DRAFT

Contract Research

GDOT Research Project No. 8602

Final Report

CRITERIA FOR TWO-WAY LEFT-TURN LANES VS. OTHER MEDIANS

Volume II:
Accident Comparison of Raised Median and Two-Way Left-Turn Median Treatments

by

Christopher A. Squires, Graduate Student
Peter S. Parsonson, Professor

School of Civil Engineering
Georgia Institute of Technology

Contract with

Department of Transportation
State of Georgia

In cooperation with

U. S. Department of Transportation
Federal Highway Administration

April, 1988

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A UNIT OF THE UNIVERSITY SYSTEM OF GEORGIA
SCHOOL OF CIVIL ENGINEERING
ATLANTA, GEORGIA 30332

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SCHOOL OF CIVIL ENGINEERING
TELEX: 542507 GTRC OCA ATL
TELEPHONE (404) 894-

April 6, 1988

Mr. Peter Malphurs
State Materials & Research Engineer
Office of Materials and Research
Georgia DOT, 15 Kennedy Drive
Forest Park, GA 30050

Attention: Ms. Sondra Selph, Research & Development Bureau

Dear Mr. Malphurs:

Criteria for Two-Way Left-Turn Lanes Vs. Other Medians
GDOT Research Project No. 8602
Georgia Tech Research Project No. E-20-G03

The purpose of this project is to develop a set of design criteria for the choice between two-way left-turn lanes (TWLTL) and raised-curb medians, considering both capacity and safety.

Transmitted herewith are 10 copies of Volume II of the Final Report. It is the last in the series and is entitled "Accident Comparison of Raised Median and Two-Way Left-Turn Lane Median Treatments." It was produced by our graduate student Chris Squires, under my supervision, as his special research project for the Masters Degree. The data base for this report was state-wide in scope and included 50 TWLTL sections and 32 raised-median sections, each over 0.75 miles in length. This data base was much larger than the one used for the Interim Report submitted to your office by letter of October 13, 1987. Therefore we believe that this present report should supersede and replace the portion of the Interim Report dealing with accident-data collection and analysis.

This report concludes that total accidents per million vehicle miles provide the best indication of relative safety of a median type. For the sections studied, these rates showed raised medians to be safer than TWLTL for both four and six-lane sections. Therefore the selection of type of median, considering safety criteria, clearly favors the raised median design.

Most of the Interim Report was concerned with an introduction to the problem, a review of literature, and extensive research on delay and capacity by our graduate students John Hibbard, Joaquin Vargas and Steve Celniker. That portion of the Interim Report has been separated from the accident-data portion and printed as Volume I of the Final Report.

We are very pleased that we have been able to perform much more work than was contemplated in our agreement, without an increase in budget. This was due to the fact that some of the graduate students involved in the project, particularly Chris Squires, performed their work in fulfillment of course requirements, without charge to our budget.

We hope that you will find this project to have been a good value for your research dollar, and that you will allow us other opportunities in the future to be of some service to your office.

Yours very truly,

Peter S. Parsonson
Professor and Project Director

Acknowledgements

The authors gratefully acknowledge Tim Christian at the Georgia D.O.T. Planning Data Services office in Chamblee for answering questions and putting in a lot of computer time to furnish inventory data required for the project. We also thank Dick Graves of the Traffic and Safety Division for providing accident data. Jim Fincher, also of Traffic and Safety, was especially helpful in guiding our procedure and discussing the significance of our results.

Abstract

It is an accepted fact that the installation of a median will reduce accident occurrence along a previously undivided road. However, choice of a median type is often difficult. Two median treatments in common usage are two-way left-turn lanes (TWLTL) and raised medians. Although a great deal of research has focused on these median treatments, there is still doubt as to the comparative safety of these median types.

The purpose of this report is to provide a comparison of safety of raised medians and TWLTL used as median treatments on four and six-lane roads. (Earlier work in this project compared the delay produced by the two types; the results were presented in an Interim Report dated October, 1987). The objective is to provide a statistical comparison of accident rates for the two sections and develop regression equations to model accident experience for each section. Regression analysis was performed using the Biomedical computer programs (BMDP) statistical software.

Suitable sections of state roads were identified throughout Georgia. Data collection for these sites was accomplished with a combination of field collection and data supplied by the Georgia Department of Transportation. Accident data used in the study covered three years: 1984, 1985 and 1986. The average daily traffic (ADT) for the sections ranged from 9500 to 59,000.

The comparison of accident rates was performed for a variety of conditions. Four and six lane sections were analyzed separately. Midblock accident occurrence was also examined in addition to the total accident rates. Comparisons were made on the basis of accidents per million vehicle miles (MVM) and accidents per mile per year. As a point of reference, injury accidents were also compared. It was concluded that total accidents per MVM provide the best indication of relative safety of a median type. For the sections studied, these rates showed raised medians to be safer than TWLTL for both four and six lane sections.

Sixteen regression equations were created to model conditions similar to those of the accident comparison. Equations were developed for raised median and TWLTL sections, four and six lane sections, total and midblock accidents, and accidents per MVM and accidents per mile per year. From the regression equations, tables of expected accident rate values were developed. Conclusions from these tables are based on total accidents per MVM for four and six lane sections. The tables indicated that for four-lane sections, raised medians had a lower accident rate over the range of data studied. Results from six-lane sections were somewhat more complicated. The tables indicated that raised medians would be safer for most conditions. TWLTL had a lower accident rate when the number of driveways per mile is high, the number of signals per mile is low, and the number of approaches per mile is low.

For the most part, results compared favorably with previous research. It was necessary to perform these comparisons on the same terms as the original study. This usually meant using accidents per mile per year along four-lane sections as an indicator of safety, rather than accidents per MVM over all of the sites.

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Chapter 1:
Introduction

This study is intended to provide a basis of comparison between two alternative median treatment types frequently used on arterial roads. Both raised medians and continuous two-way left-turn lanes (TWLTL) are often used on busy four and six lane roads. Implementing either type of median treatment will reduce the number of accidents experienced on an undivided road. This study compares the relative safety of these two median treatments.

A TWLTL is a lane in the center of a road dedicated to left turns by both directions of traffic. TWLTL provide excellent service to the land adjoining a roadway. They provide an area for deceleration and stopping prior to a left turn off of the road. By providing such an area, TWLTL reduce the frequency and severity of rear-end conflicts. They grant additional perception time to drivers making left-turns. They are also used by cars turning onto the road as they accelerate up to speed. TWLTL allow more flexible use of the entire roadway. For instance, temporary work zones can easily be established.

Raised medians facilitate the movement of through traffic along a roadway. Turning movements are concentrated at planned points where they can be accommodated. This concentration reduces the basic number of conflict points for vehicles turning onto or off of the roadway. There is also a reduction in the number of types of driveway manuevers. Raised medians may also be used for their aesthetic qualities.

The purpose of the study is to provide a quantitative basis for determining whether raised medians or TWLTL are safer for a given situation. In order to facilitate this objective, as many sites as possible were identified. The sites were located throughout the state of Georgia. All of the sites were visited in order to determine their suitability and to collect data. The Georgia Department of Transportation provided all of the information which could not be readily collected in the field.

The study was limited to roads with either four or six travel lanes. Data for these two site-types were analyzed independently. Accident data was obtained for injury, and all accidents occurring along a section. Full data analysis was performed for both total and midblock accident occurrence.

The research included a review of previous research, location of sites, collection of site data, statistical analysis of data, development of regression equations to model data, and a comparison with other research results.

Chapter 2:
Previous Research

Since this study was directly linked with a similar project by Joaquin Vargas (1), no literature review, per se, was conducted. A brief summary of the previous research is provided here. For a more detailed review, the Vargas report should be referenced.

An FHWA report by Glennon (2) advocated the use of either TWLTL or raised medians to reduce accidents and delay caused by an undivided roadway. Accident reductions from the undivided highway condition were predicted. Comparing the reductions for raised medians and TWLTL implies that TWLTL would be safer for low and moderate levels of development (measured as having fewer than 60 commercial driveways per mile). Raised medians would be considered safer for high levels of development. The relative safety of the two median types remained constant for all ADT levels studied (less than 5,000, 5,000 to 15,000, and above 15,000).

Glennon also had general comments about each median type. The attractiveness of a TWLTL is the removal of left-turning vehicles from through traffic while still providing maximum left-turn access. TWLTL should be used, in lieu of an undivided road, when there are frequent rear-end conflicts caused by left turning vehicles. They are used on moderate to high-volume highways which have a low number of cross streets and a high number of driveways.

The report went on to say that raised medians eliminate severe conflicts from all minor driveways. Also, there will be a reduction of conflicts at major driveways. However, there will be some increase in conflicts because of indirect left-turn manuevers used to move vehicles to minor driveways. Raised medians are used on major arterials with a moderate to high number of driveways per mile. A cross-street spacing of one-half mile or greater is desired.

Perhaps the most quoted report, to date, has been Martin Parker's Virginia study (3). The study produced regression equations for the accident occurrence of raised median, traversable median (including TWLTL), and undivided highway sections. In addition to the development of regression equations to model accident occurrence, Parker presented general guidelines for the implementation of the various median types. The report said that if stopping sight distance is less than AASHTO standards, a TWLTL should not be used. A raised median should not be used where speeds exceed 45 mph unless the curb face is mountable. Raised medians are desirable when access points are limited to major intersections, there are large pedestrian volumes, or a grid pattern permits circuitous flow of traffic without disrupting residential traffic. Additionally, TWLTL should not be used when access is required on only one side of the street in question.

Douglas Harwood (4) listed characteristics and appropriate implementations of raised medians and TWLTL. Raised medians discourage new strip development. However, they increase travel time for vehicles desiring to turn left where median openings are not provided. They also reduce operational flexibility, such as emergency vehicle operations, lane closures, or work zones. Raised medians are best suited for use on major arterials with high volumes of through traffic and limited access points. They are also appropriate when a highway agency makes a conscious choice to favor the traffic movement function through an area. He went on to say that two-way left-turn lanes reduce delay to left-turning vehicles. They enhance operational flexibility. However, they do not provide any refuge area for pedestrians. Also the inappropriate use of TWLTL by drivers may cause vehicular conflicts. They may encourage strip development. They should be used when there are low to moderate volumes of through traffic.

Several reports, including Hoffman (5), Nemeth (6), McCormick (7), and Thakkar (8), have been written comparing TWLTL with undivided roads. All of this research indicated that TWLTL were preferable to an undivided road. However, these reports did not indicate whether a TWLTL would be preferable to a raised median.

Chapter 3:
Data Collection

Site Selection

Sites were chosen to fit into one of four catagories: TWLTL with 4 or 6 through lanes or Raised Median with 4 or 6 through lanes. Other than the following restrictions, there were no preconceived ideas about the range of data to be expected from these sites. The parameters used for selection were:

- ADT $\geq$ 9500
- Be on a State Route
- Have a constant 4 or 6 through lanes
- Free access to the road at grade (Uncontrolled access)

It was desired to keep ADTs above 9500 and have free access to the road in order to insure that the study incorporated only urban type sections. Sites located on a State Route were necessary to obtain accurate accident data.

Many of the sites chosen were suggested by the earlier work of Joaquin Vargas. All of the remaining sites were found through computer searches of the Georgia D.O.T. road inventories. The inventories provided the preliminary information needed to identify sites including number of through lanes, ADT, access control, type of median treatment, and lane widths.

The initial search for sites was confined to the metropolitan Atlanta area for the sake of convenience. The area included in the search was limited to Fulton, Dekalb, Cherokee, Clayton, Cobb, Gwinnett, and Rockdale counties. This area provided an adequate number of TWLTL sites. However, only four Raised Median sites were identified. Several potential sites had to be eliminated because of the use of a depressed median in some areas instead of a continuous raised median. The search for sites was then broadened to include all of Georgia. From this search, fifteen additional Raised Median sites were found. Also, the number of TWLTL sites increased from sixteen to twenty.

The twenty TWLTL sites have a total length of 74.86 miles. The nineteen Raised

Median sites have a total length of 47.60 miles. Each of these sites was subdivided into sections to the fullest extent possible. Sections were created to have a length greater than 0.75 miles. This was necessary to insure that the data for all of the sections would be representative of actual conditions. Short sections length tend to produce highly fluctuating data. It was also desired to define the sections so that ADT values would remain constant through the section. Keeping the ADT constant was a secondary consideration to maintaining an adequate section length.

SITE DESCRIPTION

Table 3.1 provides a summary of basic site and section characteristics. Table 3.2 lists the location of the sites used in the study. The mileage indicators were used to reference the sites to Georgia D.O.T. road inventories and accident data. In addition to the site summary, an extended site description is given in Appendix A.

Table 3.1: Site and Section characteristics

	TWLTL	Raised Medians
Number of Sites		
4 Lane sections	17	13
6 Lane sections	3	6
Totals	20	19
Number of Sections		
4 Lane sections	42	15
6 Lane sections	8	17
Totals	50	32
Site Lengths		
4 Lane sections	62.48	24.68
6 Lane sections	12.38	22.92
Totals	74.68	47.60
Million Vehicle Miles per year		
4 Lane sections	691.48	228.25
6 Lane sections	149.05	264.42
Totals	840.53	492.68

Table 3.2: Site Location Summary

Site	SR No.	County	Begin Mile	End Mile	Thru Lanes
TWO-WAY LEFT-TURN LANES:					
T1	3	Cobb	1.92	7.12	4
T2	3	Cobb	7.31	7.80	4
T3	3	Cobb	8.12	9.29	4
T4	9	Fulton	19.38	20.69	4
T5	9	Fulton	6.41	17.61	4
T6	54	Clayton	8.22	13.49	4
T7	3	Clayton	11.69	14.42	4
T8	85	Clayton	3.44	4.64	4
T9	279	Fulton	0.24	5.01	4
T10	155	Dekalb	7.70	11.28	4
T11	10	Dekalb	5.67	9.86	6
T12	10	Gwinnett	0.56	12.90	4
T13	13	Dekalb	0.00	6.75	6
T14	13	Dekalb/Gwinnett	7.74(Dekalb)	2.35(Gwin.)	4
T15	42	Dekalb	3.60	4.96	4
T16	26	Bulloch	19.06	20.30	4
T17	121	Richmond	13.54	14.98	6
T18	28	Richmond	7.32	10.76	4
T19	52	Whitfield	0.19	1.86	4
T20	141	Dekalb	2.26	4.88	4
RAISED MEDIANS:					
R1	140	Fulton	6.82	8.24	6
R2	331	Clayton	1.23	3.31	4
R3	42	Dekalb	0.70	3.55	4
R4	11	Bibb	14.96	16.87	4
R5	22	Bibb	11.69	13.47	4
R6	204	Chatham	15.75	21.47	6
R7	204	Chatham	21.47	23.21	4
R8	21	Chatham	11.43	13.04	4
R9	26	Chatham	18.34	21.74	4
R10	26	Bulloch	17.86	18.99	4
R11	4	Richmond	16.96	20.73	6
R12	121	Richmond	10.12	13.46	6
R13	28	Richmond	3.81	4.67	4
R14	52	Whitfield	2.52	4.32	6
R15	85	Muscogee	3.43	4.82	4
R16	1	Muscogee	2.68	6.70	6
R17	1	Muscogee	6.70	7.70	4
R18	1	Muscogee	8.90	12.82	4
R19	141	Dekalb	5.37	7.23	4

DATA COLLECTED

Data for the sections were obtained from three sources:

- Road inventories from Ga. D.O.T. Planning Data Services
- Field collection
- Accident data from Ga. D.O.T. Traffic and Safety Division

Road inventories provided ADT and mileage points accurate to one one-hundredth of a mile. These were used to subdivide sites into sections.

The accident data were obtained in summary form showing fatal accidents, injury accidents, and total accidents for each section. Additionally, this data was provided for the total length of the section and for midblock portions of the section. Accident data were available for 1984, 1985, and 1986 on all sites except T18 and R13, each of which had only two years of data.

Data collected in the field for each section consisted of the number of driveways, signalized intersections, unsignalized approaches (streets), and, for Raised Median sections, median openings other than at signalized intersections.

DATA SUMMARY

The accident data obtained from the Georgia D.O.T. were used to calculate accidents per million vehicle miles and accidents per mile per year. Accidents per million vehicle miles was felt to be the best indicator for comparison between median types. This was true because of the great variation of ADT present in the sites used. However, accidents per mile per year has been calculated for use in comparing this study with other research.

Table 3.3 provides a summary of the accident calculations. The accident rates for each section are shown in Appendix B. Accident rates were calculated for injury accidents, and all accidents (called simply "accidents"). There was no determination made of the number of injuries associated with each section as these numbers are dependent on too many variables outside of the scope of this research.

The summary rates presented in the table were not obtained by averaging the accident rates for individual sections. This would have created an error as the site lengths and ADTs vary. Instead, accidents per MVM were obtained for each section type by summing the number of accidents per year and then dividing that number by the total number of million vehicle miles (MVM) traveled per year. Accidents per mile per year were found by dividing the same accidents per year figure by the sum of section lengths for the section type.

Table 3.3: Summary of Accident Data

	Total Accidents TWLTL	Total Accidents RM	% Diff	Midblock Accidents TWLTL	Midblock Accidents RM	% Diff
Accidents / MVM						
4 Lane sections	8.99	7.67	-14.7%	3.50	1.34	-61.7%
6 Lane sections	10.82	8.15	-24.7%	4.19	1.92	-54.2%
Accidents / Mi / Yr						
4 Lane sections	99.45	70.91	-28.7%	38.78	12.39	-68.1%
6 Lane sections	130.26	94.07	-27.8%	50.46	22.13	-56.1%
Injury Accidents / MVM						
4 Lane sections	2.00	1.70	-15.0%	0.81	0.32	-60.5%
6 Lane sections	3.61	1.90	-47.4%	1.09	0.43	-60.6%
Injury Accidents / Mi / Yr						
4 Lane sections	22.14	15.76	-28.8%	8.91	2.92	-67.2%
6 Lane sections	43.46	21.87	-49.7%	13.14	4.93	-62.5%
Fatal Accidents / MVM						
4 Lane sections	0.01	0.03	-66.7%	0.01	0.01	0.0
6 Lane sections	0.03	0.03	0.0	0.02	0.01	-50.0%
Fatal Accidents / Mi / Yr						
4 Lane sections	0.14	0.29	-51.7%	0.06	0.08	-25.0%
6 Lane sections	0.38	0.39	-2.6%	0.30	0.10	-66.7%

The determination of summary accident rates has led to a dissimilar weighting for the two median types. Accidents per mile per year are weighted on the basis of sum of section lengths for each type. The weighting was incurred from the relative section lengths. For raised medians the rates for four lane sections are weighted 1.1 times the six lane rates. For TWLTL, the weighting is far more unequal because of the long four-lane section length relative to the short six-lane section length. The four-lane section rates have 5.0 times the weight of six-lane section rates. Accidents per MVM are treated similarly. Weighting for these rates is affected on the basis of MVM per year. Again, raised median sections have a nearly equal weight: six-lane section rates are weighted 1.2 times four-lane section rates. TWLTL rates are again heavily in favor of four-lane sections as they are weighted 4.6 times those of six-lane sections.

As can be seen from the table, four-lane rates are lower than six-lane rates. Because of the dissimilar weighting between median types, TWLTL rates for all sections are not going to be as high relative to raised medians. This has the effect of producing a lower percentage difference for the rates of all of the sections than might be expected by viewing the four and six lane rate differences.

The data obtained from road inventories and field collection were converted to a per mile basis (Signals per mile, for instance). These are listed for each section in Appendix C. Table 3.4 summarizes the data. Again, the data is separated by section type.

Table 3.4: Summary of Site Data

		TWLTL		RAISED MEDIAN	
		6 Lane	4 Lane	6 Lane	4 Lane
ADT	Minimum	23712	9500	20360	10180
	Maximum	47685	52240	47180	59070
	Mean	32769	30542	31994	24605
	Stnd Dev.	8308	9881	7969	10866
Drives/mi	Minimum	36.90	10.08	18.18	5.00
	Maximum	144.34	103.53	106.40	76.74
	Mean	71.29	50.16	45.62	33.75
	Stnd Dev.	33.96	21.67	22.84	19.30
Signals/mi	Minimum	1.07	0.00	0.00	0.00
	Maximum	5.66	7.06	4.76	8.14
	Mean	2.63	2.10	2.25	2.26
	Stnd. Dev.	1.54	1.56	1.08	1.97
Openings/mi	Minimum	---	---	0.00	1.14
	Maximum	---	---	7.43	13.79
	Mean	---	---	2.89	3.98
	Stnd. Dev.	---	---	1.91	3.37

Data obtained has been plotted in the form of scatter diagrams. Each of the independent variables is plotted against accidents per MVM and against accidents per mile per year for each of the section types. These are included in Appendix D. The scatter diagrams are perhaps more informative about the data than the statistics listed above.

Four of the scatter diagrams are reproduced on the following pages. From the diagrams, a lack of Raised Median data is evident. As shown in Figure 3.1 below, no four lane raised median sites with an ADT between 30,000 and 59,000 were identified. Also, Figures 3.1 and 3.2 illustrate the difference between midblock accidents per MVM and midblock accidents per mile per year. Accidents per mile per year, plotted in Figure 3.1, show one point, section R19 with 56 accidents per mile per year, to have accidents far above any other section. However, Figure 3.2 plotting accidents per MVM, shows the same section to have a rate similar to the other sections.

Another interesting problem with the data is evident from Figures 3.3 and 3.4. Figure 3.3 seems to indicate that, for midblock accidents, one of the points, section T1A, is an outlier. However, as can be seen in Figure 3.4, this site fits in with the total accident data. Several other sections, including T2, T3, T5D, T5E, R2B, R4, R7, and R15, also have midblock accident rates which are inconsistent with total accident rates for those sections. Most likely, midblock accidents are dependent on more variables than are included in this study.

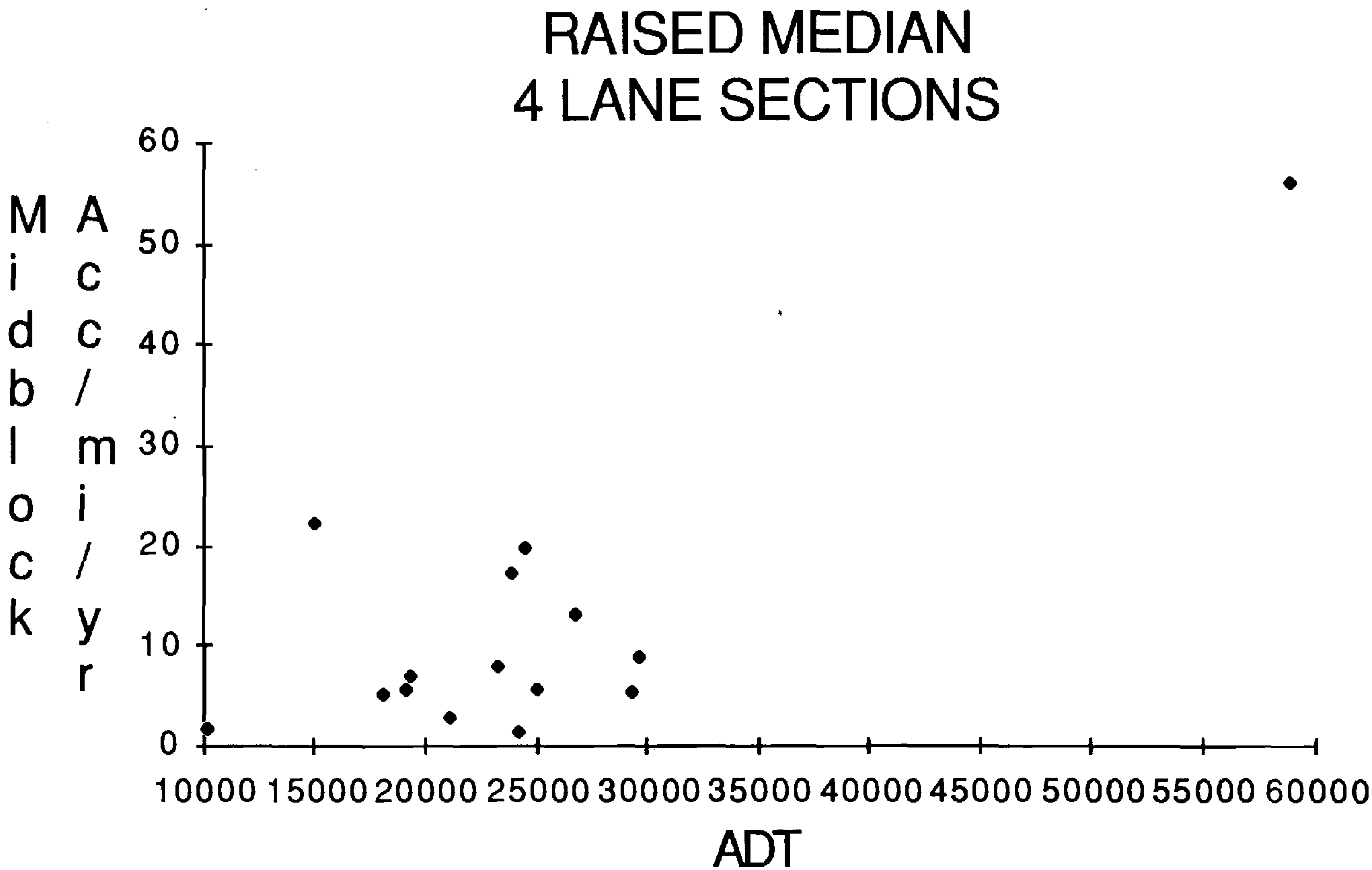

Figure 3.1: Scatter Diagram - Raised Median Four Lane Sections
Midblock Accidents per mile per year

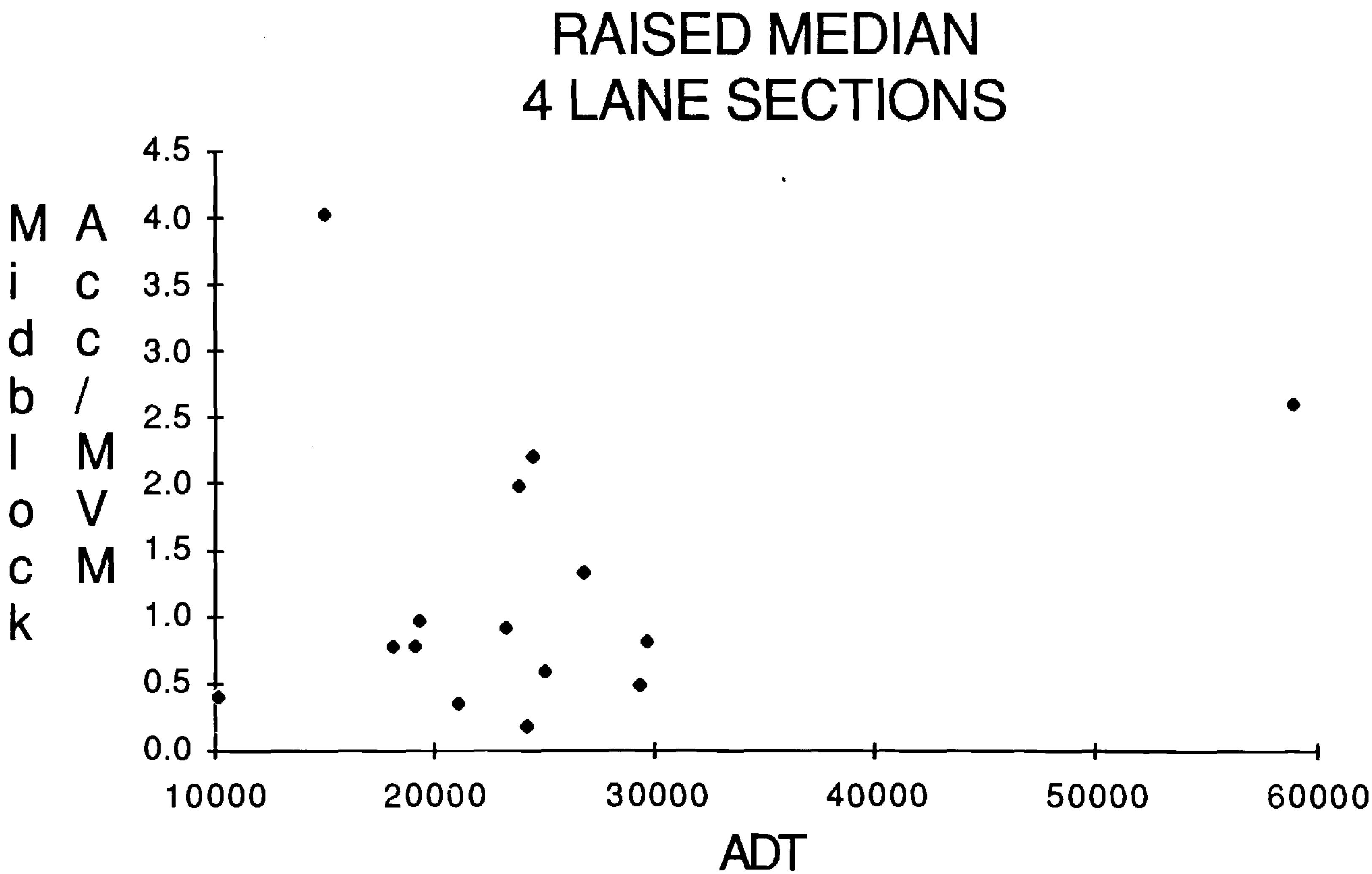

Figure 3.2: Scatter Diagram - Raised Median Four Lane Sections
Midblook Accidents per million vehicle miles

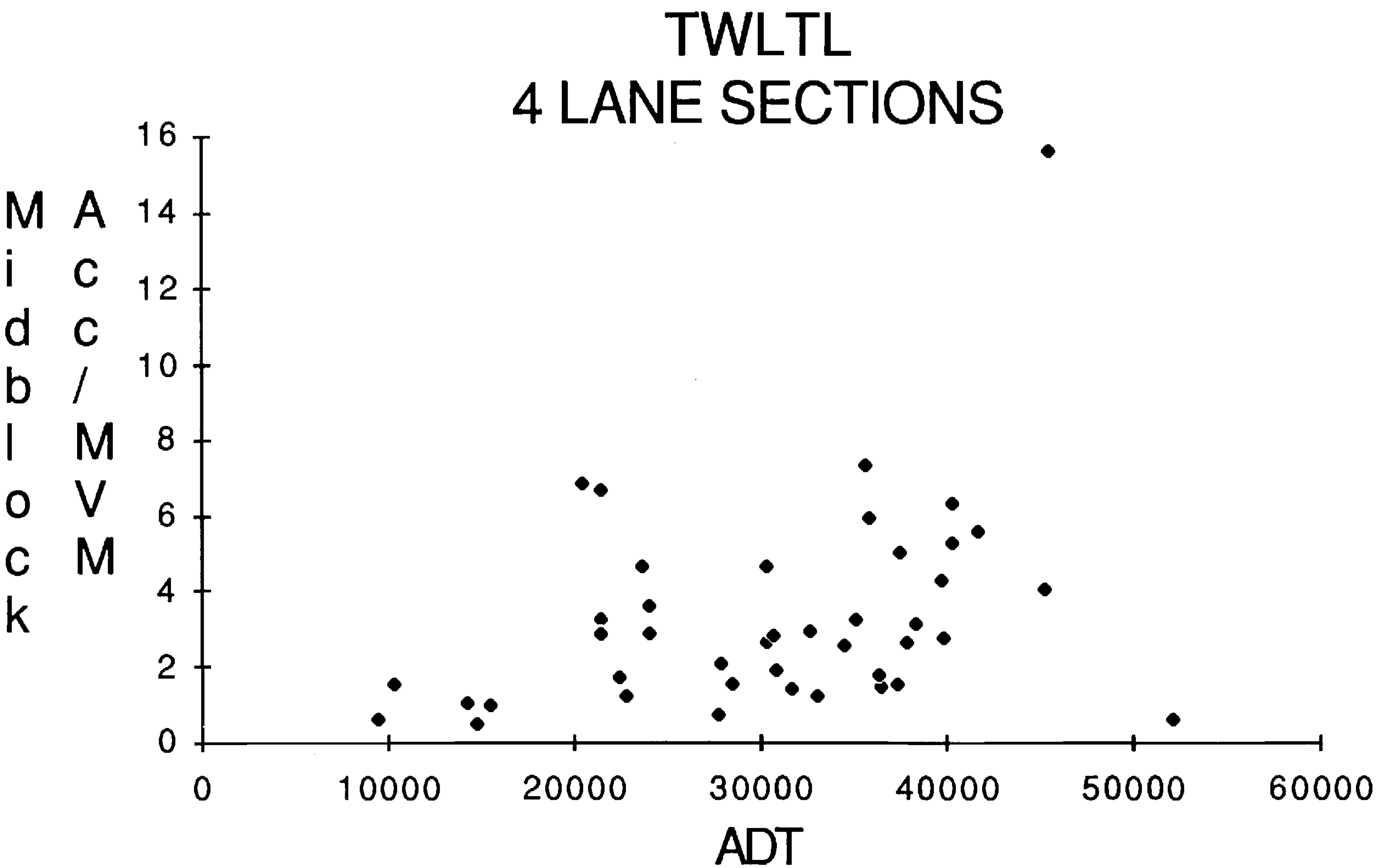

Figure 3.3: Scatter Diagram - TWLTL Four Lane Sections
Midblock Accidents per million vehicle miles

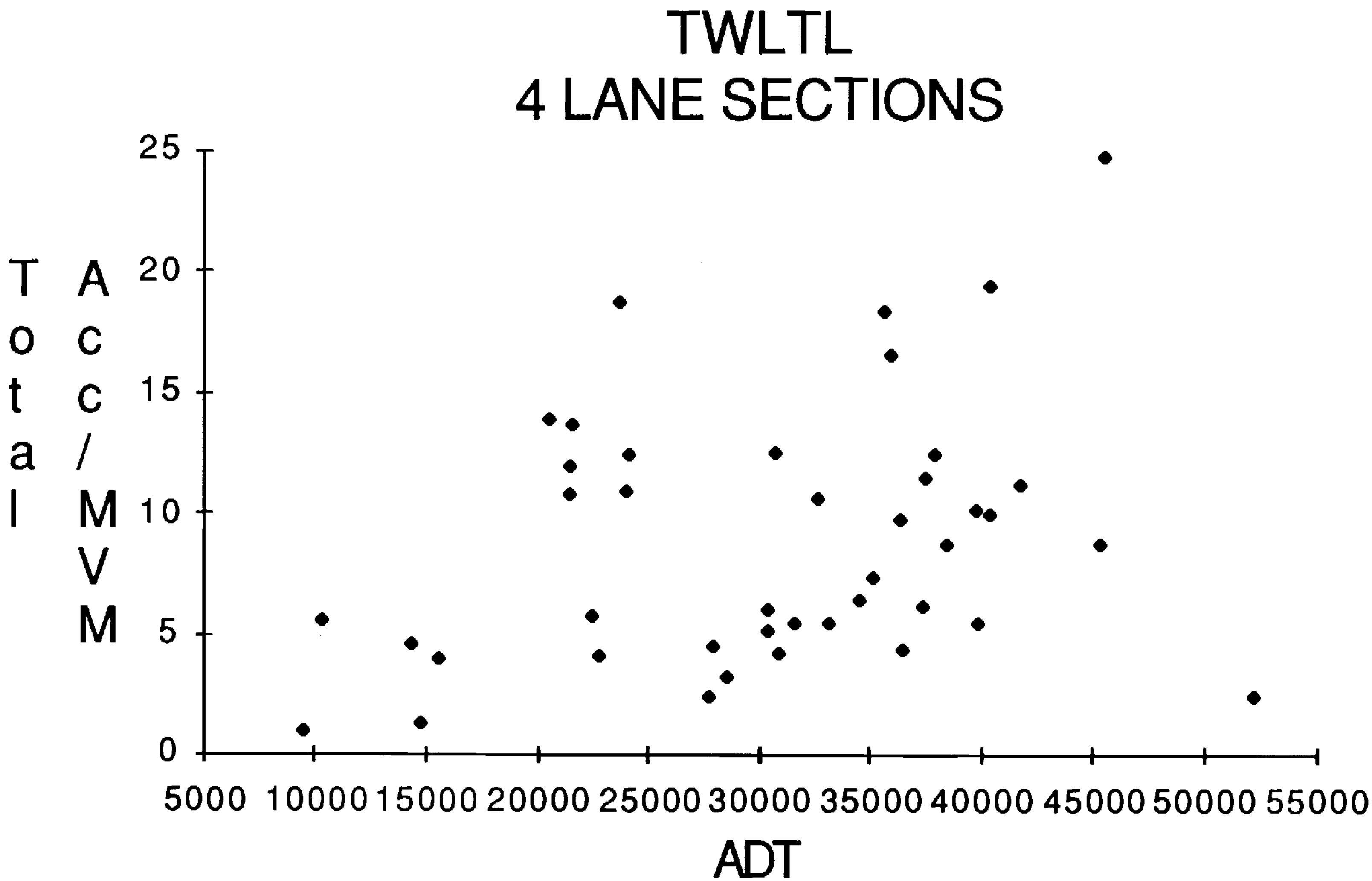

Figure 3.4: Scatter Diagram - TWLTL Four Lane Sections
Total Accidents per Million vehicle miles

Chapter 4:
DATA ANALYSIS and RESULTS

COMPARISON OF ACCIDENT RATES

The accident data were tested to find at what error level there was a significant difference between two-way left-turn lane accidents and Raised Median accidents. Table 4.1 lists the alpha error at which the two accident rates are significantly different. The column labled "Lower Acc. Rate" designates which median type has the lower accident rate in question. The last two columns on the right also indicate whether or not the two rates are significantly different at alpha values of 0.10 and 0.05.

Calculations are based on a one-sided student T distribution. The assumption that $\mu_T = \mu_{RM}$ (mean of TWLTL accidents equals mean of raised median accidents) was tested. With the initial hypothesis, any difference in accident rates is due to chance alone. The alternate hypothesis, for which the alpha error has been calculated, states that the difference in rates is not attributable to chance alone and that the means are significantly different.

Since the t-test was one sided, the alpha error for any difference in rates can vary between 0.0001 and 0.5000 (rounded up). Alpha-errors can also be stated in terms of confidence intervals/ An error of 0.3000, for example, indicates that there is a 70% confidence interval that there is a significant difference between rates.

One can never be certain, statistically speaking, that rates of finite sample sizes are definitely different. However, some of the extremely low alpha errors are as close as one could reasonably expect to get to being absolutely certain of a difference in rates.

Caution should be used in interpreting some of the differences in Table 4.1. Rate comparisons for injury and fatal accidents should be viewed in conjunction with the actual rates shown in the accident rates summary (Table 3.3). Rates for these accidents are extremely low, making them statistically unstable. With such a rare occurrence, as fatal accidents appear to be, the occurrence of just a few additional accidents would drastically affect the difference in rates.

Table 4.1: Significant Difference of Accident Rates between TWLTL and Raised Medians

Section type	Accident type	Lower Acc. Rate	Alpha-error at point of significant difference	Significant difference at alpha-error =0.10	=0.05
Total Accidents					
4 Lane sections	Acc/MVM	RM	0.2168	no	no
	Acc/mile/yr	RM	0.0980	yes	no
6 Lane sections	Acc/MVM	RM	0.0549	yes	no
	Acc/mile/yr	RM	0.0883	yes	no
Midblock Accidents					
4 Lane sections	Acc/MVM	RM	0.0009	yes	yes
	Acc/mile/yr	RM	0.0128	yes	yes
6 Lane sections	Acc/MVM	RM	<0.0005	yes	yes
	Acc/mile/yr	RM	0.0224	yes	yes
Total Injury Accidents					
4 Lane sections	Acc/MVM	RM	0.2016	no	no
	Acc/mile/yr	RM	0.0973	yes	no
6 Lane sections	Acc/MVM	RM	0.0052	yes	yes
	Acc/mile/yr	RM	0.0334	yes	yes
Midblock Injury Accidents					
4 Lane sections	Acc/MVM	RM	0.0043	yes	yes
	Acc/mile/yr	RM	0.0231	yes	yes
6 Lane sections	Acc/MVM	RM	<0.0005	yes	yes
	Acc/mile/yr	RM	<0.0005	yes	yes

(continued on next page)

Table 4.1 continued

Section type	Accident type	Lower Acc. Rate	Alpha-error at point of significant difference	Significant difference at alpha-error =0.10	=0.05
Total Fatal Accidents					
4 Lane sections	Acc/MVM	TWLTL	0.0028	yes	yes
	Acc/mile/yr	TWLTL	0.0099	yes	yes
6 Lane sections	Acc/MVM	No difference:	Rates were equal		
	Acc/mile/yr	TWLTL	0.49	no	no
Midblock Fatal Accidents					
4 Lane sections	Acc/MVM	No difference:	Rates were equal		
	Acc/mile/yr	TWLTL	0.316	no	no
6 Lane sections	Acc/MVM	RM	0.171	no	no
	Acc/mile/yr	RM	0.0385	yes	yes

It is readily apparent that raised medians were always safer in terms of the number of midblock accidents. However, for many reasons, this should not be a decisive factor in comparison of the two median types. Raised medians shift many conflicts from midblock locations to surrounding intersections. Also, conceptually, minimizing total accidents, not just midblock accidents, should be important in comparing the effects of median type.

A comparison of accident rates should be based on the total number of accidents, accepting the provision that injury and fatal accidents are not good statistical indicators. Also, as mentioned earlier, accidents per million vehicle miles (MVM) are prefered to accidents per mile per year. The use of the accident per MVM rate accounts for differences in traffic volumes among sites.

This reduces the most useful comparisons to those of total accidents per MVM for four and six lane sections. As can be seen, the rates still indicate that raised medians are, in general, safer than TWLTL for the range of variable data tested. However, the question of determining an acceptable alpha error is important in assessing significance to the difference in four-lane accident rates.

REGRESSION MODELS

Regression equations were developed to model data obtained for each section type. Four basic section types were used (Raised median and TWLTL each with four and six lane sections). Additionally, data was further subdivided by total and midblock accidents and accidents per MVM and accidents per mile per year. This created sixteen regression models.

Regression equations were found by using BMDP statistical software on the Georgia Tech mainframe computer (Cyber B). Three programs were used. Data was initially tested with BMDP9R and BMDP2R to determine which variables were significant in the regression. BMDP1R was then used to find the final regression equation based on the variable sets found by the first two programs. Appendix E presents a detailed account of the interaction with Cyber B required to use these programs. The appendix also gives part of an example output from the BMDP1R program.

BMDP9R is an "all-possible-subset" regression program, meaning that the program will test all of the possible combinations of data from single variables up to all of the independent variables. The best set of variables is then chosen from the tested combinations on the basis of Mallow's C_p.

This statistic provides a measure of whether the regression equation has enough information in it. Ideally, C_p would equal the number of variables in the equation (designated as p). If $C_p > p$, there is valuable information left out of the equation. Conversely, if $C_p < p$, there are too many variables in the equation. Use of this indicator serves to maximize both the squared multiple correlation (R^2) and the F Ratio (also called F-Statistic). Neither of these statistics, when used individually, gives an accurate description of an equation's value. While it is desired to maximize R^2, excess variables in an equation tend to inflate this figure. While the F Ratio does not describe the relationship between the regression and residual sum of squares, as R^2 does, this statistic reacts inversely with the addition of unnecessary variables. The F Ratio is used with the R^2 statistic to find the best regression equation.

BMDP2R was then employed to find what it considered to be the best set of variables. BMDP2R is a stepwise regression program. This means that the program attempts to enter a variable into an equation and then seeks to remove a variable. Quite often, this results in a smaller variable list than would be suggested by other programs. In fact, for four out of the sixteen models, BMDP9R and BMDP2R differed in their suggested variable list.

All of the suggested variables combinations were then used with BMDP1R in order to find the final regression equation for that section type. BMDP1R is a multiple linear regression program. When alternate variable lists were compared, the equation which produced the best combination of R^2 and F ratio was chosen.

Table 4.2 lists the variables tested for each section type, along with the corresponding R^2 and F Ratio values. In the cases where two variable sets are listed for one section, such as TWLTL six lane section accidents per mile per year, the set listed as number one is the basis for the final regression equation.

Table 4.2: Variable sets used for Regression with R^2 and F Ratio values

Section type		Variable sets	Multiple R^2	F Ratio
TOTAL ACCIDENTS				
TWLTL 6 Lanes -Acc/mi/yr	1)	ADT, Drives/mi, Signals/mi, Apprch/mi	0.9861	53.088
	2)	ADT, Signals/mi	0.8940	21.076
-Acc/MVM		Signals/mi, Appch/mi, Drives/mi	0.9572	29.823
TWLTL 4 Lanes -Acc/mi/yr	1)	ADT, Signals/mi, Apprch/mi	0.6018	19.146
	2)	ADT, Drives/mi, Signals/mi, Approach/mi	0.6328	15.941
-Acc/MVM	1)	Signals/mi	0.4443	31.980
	2)	Drives/mi, Signals/mi, Approach/mi	0.5538	15.720
R. Med. 6 Lanes -Acc/mi/yr		ADT, Signals/mi	0.6242	11.629
-Acc/MVM		Signals/mi	0.2639	5.378
R. Med. 4 Lanes -Acc/mi/yr		ADT, Signals/mi	0.7670	19.752
-Acc/MVM		Signals/mi	0.7990	51.661
MIDBLOCK ACCIDENTS				
TWLTL 6 Lanes -Acc/mi/yr		ADT	0.8294	29.167
-Acc/MVM		ADT	0.6281	10.131
TWLTL 4 Lanes -Acc/mi/yr		ADT, Drives/mi, Apprch/mi	0.4772	11.563
-Acc/MVM		Drives/mi, Apprch/mi	0.3939	12.671
R. Med. 6 Lanes -Acc/mi/yr		ADT	0.2768	5.741
-Acc/MVM		Openings/mi, Signals/mi	0.0749	0.567
R. Med. 4 Lanes -Acc/mi/yr	1)	ADT, Signals/mi	0.7579	18.781
	2)	Signals/mi, Appch/mi, Openings/mi	0.2130	0.993
-Acc/MVM		Drives/mi, Signals/mi	0.7175	15.236

As can be seen from Table 4.2, regression equations were found that fit total accidents well for almost all section types. Raised median six lane section accidents per

MVM were the exception to this. On the other hand, half of the midblock accident models fit poorly. This indicates that the type of data obtained was not adequate to explain midblock accidents.

Regression equations developed are linear. That is, they are of the form: $y = aX_1 + bX_2 + ... + f$. Table 4.3, on the following page, lists regression coefficients for their respective variables.

As can be seen from the table, all of the total accident equations rely on the number of signals per mile. Further, all of the total accident per mile per year equations(and none of the total accident per MVM equations) incorporate ADT.

Somewhat unexpectedly, only TWLTL six lane sections utilized the number of driveways per mile. The coefficients are believed to have been included as negative values in order to counter the partially additive effects of other variables in the equation. The same might be said for the number of approaches per mile coefficient for the TWLTL four lane sections accident per mile per year equation.

Table 4.3: Regression Coefficients

Total Accidents

Section	Accident Type	ADT	Coefficients Drives per mi	Signals per mi	Apprch per mi	Open. per mi	Constant
TWLTL 6 Lanes	Acc/Mi/Yr	0.0050848	-0.89517	32.37220	6.48221	- - -	-73.91125
	Acc/MVM	0	-0.08593	3.08711	0.44833	- - -	7.53150
TWLTL 4 Lanes	Acc/Mi/Yr	0.0038777	0	22.68622	-8.85380	- - -	-21.86862
	Acc/MVM	0	0	2.29131	0	- - -	4.01780
Raised Median 6 Lanes	Acc/Mi/Yr	0.00455	0	22.46702	0	0	-96.48022
	Acc/MVM	0	0	1.96196	0	0	3.85559
Raised Median 4 Lanes	Acc/Mi/Yr	0.0019168	0	16.13910	0	0	-14.79288
	Acc/MVM	0	0	2.72091	0	0	1.91835

Midblock Accidents

Section	Accident Type	ADT	Coefficients Drives per mi	Signals per mi	Apprch per mi	Openings per mi	Constant
TWLTL 6 Lanes	Acc/Mi/Yr	0.0033571	0	0	0	- - -	-60.86993
	Acc/MVM	0.0001292	0	0	0	- - -	-0.36498
TWLTL 4 Lanes	Acc/Mi/Yr	0.0016209	0.52512	0	-8.74647	- - -	4.19088
	Acc/MVM	0	0.05632	0	-0.61905	- - -	3.29801
Raised Median 6 Lanes	Acc/Mi/Yr	0.0009661	0	0	0	0	-8.13549
	Acc/MVM	0	0	0.16643	0	-0.10956	1.86028
							-19.32438
Raised Median 4 Lanes	Acc/Mi/Yr	0.0010357	0	2.51833	0	0	0.98599
	Acc/MVM	0	-0.04567	0.78479	0	0	

EXPECTED VALUE TABLES

From the regression equations, tables of expected accident rates were created. These tables list the accident rates predicted by the regression equations. The full set of tables are shown in Appendix F. The tables cover only data ranges which were present at the sections studied. This has led to different variables value ranges between four and six lane sections. For instance, ADTs range from 20,000 to 50,000 for six lane sections while four lane section ADTs range from 10,000 to 50,000.

However, in some places, the tables give rates at combinations of independent-variable values which were not covered by the sections used in this study. The table of expected four-lane section accidents per MVM has no rates which were not covered by the data obtained. This results from the limited number of independent variables found to be significant in the corresponding regression equations. On the other hand, the table for six lane accidents per MVM has several areas which were not found in the study sections. In this table, all of these were predicted TWLTL rates. This has occurred because of the scarcity of TWLTL six lane sections. For all values of ADT, these areas are:

- -One signal per mile, 30 drives per mile, and six approaches per mile
- -One signal per mile, 60 drives per mile, and four or six approaches per mile
- -One or two signals per mile and 90 drives per mile
- -Two signals per mile, 30 drives per mile, and four or six approaches per mile
- -Three signals per mile and 30 drives per mile
- -Three signals per mile, 60 drives per mile, and six approaches per mile
- -Three signals per mile, 90 drives per mile, and four or six approaches per mile

All of the tables use the same variable format even if some of the variables do not affect the accident rate. This is done to facilitate comparisons and promote clarity. An exception is the table showing midblock accidents per MVM expected for six lane sections which was altered to incorporate the number of openings per mile.

The tables present a great amount of data which bears scrutiny. The purpose of the tables is not to show an absolute accident rate, rather they are intended to show trends in the data and the relative difference between median types.

Two tables from that appendix are reproduced here. Tables 4.4 and 4.5 present the expected total accident per MVM for four and six lanes, respectively. Table 4.4 shows raised medians to be safer than TWLTL over the range of data studied for four lane sections. However, it should also be noted that as the number of signals per mile increases from one to four, the difference in accident rates drops from -26% to -3%.

It is also evident from Table 4.4 that the expected accident rates did not vary much. In fact, the accident rates were calculated from regression equations which were dependent only on the number of signals per mile.

Table 4.5 shows the expected total accident rates for six lane sections. As can be seen, accident rates for TWLTL and raised medians did not depend on the same variables. In an effort to provide a common basis for comparison, Table 4.6 was created. Table 4.6 is similar to Table 4.5 in all regards, except that raised median accidents were modeled as varying with the same variables as TWLTL already did. This model was not used originally because the additional variables do not explain enough information to be statistically significant.

Table 4.4: **Total Accidents/MVM Expected: 4 Lane Sections**

Signals per mile	Drives per mile	Approach per mile	ADT = 10,000 TWLTL	ADT = 10,000 RM	ADT = 30,000 TWLTL	ADT = 30,000 RM	ADT = 50,000 TWLTL	ADT = 50,000 RM
1	25	2	6.31	4.64	6.31	4.64	6.31	4.64
		4	6.31	4.64	6.31	4.64	6.31	4.64
		6	6.31	4.64	6.31	4.64	6.31	4.64
		8	6.31	4.64	6.31	4.64	6.31	4.64
	50	2	6.31	4.64	6.31	4.64	6.31	4.64
		4	6.31	4.64	6.31	4.64	6.31	4.64
		6	6.31	4.64	6.31	4.64	6.31	4.64
		8	6.31	4.64	6.31	4.64	6.31	4.64
2	25	2	8.60	7.36	8.60	7.36	8.60	7.36
		4	8.60	7.36	8.60	7.36	8.60	7.36
		6	8.60	7.36	8.60	7.36	8.60	7.36
		8	8.60	7.36	8.60	7.36	8.60	7.36
	50	2	8.60	7.36	8.60	7.36	8.60	7.36
		4	8.60	7.36	8.60	7.36	8.60	7.36
		6	8.60	7.36	8.60	7.36	8.60	7.36
		8	8.60	7.36	8.60	7.36	8.60	7.36
3	25	2	10.89	10.08	10.89	10.08	10.89	10.08
		4	10.89	10.08	10.89	10.08	10.89	10.08
		6	10.89	10.08	10.89	10.08	10.89	10.08
		8	10.89	10.08	10.89	10.08	10.89	10.08
	50	2	10.89	10.08	10.89	10.08	10.89	10.08
		4	10.89	10.08	10.89	10.08	10.89	10.08
		6	10.89	10.08	10.89	10.08	10.89	10.08
		8	10.89	10.08	10.89	10.08	10.89	10.08
4	25	2	13.18	12.80	13.18	12.80	13.18	12.80
		4	13.18	12.80	13.18	12.80	13.18	12.80
		6	13.18	12.80	13.18	12.80	13.18	12.80
		8	13.18	12.80	13.18	12.80	13.18	12.80
	50	2	13.18	12.80	13.18	12.80	13.18	12.80
		4	13.18	12.80	13.18	12.80	13.18	12.80
		6	13.18	12.80	13.18	12.80	13.18	12.80
		8	13.18	12.80	13.18	12.80	13.18	12.80

Table 4.5: Total Accidents/MVM Expected: 6 Lane Sections

Signals per mi	Drives per mile	Approach per mile	ADT = 20,000 TWLTL	ADT = 20,000 RM	ADT = 30,000 TWLTL	ADT = 30,000 RM	ADT = 40,000 TWLTL	ADT = 40,000 RM	ADT = 50,000 TWLTL	ADT = 50,000 RM
1	30	2	8.94	5.82	8.94	5.82	8.94	5.82	8.94	5.82
		4	9.83	5.82	9.83	5.82	9.83	5.82	9.83	5.82
		6	10.73	5.82	10.73	5.82	10.73	5.82	10.73	5.82
	60	2	6.36	5.82	6.36	5.82	6.36	5.82	6.36	5.82
		4	7.26	5.82	7.26	5.82	7.26	5.82	7.26	5.82
		6	8.15	5.82	8.15	5.82	8.15	5.82	8.15	5.82
2	30	2	12.02	7.78	12.02	7.78	12.02	7.78	12.02	7.78
		4	12.92	7.78	12.92	7.78	12.92	7.78	12.92	7.78
		6	13.82	7.78	13.82	7.78	13.82	7.78	13.82	7.78
	60	2	9.45	7.78	9.45	7.78	9.45	7.78	9.45	7.78
		4	10.34	7.78	10.34	7.78	10.34	7.78	10.34	7.78
		6	11.24	7.78	11.24	7.78	11.24	7.78	11.24	7.78
3	30	2	15.11	9.74	15.11	9.74	15.11	9.74	15.11	9.74
		4	16.01	9.74	16.01	9.74	16.01	9.74	16.01	9.74
		6	16.90	9.74	16.90	9.74	16.90	9.74	16.90	9.74
	60	2	12.53	9.74	12.53	9.74	12.53	9.74	12.53	9.74
		4	13.43	9.74	13.43	9.74	13.43	9.74	13.43	9.74
		6	14.33	9.74	14.33	9.74	14.33	9.74	14.33	9.74

Table 4.6: Total Accidents/MVM Expected using same variables: 6 Lane Sections

Signals per mi	Drives per mile	Approach per mile	ADT = 20,000 TWLTL	ADT = 20,000 RM	ADT = 30,000 TWLTL	ADT = 30,000 RM	ADT = 40,000 TWLTL	ADT = 40,000 RM	ADT = 50,000 TWLTL	ADT = 50,000 RM
1	30	2	8.94	5.34	8.94	5.34	8.94	5.34	8.94	5.34
		4	9.83	5.77	9.83	5.77	9.83	5.77	9.83	5.77
		6	10.73	6.20	10.73	6.20	10.73	6.20	10.73	6.20
	60	2	6.36	5.36	6.36	5.36	6.36	5.36	6.36	5.36
		4	7.26	5.78	7.26	5.78	7.26	5.78	7.26	5.78
		6	8.15	6.21	8.15	6.21	8.15	6.21	8.15	6.21
2	30	2	12.02	7.15	12.02	7.15	12.02	7.15	12.02	7.15
		4	12.92	7.58	12.92	7.58	12.92	7.58	12.92	7.58
		6	13.82	8.00	13.82	8.00	13.82	8.00	13.82	8.00
	60	2	9.45	7.16	9.45	7.16	9.45	7.16	9.45	7.16
		4	10.34	7.59	10.34	7.59	10.34	7.59	10.34	7.59
		6	11.24	8.02	11.24	8.02	11.24	8.02	11.24	8.02
3	30	2	15.11	8.95	15.11	8.95	15.11	8.95	15.11	8.95
		4	16.01	9.38	16.01	9.38	16.01	9.38	16.01	9.38
		6	16.90	9.81	16.90	9.81	16.90	9.81	16.90	9.81
	60	2	12.53	8.97	12.53	8.97	12.53	8.97	12.53	8.97
		4	13.43	9.40	13.43	9.40	13.43	9.40	13.43	9.40
		6	14.33	9.82	14.33	9.82	14.33	9.82	14.33	9.82

In regard to six lane section total accidents, the expected-value tables indicate that raised medians are safer for all ADT levels except when there are two or fewer signals per mile, there are four or fewer approaches per mile, and the number of driveways per mile exceeds 75 or when there are three signals per mile, at least 85 driveways per mile, 2 or fewer approaches per mile and the ADT is lower than 25,000.

These results should be viewed in light of the aforementioned independent variable combinations which were not covered by study data. Specifically, rates for the conditions where TWLTL were found to be safer represent an extrapolation from variable combinations present in the study sections. Of course, the same holds true for many of the conditions for which raised medians were found to be safer.

For four lane total accidents per MVM, raised medians were found to be safer for all conditions.

It is worth noting that these tables correspond well with the rate comparison shown earlier in this section (Table 4.1). Expected-value tables for sections and accident types show diversity in the type of median which is safer at a given variable level. For example, the expected-value table for four-lane section total accidents per mile per year, shown in Appendix F, shows raised medians to be safer for most conditions. However, TWLTL are safer for other conditions. This corresponds to a somewhat high alpha-error of 0.098 shown in the rate comparison (Table 4.1).

Chapter 5:
Comparison with Past Research

This section is intended to give the reader a basis for comparison of the results of this study. While no exhaustive results have been given, limited guidelines have been provided on the basis of the expected-value tables for total accidents per MVM.

Martin Parker's Virginia study (3) presented expected-value tables and a set of general guidelines. These were all developed from a study of four lane roads. The expected-value tables in that report indicate that with ADTs from 10,000 to 30,000, TWLTL have a lower number of accidents per mile when there are fewer than 30 driveways per mile and fewer than 5 streets per mile. In comparison, the expected-value table in Appendix F of this report shows that for four lane total accidents per mile per year a different relationship exists. Drives per mile was not found to be significant for either median type. Further, ADT is quite significant. At an ADT of 10,000, TWLTL are safer except when the approaches per mile are low. At an ADT of 30,000, raised medians are safer except with seven or more approaches per mile and two or fewer signals per mile. The relative safety of TWLTL under conditions of low signals per mile and a high number of approaches is probably attributable to the characteristics associated with less developed areas. Under such conditions, there are probably few points of concentrated left-turns. Such points seem to adversely affect TWLTL safety. The correspondence between ADT and accidents per mile per year is to be expected. As opposing traffic increases, left turns should become safer at concentrated and controlled points such as are found with raised medians.

Also, Parker's general guidelines were found to be applicable to the sections studied in this project only when considering accidents per mile per year. Parker recommends TWLTL when there are fewer than 12 streets per mile and the number of driveways per mile exceeds 50. While this project agrees with these guidelines based on the number of accidents per mile per year, on the basis of accidents per MVM, a TWLTL median would not be recommended for a four lane road.

Douglas Harwood (4), within subjective guidelines, such as the need to accommodate pedestrians, suggested that TWLTL should be used instead of raised medians when the number of driveways per mile exceeded 45 and there were low to moderate volumes of through traffic. Some of the expected-value tables developed in this report suggested the same thing. Certainly, driveways per mile should be high. Forty-five driveways per mile is a lower minimum than any of this report's tables would suggest. Although accidents per MVM remained constant with changing ADTs, accidents per mile per year preclude the use of TWLTL at higher ADT levels.

Joaquin Vargas' study (1) was based on a combination of four and six lane roadway sections. Vargas recommended raised medians with two or fewer signals per mile, more than 80 driveways per mile and less than 3000 peak hour volume (PHV). He found TWLTL to be safer for two to six signals per mile when there were fewer than 80 driveways per mile or when signals per mile exceeded six. The present study is not suitable for comparison above four signals per mile because of limitations in data obtained. However, for ranges that can be compared, the results of the present study run contrary to those in Vargas' report. The present study indicates that for TWLTL to be safer, a lower number of signals per mile is required. Also, TWLTL should have a high number of driveways per mile rather than less than 80 driveways per mile as his report suggests. One point of agreement occurs at the point of effect of ADT (or PHV as Vargas used). Higher ADT values favor raised medians.

The relative safety of TWLTL and raised medians may be inferred from Glennon's report(2). As discussed earlier, the application of Glennon's work is based on anticipated accident reduction from a previously undivided roadway. The accident-rate reductions were determined for a four-lane highway. From the comparison of expected accident reductions for each median type, for all ADT ranges, TWLTL were expected to be safer when "land development" was low to moderate. Low to moderate land development was used to describe areas with several concentrated sources of traffic and few low-volume driveways. The implication of Glennon's report is that for high-development areas, which are assumed to have no high-volume driveways and a large number of low-volume driveways, raised medians are safer. Further, when more high-volume driveways and fewer low-volume driveways are present, TWLTL would be safer. This is contrary to the results obtained in the present study as well as in other studies (3) (4). The unusual results obtained from Glennon's report most likely mean that the relative safety of median types can not be inferred from the accident reduction rates of those median types.

Chapter 6: Conclusions

This study provides a comparison of accident rates between raised medians and two-way left-turn lanes (TWLTL). Regression equations have also been developed to model accident occurrence for each median type. As many sections as possible were used to lend accuracy to the study. In all, 48 TWLTL and 32 raised median sections were used. This has lent stability to the analysis performed.

Comparisons were made for total and midblock accidents, four and six lane sections, accidents per million vehicle miles (MVM) and accidents per mile per year, and injury, and all accidents occurring. While the comparisons of all of these combinations are interesting, total accidents per MVM is considered to give the best indication of the safety of a median type. The comparison of accidents occurring on six lane sections showed, with a low statistical error, raised medians to be safer than TWLTL. The accident comparison for four lane sections also showed raised medians to be safer, but with a higher statistical error.

The relative safety of raised medians probably resulted from the range of ADTs used. With higher volumes of opposing traffic, left-turns seem to be safer at concentrated points, such as raised medians provide. When turns are concentrated at certain points, the area in which conflicts occur is greatly reduced. The turns may also be better accommodated at concentrated points, using traffic signals, for example.

Regression equations were developed for sixteen conditions: Raised medians and TWLTL, four and six lane sections, total and midblock accidents, and accidents per mile per year and accidents per MVM. Again, for the purposes of accurately reflecting safety, total accidents per MVM should be used. The regression equations developed for the four section types using total accidents per MVM are listed on the following page.

TWLTL 6 Lane
Acc/MVM = 3.0871*SIG - O.0859*DR + 0.4483*APP + 7.5315

TWLTL 4 Lane
Acc/MVM = 2.2913*SIG + 4.0178

Raised Median 6 Lane
Acc/MVM = 1.9620*SIG +3.8556

Raised Median 4 Lane
Acc/MVM = 2.7209*SIG + 1.9184

Where: Acc/MVM = Total accidents per million vehicle miles
SIG = Signals per mile
DR = Driveways per mile
APP = Approaches per mile

For all of the regression models created, tables showing the expected accident rates were generated. The expected-value tables for the regression equations listed above produced results comparable to the accident rate comparison performed earlier.

It was found that, for four-lane sections, raised medians were always safer than TWLTL. However, it was also noted that the difference in rates was found to decrease with increasing numbers of signals per mile. For six lane sections, raised medians were again found to be safer except under certain conditions. TWLTL were safer when the following conditions were all met: High numbers of driveways per mile (at least 75), low numbers of signals per mile (two or fewer), and low numbers of approaches per mile (a maximum of five or six depending on signals per mile).

Results of this study compared fairly well with those of other research when viewed using the parameters of the other studies. This usually meant using four lane sections and accidents per mile per year for the comparison. The general guidelines developed in other research appear to be applicable, especially to six lane sections studied. For TWLTL to be safer than raised medians, traffic should be low with few concentrated sources of traffic entering or leaving the road.

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APPENDIX A:

SITE LOCATIONS

The following is an extended site description. Mileage references are made to the Georgia D.O.T. road inventories.

T1, T2, T3: SR 3 in Cobb County from mile 1.92 to mile 9.29. Cobb Parkway runs in and out of the city limits of Marietta with 4 through lanes. SR 3 was divided into 3 sites, and subsequently 5 sections, because of inconsistencies in geometrics. Specifically, the sites are separated by sections of raised medians.

T4: SR 9 in Fulton County from mile 19.38 to mile 20.69. Atlanta Street: in the city of Roswell having 4 through lanes.

T5: SR 9 in Fulton County from mile 6.41 to mile 17.61. Roswell Road: 4 lane section partially within the city limits of Atlanta.

T6: SR 54 in Clayton County from mile 8.22 to mile 13.49. Jonesboro Road: 4 lane section through the city limits of Morrow, Lake City, and Forest Park.

T7: SR 3 in Clayton County from mile 11.69 to mile 14.42. Old Dixie Road: 4 lane section through the city limits of Forest Park.

T8: SR 85 in Clayton County from mile 3.44 to mile 4.64. 4 lane section located in the city of Riverdale.

T9: SR 279 in Fulton County from mile 0.24 to mile 5.01. Old National Highway: 4 lane section.

T10: SR 155 in Dekalb County from mile 7.70 to mile 11.28. Candler Road: 4 lane section partially within the city limits of Atlanta.

T11: SR 10 in Dekalb County from mile 5.67 to mile 9.86. Memorial Drive: 6 lane section.

T12: SR 10 in Gwinnett County from mile 0.56 to mile 12.90. Snellville-Loganville Road: 4 lane section through Snellville city limits.

T13: SR 13 in Dekalb County from mile 0.00 to mile 6.75. Buford Highway: 6 lane section through Chamblee city limits and into Doraville city limits.

T14: SR 13 in Dekalb and Gwinnett Counties from mile 7.74 (Dekalb) to mile 2.35 (Gwinnett). Buford Highway: 4 lane section.

T15: SR 42 in Fulton County from mile 3.60 to mile 4.96. Moreland Avenue: 4 lane section. Site is located along the line between Dekalb and Fulton Counties. Accident data is coded for Fulton county while road inventory information is listed for Dekalb county.

T19: SR 52 in Whitfield County from mile 0.19 to mile 1.86. Walnut Avenue: 4 lane section.

R1: SR 140 in Fulton County from mile 6.82 to mile 8.24. Holcomb Bridge Road: 6 lane section in the city of Roswell.

R2: SR 331 in Clayton County from mile 1.23 to mile 3.31. Forest Parkway: 4 lane section in the city of Forest Park.

R3: SR 42 in Dekalb County from mile 0.70 to mile 3.55. Moreland Avenue: 6 lane section.

R4: SR 11 in Bibb County from mile 14.96 to mile 16.87. 4 lane section in the city of Macon.

R5: SR 22 in Bibb County from mile 11.69 to mile 13.47. 4 lane section in the city of Macon.

R6: SR 204 in Chatham County from mile 15.75 to mile 21.47. Abercorn Street: 6 lane section in the city of Savannah.

R7: SR 204 in Chatham County from mile 21.47 to mile 23.21. Abercorn Street: 4 lane section in the city of Savannah.

R8: SR 21 in Chatham County from mile 11.43 to mile 13.04. 4 lane section in the city of Savannah.

R9: SR 26 in Chatham County from mile 18.34 to mile 21.74. Victory Drive: 4 lane section in the city of Savannah.

R10 T16: SR 26 in Bulloch County from mile 17.86 to mile 18.99 and from mile 19.06 to mile 20.30, respectively. Both are 4 lane sections within the city limits of Statesboro.

R11: SR 4 in Richmond County from mile 16.96 to mile 20.73. 6 lane section in the city of Augusta. Also designated as US 1.

R12 T17: SR 121 in Richmond County from mile 10.12 to mile 13.26 and from mile 13.54 to mile 14.98, respectively. Peach Orchard Road: 6 lane sections in the city of Augusta.

R13 T18: SR 28 in Richmond County from mile 3.82 to mile 4.67 and from mile 7.32 to mile 10.76, respectively. Washington Road: 4 lane sections in the city of Augusta.

R14: SR 52 in Whitfield County from mile 2.52 to mile 4.32. Walnut Avenue: 6 lane section partially within the city limits of Dalton.

R15: SR 85 in Muscogee County from mile 3.43 to mile 4.82. 4 lane section in the city of Columbus.

R16: SR 1 in Muscogee County from mile 2.68 to mile 6.70. 6 lane section in the city of Columbus. Also designated as US 27 and US 280.

R17 R18: SR 1 in Muscogee County from mile 6.70 to mile 11.06, excluding a 1.20 mile section. 4 lane sections in the city of Columbus.

R19 T20: SR 141 in Dekalb County from 5.37 to mile 7.23 and from 2.26 to mile 4.88. Peachtree Industrial Boulevard: 4 lane sections through the city limits of Chamblee and Doraville.

APPENDIX B:

ACCIDENT RATES BY SECTION

Raised Median Compilation: Total Accidents: Four Lane Sections

Site	Acc/mi per year	Acc per MVM	Injury Acc /mi/yr	Injury Acc/MVM	Fatal Acc /mi/yr	Fatal Acc/MVM
R2A	43.85	4.79	10.51	1.15	0.26	0.03
R2B	26.07	3.93	7.26	1.10	0.00	0.00
R4	19.20	2.75	5.06	0.72	0.35	0.05
R5	74.53	8.33	18.54	2.07	0.37	0.04
R7	65.90	8.53	21.46	2.78	0.00	0.00
R8	23.40	3.30	5.59	0.79	0.21	0.03
R9	113.04	12.96	25.69	2.95	0.29	0.03
R10	20.06	5.40	4.13	1.11	0.00	0.00
R13	147.09	26.78	29.07	5.29	0.58	0.11
R15	122.30	12.49	18.71	1.91	0.48	0.05
R17	43.22	4.88	11.33	1.28	0.11	0.01
R18A	57.58	5.31	8.71	0.80	0.38	0.03
R18B	69.79	6.52	16.67	1.56	0.52	0.05
R18C	78.03	9.18	13.45	1.58	0.38	0.04
R19	129.39	6.00	27.42	1.27	0.54	0.02
Means	70.91	7.67	15.76	1.70	0.29	0.03
Std Dev	42.15	6.01	8.36	1.19	0.20	0.03

Raised Median Compilation: Total Accidents: Six Lane Sections

Site	Acc/mi per year	Acc per MVM	Injury Acc /mi/yr	Injury Acc/MVM	Fatal Acc /mi/yr	Fatal Acc/MVM
R1	141.55	9.31	30.52	2.01	0.00	0.00
R3A	49.80	4.83	13.25	1.29	0.80	0.08
R3B	27.72	2.67	7.26	0.70	0.50	0.05
R6A	59.93	7.37	14.14	1.74	0.34	0.04
R6B	65.19	4.83	15.63	1.16	0.59	0.04
R6C	152.58	9.38	41.47	2.55	0.60	0.04
R6D	262.07	15.22	49.04	2.85	0.00	0.00
R6E	153.97	10.26	31.11	2.07	0.00	0.00
R11A	79.40	6.84	18.98	1.64	0.23	0.02
R11B	139.37	12.50	33.97	3.05	0.95	0.09
R11C	163.02	18.61	39.32	4.49	0.52	0.06
R12A	37.37	5.03	11.11	1.50	0.25	0.03
R12B	83.99	8.67	16.83	1.74	0.66	0.07
R14	55.93	5.94	11.85	1.26	0.19	0.02
R16A	82.05	7.93	18.72	1.81	0.51	0.05
R16B	95.73	7.25	23.73	1.80	0.27	0.02
R16C	43.08	3.95	12.47	1.14	0.23	0.02
Means	94.07	8.15	21.87	1.90	0.39	0.03
Std Dev	61.17	4.13	12.38	0.90	0.28	0.03

TWLTL Total Accidents: Four Lane Sections

Site	Acc/mi per year	Accidents per MVM	Injury Acc /mi /year	Injury Acc per MVM	Fatal Acc /mi /year	Fatal Acc per MVM
T1A	410.87	24.71	104.59	6.29	0.48	0.03
T1B	146.63	9.93	40.46	2.74	0.00	0.00
T1C	169.38	11.12	47.85	3.14	0.16	0.01
T2	171.43	12.38	34.69	2.51	0.00	0.00
T3	62.96	5.44	12.54	1.08	0.00	0.00
T4	80.15	6.35	18.58	1.47	0.25	0.02
T5A	126.70	10.60	27.42	2.29	0.14	0.01
T5B	121.32	8.65	26.94	1.92	0.39	0.03
T5C	286.27	19.39	43.92	2.98	0.39	0.03
T5D	238.46	18.28	46.15	3.54	0.00	0.00
T5E	67.09	6.05	17.09	1.54	0.43	0.04
T5F	56.58	5.10	13.45	1.21	0.00	0.00
T5G	94.37	7.35	22.07	1.72	0.30	0.02
T6A	103.98	13.86	18.87	2.51	0.00	0.00
T6B	34.50	4.14	8.19	0.98	0.00	0.00
T6C	139.78	12.46	29.78	2.65	0.00	0.00
T6D	95.51	10.88	23.40	2.67	0.00	0.00
T7	84.37	10.77	18.56	2.37	0.24	0.03
T8	216.94	16.53	46.11	3.51	0.00	0.00
T9A	20.72	5.49	9.91	2.63	0.45	0.12
T9B	22.78	4.01	6.67	1.17	0.00	0.00
T9C	45.72	4.47	13.57	1.33	0.00	0.00
T9D	143.03	8.64	36.67	2.21	0.00	0.00
T10A	161.95	18.67	36.36	4.19	0.00	0.00
T10B	93.75	11.93	25.35	3.23	0.00	0.00
T10C	107.57	13.67	23.93	3.04	0.00	0.00
T12A	78.54	5.40	17.24	1.18	0.19	0.01
T12B	58.73	4.40	12.17	0.91	0.53	0.04
T12C	44.72	2.35	11.55	0.61	0.17	0.01
T12D	83.75	6.14	20.17	1.48	0.28	0.02
T12E	33.33	3.20	7.32	0.70	0.00	0.00
T12F	24.54	2.42	7.69	0.76	0.73	0.07
T12G	6.67	1.23	2.60	0.48	0.00	0.00
T12H	3.40	0.98	1.13	0.33	0.00	0.00

(continued on next page)

Site	Acc/mi per year	Accidents per MVM	Injury Acc /mi /year	Injury Acc per MVM	Fatal Acc /mi /year	Fatal Acc per MVM
T14	109.11	12.38	22.49	2.55	0.00	0.00
T15	46.57	5.67	12.50	1.52	0.00	0.00
T16	23.92	4.57	4.84	0.92	0.00	0.00
T18A	147.21	10.13	23.72	1.63	0.23	0.02
T18B	156.59	11.42	25.58	1.87	0.78	0.06
T19	47.70	4.22	7.98	0.71	0.00	0.00
T20A	65.80	5.43	11.76	0.97	0.22	0.02
T20B	129.05	9.71	21.10	1.59	0.00	0.00
Means	99.45	8.99	22.14	2.00	0.14	0.01
Std Dev	79.83	5.37	17.93	1.18	0.21	0.02

TWLTL Total Accidents: Six Lane Sections

Site	Acc/mi per year	Accidents per MVM	Injury Acc /mi /year	Injury Acc per MVM	Fatal Acc /mi /year	Fatal Acc per MVM
T11A	236.55	13.59	145.45	8.36	0.76	0.04
T11B	146.67	10.07	31.31	2.15	0.20	0.01
T11C	73.93	7.16	15.81	1.53	0.00	0.00
T13A	106.98	9.98	29.13	2.72	0.44	0.04
T13B	144.86	14.54	34.16	3.43	0.82	0.08
T13C	81.28	8.19	17.83	1.80	0.18	0.02
T13D	173.27	12.27	40.88	2.89	0.00	0.00
T17	84.49	9.76	18.06	2.09	0.46	0.05
Means	130.26	10.82	43.46	3.61	0.38	0.03
Std Dev	55.85	2.57	42.91	2.20	0.32	0.03

Raised Median Compilation: Midblock Accidents: Four Lane Sections

Site	Acc/mi per year	Acc per MVM	Injury Acc /mi/yr	Injury Acc/MVM	Fatal Acc /mi/yr	Fatal Acc/MVM
R2A	5.38	0.59	0.51	0.06	0.00	0.00
R2B	5.13	0.77	1.28	0.19	0.00	0.00
R4	5.41	0.77	1.40	0.20	0.35	0.05
R5	19.66	2.20	5.24	0.59	0.00	0.00
R7	2.68	0.35	0.96	0.12	0.00	0.00
R8	6.83	0.96	1.66	0.23	0.00	0.00
R9	17.25	1.98	4.90	0.56	0.10	0.01
R10	1.47	0.40	0.29	0.08	0.00	0.00
R13	22.09	4.02	1.74	0.32	0.00	0.00
R15	12.95	1.32	2.16	0.22	0.00	0.00
R17	1.44	0.16	0.22	0.03	0.11	0.01
R18A	8.71	0.80	2.65	0.24	0.38	0.03
R18B	5.21	0.49	2.34	0.22	0.00	0.00
R18C	7.77	0.91	1.89	0.22	0.00	0.00
R19	55.91	2.59	12.54	0.58	0.18	0.01
Totals						
Means	12.39	1.34	2.92	0.32	0.08	0.01
Std Dev	13.79	1.05	3.10	0.18	0.13	0.02

Raised Median Compilation: Midblock Accidents: Six Lane Sections

Site	Acc/mi per year	Acc per MVM	Injury Acc /mi/yr	Injury Acc/MVM	Fatal Acc /mi/yr	Fatal Acc/MVM
R1	60.56	3.98	10.80	0.71	0.00	0.00
R3A	18.47	1.79	4.42	0.43	0.80	0.08
R3B	9.74	0.94	2.31	0.22	0.33	0.03
R6A	11.78	1.45	2.36	0.29	0.00	0.00
R6B	12.68	0.94	3.83	0.28	0.00	0.00
R6C	32.94	2.02	8.53	0.52	0.20	0.01
R6D	37.55	2.18	8.05	0.47	0.00	0.00
R6E	24.44	1.63	6.03	0.40	0.00	0.00
R11A	30.32	2.61	7.41	0.64	0.00	0.00
R11B	38.73	3.47	6.98	0.63	0.00	0.00
R11C	37.50	4.28	8.85	1.01	0.26	0.03
R12A	9.85	1.33	2.27	0.31	0.25	0.03
R12B	17.16	1.77	2.64	0.27	0.00	0.00
R14	13.52	1.44	2.78	0.29	0.00	0.00
R16A	10.26	0.99	2.56	0.25	0.00	0.00
R16B	12.80	0.97	4.27	0.32	0.00	0.00
R16C	8.84	0.81	2.49	0.23	0.00	0.00
Means	22.13	1.92	4.93	0.43	0.10	0.01
Std Dev	14.63	1.08	2.82	0.21	0.21	0.02

TWLTL Midblock Accidents: Four Lane Sections

Site	Acc/mi per year	Accidents per MVM	Injury Acc /mi /year	Injury Acc/MVM	Fatal Acc /mi /year	Fatal Acc/MVM
T1A	259.18	15.59	70.05	4.21	0.48	0.03
T1B	77.26	5.23	23.70	1.61	0.00	0.00
T1C	84.37	5.54	22.97	1.51	0.16	0.01
T2	36.05	2.60	8.84	0.64	0.00	0.00
T3	16.24	1.40	4.84	0.42	0.00	0.00
T4	32.06	2.54	6.87	0.54	0.00	0.00
T5A	35.06	2.93	8.66	0.72	0.00	0.00
T5B	43.99	3.14	8.72	0.62	0.19	0.01
T5C	92.55	6.27	10.20	0.69	0.00	0.00
T5D	95.60	7.33	16.12	1.24	0.00	0.00
T5E	51.71	4.66	13.68	1.23	0.43	0.04
T5F	29.41	2.65	7.28	0.66	0.00	0.00
T5G	41.33	3.22	10.81	0.84	0.15	0.01
T6A	51.15	6.82	9.64	1.29	0.00	0.00
T6B	9.94	1.19	2.92	0.35	0.00	0.00
T6C	31.33	2.79	6.89	0.61	0.00	0.00
T6D	31.73	3.61	7.05	0.80	0.00	0.00
T7	25.52	3.26	5.86	0.75	0.12	0.02
T8	77.78	5.93	15.00	1.14	0.00	0.00
T9A	5.86	1.55	2.70	0.72	0.45	0.12
T9B	5.56	0.98	1.48	0.26	0.00	0.00
T9C	20.94	2.05	6.78	0.66	0.00	0.00
T9D	66.97	4.04	17.88	1.08	0.00	0.00
T10A	40.40	4.66	11.11	1.28	0.00	0.00
T10B	52.43	6.67	12.50	1.59	0.00	0.00
T10C	22.49	2.86	4.91	0.62	0.00	0.00
T12A	40.04	2.75	8.43	0.58	0.19	0.01
T12B	19.58	1.47	5.82	0.44	0.00	0.00
T12C	11.39	0.60	2.64	0.14	0.00	0.00
T12D	20.73	1.52	6.44	0.47	0.28	0.02
T12E	15.85	1.52	3.66	0.35	0.00	0.00
T12F	7.33	0.72	2.56	0.25	0.37	0.04
T12G	2.76	0.51	0.81	0.15	0.00	0.00
T12H	2.13	0.61	0.71	0.20	0.00	0.00

	Acc/mi per year	Accidents per MVM	Injury Acc /mi /year	Injury Acc/MVM	Fatal Acc /mi /year	Fatal Acc/MVM
T14	25.49	2.89	5.65	0.64	0.00	0.00
T15	13.97	1.70	2.70	0.33	0.00	0.00
T16	5.38	1.03	0.81	0.15	0.00	0.00
T18A	61.86	4.26	9.77	0.67	0.00	0.00
T18B	68.99	5.03	9.30	0.68	0.00	0.00
T19	21.36	1.89	2.00	0.18	0.00	0.00
T20A	14.38	1.19	2.40	0.20	0.00	0.00
T20B	23.24	1.75	3.36	0.25	0.00	0.00
Means	38.78	3.50	8.91	0.81	0.06	0.01
Std Dev	42.96	2.70	11.10	0.68	0.14	0.02

TWLTL Midblock Accidents: Six Lane Sections

Site	Acc/mi per year	Accidents per MVM	Injury Acc /mi /year	Injury Acc/MVM	Fatal Acc /mi /year	Fatal Acc/MVM
T11A	118.37	6.80	29.17	1.68	0.76	0.04
T11B	57.78	3.97	13.33	0.92	0.20	0.01
T11C	29.91	2.90	4.70	0.46	0.00	0.00
T13A	41.75	3.89	11.96	1.12	0.22	0.02
T13B	42.80	4.30	14.40	1.45	0.82	0.08
T13C	23.35	2.35	8.56	0.86	0.18	0.02
T13D	53.46	3.78	12.26	0.87	0.00	0.00
T17	25.69	2.97	6.25	0.72	0.23	0.03
Means	50.46	4.19	13.14	1.09	0.30	0.02
Std Dev	30.63	1.35	7.54	0.39	0.32	0.03

APPENDIX C:

SECTION CHARACTERISTICS

Raised Median Site Data: 4 Lane Sections

Site	Distance	ADT	Drives per mile	Signals per mile	Apprch per mile	Opening per mile
R2A	1.30	25090	46.92	3.08	4.62	3.08
R2B	0.78	18150	37.18	2.56	8.97	3.85
R4	1.91	19155	10.47	0.00	5.24	2.09
R5	1.78	24525	33.71	2.81	3.37	4.49
R7	1.74	21162	42.53	2.30	24.14	13.79
R8	1.61	19417	13.04	0.00	4.35	3.11
R9	3.40	23888	23.53	2.35	5.29	2.94
R10	1.13	10180	35.40	0.88	12.39	9.73
R13	0.86	15048	76.74	8.14	1.16	2.33
R15	1.39	26825	64.75	3.60	9.35	4.32
R17	3.00	24265	5.00	0.33	4.67	2.00
R18A	0.88	29684	28.41	1.14	4.55	2.27
R18B	1.28	29325	31.25	2.34	4.69	2.34
R18C	1.76	23286	37.50	2.27	5.68	1.14
R19	1.86	59070	19.89	2.15	3.23	2.15
Totals	24.68					
Std Dev		10866	19.30	1.97	5.54	3.38

Raised Median Site Data: 6 Lane Sections

Site	Distance	ADT	Drives per mile	Signals per mile	Apprch per mile	Opening per mile
R1	1.42	41670	44.37	2.11	4.23	2.11
R3A	0.83	28247	28.92	2.41	3.61	3.61
R3B	2.02	28414	24.26	1.49	2.48	2.97
R6A	0.99	22290	18.18	2.02	2.02	3.03
R6B	1.13	36973	27.43	0.88	2.65	3.54
R6C	1.68	44570	30.95	1.79	4.17	1.79
R6D	0.87	47180	49.43	3.45	14.94	0.00
R6E	1.05	41120	34.29	4.76	4.76	0.00
R11A	1.44	31780	53.47	1.39	9.03	2.78
R11B	1.05	30550	67.62	2.86	3.81	2.86
R11C	1.28	24000	35.94	2.34	2.34	2.34
R12A	1.32	20360	22.73	1.52	3.03	3.03
R12B	2.02	26550	69.31	2.97	8.42	7.43
R14	1.80	25805	35.56	2.78	1.11	1.67
R16A	1.30	28350	60.00	3.08	8.46	6.92
R16B	1.25	36178	106.40	2.40	4.80	2.40
R16C	1.47	29862	66.67	0.00	6.80	2.72
Totals	22.92					
Std Dev		7969	22.84	1.08	3.48	1.91

TWLTL Site Data: 4 Lane Sections

Site	Distance	ADT	Drives per mile	Signal per mile	Apprch per mile
T1A	1.38	45560	52.17	2.90	0.72
T1B	1.73	40450	28.90	2.31	2.89
T1C	2.09	41740	60.77	1.44	0.96
T2	0.49	37940	40.82	2.04	8.16
T3	1.17	31724	46.15	0.85	3.42
T4	1.31	34608	83.21	1.53	9.16
T5A	2.31	32740	72.29	1.30	6.49
T5B	1.72	38440	52.91	2.33	6.40
T5C	0.85	40440	103.53	7.06	2.35
T5D	0.91	35730	86.81	4.40	2.20
T5E	0.78	30400	30.77	0.00	2.56
T5F	2.38	30400	10.08	0.00	0.84
T5G	2.25	35197	36.00	1.78	4.00
T6A	1.59	20560	42.77	2.52	3.77
T6B	1.14	22830	56.14	0.88	8.77
T6C	1.50	30737	40.67	3.33	5.33
T6D	1.04	24050	70.19	2.88	2.88
T7	2.73	21468	41.03	2.56	2.93
T8	1.20	35956	88.33	2.50	3.33
T9A	0.74	10340	16.22	2.70	2.70
T9B	1.80	15570	29.44	0.56	5.00
T9C	1.13	28000	50.44	0.88	5.31
T9D	1.10	45360	73.64	0.91	4.55
T10A	0.99	23770	44.44	3.03	4.04
T10B	0.96	21530	72.92	5.21	5.21
T10C	1.63	21562	81.60	4.29	6.75
T12A	1.74	39880	53.45	1.15	6.32
T12B	1.26	36570	39.68	0.79	3.97
T12C	2.02	52240	39.60	0.99	6.44
T12D	1.19	37400	65.55	3.36	5.88
T12E	0.82	28560	52.44	1.22	7.32
T12F	0.91	27780	29.67	0.00	5.49
T12G	2.05	14820	10.73	0.49	3.41
T12H	2.35	9500	20.85	0.00	3.83

Site	Distance	ADT	Drives per mile	Signal per mile	Apprch per mile
T14	2.89	24150	39.10	1.73	5.88
T15	1.36	22483	30.15	1.47	3.68
T16	1.24	14340	33.06	1.61	5.65
T18A	2.15	39828	68.84	2.33	1.40
T18B	1.29	37570	60.47	3.88	5.43
T19	1.67	30947	47.90	0.60	8.98
T20A	1.53	33190	40.52	4.58	1.96
T20B	1.09	36410	62.39	3.67	4.59
Totals	62.48				
Stand Dev		9881	21.67	1.56	2.19

TWLTL Site Data: 6 Lane Sections

Site	Distance	ADT	Drives per mile	Signal per mile	Apprch per mile
T11A	1.76	47685	67.61	3.41	1.70
T11B	1.65	39900	48.48	1.82	1.82
T11C	0.78	28300	61.54	1.28	2.56
T13A	3.01	29375	55.81	1.99	1.00
T13B	0.81	27300	60.49	3.70	2.47
T13C	1.87	27180	36.90	1.07	3.21
T13D	1.06	38700	144.34	5.66	0.00
T17	1.44	23712	95.14	2.08	8.33
Totals	12.38				
Stand Dev		8308.19	33.96	1.54	2.51

APPENDIX E:

GUIDE TO USING BMDP ON GEORGIA TECH'S CYBER

This appendix is intended to aid the reader in running BMDP software on the Georgia Tech Cyber B mainframe computer from a terminal cluster. It is assumed that the reader has an ID account number and password for the system. It is further assumed that the reader can log onto the system.

Logging onto Cyber may be accomplished from any terminal cluster on campus. Once a user is logged on, it is important to be sure that the account is operating in Batch mode. When in Batch mode, a "/" will always appear as a prompt on the screen. If this prompt does not appear, type "BATCH".

BMDP programs are stored by Cyber. In order to run a particular program, it must be attached to a user's local file. The BMDP program is attached from the computer library called CCLIB83. The program is then executed with a user-created instruction file and data file.

Files are created by typing "NEW, filename". It is a good idea to keep filenames as short and descriptive as possible. For example, a good name for the instruction file would be "INSTR". Once the file has been created, it is in the user's local workspace. In order to save a new file, type "SAVE, filename". To save an old file that has been altered, type "REPLACE, filename".

There are two editing programs on Cyber which may be used to change a file's contents. TED is a line editor. FSE is a full screen editor, which , to the experienced user, is easier to use. This appendix uses TED for the purpose of creating and changing an instruction file and a data file.

To create the data file to be used by BMDP:

- -Type "NEW, filename"
- -Type "TED, filename". The prompt will change to "0 ?"
- -Hit the return key. The prompt will become "1I"
- -Enter the data as numbers only--no commas, punctuation of any kind, or letters.
- -Data is entered in a columnar format. Each line of text (numbers) will represent one site. Separate the information with at least one space. Columns represent data for each variable. It is important to be consistent

when entering data, every line must have data entered in the same order as every other line. The data file for three sites with four variables would look like:

```
#####          ####     ###     ####
#####          ####     ###     ####
#####          ####     ###     ####
```

-No labels are required in this file. The instruction file is used to identify the data.
-Press return. The program will return to edit mode. The prompt will return to a "4 ?", for instance.

If data needs to be edited:
-To view the file, type "P 1 20" to print lines 1 through 20 of the file. This works for any range of lines.
-Move to the line in error by typing its number.
-To change an incorrect entry, type "C/mistake/correction/". The slash bars are delimeters. A period may be substituted for the slash bar if the item to be changed includes a slash bar.

Once the file is correct:
-Type "EXIT". The prompt "/" will appear, indicating that the user is back in local workspace.
-Save the file. ("SAVE, filename" or "REPLACE, filename")

The instruction file is created in a similar manner. A sample instruction file is reproduced below. This file is generic enough to be used in BMDP1R, BMDP2R, and BMDP9R programs. These are the three regression programs used to develop regression equations. When it is used, some of the terms will be ignored by the program. While such ignored terms generate warning messages, they do not affect the operation of the program.

The instruction file should be created by following the same procedures as used with the data file. In the example below, upper case letters and punctuation should be typed as they appear, lower case letters are names to be changed according to existing conditions. The # symbol indicates the number of variables (columns of data) that are present in the data file. Quotes, commas, and periods at the end of every line are crucial. This has proven to be a useful instruction file:

```
/PROBLEM    TITLE IS 'name of regression equation'.
/INPUT      FORMAT IS FREE.
            VARIABLES ARE #.
```

```
                FILE = data filename.
/VARIABLE       NAMES ARE var1, var2, var3, var4, varn.
/REGRESS        DEPENDENT IS dependent variable such as var2.
                INDEPENDENT ARE independent variables such as var1, var3, var4.
/PRINT          RREG.
                DATA.
                COVARIANCE.
                PARTIAL.
                FRATIO.
                CORRELATION.
/PLOT           VARIABLES, NAMES ARE var1, var3, var4.
                NORMAL.
                RESIDUALS.
/END
```

The instruction file should be saved in the same manner as the data file.

This instruction file names the variables found in the data file. Therefore, it is important to name the variables, in line 5, in the same sequence as they are found in the data file. Even if they are not to be used, all variables (columns of data) must be named. For the same reason, the number of variables must equal the number of columns used in establishing the data file.

When using this instruction file for BMDP1R, the variables specified as independent (line 7), must be limited to only those that are to be in the equation. For BMDP2R and BMDP9R, all independent variables should be listed initially. This allows the program to choose the best variable set.

Once both the data and instruction files have been created, BMDP may be run. The following command sequence will run BMDP9R. The other two regression programs may be run in the same manner.

- -Move data and instruction files into local workspace by typing "GET, filename" for each file.
- -Access to BMDP is obtained by typing "ATTACH, BMDP9R/UN=CCLIB83".
- -To run the program, type "BMDP9R, I=instruction filename, L=output filename".
  For example, BMDP9R, I=INSTR, L=OR6TV9.
- -Save the output file.
- -To send the output file to the laser printer at the Rich Building, type "LINK, filename". To send the file to the Civil Engineering printer, type "LINK, filename, GTCE". During initial runs, a user should view a file on the

terminal screen before printing it in order to make sure the file ran correctly. Files can be viewed using TED or FSE.

The output format will vary among the three programs. All start with an echo of the instruction file. The programs also all present statistics about the data found in the data file. BMDP9R lists the regression equation under the heading "Statistics of 'best' subset". BMDP2R uses the title "Stepwise Regression Coefficients" and asterisks by indicated variables. As can be seen in the example output that follows, BMDP1R lists the equation following the correlation matrix.

A portion of an output file from BMDP1R is shown on the following pages. The first page of the report is an echo of the instruction file and is not shown here. The second page list the output parameters. At the bottom of the this page are the statistics for the data file used. Page three containing the covariance matrix for the data is also not shown. A correlation matrix of all of the data is shown on page four. The results of the analysis are located on page five. Statistics about the equation are first given. Then the equation coefficients are presented. Page six holds a correlation matrix of regression coefficients. A comparison of the predicted dependent variable with the actual value is listed on a case by case basis on page seven. Further pages hold graphs of residuals and others of predicted and observed values.

```
PROBLEM TITLE IS
RAISED MEDIAN 6 LANE TOTAL ACC/MVM

NUMBER OF VARIABLES TO READ IN. . . . . . . . .        7
NUMBER OF VARIABLES ADDED BY TRANSFORMATIONS. .        0
TOTAL NUMBER OF VARIABLES . . . . . . . . . . .        7
NUMBER OF CASES TO READ IN. . . . . . . . . . . TO END
CASE LABELING VARIABLES . . . . . . . . . . . .
MISSING VALUES CHECKED BEFORE OR AFTER TRANS. . NEITHER
BLANKS ARE. . . . . . . . . . . . . . . . . . . MISSING
INPUT FILE. . . . . . . . UNIT   7 . . . . . .DR6T
REWIND INPUT UNIT PRIOR TO READING. . DATA. . .    YES
NUMBER OF WORDS OF DYNAMIC STORAGE. . . . . . .   9998

VARIABLES TO BE USED
     1 ADT          2 ACCMIYR      3 ACCMVM       4 DRIVES       5 SIGNAL
     6 APPRCH       7 OPEN

INPUT FORMAT IS
FREE

MAXIMUM LENGTH DATA RECORD IS   80 CHARACTERS.

* * * WARNING * * * IN PARAGRAPH PRINT    THE FOLLOWING TEXT IS IGNORED:
PARTIAL. FRATIO.
* * * NOTE THAT THE FOLLOWING STATEMENTS WERE NOT FOUND:
LIN       LEV       NEW       VNAM      GNAM      VUS       VALU      PAGE
DEBU

THE MOST COMMON EXPLANATIONS FOR EXTRANEOUS CONTROL LANGUAGE ARE:
- MISSPELLED PARAGRAPH OR SENTENCE NAME
- SENTENCE IN THE WRONG PARAGRAPH
- SENTENCE OR PARAGRAPH REPEATED UNEXPECTEDLY
- OPTION NOT DEFINED IN THIS PROGRAM
- MUTUALLY EXCLUSIVE OPTIONS SELECTED

  REGRESSION INTERCEPT. . . . . . . . . . . . . . .NON-ZERO
  GROUPING VARIABLE . . . . . . . . . . . . . . .
  WEIGHT VARIABLE . . . . . . . . . . . . . . . .
  PRINT COVARIANCE MATRIX . . . . . . . . . . . .     YES
  PRINT CORRELATION MATRIX. . . . . . . . . . . .     YES
  PRINT CORRELATION OF REGRESSION COEFFICIENTS. .     YES
  PRINT RESIDUALS . . . . . . . . . . . . . . . .     YES
  PRINT NORMAL PROBABILITY PLOT . . . . . . . . .     YES
  PRINT DETRENDED NORMAL PROBABILITY PLOT . . . .     YES

NUMBER OF CASES READ. . . . . . . . . . . . . .      17
```

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	MINIMUM	MAXIMUM
1 ADT	31994.05882	7969.27493	.24909	20360.00000	47180.00000
2 ACCMIYR	99.57353	61.17413	.61436	27.72000	262.07000
3 ACCMVM	8.27000	4.13198	.49963	2.67000	18.61000
4 DRIVES	45.61941	22.84242	.50072	18.18000	106.40000
5 SIGNAL	2.25000	1.08196	.48087	.00000	4.76000
6 APPRCH	5.09765	3.47635	.68195	1.11000	14.94000
7 OPEN	2.89412	1.91106	.66032	.00000	7.43000

PAGE 4 BMDP1R RAISED MEDIAN 6 LANE TOTAL ACC/MVM

CORRELATION MATRIX

		ADT 1	ACCMIYR 2	ACCMVM 3	DRIVES 4	SIGNAL 5	APPRCH 6	OPEN 7
ADT	1	1.0000						
ACCMIYR	2	.6898	1.0000					
ACCMVM	3	.2656	.8584	1.0000				
DRIVES	4	.1625	.1420	.1203	1.0000			
SIGNAL	5	.2450	.5425	.5137	.0905	1.0000		
APPRCH	6	.4411	.5158	.2885	.4150	.2262	1.0000	
OPEN	7	-.5066	-.4847	-.2750	.2211	-.1443	.0481	1.000

PAGE 5 BMDP1R RAISED MEDIAN 6 LANE TOTAL ACC/MVM

REGRESSION TITLE IS
RAISED MEDIAN 6 LANE TOTAL ACC/MVM

DEPENDENT VARIABLE. . . . . 3 ACCMVM
TOLERANCE 0100
ALL DATA CONSIDERED AS A SINGLE GROUP

MULTIPLE R	.5433	STD. ERROR OF EST.	3.8483
MULTIPLE R-SQUARE	.2952		

ANALYSIS OF VARIANCE

	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	P(TAIL)
REGRESSION	80.6473	3	26.8824	1.815	.1941
RESIDUAL	192.5245	13	14.8096		

VARIABLE		COEFFICIENT	STD. ERROR	STD. REG COEFF	T	P(2 TAIL)	TOLERANCE
INTERCEPT		3.09296					
DRIVES	4	.47911E-03	.46292E-01	.003	.010	.9919	.82779
SIGNAL	5	1.80513	.91287	.473	1.977	.0696	.94882
APPRCH	6	.21454	.31099	.180	.690	.5024	.79192

PAGE 6 BMDP1R RAISED MEDIAN 6 LANE TOTAL ACC/MVM

CORRELATION MATRIX OF REGRESSION COEFFICIENTS

		DRIVES 4	SIGNAL 5	APPRCH 6
DRIVES	4	1.0000		
SIGNAL	5	.0038	1.0000	
APPRCH	6	-.4067	-.2082	1.0000

LIST OF PREDICTED VALUES, RESIDUALS, AND VARIABLES
NOTE - NEGATIVE CASE NUMBER DENOTES A CASE WITH MISSING VALUES.
THE NUMBER OF STANDARD DEVIATIONS FROM THE MEAN IS DENOTED BY UP TO 3 ASTERISK
OF EACH RESIDUAL OR VARIABLE.
MISSING VALUES AND VALUES OUT OF RANGE ARE DENOTED BY VALUES
GREATER THAN OR EQUAL TO .2127E+38 IN ABSOLUTE VALUE.

CASE LABEL	NO.	RESIDUAL		PREDICTED VALUE	VARIABLES 1 ADT 7 OPEN	2 ACCMIYR		3 ACCMVM		4 DR
	1	1.479		7.831	.4167E+05* 2.110	141.6		9.310		44.37
	2	-3.402		8.232	.2825E+05 3.610	49.80		4.830		28.92
	3	-3.656		6.326	.2841E+05 2.970	27.72	*	2.670	*	24.26
	4	.1886		7.181	.2229E+05* 3.030	59.93		7.370		18.18
	5	-.4331		5.263	.3697E+05 3.540	65.19		4.830		27.43
	6	2.146		7.234	.4457E+05* 1.790	152.6		9.380		30.95
	7	2.670		12.55	.4718E+05* 0. *	262.1	**	15.22	*	49.43
	8	-2.463		12.72	.4112E+05* 0. *	154.0		10.26		34.29
	9	-.7250		7.565	.3178E+05 2.780	79.40		6.840		53.47
	10	3.395		9.105	.3055E+05 2.860	139.4		12.50	*	67.62
	11	10.77	**	7.836	.2400E+05* 2.340	163.0	*	18.61	**	35.94
	12	-1.468		6.498	.2036E+05* 3.030	37.37	*	5.030		22.73
	13	-1.624		10.29	.2655E+05 7.430 **	83.99		8.670		69.31
	14	-2.426		8.366	.2581E+05 1.670	55.93		5.940		35.56
	15	-2.567		10.50	.2835E+05 6.920 **	82.05		7.930		60.00
	16	-1.256		8.506	.3618E+05 2.400	95.73		7.250		106.4
	17	-.6338		4.584	.2986E+05 2.720	43.08		3.950	*	66.67

SERIAL CORRELATION OF RESIDUALS = .2171

APPENDIX F:

EXPECTED ACCIDENT RATE TABLES
(BASED ON REGRESSION EQUATIONS DEVELOPED)

Total Accidents/MVM Expected: 6 Lane Sections

Signals per mi	Drives per mile	Approach per mile	ADT = 20,000 TWLTL	ADT = 20,000 RM	ADT = 30,000 TWLTL	ADT = 30,000 RM	ADT = 40,000 TWLTL	ADT = 40,000 RM	ADT = 50,000 TWLTL	ADT = 50,000 RM
1	30	2	8.94	5.82	8.94	5.82	8.94	5.82	8.94	5.82
		4	9.83	5.82	9.83	5.82	9.83	5.82	9.83	5.82
		6	10.73	5.82	10.73	5.82	10.73	5.82	10.73	5.82
	60	2	6.36	5.82	6.36	5.82	6.36	5.82	6.36	5.82
		4	7.26	5.82	7.26	5.82	7.26	5.82	7.26	5.82
		6	8.15	5.82	8.15	5.82	8.15	5.82	8.15	5.82
2	30	2	12.02	7.78	12.02	7.78	12.02	7.78	12.02	7.78
		4	12.92	7.78	12.92	7.78	12.92	7.78	12.92	7.78
		6	13.82	7.78	13.82	7.78	13.82	7.78	13.82	7.78
	60	2	9.45	7.78	9.45	7.78	9.45	7.78	9.45	7.78
		4	10.34	7.78	10.34	7.78	10.34	7.78	10.34	7.78
		6	11.24	7.78	11.24	7.78	11.24	7.78	11.24	7.78
3	30	2	15.11	9.74	15.11	9.74	15.11	9.74	15.11	9.74
		4	16.01	9.74	16.01	9.74	16.01	9.74	16.01	9.74
		6	16.90	9.74	16.90	9.74	16.90	9.74	16.90	9.74
	60	2	12.53	9.74	12.53	9.74	12.53	9.74	12.53	9.74
		4	13.43	9.74	13.43	9.74	13.43	9.74	13.43	9.74
		6	14.33	9.74	14.33	9.74	14.33	9.74	14.33	9.74

Total Accidents/Mi/Yr Expected: 6 Lane Sections

Signals per mi	Drives per mi	Approach per mi	ADT = 20,000 TWLTL	ADT = 20,000 RM	ADT = 30,000 TWLTL	ADT = 30,000 RM	ADT = 40,000 TWLTL	ADT = 40,000 RM	ADT = 50,000 TWLTL	ADT = 50,000 RM
1	30	2	46.27	16.99	97.11	62.49	147.96	107.99	198.81	153.66
		4	59.23	16.99	110.08	62.49	160.93	107.99	211.77	153.66
		6	72.20	16.99	123.04	62.49	173.89	107.99	224.74	153.66
	60	2	19.41	16.99	70.26	62.49	121.11	107.99	171.96	153.66
		4	32.38	16.99	83.22	62.49	134.07	107.99	184.92	153.66
		6	45.34	16.99	96.19	62.49	147.04	107.99	197.88	153.66
2	30	2	78.64	39.45	129.49	84.95	180.33	130.45	231.18	176.13
		4	91.60	39.45	142.45	84.95	193.30	130.45	244.15	176.13
		6	104.57	39.45	155.42	84.95	206.26	130.45	257.11	176.13
	60	2	51.78	39.45	102.63	84.95	153.48	130.45	204.33	176.13
		4	64.75	39.45	115.60	84.95	166.44	130.45	217.29	176.13
		6	77.71	39.45	128.56	84.95	179.41	130.45	230.26	176.13
3	30	2	111.01	61.92	161.86	107.42	212.71	152.92	263.55	198.60
		4	123.98	61.92	174.82	107.42	225.67	152.92	276.52	198.60
		6	136.94	61.92	187.79	107.42	238.64	152.92	289.48	198.60
	60	2	84.16	61.92	135.00	107.42	185.85	152.92	236.70	198.60
		4	97.12	61.92	147.97	107.42	198.82	152.92	249.66	198.60
		6	110.08	61.92	160.93	107.42	211.78	152.92	262.63	198.60

Total Accidents/MVM Expected: 4 Lane Sections

Signals per mile	Drives per mile	Approach per mile	ADT = 10,000 TWLTL	ADT = 10,000 RM	ADT = 30,000 TWLTL	ADT = 30,000 RM	ADT = 50,000 TWLTL	ADT = 50,000 RM
1	25	2	6.31	4.64	6.31	4.64	6.31	4.64
		4	6.31	4.64	6.31	4.64	6.31	4.64
		6	6.31	4.64	6.31	4.64	6.31	4.64
		8	6.31	4.64	6.31	4.64	6.31	4.64
	50	2	6.31	4.64	6.31	4.64	6.31	4.64
		4	6.31	4.64	6.31	4.64	6.31	4.64
		6	6.31	4.64	6.31	4.64	6.31	4.64
		8	6.31	4.64	6.31	4.64	6.31	4.64
2	25	2	8.60	7.36	8.60	7.36	8.60	7.36
		4	8.60	7.36	8.60	7.36	8.60	7.36
		6	8.60	7.36	8.60	7.36	8.60	7.36
		8	8.60	7.36	8.60	7.36	8.60	7.36
	50	2	8.60	7.36	8.60	7.36	8.60	7.36
		4	8.60	7.36	8.60	7.36	8.60	7.36
		6	8.60	7.36	8.60	7.36	8.60	7.36
		8	8.60	7.36	8.60	7.36	8.60	7.36
3	25	2	10.89	10.08	10.89	10.08	10.89	10.08
		4	10.89	10.08	10.89	10.08	10.89	10.08
		6	10.89	10.08	10.89	10.08	10.89	10.08
		8	10.89	10.08	10.89	10.08	10.89	10.08
	50	2	10.89	10.08	10.89	10.08	10.89	10.08
		4	10.89	10.08	10.89	10.08	10.89	10.08
		6	10.89	10.08	10.89	10.08	10.89	10.08
		8	10.89	10.08	10.89	10.08	10.89	10.08
4	25	2	13.18	12.80	13.18	12.80	13.18	12.80
		4	13.18	12.80	13.18	12.80	13.18	12.80
		6	13.18	12.80	13.18	12.80	13.18	12.80
		8	13.18	12.80	13.18	12.80	13.18	12.80
	50	2	13.18	12.80	13.18	12.80	13.18	12.80
		4	13.18	12.80	13.18	12.80	13.18	12.80
		6	13.18	12.80	13.18	12.80	13.18	12.80
		8	13.18	12.80	13.18	12.80	13.18	12.80

Total Accidents/Mi/Yr Expected: 4 Lane Sections

Signals per mile	Drives per mile	Approach per mile	ADT = 10,000 TWLTL	ADT = 10,000 RM	ADT = 30,000 TWLTL	ADT = 30,000 RM	ADT = 50,000 TWLTL	ADT = 50,000 RM
1	25	2	21.89	20.51	99.44	58.85	177.00	97.19
		4	4.18	20.51	81.73	58.85	159.29	97.19
		6	-13.53	20.51	64.03	58.85	141.58	97.19
		8	-31.24	20.51	46.32	58.85	123.87	97.19
	50	2	21.89	20.51	99.44	58.85	177.00	97.19
		4	4.18	20.51	81.73	58.85	159.29	97.19
		6	-13.53	20.51	64.03	58.85	141.58	97.19
		8	-31.24	20.51	46.32	58.85	123.87	97.19
2	25	2	44.57	36.65	122.13	74.99	199.68	113.33
		4	26.87	36.65	104.42	74.99	181.97	113.33
		6	9.16	36.65	86.71	74.99	164.27	113.33
		8	-8.55	36.65	69.00	74.99	146.56	113.33
	50	2	44.57	36.65	122.13	74.99	199.68	113.33
		4	26.87	36.65	104.42	74.99	181.97	113.33
		6	9.16	36.65	86.71	74.99	164.27	113.33
		8	-8.55	36.65	69.00	74.99	146.56	113.33
3	25	2	67.26	52.79	144.81	91.13	222.37	129.46
		4	49.55	52.79	127.11	91.13	204.66	129.46
		6	31.84	52.79	109.40	91.13	186.95	129.46
		8	14.14	52.79	91.69	91.13	169.24	129.46
	50	2	67.26	52.79	144.81	91.13	222.37	129.46
		4	49.55	52.79	127.11	91.13	204.66	129.46
		6	31.84	52.79	109.40	91.13	186.95	129.46
		8	14.14	52.79	91.69	91.13	169.24	129.46
4	25	2	89.95	68.93	167.50	107.27	245.05	145.60
		4	72.24	68.93	149.79	107.27	227.35	145.60
		6	54.53	68.93	132.08	107.27	209.64	145.60
		8	36.82	68.93	114.38	107.27	191.93	145.60
	50	2	89.95	68.93	167.50	107.27	245.05	145.60
		4	72.24	68.93	149.79	107.27	227.35	145.60
		6	54.53	68.93	132.08	107.27	209.64	145.60
		8	36.82	68.93	114.38	107.27	191.93	145.60

Midblock Accidents/MVM Expected: 6 Lane Sections

Signals per mi	Openings per mile	ADT = 20,000 TWLTL	ADT = 20,000 RM	ADT = 30,000 TWLTL	ADT = 30,000 RM	ADT = 40,000 TWLTL	ADT = 40,000 RM	ADT = 50,000 TWLTL	ADT = 50,000 RM
1	1	2.22	1.92	3.51	1.92	4.80	1.92	6.10	1.92
	2	2.22	1.81	3.51	1.81	4.80	1.81	6.10	1.81
	3	2.22	1.70	3.51	1.70	4.80	1.70	6.10	1.70
	4	2.22	1.59	3.51	1.59	4.80	1.59	6.10	1.59
2	1	2.22	2.08	3.51	2.08	4.80	2.08	6.10	2.08
	2	2.22	1.97	3.51	1.97	4.80	1.97	6.10	1.97
	3	2.22	1.86	3.51	1.86	4.80	1.86	6.10	1.86
	4	2.22	1.75	3.51	1.75	4.80	1.75	6.10	1.75
3	1	2.22	2.25	3.51	2.25	4.80	2.25	6.10	2.25
	2	2.22	2.14	3.51	2.14	4.80	2.14	6.10	2.14
	3	2.22	2.03	3.51	2.03	4.80	2.03	6.10	2.03
	4	2.22	1.92	3.51	1.92	4.80	1.92	6.10	1.92

Midblock Accidents/mi/yr Expected: 6 Lane Sections

Signals per mi	Drives per mile	Approach per mile	ADT = 20,000 TWLTL	ADT = 20,000 RM	ADT = 30,000 TWLTL	ADT = 30,000 RM	ADT = 40,000 TWLTL	ADT = 40,000 RM	ADT = 50,000 TWLTL	ADT = 50,000 RM
1	30	2	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
		4	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
		6	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
	60	2	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
		4	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
		6	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
2	30	2	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
		4	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
		6	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
	60	2	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
		4	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
		6	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
3	30	2	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
		4	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
		6	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
	60	2	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
		4	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17
		6	6.27	11.19	39.84	20.85	73.41	30.51	106.99	40.17

Midblock Accidents/MVM Expected: 4 Lane Sections
Sheet 1: 1 and 2 Signals/mile

Signals per mile	Drives per mile	Approach per mile	ADT = 10,000 TWLTL	ADT = 10,000 RM	ADT = 30,000 TWLTL	ADT = 30,000 RM	ADT = 50,000 TWLTL	ADT = 50,000 RM
1	20	2	3.19	0.86	3.19	0.86	3.19	0.86
		4	1.95	0.86	1.95	0.86	1.95	0.86
		6	0.71	0.86	0.71	0.86	0.71	0.86
		8	-0.53	0.86	-0.53	0.86	-0.53	0.86
	40	2	4.31	-0.06	4.31	-0.06	4.31	-0.06
		4	3.07	-0.06	3.07	-0.06	3.07	-0.06
		6	1.84	-0.06	1.84	-0.06	1.84	-0.06
		8	0.60	-0.06	0.60	-0.06	0.60	-0.06
	60	2	5.44	-0.97	5.44	-0.97	5.44	-0.97
		4	4.20	-0.97	4.20	-0.97	4.20	-0.97
		6	2.96	-0.97	2.96	-0.97	2.96	-0.97
		8	1.72	-0.97	1.72	-0.97	1.72	-0.97
	80	2	6.57	-1.88	6.57	-1.88	6.57	-1.88
		4	5.33	-1.88	5.33	-1.88	5.33	-1.88
		6	4.09	-1.88	4.09	-1.88	4.09	-1.88
		8	2.85	-1.88	2.85	-1.88	2.85	-1.88
2	20	2	3.19	1.64	3.19	1.64	3.19	1.64
		4	1.95	1.64	1.95	1.64	1.95	1.64
		6	0.71	1.64	0.71	1.64	0.71	1.64
		8	-0.53	1.64	-0.53	1.64	-0.53	1.64
	40	2	4.31	0.73	4.31	0.73	4.31	0.73
		4	3.07	0.73	3.07	0.73	3.07	0.73
		6	1.84	0.73	1.84	0.73	1.84	0.73
		8	0.60	0.73	0.60	0.73	0.60	0.73
	60	2	5.44	-0.18	5.44	-0.18	5.44	-0.18
		4	4.20	-0.18	4.20	-0.18	4.20	-0.18
		6	2.96	-0.18	2.96	-0.18	2.96	-0.18
		8	1.72	-0.18	1.72	-0.18	1.72	-0.18
	80	2	6.57	-1.10	6.57	-1.10	6.57	-1.10
		4	5.33	-1.10	5.33	-1.10	5.33	-1.10
		6	4.09	-1.10	4.09	-1.10	4.09	-1.10
		8	2.85	-1.10	2.85	-1.10	2.85	-1.10

Midblock Accidents/MVM Expected: 4 Lane Sections
Sheet 2: 3 and 4 Signals/mile

Signals per mile	Drives per mile	Approach per mile	ADT = 10,000 TWLTL	ADT = 10,000 RM	ADT = 30,000 TWLTL	ADT = 30,000 RM	ADT = 50,000 TWLTL	ADT = 50,000 RM
3	20	2	3.19	2.43	3.19	2.43	3.19	2.43
		4	1.95	2.43	1.95	2.43	1.95	2.43
		6	0.71	2.43	0.71	2.43	0.71	2.43
		8	-0.53	2.43	-0.53	2.43	-0.53	2.43
	40	2	4.31	1.51	4.31	1.51	4.31	1.51
		4	3.07	1.51	3.07	1.51	3.07	1.51
		6	1.84	1.51	1.84	1.51	1.84	1.51
		8	0.60	1.51	0.60	1.51	0.60	1.51
	60	2	5.44	0.60	5.44	0.60	5.44	0.60
		4	4.20	0.60	4.20	0.60	4.20	0.60
		6	2.96	0.60	2.96	0.60	2.96	0.60
		8	1.72	0.60	1.72	0.60	1.72	0.60
	80	2	6.57	-0.31	6.57	-0.31	6.57	-0.31
		4	5.33	-0.31	5.33	-0.31	5.33	-0.31
		6	4.09	-0.31	4.09	-0.31	4.09	-0.31
		8	2.85	-0.31	2.85	-0.31	2.85	-0.31
4	20	2	3.19	3.21	3.19	3.21	3.19	3.21
		4	1.95	3.21	1.95	3.21	1.95	3.21
		6	0.71	3.21	0.71	3.21	0.71	3.21
		8	-0.53	3.21	-0.53	3.21	-0.53	3.21
	40	2	4.31	2.30	4.31	2.30	4.31	2.30
		4	3.07	2.30	3.07	2.30	3.07	2.30
		6	1.84	2.30	1.84	2.30	1.84	2.30
		8	0.60	2.30	0.60	2.30	0.60	2.30
	60	2	5.44	1.39	5.44	1.39	5.44	1.39
		4	4.20	1.39	4.20	1.39	4.20	1.39
		6	2.96	1.39	2.96	1.39	2.96	1.39
		8	1.72	1.39	1.72	1.39	1.72	1.39
	80	2	6.57	0.47	6.57	0.47	6.57	0.47
		4	5.33	0.47	5.33	0.47	5.33	0.47
		6	4.09	0.47	4.09	0.47	4.09	0.47
		8	2.85	0.47	2.85	0.47	2.85	0.47

Midblock Accidents/Mi/Yr Expected: 4 Lane Sections
Sheet 1: 1 and 2 Signals/mile

Signals per mile	Drives per mile	Approach per mile	ADT = 10,000 TWLTL	ADT = 10,000 RM	ADT = 30,000 TWLTL	ADT = 30,000 RM	ADT = 50,000 TWLTL	ADT = 50,000 RM
1	20	2	13.41	-6.45	45.83	14.27	78.25	34.99
		4	-4.08	-6.45	28.34	14.27	60.76	34.99
		6	-21.58	-6.45	10.84	14.27	43.26	34.99
		8	-39.07	-6.45	-6.65	14.27	25.77	34.99
	40	2	23.91	-6.45	56.33	14.27	88.75	34.99
		4	6.42	-6.45	38.84	14.27	71.26	34.99
		6	-11.07	-6.45	21.35	14.27	53.77	34.99
		8	-28.57	-6.45	3.85	14.27	36.27	34.99
	60	2	34.41	-6.45	66.83	14.27	99.25	34.99
		4	16.92	-6.45	49.34	14.27	81.76	34.99
		6	-0.57	-6.45	31.85	14.27	64.27	34.99
		8	-18.07	-6.45	14.35	14.27	46.77	34.99
	80	2	44.92	-6.45	77.34	14.27	109.76	34.99
		4	27.42	-6.45	59.84	14.27	92.26	34.99
		6	9.93	-6.45	42.35	14.27	74.77	34.99
		8	-7.56	-6.45	24.86	14.27	57.28	34.99
2	20	2	13.41	-3.93	45.83	16.79	78.25	37.51
		4	-4.08	-3.93	28.34	16.79	60.76	37.51
		6	-21.58	-3.93	10.84	16.79	43.26	37.51
		8	-39.07	-3.93	-6.65	16.79	25.77	37.51
	40	2	23.91	-3.93	56.33	16.79	88.75	37.51
		4	6.42	-3.93	38.84	16.79	71.26	37.51
		6	-11.07	-3.93	21.35	16.79	53.77	37.51
		8	-28.57	-3.93	3.85	16.79	36.27	37.51
	60	2	34.41	-3.93	66.83	16.79	99.25	37.51
		4	16.92	-3.93	49.34	16.79	81.76	37.51
		6	-0.57	-3.93	31.85	16.79	64.27	37.51
		8	-18.07	-3.93	14.35	16.79	46.77	37.51
	80	2	44.92	-3.93	77.34	16.79	109.76	37.51
		4	27.42	-3.93	59.84	16.79	92.26	37.51
		6	9.93	-3.93	42.35	16.79	74.77	37.51
		8	-7.56	-3.93	24.86	16.79	57.28	37.51

Midblock Accidents/Mi/Yr Expected: 4 Lane Sections
Sheet 2: 3 and 4 Signals/mile

Signals per mile	Drives per mile	Approach per mile	ADT = 10,000 TWLTL	ADT = 10,000 RM	ADT = 30,000 TWLTL	ADT = 30,000 RM	ADT = 50,000 TWLTL	ADT = 50,000 RM
3	20	2	13.41	-1.41	45.83	19.31	78.25	40.03
		4	-4.08	-1.41	28.34	19.31	60.76	40.03
		6	-21.58	-1.41	10.84	19.31	43.26	40.03
		8	-39.07	-1.41	-6.65	19.31	25.77	40.03
	40	2	23.91	-1.41	56.33	19.31	88.75	40.03
		4	6.42	-1.41	38.84	19.31	71.26	40.03
		6	-11.07	-1.41	21.35	19.31	53.77	40.03
		8	-28.57	-1.41	3.85	19.31	36.27	40.03
	60	2	34.41	-1.41	66.83	19.31	99.25	40.03
		4	16.92	-1.41	49.34	19.31	81.76	40.03
		6	-0.57	-1.41	31.85	19.31	64.27	40.03
		8	-18.07	-1.41	14.35	19.31	46.77	40.03
	80	2	44.92	-1.41	77.34	19.31	109.76	40.03
		4	27.42	-1.41	59.84	19.31	92.26	40.03
		6	9.93	-1.41	42.35	19.31	74.77	40.03
		8	-7.56	-1.41	24.86	19.31	57.28	40.03
4	20	2	13.41	1.11	45.83	21.83	78.25	42.55
		4	-4.08	1.11	28.34	21.83	60.76	42.55
		6	-21.58	1.11	10.84	21.83	43.26	42.55
		8	-39.07	1.11	-6.65	21.83	25.77	42.55
	40	2	23.91	1.11	56.33	21.83	88.75	42.55
		4	6.42	1.11	38.84	21.83	71.26	42.55
		6	-11.07	1.11	21.35	21.83	53.77	42.55
		8	-28.57	1.11	3.85	21.83	36.27	42.55
	60	2	34.41	1.11	66.83	21.83	99.25	42.55
		4	16.92	1.11	49.34	21.83	81.76	42.55
		6	-0.57	1.11	31.85	21.83	64.27	42.55
		8	-18.07	1.11	14.35	21.83	46.77	42.55
	80	2	44.92	1.11	77.34	21.83	109.76	42.55
		4	27.42	1.11	59.84	21.83	92.26	42.55
		6	9.93	1.11	42.35	21.83	74.77	42.55
		8	-7.56	1.11	24.86	21.83	57.28	42.55