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16. Abstract

With the increased expansion of rural Interstates to six lanes, questions have arisen as to the proper operational strategy of those facilities. One approach is to restrict trucks and other large vehicles from one or more of the lanes. The effects of such a restriction, however, have not been extensively studied. This study analyzes the operational effects of three left-lane truck restrictions on six-lane rural Interstates in Texas. Although the directional distribution of trucks changed significantly, no effects were found on the directional distribution of cars, the time gaps between vehicles, or the speeds of either cars or trucks that could be attributed to the truck restriction.

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

LENGTH

Symbol	When You Know	Multiply By	To Find	Symbol
in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km

AREA

Symbol	When You Know	Multiply By	To Find	Symbol
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.0929	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
mi^2	square miles	2.59	kilometres squared	km^2
ac	acres	0.395	hectares	ha

MASS (weight)

Symbol	When You Know	Multiply By	To Find	Symbol
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg

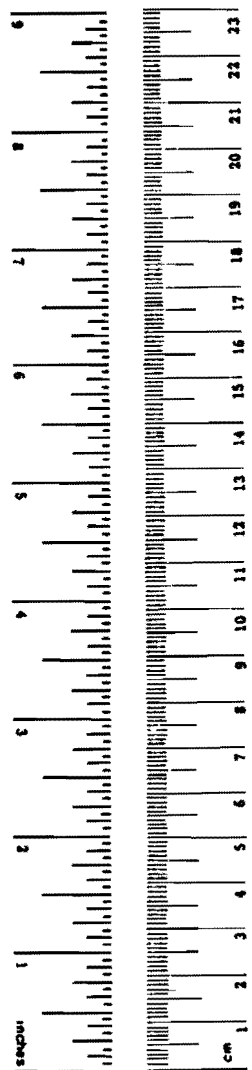
VOLUME

Symbol	When You Know	Multiply By	To Find	Symbol
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.0328	metres cubed	m^3
yd^3	cubic yards	0.0765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

TEMPERATURE (exact)

Symbol	When You Know	Multiply By	To Find	Symbol
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



APPROXIMATE CONVERSIONS TO SI UNITS

LENGTH

Symbol	When You Know	Multiply By	To Find	Symbol
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi

AREA

Symbol	When You Know	Multiply By	To Find	Symbol
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
km^2	kilometres squared	0.39	square miles	mi^2
ha	hectores (10 000 m^2)	2.53	acres	ac

MASS (weight)

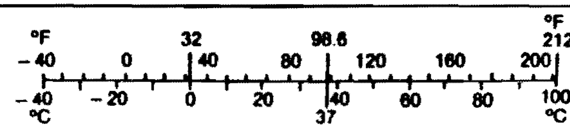
Symbol	When You Know	Multiply By	To Find	Symbol
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T

VOLUME

Symbol	When You Know	Multiply By	To Find	Symbol
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3

TEMPERATURE (exact)

Symbol	When You Know	Multiply By	To Find	Symbol
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements

ABSTRACT

With the increased expansion of rural Interstates to six lanes, questions have arisen as to the proper operational strategy of those facilities. One approach is to restrict trucks and other large vehicles from one or more of the lanes. The effects of such a restriction, however, have not been extensively studied. This study analyzes the operational effects of three left-lane truck restrictions on six-lane rural Interstates in Texas. Although the directional distribution of trucks changed significantly, no effects were found on the directional distribution of cars, the time gaps between vehicles, or the speeds of either cars or trucks that could be attributed to the truck restriction.

Key Words: Truck Restrictions, Lane Restrictions, Freeway Operations

IMPLEMENTATION STATEMENT

This study involves the implementation of truck restrictions at virtually all rural six-lane Interstates in Texas. It provides valuable data on current operational conditions that should be useful to pavement design engineers regardless of the final disposition of truck restrictions on rural Interstates. A final decision as to the implementation of the restriction awaits further research.

SUMMARY

Restrictions of trucks or other large vehicles from certain highway lanes have not been implemented extensively to date. There has been limited research on the effects of such restrictions on highway operations, accident rates, and pavement wear. This study evaluates the operational effects of truck restrictions on six-lane rural Interstates in Texas. Data was collected before and after implementation of the restriction at three of the four sites known to exist in Texas: Interstate 10 west of Houston, Interstate 20 west of Fort Worth, and Interstate 35E north of Dallas. To implement the restriction, regulatory signs were posted every mile along the sites, and no attempts were made at enforcement. No analysis of accident rates or pavement wear was attempted, but those factors are discussed in the report.

In determining the restriction's effects on highway operations, three parameters were analyzed: directional distribution of vehicles, vehicle speed, and the time gap between vehicles. Vehicles were divided into two classifications, which varied according to the site because of the different data collection methods used. At Interstates 10 and 20, the classification system included those vehicles with two axles and those with greater than two axles. At Interstate 35E, vehicles were divided into those with lengths of 22 feet or less and those with lengths greater than 22 feet. Approximately 48 hours of operational data was collected before implementation of the restriction, and 71 hours after implementation. Because of the variability in volumes throughout the data sets, the data was separated into peak and non-peak periods, except at Interstate 10 where no variation in volume was found to necessitate such a distinction.

From observations of the data collected before implementation of the restriction, it was determined that a left-lane restriction of trucks and other large vehicles would be the

best operational strategy to be implemented. This decision was made for the following reasons:

1) The existence of very few trucks in the left-most lane. Even during the non-peak period (when truck percentages are higher), the percentage of trucks in the left lane as a percentage of total traffic was less than 1.3% at all sites.

2) The trucks in the left lane were exceeding the speed limit by as many as ten miles per hour on average. The average speeds of trucks in the left lane ranged from 64.6 MPH to 70.0 MPH. The speed limit for trucks is 60 MPH at all sites.

3) Trucks *may be* impeding the free-flow ability of cars. In analyzing this effect, the average speeds of cars following cars were compared to those of cars following trucks. Although the speeds of the former group were generally greater, they did not exhibit any consistent pattern of significance (alpha = 0.05).

In order to assess the opinions of drivers and to determine the best sign to convey the intended message, two surveys were conducted before implementation of the restriction: a survey of motorists and one of truckers. The surveys revealed that while 60% of motorists favored the restriction, only 28% of truckers shared the same opinion. The survey also revealed that a sign that read "No Trucks, Buses, Trailers in Left Lane" was most understood by both sets of drivers. The sign was altered to ultimately read, "No Trucks, Trailers in Left Lane." After the restriction was implemented, three additional surveys were conducted, one at each site, to again assess driver opinions and to evaluate the effectiveness of the regulatory signing system. These surveys revealed that 32% of the motorists and 24% of the truckers surveyed did not even see the signs, while 12% and 27%, respectively, did not fully understand their meaning. Additionally, it was found that 45% of the motorists surveyed felt that the restriction had improved operations, while only 20% of the truckers felt that it had.

The 119 hours of operational data collected before and after the restriction provide a substantial base of information on which to evaluate the restriction's effectiveness. In addition, because the sites were simultaneously videotaped during data collection, additional information can be gained and verifications made. In evaluating this data, the distributions of cars and trucks were investigated by analyzing each classification's percentage of total vehicles in the lane, total vehicles in the direction, and total vehicles in both directions. The chi-square statistic was used to test the statistical significance of the changes in directional distributions. Both the arithmetic averages and the cumulative distribution functions of time gap and speed were analyzed. Comparisons of the arithmetic means were made between the before and after data sets using the Student's *t*-test to check for statistical significance. The results of the above tests and comparisons revealed the following information:

1) The directional distribution of trucks changed significantly after the restriction (alpha = 0.05).

2) The percentage of trucks increased significantly in the right lane (only) of each direction of Interstate 20 and in the right two lanes of each direction of Interstate 35E. Changes in the distributions of trucks at Interstate 10 were mixed, most likely due to a change in the geometric configuration of an adjacent roadway segment after the initial data was collected.

3) The redistribution of trucks did not effect corresponding changes in the distributions of cars.

4) Overall, an average 62% compliance rate was achieved, which resulted in an average of only 3.0% of the trucks in a direction remaining in the left lane.

5) The time gaps of trucks following trucks were significantly less than those of trucks following cars (alpha = 0.05).

6) The redistribution of trucks does not seem to effect any discernible changes in the time gaps of either cars or trucks or in the speeds of either cars or trucks.

7) Grade significantly affects the speeds of trucks.

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CHAPTER I
INTRODUCTION

Recent emphasis of transportation engineering has shifted from the design of new facilities toward maintaining, enlarging, and improving the operation of existing facilities. Computer traffic monitoring systems, changeable message signs, signal re-timing and/or coordination, and high-occupancy vehicle lanes have all been employed to improve operational characteristics. Another area in which such changes are taking place is in the operational strategy of multilane highways.

With the emergence of more and more six-lane rural highways, questions have arisen as to the most efficient operation of such facilities. Can their operation be modified so as to limit accidents or increase the level of service? Some engineers and highway users suggest that large trucks are impeding the free-flow abilities of smaller vehicles. It has been suggested that trucks should be restricted, leaving one or more lanes clear for non-truck traffic. Conversely, it has been suggested that increasing the concentration of truck traffic would induce increased pavement damage and otherwise restrict the movement of other vehicles. The validity of these suggestions, however, has not been fully evaluated. It is the objective of this study, therefore, to examine the operational effects of lane restrictions.

Background

The idea of restricting classes of vehicles from certain highway lanes is relatively new; therefore, there has been limited research on the effects of such restrictions. The Federal Highway Administration surveyed the fifty states, the District of Columbia, and Puerto Rico in June of 1986 to study the extent to which lane restrictions had been used (1)*. All 52 surveys were returned, 28 of which reported using no restrictions. The other states reported using restrictions, usually temporarily, for one *or more* of the following reasons:

1) To improve highway operations (move truck traffic to the right lane/s). (15 responses)

2) To reduce accidents (move truck traffic to the right lane/s). (7 responses)

3) To provide for more even pavement wear (move truck traffic to the left lane/s). (7 responses)

4) To ensure better operation and safety through construction zones (move truck traffic away from construction workers). (5 responses)

A similar study was performed by Sirisoponsilp and Schonfeld in February of 1988 (2). This study also surveyed the fifty states, the District of Columbia, and Puerto Rico, but only 31 of those surveyed responded. Fourteen states reported having experience with truck restrictions, while seventeen states reported no experience. Of the 14 states having truck restriction experience, five implemented statewide restrictions, and four were currently studying their effectiveness.

Although this study does not investigate accident rates, the effect a restriction has on accident rates is very important. Two recent studies have examined accident rates on highway segments with truck restrictions. The Maryland State Highway Administration examined accident rates on portions of the eight-lane Capital Beltway (Interstates 95 and 495) on which large trucks (heavy-duty single unit trucks and tractor trailers) were restricted from the left-most lane (3). This study found that although the truck accident rate did not change significantly *overall* since the restriction, that rate increased in the right two lanes by

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*Numbers in parentheses refer to references listed at the end of the report.

40%. However, due to changing conditions between the before and after study period, such as a significant volume fluctuation, these changes may have been caused by other factors. The Virginia Department of Transportation also studied accident rates on the Capital Beltway and similarly found that truck accident rates increased after the restriction (4). However, due to a lack of before/after comparisons and an inadequacy of control, these results are also somewhat questionable.

Other studies have analyzed the effects of truck restrictions on highway operations (5 and 6). Due to the methods used in these studies, however, reliable conclusions can not be drawn without the results first being replicated. Perhaps the most comprehensive research on this subject was performed by Hanscom in 1989 (7). A before/after study design with a control site was used to evaluate the effectiveness of three truck restrictions. Hanscom reported voluntary compliance by a high percentage of trucks at all three sites. To determine the impedance of cars by trucks, the average platoon lengths behind trucks during the before and after periods were computed. The average platoon length change between the before and after periods for the test and control sites was then compared, and significant differences between the two were found. The report also found that there were no adverse speed effects resulting from the restrictions. Although the study design was very good, the lack of an appropriate control site makes conclusions based on comparisons between the test and control sites less meaningful. The control sites exist upstream of the test sites and therefore may differ both in composition of traffic and in total volume. The platoon length discussed above is highly dependent upon volume, and since the volume of the test and control sites vary by as much as 30%, that measurement is questionable for determining impedance. The fact that volumes were determined by five-minute counts and that manual methods were used to measure speeds and determine following distances casts further doubt upon the validity of the results. The need for replication of the results is therefore very evident.

Because it is difficult to control all intervening variables in studies of this type, more research needs to be performed to better sort out the effects of those variables. The ability of truck restrictions to improve highway operations, to reduce accident rates, to produce more even pavement wear, and to provide better safety through construction zones has not been previously verified. The lack of relevant research, therefore, points to the need for a well-designed, controlled experiment to study the effects of truck restrictions.

Objectives

The above surveys of current practice (1 and 2) reveal the need of performing a study in which the conditions before *and* after the lane restriction are thoroughly examined. It is the primary objective of this study to perform such an experiment. Specifically, this study is concerned with the highway operations aspect of truck restrictions as discussed above. Volumes, speeds, and headways by classification will be examined in an attempt to determine the most efficient and safe operational strategy for six-lane Interstates in rural areas. No analysis or evaluation of accident rates or pavement wear will be undertaken.

Overview

This report will follow the general sequence of events conducted during the study and will be organized accordingly:

Chapter I. Introduction

This chapter presents a general introduction, a review of similar studies in this subject area, the objectives of the study, and an overview of the report.

Chapter II. Data Collection and Analysis Before Implementation of Truck Restriction

This chapter begins with discussing the characteristics of traffic flow which were analyzed. The three study sites are then introduced followed by a discussion of the methods of data collection and reduction. Finally, summaries of the data collected before implementation of the restriction are presented along with a discussion of a few preliminary results concerning the composition of traffic at the three sites.

Chapter III. Observations of Operational Data Before Implementation of Truck Restriction

This chapter discusses three important observations made of the data presented in Chapter II and analyzes the option of restricting trucks from the left-most lane. The reasons for selecting a left-lane restriction of trucks concludes the chapter.

Chapter IV. Motorist and Trucker Surveys

This chapter presents the purposes, format, and results of two surveys of highway users that were conducted to determine the best sign for conveying the intent of the restriction. Sign alternatives are presented, and reasons for the selection of the sign ultimately used are discussed.

Chapter V. Data Collection and Analysis After Implementation of Truck Restriction

This chapter begins with a discussion of all relevant information concerning the installation of the regulatory signs. Summaries of the data collected after implementation of the restriction are presented along with a discussion of a few results concerning the composition of traffic at the three sites.

Chapter VI. User-Response Surveys

This chapter presents the purposes, format, and results of three user-response surveys of highway users designed to assess the effectiveness of the sign and the opinions of users.

Chapter VII. Results and Comparisons

This chapter presents the observations and statistical comparisons of the data collected before and after the restriction. Results concerning the rate of compliance, vehicle distributions, time gaps between vehicles, and vehicle speeds are presented. Explanations of all procedures and findings are given.

Chapter VIII. Conclusions and Recommendations

This chapter presents the primary findings of the study and recommendations for additional research.

CHAPTER II
DATA COLLECTION AND ANALYSIS BEFORE IMPLEMENTATION OF TRUCK RESTRICTION

In order to accurately determine the effects of any type of lane restriction, the existing roadway conditions must first be determined. Extensive data collection at multiple sites is beneficial so as to eliminate statistical, geographical, or seasonal biases. Chapter II will focus on the collection, reduction, and analysis of forty-eight hours of data collected at three different sites. Possible explanations for the observed conditions will be discussed, providing a basis for discussion after the follow-up data has been collected.

Parameters of Interest

In order to fully describe the operational characteristics of a roadway, it is beneficial to examine as many characteristics of traffic flow as possible. For this study, a vehicle classification system was employed so that comparisons could be made between vehicles with similar operating characteristics. This system was designed to differentiate "cars" from "trucks." In addition to making comparisons of speed or headway possible, a classification system allows the distribution of a class of vehicle across a direction to be analyzed. Vehicle speeds are also of interest, as variances between the speeds of different classes of vehicles and the speeds of vehicles in different lanes before and after the restriction need to be examined.

Headways are very useful for they relate information as to the closeness of vehicles to one another. Headway is defined as the time between the arrival of successive vehicles in a traffic stream. More precisely, it is the time between which the *same point* on successive vehicles in a traffic stream passes an arbitrary point. Leading headway, therefore, can be defined as the time difference between the front bumpers of successive vehicles.

Likewise, lagging headway can be defined as the time difference between rear bumpers of successive vehicles. Leading and lagging headways are not necessarily equivalent because of differences in the lengths and speeds of the associated vehicles. The time gap between vehicles is the time difference between the rear bumper of the first vehicle and the front bumper of the second vehicle. Note that this time gap is not a "headway," but it does better illustrate how closely one vehicle follows another.

Study Sites

As stated above, data was collected at three sites. These sites were chosen first and foremost because they met the requirements of the study. That is, the study sites were chosen because they were six-lane, rural interstate highways with a speed limit of 65 miles per hour. Because of the short lengths of the sites, no control sections were used. It was decided that there was not sufficient length to include control and test sections void of end effects. Grade was not intentionally varied, but is a factor on Interstate 20. A varying truck percentage was desired to determine the effects of truck volume on highway operations.

Locations

The first site was located in the Houston District (District 12) on Interstate 10 between Brookshire and Katy in Waller County, Texas. The total length of the section was five miles and its 1988 Average Annual Daily Traffic (AADT) was 32,000 vehicles. Data was collected at an overpass 1.8 miles east of the F.M. 359/I-10 interchange. The grade was level, and no entrance or exit ramps were located within one mile. The inside shoulder width was 11 feet; the outside shoulder width was 12 feet. All lane widths were approximately 12 feet.

The second site was located in the Fort Worth District (District 2) on Interstate 20 between Fort Worth and Weatherford in Parker County, Texas. The total length of the section was approximately nine miles and its 1988 AADT was 39,000 vehicles. Data was collected at the F.M. 1187 overpass, 1.9 miles west of the I-20/I-30 interchange. There was an approximate three percent upgrade in the eastbound direction and a three percent downgrade in the westbound direction. F.M. 1187 has entrance and exit ramps for both the eastbound and westbound directions. The inside shoulder width was 10 feet; the outside shoulder width was 12 feet. All lane widths were approximately 12 feet.

The third site was located in the Dallas District (District 18) on Interstate 35E between Dallas and Lewisville in Denton County, Texas. The total length of the section was nine miles and its 1988 AADT was 87,000 vehicles. Data was collected just north of the Denton County line between the Corporate Drive and F.M. 3040 underpasses. The grade was approximately level, and no entrance or exit ramps were located within one-quarter mile. The inside and outside shoulder widths were 12 feet and all lane widths were approximately 12 feet.

Data Collection

A method of data collection was needed which would obtain all of the desired parameters discussed above with minimum cost and a high degree of accuracy. In order to help determine the best method, two means of data collection were utilized. A system of tapeswitches was used on Interstates 10 and 20, while loop detectors were used on Interstate 35E.

Interstates 10 and 20

A tapeswitch consists of two wires encased in plastic which, when pressure is applied, make contact with each other. An electrical circuit can effectively be opened and closed when contact is made and released. In order to collect data, therefore, tapeswitches were temporarily installed across all traffic lanes. A computer (termed the Environmental

Computer) detected the electronic activations of all tapeswitches and assigned them a time-stamp. These time-stamps, along with the tapeswitch's pre-assigned channel number, were then output to the disk of another computer (a portable, personal computer). Using this procedure, a master file consisting of a series of channel numbers and time-stamps (in increasing order of time) was obtained. In order to obtain the speeds of vehicles, two tapeswitches, placed 15 feet apart, were used in each lane. Also, in order to check the accuracy of the collection/reduction procedure, the highway segment was videotaped during all data collection periods. Figure 1 shows the layout of the equipment just described. Table 1 presents the dates and approximate times during which data was collected at Interstates 10 and 20. As can be seen in Table 1, a total of 24 hours of data were collected at these two sites.

Table 1. IH 10 and IH 20 - Dates and Approximate Times of Data Collection
Before Implementation of Truck Restriction

Date	Time	Hours Collected
April 25, 1989	13:45 - 19:00	5.25
April 26, 1989	13:30 - 16:30	3.00
April 27, 1989	06:30 - 12:00	5.50
	Total	13.75
	Interstate 20	
Date	Time	Hours Collected
August 17, 1988	15:00 - 18:30	3.50
August 18, 1988	07:30 - 10:15	2.75
August 18, 1988	11:00 - 15:00	4.00
	Total	10.25

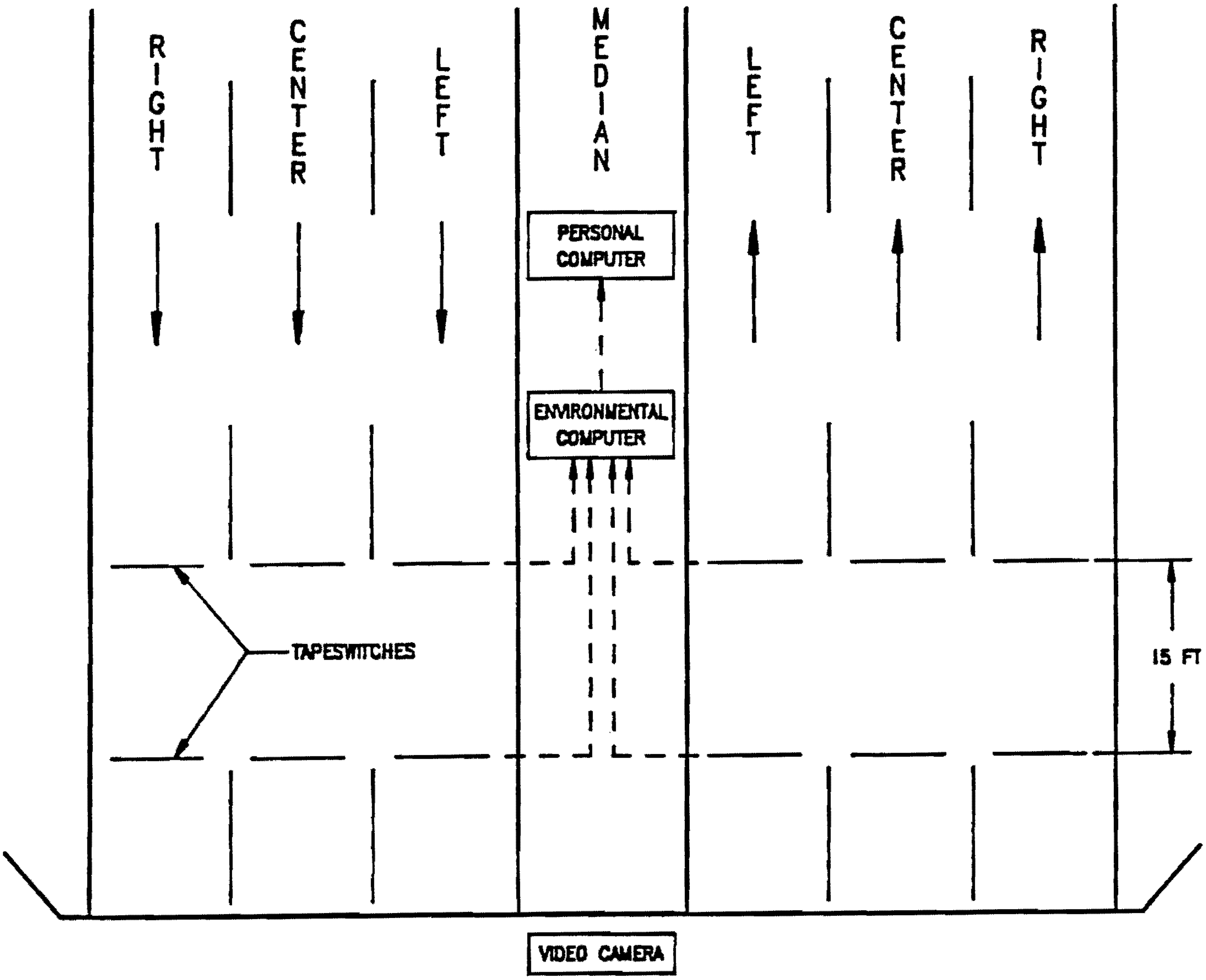


Figure 1. Site Layout

Interstate 35E

As stated above, loop detectors were utilized at this site for the collection of data. Two loop detectors were installed in each lane to permit the determination of vehicle speed. A counter/classifier collected and analyzed all loop detector activations, automatically calculating the speed and length of each vehicle in all lanes; the unit could not compute headways. The speed of each vehicle was then sorted into one of eight speed categories, or ranges; the length of each vehicle was sorted into one of two length categories. Table 2 provides a summary of the length and speed categories used. As can be seen in Table 2, vehicles with lengths greater than 70 feet and speeds greater than 89 miles per hour were excluded from the sample. The counter/classifier ultimately reports the number of vehicles in each category within a specified time period for each lane. This method of collection, however, does not permit speed comparisons by classification, as speeds *by classification* were not differentiated. Data was collected for a continuous 24 hour period, from 17:00 on Monday, August 15, 1988 to 17:00 on Tuesday, August 16, 1988.

Table 2. Summary of Speed and Length Categories

Length Categories	Range (ft)
1	0-22
2	23-70
Speed Categories	**Range (mph)**
1	0-50
2	51-55
3	56-60
4	61-65
5	66-70
6	71-75
7	76-80
8	81-89

Data Reduction

Interstates 10 and 20

The reduction of the tapeswitch data began with running the data collected by the Environmental Computer (channel numbers and time stamps) through a preliminary "splitter" computer program. This program created six separate files out of each master file, with the actuations from only one lane in each file. The six "lane" files were then automatically analyzed through the use of another computer program. This program systematically paired actuations of the first and second tapeswitch to differentiate axles. It then systematically combined axles by comparing the time differences between them to differentiate vehicles. Once individual vehicles were identified, the parameters discussed above were calculated. The program also incorporated a complex system of error checks to reduce the amount of erroneous classifications caused by factors such as electronic cross talk. The results of the program were verified using the videotape.

Interstate 35E

The reduction of the loop detector data was almost completely performed by the counter/classifier, as it reduced the loop detector activations automatically. The only reduction required, therefore, was to sum the number of vehicles in each category of interest over the desired time period.

Classification Systems

When analyzing all data, vehicles were divided into two classifications in an attempt to differentiate "cars" from "trucks." Because two different methods of data collection were used for Interstates 10 and 20 and for Interstate 35E, two classification systems were employed. These classification systems were used throughout the study to draw comparisons between two groups of vehicles assumed to have similar operating characteristics. It is, therefore, important to understand the limitations of the classification system. Because the vehicles from Interstates 10 and 20 were categorized according to their number of axles, the two classifications used for that data were vehicles with two axles and those with greater than two axles. Similarly, because the vehicles from Interstate 35E were categorized according to their length, the two classifications used for that data were vehicles with lengths between zero and 22 feet and those with lengths between 23 and 70 feet. These classifications permit assumptions to be made as to the nature of the vehicles within them: vehicles with two axles and those with lengths between 0 and 22 feet generally include passenger cars, pickups, vans, motorcycles, and some single unit trucks; vehicles with greater than two axles and those with lengths between 23 and 70 feet generally include some single unit trucks, passenger cars/pickups pulling trailers, all tractor-trailer combinations, and buses.

Results

Although the data from each site was collected in multiple sets, these sets were combined to create one data set for each site. This data set was then analyzed as a whole. In order to account for volume differences within the data, a peak period was defined for each site. In this manner, speed and headway averages can be compared with some confidence that volume does not control the results. Peak periods were determined by analyzing fifteen-minute volumes in both directions. The intervals in which the volumes were clearly greater than the average were considered to be in the peak period, with everything else constituting the non-peak period. This method presented fairly clear cut-off points for the peak period, except for the data collected at Interstate 10. The Interstate 10 data did not exhibit a peak period and therefore was not split into peak and non-peak periods. Table 3 presents the time periods defined as "peak" for both directions of all sites. Peak flow constituted 24.7% of total flow in the Interstate 20 data set and 34.7% of total flow in the Interstate 35E data set.

Table 3. Peak Period Definitions

Interstate 10	
No Peak Period Defined	
Interstate 20	
Westbound	Eastbound
16:00 - 18:00	06:30 - 08:30
Interstate 35E	
Northbound	Southbound
15:30 - 19:00	06:00 - 09:00

Complete descriptive summaries of the data collected before implementation of the truck restrictions at all three sites can be found in Appendix A. Detailed analysis of this data will be presented in Chapter VII when it is compared to the data collected after the restriction was implemented. A few observations about the composition of the traffic, however, are presented below, while more observations will be discussed in Chapter III.

Traffic Composition

From the data, we can easily determine trucks as a percentage of total traffic presently on the roadways. As expected, truck percentages varied considerably at the three sites with those at Interstate 10 being the highest. Table 4 summarizes the car and truck percentages at the three sites and was compiled from the tables in Appendix A. From this table it can be seen that the percentage of trucks (vehicles with three or more axles) was 22.0% at Interstate 10. Similarly, the percentage of trucks was 8.4% and 14.2% at Interstate 20 during the peak and non-peak periods, respectively. Since a different "definition" of trucks was used at Interstate 35E (vehicles with lengths greater than 22 feet), the truck percentages found there can not be compared directly to those at Interstates 10 and 20. The truck percentages at Interstate 35E were fairly low, however, at 3.1% and 8.1% during the peak and non-peak periods, respectively. Higher truck percentages during the non-peak periods versus the peak periods are also clearly evident.

Table 4. Summary of Car and Truck Percentages Before Implementation of Truck Restriction

Interstate 10			
% Cars		% Trucks	
78.0		22.0	
Interstate 20			
Peak Period		Non-Peak Period	
% Cars	% Trucks	% Cars	% Trucks
91.6	8.4	85.8	14.2
Interstate 35E			
Peak Period		Non-Peak Period	
% Cars	% Trucks	% Cars	% Trucks
96.9	3.1	91.9	8.1

Also of interest in this study is the number of trucks driving in the left lane of each direction. The data shows that the number of trucks in the left lane is very small as both a percentage of total traffic and of truck traffic (in their respective directions). Table 5 summarizes the percentages mentioned above at the three sites and was compiled from the tables in Appendix A.

Table 5. Left-Lane Truck Percentages Before Implementation of Truck Restriction

Interstate 10				
	Westbound		Eastbound	
	% of Total	% of Trucks	% of Total	% of Trucks
(No Peak Period)	0.8	3.8	1.2	5.2
Interstate 20				
	Westbound		Eastbound	
	% of Total	% of Trucks	% of Total	% of Trucks
Peak Period	0.7	8.9	1.3	11.7
Non-Peak Period	0.8	5.3	1.1	7.9
Interstate 35E				
	Northbound		Southbound	
	% of Total	% of Trucks	% of Total	% of Trucks
Peak Period	0.5	14.3	0.3	8.5
Non-Peak Period	0.7	8.2	0.7	8.6

CHAPTER III
OBSERVATIONS OF OPERATIONAL DATA BEFORE IMPLEMENTATION OF TRUCK RESTRICTION

With the pilot data having been collected, an analysis was performed in order to determine the type of restriction to be implemented. In making this decision, the following factors were considered.

1) **Restrictions Attempted in Other States.** The literature review presented in Chapter I was used as a basis in determining the type of restriction to be used because it relates the successes and failures of restrictions already attempted.

2) **User Benefit.** The restriction must be well-founded and supply the most benefit at the least cost to the greatest segment of the population.

3) **Driver Expectancy.** A deviation in driver expectancy should be avoided.

4) **Driver Perspective.** This must be considered, as a change for the "better" might not be *perceived* as such by the public.

5) **Simplicity.** A restriction too complicated in nature will be difficult to relate to drivers (through signing) for them to understand.

6) **Legal Foundation.** A basis for the restriction must be found within the law, with special consideration given to the feasibility of its implementation.

7) **Compliance.** If high compliance is vital to proper operation, the restriction must be socially acceptable to the majority of the users.

8) **Enforcement.** If compliance is to be enforced, support of the restriction must be gained from local and state law enforcement agencies.

Observations

An investigation of existing conditions provides the necessary insight into determining an effective operational strategy. The 48 hours of data presented in Chapter II provide a summary of the existing conditions. Through analysis of that data, three important observations resulted.

First Observation - Lack of Trucks in Left Lane

The first observation is the relative scarcity of vehicles with greater than two axles in the left lanes at all sites. Only 0.8% and 1.2% of the vehicles traveling in the left lanes of Interstate 10 had greater than two axles (see Table A-1). This comprised only 3.8% and 5.2% of the vehicles in those directions with greater than two axles (see Table A-6). Similarly, only 0.7% and 1.3% of the vehicles during the peak period and 0.8% and 1.1% during the non-peak period traveling in the left lanes of Interstate 20 had greater than two axles (see Tables A-2 and A-3). This comprised only 8.9% and 11.7% during the peak period and 5.3% and 7.9% during the non-peak period of the vehicles in those directions with greater than two axles (see Tables A-7 and A-8). Only 0.5% and 0.3% of the vehicles during the peak period and 0.7% and 0.7% during the non-peak period traveling in the left lanes of Interstate 35E had vehicle lengths greater than 22 feet (see Tables A-4 and A-5). This comprised only 14.3% and 8.5% during the peak period and 8.2% and 8.6% during the non-peak period of the vehicles in those directions with vehicle lengths greater than 22 feet (see Tables A-9 and A-10). These results clearly show that "trucks" at all three sites rarely use the left lanes of the facilities.

Second Observation - Trucks Are Speeding

The second observation is the high speeds of vehicles with greater than two axles in the left lanes at Interstates 10 and 20. As stated before, speeds by classification at Interstate 35E were not collected and therefore are not presented. The average speeds of vehicles with greater than two axles traveling in the left lanes of Interstate 10 were 69.2 MPH and 68.3 MPH (see Table A-11). Similarly, the average speeds of vehicles with greater than two axles traveling in the left lanes of Interstate 20 were 69.7 MPH and 66.6 MPH during the peak period and 70.0 and 64.6 during the non-peak period (see Tables A-12 and A-13). Although not every vehicle with greater than two axles is restricted by the 60 MPH truck speed limit at these sites, all of these average speeds are well above that limit.

Third Observation - Trucks May Impede the Free-Flow Ability of Cars

Although it is a very difficult effect to substantiate, it appears that trucks (vehicles with greater than two axles) may be impeding cars (vehicles with two axles). One way to examine this effect is to compare the speeds of those two classes of vehicles. A difference in the average speeds might indicate that one group is impeding the other. Since the speed limit is different for those two classes of vehicles, however, this would not yield useful results. Another way to examine the effect is to compare the speeds of cars following cars to those of cars following trucks. If the speeds of the former group are greater, that would also suggest that trucks are impeding cars. This approach was taken, and t-tests were used to compare the speeds of two-axle vehicles following two-axle vehicles (cars following cars) to the speeds of two-axle vehicles following vehicles with greater than two axles (cars following trucks). The data from both Interstate 10 and Interstate 20 (both the peak and non-peak periods) were tested; Interstate 35E was not tested due to the lack of speed data by classification at that site. Although the average speeds of cars following cars were generally greater (see Tables A-11 through A-13), they were not significantly greater (alpha = 0.05) with any consistency. Although these results are not significant enough to state that trucks impede the flow of cars, it does *suggest* that possibility and therefore warrants further investigation.

Determination of Operational Strategy

Based on the observations discussed above and the practice of other states, it was decided that an effective strategy would be to restrict large vehicles from the left lane. This decision was made for the following four reasons:

1) The primary reason for restricting large vehicles from the left lane is the lack of such vehicles presently in those lanes. In other words, restricting large vehicles from the left lane results in little restriction at all.

2) It is believed that an increase in the operational performance of the highway would result from such a restriction. Other studies have suggested this possibility. For example, Krammes and Crowley suggested that "the truck management strategy [of prohibiting trucks from the median lane] may be an effective way to minimize the adverse effect of trucks on freeway capacity" (8).

3) Since vehicles with greater than two axles are violating the speed limit, it is believed that the restriction might force those vehicles into a slower operating speed.

4) This restriction might improve operations *as perceived by the drivers of cars*: a full lane would be reserved solely for their use, thus they would not be impeded by the "slower" trucks.

There are, however, some possible drawbacks to such a restriction. Foremost among these is the possibility of increased pavement wear caused by a greater degree of concentration of large vehicles on the outside lanes. Although there are some construction limitations, this might be countered in the future by applying higher design standards to the outer lanes and lower standards to the inside lane. Another potential disadvantage is criticism by drivers of large vehicles. Although it may seem to be an improvement from the small-vehicle standpoint, large-vehicle drivers may disagree. Another important consideration is traffic safety. If weaving is minimized because faster vehicles (presumably "cars") have a clear route, safety might be increased. Conversely, increased volume on the outside lanes might actually *decrease* safety. Safety as well as all factors discussed above needs to be observed after the restriction is made to determine the effects, if any, which the restriction had. Some of these factors will be discussed in Chapter VII.

CHAPTER IV
MOTORIST AND TRUCKER SURVEYS

In order to determine the opinions of drivers and the most effective signing system, two surveys were conducted. A "trucker" survey was conducted to determine the opinions of large-vehicle operators. Since it is the drivers of large vehicles who must act upon the sign, the sign must obviously be clear in meaning to them. This survey was conducted by polling truck drivers at a truckstop in Brookshire, Texas (the first study site, on Interstate 10). A "motorist" survey was also conducted in order to determine the opinions of automobile operators. Although automobile operators would not be required to act upon the sign, the sign must not be so confusing that they *think* they are required to act. This survey was conducted by polling drivers at a mall in College Station, Texas.

Sign Alternatives

Three signing alternatives were chosen to be offered to the survey respondents (see Figure 2). Sign descriptions and a discussion of each are described below.

The first sign reads, "No Trucks, Buses, Trailers in Left Lane." Drivers may interpret the meaning of this sign differently because of the words "trucks" and "trailers." For example, "trucks" may mean only pick-up trucks to some, but may mean all load-carrying vehicles to another.

The second sign reads, "No Vehicles With 3 or More Axles in Left Lane." A similar sign was used with some success by the Florida Department of Transportation (5). A problem with this sign is concerned with the word "axles," as some drivers may be unclear

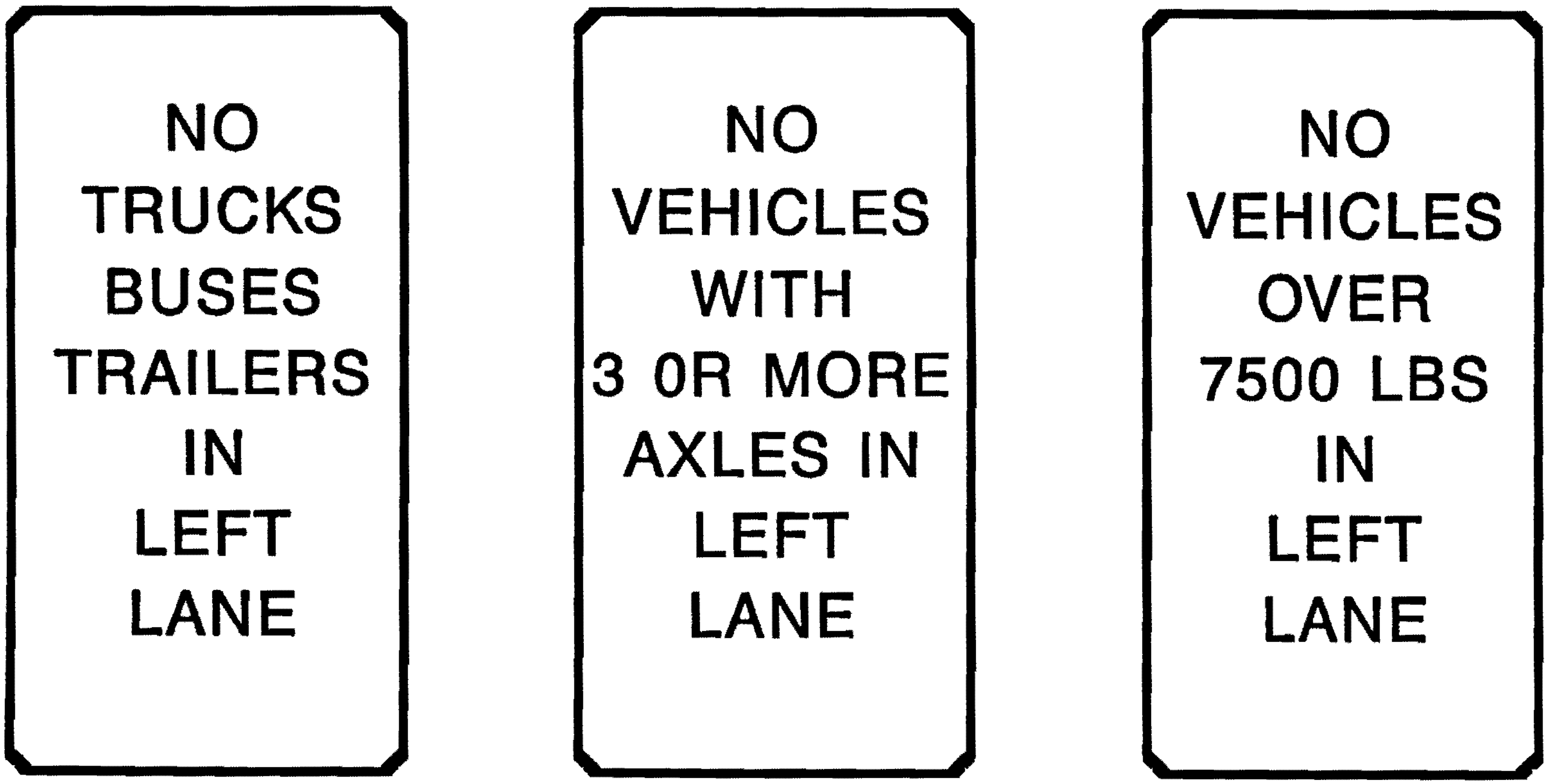


Figure 2. Signing Alternatives

as to its meaning. Furthermore, since the sign attempts to restrict too broad a classification, finding a legal basis for the restriction might be difficult.

The third sign reads, "No Vehicles Over 7500 lbs in Left Lane." The problem with this sign centers on the phrase "7500 lbs," as many drivers, especially non-truckers, are unsure of the weights of their vehicles. This sign may cause the unintentional removal of "non-trucks" from the left lane.

Survey Format

The motorist survey and the trucker survey are very similar in format and can be found in Figures 3 and 4. These figures are copies of the actual surveys and also present the percentages of responses to each question. The surveys were structured to perform two principal functions:

1) Gain an understanding of the opinions of motorists and truckers toward the restriction, and

2) Identify which sign best relates the intended message to both motorists *and* truckers.

Results

As stated before, the results of the motorist survey are presented in Figure 3 and the results of the trucker survey are presented in Figure 4. The following information was compiled or taken from those figures. A total of 124 motorist surveys and 140 trucker surveys were completed.

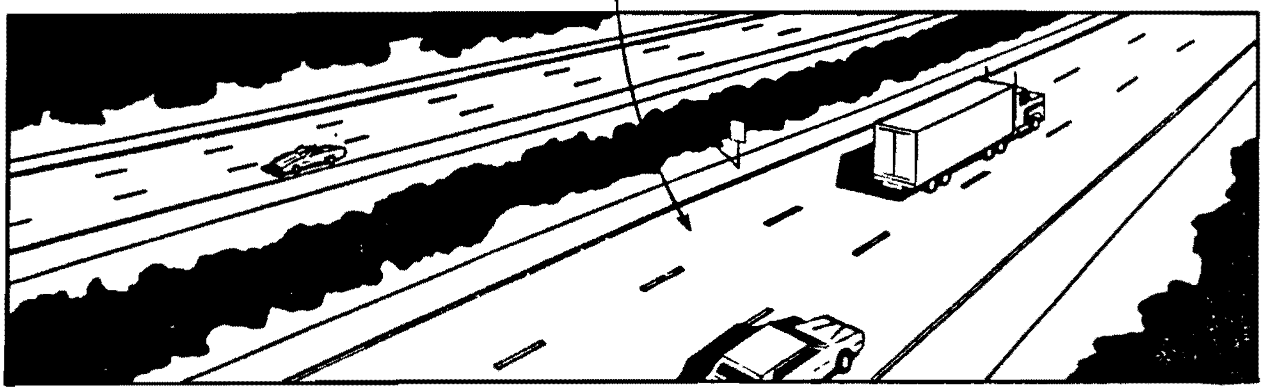
MOTORIST SURVEY

The Texas State Department of Highways and Public Transportation is conducting this survey in order to determine your reaction to possible restrictions on rural interstate highways with 65 mph speed limits and three lanes in each direction. Please take a few minutes to answer the questions below and return the completed form to the survey taker. Thank you for your cooperation.

1. What type of vehicle do you normally drive?

77% Passenger Car
19% Pick-Up Truck
<1% Van
3% Other (*please specify*) ______________________

Note: The following questions concern the left most lane of an interstate highway as shown below.



2. If you observed the following sign,

would you be allowed to legally drive in the left lane with the following types of vehicles?

	Yes	*No*	*Not Sure*
Passenger Car	98%	2%	0%
Pick-Up Truck	75%	17%	7%
Van	82%	7%	10%
Vehicle Pulling Trailer	3%	90%	5%

Figure 3. Motorist Survey and Results

3. If you observed the following sign,

**NO
VEHICLES
WITH
3 OR MORE
AXLES
IN
LEFT
LANE**

would you be able to legally drive in the left lane with the following vehicles?

	Yes	*No*	*Not Sure*
Passenger Car	97%	3%	0%
Pick-Up Truck	90%	5%	5%
Van	87%	6%	7%
Vehicle Pulling Trailer	8%	81%	10%

4. If you observed the following sign,

**NO
VEHICLES
OVER
7500 LBS
IN
LEFT
LANE**

would you be able to legally drive in the left lane with the following vehicles?

	Yes	*No*	*Not Sure*
Passenger Car	97%	<1%	2%
Pick-Up Truck	79%	4%	16%
Van	63%	10%	27%
Vehicle Pulling Trailer	9%	52%	38%

Figure 3. Motorist Survey and Results, Continued

5. Do you feel that vehicles such as trucks, buses and vehicles pulling trailers should be prohibited from using the left lane when three lanes are available in one direction?

60% **Yes**
39% **No**

Comments: ______________________________

6. What is your . . . **Age?** Range 17 - 80, Mean 30 **Sex?** 62% - Male, 38% - Female

Thank you for your cooperation.

Figure 3. Motorist Survey and Results, Continued

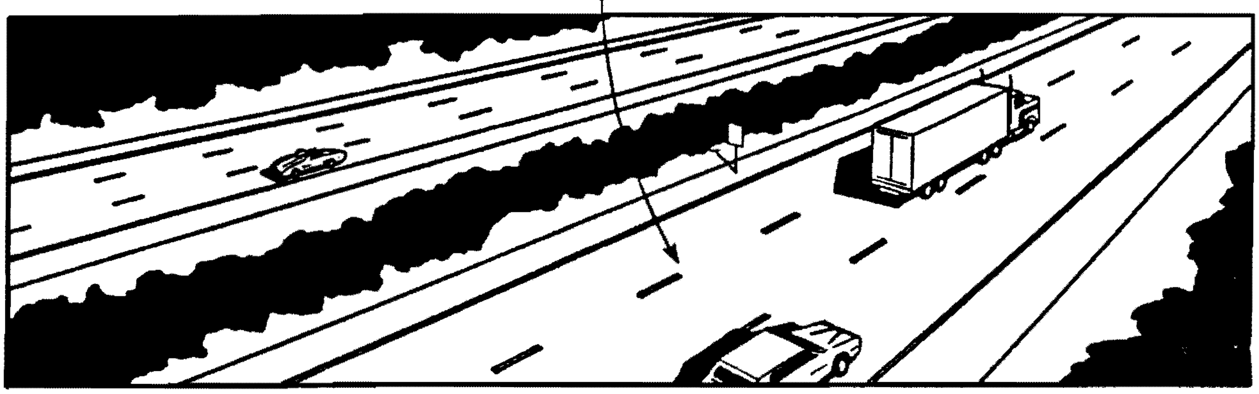
TRUCKER SURVEY

The Texas State Department of Highways and Public Transportation is conducting a survey concerning possible restrictions on certain vehicles using the left lane of rural interstate highways with 3 lanes in each direction and 65 mph speed limits. Currently, there are very few such highways in Texas. Please take a few minutes to answer the questions below and return the completed form to the survey taker. Thank you for your cooperation.

1. What type of vehicle do you normally drive?

< 1% Single-Unit Truck (Straight Truck)
84% Tractor-Semi Trailer
15% Tractor-Semi Trailer-Full Trailer (Twin Trailer Truck)
< 1% Other *(please specify)* ______________________

Note: The following questions concern the left most lane of an interstate highway as shown below.



2. If you observed the following sign,

NO
TRUCKS
BUSES
TRAILERS
IN
LEFT
LANE

would you be allowed to legally drive in the left lane with the following types of vehicles?

	Yes	*No*	*Not Sure*
Single-Unit Truck	11%	72%	6%
Tractor-Semi Trailer	7%	87%	1%
Tractor-Semi Trailer-Full Trailer	6%	83%	1%

Figure 4. Trucker Survey and Results

3. If you observed the following sign,

NO **VEHICLES** **WITH** **3 OR MORE** **AXLES** **IN** **LEFT** **LANE**

would you be able to legally drive in the left lane with the following vehicles?

	Yes	*No*	*Not Sure*
Single-Unit Truck	41%	33%	12%
Tractor-Semi Trailer	5%	89%	1%
Tractor-Semi Trailer-Full Trailer	4%	84%	1%

4. If you observed the following sign,

NO **VEHICLES** **OVER** **7500 LBS** **IN** **LEFT** **LANE**

would you be able to legally drive in the left lane with the following vehicles?

	Yes	*No*	*Not Sure*
Single-Unit Truck	23%	55%	11%
Tractor-Semi Trailer	4%	90%	<1%
Tractor-Semi Trailer-Full Trailer	5%	85%	0

Figure 4. Trucker Survey and Results, Continued

5. Do you feel that restricting trucks, buses and trailers from the left lane when three lanes are available is reasonable?

28% **Yes**
70% **No** If "No," why not?____________________

____

____

6. What is your. . . **Age?** Range 22 - 69 / Mean 41 **Sex?** 97% - Male / 3% - Female

Thank you for your cooperation.

Figure 4. Trucker Survey and Results, Continued

As stated before, the surveys had two main functions: identify motorist and trucker opinion, and identify the best sign to relate the intended message. The first function was fulfilled by Question 5 on both surveys, which revealed that 60% of motorists favor the left-lane restriction of larger vehicles while only 28% of truckers favor such a restriction (see Figures 3 and 4). Of the motorists not favoring the restriction, 15% stated that the restriction should be based on speed, not size; and 10% stated that none of the three signs would convey the proper meaning. Of the truckers not favoring the restriction, 19% stated that the restriction would cause merging conflicts; 14% stated that the restriction would impede cars; and 13% stated that the restriction would cause undue congestion.

The second function was fulfilled by Questions 2, 3, and 4. The effectiveness of each sign was analyzed by determining the percentages of correct responses to Questions 2, 3, and 4 by both motorists and truckers. The sign which exhibited the highest percentage of correct responses by *both* types of drivers is therefore most clear in conveying its meaning. The percentages of correct responses by motorists were 86%, 89%, and 73% to sign options one, two, and three, respectively. Percentages of correct responses by truckers were 81%, 69%, and 77%, respectively.

Sign Selection

Because the first sign elicited the most correct responses from both motorists and truckers, it was chosen as the sign to be used. The sign as presented above and seen in Figure 2 was, however, slightly modified. The Texas Motor Vehicle Laws (Article XIX) states that the "speed limit for any bus...shall be the same as prescribed for passenger cars at the same location" (9). Because buses are not limited to the same speed limits as trucks, the word "buses" was removed from the sign. Therefore, the sign ultimately read, "No Trucks, Trailers in Left Lane" (see Figure 5).

Figure 5. Example of Regulatory Sign

CHAPTER V
DATA COLLECTION AND ANALYSIS AFTER IMPLEMENTATION OF TRUCK RESTRICTION

Sign Installation

After the sign was selected, the signs were manufactured and installed by the Texas State Department of Highways and Public Transportation. These signs were spaced evenly throughout the length of the sites with approximately one mile between signs. Two signs were placed back to back on one pole in the medians of Interstates 20 and 35E. The Interstate 10 signs were mounted on the right side of the roadway. A "BEGIN" and "END" message sign was placed atop the first and last signs at each site. Since the Interstate 20 and 35E sites were each approximately nine miles long, ten signs in all were erected at these sites. As the Interstate 10 site was approximately five miles long, six signs were erected at this site. Signs were first installed at Interstate 20, followed by Interstates 35E and 10. Table 6 presents the dates on which the signs were installed at each site. No attempts were made to enforce the restriction.

Table 6. Sign Installation Dates

Location	Date
Interstate 20	August 17, 1989
Interstate 35E	October 13, 1989
Interstate 10	November 30, 1989

Data Collection and Reduction

The same methods of data collection and reduction used in the collection of the initial data were again utilized in collecting the secondary data. Table 7 presents the dates and approximate times during which data was collected at Interstates 10 and 20. As can be seen in Table 7, a total of 23 hours of data were collected at these two sites. While data was being collected at Interstate 10 on May 31, 1990 (see Table 7), a tapeswitch malfunctioned in the left lane of the eastbound direction at approximately 16:30. Rather than discarding the data from 16:30 to 18:00, however, all of the data was used in computing the average speeds and average time gaps (Table B-15 and Table B-22). To check the validity of this procedure, the speeds and volumes (and thus time gaps) were analyzed over all time periods. It was found that the speeds and volumes during the period 16:30 to 18:00 were not discernibly different from those during other periods. When analyzing the distribution of vehicles (Table B-1 and Table B-8), the data from 16:30 to 18:00 was discarded, as the missing data would have skewed the distributions.

Data was collected twice at Interstate 35E after implementation of the restriction. Twenty-four hours of data were collected from 12:00 on Tuesday, December 5, 1989 to 12:00 on Wednesday, December 6, 1989 (After Period I). Also, twenty-four hours of data were collected from 10:00 on Tuesday, February 13, 1990 to 10:00 on Wednesday, February 14, 1990 (After Period II).

Table 7. IH 10 and 20 - Dates and Approximate Times of Data Collection After Implementation of Truck Restriction

Interstate 10		
Date	Time	Hours Collected
May 31, 1990	07:30 - 13:30	6.00
May 31, 1990	16:00 - 18:00[1]	2.00
	Total	8.00
Interstate 20		
Date	Time	Hours Collected
November 14, 1989	14:15 - 18:00	3.75
November 15, 1989	11:15 - 18:00	6.75
November 16, 1989	06:30 - 11:00	4.50
	Total	15.00

[1] See text in "Data Collection and Reduction"

Results

Just as with the data collected before the restriction, the data from Interstate 10 did not exhibit a peak period. The data from Interstates 20 and 35E, however, were again separated into peak and non-peak periods, using the same definitions outlined in Chapter II. Peak flow constituted 35.8% of total flow in the Interstate 20 data set and 33.1% and 34.1 % of total flow in the first and second data sets from Interstate 35E, respectively. The two data sets collected at Interstate 35E exhibited very similar operational characteristics, as can be seen in the tables in Appendix B. Complete descriptive summaries of the data collected after implementation of the truck restriction at all three sites can be found in Appendix B. As was done in Chapter II, a few observations about the composition of the traffic are presented below. Results of comparisons between the data collected before and after implementation of the truck restriction are presented in Chapter VII.

Traffic Composition

Table 8 summarizes the car and truck percentages at the three sites and was compiled from the tables in Appendix B. From this table it can be seen that the percentage of trucks was 20.5% at Interstate 10. Similarly, the percentage of trucks was 6.6% and 15.0% at Interstate 20 during the peak and non-peak periods, respectively; and the percentage of trucks was 2.6% and 7.5% (averages of After Periods I and II) at Interstate 35E during the peak and non-peak periods, respectively. Again, higher truck percentages during the non-peak periods are clearly evident.

In analyzing the distribution of truck traffic across a direction, the data indicate a reduction in the percentage of trucks in the left lanes at all three sites. The actual violation/compliance rate will be discussed in Chapter VII. Table 9 summarizes the left-lane truck percentages mentioned above at the three sites and was compiled from the tables in Appendix B.

Table 8. Summary of Car and Truck Percentages
After Implementation of Truck Restriction

Interstate 10			
% Cars		% Trucks	
79.5		20.5	
Interstate 20			
Peak Period		Non-Peak Period	
% Cars	% Trucks	% Cars	% Trucks
93.4	6.6	85.0	15.0
Interstate 35E			
Peak Period		Non-Peak Period	
% Cars	% Trucks	% Cars	% Trucks
After Period I			
97.4	2.6	92.5	7.5
After Period II			
97.3	2.7	92.6	7.4

Table 9. Left-Lane Truck Percentages After Implementation of Truck Restriction

Interstate 10				
	Westbound		Eastbound	
	% of Total	% of Trucks	% of Total	% of Trucks
(No Peak Period)	0.5	2.5	0.3	1.3
Interstate 20				
	Westbound		Eastbound	
	% of Total	% of Trucks	% of Total	% of Trucks
Peak Period	0.2	3.2	0.3	4.4
Non-Peak Period	0.2	1.3	0.4	2.9
Interstate 35E				
	Northbound		Southbound	
	% of Total	% of Trucks	% of Total	% of Trucks
	After Period I			
Peak Period	0.1	3.4	0.1	3.5
Non-Peak Period	0.2	3.1	0.3	4.0
	After Period II			
Peak Period	0.1	2.4	0.2	5.9
Non-Peak Period	0.2	3.1	0.2	3.3

CHAPTER VI
USER-RESPONSE SURVEYS

In order to determine the attitudes and opinions of motorists as to the effectiveness of the sign as well as the restriction, three surveys were conducted. Two of these surveys polled the opinions of motorists observed using the facility at sites two and three (Interstates 20 and 35E), the other polled the opinions of truckers at the first site (Interstate 10). The Interstate 20 and 35E surveys were conducted by manually collecting license plate numbers from vehicles observed on those facilities. Surveys were then mailed to the owners of each of those vehicles. The Interstate 10 survey was conducted by polling truck drivers at a truckstop in Brookshire, Texas. Table 10 presents the dates on which the surveys were conducted at all three sites.

Table 10. Survey Dates

Location	Date
Interstate 20	November 16, 1989[1]
Interstate 35E	January 31, 1990[1]
Interstate 10	April 20, 1990

[1] NOTE: License plate data collected for survey mailing.

Survey Format

All three surveys are alike in format and can be found in Figures 6, 7 and 8. These figures are actual copies of the surveys and also present the percentages of responses to each question. The surveys were structured to perform two principle functions:

1) Assess the effectiveness of the sign, in both being noticed and in conveying its intended meaning, and

2) Assess the opinions of motorists and truckers towards the restriction and its impact on highway operations.

A total of 480 Interstate 20 motorist surveys were mailed, and 161 of them (34%) were returned. A total of 490 Interstate 35E motorist surveys were mailed, and 184 of them (38%) were returned. Finally, 87 Interstate 10 trucker surveys were completed.

Results

As the results of the three surveys are presented in Figures 6, 7, and 8, the following information was compiled or taken from those figures. As stated before, the surveys had two main functions: assess sign effectiveness and assess driver opinions. The first function was fulfilled by Questions 1 and 2. When asked if drivers noticed the signs as they drove by (Question 1), 74%, 61%, and 76% answered positively from Interstates 20, 35E, and 10, respectively. In determining the effectiveness of the sign in conveying its intended meaning, Question 2 was employed. This question is very similar to questions used in the motorist and trucker surveys presented in Chapter IV. The effectiveness of the sign can be analyzed by determining the percentages of correct responses to each part of Question 2. The average percentages of correct responses were 88%, 90%, and 73% from Interstates 20, 35E, and 10, respectively. Recall that the surveys from Interstates 20 and 35E were motorist surveys, while the Interstate 10 survey was of truckers.

TEXAS TRANSPORTATION INSTITUTE

TRANSPORT OPERATIONS PROGRAM

Area Code 409
Telephone 845 - 1535
TexAn 857-1535

Dear Motorist:

Your vehicle was recently observed traveling on Interstate 20 west of Fort Worth. Since you travel this roadway, your help is needed in a special study being conducted by the Texas State Department of Highways and Public Transportation.

The purpose of this study is to provide the motoring public with a safer and more efficient transportation system. One alternative that is being studied is restricting trucks/trailers from the inner lane of 6-lane rural interstate roadways. Please take a few minutes to answer the questions below. The information you provide will assist the Texas State Department of Highways and Public Transportation in determining what improvements are necessary to better serve the motorist. All answers will remain strictly confidential.

Your cooperation and timely return of this questionnaire in the enclosed postage-paid envelope will be greatly appreciated. Thank you for your assistance in this important undertaking.

1. Did you notice the following sign as you travelled along Interstate 20?

NO
TRUCKS
TRAILERS
IN LEFT
LANE

Yes	No
74.4%	25.6%

2. Please check the types of vehicles to which you think this sign applies.

	Yes	No	Not Sure
Passenger Cars	1.3%	98.7%	0.0%
Pickups	4.4%	91.2%	4.4%
Vans	4.4%	94.3%	1.3%
Vehicles Pulling Trailers	76.7%	15.7%	7.5%
Single Unit Trucks	70.4%	22.0%	7.5%
Tractor Semi-Trailer	95.6%	1.9%	2.5%

3. Do you think this lane restriction has improved operations along Interstate 20?

Yes	No	Not Sure
56.3%	7.0%	36.7%

4. Comments: (continue on back if necessary)

No comment 55.3% Good idea 19.9% Bad idea 4.3%
Other 20.5%

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Figure 6. IH 20 - User-Response Survey and Results

TEXAS TRANSPORTATION INSTITUTE

TRANSPORT OPERATIONS PROGRAM

Area Code 409
Telephone 845 - 1535
TexAn 857-1535

Dear Motorist:

Your vehicle was recently observed traveling on Interstate 35E north of Dallas. Since you travel this roadway, your help is needed in a special study being conducted by the Texas State Department of Highways and Public Transportation.

The purpose of this study is to provide the motoring public with a safer and more efficient transportation system. One alternative that is being studied is restricting trucks/trailers from the inner lane of 6-lane rural interstate roadways. Please take a few minutes to answer the questions below. The information you provide will assist the Texas State Department of Highways and Public Transportation in determining what improvements are necessary to better serve the motorist. All answers will remain strictly confidential.

Your cooperation and timely return of this questionnaire in the enclosed postage-paid envelope will be greatly appreciated. Thank you for your assistance in this important undertaking.

1. Did you notice the following sign as you travelled along Interstate 35E?

NO
TRUCKS
TRAILERS
IN LEFT
LANE

Yes	No
61.4%	38.6%

2. Please check the types of vehicles to which you think this sign applies.

	Yes	No	Not Sure
Passenger Cars	0.5%	99.5%	0.0%
Pickups	2.2%	95.1%	2.7%
Vans	2.2%	96.2%	1.6%
Vehicles Pulling Trailers	77.7%	15.8%	6.5%
Single Unit Trucks	74.5%	16.8%	8.7%
Tractor Semi-Trailer	98.4%	1.1%	0.5%

3. Do you think this lane restriction has improved operations along Interstate 35E?

Yes	No	Not Sure
35.3%	16.3%	48.4%

4. Comments: (continue on back if necessary)

No comment 56.5% Good idea 19.6% Bad idea 2.6%
Other 21.3%

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Figure 7. IH 35E - User-Response Survey and Results

Interstate 10
Trucker Survey

The Texas State Department of Highways and Public Transportation is conducting a survey concerning restrictions on certain vehicles using the left lane of rural interstate highways with 3 lanes in each direction and 65 mph speed limits. Please take a few minutes to answer the questions below and return the completed form to the survey taker. Thank you for your cooperation.

1. Did you notice the following sign as you travelled along Interstate 10?

NO
TRUCKS
TRAILERS
IN LEFT
LANE

Yes	No
75.9%	24.1%

2. Please check the types of vehicles to which you think this sign applies.

	Yes	No	Not Sure
Passenger Cars	12.6%	85.1%	2.3%
Pickups	12.6%	85.1%	2.3%
Vans	11.5%	86.2%	2.3%
Vehicles Pulling Trailers	55.2%	43.7%	1.1%
Single Unit Trucks	42.5%	56.3%	1.1%
Tractor Semi-Trailer	83.9%	14.9%	1.1%

3. Do you think this lane restriction has improved operations along Interstate 10?

Yes	No	Not Sure
19.5%	52.9%	27.6%

4. Comments: (continue on back if necessary)

No comment 47.1% Bad idea 27.6% Good idea 3.4%

Other 21.9%

Figure 8. IH 10 - User-Response Survey and Results

The second function was fulfilled by questions 3 and 4. From Question 3 it can be seen that 56% and 35% of the motorists think the restriction has improved operations while only 20% of the truckers believe that it has. From the comments provided in Question 4, 20% of the motorists offered that the restriction was a good idea, while to the contrary, 28% of the truckers thought that it was a bad idea.

CHAPTER VII
RESULTS AND COMPARISONS

Compliance

An important aspect to consider when evaluating a restriction is the rate of compliance to that restriction. This factor is analyzed by comparing the percentage of trucks in the left lane before and after implementation of the restriction. Violations may be either unintentional or intentional. Unintentional violations may occur either because the driver did not see the sign (see Chapter VI) or because they did not understand which types of vehicles were affected by the sign. The latter problem may be more true with certain classes of vehicles. Incorrect responses were much more common when survey respondents were asked about vehicles pulling trailers and single unit trucks (see Figures 6, 7, and 8). These factors could bring about unintentional violations.

Whether intentional or not, some violations did occur. However, the percentage of trucks decreased significantly in the left lanes at all sites with one exception (alpha = 0.05). Table 11 summarizes the percent reductions of truck traffic in the left lane (as a percentage of truck traffic in the direction) at Interstates 10, 20 and 35E. The percentage of trucks in the left lane decreased by an average of 55% at Interstate 10, 66% at Interstate 20 and 61% at Interstate 35E. Because of the small number of trucks in the left lane initially, only 1.9% of the trucks at Interstate 10, 2.9% of the trucks at Interstate 20, and 3.6% of the trucks at Interstate 35E remained in the left lane after the restriction. In addition, because of the small ratio of trucks to cars, only 0.4% of total traffic at Interstate 10, 0.3% of total traffic at Interstate 20, and 0.2% of total traffic at Interstate 35E were trucks driving in the left lanes. These results exhibit the near non-existence of trucks in the left lanes at these sites after the restriction.

Table 11. Percent Reduction of Truck Traffic in Left Lanes

Interstate 10			
Westbound		Eastbound	
34%		75%	
Interstate 20			
Westbound		Eastbound	
Peak	Non-Peak	Peak	Non-Peak
64%	76%	62%	64%
Interstate 35E			
Northbound		Southbound	
Peak	Non-Peak	Peak	Non-Peak
80%	62%	45%	57%

Vehicle Distribution

Changes in the distribution of cars and trucks across each direction should be evaluated in order to determine the impacts of the restriction, if any, on pavement wear and highway operations. A redistribution of trucks is certainly expected, but the magnitude of such a change is not known. Furthermore, a redistribution of trucks may cause a corresponding redistribution of cars. The combination of these changes may have either positive or negative consequences. A decrease in the speed differential in a lane will likely increase the safety of the roadway. However, the concentration of large vehicles on the outside lane may prohibit ingress/egress or may increase pavement wear. Restricted access of entering vehicles may decrease safety, while increased pavement wear may demand higher design standards for the roadway, at least for the outside lanes. The chi-square statistic was used to test the significance of the changes in the directional distributions of vehicles.

Distribution of Trucks

After the restriction was implemented at Interstate 10, the distribution of trucks did not change significantly (alpha = 0.05) in the westbound direction. The distribution of trucks did change significantly, however, in the eastbound direction, where the percentage of trucks decreased in the left lane by 75%. Table 12 summarizes the changes in the distributions of trucks at Interstate 10. The percentages of trucks in the right two lanes did not change in a consistent manner across both directions. In one direction, the percentage of trucks increased in the center lane and decreased in the right lane; while in the other direction, the exact opposite occurred. These peculiar changes in the distributions of trucks is almost certainly due to the changes in the geometric configuration of the westbound direction. When the "before" data was collected, the inside (median) lane began as a left-lane addition from the adjacent four-lane section. Later, when the "after" data was collected, the four-lane section had been widened to six lanes (see Figure 9). This change occurred only in the westbound direction. Because of this difference, a lower truck compliance is expected, because with the present configuration, trucks have to move *out of* the median lane. As can be seen in Table 12, the percentage of trucks decreased by only 34% in the left lane of the westbound direction, the smallest reduction found at all three sites. Because of the change in geometry, no conclusions can be drawn as to the effect the restriction had on the distribution of trucks, based on the data from the westbound direction of Interstate 10.

After the restriction was implemented at Interstate 20, the distribution of trucks changed significantly (alpha = 0.05) across both directions and during both the peak and non-peak periods. In addition, these distributions changed in a peculiar way. Table 13 summarizes the changes in the distributions of trucks at Interstate 20. As expected, the

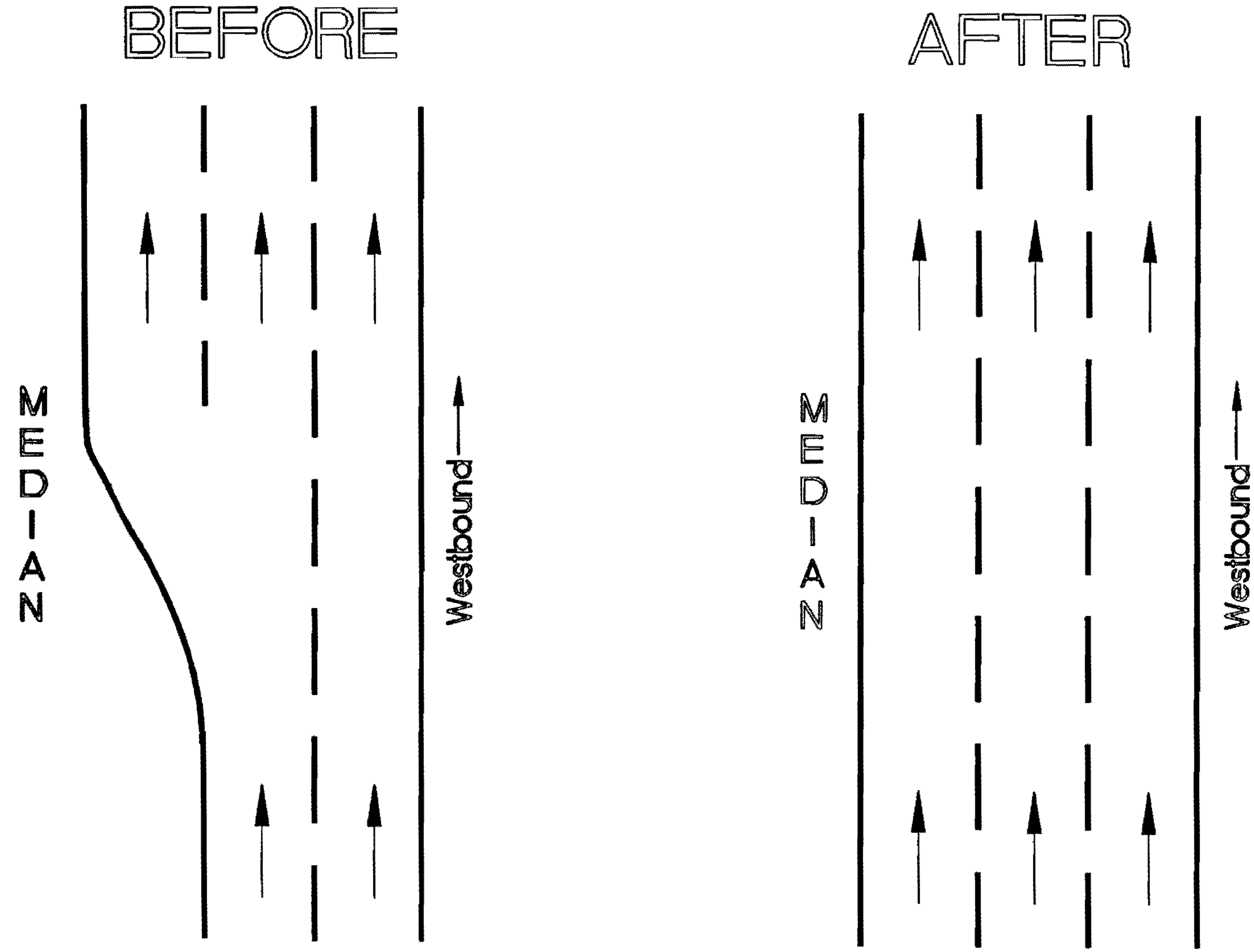

Figure 9. IH 10 - Geometric Configuration Changes

Table 12. IH 10 - Changes in the Distribution of Trucks

Lane	Percentage of Trucks (Before - After)	Change
Westbound		
Left	3.8 - 2.5	DOWN 34%
Center	32.0 - 33.5	UP 5%
Right	64.2 - 64.0	DOWN <1%
Eastbound		
Left	5.2 - 1.3	DOWN 75%
Center	40.0 - 27.8	DOWN 31%
Right	54.8 - 70.9	UP 29%

percentage of trucks decreased in the left lane by between 62% and 76%. Because of the small percentage of trucks in the left lane initially, however, a high *percentage* reduction in trucks does not result in the removal of a large *number* of trucks from the left lane. Unexpectedly, however, the percentage of trucks decreased in the *middle* lane as well (between 6% and 23%), with the percentage of trucks increasing only in the right lane (between 17% and 60%). This same pattern of change appeared in both the westbound and eastbound directions, and during both the peak and non-peak periods. Although the percentage of trucks in the right lane increased by as much 60% (eastbound peak period, see Table 13), that increase was generally less than 25%. These results *suggest* that the trucks that moved from the left lane to the center lane caused a subsequent movement of trucks from the center lane to the right lane. Although not likely, however, it is possible that the trucks moved from the left lane to the right lane. Whatever the case, the concentration of trucks in the right lane is more pronounced than expected, while the concentration of trucks in the middle lane is actually less than expected.

Table 13. IH 20 - Changes in the Distribution of Trucks

Lane	Percentage of Trucks (Before - After)	Change
Peak Period		
Westbound		
Left	8.9 - 3.2	DOWN 64%
Center	41.9 - 39.1	DOWN 7%
Right	49.2 - 57.7	UP 17%
Eastbound		
Left	11.7 - 4.4	DOWN 62%
Center	55.5 - 43.0	DOWN 23%
Right	32.8 - 52.6	UP 60%
Non-Peak Period		
Westbound		
Left	5.4 - 1.3	DOWN 76%
Center	40.6 - 31.1	DOWN 23%
Right	54.1 - 67.7	UP 25%
Eastbound		
Left	8.0 - 2.9	DOWN 64%
Center	51.1 - 48.0	DOWN 6%
Right	41.0 - 49.1	UP 20%

Although the distribution of trucks changed significantly (alpha = 0.05) at Interstate 35E as well (both directions, peak and non-peak periods), the pattern of change was not identical to that of Interstate 20. Table 14 summarizes the changes in the distributions of trucks at Interstate 35E. At this site, the percentage of trucks again decreased in the left lanes (between 45% and 80%), but increased slightly in both the middle lanes (between 1% and 14%) and the right lanes (between 8% and 12%). This same pattern of change appeared in both the northbound and southbound directions, and during both the peak and non-peak periods. The effect of these changes is an increase in the concentration of trucks in the middle lanes and a much more moderate increase in the concentration of trucks in the right lanes as compared to that on Interstate 20.

Table 14. IH 35E - Changes in the Distribution of Trucks

Lane	Percentage of Trucks (Before - After)	Change
Peak Period		
Westbound		
Left	14.3 - 2.9	DOWN 80%
Center	48.1 - 55.0	UP 14%
Right	37.7 - 42.2	UP 12%
Eastbound		
Left	8.5 - 4.7	DOWN 45%
Center	50.5 - 51.0	UP 1%
Right	41.0 - 44.4	UP 8%
Non-Peak Period		
Westbound		
Left	8.2 - 3.1	DOWN 62%
Center	52.5 - 54.0	UP 3%
Right	39.4 - 43.0	UP 9%
Eastbound		
Left	8.6 - 3.7	DOWN 57%
Center	53.0 - 54.1	UP 2%
Right	38.4 - 42.2	UP 10%

Distribution of Cars

At Interstate 10, the distribution of cars changed significantly (alpha = 0.05) across both directions. Table 15 summarizes the changes in the distributions of cars at Interstate 10. Just as with the distribution of trucks at this site, however, they did not change in any consistent manner, most likely due to the change in geometry discussed earlier. As would be expected, the percentage of cars increased in the left lane of the westbound direction by 48% (see Table 15), because cars now have more time than before to occupy that lane. Therefore, no conclusions can be drawn as to the effect of the restriction on the distribution of cars in the westbound direction of Interstate 10. The large decrease in the percentage of cars in the left lane of the eastbound direction is unexplained and is not substantiated by changes at the other sites.

At Interstate 20, the distribution of cars did not change significantly (alpha = 0.05) during the peak period (both directions), but did change significantly during the non-peak period (both directions). Table 16 summarizes the changes in the distributions of cars at Interstate 20. The sample sizes during the non-peak periods of both directions are so large, however, that any variations between the before and after periods would be found statistically significant. The actual differences found are so small in all lanes (usually <2%) that they are of no practical importance. Therefore, there was no change *of practical significance* in the distribution of cars across both directions and during both periods. It can be seen in Table 16 that all of the changes are less than 7% in magnitude and exhibit no consistent pattern in their direction of change. Similar results were found at Interstate 35E, where the distribution of cars did not change significantly (alpha = 0.05) across either direction or during either period. Table 17 summarizes the changes in the distributions of cars at Interstate 35E. Here again, the changes are less than 7% in magnitude and exhibit no consistent pattern in their direction of change. Therefore, these results suggest that a redistribution of the few trucks in the left lane does not effect a meaningful redistribution of the surrounding cars.

Table 15. IH 10 - Changes in the Distribution of Cars

Lane	Percentage of Cars (Before - After)	Change
Westbound		
Left	19.4 - 28.7	UP 48%
Center	48.6 - 48.8	UP <1%
Right	32.1 - 22.5	DOWN 30%
Eastbound		
Left	23.3 - 17.7	DOWN 24%
Center	48.6 - 49.5	UP 2%
Right	28.1 - 32.8	UP 17%

Table 16. IH 20 - Changes in the Distribution of Cars

Lane	Percentage of Cars (Before - After)	Change
Peak Period		
Westbound		
Left	31.1 - 32.8	UP 5%
Center	42.8 - 41.5	DOWN 3%
Right	26.1 - 25.7	DOWN 2%
Eastbound		
Left	35.2 - 37.3	UP 6%
Center	41.6 - 40.6	DOWN 2%
Right	23.2 - 22.1	DOWN 5%
Non-Peak Period		
Westbound		
Left	20.7 - 19.3	DOWN 7%
Center	47.9 - 50.3	UP 5%
Right	31.3 - 30.4	DOWN 3%
Eastbound		
Left	29.1 - 27.4	DOWN 6%
Center	46.6 - 48.1	UP 3%
Right	24.3 - 24.5	UP 1%

Table 17. IH 35E - Changes in the Distribution of Cars

Lane	Percentage of Cars (Before - After)	Change
Peak Period		
Westbound		
Left	34.9 - 35.1	UP 1%
Center	32.7 - 31.3	DOWN 4%
Right	32.5 - 33.6	UP 3%
Eastbound		
Left	38.7 - 36.4	DOWN 6%
Center	32.4 - 32.7	UP 1%
Right	28.9 - 31.0	UP 7%
Non-Peak Period		
Westbound		
Left	25.8 - 26.8	UP 4%
Center	38.3 - 35.8	DOWN 7%
Right	35.9 - 37.5	UP 4%
Eastbound		
Left	27.5 - 29.1	UP 6%
Center	39.8 - 37.4	DOWN 6%
Right	32.6 - 33.6	UP 3%

Time Gaps Between Vehicles

The average time gaps presented in Tables A-16 through A-18 and Tables B-22 through B-24 can be used to obtain an indication of how closely vehicles are following one another. As stated in Appendices A and B, however, comparisons of these numbers from before and after the restriction should be made knowing that the *average* time gaps are only meaningful if the vehicles are evenly distributed throughout the time period studied. The entire distribution of time gaps, therefore, needs to be examined in order to understand changes between the before and after stage. Examination of the cumulative distribution function allows comparisons to be made only at the smaller time gaps, where differences imply interactions among vehicles. This is important because as the time gaps become larger, the influence the leading car has on the following vehicle's decision as to how closely to follow is minimal, but instead depends on traffic volume. Since Interstates 10 and 20 were the only sites at which time gap data was obtained, the analyses presented in this section pertain only to those two sites.

Comparison Methods

The cumulative distribution functions of the time gaps between vehicles were examined according to the following four variables:

1) **Stage.** This defines whether the data was collected before or after implementation of the truck restriction.

2) **Lane.** This defines the lane from which the data was taken.

3) **Period.** This defines whether the data is from the peak or non-peak period.

4) **Group.** Four groups were defined and included the four combinations of the leading vehicle's classification and the following vehicle's classification. The

classification systems presented in Chapter II were again used. Therefore, the four groups were: cars following cars, cars following trucks, trucks following cars, and trucks following trucks.

Manipulation of the above four variables allowed many different types of comparisons to be made. Four types of analyses were performed by plotting and examining the cumulative distribution functions in the following manners: .

1) All four groups on one graph, with stage, lane, and period variable. (24 graphs for Interstate 20 data, 12 for Interstate 10 data)

2) Both stages on one graph, with lane, period, and group variable. (48 graphs for Interstate 20 data, 24 for Interstate 10 data)

3) Comparable lanes (left, center, or right lanes of both directions) on one graph, with lane pair (1/4, 2/5, and 3/6), stage, period, and group variable. (48 graphs for Interstate 20 data, 24 for Interstate 10 data)

4) Comparable lanes *and* both stages on one graph, with lane pair, period, and group variable. (24 graphs for Interstate 20 data, 12 for Interstate 10 data)

Results

The above graphs were analyzed to determine the changes, if any, that occurred between the before and after periods, or if meaningful observations could be made by looking at one stage only. When analyzing the time gaps from one stage, the only consistent observation is that the time gaps of trucks following trucks are less than those of trucks following cars. Furthermore, the time gaps of trucks following trucks are *usually* also less than those of cars following cars and of cars following trucks. The hypothesis that like vehicles follow like vehicles closer than unlike vehicles, however, could not be substantiated.

These observations generally held true during both stages, across all lanes, and during both periods. To demonstrate this effect, Figure 9 presents the cumulative distribution function for gap of all four groups in the middle lane of the westbound direction of Interstate 20 during the non-peak period of the after stage. This figure clearly shows the smaller time gaps of trucks following trucks relative to trucks following cars *and* shows that the time gaps of that group are also less than the other two groups. Figure 10 presents the cumulative distribution function for gap of all four groups in the *outside* lane of the westbound direction of Interstate 20 during the non-peak period of the after stage. This figure demonstrates that although the time gaps of trucks following trucks are still less than trucks following cars, they are about the same as the other two groups. As stated before, the observation demonstrated in Figure 9 held true in most instances; Figure 10 is presented to show that it was not *always* the case.

When examining the cumulative distribution function for gap of both stages (before and after) on one graph, it is important to first establish that the volume has not changed significantly from the before to the after stage. If the volume changed coincident with the implementation of the truck restriction, the headways likewise changed due to the interdependence of headway and volume, thereby making headway comparisons meaningless. To determine if the volume changed, the fifteen-minute flow rates examined in Chapter II for determining the peak and non-peak period definitions were again examined. After taking averages of all of the fifteen-minute flow rates for each stage, lane, and period, it was determined that there were no significant volume changes except during the peak period in the eastbound direction of Interstate 20. In that direction, volumes increased by between 31% and 58% from the before to the after stage. To graphically demonstrate the effect this had, Figures 11 and 12 are presented. Figure 11 presents the cumulative distribution function for gap of cars following cars before and after the restriction in the right lane of the westbound direction of Interstate 20 during the peak period. Here, the before and after functions are almost identical. Figure 12 presents the cumulative distribution function for gap of cars following cars before and after the restriction in the right lane of the *eastbound* direction of Interstate 20 during the peak

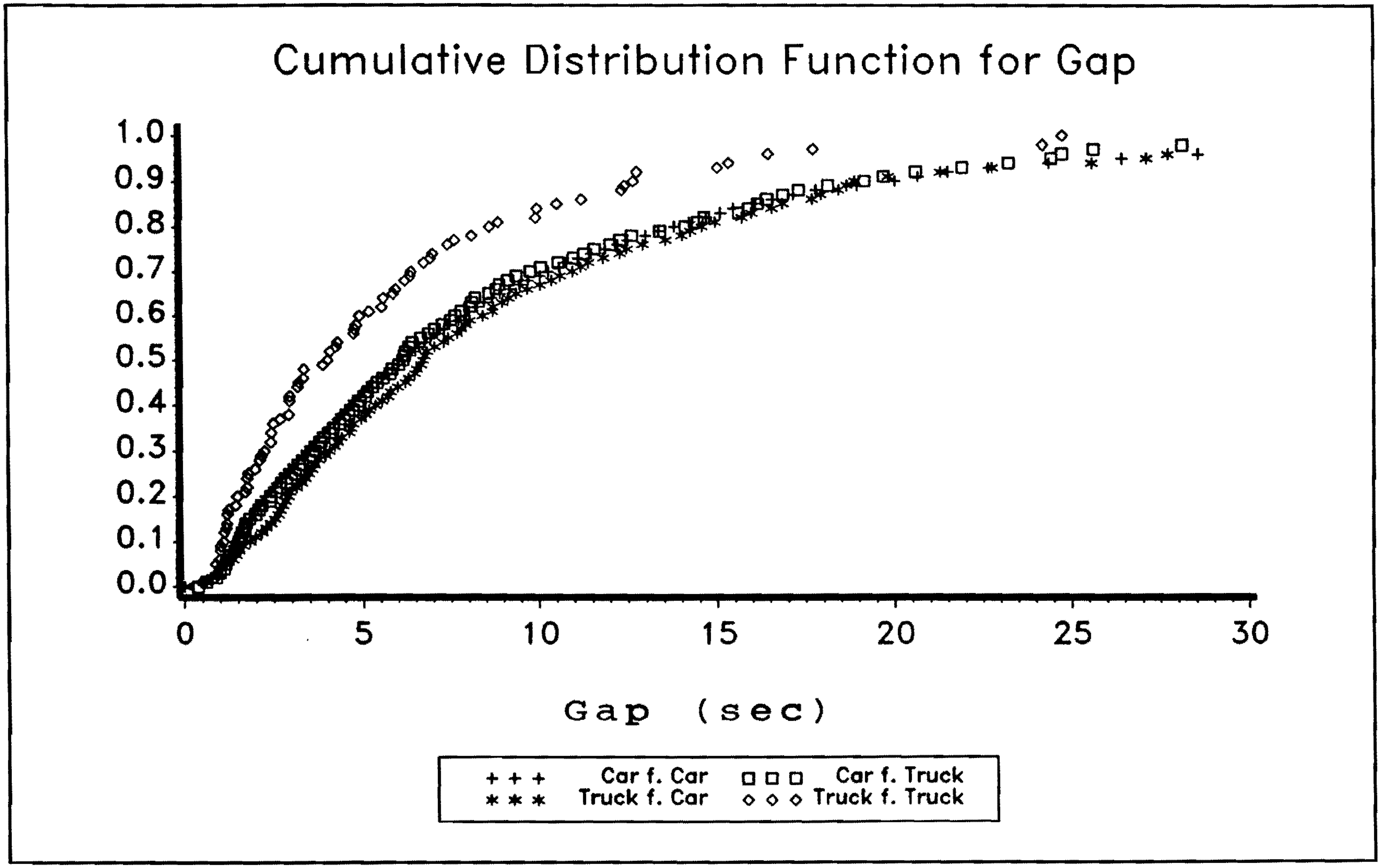

Figure 9. Cumulative Distribution Function For Gap of All Four Groups in the Middle Lane of the Westbound Direction of Interstate 20 During the Non-Peak Period of the After Stage

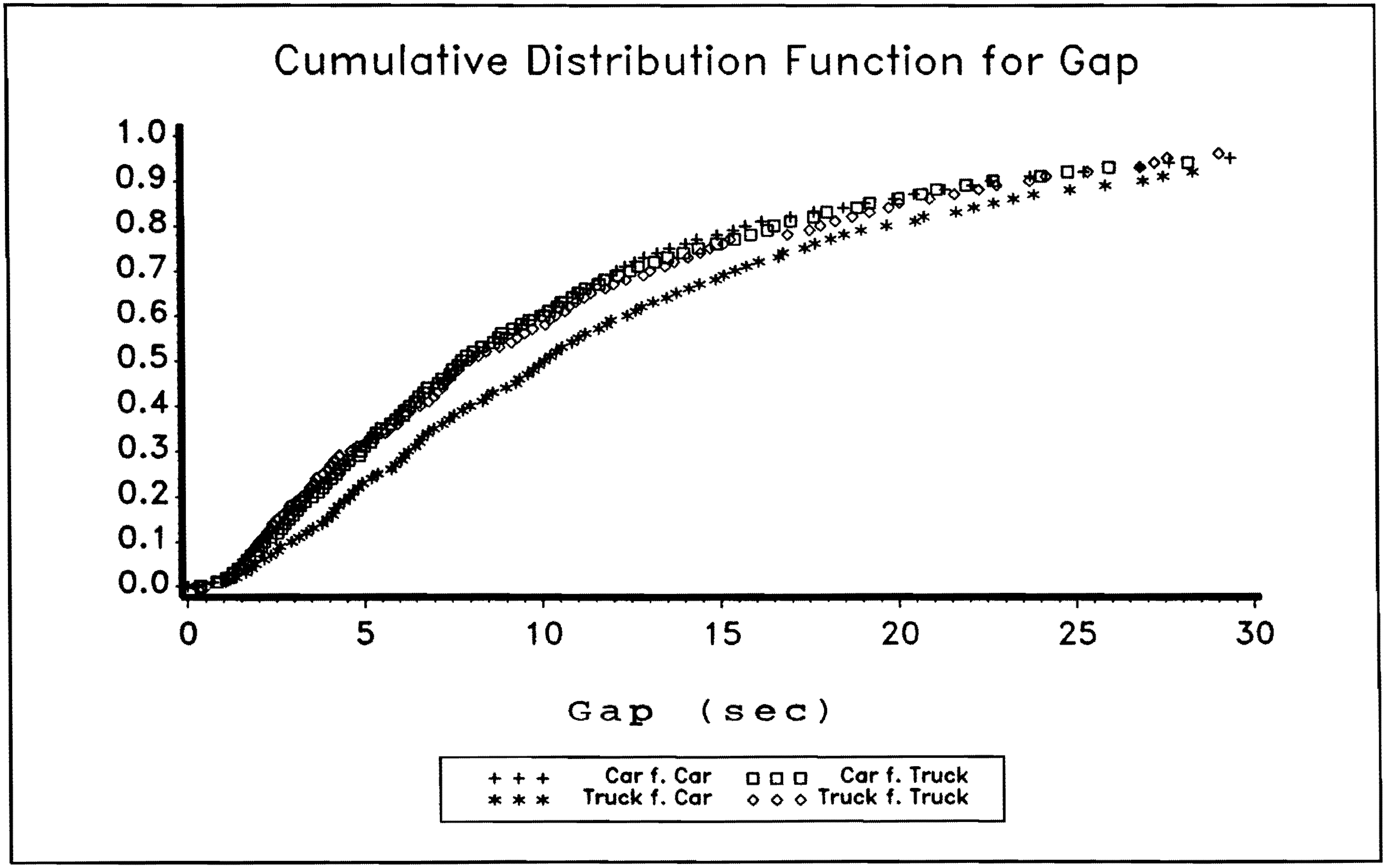

Figure 10. Cumulative Distribution Function for Gap of All Four Groups in the Outside Lane of the Westbound Direction of Interstate 20 During the Non-Peak Period of the After Stage

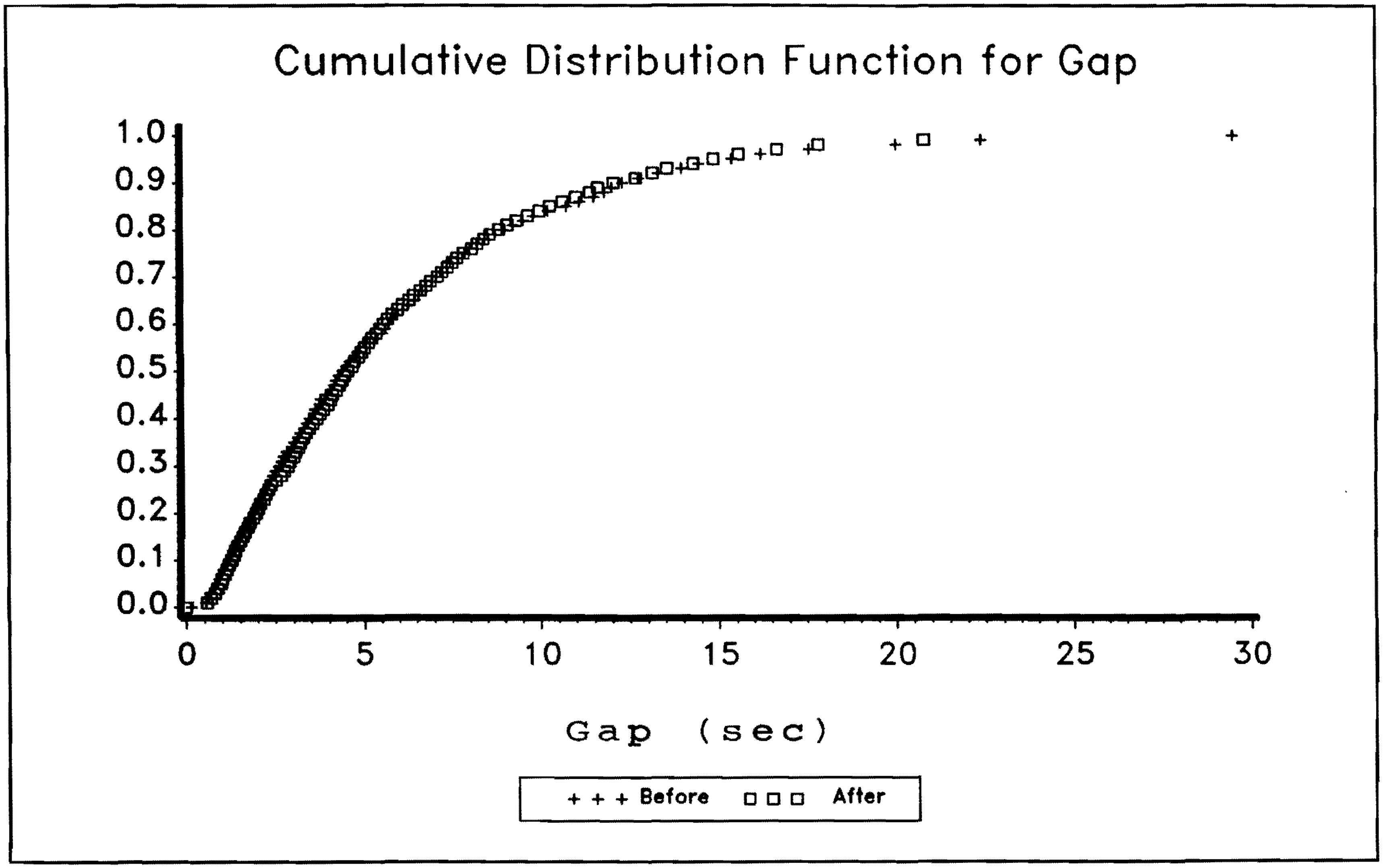

Figure 11. Cumulative Distribution Function for Gap of Cars Following Cars
Before and After the Restriction in the Right Lane
of the Westbound Direction of Interstate 20 During the Peak Period

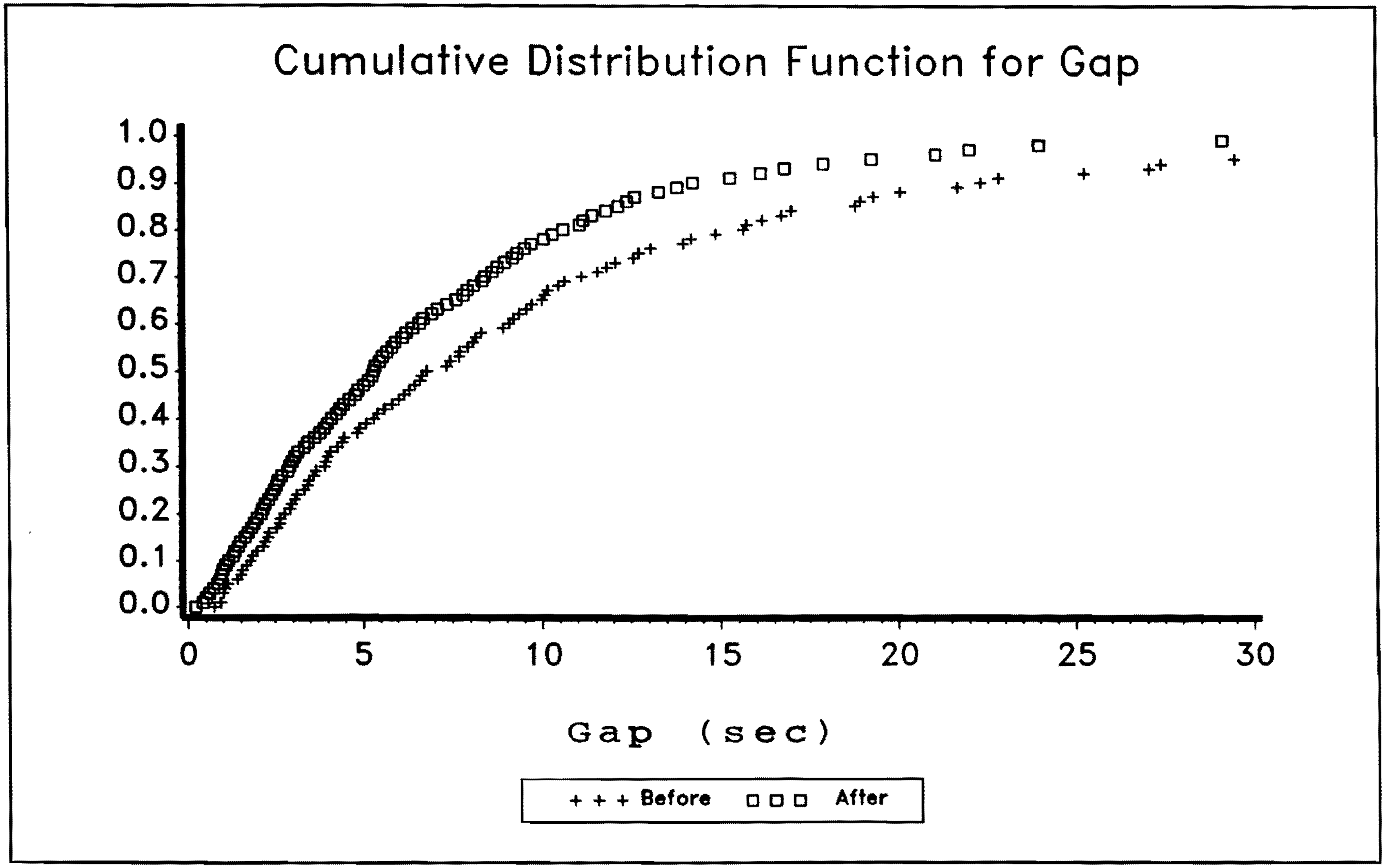

Figure 12. Cumulative Distribution Function for Gap of Cars Following Cars
Before and After the Restriction in the Right Lane
of the Eastbound Direction of Interstate 20 During the Peak Period

period. Here, due to the increase in volume during the after stage, the gaps between vehicles during that stage are decidedly smaller.

In trying to discover differences between the data collected before and after implementation of the restrictions, all of the graphs mentioned above were prepared and examined in an attempt to detect meaningful differences. However, no *consistent* differences could be found, even taking all variables into consideration. It is important to remember, however, that this is a *rural* site, with a low volume-to-capacity (v/c) ratio. With such large average headways (usually greater than five seconds), vehicles are not greatly affected by the vehicle in front of them even during the peak period. Therefore, it is difficult to detect meaningful differences in time gaps under these conditions, as those gaps are generally quite large due to the low volume. Nevertheless, under the current conditions these results suggest that a redistribution of trucks does not effect any discernible changes in the time gaps of either cars or trucks.

Vehicle Speeds

One way to investigate vehicle speeds is to analyze the average speeds as presented in Tables A-11 through A-15 and Tables B-15 through B-21. These average speeds can relate important information about the facility, even if changes in volume occur. One important point to consider when forcing trucks to switch lanes is the fact that those trucks may not adjust their speeds after they switch lanes. Furthermore, which trucks are complying with the restriction, the faster or the slower ones? This is important because those trucks previously in the left lane are exceeding the speed limit on average by as many as ten miles per hour. If the trucks that switch lanes do not adjust their speeds, an increase in speeds in the center or even the right lane might result, thereby increasing the potential for hazard within those lanes. To investigate this effect, changes in the average speeds of trucks and cars after the restriction were analyzed. Tables 18 and 19 summarize the changes in the speeds of trucks at Interstates 10 and 20, respectively. Tables 20 and 21 summarize the changes in the speeds of cars at Interstates 10 and 20, respectively. Changes in the speeds of cars were analyzed to verify that any changes in the speeds of trucks were classification dependent. Since speeds by classification were not collected at Interstate 35E, only the data from Interstates 10 and 20 are presented here. As can be seen in Tables 18 and 19, the speeds of trucks both increased and decreased after the restriction at both sites, depending on direction, lane, and period (at Interstate 20). As can be seen in Tables 20 and 21, the speeds of cars changed very little at both sites, usually less than 2%. Although some of those changes were statistically significant (alpha = 0.05), the sample sizes were so large as to make *any* differences significant. The changes observed in the speeds of trucks were generally in the same direction as the changes in the speeds of cars, although they were generally larger in magnitude. Based on these observations, there seems to be no positive or negative impact, as far as speeds are concerned, associated with the redistribution of trucks.

Table 18. IH 10 - Changes in the Speeds of Trucks

Lane	Speed (Before - After)	Change	Statistically Significant
Westbound			
Left	69.2 - 67.8	DOWN 2.0%	NO
Center	66.3 - 65.5	DOWN 1.2%	YES
Right	61.8 - 62.2	UP 0.6%	NO
Eastbound			
Left	68.3 - 73.1	UP 7.0%	YES
Center	64.9 - 67.1	UP 3.4%	YES
Right	60.7 - 62.8	UP 3.5%	YES

Table 19. IH 20 - Changes in the Speeds of Trucks

Lane	Speed (Before - After)	Change	Statistically Significant
Peak Period			
Westbound			
Left	69.7 - 66.1	DOWN 5.2%	YES
Center	64.4 - 61.9	DOWN 3.9%	YES
Right	60.7 - 58.4	DOWN 3.8%	YES
Eastbound			
Left	66.6 - 64.4	DOWN 3.3%	NO
Center	61.2 - 61.1	DOWN 0.2%	NO
Right	56.0 - 56.5	UP 0.9%	NO
Non-Peak Period			
Westbound			
Left	70.0 - 67.0	DOWN 4.3%	YES
Center	64.6 - 61.6	DOWN 4.6%	YES
Right	60.7 - 57.7	DOWN 4.9%	YES
Eastbound			
Left	64.6 - 68.4	UP 5.9%	YES
Center	61.2 - 61.5	UP 0.5%	NO
Right	57.0 - 57.9	UP 1.6%	YES

Table 20. IH 10 - Changes in the Speeds of Cars

Lane	Speed (Before - After)	Change	Statistically Significant
<u>Westbound</u>			
Left	71.2 - 71.0	DOWN 0.3%	NO
Center	68.2 - 68.1	DOWN 0.1%	NO
Right	63.4 - 64.3	UP 1.4%	YES
<u>Eastbound</u>			
Left	72.4 - 72.8	UP 0.6%	NO
Center	68.9 - 69.3	UP 0.6%	YES
Right	63.9 - 64.2	UP 0.5%	NO

In examining vehicle speeds, the cumulative distribution function may also be employed to gain a better understanding of how fast vehicles are traveling. The average speeds as analyzed above are very meaningful, but the cumulative distribution function relates additional information about the *variability* of those speeds. In examining the cumulative distribution function of vehicle speeds, the same methods of comparison used for the time gaps between vehicles were again utilized; the graphs prepared for time gaps were also prepared for vehicle speeds. When analyzing the cumulative distribution functions of only one stage (before or after) on a graph, the effect of grade on the speeds of trucks became quite clear. At the Interstate 20 site, there is a three percent downgrade in the westbound direction and a three percent upgrade in the eastbound direction. From Table 19 it can be seen that the average speeds of trucks in all lanes, during both periods, and during both stages are less in the eastbound direction. This effect is shown graphically in Figures 13 and 14 through the use of the cumulative distribution function. Figure 13 presents the cumulative distribution function for speed of *all* cars and *all* trucks in the left lane of the westbound direction (downhill) of Interstate 20 during the non-peak period of the before stage. This figure shows that the speeds of cars and trucks are almost identical. Figure 14 presents the cumulative distribution function for speed of all cars and all trucks

Table 21. IH 20 - Changes in the Speeds of Cars

Lane	Speed (Before - After)	Change	Statistically Significant
Peak Period			
Westbound			
Left	70.8 - 69.5	DOWN 1.8%	YES
Center	66.4 - 65.4	DOWN 1.5%	YES
Right	62.9 - 61.9	DOWN 1.6%	YES
Eastbound			
Left	70.1 - 70.1	NONE	NO
Center	67.6 - 68.3	UP 1.0%	NO
Right	65.0 - 65.4	UP 0.6%	NO
Non-Peak Period			
Westbound			
Left	70.6 - 69.3	DOWN 1.8%	YES
Center	66.4 - 65.2	DOWN 1.8%	YES
Right	63.5 - 61.6	DOWN 3.0%	YES
Eastbound			
Left	68.8 - 69.8	UP 1.5%	YES
Center	66.0 - 67.0	UP 1.5%	YES
Right	62.8 - 64.1	UP 2.1%	YES

in the left lane of the *eastbound* direction (uphill) of Interstate 20 during the non-peak period of the before stage. In contrast, this figure clearly shows that the speeds of trucks are falling behind those of cars. This suggests that, especially with steeper grades, the trucks in the left lane may impede the free-flow ability of cars.

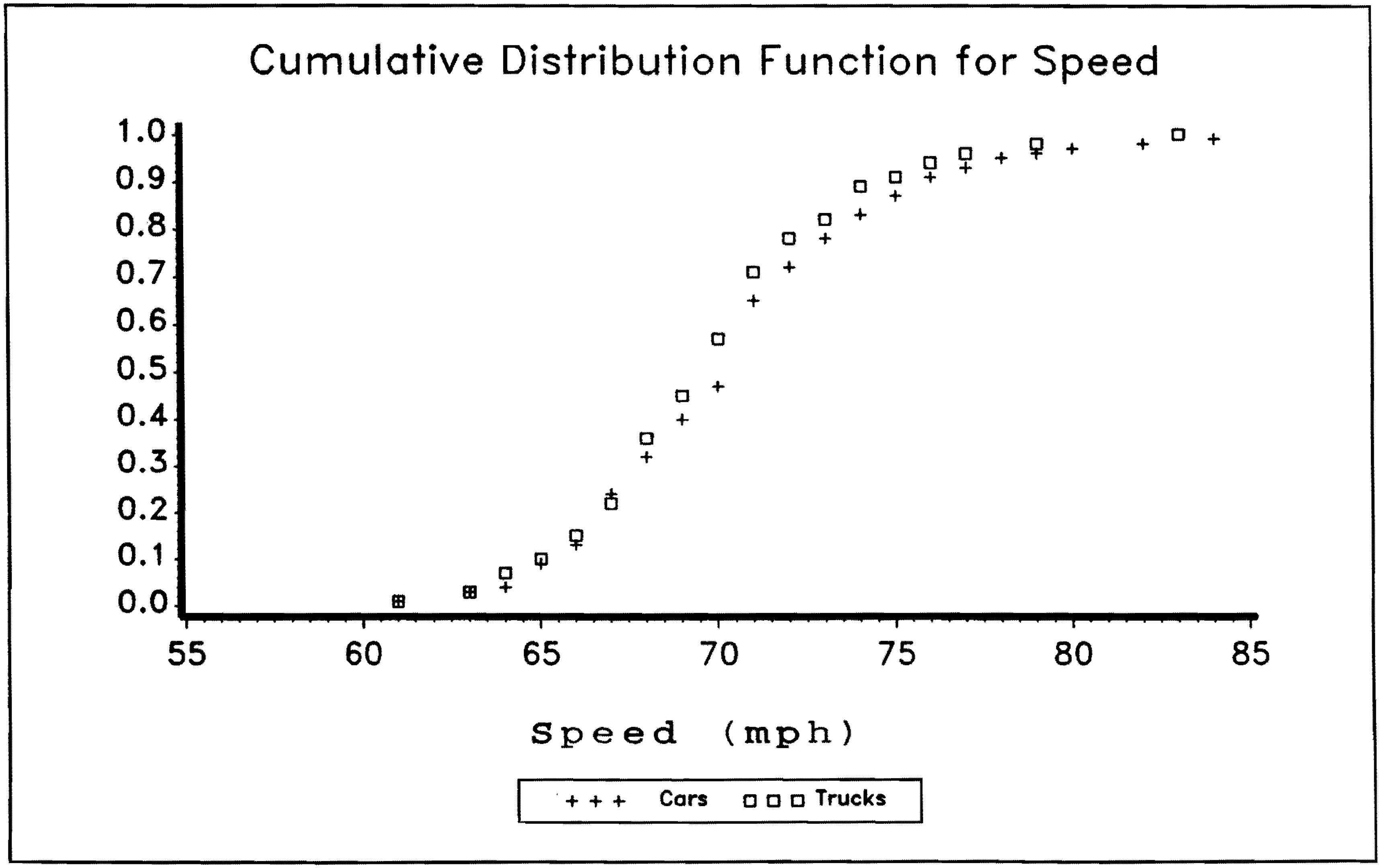

Figure 13. Cumulative Distribution Function for Speed of All Cars and Trucks in the Left Lane of the Westbound Direction (Downhill) of Interstate 20 During the Non-Peak Period of the Before Stage

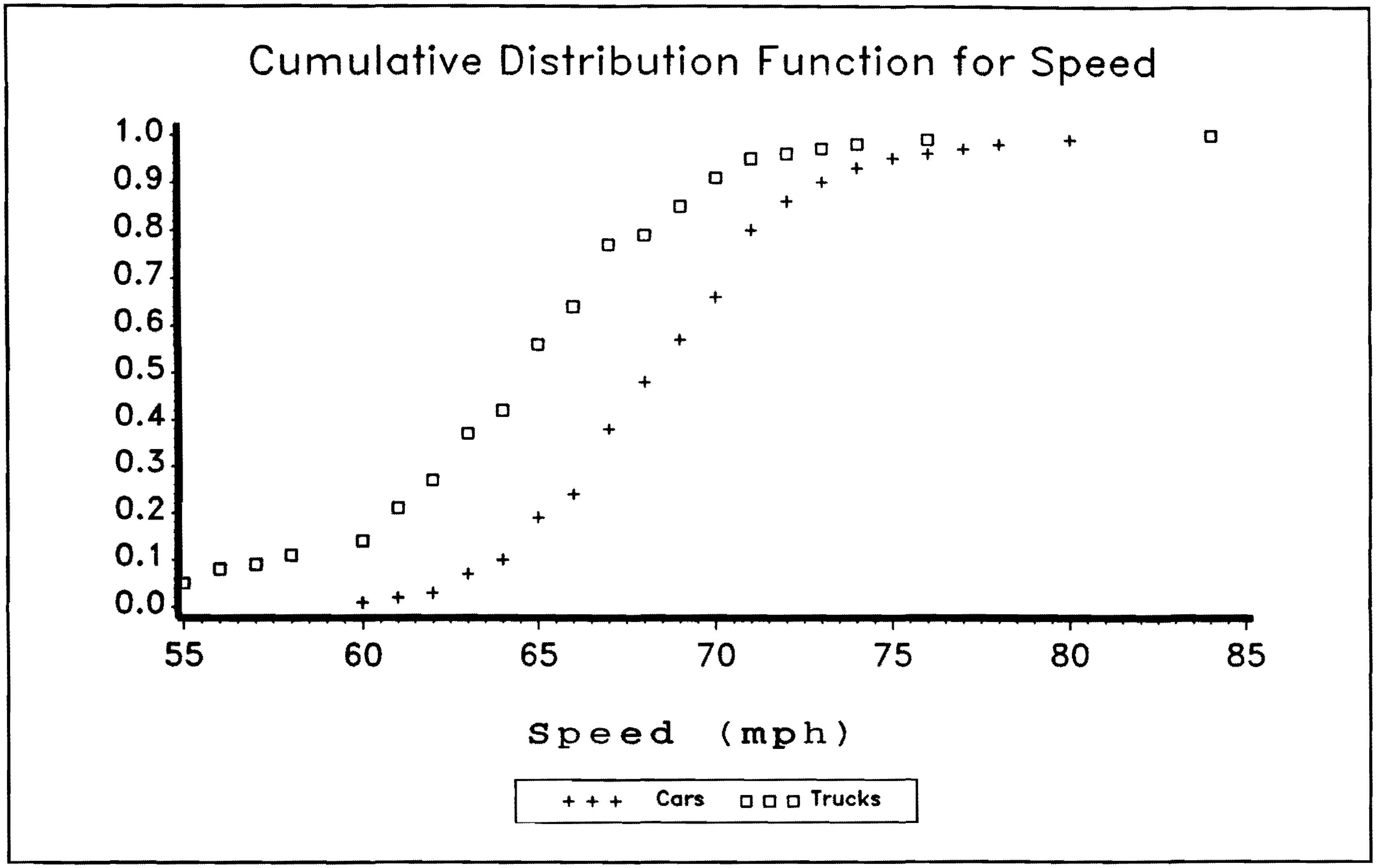

Figure 14. Cumulative Distribution Function for Speed of All Cars and Trucks in the Left Lane of the Eastbound Direction (Uphill) of Interstate 20 During the Non-Peak Period of the Before Stage

In trying to discover differences between the data collected before and after implementation of the restrictions, the graphs mentioned above were analyzed in an attempt to detect meaningful differences. Again, just as with the time gaps between vehicles, no *consistent* differences could be found, even taking all variables into consideration. Under the current conditions, therefore, these results suggest that a redistribution of trucks does not effect any discernible changes in the speeds of either cars or trucks.

CHAPTER VIII
CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following are the most significant findings:

1) Very few trucks drive in the left lane. This suggests that the left lanes of six-lane rural interstates can currently be designed for lesser loads than the other two lanes.

2) Trucks in the left lane are exceeding the speed limit by as many as ten miles per hour on average.

3) Before its implementation, 60% of motorists surveyed favored the restriction while only 28% of truckers surveyed favored it.

4) Of those surveyed utilizing one of the facilities, 33% of the motorists and 24% of the truckers did not see the regulatory sign. Furthermore, 11% of the motorists and 27% of the truckers indicated that they did not fully understand the meaning of the sign.

5) After its implementation, 45% of the motorists surveyed felt that the restriction had improved highway operations, while only 20% of the truckers felt that it had.

6) An overall average compliance rate of 62% was achieved without any attempts at enforcement and despite some drivers being unsure as to the meaning of the regulatory sign. This resulted in only 3.0% of all trucks remaining in the left lane.

7) While the distribution of trucks across a direction changed significantly, it did not effect a corresponding change of practical significance in the distribution of cars.

8) The percentage of trucks increased significantly in the right lane (only) of each direction of Interstate 20 and in the right two lanes of each direction of Interstate 35E. Changes in the distributions of trucks at Interstate 10 were mixed, most likely due to the change in the geometric configuration of an adjacent roadway segment after the initial data was collected.

9) The time gaps of trucks following trucks are significantly less than those of trucks following cars. Furthermore, they are *usually* also less than the time gaps of cars following cars and of cars following trucks.

10) The redistribution of trucks does not seem to effect any discernible changes in the time gaps of either cars or trucks.

11) Grade significantly affects the speeds of trucks.

12) Although there were statistically significant differences in the speeds of cars and trucks from before to after the restriction, the changes observed cannot be attributed to the redistribution of trucks.

Recommendations

Because there were no discernible negative effects of the truck restriction on highway operations, the restriction should be left in place. After a two-year period, an accident analysis study should be performed to determine if the restriction caused an increase in accidents. In addition, more research should be performed on the differential design of pavements on six-lane highways.

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APPENDIX A
SUMMARIES OF DATA COLLECTED BEFORE IMPLEMENTATION OF THE TRUCK RESTRICTIONS

This appendix contains summaries of all data collected before implementation of the truck restrictions at Interstates 10, 20 and 35E.

<u>Distribution of Vehicles</u>

Tables A-1 through A-5 present the distributions of both classifications of vehicles (see Chapter II, Classification Systems) at Interstates 10, 20, and 35E. In each table, the number of vehicles in each classification as well as its percentage of the total vehicles in the lane, the total vehicles in the direction, and the total vehicles in both directions are given. In addition, directional and grand totals (both directions) for both classifications are presented. Table A-1 shows the distribution of vehicles at Interstate 10. Table A-2 and Table A-3 show the distribution of vehicles at Interstate 20 during the peak and non-peak periods, respectively. Table A-4 and Table A-5 show the distribution of vehicles at Interstate 35E during the peak and non-peak periods, respectively.

Tables A-6 through A-10 relate how each classification of vehicle is distributed across each direction of Interstates 10, 20, and 35E. The percentages given in these tables are similar to those found in the columns headed "Percentage of Direction" in Tables A-1 through A-5. However, instead of being based on the total number of vehicles in a direction, these percentages are based only on the number of vehicles *of the same classification* in a direction. Table A-6 relates how each class of vehicle is distributed across both directions of Interstate 10. Table A-7 and Table A-8 relate how each class of vehicle is distributed across both directions of Interstate 20 during the peak and non-peak periods, respectively. Table A-9 and Table A-10 relate how each class of vehicle is distributed across both directions of Interstate 35E during the peak and non-peak periods, respectively.

Table A-1. IH 10 - Vehicle Distribution By Classification Before Implementation of Truck Restriction

Lane	Classification	Vehicles	Percentage of Lane	Percentage of Direction	Percentage of Both Directions
WESTBOUND					
Left	Axle = 2	1370	94.9	15.3	7.5
	Axle > 2	73	5.1	0.8	0.4
		1443		16.1	7.9
Center	Axle = 2	3434	84.9	38.2	18.8
	Axle > 2	613	15.1	6.8	3.3
		4047		45.0	22.1
Right	Axle = 2	2267	64.8	25.2	12.4
	Axle > 2	1232	35.2	13.7	6.7
		3499		38.9	19.1
Westbound Totals	Axle = 2	7071		78.7	38.7
	Axle > 2	1918		21.3	10.4
		8989			49.1
EASTBOUND					
Left	Axle = 2	1677	93.8	18.0	9.2
	Axle > 2	111	6.2	1.2	0.6
		1788		19.2	9.8
Center	Axle = 2	3502	80.5	37.6	19.1
	Axle > 2	847	19.5	9.1	4.6
		4349		46.7	23.7
Right	Axle = 2	2022	63.5	21.7	11.0
	Axle > 2	1162	36.5	12.4	6.4
		3184		34.1	17.4
Eastbound Totals	Axle = 2	7201		77.3	39.3
	Axle > 2	2120		22.7	11.6
		9321			50.9
Both Directions	Axle = 2	14272			78.0
	Axle > 2	4038			22.0
		18310			

Table A-2. IH 20 - Peak Period Vehicle Distribution By Classification Before Implementation of Truck Restriction

Lane	Classification	Vehicles	Percentage of Lane	Percentage of Direction	Percentage of Both Directions
WESTBOUND					
Left	Axle = 2	1180	97.7	28.7	22.0
	Axle > 2	28	2.3	0.7	0.5
		1208		29.4	22.5
Center	Axle = 2	1627	92.5	39.6	30.3
	Axle > 2	131	7.5	3.2	2.4
		1758		42.8	32.7
Right	Axle = 2	993	86.6	24.1	18.5
	Axle > 2	154	13.4	3.7	2.9
		1147		27.8	21.4
Westbound Totals	Axle = 2	3800		92.4	70.7
	Axle > 2	313		7.6	5.8
		4113			76.5
EASTBOUND					
Left	Axle = 2	396	96.1	31.4	7.4
	Axle > 2	16	3.9	1.3	0.3
		412		32.7	7.7
Center	Axle = 2	468	86.0	37.1	8.7
	Axle > 2	76	14.0	6.0	1.4
		544		43.1	10.1
Right	Axle = 2	261	85.3	20.7	4.9
	Axle > 2	45	14.7	3.6	0.8
		306		24.3	5.7
Eastbound Totals	Axle = 2	1125		89.1	20.9
	Axle > 2	137		10.9	2.5
		1262			23.4
Both Directions	Axle = 2	4925			91.6
	Axle > 2	450			8.4
		5375			

Table A-3. IH 20 - Non-Peak Period Vehicle Distribution By Classification Before Implementation of Truck Restriction

Lane	Classification	Vehicles	Percentage of Lane	Percentage of Direction	Percentage of Both Directions
WESTBOUND					
Left	Axle = 2	1291	95.8	17.7	7.9
	Axle > 2	57	4.2	0.8	0.3
		1348		18.5	8.2
Center	Axle = 2	2982	87.3	40.9	18.2
	Axle > 2	432	12.7	5.9	2.6
		3414		46.8	20.8
Right	Axle = 2	1949	77.2	26.7	11.9
	Axle > 2	576	22.8	7.9	3.5
		2525		34.6	15.4
Westbound Totals	Axle = 2	6222		85.4	38.0
	Axle > 2	1065		14.6	6.5
		7287			44.5
EASTBOUND					
Left	Axle = 2	2275	95.8	25.1	13.9
	Axle > 2	100	4.2	1.1	0.6
		2375		26.2	14.5
Center	Axle = 2	3642	85.0	40.2	22.3
	Axle > 2	642	15.0	7.1	3.9
		4284		47.3	26.2
Right	Axle = 2	1896	78.6	20.9	11.6
	Axle > 2	515	21.4	5.7	3.1
		2411		26.6	14.7
Eastbound Totals	Axle = 2	7813		86.1	47.8
	Axle > 2	1257		13.9	7.7
		9070			55.5
Both Directions	Axle = 2	14035			85.8
	Axle > 2	2322			14.2
		16357			

Table A-4. IH 35E - Peak Period Vehicle Distribution By Classification Before Implementation of Truck Restriction

Lane	Vehicle Length (Feet)	24 Hr. Volume	Percentage of Lane	Percentage of Direction	Percentage of Both Directions
NORTHBOUND					
Left	0 - 22	5069	98.6	33.7	17.8
	23 - 70	70	1.4	0.5	0.2
		5139		34.2	18.0
Center	0 - 22	4752	95.3	31.6	16.7
	23 - 70	236	4.7	1.6	0.8
		4988		33.2	17.5
Right	0 - 22	4719	96.2	31.4	16.6
	23 - 70	185	3.8	1.2	0.6
		4904		32.6	17.2
Northbound Totals	0 - 22	14540		96.7	51.0
	23 - 70	491		3.3	1.7
		15031			52.7
SOUTHBOUND					
Left	0 - 22	5056	99.3	37.5	17.7
	23 - 70	34	0.7	0.3	0.1
		5090		37.8	17.8
Center	0 - 22	4232	95.4	31.4	14.8
	23 - 70	203	4.6	1.5	0.7
		4435		32.9	15.5
Right	0 - 22	3779	95.8	28.1	13.3
	23 - 70	165	4.2	1.2	0.6
		3944		29.3	13.9
Southbound Totals	0 - 22	13067		97.0	45.8
	23 - 70	402		3.0	1.4
		13469			47.2
Both Directions	0 - 22	27607			96.9
	23 - 70	893			3.1
		28500			

Table A-5. IH 35E - Non-Peak Period Vehicle Distribution By Classification Before Implementation of Truck Restriction

Lane	Vehicle Length (Feet)	24 Hr. Volume	Percentage of Lane	Percentage of Direction	Percentage of Both Directions
NORTHBOUND					
Left	0 - 22	6151	97.1	23.6	11.5
	23 - 70	183	2.9	0.7	0.3
		6334		24.3	11.8
Center	0 - 22	9126	88.6	35.0	17.0
	23 - 70	1174	11.4	4.5	2.2
		10300		39.5	19.2
Right	0 - 22	8568	90.7	32.8	16.0
	23 - 70	881	9.3	3.4	1.6
		9449		36.2	17.6
Northbound Totals	0 - 22	23845		91.4	44.4
	23 - 70	2238		8.6	4.2
		26083			48.6
SOUTHBOUND					
Left	0 - 22	7012	97.5	25.4	13.1
	23 - 70	183	2.5	0.7	0.3
		7195		26.1	13.4
Center	0 - 22	10146	90.0	36.8	18.9
	23 - 70	1131	10.0	4.1	2.1
		11277		40.9	21.0
Right	0 - 22	8309	91.0	30.1	15.5
	23 - 70	818	9.0	3.0	1.5
		9127		33.1	17.0
Southbound Totals	0 - 22	25467		92.3	47.4
	23 - 70	2132		7.7	4.0
		27599			51.4
Both Directions	0 - 22	49312			91.9
	23 - 70	4370			8.1
		53682			

Table A-6. IH 10 - Percentage of Classification Before Implementation of Truck Restriction

Classification	Percentage of Classification by Direction		
	Left	Center	Right
<u>Westbound</u>			
Axle = 2	19.4%	48.6%	32.0%
Axle > 2	3.8%	32.0%	64.2%
<u>Eastbound</u>			
Axle = 2	23.3%	48.6%	28.1%
Axle > 2	5.2%	40.0%	54.8%

Table A-7. IH 20 - Peak Period Percentage of Classification Before Implementation of Truck Restriction

Classification	Percentage of Classification by Direction		
	Left	Center	Right
<u>Westbound</u>			
Axle = 2	31.1%	42.8%	26.1%
Axle > 2	8.9%	41.9%	49.2%
<u>Eastbound</u>			
Axle = 2	35.2%	41.6%	23.2%
Axle > 2	11.7%	55.5%	32.8%

Table A-8. IH 20 - Non-Peak Period Percentage of Classification Before Implementation of Truck Restriction

Classification	Percentage of Classification by Direction		
	Left	Center	Right
<u>Westbound</u>			
Axle = 2	20.8%	47.9%	31.3%
Axle > 2	5.3%	40.6%	54.1%
<u>Eastbound</u>			
Axle = 2	29.1%	46.6%	24.3%
Axle > 2	7.9%	51.1%	41.0%

Table A-9. IH 35E - Peak Period Percentage of Classification Before Implementation of Truck Restriction

Vehicle Length (Feet)	Percentage of Classification by Direction		
	Left	Center	Right
<u>Northbound</u>			
0 - 22	34.9%	32.7%	32.5%
23 - 70	14.3%	48.1%	37.7%
<u>Southbound</u>			
0 - 22	38.7%	32.4%	28.9%
23 - 70	8.5%	50.5%	41.0%

Table A-10. IH 35E - Non-Peak Period Percentage of Classification Before Implementation of Truck Restriction

Vehicle Length (Feet)	Percentage of Classification by Direction		
	Left	Center	Right
<u>Northbound</u>			
0 - 22	25.8%	38.3%	35.9%
23 - 70	8.2%	52.5%	39.4%
<u>Southbound</u>			
0 - 22	27.5%	39.8%	32.6%
23 - 70	8.6%	53.0%	38.4%

Vehicle Speeds

Tables A-11 through A-13 present the average speeds of vehicles in four classifications at Interstates 10 and 20. In addition to the two classifications used in Tables A-1 through A-10, two classifications are added in the above tables. The average speeds of two-axle vehicles (AXLE = 2) *following* two-axle vehicles (PREVIOUS = 2) and two-axle vehicles *following* vehicles with greater than two axles (PREVIOUS > 2) are now included. These latter two classifications allow the speeds of cars following cars to be compared with those of cars following trucks. Significant differences in these two speeds may indicate that trucks are impeding the free-flow ability of cars. Lane totals of all vehicles are given in the last column; directional and grand totals (both directions) for all classifications are also presented. The size of each sample (N) is given below the average speed. Table A-11 summarizes the average vehicle speeds at Interstate 10. Table A-12 and Table A-13 summarize the average vehicle speeds at Interstate 20 during the peak and non-peak periods, respectively.

Tables A-14 through A-15 present the speed distributions of vehicles at Interstate 35E. The numbers in these tables are the number of vehicles in a twenty-four hour period in each of the eight speed categories introduced in Chapter II (see Table 2). The average speeds of all vehicles in each lane, computed by multiplying the median of each interval by its frequency and dividing by the number of vehicles in the lane, are also given. The method of data collection did not permit the determination of average speeds by classification. Table A-14 and Table A-15 summarize the number of vehicles in the eight speed categories at Interstate 35E during the peak and non-peak periods, respectively.

Table A-11. IH 10 - Average Speeds Before Implementation of Truck Restriction

Lane	Average Speeds (mph)				
			(Axle = 2 Only)		
	Axle = 2	Axle > 2	Previous = 2	Previous > 2	All Vehicles
WESTBOUND					
Left	71.2 (N = 1370)	69.2 (N = 73)	71.2 (N = 1296)	71.6 (N = 69)	71.1 (N = 1443)
Center	68.2 (N = 3434)	66.3 (N = 613)	68.3 (N = 2948)	67.9 (N = 481)	67.9 (N = 4047)
Right	63.4 (N = 2267)	61.8 (N = 1232)	63.6 (N = 1550)	62.9 (N = 715)	62.8 (N = 3499)
Westbound Totals	67.2 (N = 7071)	63.5 (N = 1918)	67.7 (N = 5794)	65.3 (N = 1265)	66.4 (N = 8989)
EASTBOUND					
Left	72.4 (N = 1677)	68.3 (N = 111)	72.4 (N = 1572)	71.8 (N = 100)	72.1 (N = 1788)
Center	68.9 (N = 3502)	64.9 (N = 847)	69.0 (N = 2875)	68.3 (N = 622)	68.1 (N = 4349)
Right	63.9 (N = 2022)	60.7 (N = 1162)	64.1 (N = 1319)	63.4 (N = 700)	62.7 (N = 3184)
Eastbound Totals	68.3 (N = 7201)	62.8 (N = 2120)	68.8 (N = 5766)	66.1 (N = 1422)	67.0 (N = 9321)
Both Directions	67.8 (N = 14272)	63.1 (N = 4038)	68.2 (N = 11560)	65.7 (N = 2687)	66.7 (N = 18310)

Table A-12. IH 20 - Peak Period Average Speeds
Before Implementation of Truck Restriction

Lane	Average Speeds (mph)				
			(Axle = 2 Only)		
	Axle = 2	Axle > 2	Previous = 2	Previous > 2	All Vehicles
WESTBOUND					
Left	70.8 (N = 1180)	69.7 (N = 28)	70.8 (N = 1151)	70.5 (N = 28)	70.7 (N = 1208)
Center	66.4 (N = 1627)	64.4 (N = 131)	66.5 (N = 1508)	65.8 (N = 118)	66.3 (N = 1758)
Right	62.9 (N = 993)	60.7 (N = 154)	63.1 (N = 859)	61.8 (N = 133)	62.6 (N = 1147)
Westbound Totals	66.9 (N = 3800)	63.1 (N = 313)	67.1 (N = 3518)	64.4 (N = 279)	66.6 (N = 4113)
EASTBOUND					
Left	70.1 (N = 396)	66.6 (N = 16)	70.1 (N = 383)	70.3 (N = 12)	69.9 (N = 412)
Center	67.6 (N = 468)	61.2 (N = 76)	67.9 (N = 407)	66.0 (N = 60)	66.7 (N = 544)
Right	65.0 (N = 261)	56.0 (N = 45)	65.3 (N = 224)	63.5 (N = 36)	63.7 (N = 306)
Eastbound Totals	67.9 (N = 1125)	60.1 (N = 137)	68.1 (N = 1014)	65.7 (N = 108)	67.0 (N = 1262)
Both Directions	67.1 (N = 4925)	62.2 (N = 450)	67.3 (N = 4532)	64.7 (N = 387)	66.7 (N = 5375)

Table A-13. IH 20 - Non-Peak Period Average Speeds
Before Implementation of Truck Restriction

Lane	Average Speeds (mph)				
			(Axle = 2 Only)		
	Axle = 2	Axle > 2	Previous = 2	Previous > 2	All Vehicles
WESTBOUND					
Left	70.6 (N = 1291)	70.0 (N = 57)	70.6 (N = 1237)	70.5 (N = 50)	70.6 (N = 1348)
Center	66.4 (N = 2982	64.6 (N = 432)	66.5 (N = 2624)	66.3 (N = 355)	66.2 (N = 3414)
Right	63.5 (N = 1949)	60.7 (N = 576)	63.7 (N = 1530)	62.8 (N = 415)	62.9 (N = 2525)
Westbound Totals	66.4 (N = 6222)	62.8 (N = 1065)	66.6 (N = 5391)	64.8 (N = 820)	65.9 (N = 7287)
EASTBOUND					
Left	68.8 (N = 2275)	64.6 (N = 100)	68.9 (N = 2177)	67.5 (N = 94)	68.7 (N = 2375)
Center	66.0 (N = 3642)	61.2 (N = 642)	66.1 (N = 3118)	65.4 (N = 521)	65.3 (N = 4284)
Right	62.8 (N = 1896)	57.0 (N = 515)	63.0 (N = 1511)	62.1 (N = 381)	61.6 (N = 2411)
Eastbound Totals	66.1 (N = 7813)	59.7 (N = 1257)	66.3 (N = 6806)	64.3 (N = 996)	65.2 (N = 9070)
Both Directions	66.2 (N = 14035)	61.1 (N = 2322)	66.5 (N = 12197)	64.5 (N = 1816)	65.5 (N = 16357)

Table A-14. IH 35E - Peak Period Speed Distribution
Before Implementation of Truck Restriction

Speed Category (mph)	Speed Distribution by Lane (24 Hour Volumes)		
	Left	Center	Right
Northbound			
0 - 50	7	7	137
51 - 55	10	95	651
56 - 60	196	881	1710
61 - 65	1260	1921	1526
66 - 70	2411	1475	656
71 - 75	1038	508	182
76 - 80	168	74	35
81 - 89	42	20	7
	5132	4981	4904
Average (MPH)	67.3	64.2	60.1
Southbound			
0 - 50	2	3	49
51 - 55	16	38	455
56 - 60	79	409	1347
61 - 65	650	1527	1261
66 - 70	2444	1639	619
71 - 75	1575	618	181
76 - 80	255	156	22
81 - 89	66	43	6
	5087	4433	3940
Average (MPH)	68.9	65.9	60.8

Table A-15. IH 35E - Non-Peak Period Speed Distribution Before Implementation of Truck Restriction

Speed Category (mph)	Speed Distribution by Lane (24 Hour Volumes)		
	Left	Center	Right
<u>Northbound</u>			
0 - 50	24	55	179
51 - 55	12	247	850
56 - 60	181	1629	2466
61 - 65	1216	3480	3153
66 - 70	2611	3154	1914
71 - 75	1729	1354	699
76 - 80	409	286	126
81 - 89	142	89	54
	6324	10294	9441
Average (MPH)	68.5	64.8	62.0
<u>Southbound</u>			
0 - 50	4	49	325
51 - 55	17	330	1245
56 - 60	186	1826	3081
61 - 65	1354	4084	2833
66 - 70	2971	3396	1243
71 - 75	2006	1275	308
76 - 80	491	245	67
81 - 89	158	71	23
	7187	11276	9125
Average (MPH)	68.7	64.4	60.0

Time Gaps Between Vehicles

Tables A-16 through A-18 present the average time gaps between vehicles at Interstates 10 and 20. Because of the method of data collection used at Interstate 35E, no headway data was obtained at that site. For the purposes of this study, the time gap between successive vehicles was deemed more important than both leading and lagging headway and was therefore the only one of the three analyzed. The time gap between vehicles does not incorporate vehicle length and therefore gives a more accurate description of how closely vehicles are following one another. It should be noted that the *average* time gaps are given in the above tables. These numbers are insignificant unless all vehicles are evenly distributed throughout the period. Using two different periods, peak and non-peak, reduces the chances of irregular distributions but does not guarantee an even one. Therefore, conclusions based on the time gaps as presented in Tables A-16 through A-18 should be made with care. The numbers given in the above tables are the average time gaps between vehicles in each of four categories. These categories are the four combinations of the present vehicle's classification (THIS VEHICLE...) and the previous vehicle's classification (PREV VEHICLE...). Classifications are again divided into vehicles with two axles and those with greater than two. Lane totals of all vehicles are given in the last column; directional and grand totals (both directions) for all classifications are also presented. The size of each sample (N) is given below the average time gap. Table A-16 summarizes the average time gaps between successive vehicles at Interstate 10. Table A-17 and Table A-18 summarize the average time gaps between successive vehicles at Interstate 20 during the peak and non-peak periods, respectively.

Table A-16. IH 10 - Average Time Between Vehicles Before Implementation of Truck Restriction

Lane	Gaps (Sec)				
	This Vehicle = 2 Prev Vehicle = 2	This Vehicle = 2 Prev Vehicle > 2	This Vehicle > 2 Prev Vehicle = 2	This Vehicle > 2 Prev Vehicle > 2	All Vehicles
WESTBOUND					
Left	26.015 (N = 1296)	24.857 (N = 69)	20.639 (N = 69)	5.640 (N = 4)	25.645 (N = 1438)
Center	11.238 (N = 2948)	12.418 (N = 481)	10.644 (N = 481)	7.493 (N = 132)	11.185 (N = 4042)
Right	12.897 (N = 1550)	13.080 (N = 715)	13.617 (N = 715)	10.468 (N = 514)	12.724 (N = 3494)
Westbound Totals	14.987 (N = 5794)	13.471 (N = 1265)	12.869 (N = 1265)	9.834 (N = 650)	14.102 (N = 8974)
EASTBOUND					
Left	24.008 (N = 1572)	22.634 (N = 100)	21.407 (N = 101)	16.158 (N = 10)	23.739 (N = 1783)
Center	10.760 (N = 2875)	11.496 (N = 622)	10.544 (N = 623)	8.175 (N = 224)	10.701 (N = 4344)
Right	14.177 (N = 1319)	14.793 (N = 700)	16.192 (N = 701)	13.927 (N = 459)	14.721 (N = 3179)
Eastbound Totals	15.153 (N = 5766)	13.902 (N = 1422)	14.093 (N = 1425)	12.100 (N = 693)	14.572 (N = 9306)
Both Directions	15.070 (N = 11560)	13.699 (N = 2687)	13.517 (N = 2690)	11.003 (N = 1343)	14.341 (N = 18280)

Table A-17. IH 20 - Peak Period Average Time Between Vehicles Before Implementation of Truck Restriction

Lane	Gaps (Sec)				
	This Vehicle = 2 Prev Vehicle = 2	This Vehicle = 2 Prev Vehicle > 2	This Vehicle > 2 Prev Vehicle = 2	This Vehicle > 2 Prev Vehicle > 2	All Vehicles
WESTBOUND					
Left	5.813 (N = 1151)	6.308 (N = 28)	5.020 (N = 28)	N/A (N = 0)	5.806 (N = 1207)
Center	3.979 (N = 1508)	3.725 (N = 118)	4.007 (N = 118)	3.064 (N = 13)	3.957 (N = 1757)
Right	5.802 (N = 859)	5.542 (N = 133)	8.010 (N = 133)	6.312 (N = 21)	6.037 (N = 1146)
Westbound Totals	5.024 (N = 3518)	4.850 (N = 279)	6.017 (N = 279)	5.070 (N = 34)	5.080 (N = 4110)
EASTBOUND					
Left	7.236 (N = 383)	11.239 (N = 12)	8.423 (N = 12)	6.348 (N = 4)	7.379 (N = 411)
Center	5.392 (N = 407)	5.302 (N = 60)	6.662 (N = 60)	4.705 (N = 16)	5.502 (N = 543)
Right	9.882 (N = 224)	8.743 (N = 36)	11.216 (N = 36)	9.204 (N = 9)	9.885 (N = 305)
Eastbound Totals	7.080 (N = 1014)	7.109 (N = 108)	8.375 (N = 108)	6.328 (N = 29)	7.177 (N = 1259)
Both Directions	5.484 (N = 4532)	5.481 (N = 387)	6.675 (N = 387)	5.649 (N = 63)	5.571 (N = 5369)

Table A-18. IH 20 - Non-Peak Period Average Time Between Vehicles Before Implementation of Truck Restriction

Lane	Gaps (Sec)				
	This Vehicle = 2 Prev Vehicle = 2	This Vehicle = 2 Prev Vehicle > 2	This Vehicle > 2 Prev Vehicle = 2	This Vehicle > 2 Prev Vehicle > 2	All Vehicles
<u>WESTBOUND</u>					
Left	18.195 (N = 1237)	19.138 (N = 50)	17.785 (N = 50)	8.373 (N = 7)	18.164 (N = 1344)
Center	8.166 (N = 2624)	8.839 (N = 355)	7.879 (N = 354)	5.825 (N = 77)	8.153 (N = 3410)
Right	10.834 (N = 1530)	10.617 (N = 415)	11.654 (N = 416)	11.759 (N = 160)	10.992 (N = 2521)
Westbound Totals	11.224 (N = 5391)	10.367 (N = 820)	10.398 (N = 820)	9.790 (N = 244)	10.986 (N = 7275)
<u>EASTBOUND</u>					
Left	13.702 (N = 2177)	10.613 (N = 94)	13.005 (N = 94)	8.278 (N = 6)	13.539 (N = 2371)
Center	7.379 (N = 3118)	7.164 (N = 521)	7.665 (N = 521)	6.791 (N = 120)	7.371 (N = 4280)
Right	12.744 (N = 1511)	13.064 (N = 381)	14.350 (N = 383)	11.224 (N = 132)	12.967 (N = 2407)
Eastbound Totals	10.593 (N = 6806)	9.747 (N = 996)	10.733 (N = 998)	9.094 (N = 258)	10.472 (N = 9058)
Both Directions	10.872 (N = 12197)	10.027 (N = 1816)	10.582 (N = 1818)	9.432 (N = 502)	10.701 (N = 16333)

APPENDIX B
SUMMARIES OF DATA COLLECTED AFTER IMPLEMENTATION OF THE TRUCK RESTRICTIONS

This appendix contains summaries of all data collected after implementation of the truck restrictions at Interstates 10, 20, and 35E.

Distribution of Vehicles

Tables B-1 through B-7 present the distributions of both classifications of vehicles (see Chapter II, Classification Systems) at Interstates 10, 20 and 35E. In each table, the number of vehicles in each classification as well as its percentage of the total vehicles in the lane, the total vehicles in the direction, and the total vehicles in both directions are given. In addition, directional and grand totals (both directions) for both classifications are presented. Table B-1 shows the distribution of vehicles at Interstate 10. Table B-2 and Table B-3 show the distribution of vehicles at Interstate 20 during the peak and non-peak periods, respectively. Table B-4 and Table B-5 show the distribution of vehicles at Interstate 35E during the peak and non-peak periods, respectively, for the first collection period after implementation of the restriction. Table B-6 and Table B-7 show the distribution of vehicles at Interstate 35E during the peak and non-peak periods, respectively, for the second collection period after implementation of the restriction.

Tables B-8 through B-14 relate how each classification of vehicle is distributed across each direction of Interstates 10, 20 and 35E. The percentages given in these tables are similar to those found in the columns headed "Percentage of Direction" in Tables B-1 through B-7. However, instead of being based on the total number of vehicles in a direction, these percentages are based only on the number of vehicles *of the same classification* in a direction. Table B-8 relates how each class of vehicle is distributed across both directions of Interstate 10. Table B-9 and Table B-10 relate how each class of vehicle is distributed across both directions of Interstate 20 during the peak and non-peak periods, respectively. Table B-11 and Table B-12 relate how each class of vehicle is distributed across both directions of Interstate 35E during the peak and non-peak periods, respectively, for the first collection period after implementation of the restriction. Table B-13 and Table B-14 relate how each class of vehicle is distributed across both directions of Interstate 35E during the peak and non-peak periods, respectively, for the second collection period after implementation of the restriction.

Table B-1. IH 10 - Vehicle Distribution By Classification After Implementation of Truck Restriction

Lane	Classification	Vehicles	Percentage of Lane	Percentage of Direction	Percentage of Both Directions
WESTBOUND					
Left	Axle = 2	1112	98.0	23.2	12.0
	Axle > 2	23	2.0	0.5	0.2
		1135		23.7	12.2
Center	Axle = 2	1891	86.0	39.4	20.4
	Axle > 2	307	14.0	6.4	3.3
		2198		45.8	23.7
Right	Axle = 2	874	59.8	18.2	9.4
	Axle > 2	587	40.2	12.2	6.3
		1461		30.4	15.7
Westbound Totals	Axle = 2	3877		80.9	41.8
	Axle > 2	917		19.1	9.9
		4794			51.7
EASTBOUND					
Left	Axle = 2	618	97.9	13.8	6.7
	Axle > 2	13	2.1	0.3	0.1
		631		14.1	6.8
Center	Axle = 2	1729	86.3	38.6	18.6
	Axle > 2	275	13.7	6.1	3.0
		2004		44.7	21.6
Right	Axle = 2	1145	62.1	25.6	12.3
	Axle > 2	700	37.9	15.6	7.5
		1845		41.2	19.8
Eastbound Totals	Axle = 2	3492		77.9	37.7
	Axle > 2	988		22.1	10.7
		4480			48.4
Both Directions	Axle = 2	7369			79.5
	Axle > 2	1905			20.5
		9274			

Table B-2. IH 20 - Peak Period Vehicle Distribution By Classification After Implementation of Truck Restriction

Lane	Classification	Vehicles	Percentage of Lane	Percentage of Direction	Percentage of Both Directions
WESTBOUND					
Left	Axle = 2	2570	99.3	30.6	21.0
	Axle > 2	18	0.7	0.2	0.1
		2588		30.8	21.1
Center	Axle = 2	3257	93.7	38.8	26.6
	Axle > 2	220	6.3	2.6	1.8
		3477		41.4	28.4
Right	Axle = 2	2015	86.1	24.0	16.5
	Axle > 2	325	13.9	3.9	2.7
		2340		27.9	19.2
Westbound Totals	Axle = 2	7842		93.3	64.1
	Axle > 2	563		6.7	4.6
		8405			68.7
EASTBOUND					
Left	Axle = 2	1331	99.2	34.8	10.9
	Axle > 2	11	0.8	0.3	0.1
		1342		35.1	11.0
Center	Axle = 2	1451	93.1	38.0	11.9
	Axle > 2	107	6.9	2.8	0.9
		1558		40.8	12.8
Right	Axle = 2	790	85.8	20.7	6.5
	Axle > 2	131	14.2	3.4	1.1
		921		24.1	7.6
Eastbound Totals	Axle = 2	3572		93.5	29.2
	Axle > 2	249		6.5	2.0
		3821			31.2
Both Directions	Axle = 2	11414			93.4
	Axle > 2	812			6.6
		12226			

Table B-3. IH 20 - Non-Peak Period Vehicle Distribution By Classification After Implementation of Truck Restriction

Lane	Classification	Vehicles	Percentage of Lane	Percentage of Direction	Percentage of Both Directions
WESTBOUND					
Left	Axle = 2	1523	98.7	16.2	6.9
	Axle > 2	20	1.3	0.2	0.1
		1543		16.4	7.0
Center	Axle = 2	3967	89.3	42.1	18.1
	Axle > 2	475	10.7	5.0	2.2
		4442		47.1	20.3
Right	Axle = 2	2403	69.9	25.5	11.0
	Axle > 2	1035	30.1	11.0	4.7
		3438		36.5	15.7
Westbound Totals	Axle = 2	7893		83.8	36.0
	Axle > 2	1530		16.2	7.0
		9423			43.0
EASTBOUND					
Left	Axle = 2	2949	98.3	23.6	13.4
	Axle > 2	50	1.7	0.4	0.2
		2999		24.0	13.6
Center	Axle = 2	5174	86.0	41.3	23.6
	Axle > 2	842	14.0	6.7	3.8
		6016		48.0	27.4
Right	Axle = 2	2641	75.4	21.1	12.0
	Axle > 2	861	24.6	6.9	3.9
		3502		28.0	15.9
Eastbound Totals	Axle = 2	10764		86.0	49.1
	Axle > 2	1753		14.0	8.0
		12517			57.1
Both Directions	Axle = 2	18657			85.0
	Axle > 2	3283			15.0
		21940			

Table B-4. IH 35E - Peak Period Vehicle Distribution By Classification During After Period I

Lane	Vehicle Length (Feet)	24 Hr. Volume	Percentage of Lane	Percentage of Direction	Percentage of Both Directions
NORTHBOUND					
Left	0 - 22	5710	99.7	34.0	18.4
	23 - 70	15	0.3	0.1	<0.1
		5725		34.1	18.4
Center	0 - 22	5083	95.4	30.3	16.4
	23 - 70	244	4.6	1.5	0.8
		5327		31.8	17.2
Right	0 - 22	5546	96.8	33.0	17.9
	23 - 70	185	3.2	1.1	0.6
		5731		34.1	18.5
Northbound Totals	0 - 22	16339		97.4	52.6
	23 - 70	444		2.6	1.4
		16783			54.0
SOUTHBOUND					
Left	0 - 22	5085	99.7	35.6	16.4
	23 - 70	13	0.3	0.1	<0.1
		5098		35.7	16.4
Center	0 - 22	4581	95.9	32.1	14.8
	23 - 70	194	4.1	1.4	0.6
		4775		33.5	15.4
Right	0 - 22	4226	96.2	29.6	13.6
	23 - 70	166	3.8	1.2	0.5
		4392		30.8	14.1
Southbound Totals	0 - 22	13892		97.4	44.7
	23 - 70	373		2.6	1.2
		14265			45.9
Both Directions	0 - 22	30231			97.4
	23 - 70	817			2.6
		31048			

Table B-5. IH 35E - Non-Peak Period Vehicle Distribution By Classification During After Period I

Lane	Vehicle Length (Feet)	24 Hr. Volume	Percentage of Lane	Percentage of Direction	Percentage of Both Directions
NORTHBOUND					
Left	0 - 22 23 - 70	7489 73 7562	99.0 1.0	24.8 0.2 25.0	11.9 0.1 12.0
Center	0 - 22 23 - 70	9895 1281 11176	88.5 11.5	32.8 4.2 37.0	15.8 2.0 17.8
Right	0 - 22 23 - 70	10476 987 11463	91.4 8.6	34.7 3.3 38.0	16.7 1.6 18.3
Northbound Totals	0 - 22 23 - 70	27860 2341 30201		92.2 7.8	44.4 3.7 48.1
SOUTHBOUND					
Left	0 - 22 23 - 70	8905 95 9000	98.9 1.1	27.3 0.3 27.6	14.2 0.2 14.4
Center	0 - 22 23 - 70	11242 1282 12524	89.8 10.2	34.5 3.9 38.4	17.9 2.0 19.9
Right	0 - 22 23 - 70	10107 982 11089	91.1 8.9	31.0 3.0 34.0	16.1 1.6 17.7
Southbound Totals	0 - 22 23 - 70	30254 2359 32613		92.8 7.2	48.2 3.8 52.0
Both Directions	0 - 22 23 - 70	58114 4700 62814			92.5 7.5

Table B-6. IH 35E - Peak Period Vehicle Distribution By Classification During After Period II

Lane	Vehicle Length (Feet)	24 Hr. Volume	Percentage of Lane	Percentage of Direction	Percentage of Both Directions
NORTHBOUND					
Left	0 - 22 23 - 70	5834 11 5845	99.8 0.2	34.4 0.1 34.5	18.6 <0.1 18.6
Center	0 - 22 23 - 70	5184 253 5437	95.3 4.7	30.5 1.5 32.0	16.5 0.8 17.3
Right	0 - 22 23 - 70	5503 196 5699	96.6 3.4	32.4 1.2 33.6	17.6 0.6 18.2
Northbound Totals	0 - 22 23 - 70	16521 460 16981		97.3 2.7	52.7 1.5 54.2
SOUTHBOUND					
Left	0 - 22 23 - 70	5068 22 5090	99.6 0.4	35.3 0.2 35.5	16.2 <0.1 16.2
Center	0 - 22 23 - 70	4511 186 4697	96.0 4.0	31.4 1.3 32.7	14.4 0.6 15.0
Right	0 - 22 23 - 70	4407 165 4572	96.4 3.6	30.7 1.1 31.8	14.1 0.5 14.6
Southbound Totals	0 - 22 23 - 70	13986 373 14359		97.4 2.6	44.6 1.2 45.8
Both Directions	0 - 22 23 - 70	30507 833 31340			97.3 2.7

Table B-7. IH 35E - Non-Peak Period Vehicle Distribution By Classification During After Period II

Lane	Vehicle Length (Feet)	24 Hr. Volume	Percentage of Lane	Percentage of Direction	Percentage of Both Directions
NORTHBOUND					
Left	0 - 22 23 - 70	7203 68 7271	99.1 0.9	24.5 0.2 24.7	11.9 0.1 12.0
Center	0 - 22 23 - 70	9772 1185 10957	89.2 10.8	33.3 4.0 37.3	16.1 2.0 18.1
Right	0 - 22 23 - 70	10144 973 11117	91.2 8.8	34.6 3.3 37.9	16.7 1.6 18.3
Northbound Totals	0 - 22 23 - 70	27119 2226 29345		92.4 7.6	44.7 3.7 48.4
SOUTHBOUND					
Left	0 - 22 23 - 70	8318 75 8393	99.1 0.9	26.6 0.2 26.8	13.7 0.1 13.8
Center	0 - 22 23 - 70	10911 1208 12119	90.0 10.0	34.9 3.9 38.8	18.0 2.0 20.0
Right	0 - 22 23 - 70	9795 961 10756	91.1 8.9	31.3 3.1 34.4	16.2 1.6 17.8
Southbound Totals	0 - 22 23 - 70	29024 2244 31268		92.8 7.2	47.9 3.7 51.6
Both Directions	0 - 22 23 - 70	56143 4470 60613			92.6 7.4

Table B-8. IH 10 - Percentage of Classification After Implementation of Truck Restriction

Classification	Percentage of Classification by Direction		
	Left	Center	Right
Westbound			
Axle = 2	28.7%	48.8%	22.5%
Axle > 2	2.5%	33.5%	64.0%
Eastbound			
Axle = 2	17.7%	49.5%	32.8%
Axle > 2	1.3%	27.8%	70.9%

Table B-9. IH 20 - Peak Period Percentage of Classification After Implementation of Truck Restriction

Classification	Percentage of Classification by Direction		
	Left	Center	Right
Westbound			
Axle = 2	32.8%	41.5%	25.7%
Axle > 2	3.2%	39.1%	57.7%
Eastbound			
Axle = 2	37.3%	40.6%	22.1%
Axle > 2	4.4%	43.0%	52.6%

Table B-10. IH 20 - Non-Peak Period Percentage of Classification After Implementation of Truck Restriction

Classification	Percentage of Classification by Direction		
	Left	Center	Right
Westbound			
Axle = 2	19.3%	50.3%	30.4%
Axle > 2	1.3%	31.1%	67.6%
Eastbound			
Axle = 2	27.4%	48.1%	24.5%
Axle > 2	2.9%	48.0%	49.1%

Table B-11. IH 35E - Peak Period Percentage of Classification During After Period I

Vehicle Length (Feet)	Percentage of Classification by Direction		
	Left	Center	Right
<u>Northbound</u>			
0 - 22	34.9%	31.1%	33.9%
23 - 70	3.4%	55.0%	41.7%
<u>Southbound</u>			
0 - 22	36.6%	33.0%	30.4%
23 - 70	3.5%	52.0%	44.5%

Table B-12. IH 35E - Non-Peak Period Percentage of Classification During After Period I

Vehicle Length (Feet)	Percentage of Classification by Direction		
	Left	Center	Right
<u>Northbound</u>			
0 - 22	26.9%	35.5%	37.6%
23 - 70	3.1%	54.7%	42.2%
<u>Southbound</u>			
0 - 22	29.4%	37.2%	33.4%
23 - 70	4.0%	54.3%	41.6%

Table B-13. IH 35E - Peak Period Percentage of Classification During After Period II

Vehicle Length (Feet)	Percentage of Classification by Direction		
	Left	Center	Right
Northbound			
0 - 22	35.3%	31.4%	33.3%
23 - 70	2.4%	55.0%	42.6%
Southbound			
0 - 22	36.2%	32.3%	31.5%
23 - 70	5.9%	49.9%	44.2%

Table B-14. IH 35E - Non-Peak Period Percentage of Classification During After Period II

Vehicle Length (Feet)	Percentage of Classification by Direction		
	Left	Center	Right
Northbound			
0 - 22	26.6%	36.0%	37.4%
23 - 70	3.1%	53.2%	43.7%
Southbound			
0 - 22	28.7%	37.6%	33.7%
23 - 70	3.3%	53.8%	42.8%

Vehicle Speeds

Tables B-15 through B-17 present the average speeds of four classifications of vehicles at Interstates 10 and 20. In addition to the two classifications used in Tables B-1 through B-3 and Tables B-8 through B-10, two classifications are added in the above tables. The average speeds of two-axle vehicles (AXLE = 2) *following* two-axle vehicles (PREVIOUS = 2) and two-axle vehicles *following* vehicles with greater than two axles (PREVIOUS > 2) are now included. These latter two classifications allow the speeds of cars following cars to be compared with those of cars following trucks. Significant differences in these two speeds may indicate that trucks are impeding the free-flow ability of cars. Lane totals of all vehicles are given in the last column; directional and grand totals (both directions) for all classifications are also presented. The size of each sample (N) is given below the average speed. Table B-15 summarizes the average vehicle speeds at Interstate 10. Table B-16 and Table B-17 summarize the average vehicle speeds at Interstate 20 during the peak and non-peak periods, respectively.

Tables B-18 through B-21 present the speed distributions of vehicles at Interstate 35E. The numbers in these tables are the number of vehicles in a twenty-four hour period in each of the eight speed categories introduced in Chapter II (see Table 2). The average speeds of all vehicles in each lane, computed by multiplying the median of each interval by its frequency and dividing by the number of vehicles in the lane, are also given. The method of data collection utilized did not permit the determination of speeds by vehicle classification. Table B-18 and Table B-19 summarize the number of vehicles in the eight speed categories at Interstate 35E during the peak and non-peak periods, respectively, for the first collection period after implementation of the restriction. Table B-20 and Table B-21 summarize the number of vehicles in the eight speed categories at Interstate 35E during the peak and non-peak periods, respectively, for the second collection period after implementation of the restriction.

Table B-15. IH 10 - Average Speeds After Implementation of Truck Restriction

Lane	Average Speeds (mph)				
			(Axle = 2 Only)		
	Axle = 2	Axle > 2	Previous = 2	Previous > 2	All Vehicles
WESTBOUND					
Left	71.0 (N = 1486)	67.8 (N = 26)	70.9 (N = 1456)	73.4 (N = 26)	70.9 (N = 1512)
Center	68.1 (N = 2506)	65.5 (N = 387)	68.1 (N = 2203)	67.7 (N = 299)	67.7 (N = 2893)
Right	64.3 (N = 1212)	62.2 (N = 695)	64.8 (N = 815)	63.4 (N = 394)	63.6 (N = 1907)
Westbound Totals	68.0 (N = 5204)	63.4 (N = 1108)	68.4 (N = 4474)	65.6 (N = 719)	67.2 (N = 6312)
EASTBOUND					
Left	72.8 (N = 627)	73.1 (N = 14)	72.8 (N = 610)	73.5 (N = 14)	72.8 (N = 641)
Center	69.3 (N = 2253)	67.1 (N = 327)	69.3 (N = 1992)	69.3 (N = 258)	69.1 (N = 2580)
Right	64.2 (N = 1465)	62.8 (N = 841)	64.5 (N = 982)	63.6 (N = 480)	63.7 (N = 2306)
Eastbound Totals	68.1 (N = 4345)	64.1 (N = 1182)	68.6 (N = 3584)	65.7 (N = 752)	67.2 (N = 5527)
Both Directions	68.0 (N = 9549)	63.8 (N = 2290)	68.5 (N = 8058)	65.7 (N = 1471)	67.2 (N = 11839)

Table B-16. IH 20 - Peak Period Average Speeds After Implementation of Truck Restriction

Lane	Average Speeds (mph)				
			(Axle = 2 Only)		
	Axle = 2	Axle > 2	Previous = 2	Previous > 2	All Vehicles
WESTBOUND					
Left	69.5 (N = 2570)	66.1 (N = 18)	69.5 (N = 2552)	67.9 (N = 17)	69.5 (N = 2588)
Center	65.4 (N = 3257)	61.9 (N = 220)	65.4 (N = 3063	64.6 (N = 193)	65.1 (N = 3477)
Right	61.9 (N = 2015)	58.4 (N = 325)	62.1 (N = 1741)	60.6 (N = 273)	61.4 (N = 2340)
Westbound Totals	65.8 (N = 7842)	60.0 (N = 563)	66.0 (N = 7356)	62.5 (N = 483)	65.4 (N = 8405)
EASTBOUND					
Left	70.1 (N = 1331)	64.4 (N = 11)	70.1 (N = 1321)	65.5 (N = 10)	70.1 (N = 1342)
Center	68.3 (N = 1451)	61.1 (N = 107)	68.4 (N = 1356)	66.7 (N = 95)	67.8 (N = 1558)
Right	65.4 (N = 790)	56.5 (N = 131)	65.8 (N = 687)	63.1 (N = 103)	64.1 (N = 921)
Eastbound Totals	68.3 (N = 3572)	58.8 (N = 249)	68.5 (N = 3364)	64.9 (N = 208)	67.7 (N = 3821)
Both Directions	66.6 (N = 11414)	59.6 (N = 812)	66.8 (N = 10720)	63.2 (N = 691)	66.1 (N = 12226)

Table B-17. IH 20 - Non-Peak Period Average Speeds After Implementation of Truck Restriction

Lane	Average Speeds (mph)				
			(Axle = 2 Only)		
	Axle = 2	Axle > 2	Previous = 2	Previous > 2	All Vehicles
<u>WESTBOUND</u>					
Left	69.3 (N = 1523)	67.0 (N = 20)	69.3 (N = 1497)	69.5 (N = 21)	69.2 (N = 1543)
Center	65.2 (N = 3967)	61.6 (N = 475)	65.3 (N = 3563)	64.7 (N = 399)	64.8 (N = 4442)
Right	61.6 (N = 2403)	57.7 (N = 1035)	61.7 (N = 1747)	61.2 (N = 652)	60.4 (N = 3438)
Westbound Totals	64.9 (N = 7893)	59.0 (N = 1530)	65.3 (N = 6807)	62.7 (N = 1072)	64.0 (N = 9423)
<u>EASTBOUND</u>					
Left	69.8 (N = 2949)	68.4 (N = 50)	69.8 (N = 2893)	69.7 (N = 50)	69.8 (N = 2999)
Center	67.0 (N = 5174)	61.5 (N = 842)	67.2 (N = 4504)	65.8 (N = 665)	66.2 (N = 6016)
Right	64.1 (N = 2641)	57.9 (N = 861)	64.4 (N = 2060)	63.2 (N = 577)	62.6 (N = 3502)
Eastbound Totals	67.1 (N = 10764)	59.9 (N = 1753)	67.4 (N = 9457)	64.8 (N = 1292)	66.1 (N = 12517)
Both Directions	66.1 (N = 18657)	59.5 (N = 3283)	66.5 (N = 16264)	63.8 (N = 2364)	65.2 (N = 21940)

Table B-18. IH 35E - Peak Period Speed Distribution During After Period I

Speed Category (mph)	Speed Distribution by Lane (24 Hour Volumes)		
	Left	Center	Right
Northbound			
0 - 50	525	530	984
51 - 55	121	332	1115
56 - 60	404	1170	1837
61 - 65	1484	1837	1220
66 - 70	2166	1051	416
71 - 75	870	322	127
76 - 80	131	67	31
81 - 89	20	18	1
	5721	5327	5731
Average (MPH)	64.2	60.9	56.6
Southbound			
0 - 50	0	10	166
51 - 55	17	79	659
56 - 60	130	642	1514
61 - 65	919	1766	1253
66 - 70	2204	1566	625
71 - 75	1483	548	133
76 - 80	273	131	33
81 - 89	68	31	7
	5094	4773	4390
Average (MPH)	68.5	65.0	59.8

Table B-19. IH 35E - Non-Peak Period Speed Distribution During After Period I

Speed Category (mph)	Speed Distribution by Lane (24 Hour Volumes)		
	Left	Center	Right
Northbound			
0 - 50	3	55	205
51 - 55	7	228	959
56 - 60	137	1491	3122
61 - 65	1057	3659	3770
66 - 70	3071	3623	2345
71 - 75	2417	1595	814
76 - 80	645	405	163
81 - 89	201	110	72
	7538	11166	11450
Average (MPH)	69.5	65.4	62.1
Southbound			
0 - 50	3	42	186
51 - 55	14	186	1068
56 - 60	89	1409	3265
61 - 65	991	3981	3629
66 - 70	3440	4332	2119
71 - 75	3131	1926	595
76 - 80	976	469	177
81 - 89	319	164	45
	8963	12509	11084
Average (MPH)	70.3	65.9	61.6

Table B-20. IH 35E - Peak Period Speed Distribution During After Period II

Speed Category (mph)	Speed Distribution by Lane (24 Hour Volumes)		
	Left	Center	Right
Northbound			
0 - 50	0	13	187
51 - 55	13	118	821
56 - 60	222	875	2015
61 - 65	1532	1974	1673
66 - 70	2846	1679	744
71 - 75	1040	641	198
76 - 80	161	114	39
81 - 89	25	19	18
	5839	5433	5695
Average (MPH)	67.0	64.6	59.9
Southbound			
0 - 50	29	37	242
51 - 55	30	122	969
56 - 60	238	797	1689
61 - 65	1296	1754	1098
66 - 70	2151	1375	449
71 - 75	1111	469	104
76 - 80	176	117	17
81 - 89	47	23	2
	5078	4694	4570
Average (MPH)	67.1	64.2	58.4

Table B-21. IH 35E - Non-Peak Period Speed Distribution During After Period II

Speed Category (mph)	Speed Distribution by Lane (24 Hour Volumes)		
	Left	Center	Right
Northbound			
0 - 50	4	52	152
51 - 55	9	191	793
56 - 60	121	1225	2805
61 - 65	1049	3486	3808
66 - 70	3020	3706	2350
71 - 75	2318	1741	927
76 - 80	576	410	208
81 - 89	157	135	64
	7254	10946	11107
Average (MPH)	69.3	65.8	62.6
Southbound			
0 - 50	5	56	324
51 - 55	14	235	1405
56 - 60	169	1762	3479
61 - 65	1389	4335	3316
66 - 70	3476	3784	1621
71 - 75	2481	1523	486
76 - 80	661	330	89
81 - 89	171	95	32
	8366	12120	10752
Average (MPH)	69.0	64.9	60.4

Time Gaps Between Vehicles

Tables B-22 through B-24 present the average time gaps between vehicles at Interstates 10 and 20. Because of the method of data collection used at Interstate 35E, no headway data was obtained at that site. For the purposes of this study, the time gap between successive vehicles was deemed more important than both leading and lagging headway and was therefore the only one of the three analyzed. The time gap between vehicles does not incorporate vehicle length and therefore gives a more accurate description of how closely vehicles are following one another. It should be noted that the *average* time gaps are given in the above tables. These numbers are insignificant unless all vehicles are evenly distributed throughout the period. Using two different periods, peak and non-peak, reduces the chances of irregular distributions but does not guarantee an even one. Therefore, conclusions based on the time gaps as presented in Tables B-22 and B-24 should be made with care. The numbers given in the above tables are the average time gaps between vehicles in each of four categories. These categories are the four combinations of the present vehicle's classification (THIS VEHICLE...) and the previous vehicle's classification (PREV VEHICLE...). Classifications are again divided into vehicles with two axles and those with greater than two. Lane totals of all vehicles are given in the last column; directional and grand totals (both directions) for all classifications are also presented. The size of each sample (N) is given below the average time gap. Table B-22 summarizes the average time gaps between vehicles at Interstate 10. Table B-23 and Table B-24 summarize the average time gaps between vehicles at Interstate 20 during the peak and non-peak periods, respectively.

Table B-22. IH 10 - Average Time Between Vehicles
After Implementation of Truck Restriction

Lane	Gaps (Sec)				
	This Vehicle = 2 Prev Vehicle = 2	This Vehicle = 2 Prev Vehicle > 2	This Vehicle > 2 Prev Vehicle = 2	This Vehicle > 2 Prev Vehicle > 2	All Vehicles
WESTBOUND					
Left	17.752 (N = 1456)	18.946 (N = 26)	17.337 (N = 26)	N/A (N = 0)	17.765 (N = 1508)
Center	9.460 (N = 2203)	11.081 (N = 299)	10.366 (N = 299)	6.912 (N = 88)	9.644 (N = 2889)
Right	14.881 (N = 815)	15.185 (N = 394)	13.559 (N = 394)	13.447 (N = 300)	14.440 (N = 1903)
Westbound Totals	13.146 (N = 4474)	13.614 (N = 719)	12.367 (N = 719)	11.965 (N = 388)	13.038 (N = 6300)
EASTBOUND					
Left	27.181 (N = 610)	28.247 (N = 14)	29.044 (N = 14)	N/A (N = 0)	27.245 (N = 638)
Center	11.049 (N = 1992)	12.352 (N = 258)	9.207 (N = 257)	5.690 (N = 69)	10.852 (N = 2576)
Right	11.772 (N = 982)	12.120 (N = 480)	13.232 (N = 482)	10.551 (N = 358)	11.960 (N = 2302)
Eastbound Totals	13.993 (N = 3584)	12.500 (N = 752)	12.152 (N = 753)	9.766 (N = 427)	13.211 (N = 5516)
Both Directions	13.523 (N = 8058)	13.045 (N = 1471)	12.257 (N = 1472)	10.813 (N = 815)	13.119 (N = 11816)

Table B-23. IH 20 - Peak Period Average Time Between Vehicles After Implementation of Truck Restriction

Lane	Gaps (Sec)				
	This Vehicle = 2 Prev Vehicle = 2	This Vehicle = 2 Prev Vehicle > 2	This Vehicle > 2 Prev Vehicle = 2	This Vehicle > 2 Prev Vehicle > 2	All Vehicles
<u>WESTBOUND</u>					
Left	5.426 (N = 2552)	3.713 (N = 17)	5.330 (N = 18)	N/A (N = 0)	5.414 (N = 2587)
Center	3.956 (N = 3063)	4.078 (N = 193)	4.175 (N = 192)	3.445 (N = 28)	3.970 (N = 3476)
Right	5.789 (N = 1741)	5.593 (N = 273)	6.815 (N = 274)	5.531 (N = 51)	5.880 (N = 2339)
Westbound Totals	4.900 (N = 7356)	4.922 (N = 483)	5.712 (N = 484)	4.792 (N = 79)	4.947 (N = 8402)
<u>EASTBOUND</u>					
Left	5.268 (N = 1321)	1.825 (N = 10)	6.574 (N = 10)	2.160 (N = 1)	5.249 (N = 1342)
Center	4.367 (N = 1356)	4.392 (N = 95)	4.956 (N = 95)	3.748 (N = 12)	4.400 (N = 1558)
Right	6.900 (N = 687)	7.294 (N = 103)	7.853 (N = 104)	8.025 (N = 27)	7.085 (N = 921)
Eastbound Totals	5.238 (N = 3364)	5.706 (N = 208)	6.475 (N = 209)	6.595 (N = 40)	5.345 (N = 3821)
Both Directions	5.006 (N = 10720)	5.158 (N = 691)	5.942 (N = 693)	5.398 (N = 119)	5.071 (N = 12223)

Table B-24. IH 20 - Non-Peak Period Average Time Between Vehicles After Implementation of Truck Restriction

Lane	Gaps (Sec)				
	This Vehicle = 2 Prev Vehicle = 2	This Vehicle = 2 Prev Vehicle > 2	This Vehicle > 2 Prev Vehicle = 2	This Vehicle > 2 Prev Vehicle > 2	All Vehicles
WESTBOUND					
Left	20.794 (N = 1497)	19.369 (N = 21)	20.985 (N = 20)	N/A (N = 0)	20.777 (N = 1538)
Center	8.869 (N = 3563)	8.489 (N = 399)	9.310 (N = 400)	5.612 (N = 75)	8.820 (N = 4437)
Right	10.522 (N = 1747)	10.848 (N = 652)	12.848 (N = 651)	10.748 (N = 383)	11.050 (N = 3433)
Westbound Totals	11.916 (N = 6807)	10.137 (N = 1072)	11.679 (N = 1071)	9.907 (N = 458)	11.588 (N = 9408)
EASTBOUND					
Left	15.243 (N = 2893)	12.788 (N = 50)	17.237 (N = 50)	N/A (N = 0)	15.235 (N = 2993)
Center	7.542 (N = 4504)	7.155 (N = 665)	8.390 (N = 664)	5.829 (N = 177)	7.543 (N = 6010)
Right	12.554 (N = 2060)	12.535 (N = 577)	13.545 (N = 578)	11.825 (N = 281)	12.656 (N = 3496)
Eastbound Totals	10.990 (N = 9457)	9.776 (N = 1292)	11.039 (N = 1292)	9.508 (N = 458)	10.815 (N = 12499)
Both Directions	11.377 (N = 16264)	9.940 (N = 2364)	11.329 (N = 2363)	9.707 (N = 916)	11.147 (N = 21907)