	3	16,843	19,100	1.134	1.844	0.335
70031-0001	2	1	2	11,945	12,121	1.015	0.229	0.113
70041-0005	10	2	2	10,350	11,100	1.070	1.324	0.247
73032-0002	2	4	3	20,245	25,657	1.267	0.090	0.142
73033-0009	6	1	3	29,031	35,819	1.234	0.189	0.025
73062-0023	0	0	3	23,170	21,905	0.945	0.000	0.000
76041-0014	1	1	3	17,214	17,214	1.000	0.053	0.053
76062-01011	9	13	3	27,474	26,356	0.959	0.229	0.450
77012-0002	6	3	3	9,693	8,443	0.870	0.565	0.324

Table 2-2. Intersection Locations - "Right-Angle" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
77031-0010	11	1	2	13,618	14,475	1.063	1.107	0.095
77052-0109	13	3	2	11,874	12,909	1.087	1.500	0.318
77132-0001	5	0	3	16,915	17,340	1.025	0.270	0.000
78042-0008	3	2	3	10,025	20,000	1.995	0.273	0.091
80041-0004	20	4	3	9,797	8,356	0.853	1.864	0.437
81031-0005	9	7	2	17,177	18,574	1.081	0.718	0.516
81031-0006	2	4	3	20,455	18,480	0.903	0.089	0.198
81031-0011	6	1	3	22,260	25,378	1.140	0.246	0.036
81032-0010	9	0	3	21,022	16,815	0.800	0.391	0.000
81072-0012	0	0	3	17,567	17,200	0.979	0.000	0.000
81072-0015	0	1	3	32,097	23,632	0.736	0.000	0.039
82051-0004	5	0	3	15,644	14,872	0.950	0.292	0.000
82051-0007	0	0	3	21,860	22,594	1.034	0.000	0.000
82061-0046	18	21	3	42,331	34,188	0.808	0.388	0.561
82061-0047	19	11	3	29,800	34,333	1.152	0.582	0.293
82131-0066	0	1	2	25,500	20,350		0.000	0.067
82141-0011	6	1	3	44,925	46,866	1.043	0.122	0.019
83031-0004	1	1	3	21,981	22,724	1.034	0.042	0.040
83032-0113	2	4	3	15,770	17,310	1.098	0.116	0.211

Table 2-3. Intersection Locations - "Rear-End" Accidents

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	2	13	2	11,550	14,000	1.212	0.237	1.272
09011-0101	2	7	1	21,600	20,829	0.964	0.254	0.921
09011-01003	3	14	3	22,500	27,200	1.209	0.122	0.470
09012-0005	7	1	2	7,050	7,633	1.083	1.360	0.179
09033-0006	5	7	2	11,050	12,900	1.167	0.620	0.743
09042-0019	3	6	3	24,000	16,200	0.675	0.114	0.338
09042-0126	2	6	3	20,000	15,000	0.750	0.091	0.365
11052-0017	0	4	3	18,046	22,106	1.220	0.000	0.165
11101-0001	2	4	3	11,313	12,121	1.071	0.161	0.301
13031-0008	2	2	3	9,063	8,460	0.933	0.202	0.216
13061-0046	10	8	3	22,714	11,770	0.518	0.402	0.621
13121-0007	3	9	2	11,449	12,600	0.000	0.359	0.978
14011-0112	12	9	3	7,200	7,500	1.042	1.522	1.096
14032-0001	2	5	3	8,450	7,733	0.915	0.216	0.590
18032-0006	1	7	3	3,633	2,733	0.752	0.251	2.339
19021-0006	4	3	3	12,950	11,200	0.865	0.282	0.245
19031-0002	3	4	3	17,510	19,267	1.100	0.156	0.190
22011-0008	7	5	3	10,000	12,000	1.200	0.639	0.381
23012-0003	6	8	3	33,113	37,000	1.117	0.165	0.197
23012-0007	5	14	3	20,771	22,032	1.061	0.220	0.580
24011-0009	4	5	2	18,972	17,685	0.932	0.289	0.387
26011-0002	0	7	3	12,143	13,164	1.084	0.000	0.486
28013-0006	20	20	3	17,600	22,320	1.268	1.038	0.818
28013-0119	7	11	2	19,200	21,750	1.133	0.499	0.693
28013-0021	7	5	3	26,733	23,860	0.890	0.239	0.191
28013-0024	5	7	2	16,800	16,317	0.970	0.408	0.588

Table 2-3. Intersection Locations - "Rear-End" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
28013-0026	9	11	2	22,124	21,241	0.960	0.557	0.709
33043-0115	5	15	3	21,073	38,965	1.849	0.217	0.352
34081-0001	2	2	3	5,855	6,200	1.058	0.312	0.295
39011-0012	1	6	2	18,184	22,317	1.227	0.075	0.368
39081-0015	5	14	2	23,500	25,650	1.091	0.291	0.748
39082-0016	6	4	2	16,169	19,422	1.200	0.508	0.282
39121-0002	0	5	2	6,608	13,301	2.013	0.000	0.515
41063-0019	4	15	2	29,000	33,750	1.164	0.189	0.609
41081-0012	6	9	3	16,975	22,135	1.300	0.323	0.371
41081-0015	3	9	2	16,860	18,000	1.068	0.244	0.685
41101-0005	8	8	2	15,027	14,684	0.977	0.729	0.746
44011-0007	2	10	2	19,833	35,377	1.784	0.138	0.387
46061-0018	3	4	3	14,528	13,075	0.900	0.189	0.279
46082-0010	4	5	3	18,400	15,855	0.862	0.199	0.288
47082-0013	3	4	2	13,121	11,692	0.891	0.313	0.469
47121-0003	4	3	3	6,700	5,100	0.760	0.545	0.537
50011-0055	0	11	1	60,433	54,700	0.905	0.000	0.551
50031-0028	21	54	3	36,400	34,600	0.951	0.527	1.425
50031-0033	13	20	3	37,637	39,118	1.039	0.315	0.467
50072-0010	0	12		22,593	19,837	0.878	0.000	0.552
52042-0014	5	2	3	23,634	21,470	0.908	0.193	0.085
52044-0010	6	9	3	18,988	15,752	0.830	0.289	0.522
52044-0011	9	5	3	17,495	18,303	1.046	0.470	0.249
52061-0001	2	10	3	16,899	19,508	1.150	0.108	0.468
53021-0009	9	11	3	20,653	19,816	0.959	0.398	0.507
54022-0002	2	1	2	13,151	14,994	1.140	0.208	0.091
56023-0027	2	8	3	10,166	11,600	1.141	0.180	0.630
58042-0011	2	6	3	12,582	15,541	1.230	0.145	0.353

Table 2-3. Intersection Locations - "Rear-End" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
58052-0005	10	7	3	29,030	36,341	1.252	0.315	0.176
58053-01002	13	2	3	13,043	10,412	0.798	0.910	0.175
59043-0001	0	1	1	9,254	8,767	0.947		
61023-0002	4	4	3	14,833	13,192	0.889	0.246	0.277
61151-0008	10	24	2	19,440	22,646	1.165	0.705	1.452
62011-0005	3	10	2	9,200	16,250		0.447	0.843
63041-0113	15	22	2	22,369	25,539	1.142	0.919	1.180
63041-0021	14	24	3	28,650	25,200	0.880	0.446	0.870
63052-0022	10	11	3	40,118	51,141	1.275	0.228	0.196
63053-0011	2	4	3	36,611	36,385	0.990	0.050	0.100
63054-0003	12	11	3	19,208	18,391	0.957	0.571	0.546
63082-0009	6	8	3	40,992	42,868	1.046	0.134	0.170
63112-0013	8	22	3	28,518	33,843	1.187	0.256	0.594
63112-0125	3	18	3	30,301	30,329	1.001	0.090	0.542
63131-01028	12	18	3	36,463	41,135	1.128	0.301	0.400
63132-0009	19	21	3	31,629	37,432	1.183	0.549	0.512
70012-0014	7	10	3	21,308	16,280	0.764	0.300	0.561
70012-0121	5	6	3	18,664	16,682	0.894	0.245	0.328
70013-0001	7	11	3	23,075	23,208	1.006	0.277	0.433
70023-0012	11	7	3	20,277	21,937	1.300	0.495	0.291
70023-0120	4	13	3	16,843	19,100	1.134	0.217	0.622
70031-0001	2	2	2	11,945	12,121	1.015	0.229	0.226
70041-0005	2	4	2	10,350	11,100	1.070	0.265	0.494
73032-0002	1	9	3	20,245	25,657	1.267	0.045	0.320
73033-0009	5	14	3	29,031	35,819	1.234	0.157	0.357
73062-0023	11	6	3	23,170	21,905	0.945	0.434	0.250
76041-0014	3	7	3	17,214	17,214	1.000	0.159	0.371
76062-01011	17	10	3	27,474	26,356	0.959	0.565	0.347
77012-0002	3	6	3	9,693	8,443	0.870	0.283	0.649

Table 2-3. Intersection Locations - "Rear-End" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
77031-0010	3	0	2	13,618	14,475	1.063	0.302	0.000
77052-0109	3	4	2	11,874	12,909	1.087	0.346	0.424
77132-0001	2	8	3	16,915	17,340	1.025	0.108	0.421
78042-0008	2	4	3	10,025	20,000	1.995	0.182	0.183
80041-0004	3	2	3	9,797	8,356	0.853	0.280	0.219
81031-0005	3	12	2	17,177	18,574	1.081	0.239	0.885
81031-0006	4	6	3	20,455	18,480	0.903	0.179	0.297
81031-0011	5	20	3	22,260	25,378	1.140	0.205	0.720
81032-0010	6	10	3	21,022	16,815	0.800	0.261	0.543
81072-0012	10	11	3	17,567	17,200	0.979	0.520	0.584
81072-0015	7	9	3	32,097	23,632	0.736	0.199	0.348
82051-0004	16	9	3	15,644	14,872	0.950	0.934	0.553
82051-0007	4	8	3	21,860	22,594	1.034	0.167	0.323
82061-0046	9	16	3	42,331	34,188	0.808	0.194	0.427
82061-0047	4	11	3	29,800	34,333	1.152	0.123	0.293
82131-0066	2	2	2	25,500	20,350		0.107	0.135
82141-0011	9	11	3	44,925	46,866	1.043	0.183	0.214
83031-0004	7	22	3	21,981	22,724	1.034	0.291	0.884
83032-0113	2	6	3	15,770	17,310	1.098	0.116	0.317

Table 2-4. Intersection Locations - "Injury" Accidents

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	6	13	2	11,550	14,000	1.212	0.712	1.272
09011-0101	5	7	1	21,600	20,829	0.964	0.634	0.921
09011-0[illegible]003	8	7	3	22,500	27,200	1.209	0.325	0.235
09012-0[illegible]05	7	2	3	7,050	7,633	1.083	0.907	0.239
09033-0006	9	10	2	11,050	12,900	1.167	1.116	1.062
09042-0019	5	8	3	24,000	16,200	0.675	0.190	0.451
09042-0126	6	3	3	20,000	15,000	0.750	0.274	0.183
11052-0017	2	9	3	18,046	22,106	1.220	0.101	0.372
11101-0001	18	11	3	11,313	12,121	1.071	1.453	0.829
13031-0008	10	4	3	9,063	8,460	0.933	1.008	0.432
13061-0046	9	7	3	22,714	11,770	0.518	0.362	0.543
13121-0007	11	23	2	11,449	12,600	0.000	1.316	2.501
14011-0112	15	1	3	7,200	7,500	1.042	1.903	0.122
14032-0001	3	3	3	8,450	7,733	0.915	0.324	0.354
18032-0006	10	6	3	3,633	2,733	0.752	2.514	2.005
19021-0006	14	2	3	12,950	11,200	0.865	0.987	0.163
19031-0002	13	10	3	17,510	19,267	1.100	0.678	0.474
22011-0008	5	2	3	10,000	12,000	1.200	0.457	0.152
23012-0003	22	11	3	33,113	37,000	1.117	0.607	0.272
23012-0007	15	14	3	20,771	22,032	1.061	0.660	0.580
24011-0009	6	5	3	18,972	17,685	0.932	0.433	0.387
26011-0002	2	5	3	12,143	13,164	1.084	0.150	0.347
28013-0006	18	13	3	17,600	22,320	1.268	0.934	0.532
28013-0119	5	6	2	19,200	21,750	1.133	0.357	0.378
28013-0021	7	7	3	26,733	23,860	0.890	0.239	0.268
28013-0024	1	5	2	16,800	16,317	0.970	0.082	0.420

Table 2-4. Intersection Locations - "Injury" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
28013-0026	13	6	2	22,124	21,241	0.960	0.805	0.387
33043-0115	23	16	3	21,073	38,965	1.849	0.997	0.375
34081-0001	3	1	3	5,855	6,200	1.058	0.468	0.147
39011-0012	2	8	2	18,184	22,317	1.227	0.151	0.491
39081-0015	2	13	2	23,500	25,650	1.091	0.117	0.694
39082-0016	5	2	2	16,169	19,422	1.200	0.424	0.141
39121-0002	6	3	2	6,608	13,301	2.013	1.244	0.309
41063-0019	13	22	2	29,000	33,750	1.164	0.614	0.893
41081-0012	13	5	3	16,975	22,135	1.300	0.699	0.206
41081-0015	13	6	2	16,860	18,000	1.068	1.056	0.457
41101-0005	12	7	2	15,027	14,684	0.977	1.094	0.653
44011-0007	6	12	2	19,833	35,377	1.784	0.414	0.465
46061-0018	5	6	3	14,528	13,075	0.900	0.314	0.419
46082-0010	5	11	3	18,400	15,855	0.862	0.248	0.634
47082-0013	4	6	2	13,121	11,692	0.891	0.418	0.703
47121-0003	9	3	3	6,700	5,100	0.760	1.227	0.537
50011-0055	3	20	3	60,433	54,700	0.905	0.045	0.334
50031-0028	20	44	3	36,400	34,600	0.951	0.502	1.161
50031-0033	16	19	3	37,637	39,118	1.039	0.388	0.444
50072-0010	1	0	3	22,593	19,837	0.878	0.040	0.000
52042-0014	12	14	3	23,634	21,470	0.908	0.464	0.596
52044-0010	7	3	3	18,988	15,752	0.830	0.337	0.174
52044-0011	9	2	3	17,495	18,303	1.046	0.470	0.100
52061-0001	4	17	3	16,899	19,508	1.150	0.216	0.796
53021-0009	9	14	3	20,653	19,816	0.959	0.398	0.645
54022-0002	4	2	2	13,151	14,994	1.140	0.417	0.183
56023-0027	2	5	3	10,166	11,600	1.141	0.180	0.394
58042-0011	8	15	3	12,582	15,541	1.230	0.581	0.881

Table 2-4. Intersection Locations - "Injury" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
58052-0005	32	9	3	29,030	36,341	1.252	1.007	0.226
58053-01002	21	5	3	13,043	10,412	0.798	1.470	0.439
59043-0001	5	1	3	9,254	8,767	0.947	0.493	0.104
61023-0002	12	5	3	14,833	13,192	0.889	0.739	0.346
61151-0008	9	15	2	19,440	22,646	1.165	0.634	0.907
62011-0005	6	15	2	9,200	16,250	1.766	0.893	1.264
63041-0113	14	15	2	22,369	25,539	1.142	0.857	0.805
63041-0021	20	30	3	28,650	25,200	0.880	0.638	1.087
63052-0022	9	25	3	40,118	51,141	1.275	0.205	0.446
63053-0011	3	7	3	36,611	36,385	0.990	0.075	0.176
63054-0003	30	18	3	19,208	18,391	0.957	1.426	0.894
63082-0009	26	9	3	40,992	42,868	1.046	0.579	0.192
63112-0013	15	19	3	28,518	33,843	1.187	0.480	0.513
63112-0125	4	15	3	30,301	30,329	1.001	0.121	0.452
63131-01028	8	14	3	36,463	41,135	1.128	0.200	0.311
63132-0009	10	5	3	31,629	37,432	1.183	0.289	0.122
70012-0014	10	8	3	21,308	16,280	0.764	0.429	0.449
70012-0121	22	4	3	18,664	16,682	0.894	1.076	0.219
70013-0001	16	10	3	23,075	23,208	1.006	0.633	0.394
70023-0012	11	10	3	20,277	21,937	1.300	0.495	0.416
70023-0120	20	10	3	16,843	19,100	1.134	1.084	0.478
70031-0001	4	2	2	11,945	12,121	1.015	0.459	0.226
70041-0005	9	7	2	10,350	11,100	1.070	1.191	0.864
73032-0002	2	4	3	20,245	25,657	1.267	0.090	0.142
73033-0009	3	9	3	29,031	35,819	1.234	0.094	0.229
73062-0023	9	4	3	23,170	21,905	0.945	0.355	0.167
76041-0014	4	7	3	17,214	17,214	1.000	0.212	0.371
76062-01011	19	24	3	27,474	26,356	0.959	0.632	0.832
77012-0002	5	2	3	9,693	8,443	0.870	0.471	0.216

Table 2-4. Intersection Locations - "Injury" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
77031-0010	6	2	2	13,618	14,475	1.063	0.604	0.189
77052-0109	10	2	2	11,874	12,909	1.087	1.154	0.212
77132-0001	4	6	3	16,915	17,340	1.025	0.216	0.316
78042-0008	6	1	3	10,025	20,000	1.995	0.547	0.046
80041-0004	9	6	3	9,797	8,356	0.853	0.839	0.656
81031-0005	11	8	2	17,177	18,574	1.081	0.877	0.590
81031-0006	6	7	3	20,455	18,480	0.903	0.268	0.346
81031-0011	10	11	3	22,260	25,378	1.140	0.410	0.396
81032-0010	19	6	3	21,022	16,815	0.800	0.825	0.326
81072-0012	6	6	3	17,567	17,200	0.979	0.312	0.319
81072-0015	5	10	3	32,097	23,632	0.736	0.142	0.386
82051-0004	11	9	3	15,644	14,872	0.950	0.642	0.553
82051-0007	7	9	3	21,860	22,594	1.034	0.292	0.364
82061-0046	17	15	3	42,331	34,188	0.808	0.367	0.401
82061-0047	13	9	3	29,800	34,333	1.152	0.398	0.239
82131-0066	2	5	2	25,500	20,350		0.107	0.337
82141-0011	7	10	3	44,925	46,866	1.043	0.142	0.195
83031-0004	8	9	3	21,981	22,724	1.034	0.332	0.362
83032-0113	5	11	3	15,770	17,310	1.098	0.290	0.580

Table 2-5. Intersection Locations - "Left-Turn Head-On" Accidents

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	2	3	2	11,550	14,000	1.212	0.237	0.294
09011-0101	0	0	1	21,600	20,829	0.964	0.000	0.000
09011-01003	1	0	3	22,500	27,200	1.209	0.041	0.000
09012-0005	1	1	2	7,050	7,633	1.083	0.194	0.179
09033-0006	9	3	2	11,050	12,900	1.167	1.116	0.319
09042-0019	4	1	3	24,000	16,200	0.675	0.152	0.056
09042-0126	0	0	3	20,000	15,000	0.750	0.000	0.000
11052-0017	1	0	3	18,046	22,106	1.220	0.051	0.000
11101-0001	1	2	3	11,313	12,121	1.071	0.081	0.151
13031-0008	1	2	3	9,063	8,460	0.933	0.101	0.216
13061-0046	0	0	3	22,714	11,770	0.518	0.000	0.000
13121-0007	1	6	2	11,449	12,600	0.000	0.120	0.652
14011-0112	1	1	3	7,200	7,500	1.042	0.127	0.122
14032-0001	2	0	3	8,450	7,733	0.915	0.216	0.000
18032-0006	1	4	3	3,633	2,733	0.752	0.251	1.337
19021-0006	1	2	3	12,950	11,200	0.865	0.071	0.163
19031-0002	2	1	3	17,510	19,267	1.100	0.104	0.047
22011-0008	1	5	3	10,000	12,000	1.200	0.091	0.381
23012-0003	1	0	3	33,113	37,000	1.117	0.028	0.000
23012-0007	5	7	3	20,771	22,032	1.061	0.220	0.290
24011-0009	0	3	2	18,972	17,685	0.932	0.000	0.232
26011-0002	0	3	3	12,143	13,164	1.084	0.000	0.208
28013-0006	5	5	3	17,600	22,320	1.268	0.259	0.205
28013-0119	0	2	2	19,200	21,750	1.133	0.000	0.126
28013-0021	1	2	3	26,733	23,860	0.890	0.034	0.077
28013-0024	0	1	2	16,800	16,317	0.970	0.000	0.084

Table 2-5. Intersection Locations - "Left-Turn Head-On" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
28013-0026	1	2	2	22,124	21,241	0.960	0.062	0.129
33043-0115	1	5	3	21,073	38,965	1.849	0.043	0.117
34081-0001	0	0	3	5,855	6,200	1.058	0.000	0.000
39011-0012	2	11	2	18,184	22,317	1.227	0.151	0.675
39081-0015	1	10	2	23,500	25,650		0.058	0.534
39082-0016	0	0	2	16,169	19,422	1.200	0.000	0.000
39121-0002	0	2	2	6,608	13,301	2.013	0.000	0.206
41063-0019	7	16	2	29,000	33,750	1.164	0.331	0.649
41081-0012	10	5	3	16,975	22,135	1.300	0.538	0.206
41081-0015	13	8	2	16,860	18,000	1.068	1.056	0.609
41101-0005	0	3	2	15,027	14,684	0.977	0.000	0.280
44011-0007	3	10	2	19,833	35,377	1.784	0.207	0.387
46061-0018	1	2	3	14,528	13,075	0.900	0.063	0.140
46082-0010	0	4	3	18,400	15,855	0.862	0.000	0.230
47082-0013	1	4	2	13,121	11,692	0.891	0.104	0.469
47121-0003	1	3	3	6,700	5,100	0.760	0.136	0.537
50011-0055	2	2	1	60,433	54,700	0.905	0.091	0.100
50031-0028	5	19	3	36,400	34,600	0.951	0.125	0.501
50031-0033	2	13	3	37,637	39,118	1.039	0.049	0.303
50072-0010				22,593	19,837	0.878		
52042-0014	2	1	3	23,634	21,470	0.908	0.077	0.043
52044-0010	5	2	3	18,988	15,752	0.830	0.240	0.116
52044-0011	1	0	3	17,495	18,303	1.046	0.052	0.000
52061-0001	1	5	3	16,899	19,508	1.150	0.054	0.234
53021-0009	1	4	3	20,653	19,816	0.959	0.044	0.184
54022-0002	2	1	2	13,151	14,994	1.140	0.208	0.091
56023-0027	0	0	3	10,166	11,600	1.141	0.000	0.000
58042-0011	0	6	3	12,582	15,541	1.230	0.000	0.353

Table 2-5. Intersection Locations - "Left-Turn Head-On" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
58052-0005	25	4	3	29,030	36,341	1.252	0.786	0.101
58053-01002	7	3	3	13,043	10,412	0.798	0.490	0.263
59043-0001	0	0	1	9,254	8,767	0.947	0.000	0.000
61023-0002	4	5	3	14,833	13,192	0.889	0.246	0.346
61151-0008	0	1	2	19,440	22,646	1.165	0.000	0.060
62011-0005	2	12	2	9,200	16,250		0.298	1.012
63041-0113	3	7	2	22,369	25,539	1.142	0.184	0.375
63041-0021	9	26	3	28,650	25,200	0.880	0.287	0.942
63052-0022	1	5	3	40,118	51,141	1.275	0.023	0.089
63053-0011	0	1	3	36,611	36,385	0.990	0.000	0.025
63054-0003	21	7	3	19,208	18,391	0.957	0.998	0.348
63082-0009	0	0	3	40,992	42,868	1.046	0.000	0.000
63112-0013	3	4	3	28,518	33,843	1.187	0.096	0.108
63112-0125	0	2	3	30,301	30,329	1.001	0.000	0.060
63131-01028	1	4	3	36,463	41,135	1.128	0.025	0.089
63132-0009	5	4	3	31,629	37,432	1.183	0.114	0.098
70012-0014	2	5	3	21,308	16,280	0.764	0.086	0.280
70012-0121	0	0	3	18,664	16,682	0.894	0.000	0.000
70013-0001	3	3	3	23,075	23,208	1.006	0.119	0.118
70023-0012	1	4	3	20,277	21,937	1.300	0.045	0.167
70023-0120	3	9	3	16,843	19,100	1.134	0.163	0.430
70031-0001	3	6	2	11,945	12,121	1.015	0.344	0.678
70041-0005	3	7	2	10,350	11,100	1.070	0.397	0.864
73032-0002	1	5	3	20,245	25,657	1.267	0.045	0.178
73033-0009	1	3	3	29,031	35,819	1.234	0.031	0.076
73062-0023	4	3	3	23,170	21,905	0.945	0.158	0.125
76041-0014	0	0	3	17,214	17,214	1.000	0.000	0.000
76062-01011	27	30	3	27,474	26,356	0.959	0.897	1.040
77012-0002	2	0	3	9,693	8,443	0.870	0.188	0.000

Table 2-5. Intersection Locations - "Left-Turn Head-On" Accidents (Continued)

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Volume Growth Rate	Acc. Rate Before Signal	Acc. Rate After Signal
77031-0010	0	1	2	13,618	14,475	1.063	0.000	0.095
77052-0109	2	0	2	11,874	12,909	1.087	0.231	0.000
77132-0001	2	0	3	16,915	17,340	1.025	0.108	0.000
78042-0008	5	1	3	10,025	20,000	1.995	0.445	0.046
80041-0004	0	3	3	9,797	8,356	0.853	0.000	0.328
81031-0005	1	2	2	17,177	18,574	1.081	0.080	0.148
81031-0006	3	0	3	20,455	18,480	0.903	0.134	0.000
81031-0011	0	2	3	22,260	25,378	1.140	0.000	0.072
81032-0010	2	1	3	21,022	16,815	0.800	0.087	0.054
81072-0012	0	0	3	17,567	17,200	0.979	0.000	0.000
81072-0015	0	0	3	32,097	23,632	0.736	0.000	0.000
82051-0004	1	0	3	15,644	14,872	0.950	0.058	0.000
82051-0007	1	3	3	21,860	22,594	1.034	0.042	0.121
82061-0046	0	1	3	42,331	34,188	0.808	0.000	0.027
82061-0047	0	0	3	29,800	34,333	1.152	0.000	0.000
82131-0066	0	0	2	25,500	20,350		0.000	0.000
82141-0011	0	0	3	44,925	46,866	1.043	0.000	0.000
83031-0004	1	1	3	21,981	22,724	1.034	0.042	0.040
83032-0113	1	2	3	15,770	17,310	1.098	0.058	0.106

APPENDIX 3 - "BEFORE" AND "AFTER" ACCIDENT DATA AT 27 CROSSOVER LOCATIONS

NOTE: Study period is the number of years of "before" or "after" accident data considered in the analysis. For example, study period 2 years means, 2 years of "before" accident data and 2 years of "after" accident data were considered.

Table 3-1. Crossover Locations - "Total" Accidents

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Rates Acc. Before Signal	Rates Acc. After Signal
50051-0107	48	47	3	51,733	57,800	0.847	0.743
50051-0123	54	47	3	42,600	41,733	1.158	1.028
50051-0146	27	13	3	37,400	41,200	0.659	0.288
50051-0204	25	46	2	47,150	46,600	0.726	1.352
50051-0223	29	42	3	42,600	41,733	0.622	0.919
50051-0246	18	22	3	37,400	41,200	0.440	0.488
63031-0104	153	143	2	49,400	64,400	4.240	3.040
63051-0134	3	12	2	44,470	43,600	0.092	0.377
63051-0234	16	25	2	44,470	43,600	0.493	0.785
63082-0016	16	12	2	38,900	44,300	0.563	0.371
63082-0212	18	13	3	52,524	65,696	0.313	0.181
63111-0101	15	41	3	33,550	32,467	0.408	1.153
63112-0112	35	42	3	38,568	34,678	0.829	1.106
82052-0031	46	70	2	55,400	56,425	1.137	1.699
82052-0040	44	54	3	58,500	48,867	0.687	1.009
82052-0102	17	11	3	43,550	51,600	0.356	0.195
82052-0111	48	57	3	61,500	51,600	0.713	1.009
82052-0211	43	27	3	60,900	51,600	0.645	0.478
82061-0213	96	57	3	47,422	36,487	1.849	1.427
82062-0101	23	54	3	61,213	64,970	0.343	0.759
82062-0201	31	56	3	61,213	65,826	0.462	0.777
82141-0015	12	17	2	34,400	50,850	0.478	0.458
82143-0105	65	48	3	89,000	78,400	0.667	0.559
82192-0225	25	50	3	61,633	57,400	0.370	0.796
82211-0121	18	2	1	42,169	41,805	1.169	0.131
82211-0146	10	9	3	43,566	37,024	0.210	0.222
82211-0221	34	25	3	49,327	43,643	0.629	0.523

Table 3-2. Crossover Locations - "Right-Angle" Accidents

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Rates Acc. Before Signal	Rates Acc. After Signal
50051-0107	4	5	3	51,733	57,800	0.071	0.079
50051-0123	16	15	3	42,600	41,733	0.343	0.394
50051-0146	3	8	3	37,400	41,200	0.073	0.177
50051-0204	1	7	2	47,150	46,600	0.029	0.206
50051-0223	0	1	3	42,600	41,733	0.000	0.022
50051-0246	1	0	3	37,400	41,200	0.024	0.000
63031-0104	26	31	2	49,400	64,400	0.720	0.660
63051-0134	0	0	2	44,470	43,600	0.000	0.000
63051-0234	1	0	2	44,470	43,600	0.031	0.000
63082-0016	0	1	2	38,900	44,300	0.000	0.031
63082-0212	0	0	3	52,524	65,696	0.000	0.000
63111-0101	0	1	3	33,550	32,467	0.000	0.028
63112-0112	2	5	3	38,568	34,678	0.047	0.132
82052-0031	9	4	2	55,400	56,425	0.223	0.097
82052-0040	3	1	3	58,500	48,867	0.047	0.019
82052-0102	0	0	3	43,550	51,600	0.000	0.000
82052-0111	4	3	3	61,500	51,600	0.059	0.053
82052-0211	7	0	3	60,900	51,600	0.105	0.000
82061-0213	20	11	3	47,422	36,487	0.385	0.275
82062-0101	1	0	3	61,213	64,970	0.015	0.000
82062-0201	1	1	3	61,213	65,826	0.015	0.014
82141-0015	1	0	2	34,400	50,850	0.040	0.000
82143-0105	13	8	3	89,000	78,400	0.133	0.093
82192-0225	0	2	3	61,633	57,400	0.000	0.032
82211-0121	2	0	1	42,169	41,805	0.130	0.000
82211-0146	0	0	3	43,566	37,024	0.000	0.000
82211-0221	6	0	3	49,327	43,643	0.111	0.000

Table 3-3. Crossover Locations - "Rear-End" Accidents

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Rates Acc. Before Signal	Rates Acc. After Signal
50051-0107	15	31	3	51,733	57,800	0.265	0.490
50051-0123	14	14	3	42,600	41,733	0.300	0.306
50051-0146	8	2	3	37,400	41,200	0.195	0.044
50051-0204	6	22	2	47,150	46,600	0.174	0.647
50051-0223	12	24	3	42,600	41,733	0.257	0.525
50051-0246	9	12	3	37,400	41,200	0.220	0.266
63031-0104	78	70	2	49,400	64,400	2.160	1.480
63051-0134	2	6	2	44,470	43,600	0.062	0.189
63051-0234	4	12	2	44,470	43,600	0.123	0.377
63082-0016	4	3	2	38,900	44,300	0.141	0.093
63082-0212	7	4	3	52,524	65,696	0.122	0.056
63111-0101	7	27	3	33,550	32,467	0.191	0.759
63112-0112	13	20	3	38,568	34,678	0.308	0.527
82052-0031	18	47	2	55,400	56,425	0.445	1.141
82052-0040	10	42	3	58,500	48,867	0.156	0.785
82052-0102	5	9	3	43,550	51,600	0.105	0.159
82052-0111	18	33	3	61,500	51,600	0.267	0.584
82052-0211	19	18	3	60,900	51,600	0.285	0.319
82061-0213	43	15	3	47,422	36,487	0.828	0.375
82062-0101	10	36	3	61,213	64,970	0.149	0.506
82062-0201	7	30	3	61,213	65,826	0.104	0.416
82141-0015	6	10	2	34,400	50,850	0.239	0.269
82143-0105	20	13	3	89,000	78,400	0.205	0.151
82192-0225	7	25	3	61,633	57,400	0.104	0.398
82211-0121	13	2	1	42,169	41,805	0.845	0.131
82211-0146	4	7	3	43,566	37,024	0.084	0.173
82211-0221	11	21	3	49,327	43,643	0.204	0.439

Table 3-4. Crossover Locations - "Injury" Accidents

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Rates Acc. Before Signal	Rates Acc. After Signal
50051-0107	13	18	3	51,733	57,800	0.229	0.284
50051-0123	9	14	3	42,600	41,733	0.193	0.306
50051-0146	7	5	3	37,400	41,200	0.171	0.111
50051-0204	5	18	2	47,150	46,600	0.145	0.529
50051-0223	5	12	3	42,600	41,733	0.107	0.263
50051-0246	5	5	3	37,400	41,200	0.122	0.111
63031-0104	52	46	2	49,400	64,400	1.440	0.978
63051-0134	1	5	2	44,470	43,600	0.031	0.157
63051-0234	3	8	2	44,470	43,600	0.092	0.251
63082-0016	4	4	2	38,900	44,300	0.141	0.124
63082-0212	4	4	3	52,524	65,696	0.070	0.056
63111-0101	5	15	3	33,550	32,467	0.136	0.422
63112-0112	10	8	3	38,568	34,678	0.237	0.211
82052-0031	6	19	2	55,400	56,425	0.148	0.461
82052-0040	14	21	3	58,500	48,867	0.219	0.392
82052-0102	6	2	3	43,550	51,600	0.126	0.035
82052-0111	9	23	3	61,500	51,600	0.134	0.407
82052-0211	13	9	3	60,900	51,600	0.195	0.159
82061-0213	23	18	3	47,422	36,487	0.440	0.451
82062-0101	8	19	3	61,213	64,970	0.119	0.267
82062-0201	8	19	3	61,213	65,826	0.119	0.264
82141-0015	6	4	2	34,400	50,850	0.239	0.108
82143-0105	29	18	3	89,000	78,400	0.298	0.210
82192-0225	9	19	3	61,633	57,400	0.133	0.302
82211-0121	6	1	1	42,169	41,805	0.390	0.066
82211-0146	7	5	3	43,566	37,024	0.147	0.123
82211-0221	6	10	3	49,327	43,643	0.111	0.209

Table 3-5. Crossover Locations - "Left-Turn Head-On" Accidents

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Before Volume	After Volume	Rates Acc. Before Signal	Rates Acc. After Signal
50051-0107	1	0	3	51,733	57,800	0.018	0.000
50051-0123	0	2	3	42,600	41,733	0.000	0.044
50051-0146	0	0	3	37,400	41,200	0.000	0.000
50051-0204	0	3	2	47,150	46,600	0.000	0.088
50051-0223	0	1	3	42,600	41,733	0.000	0.022
50051-0246	0	0	3	37,400	41,200	0.000	0.000
63031-0104	3	6	2	49,400	64,400	0.083	0.127
63051-0134	0	1	2	44,470	43,600	0.000	0.031
63051-0234	0	0	2	44,470	43,600	0.000	0.000
63082-0016	0	1	2	38,900	44,300	0.000	0.031
63082-0212	1	2	3	52,524	65,696	0.017	0.028
63111-0101	1	2	3	33,550	32,467	0.027	0.056
63112-0112	0	2	3	38,568	34,678	0.000	0.053
82052-0031	0	0	2	55,400	56,425	0.000	0.000
82052-0040	4	0	3	58,500	48,867	0.062	0.000
82052-0102	0	0	3	43,550	51,600	0.000	0.000
82052-0111	0	1	3	61,500	51,600	0.000	0.018
82052-0211	1	0	3	60,900	51,600	0.015	0.000
82061-0213	0	2	3	47,422	36,487	0.000	0.050
82062-0101	0	1	3	61,213	64,970	0.000	0.014
82062-0201	0	5	3	61,213	65,826	0.000	0.069
82141-0015	0	1	2	34,400	50,850	0.000	0.027
82143-0105	2	5	3	89,000	78,400	0.021	0.058
82192-0225	0	1	3	61,633	57,400	0.000	0.016
82211-0121	0	0	1	42,169	41,805	0.000	0.000
82211-0146	0	0	3	43,566	37,024	0.000	0.000
82211-0221	0	0	3	49,327	43,643	0.000	0.000

APPENDIX 4 - "BEFORE" AND "AFTER" ACCIDENT DATA AT 26 RAMP LOCATIONS

NOTE: Study period is the number of years of "before" or "after" accident data considered in the analysis. For example, study period 2 years means, 2 years of "before" accident data and 2 years of "after" accident data were considered.

Table 4-1. Ramp Locations - "Total" Accidents

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Average Acc. Freq./Year Before	After
23081-0002	18	16	3	6.00	5.33
25031-0005	14	8	1	14.00	8.00
25032-0006	25	29	2	12.50	14.50
25084-0004	6	9	2	3.00	4.50
38101-0008	6	25	2	3.00	12.50
39022-0004	50	20	3	16.67	6.67
39024-0003	2	2	1	2.00	2.00
41027-0006	73	25	3	24.33	8.30
41027-0007	8	18	2	4.00	9.00
41051-0011	29	24	3	9.67	8.00
44011-0003	7	8	1	7.00	8.00
50061-0018	4	9	1	4.00	9.00
58152-0005	9	14	2	4.50	7.00
61072-0109	32	16	2	16.00	8.00
63022-0001	31	6	1	31.00	6.00
63022-0006	62	72	3	20.67	24.00
63022-0101	23	4	1	23.00	4.00
63081-0202	5	7	2	2.50	3.50
63174-0001	48	19	2	24.00	9.50
63174-0003	100	95	2	50.00	47.50
81074-0002	22	12	2	11.00	6.00
82025-0011	28	24	3	9.33	8.00
82125-0001	17	12	3	5.70	4.00
82125-0003	5	4	1	5.00	4.00
82194-0003	32	21	2	16.00	10.50
82292-0103	14	14	2	7.00	7.00

Table 4-2. Ramp Locations -- "Right-Angle" Accidents

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Average Acc. Freq./Year Before	After
23081-0002	0	1	3	0.00	0.33
25031-0005	0	0	1	0.00	0.00
25032-0006	2	4	2	1.00	2.00
25084-0004	2	1	2	1.00	0.50
38101-0008	0	3	2	0.00	1.50
39022-0004	5	2	3	1.67	0.67
39024-0003	0	0	1	0.00	0.00
41027-0006	3	1	3	1.00	0.33
41027-0007	1	3	2	0.50	1.50
41051-0011	1	1	3	0.33	0.33
44011-0003	0	0	1	0.00	0.00
50061-0018	0	0	1	0.00	0.00
58152-0005	1	0	2	0.50	0.00
61072-0109	2	0	2	1.00	0.00
63022-0001	0	0	1	0.00	0.00
63022-0006	17	4	3	5.67	1.33
63022-0101	0	0	1	0.00	0.00
63081-0202	0	0	2	0.00	0.00
63174-0001	2	0	2	1.00	0.00
63174-0003	3	2	2	1.50	1.00
81074-0002	0	2	2	0.00	1.00
82025-0011	16	9	2	8.00	4.50
82125-0001	1	1	3	0.33	0.33
82125-0003	0	0	1	0.00	0.00
82194-0003	2	1	2	1.00	0.50
82292-0103	2	0	2	1.00	0.00

Table 4-3. Ramp Locations -- "Rear-End" Accidents

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Average Acc. Freq./Year Before	After
23081-0002	4	6	3	1.33	2.00
25031-0005	0	0	1	0.00	0.00
25032-0006	6	11	2	3.00	5.50
25084-0004	0	2	2	0.00	1.00
38101-0008	1	8	2	0.50	4.00
39022-0004	8	9	3	2.67	3.00
39024-0003	0	0	1	0.00	0.00
41027-0006	33	5	3	11.00	1.67
41027-0007	3	6	2	1.50	3.00
41051-0011	7	9	3	2.33	3.00
44011-0003	0	0	1	0.00	0.00
50061-0018	0	0	1	0.00	0.00
58152-0005	2	7	2	1.00	3.50
61072-0109	6	4	2	3.00	2.00
63022-0001	0	0	1	0.00	0.00
63022-0006	17	41	3	5.67	13.67
63022-0101	0	0	1	0.00	0.00
63081-0202	1	1	2	0.50	0.50
63174-0001	4	3	2	2.00	1.50
63174-0003	33	31	2	16.50	15.50
81074-0002	4	1	2	2.00	0.50
82025-0011	5	82 missing	3	1.67	0.00
82125-0001	2	6	3	0.67	2.00
82125-0003	0	0	1	0.00	0.00
82194-0003	3	2	2	1.50	1.00
82292-0103	5	7	2	2.50	3.50

Table 4-4. Ramp Locations - "Injury" Accidents

Site No.	Acc. Before Signal	Acc. After Signal	Study Period (Yrs)	Average Acc. Freq./Year Before	After
23081-0002	1	2	3	0.33	0.67
25031-0005	6	5	1	6.00	5.00
25032-0006	9	9	2	4.50	4.50
25084-0004	3	3	2	1.50	1.50
38101-0008	1	9	2	0.50	4.50
39022-0004	11	3	3	3.67	1.00
39024-0003	0	1	1	0.00	1.00
41027-0006	15	6	3	5.00	2.00
41027-0007	1	4	2	0.50	2.00
41051-0011	7	8	3	2.33	2.67
44011-0003	2	2	1	2.00	2.00
50061-0018	2	4	1	2.00	4.00
58152-0005	2	3	2	1.00	1.50
61072-0109	8	5	2	4.00	2.50
63022-0001	9	2	1	9.00	2.00
63022-0006	19	26	3	6.33	8.67
63022-0101	8	2	1	8.00	2.00
63081-0202	0	1	2	0.00	0.50
63174-0001	10	6	2	5.00	3.00
63174-0003	23	33	2	11.50	16.50
81074-0002	7	4	2	3.50	2.00
82025-0011	18	16	3	6.00	5.33
82125-0001	5	3	3	1.67	1.00
82125-0003	3	1	1	3.00	1.00
82194-0003	5	5	2	2.50	2.50
82292-0103	4	3	2	2.00	1.50

APPENDIX 5 - ACCIDENT DATA OF INTERSECTIONS WITH NO GEOMETRIC CHANGES

Table 5-1. Intersection Locations With No Geometric Changes - "Total" Accidents

Intersections-Individual Locations "Before"/"After"

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	1.660	2.446
09011-0101	1.522	1.973
09012-0005	4.663	1.077
09033-0006	3.471	2.442
09042-0019	0.951	1.578
09042-0126	1.142	1.035
11052-0017	0.405	0.785
13061-0046	1.568	1.552
13121-0007	5.743	5.871
14011-0112	6.722	2.922
14032-0001	3.567	1.890
18032-0006	4.525	7.686
19031-0002	1.565	0.806
23012-0003	1.544	0.740
23012-0007	1.715	1.451
26011-0002	1.279	1.110
33043-0115	2.210	1.008
34081-0001	1.560	0.736
39011-0012	0.452	1.473
39081-0015	0.758	2.296
39082-0016	1.271	0.494
39121-0002	2.280	0.824
41063-0019	1.559	2.232
41101-0005	2.826	1.866
44011-0007	1.243	1.084
46082-0010	1.142	1.267
47082-0013	1.670	1.640
47121-0003	3.135	4.119
50031-0028	1.280	2.639
52044-0010	1.587	1.102
52044-0011	2.714	0.748
52061-0001	1.513	1.685
54022-0002	1.250	1.096
56023-0027	2.785	1.496
58042-0011	1.306	1.645
58053-01002	3.781	1.316
59043-0001	2.072	0.313
61023-0002	1.847	1.731
61151-0008	1.832	2.662
62011-0005	2.978	3.203

Table 5-1. Intersection Locations With No Geometric Changes - "Total" Accidents (Continued)

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
63041-0021	1.498	2.609
63052-0022	1.275	1.179
63053-0011	0.374	0.326
63082-0009	1.181	0.511
63112-0013	1.377	1.052
63112-0125	0.482	0.903
63132-0009	1.819	1.488
70012-0014	1.329	1.402
70012-0121	2.887	1.588
70023-0012	2.567	1.124
73032-0002	0.722	0.712
73033-0009	0.503	0.765
76041-0014	0.584	0.743
76062-01011	2.593	2.356
77012-0002	3.203	2.055
78042-0008	1.366	0.731
81031-0005	1.435	1.991
81031-0006	0.848	1.235
81031-0011	1.354	1.116
81032-0010	2.259	1.466
81072-0015	0.484	0.657
82051-0004	3.211	0.860
82051-0007	0.961	0.687
82061-0046	0.971	1.229
82061-0047	1.195	0.798
82131-0066	0.591	0.942
83032-0113	0.927	1.319

Table 5-2. Intersection Locations With No Geometric Changes - "Right-Angle" Accidents

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	0.474	0.391
09011-0101	0.254	0.263
09012-0005	1.943	0.179
09033-0006	0.000	0.637
09042-0019	0.609	1.127
09042-0126	0.320	0.061
11052-0017	0.051	0.413
13061-0046	0.844	0.543
13121-0007	2.512	1.631
14011-0112	3.551	0.852
14032-0001	0.540	0.236
18032-0006	1.508	0.668
19031-0002	0.574	0.237
23012-0003	1.048	0.370
23012-0007	0.835	0.332
26011-0002	0.301	0.069
33043-0115	1.647	0.352
34081-0001	0.312	0.147
39011-0012	0.075	0.123
39081-0015	0.000	0.481
39082-0016	0.169	0.000
39121-0002	1.866	0.206
41063-0019	0.472	0.406
41101-0005	1.094	0.373
44011-0007	0.207	0.039
46082-0010	0.347	0.173
47082-0013	0.522	0.351
47121-0003	0.954	0.000
50031-0028	0.125	0.158
52044-0010	0.192	0.116
52044-0011	0.418	0.050
52061-0001	0.432	0.281
54022-0002	0.000	0.091
56023-0027	1.168	0.157
58042-0011	0.435	0.529
58053-01002	0.980	0.263
59043-0001	1.480	0.000
61023-0002	0.677	0.069
61151-0008	0.282	0.726
62011-0005	0.596	0.674
63041-0021	0.096	0.145
63052-0022	0.478	0.196

Table 5-2. Intersection Locations With No Geometric Changes - "Right-Angle" Accidents (Continued)

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
63053-0011	0.000	0.025
63082-0009	0.869	0.277
63112-0013	0.448	0.189
63112-0125	0.030	0.090
63132-0009	0.231	0.244
70012-0014	0.171	0.168
70012-0121	2.006	0.493
70023-0012	0.991	0.250
73032-0002	0.090	0.142
73033-0009	0.189	0.025
76041-0014	0.053	0.053
76062-01011	0.229	0.450
77012-0002	0.565	0.324
78042-0008	0.273	0.091
81031-0005	0.718	0.516
81031-0006	0.089	0.198
81031-0011	0.246	0.036
81032-0010	0.391	0.000
81072-0015	0.000	0.039
82051-0004	0.292	0.000
82051-0007	0.000	0.000
82061-0046	0.388	0.561
82061-0047	0.582	0.293
82131-0066	0.000	0.067
83032-0113	0.116	0.211

Table 5-3. Intersection Locations With No Geometric Changes - "Rear-End" Accidents

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	0.237	1.272
09011-0101	0.254	0.921
09012-0005	1.360	0.179
09033-0006	0.620	0.743
09042-0019	0.114	0.338
09042-0126	0.091	0.365
11052-0017	0.000	0.165
13061-0046	0.402	0.621
13121-0007	0.359	0.978
14011-0112	1.522	1.096
14032-0001	0.216	0.590
18032-0006	0.251	2.339
19031-0002	0.156	0.190
23012-0003	0.165	0.197
23012-0007	0.220	0.580
26011-0002	0.000	0.486
33043-0115	0.217	0.352
34081-0001	0.312	0.295
39011-0012	0.075	0.368
39081-0015	0.291	0.748
39082-0016	0.508	0.282
39121-0002	0.000	0.515
41063-0019	0.189	0.609
41101-0005	0.729	0.746
44011-0007	0.138	0.387
46082-0010	0.199	0.288
47082-0013	0.313	0.469
47121-0003	0.545	0.537
50031-0028	0.527	1.425
52044-0010	0.289	0.522
52044-0011	0.470	0.249
52061-0001	0.108	0.468
54022-0002	0.208	0.091
56023-0027	0.180	0.630
58042-0011	0.145	0.353
58053-01002	0.910	0.175
59043-0001		
61023-0002	0.246	0.277
61151-0008	0.705	1.452
62011-0005	0.447	0.843
63041-0021	0.446	0.870
63052-0022	0.228	0.196

Table 5-3. Intersection Locations With No Geometric Changes - "Rear-End" Accidents (Continued)

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
63053-0011	0.050	0.100
63082-0009	0.134	0.170
63112-0013	0.256	0.594
63112-0125	0.090	0.542
63132-0009	0.549	0.512
70012-0014	0.300	0.561
70012-0121	0.245	0.328
70023-0012	0.495	0.291
73032-0002	0.045	0.320
73033-0009	0.157	0.357
76041-0014	0.159	0.371
76062-01011	0.565	0.347
77012-0002	0.283	0.649
78042-0008	0.182	0.183
81031-0005	0.239	0.885
81031-0006	0.179	0.297
81031-0011	0.205	0.720
81032-0010	0.261	0.543
81072-0015	0.199	0.348
82051-0004	0.934	0.553
82051-0007	0.167	0.323
82061-0046	0.194	0.427
82061-0047	0.123	0.293
82131-0066	0.107	0.135
83032-0113	0.116	0.317

Table 5-4. Intersection Locations With No Geometric Changes - "Injury" Accidents

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	0.712	1.272
09011-0101	0.634	0.921
09012-0005	0.907	0.239
09033-0006	1.116	1.062
09042-0019	0.190	0.451
09042-0126	0.274	0.183
11052-0017	0.101	0.372
13061-0046	0.362	0.543
13121-0007	1.316	2.501
14011-0112	1.903	0.122
14032-0001	0.324	0.354
18032-0006	2.514	2.005
19031-0002	0.678	0.474
23012-0003	0.607	0.272
23012-0007	0.660	0.580
26011-0002	0.150	0.347
33043-0115	0.997	0.375
34081-0001	0.468	0.147
39011-0012	0.151	0.491
39081-0015	0.117	0.694
39082-0016	0.424	0.141
39121-0002	1.244	0.309
41063-0019	0.614	0.893
41101-0005	1.094	0.653
44011-0007	0.414	0.465
46082-0010	0.248	0.634
47082-0013	0.418	0.703
47121-0003	1.227	0.537
50031-0028	0.502	1.161
52044-0010	0.337	0.174
52044-0011	0.470	0.100
52061-0001	0.216	0.796
54022-0002	0.417	0.183
56023-0027	0.180	0.394
58042-0011	0.581	0.881
58053-01002	1.470	0.439
59043-0001	0.493	0.104
61023-0002	0.739	0.346
61151-0008	0.634	0.907
62011-0005	0.893	1.264
63041-0021	0.857	0.805
63052-0022	0.638	1.087

Table 5-4. Intersection Locations With No Geometric Changes - "Injury" Accidents (Continued)

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
63053-0011	0.075	0.176
63082-0009	0.579	0.192
63112-0013	0.480	0.513
63112-0125	0.121	0.452
63132-0009	0.289	0.122
70012-0014	0.429	0.449
70012-0121	1.076	0.219
70023-0012	0.495	0.416
73032-0002	0.090	0.142
73033-0009	0.094	0.229
76041-0014	0.212	0.371
76062-01011	0.632	0.832
77012-0002	0.471	0.216
78042-0008	0.547	0.046
81031-0005	0.877	0.590
81031-0006	0.268	0.346
81031-0011	0.410	0.396
81032-0010	0.825	0.326
81072-0015	0.142	0.386
82051-0004	0.642	0.553
82051-0007	0.292	0.364
82061-0046	0.367	0.401
82061-0047	0.398	0.239
82131-0066	0.107	0.337
83032-0113	0.290	0.580

Table 5-5. Intersection Locations With No Geometric Changes - "Head-On Left-Turn" Accidents

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	0.237	0.294
09011-0101	0.000	0.000
09012-0005	0.194	0.179
09033-0006	1.116	0.319
09042-0019	0.152	0.056
09042-0126	0.000	0.000
11052-0017	0.051	0.000
13061-0046	0.000	0.000
13121-0007	0.120	0.652
14011-0112	0.127	0.122
14032-0001	0.216	0.000
18032-0006	0.251	1.337
19031-0002	0.104	0.047
23012-0103	0.028	0.000
23012-0007	0.220	0.290
26011-0002	0.000	0.208
33043-0115	0.043	0.117
34081-0001	0.000	0.000
39011-0012	0.151	0.675
39081-0015	0.058	0.534
39082-0016	0.000	0.000
39121-0002	0.000	0.206
41063-0019	0.331	0.649
41101-0005	0.000	0.280
44011-0007	0.207	0.387
46082-0010	0.000	0.230
47082-0013	0.104	0.469
47121-0003	0.136	0.537
50031-0028	0.125	0.501
52044-0010	0.240	0.116
52044-0011	0.052	0.000
52061-0001	0.054	0.234
54022-0002	0.208	0.091
56023-0027	0.000	0.000
58042-0011	0.000	0.353
58053-01002	0.490	0.263
59043-0001	0.000	0.000
61023-0002	0.246	0.346
61151-0008	0.000	0.060
62011-0005	0.298	1.012
63041-0021	0.287	0.942
63052-0022	0.023	0.089

Table 5-5. Intersection Locations With No Geometric Changes - "Head-On Left-Turn" Accidents (Continued)

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
63053-0011	0.000	0.025
63082-0009	0.000	0.000
63112-0013	0.096	0.108
63112-0125	0.000	0.060
63132-0009	0.114	0.098
70012-0014	0.086	0.280
70012-0121	0.000	0.000
70023-0012	0.045	0.167
73032-0002	0.045	0.178
73033-0009	0.031	0.076
76041-0014	0.000	0.000
76062-01011	0.897	1.040
77012-0002	0.188	0.000
78042-0008	0.445	0.046
81031-0005	0.080	0.148
81031-0006	0.134	0.000
81031-0011	0.000	0.072
81032-0010	0.087	0.054
81072-0015	0.000	0.000
82051-0004	0.058	0.000
82051-0007	0.042	0.121
82061-0046	0.000	0.027
82061-0047	0.000	0.000
82131-0066	0.000	0.000
83032-0113	0.058	0.106

APPENDIX 6 - "BEFORE" AND "AFTER" ACCIDENT RATES FOR SITES WHERE LEFT-TURN LANE ADDED COINCIDENT TO SIGNAL INSTALLATION

Table 6-1. Intersection Locations With Left-Turn Lane Added Coincident to Signal Installation - "Total" Accidents

Site No.	Before Rate	After Rate
11101-0001	3.310	1.582
13031-0008	1.522	0.756
22011-0008	1.918	1.979
28013-0021	0.683	0.804
28013-0026	2.105	1.032
41081-0012	1.937	1.403
41081-0015	2.844	2.207
46061-0018	1.634	1.467
47082-0013	1.670	1.640
58052-0005	2.800	0.930
70013-0001	1.781	0.984
70023-0120	2.494	1.530
70041-0005	3.706	3.085
73062-0023	0.709	0.542

Table 6-2. Intersection Locations With Left-Turn Lane Added Coincident to Signal Installation - "Right-Angle" Accidents

Site No.	Before Rate	After Rate
11101-0001	2.341	0.904
13031-0008	1.209	0.324
22011-0008	0.457	0.304
28013-0021	0.034	0.230
28013-0026	0.248	0.000
41081-0012	0.377	0.165
41081-0015	0.244	0.076
46061-0018	0.377	0.489
47082-0013	0.522	0.351
58052-0005	0.598	0.126
70013-0001	0.831	0.157
70023-0120	1.844	0.335
70041-0005	1.324	0.247
73062-0023	0.000	0.000

Table 6-3. Intersection Locations With Left-Turn Lane Added Coincident to Signal Installation - "Rear-End" Accidents

Site No.	Before Rate	After Rate
11101-0001	0.161	0.301
13031-0008	0.202	0.216
22011-0008	0.639	0.381
28013-0021	0.239	0.191
28013-0026	0.557	0.709
41081-0012	0.323	0.371
41081-0015	0.244	0.685
46061-0018	0.189	0.279
47082-0013	0.313	0.469
58052-0005	0.315	0.176
70013-0001	0.277	0.433
70023-0120	0.217	0.622
70041-0005	0.265	0.494
73062-0023	0.434	0.250

Table 6-4. Intersection Locations With Left-Turn Lane Added Coincident to Signal Installation - "Injury" Accidents

Site No.	Before Rate	After Rate
11101-0001	1.453	0.829
13031-0008	1.008	0.432
22011-0008	0.457	0.152
28013-0021	0.239	0.268
28013-0026	0.805	0.387
41081-0012	0.699	0.206
41081-0015	1.056	0.457
46061-0018	0.314	0.419
47082-0013	0.418	0.703
58052-0005	1.007	0.226
70013-0001	0.633	0.394
70023-0120	1.084	0.478
70041-0005	1.191	0.864
73062-0023	0.355	0.167

Table 6-5. Intersection Locations With Left-Turn Lane Added Coincident to Signal Installation - "Head-On Left-Turn" Accidents

Site No.	Before Rate	After Rate
11101-0001	0.081	0.151
13031-0008	0.101	0.216
22011-0008	0.091	0.381
28013-0021	0.034	0.077
28013-0026	0.062	0.129
41081-0012	0.538	0.206
41081-0015	1.056	0.609
46061-0018	0.063	0.140
47082-0013	0.104	0.469
58052-0005	0.786	0.101
70013-0001	0.119	0.118
70023-0120	0.163	0.430
70041-0005	0.397	0.864
73062-0023	0.158	0.125

APPENDIX 7 - ACCIDENT DATA FOR SITES WITH AND WITHOUT LEFT-TURN LANE

Table 7-1. Intersection Locations - "Total" Accidents With Left-Turn Lane

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	1.660	2.446
09011-0101	1.522	1.973
09012-0005	4.663	1.077
11052-0017	0.405	0.785
14032-0001	3.567	1.890
18032-0006	4.525	7.686
19031-0002	1.565	0.806
23012-0003	1.544	0.740
33043-0115	2.210	1.008
34081-0001	1.560	0.736
41063-0019	1.559	2.232
44011-0007	1.243	1.084
46082-0010	1.142	1.267
47082-0013	1.670	1.640
47121-0003	3.135	4.119
50031-0028	1.280	2.639
52044-0010	1.587	1.102
52061-0001	1.513	1.685
58053-01002	3.781	1.316
61023-0002	1.847	1.731
63041-0021	1.498	2.609
63132-0009	1.819	1.488
70031-0001	1.376	1.243
73032-0002	0.722	0.712
73033-0009	0.503	0.765
77012-0002	3.203	2.055
77052-0109	2.653	1.273
81031-0005	1.435	1.991
81032-0010	2.259	1.466

Table 7-2. Intersection Locations - "Total" Accidents Without Left-Turn Lane

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
09033-0006	3.471	2.442
09042-0019	0.951	1.578
09042-0126	1.142	1.035
13061-0046	1.568	1.552
14011-0112	6.722	2.922
23012-0007	1.715	1.451
26011-0002	1.279	1.110
39011-0012	0.452	1.473
39081-0015	0.758	2.296
39082-0016	1.271	0.494
39121-0002	2.280	1.030
41101-0005	2.826	1.866
52044-0011	2.714	0.748
54022-0002	1.250	1.096
56023-0027	2.785	1.496
58042-0011	1.306	1.645
59043-0001	2.072	0.313
61151-0008	1.832	2.662
62011-0005	2.978	3.203
63052-0022	1.275	1.179
63053-0011	0.374	0.326
63082-0009	1.181	0.511
63112-0125	0.482	0.903
70012-0014	1.329	1.402
76041-0014	0.584	0.743
76062-01011	2.593	2.356
77031-0010	1.609	0.568
78042-0008	1.366	0.731
80041-0004	2.610	0.994
81031-0006	0.848	1.235
81031-0011	1.354	1.116
82051-0004	3.211	0.860
82051-0007	0.961	0.687
82061-0046	0.971	1.229
83032-0113	0.927	1.319

Table 7-3. Intersection Locations - "Right-Angle" Accidents With Left-Turn Lane

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	0.474	0.391
09011-0101	0.254	0.263
09012-0005	1.943	0.179
11052-0017	0.051	0.413
14032-0001	0.540	0.236
18032-0006	1.508	0.668
19031-0002	0.574	0.237
23012-0003	1.048	0.370
33043-0115	1.647	0.352
34081-0001	0.312	0.147
41063-0019	0.472	0.406
44011-0007	0.207	0.039
46082-0010	0.347	0.173
47082-0013	0.522	0.351
47121-0003	0.954	0.000
50031-0028	0.125	0.158
52044-0010	0.192	0.116
52061-0001	0.432	0.281
58053-01002	0.980	0.263
61023-0002	0.677	0.069
63041-0021	0.096	0.145
63132-0009	0.231	0.244
70031-0001	0.229	0.113
73032-0002	0.090	0.142
73033-0009	0.189	0.025
77012-0002	0.565	0.324
77052-0109	1.500	0.318
81031-0005	0.718	0.516
81032-0010	0.391	0.000

Table 7-4. Intersection Locations - "Right-Angle" Accidents Without Left-Turn Lane

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
09033-0006	0.000	0.637
09042-0019	0.609	1.127
09042-0126	0.320	0.061
13061-0046	0.844	0.543
14011-0112	3.551	0.852
23012-0007	0.835	0.332
26011-0002	0.301	0.069
39011-0012	0.075	0.123
39081-0015	0.000	0.481
39082-0016	0.169	0.000
39121-0002	1.866	0.206
41101-0005	1.094	0.373
52044-0011	0.418	0.050
54022-0002	0.000	0.091
56023-0027	1.168	0.157
58042-0011	0.435	0.529
59043-0001	1.480	0.000
61151-0008	0.282	0.726
62011-0005	0.596	0.674
63052-0022	0.478	0.196
63053-0011	0.000	0.025
63082-0009	0.869	0.277
63112-0125	0.030	0.090
70012-0014	0.171	0.168
76041-0014	0.053	0.053
76062-01011	0.229	0.450
77031-0010	1.107	0.095
78042-0008	0.273	0.091
80041-0004	1.864	0.437
81031-0006	0.089	0.198
81031-0011	0.246	0.036
82051-0004	0.292	0.000
82051-0007	0.000	0.000
82061-0046	0.388	0.561
83032-0113	0.116	0.211

Table 7-5. Intersection Locations - "Rear-End" Accidents With Left-Turn Lane

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	0.237	1.272
09011-0101	0.254	0.921
09012-0005	1.360	0.179
11052-0017	0.000	0.165
14032-0001	0.216	0.590
18032-0006	0.251	2.339
19031-0002	0.156	0.190
23012-0003	0.165	0.197
33043-0115	0.217	0.352
34081-0001	0.312	0.295
41063-0019	0.189	0.609
44011-0007	0.138	0.387
46082-0010	0.199	0.288
47082-0013	0.313	0.469
47121-0003	0.545	0.537
50031-0028	0.527	1.425
52044-0010	0.289	0.522
52061-0001	0.108	0.468
58053-01002	0.910	0.175
61023-0002	0.246	0.277
63041-0021	0.446	0.870
63132-0009	0.549	0.512
70031-0001	0.229	0.226
73032-0002	0.045	0.320
73033-0009	0.157	0.357
77012-0002	0.283	0.649
77052-0109	0.346	0.424
81031-0005	0.239	0.885
81032-0010	0.261	0.543

Table 7-6. Intersection Locations - "Rear-End" Accidents Without Left-Turn Lane

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
09033-0006	0.620	0.743
09042-0019	0.114	0.338
09042-0126	0.091	0.365
13061-0046	0.402	0.621
14011-0112	1.522	1.096
23012-0007	0.220	0.580
26011-0002	0.000	0.486
39011-0012	0.075	0.368
39081-0015	0.291	0.748
39082-0016	0.508	0.282
39121-0002	0.000	0.515
41101-0005	0.729	0.746
52044-0011	0.470	0.249
54022-0002	0.208	0.091
56023-0027	0.180	0.630
58042-0011	0.145	0.353
59043-0001	0.000	0.000
61151-0008	0.705	1.452
62011-0005	0.447	0.843
63052-0022	0.228	0.196
63053-0011	0.050	0.100
63082-0009	0.134	0.170
63112-0125	0.090	0.542
70012-0014	0.300	0.561
76041-0014	0.159	0.371
76062-01011	0.565	0.347
77031-0010	0.302	0.000
78042-0008	0.182	0.183
80041-0004	0.280	0.219
81031-0006	0.179	0.297
81031-0011	0.205	0.720
82051-0004	0.934	0.553
82051-0007	0.167	0.427
82061-0046	0.194	0.427
83032-0113	0.116	0.317

Table 7-7. Intersection Locations - "Injury" Accidents With Left-Turn Lane

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	0.712	1.272
09011-0101	0.634	0.921
09012-0005	0.907	0.239
11052-0017	0.101	0.372
14032-0001	0.324	0.354
18032-0006	2.514	2.005
19031-0002	0.678	0.474
23012-0003	0.607	0.272
33043-0115	0.997	0.375
34081-0001	0.468	0.147
41063-0019	0.614	0.893
44011-0007	0.414	0.465
46082-0010	0.248	0.634
47082-0013	0.418	0.703
47121-0003	1.227	0.537
50031-0028	0.502	1.161
52044-0010	0.337	0.174
52061-0001	0.216	0.796
58053-01002	1.470	0.439
61023-0002	0.739	0.346
63041-0021	0.638	1.087
63132-0009	0.289	0.122
70031-0001	0.459	0.226
73032-0002	0.090	0.142
73033-0009	0.094	0.229
77012-0002	0.471	0.216
77052-0109	1.154	0.212
81031-0005	0.877	0.590
81032-0010	0.825	0.326

Table 7-8. Intersection Locations - "Injury" Accidents Without Left-Turn Lane

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
09033-0006	1.116	1.062
09042-0019	0.190	0.451
09042-0126	0.274	0.183
13061-0046	0.362	0.543
14011-0112	1.903	0.122
23012-0007	0.660	0.580
26011-0002	0.150	0.347
39011-0012	0.151	0.491
39081-0015	0.117	0.694
39082-0016	0.424	0.141
39121-0002	1.244	0.309
41101-0005	1.094	0.653
52044-0011	0.470	0.100
54022-0002	0.417	0.183
56023-0027	0.180	0.394
58042-0011	0.581	0.881
59043-0001	0.493	0.104
61151-0008	0.634	0.907
62011-0005	0.893	1.264
63052-0022	0.205	0.446
63053-0011	0.075	0.176
63082-0009	0.579	0.192
63112-0125	0.121	0.452
70012-0014	0.429	0.449
76041-0014	0.212	0.371
76062-01011	0.632	0.832
77031-0010	0.604	0.189
78042-0008	0.547	0.046
80041-0004	0.839	0.656
81031-0006	0.268	0.346
81031-0011	0.410	0.396
82051-0004	0.642	0.553
82051-0007	0.292	0.364
82061-0046	0.367	0.401
83032-0113	0.290	0.580

Table 7-9. Intersection Locations - "Head-On Left-Turn" Accidents With Left-Turn Lane

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
03051-0003	0.237	0.294
09011-0101	0.000	0.000
09012-0005	0.194	0.179
11052-0017	0.051	0.000
14032-0001	0.216	0.000
18032-0006	0.251	1.337
19031-0002	0.104	0.047
23012-0003	0.028	0.000
33043-0115	0.043	0.117
34081-0001	0.000	0.000
41063-0019	0.331	0.649
44011-0007	0.207	0.387
46082-0010	0.000	0.230
47082-0013	0.104	0.469
47121-0003	0.136	0.537
50031-0028	0.125	0.501
52044-0010	0.240	0.116
52061-0001	0.054	0.234
58053-01002	0.490	0.263
61023-0002	0.246	0.346
63041-0021	0.287	0.942
63132-0009	0.114	0.098
70031-0001	0.344	0.678
73032-0002	0.045	0.178
73033-0009	0.031	0.076
77012-0002	0.188	0.000
77052-0109	0.231	0.000
81031-0005	0.080	0.148
81032-0010	0.087	0.054

Table 7-10. Intersection Locations - "Head-On Left-Turn" Accidents Without Left-Turn Lane

Site No.	Acc. Rate Before Signal	Acc. Rate After Signal
09033-0006	1.116	0.319
09042-0019	0.152	0.056
09042-0126	0.000	0.000
13061-0046	0.000	0.000
14011-0112	0.127	0.122
23012-0007	0.220	0.290
26011-0002	0.000	0.208
39011-0012	0.151	0.675
39081-0015	0.058	0.534
39082-0016	0.000	0.000
39121-0002	0.000	0.206
41101-0005	0.000	0.280
52044-0011	0.052	0.000
54022-0002	0.208	0.091
56023-0027	0.000	0.000
58042-0011	0.000	0.353
59043-0001	0.000	0.000
61151-0008	0.000	0.060
62011-0005	0.298	1.012
63052-0022	0.023	0.089
63053-0011	0.000	0.025
63082-0009	0.000	0.000
63112-0125	0.000	0.060
70012-0014	0.086	0.280
76041-0014	0.000	0.000
76062-01011	0.897	1.040
77031-0010	0.000	0.095
78042-0008	0.445	0.046
80041-0004	0.000	0.328
81031-0006	0.134	0.000
81031-0011	0.000	0.072
82051-0004	0.058	0.000
82051-0007	0.042	0.121
82061-0046	0.000	0.027
83032-0113	0.058	0.106