TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/TX-86/ +397-4		

4. Title and Subtitle	5. Report Date
Statistics of Truck Accidents: An Addendum to a Study of Longer and Wider Trucks on the Texas Highway System	August 1987
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
T. Chira-Chavala and Dock Burke	Research Report 397-4

9. Performing Organization Name and Address	10. Work Unit No.
Texas Transportation Institute The Texas A&M University System College Station, TX 77843	11. Contract or Grant No. HPR Study 2-18-85-397
	13. Type of Report and Period Covered Interim - September 1984 August 1987
12. Sponsoring Agency Name and Address Texas State Department of Highways and Public Transportation; Transportation Planning Division P. O. Box 5051 Austin, Texas 78763	14. Sponsoring Agency Code

15. Supplementary Notes
Research performed in cooperation with DOT, FHWA.
Research Study Title: Longer and Wider Trucks on the Texas Highway System

16. Abstract

This addendum provides a summary of truck accident statistics on the Texas highway system which include reported frequency of truck accident involvements; distributions of truck accident involvements by some accident, vehicle, and environmental variables; and severity of truck accidents. The data source, methodology, and results are presented. These accident statistics are useful as preliminary information for further sensitivity tests or policy analyses concerning truck usage and routing. Such sensitivity tests or policy analyses are not part of this addendum.

17. Key Words	18. Distribution Statement
truck, accident, statistics, severity, highway, safety	No restrictions. This document is available to the public through the National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	177	

Form DOT F 1700.7 (8-69)

STATISTICS OF TRUCK ACCIDENTS: AN ADDENDUM TO A STUDY OF LONGER AND WIDER TRUCKS ON THE TEXAS HIGHWAY SYSTEM

by

T. Chira-Chavala
Dock Burke

Research Report 397-4
TTI Research Study Number 2-18-85-397

Sponsored by

Texas State Department of Highways
and Public Transportation

in cooperation with

U.S. Department of Transportation

and

Federal Highway Administration

August 1987

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843

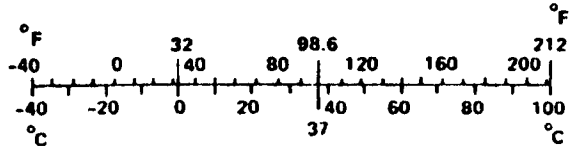
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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

DISCLAIMER

The contents of this report reflect the views of the authors and do not necessarily represent the official views or policies of the Texas State Department of Highways and Public Transportation. This report does not constitute a standard, specification, or regulation.

SUMMARY

Enactment of recent Federal and State legislation has permitted the use of longer and wider trucks on the highway system. The safe and efficient accommodation and regulation of these vehicles require that their operating characteristics be compatible with existing and planned highway systems.

The dynamics of the legislative, regulatory, and technological trends that define the major tendencies of highway freight movements are incessant. To keep abreast of this dynamic segment of highway users, the SDHPT needs valid, current information about the nature of the vehicles, their operations, their accident experience, and their impacts on highway design standards, procedures, and policies.

This document is an addendum to a study (HPR 2-18-85-397) concerning longer and wider trucks on the Texas highway system. It provides a summary of truck accident statistics on the Texas highways. These statistics were based on the 1984 Department of Public Safety's (DPS) computerized accident file and aimed at describing the accident experience of trucks over 10,000 pounds. Included in this document are results of three analyses: reported frequency of truck accident involvements; distributions of truck accident involvements by some accident, vehicle, and environmental factors; and severity of truck accidents.

In 1984, there were 56,045 reported accident involvements of trucks over 10,000 pounds which were not fire trucks, motor-homes, travel-alls, or pickups with campers. Of these, 36 percent (19,992) were semi-trailers and 64 percent (36,053) were single-unit (SU) trucks.

Table S1 indicates that the distributions of accident involvements by major road classes for different truck configurations (semi-trailers or SU trucks) were quite different. Accidents involving semi-trailers were quite significant in number on all road classes. The number of accidents involving single-unit (SU) trucks was very high on city streets but was small on rural highways. Types of accident involvements were also different for semi-trailers and SU trucks as shown in Table S2. Semi-trailers showed that about

Table S1

Distribution of Truck Accident Involvements by Road Class

(1984)

Semitrailers

Road Class	Frequency	Percentage
Rural Interstate	1,703	8.53
Rural US/State	3,205	16.05
Farm-to-Market	1,830	9.16
Small-Urban Interstate*	916	4.59
Small-Urban US/State*	3,085	15.45
Urban Interstate	3,532	17.69
Urban US/State	2,551	12.77
City Streets	3,149	15.77
Total	19,971	100.00

Single-Unit Trucks

Road Class	Frequency	Percentage
Rural Interstate	545	1.52
Rural US/State	1,985	5.52
Farm-to-Market	5,245	14.59
Small-Urban Interstate *	647	1.80
Small-Urban US/State *	3,778	10.51
Urban Interstate	4,074	11.33
Urban US/State	5,271	14.67
City Streets	14,397	40.06
Total	35,942	100.00

* Small urban areas were those with population less than 50,000

Table S2

Distribution of Truck Accident Involvement by Accident Type
(1984)

Semitrailers

Accident Type	Frequency	Percentage
Overturn *	1,222	6.11
Other Non-Collision *	780	3.90
Fixed Object *	2,423	12.12
Collision With Car	9,076	45.40
Collision With Pickup	3,239	16.20
Collision With Truck	267	1.34
Collision With Other Vehicle	1,932	9.66
Other**	1,053	5.27
Total	19,992	100.00

Single-Unit Trucks

Accident Type	Frequency	Percentage
Overturn*	1,348	3.74
Other Non-Collision*	123	0.34
Fixed Object*	2,495	6.92
Collision With Car	19,552	54.23
Collision With Pickup	5,952	16.51
Collision With Truck	347	0.96
Collision With Other Vehicle	4,313	11.96
Other**	1,923	5.33
Total	36,053	100.00

* These are as reported by the DPS in the first harmful event variable.

** Includes the reported first harmful events of collisions with pedestrians, parked cars, trains, pedalcyclists, animals, or other objects not classified by the DPS as fixed objects.

22 percent of their total involvements were single-vehicle (i.e., overturns, other non-collision and fixed-object accidents) whereas SU trucks showed that about 11 percent of their total involvements were single-vehicle accidents.

A multivariate analysis of truck accident involvements reveals that the proportions of involvements for each truck type (defined by truck configuration and vehicle body style) varied significantly by road class, accident type, day/night and intersection related. Table S3 shows a summary of the estimated percentages of accident involvements (the "prevalence" of involvements) for selected truck types. The percentages shown in the table were fractions of accident involvements within each particular truck type. The percentages in each row do not sum to 100 percent because only major, but not all, accident types were included in the table.

The analysis of truck accident involvements also yielded the estimated probabilities of involvements on each road class independent of other road classes for each truck type. Table S4 ranks the accident characteristics on individual road classes with particularly high probabilities of occurrence within each selected truck type. The table indicates that collisions with passenger cars had very high probabilities of occurrence on all road classes for all truck types. Furthermore, the probabilities of non-collision accidents (i.e. overturns and other non-collision accidents) on rural highways were also significantly high for all types of semi-trailers.

Table S5 shows the distributions of the severity for accidents involving semi-trailers and SU trucks. Severity of truck accidents was found to be significantly affected by truck configuration, accident type, road class, day/night, pavement surface condition, and intersection related. Specific factors that were found to be associated with increased severity are summarized in Table S6 for non-collision accidents, fixed-object accidents, and collisions with passenger vehicles (cars or pickups). The odds of fatal or incapacitating injury accidents represented a ratio of fatal or incapacitating injury accidents to all other accidents, while the odds of non-incapacitating injury accidents represented a ratio of non-incapacitating injury or possible injury accidents to property-damage-only (PDO) accidents.

Table S3: Summary of Estimated Percentages of Accident Involvements by Selected Truck Types

Truck Type	Single-Vehicle Accidents					Collisions with Cars or Pickups				
	Rural IH	Rural US/State	FM	Urban Highways	City Streets	Rural IH	Rural US/State	FM	Urban Highways	City Streets
Flatbed Semi-Trailer	3.2	8.1	3.7	12.0	3.7	3.1	7.9	5.4	28.0	7.9
Van Semi-Trailer	5.9	9.8	1.4	8.5	3.5	3.4	4.5	3.1	32.1	11.9
Tank Semi-Trailer	2.1	8.0	7.3	8.2	1.9	1.8	10.6	7.6	30.4	6.5
Dump Semi-Trailer	0.7	5.0	6.0	10.3	3.0	1.2	8.3	7.1	32.6	8.1
"Mixed" Semi-Trailer	2.9	4.6	2.2	7.1	2.6	3.7	7.2	4.4	38.4	10.7
Flatbed SU	0.6	2.1	3.2	3.2	2.6	1.1	3.8	10.2	33.3	23.0
Van SU	1.1	3.1	2.0	3.8	2.2	0.4	2.5	5.6	28.2	29.8
Tank SU	0.3	1.8	3.0	4.6	3.3	1.6	9.2	16.4	25.1	17.9
Dump SU	0.2	1.1	4.5	4.7	2.9	1.0	4.0	12.0	32.7	19.1
"Mixed" SU	0.5	1.3	3.0	2.6	3.2	0.6	3.0	8.7	28.9	29.9

Percentages were fractions within each particular truck type.

Table S4

Summary of Accident Characteristics on Individual Road Classes With Particularly High Probabilities Occurrence by Truck Type

Truck Type	Characteristics With High Probabilities of Occurrence
Flatbed Semi-Trailers	(1) Collisions with cars on urban IH (particularly during the day) (2) Collisions with cars on city streets (particularly during the day) (3) Collisions with cars on urban US/State (particularly during the day or at intersections) (4) Collisions with cars on FM roads (particularly during the day or at intersections) (5) Collisions with cars on rural US/State (6) Collisions with cars on rural IH (7) Non-collision accidents on rural IH
Van Semi-Trailers	(1) Collisions with cars on urban IH (particularly during the day) (2) Collisions with cars on urban US/State (particularly during the day) (3) Collisions with cars on city streets (particularly during the day) (4) Collisions with cars on FM roads (particularly during the day) (5) Non-collision accidents on rural US/State (6) Non-collision accidents on rural IH
Tank Semi-Trailers	(1) Collisions with cars on urban IH (2) Collisions with cars on city streets (particularly during the day) (3) Collisions with cars on urban US/State (particularly during the day or at intersections) (4) Non-collision accidents on FM roads (5) Collisions with Cars on rural US/State (6) Collisions with Cars on FM roads (7) Non-collision accidents on rural IH (8) Non-collision accidents on rural US/State
Dump Semi-Trailers	(1) Collisions with cars on urban IH (particularly at intersections) (2) Collisions with cars on city streets (3) Collisions with cars on urban IH (4) Collisions with cars on rural IH (5) Collisions with cars on rural US/State (6) Collisions with cars on FM roads (7) Collisions with pickups on rural US/State (8) Non-collision accidents on rural US/State
"Mixed" Semi-Trailers	(1) Collisions with cars on urban IH (particularly during the day) (2) Collisions with cars on urban US/State (particularly during the day or at intersections) (3) Collisions with cars on city streets (particularly during the day or at intersections) (4) Collisions with cars on FM roads (5) Collisions with cars on rural IH (6) Collisions with cars on rural US/State

Summary of Accident Characteristics on Individual Road Classes With Particularly High Probabilities Occurrence by Truck Type (Cont.)

Truck Type	Characteristics With High Probabilities of Occurrence
Flatbed SU	(1) Collisions with cars on urban US/State (particularly during the day or at intersections) (2) Collisions with cars on city streets (particularly during the day) (3) Collisions with cars on urban IH (particularly during the day) (4) Collisions with cars on FM roads (particularly during the day) (5) Collisions with cars on rural IH (particularly during the day) (6) Collisions with cars on rural US/State (particularly during the day)
Van SU	(1) Collisions with cars on city streets (particularly at intersections) (2) Collisions with cars on urban IH (3) Collisions with cars on FM roads (particularly at intersections) (4) Collisions with cars on urban US/State (particularly at intersections) (5) Non-collision accidents on rural IH (6) Non-collision accidents on rural US/State
Tank SU	(1) Similar and high probabilities were found for collisions with cars on all 6 road classes
Dump SU	(1) Collisions with cars on urban IH (particularly during the day) (2) Collisions with cars on city streets (particularly during the day) (3) Collisions with cars on urban US/State (particularly during the day or at intersections) (4) Collisions with cars on rural IH (particularly during the day) (5) Collisions with cars on rural US/State (particularly during the day) (6) Collisions with cars on FM roads (particularly during the day) (7) Collisions with pickups on rural IH (particularly during the day)
Mixed SU	(1) Collisions with cars on urban US/State (particularly during the day or at intersections) (2) Collisions with cars on city streets (particularly during the day or at intersections) (3) Collisions with cars on urban IH (particularly during the day) (4) Collisions with cars on FM roads (particularly during the day) (5) Collisions with cars on rural US/State (6) Collisions with cars on rural IH

Table S5

Distribution of Severity of Truck Accident Involvements in Texas for 1984

Truck Configuration	Number of Accident Involvements				
	Fatal	Incapacitating Injury	Possible or Non-Incapacitating Injury	P.D.O.	Total
Single-Unit	270 (0.75)	1393 (3.86)	9054 (25.11)	25336 (70.27)	36053 (100.00)
Semi-trailers	408 (2.04)	1130 (5.65)	4542 (22.72)	13912 (69.59)	19992 (100.00)
Total	678	2523	13596	39248	56045

Table S6. Summary of Factors Associated With Increased Severity of Truck Accidents

Accident Type	Measure of Severity	Factors Associated with Increased Severity*
Non-collisions involving semi-trailers	Odds of fatal or incapacitating injury accidents	Decreased degree of urbanization; increased road design standards* (for rural highway on dry pavements only); dry condition (for rural highways).
	Odds of non-incapacitating injury accidents	Decreased road design standards (for rural highways); increased road design standards (for urban roadways); dry condition.
Fixed-object accidents involving semi-trailers	Odds of fatal or incapacitating injury accidents	Decreased degree of urbanization; increased road design standards (for rural highway on dry pavements only); dry condition (for rural highways).
	Odds of non-incapacitating injury accidents	Increased road design standards; wet condition.
Collisions between semi-trailers and passenger vehicles	Odds of fatal or incapacitating injury accidents	Night-time; decreased degree of urbanization.
	Odds of non-incapacitating injury accidents	Night-time; decreased degree of urbanization.
Non-collisions involving SU trucks	Odds of fatal or incapacitating injury accidents	Night-time; decreased degree of urbanization; increased road design standards.
	Odds of non-incapacitating injury accidents	Night-time; increased degree of urbanization; decreased road design standard (for rural highways).
Fixed-object accidents involving SU trucks	Odds of fatal or incapacitating injury accidents	Night-time; increased degree of urbanization; increased road design standards.
	Odds of non-incapacitating injury accidents	Night-time; decreased degree of urbanization.
Collisions between SU trucks and passenger vehicles	Odds of fatal or incapacitating injury accidents	Night-time; decreased degree of urbanization.
	Odds of non-incapacitating injury accidents	Night-time; wet condition.

* The hierarchy of road design standards was interstate highways, US/State highways, and FM roads in rural areas; interstate highways, US/State highways, and city streets in urban areas.

The severity analysis reveals that the highest odds of fatal or incapacitating injury accidents were indicated by night-time collisions between semi-trailers and passenger vehicles on rural US/State highways. One out of 3 to 4 such accidents might be expected to be fatal or incapacitating injurious. The next highest odds of fatal or incapacitating injury accidents were indicated by non-collision accidents involving SU trucks at night on rural interstate and rural US/State highways. About one out of every 4 such accidents might be expected to result in fatalities or incapacitating injuries. In general, the odds of fatal or incapacitating injury accidents for collisions between trucks and passenger vehicles at night were 2 to 3 times the odds during the day for all road classes. Further investigations of the accident data did not reveal specific factors that might have caused this considerable severity difference between night-time and day-time collisions. However, it was revealed that for all manners of collision (i.e. rear-end, angle, sideswipe, etc.), night-time always showed higher probabilities of fatal or severe-injury accidents than did day-time.

Finally, the DPS accident file had problems of missing data which were substantial for some variables, as well as other reporting inconsistencies. These missing data and reporting anomalies of truck accidents were further compounded by very limited information describing truck accidents and the important characteristics of trucks involved in the accidents. Despite these shortcomings, the accident statistics contained in this addendum should be useful as preliminary information for further sensitivity tests or policy analyses of truck usage and routing on the Texas highway system. Such sensitivity tests or policy analyses are not part of this addendum.

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1. INTRODUCTION

Enactment of recent Federal and State legislation has permitted the use of wider and longer trucks on the highway system. The safe and efficient accommodation and regulation of these vehicles require that their operating characteristics be compatible with existing and planned highway systems.

Several years ago, the Texas State Department of Highways and Public Transportation (SDHPT) initiated a study of the truck weights that the highway system could safely and efficiently accommodate. This study was the beginning of a continuing research effort to identify, analyze, and document a myriad of selected highway-truck nexus: pavements, bridges, truck operations, truck accident analysis, special-use trucks, exclusive truck routes, truck lane needs, truck routing regulations, highway cost allocation, and economic analysis.

The dynamics of the legislative, regulatory, and technological trends that define the major tendencies of highway freight movements are incessant. New laws have legalized longer and wider trucks. Deregulation is propelling economic incentives toward much more efficient vehicles; these are characterized by ever greater carrying capacities, both cubic and tonnage. Furthermore, technological breakthroughs in vehicle and power plant design are producing fleet mix changes that are likely to affect vehicular performances and operations.

To keep abreast of this dynamic segment of highway users, the SDHPT needs valid, current information about the nature of the vehicles, their operations, their accident experience, and their impacts on highway design standards, procedures, and policies. The ability of the Texas highway system to keep abreast of fundamental trends in transportation requires that significant problems be identified so that appropriate solutions may be developed and sound planning may be initiated prior to implementation.

This document is an addendum to a large multi-faceted study entitled "Longer and Wider Trucks on the Texas Highway System" (HPR 2-18-85-397). It

contains the statistical results pertaining to the "Accident Data and Statistical Analysis" task. Its objectives were:

a) to examine the truck accident data available in the Department of Public Safety's (DPS) computerized accident file and to assess the quality and sufficiency of the available data;

b) to document the accident experience of trucks, using the information available from the DPS computerized file, by various characteristics including highway class, degree of urbanization, truck type, accident type, severity, and the environment in which truck accidents occurred; and

c) to identify significant variables and relationships among these variables within the truck accident population.

The results reported here were aimed at providing preliminary information for further sensitivity tests or policy analyses concerning truck usage and routing on the Texas highway system. Such policy analyses or sensitivity tests are not part of this addendum.

This document consists of three main sections: analysis plan; analysis results; and summary and discussion. It also includes several appendices containing descriptions of the analysis methods used, as well as data and results that are too cumbersome for the text portion but are useful for reference purposes.

2. ANALYSIS PLAN

The analysis of truck accidents was based on the 1984 DPS accident file. It was aimed at examining the following:

a) Reported truck accident frequency;

b) Nature of truck accident involvements and factors associated with these accident involvements; and

c) Severity of truck accidents.

Descriptions of these 3 tasks are presented below.

2.1 Reported Truck Accident Frequency

In this task, the subset of truck accidents in the 1984 DPS file was examined. For this study, trucks were defined as those over 10,000 pounds which were not fire trucks, motor-homes, travel-alls, or pickups with campers. This definition excluded small vans and pickups. A truck might, therefore, be a single-unit (SU) truck or a truck/tractor pulling a trailer (i.e., a semi-trailer). Both SU trucks and semi-trailers had a variety of load compartment units (generally referred to as vehicle body styles) such as flatbed, lowboy, stake, float, boxed van, tank, dump, livestock/pole, etc. The coding of vehicle body style used by the DPS did not make the distinction between flatbed, lowboy, platform, float, and stake. For brevity, these five body styles are collectively referred to as flatbeds.

A large number of variables contained in the DPS file was examined, particularly the following:

a) Truck configuration (SU or semi-trailer)
b) Vehicle body style
c) Road class
d) Accident type
e) Ramp related

f) Intersection related
g) Pavement surface condition
h) Alignment
i) Degree of curvature
j) Time-of-day
k) Light condition
l) Driver age
m) Accident severity

Accident frequencies by the above variables were tabulated. They were then examined together with any missing data and reporting/coding anomalies. In this way, the quality of the data which was the basis for the study might be assessed.

The preliminary results obtained from these accident tabulations provided a general description of truck accidents in Texas. Accident distributions by these individual variables, although informative, were limited in providing insight into the accident experience of trucks. This was due to complex interactions brought about by different usage of different truck types and by interactions between truck usage and accident variables, as well as interactions among the accident variables themselves. There was therefore a need to identify some of these interactions in order to better understand truck accident statistics. To do this, the factors significantly associated with truck accidents must be identified and simultaneously analyzed so as to minimize possible effects of any confounding variables. Further, truck exposure data must be incorporated into the analysis of truck accidents so that the effects of truck exposure might be separated from the effects of important accident variables.

Attempts were made to identify sources for truck exposure data (i.e., truck miles of travel) which might have sufficient detail and reasonable accuracy for the purpose of this study. The Highway Cost Allocation Study (HCAS) and the State's Roadway Information (RI) files were examined. It was considered that the HCAS file, which was based on a nationwide sample survey of truck operators in 1977, had so many shortcomings that its Texas portion of the file would not provide sufficiently accurate or up-to-date information

on truck mileage. The State's RI file did not have sufficient detail for the accident analyses planned for the study. Therefore, truck exposure data was not incorporated into any of the subsequent truck accident analyses. The tasks of analyzing truck accident involvements and severity were therefore limited to examining the information which was available from the DPS file.

2.2 Truck Accident Involvements And Factors Associated With These Involvements

In this analysis, factors associated with the accident experience of different types of trucks were identified and the extent of truck accident involvements by these factors quantified. In this way, patterns of truck accident involvements, if any, might be determined and these patterns for different truck types might be compared. Furthermore, conditions that were associated with high incidence of truck accidents might be singled out for further investigations.

The analysis involved was a two-stage analysis. In the first stage, a set of candidate variables was analyzed and then ranked by their importance in explaining the variability of truck accidents. This ranking was desirable because it would ensure that the most significant variables were further analyzed while the non-significant variables were eliminated. The algorithm to rank-order candidate variables is fully described in (1, 2).

Once candidate variables were ranked, a small number of them were then selected for a further analysis in the second stage to identify factors or combinations of factors significantly associated with truck accident involvements. The analysis method used was a multivariate analysis for contingency tables based on the principles of log-linear models. The method is described in Appendix A. From the output of the log-linear model estimation, the following statistics could be computed:

a) The percentages (distribution) of truck accident involvements by various combinations of factors, and

b) The probabilities of truck accident involvements under various conditions within each road class.

The percentages of truck accident involvements by various combinations of factors indicate the magnitude of truck accident problems presently exist on the Texas highways for the current level of truck usage, or the "prevalence" of truck accident involvements. In the absence of any truck exposure data, these percentages were likely to reflect the amount of truck travel under those conditions as well.

The probabilities of truck accident involvements within each individual road class indicate the chances of truck accident involvements under various conditions for that road class independent of other road classes. These probabilities might be used for comparing accident propensities among different truck types and different road classes. Because these probabilities were independent of the different amount of truck exposure by truck type or road class, they might also be used for predicting truck accident problems on a particular road class for which changes in the amount of truck traffic and/or mix of truck traffic might be expected.

2.3 Severity of Truck Accidents

In this analysis, factors associated with severity of truck accidents were identified and the probabilities of various severity levels estimated. The severity analysis was also a two-stage analysis. In the first stage, a list of variables which were potentially important predictors of truck-accident severity was systematically selected from a larger set of candidate variables by means of a statistical algorithm similar to that mentioned in Section 2.2. Once a set of the significant variables was selected, modeling of truck-accident severity was performed in the second stage. Three levels of accident severity were defined for the study:

a) Accident involvements that resulted in fatalities or incapacitating injuries,

b) Accident involvements that resulted in non-incapacitating or possible injuries, which were not included in (a), and

c) Accident involvements that resulted in no injuries but only in property damage.

Estimation of the probabilities of these severity levels involved defining two severity odds and modeling these two odds as a function of the variables affecting them. These two odds were:

(i) Odds of fatal or incapacitating injury accidents Defined as a ratio of the number of fatal or incapacitating injury accidents to the number of all other accidents, and

(ii) Odds of non incapacitating injury accidents Defined as a ratio of the number of non-incapacitating injury or possible injury accidents to the number of PDO accidents, for accidents which had no fatalities or incapacitating injuries.

High values of both odds would indicate serious consequences of truck accidents. High values of the first odds indicate high likelihood of fatalities or incapacitating injuries. High values of the second odds indicate that, in the absence of fatalities or incapacitating injuries, the likelihood of some less serious injuries would still be high. The model estimation technique used was based on logit models of continuous ratios for contingency tables (2, 3). The models for the two severity odds could be expressed as follows:

Log (odds of fatal or incapacitating injury accidents)

$$= \text{Log}\ (m_1/(m_2 + m_3))$$

$$= f\ (X_1, X_2, X_3, \ldots)$$

Log (odds of non-incapacitating injury accidents, given no fatalities or injuries)

$$= \text{Log } (m_2/m_3)$$

$$= f' (X_1, X_2, X_3, \ldots)$$

where m_1, m_2, m_3 are the numbers of fatal or incapacitating injury accidents, non-incapacitating injury accidents, and PDO accidents, respectively; and X_1, X_2, X_3, ..., are the independent variables.

The model estimation method for these two odds is also described in Appendix A.

3. ANALYSIS RESULTS

The analysis results are presented in the following order: reported truck accident frequency, truck accident involvements, and truck accident severity.

3.1 Reported Truck Accident Frequency

In 1984, there were 56,045 reported truck accident involvements in Texas. Table 1 shows the distribution of the DPS-reported truck accident involvements by various truck types. Truck type was defined by truck configuration (SU or semi-trailer) and vehicle body style. Of all the DPS-reported truck accident involvements in 1984, about 64 percent (36,053 accidents) involved SU trucks while the other 36 percent (19,992 accidents) involved semi-trailers. Among the semi-trailers, flatbeds and large vans each accounted for about 10 percent, tanks about 5 percent, dumps 4 percent, and unreported vehicle body style or other body styles 72 percent. Considering that most semi-trailers were either flatbeds, vans, tanks, or dumps, it was highly likely that the last category of vehicle body style (unreported or other) also included a substantial number of these four body styles. Such an overwhelmingly large percentage of this category could only have been caused by accident investigators ignoring vehicle body styles altogether or recording them by various other different names. At this time, there is no knowledge or evidence to indicate that the missing codes are significantly biased by particular vehicle body styles. The unreported/other category of body style therefore might be considered to contain a mix of all vehicle body styles similar to that in the semi-trailer population. For brevity, this missing-code category is referred to in this report as "mixed" body style.

A similar situation regarding reported vehicle body style was also found to be true with SU-truck accidents. Of all the reported accident involvements of SU trucks, 78 percent were without body styles or with different names other than those commonly known.

Table 1

Distribution of Truck Accident Involvements by Truck Type
(1984)

Truck Configuration	Vehicle Body Style	Frequency	Percentage
Semitrailer	Flatbed	1,888	3.37
	Van	1,786	3.19
	Tank	1,057	1.89
	Dump	700	1.25
	Livestock/Pole	205	0.36
	"Mixed" Body Style	14,356	25.61
Subtotal		19,992	35.67
Single-Unit	Flatbed	2,317	4.14
	Van	449	0.80
	Tank	260	0.46
	Dump	2,242	4.00
	Garbage/Wrecker	1,386	2.47
	Mixer/Cement	620	1.11
	Bobtail	563	1.00
	"Mixed" Body Style	28,216	50.34
Subtotal		36,053	64.33
Total		56,045	100.00

It was noted that the DPS computerized file contained very little information about the trucks which were involved in accidents. The DPS file lacked information on commodity carried, type of operation, truck dimensions, truck weight, axles information, wheel base, etc. Some of these features, however, were correlated with vehicle body style and truck configuration. Table 2 summarizes trailer widths, trailer lengths, commodities carried, gross vehicle weights (GVW), haul distances, and regions of operation within the State for vans, flatbeds, dumps, tanks, and lowboys before 1983. It can be seen from Table 2 that the types of commodities carried were quite unique for individual vehicle body styles. Other features such as trailer lengths, haul distances, and ranges in GVW's varied among different vehicle body styles as well as within the same vehicle body styles. Table 3 shows trends in trailer widths and lengths for various vehicle body styles after 1983 as the result of the passage of the 1982 Surface Transportation Assistance Act. Because vehicle body style could indicate many important truck characteristics not reported in the DPS file, it was desirable to examine truck accident experience by various major vehicle body styles so that confounding effects due to the inherent differences among different vehicle body styles might be minimized in developing truck accident statistics.

Distributions of truck accident involvements by several variables described in Table 4 were examined. Table 5(a) shows the distributions of truck accident involvements by eight different highway classes, for semi-trailers and for SU trucks. The table indicates that about 40 percent of accident involvements of SU trucks were on city streets, about 15 percent each on farm-to-market roads and urban US/State highways; their involvements on rural and small-urban interstate highways were relatively small. On the other hand, accident involvements of semi-trailers tended to be more spread out among all road classes, with smaller proportions of the involvements on small-urban and rural interstate highways, and farm-to-market roads.

Table 5(b) shows the distributions of intersection-related truck accident involvements for semi-trailers and for SU trucks. Substantial numbers of truck accident involvements were reported to be intersection related for both semi-trailers and for SU trucks, particularly the latter. Table 5(c) shows the distributions of truck accident involvements by accident

Table 2. Truck Characteristics in Texas (Before 1983)

Vehicle Body Style	Trailer Width (ft)	Trailer Length (ft)	Commodity Carried	GVW (kips)	Haul Distance (miles)	Region of State
Vans	8.0	40-53	Manuf. goods, produce, wood products	70-80	100-600	All
Flatbeds	8.0	40-48	Steel, lumber, grain, cotton, manuf. goods	70-80	100-600	All
Dumps	8.0	33-38	Aggregate	75-80	30-100	All
Tanks	8.0	42-43	Petroleum, other liquid bulk	70-85	30-200	All
Lowboys	8.0	40-55	Equipment, machinery	80-150	50-600	All

Table 3. Trends in Trailer Widths and Lengths Since 1983

Vehicle Body Style (Trailer)	Trailer Width	Trailer Length
Vans	Most are 8.5 feet wide, with emphasis on greater capacity (i.e. more cube).	At least 48 feet; some are 53 feet or even 57 feet
Flatbeds	Most are 8.0 feet but some are 8.5 feet wide. Some with tandem axles spread 10'-2" apart to allow 20 kips per axle.	Mostly 45 feet
Tanks	Still 8.0 feet wide	42-43 feet
Dumps	Some are 8.5 feet wide for better stability when unloading. Double bottom belly dump trailers may increase in the future.	Great demand for 37-38 feet with gross vehicle weight of 80,000 pounds
Lowboys	Most are 8.0 feet and some are 8.5 feet wide. Some with expandable widths of 10 feet, when needed.	45-55 feet

Table 4. A List of Candidate Variables

Variable	Level
Truck Type	Single-Unit (SU) Trucks: Flatbed Large Van Tank Dump Garbage, Wrecker Mixer, Cement Bobtail "Mixed" Body Style Combination Trucks: Flatbed Large Van Tank Dump Livestock/Pole "Mixed" Body Style
Accident Type	o Overturn o Other Single-Vehicle Accidents o Fixed-Object Accidents o Collisions With Passenger Car o Collisions With Pickup/Panel Van o Collisions With Large Truck o Collisions With Other Vehicle Types o Other (included pedestrians, trains, parked cars, cyclists, animals, other objects)
Accident Severity	o Fatal Accidents o Accidents Resulting in Incapacitating Injuries o Accidents Resulting in Non-Incapacitating or Possible Injuries o Property-Damage-Only Accidents
Road Class	o Rural Interstate o Rural U.S. or State o Farm-to-Market o Interstate in small urbanized areas (population less than 50,000) o U.S. or State in small urbanized areas o Urban Interstate (population greater than 50,000) o Urban U.S. or State o City Streets

A List of Candidate Variables (Cont.)

Variable	Level
Ramp Related	o Entrance Ramp o Exit Ramp o Main Lane or Frontage Road
Intersection Related	o Yes o No
Pavement Surface Condition	o Yes o No
Alignment	o Straight and level o Straight, grade or hillcrest o Curve
Degree of Curvature	o No curve of less than 2 degrees o 2 to 4 degrees o Greater than 4 degrees
Time-of-Day	o Midnight to 3:00 a.m. o 3:01 a.m. to 6:00 a.m. o 6:01 a.m. to 9:00 a.m. o 9:01 a.m. to Noon o 12:01 p.m. to 3:00 p.m. o 3:01 p.m. to 6:00 p.m. o 6:01 p.m. to 9:00 p.m. o 9:01 p.m. to Midnight
Light Condition	o Daylight (day) o Other (night)
Driver Age	o Less than 25 o 25 to 35 o 36 to 55 o Over 55

Table 5(a)

Distribution of Truck Accident Involvements by Road Class

(1984)

Semitrailers

Road Class	Frequency	Percentage
Rural Interstate	1,703	8.53
Rural US/State	3,205	16.05
Farm-to-Market	1,830	9.16
Small-Urban Interstate*	916	4.59
Small-Urban US/State*	3,085	15.45
Urban Interstate	3,532	17.69
Urban US/State	2,551	12.77
City Streets	3,149	15.77
Total	19,971	100.00

Single-Unit Trucks

Road Class	Frequency	Percentage
Rural Interstate	545	1.52
Rural US/State	1,985	5.52
Farm-to-Market	5,245	14.59
Small-Urban Interstate *	647	1.80
Small-Urban US/State *	3,778	10.51
Urban Interstate	4,074	11.33
Urban US/State	5,271	14.67
City Streets	14,397	40.06
Total	35,942	100.00

* Small urban areas were those with population less than 50,000

Table 5(b)

Distribution of Truck Accident Involvements by Intersection

and Non-Intersection Related
(1984)

Semitrailers

Intersection Related	Frequency	Percentage
Intersection	7,683	38.43
Non-Intersection	12,309	61.57
Total	19,992	100.00

Single-Unit Trucks

Intersection	17,650	48.96
Non-Intersection	18,403	51.04
Total	36,053	100.00

Table 5(c)

Distribution of Truck Accident Involvement by Accident Type
(1984)

Semitrailers

Accident Type	Frequency	Percentage
Overturn *	1,222	6.11
Other Non-Collision *	780	3.90
Fixed Object *	2,423	12.12
Collision With Car	9,076	45.40
Collision With Pickup	3,239	16.20
Collision With Truck	267	1.34
Collision With Other Vehicle	1,932	9.66
Other **	1,053	5.27
Total	19,992	100.00

Single-Unit Trucks

Accident Type	Frequency	Percentage
Overturn*	1,348	3.74
Other Non-Collision*	123	0.34
Fixed Object*	2,495	6.92
Collision With Car	19,552	54.23
Collision With Pickup	5,952	16.51
Collision With Truck	347	0.96
Collision With Other Vehicle	4,313	11.96
Other **	1,923	5.33
Total	36,053	100.00

* These are as reported by the DPS in the first harmful event variable.

** Includes the reported first harmful events of collisions with pedestrians, parked cars, trains, pedalcyclists, animals, or other objects not classified by the DPS as fixed objects.

type for semi-trailers and for SU trucks. A notable difference between semi-trailers and SU trucks was indicated by a considerably higher proportion of single-vehicle accidents (i.e. overturn, other non-collision, and fixed-object accidents) for semi-trailers than for SU trucks. Semi-trailers showed that about 22 percent of their total involvements were single-vehicle accidents while SU trucks showed that only 11 percent of their involvements were single-vehicle accidents. On the other hand, the proportions of multiple-vehicle collisions were smaller for semi-trailers than for SU trucks (73 percent versus 84 percent).

Table 5(d) shows the distributions of truck accident involvements by highway ramps for SU trucks and for semi-trailers. The table indicates a very small proportion of ramp accident involvements for both: about 1 percent for semi-trailers and about 0.7 percent for SU trucks.

3.2 Truck Accident Involvements and Factors Associated With These Involvements

Thirteen candidate variables previously mentioned in Section 2.1 were analyzed. They were ranked in the order of their contributions to explaining the statistical variability in the truck accident population, from the most to the least significant, as follows:

1. Truck configuration (SU a semi-trailer)
2. Road class
3. Vehicle body style (flatbed, van, tank, etc.)
4. Light condition
5. Driver age
6. Accident type
7. Intersection related
8. Accident severity
9. Time-of-day
10. Pavement surface condition

Table 5(d)

Distribution of Truck Accident Involvements by Highway Ramps
(1984)

Truck Type	Entrance Ramp	Exit Ramp	Main Lane	Total
Semitrailers	60 (0.33%)	127 (0.71%)	17,792 (98.96%)	17,979 (100.0%)
Single-Unit	51 (0.18%)	136 (0.50%)	27,436 (99.32%)	27,650 (100.0%)

Three variables: ramp-related, degree of curvature, and alignment were not analyzed and ranked because they had resulted in a very large number of empty cells due to the skewness of their distributions.

Road class was re-defined in order to make the variable-selection analysis more effective in terms of the sample size involved:

a) Rural interstate
b) Rural US/State
c) Farm-to-market
d) Urban interstate
e) Urban US/State
f) City streets

"Urban" included small urbanized and large urbanized areas.

The implication of the above list of rank-ordered variables was that accident proportions within the population investigated differed the most among the levels of the first variable. Having adjusted for this first variable, accident proportions still significantly differed among the levels of the second variable in the ranking. After accounting for both the first and the second variables in the ranking, accident proportions still significantly differed among the levels of the variable next in the ranking, and so on.

The variables which had been highly ranked, truck configuration, vehicle body style, road class, light condition, accident type, and intersection-related were included in the model estimations. Driver age, although more highly ranked than accident type and intersection-related, was not included due to a constraint of the sample size and the fact that driver age is not directly applicable to traffic-engineering related countermeasure, as are accident type and intersection related.

Because the number of accident involvements varied considerably from one truck type to another as shown in Table 1, it was desirable to carry out the model estimations of accident involvements separately for individual truck

types. Further, truck accident involvements on highway ramps, which made up about 1 percent of total truck involvements, were analyzed and reported separately from truck accident involvements on the mainlanes.

Six types of semi-trailers and eight types of SU trucks resulted in 14 individual analyses. For semi-trailers, flatbed, van, tank, dump, livestock/pole, and "mixed" semi-trailers were analyzed. For SU trucks, flatbed, van, tank, dump, cement/mixer, garbage/wrecker, bobtail, and "mixed" SU trucks were analyzed.

Contingency tables of accident involvements for these 14 subsets were prepared. The tables were cross-classified by road class, intersection-related, light condition, and accident types as shown in Appendix B. The levels of most of these variables are self-explanatory. For accident type, non-collision combined two reported first harmful events of overturn and other non-collision accidents. Collisions with another truck included collisions with trucks over 10,000 pounds that were not pickups, fire trucks, travel-alls, or pickups with campers. "Other" accident type included the reported first harmful events of collisions with pedestrians, parked cars, trains, pedalcyclists, animals, and other objects not classified by the DPS as fixed objects.

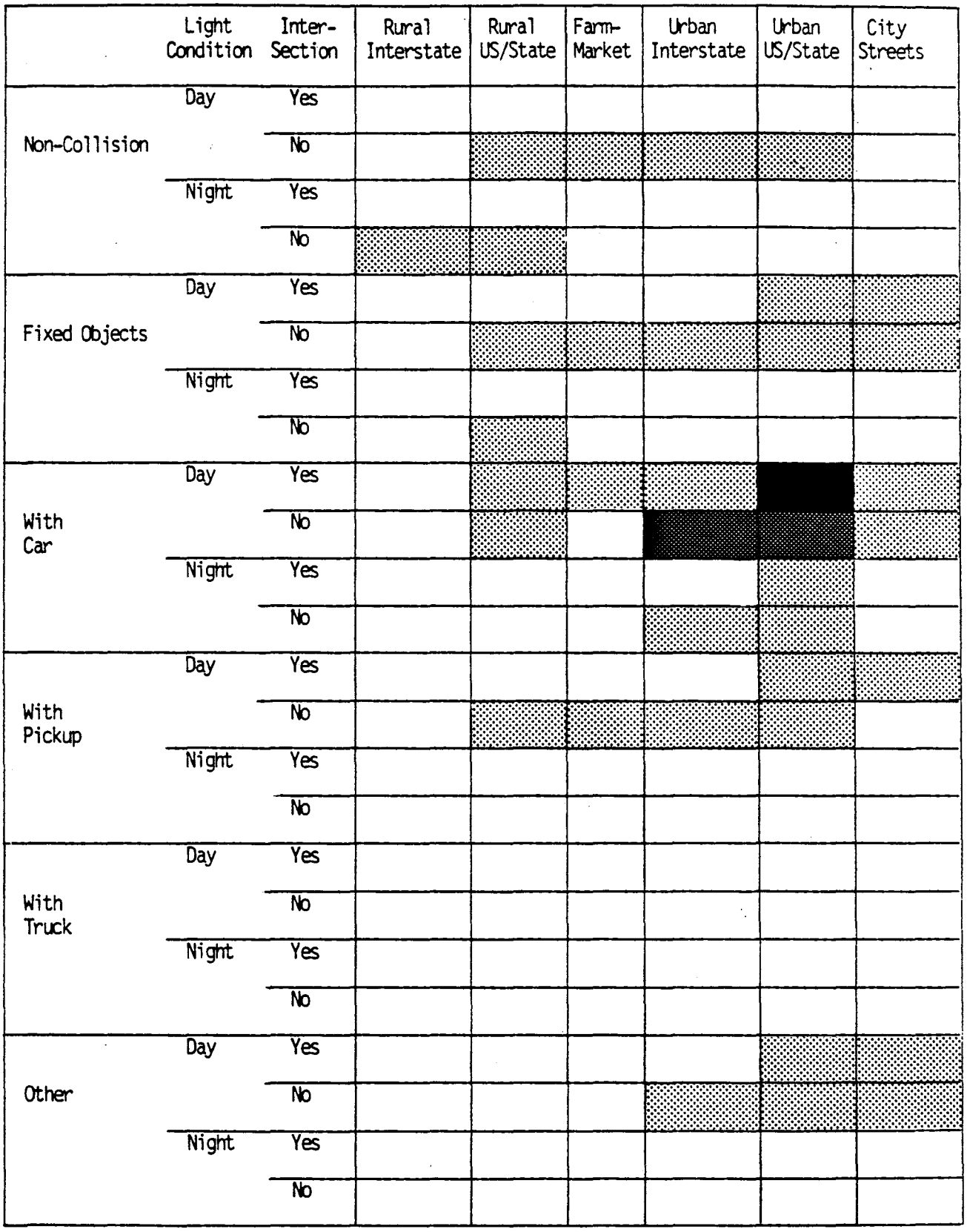
Model estimations were performed for the 14 truck types. The results in terms of the estimated model parameters are shown in Appendix C. The estimated percentages (distribution) of truck accident involvements for each truck type by various combinations of factors (or conditions) made up of road class, intersection-related, light condition, and accident type were then computed. These are shown in Appendix D. A high value of the percentage in any one cell indicates that frequent occurrences of truck accidents were observed and expected under that condition. For example, Table D1 (Appendix D) shows that the estimated proportion of non-collision accidents for flatbed semi-trailers during the day on rural US/State highways was 3.97 percent (for both intersection related and non-intersection related combined). This implies that 3.97 percent of all flatbed semi-trailers accident involvements might be expected to be non-collision accidents on rural US/State highways during the daytime, given the current usage of flatbed semi-trailers.

Because these proportions indicate, for each truck type, how prevalent the truck accidents were under various conditions, they are referred to as the prevalence of truck accident involvements.

The results of the 14 tables in Appendix D are illustrated by "density" diagrams in Figures 1 through 14, one figure for each truck type. The figures indicate that the prevalence of accident involvements was significantly different among different truck types. For all types of semi-trailers, collisions with passenger cars were the most frequently occurring accidents among all accident types considered, particularly on urban US/State and urban interstate highways. This high incidence of collisions with passenger cars was even more pronounced for SU trucks on urban US/State highways and city streets. For all truck types, there were significant numbers of accidents which were intersection related on all road classes.

Because the prevalence of truck accident involvements was determined for each truck type, it was not influenced by different amount of truck exposure among different truck types. However, it was likely to be strongly affected by truck exposure by all other variables, particularly the different amount of exposure among different road classes. In the absence of truck exposure data, more useful measures of truck accident involvements might be the probabilities of involvements for each truck type under various conditions, conditional on each road class independent of other road classes. These estimated probabilities (expressed as percentages within each road class) were computed from the model estimation results for all 14 truck types, and are shown in Tables 6 through 19. These conditional probabilities, referred to as estimated accident probabilities for individual road classes, might be used for assessing and predicting the safety impacts of each truck type on a given road class in the future. For example, the number of van semi-trailers operating on farm-to-market roads might be relatively small at the present time, resulting in a small number of van semi-trailer accidents (or low prevalence of accidents) on this road class (Table D-2). However, the potential safety of this road class in accommodating van semi-trailers must not be ignored because the number of van semi-trailers operating on farm-to-market roads might substantially increase in the future. Table 7 shows that the estimated probabilities associated with collisions between van semi-

Figure 1: Prevalence of Accident Involvements for Flatbed Semitrailers



■ ≥5.0 %
▩ 3.0 to 4.9%
▨ 1.0 to 2.9%
□ <1.0%

Figure 2: Prevalence of Accident Involvements for Van Semitrailers

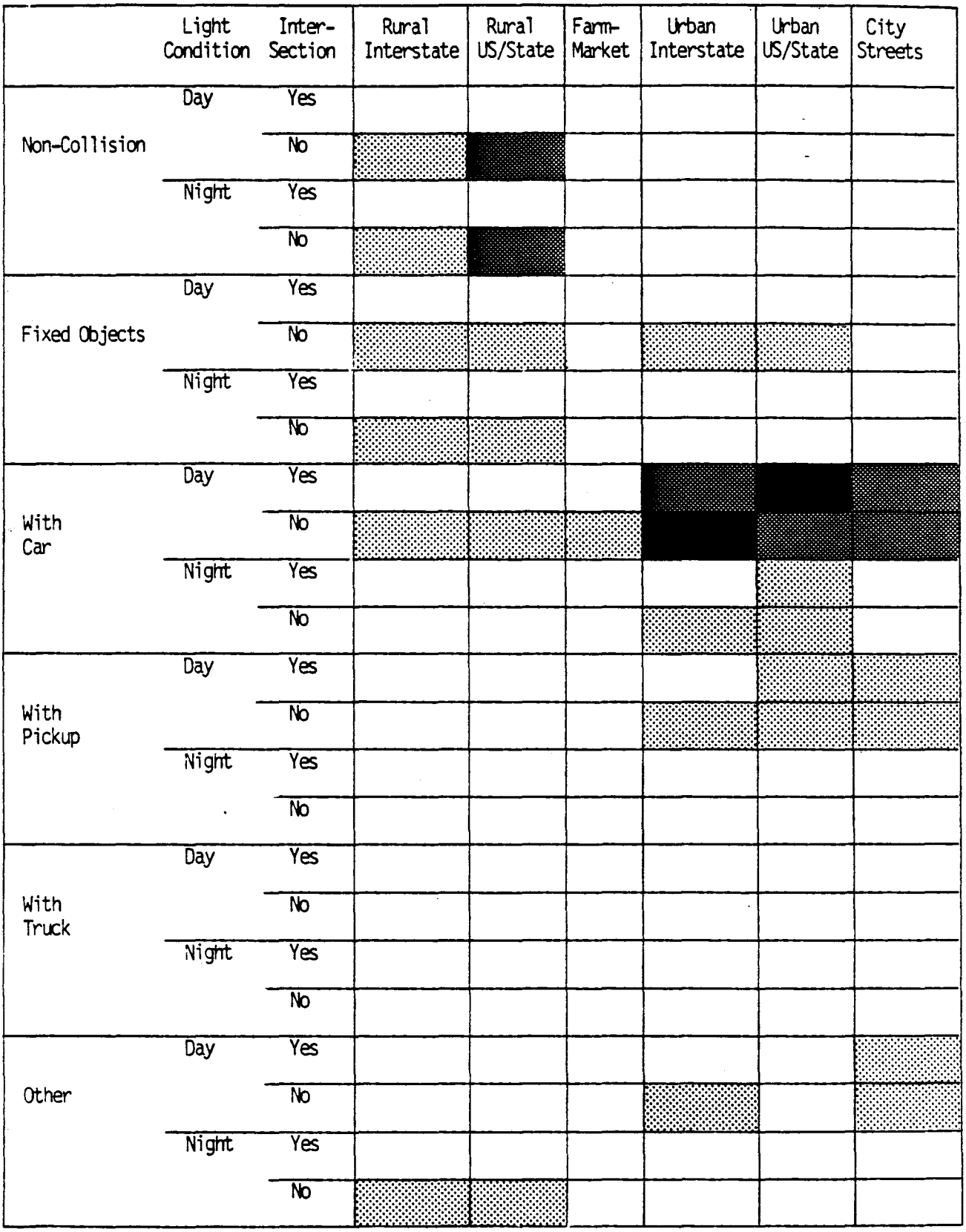
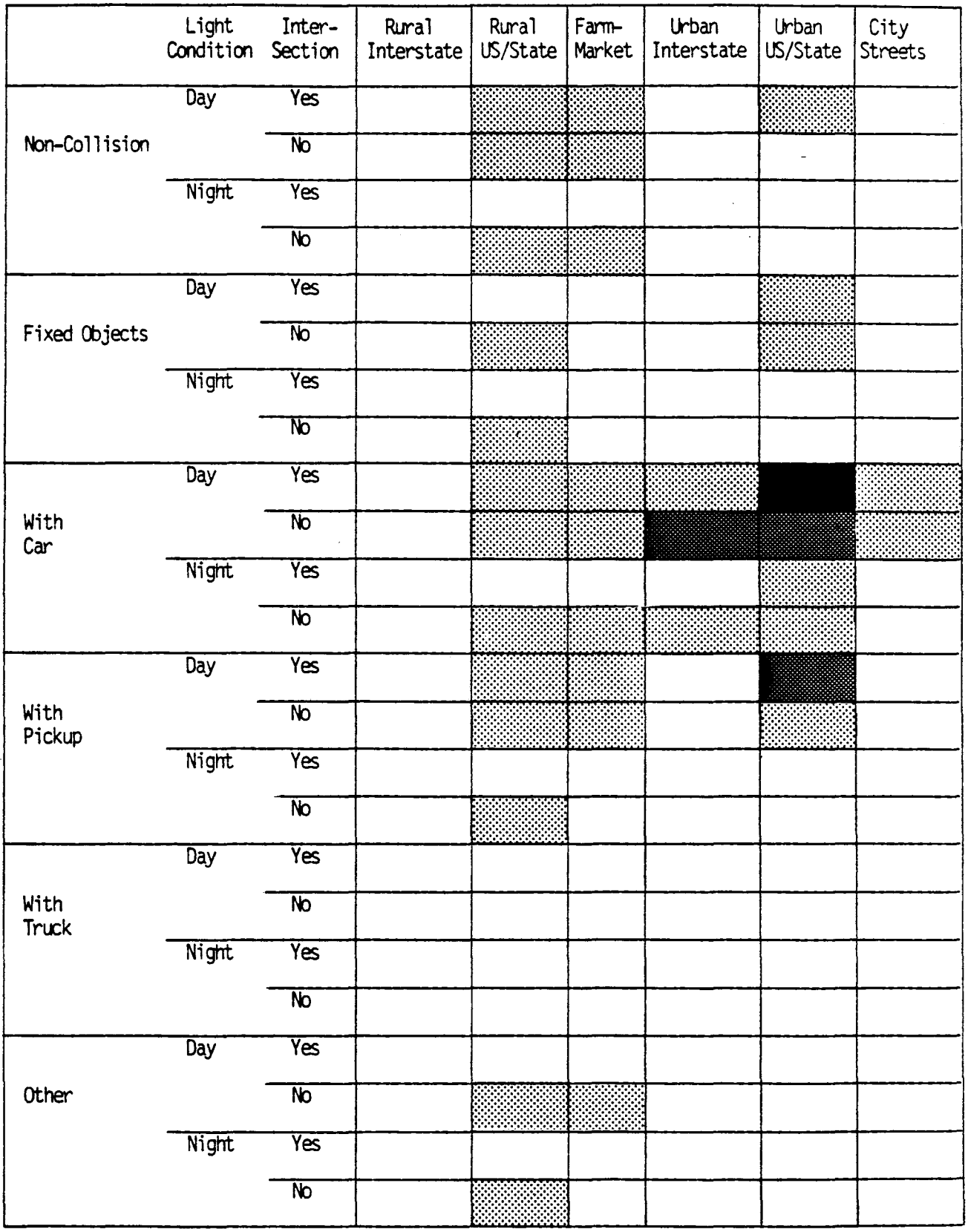
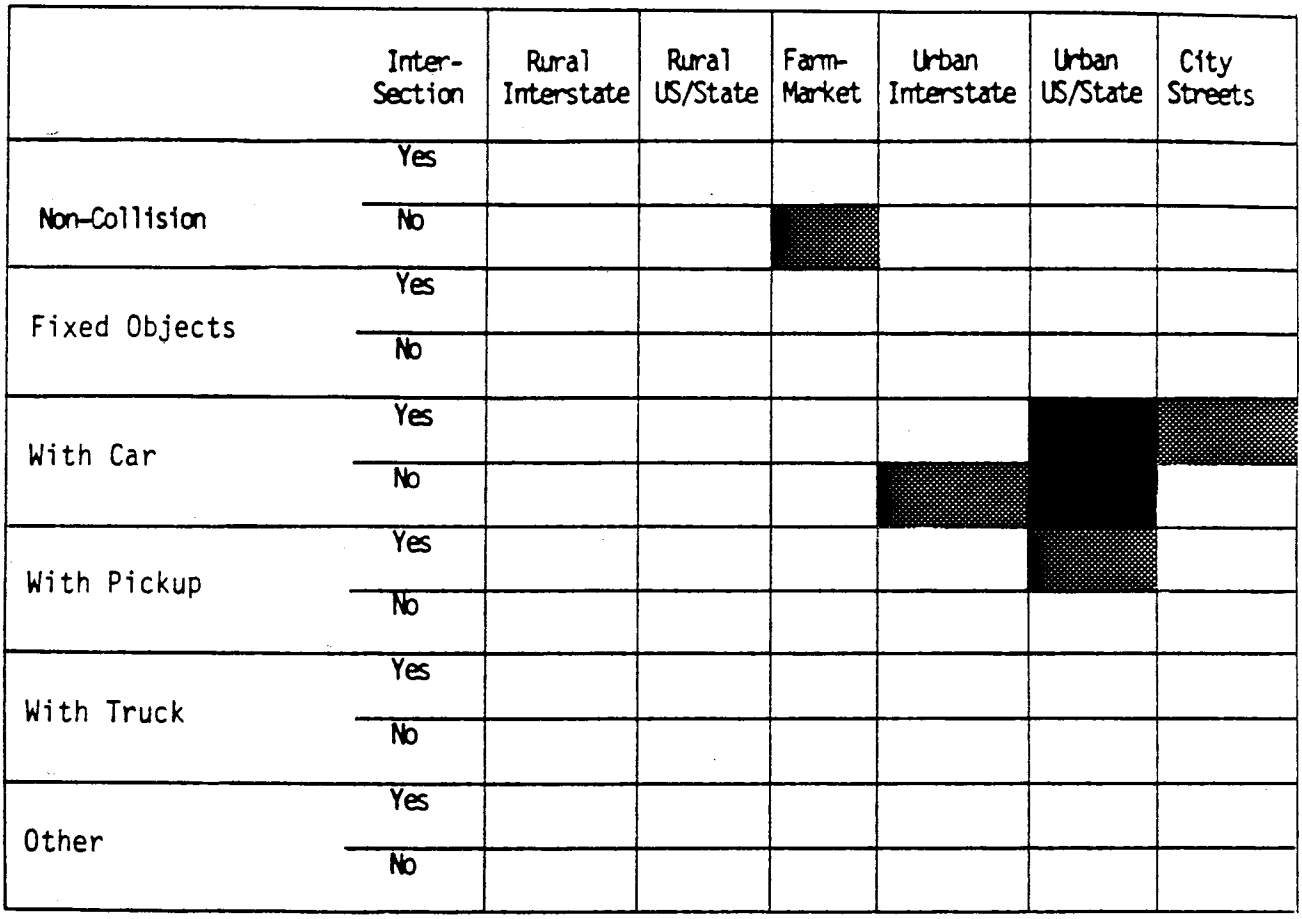


Figure 3: Prevalence of Accident Involvements for Tank Semitrailers



■ ≥ 5.0 %
▪ 3.0 to 4.9 %
▩ 1.0 to 2.9 %
□ < 1.0 %

Figure 4: Prevalence of Accident Involvements for Dump Semitrailers



■ ≥ 5.0%

■ 3.0 to 4.9%

□ < 3.0%

Figure 5: Prevalence of Accident Involvements for Livestock/Pole Semitrailers

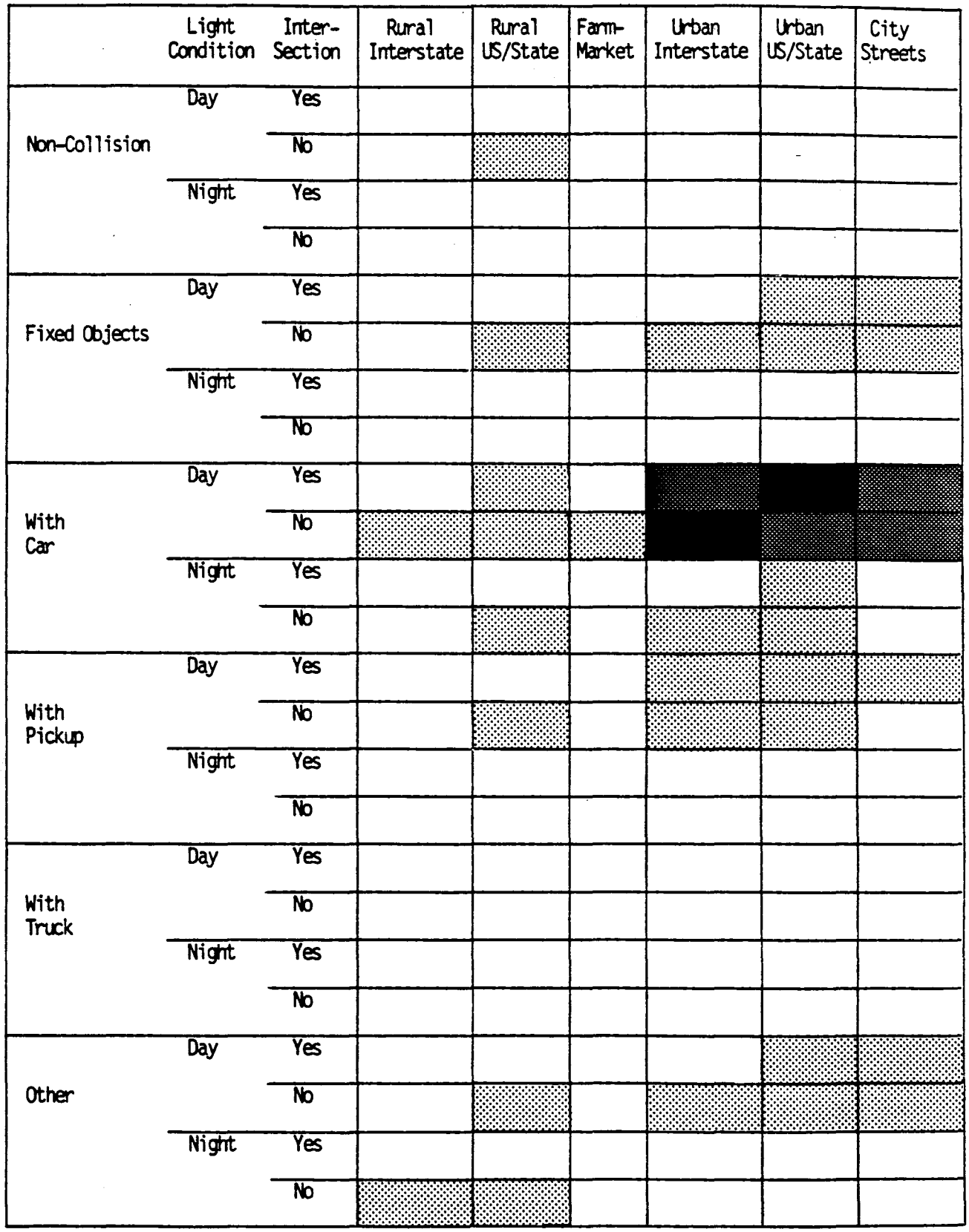
	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Single-Vehicle	Yes						
	No		■	▩		▩	
Multi-Vehcile	Yes		▩			■	
	No		▩			■	
Other	Yes						
	No		■				

■ ≥ 10.0 %

▩ 4.0 to 9.9 %

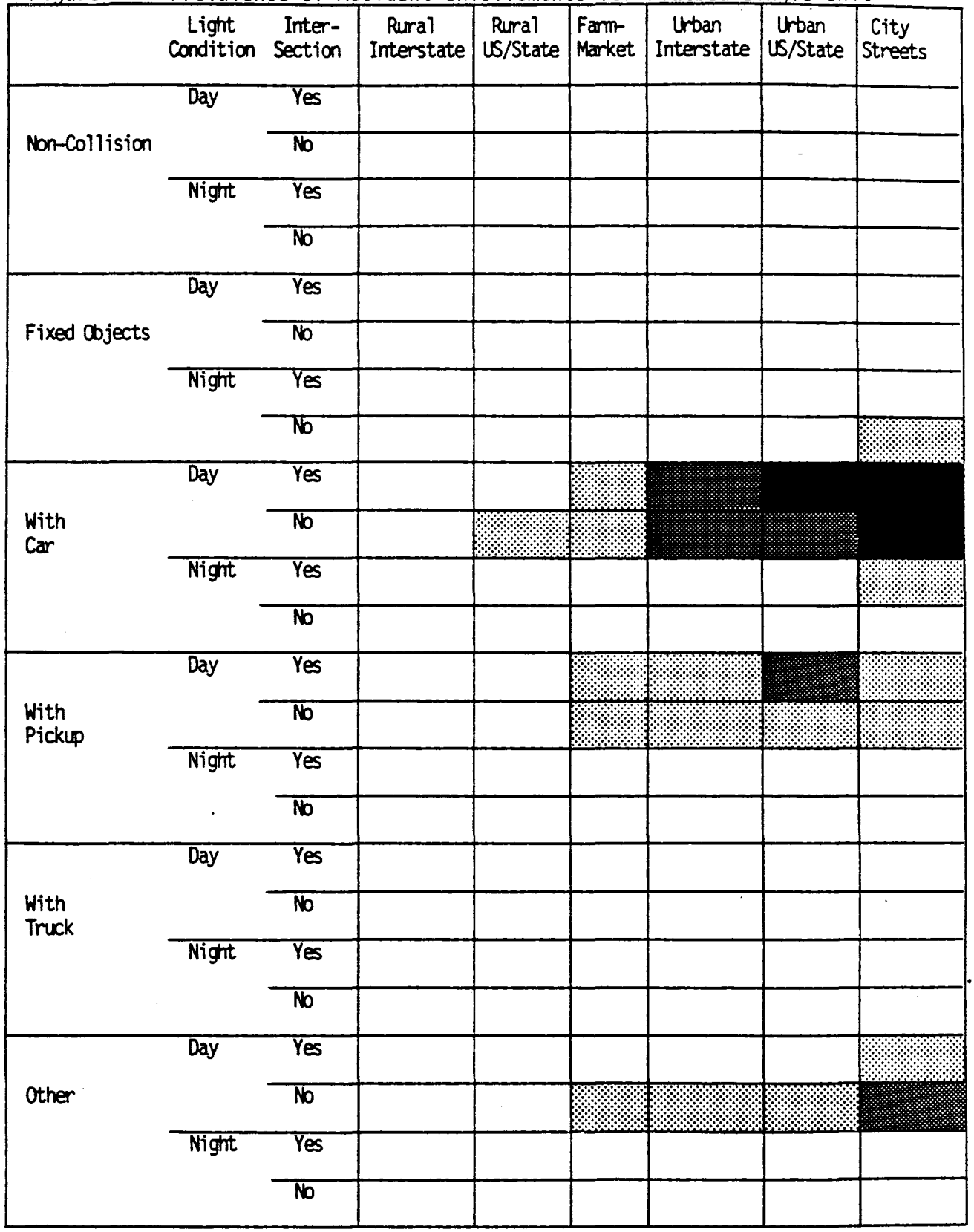
□ < 4.0 %

Figure 6: Prevalence of Accident Involvements for "Mixed" Semitrailers



■ ≥ 5.0 %
▩ 3.0 to 4.9 %
▨ 1.0 to 2.9 %
□ < 1.0 %

Figure 7: Prevalence of Accident Involvements for Flatbed Single-Unit



■ ≥5.0 %

▩ 3.0 to 4.9 %

▨ 1.0 to 2.9 %

□ <1.0 %

Figure 8: Prevalence of Accident Involvements for Van Single-Unit

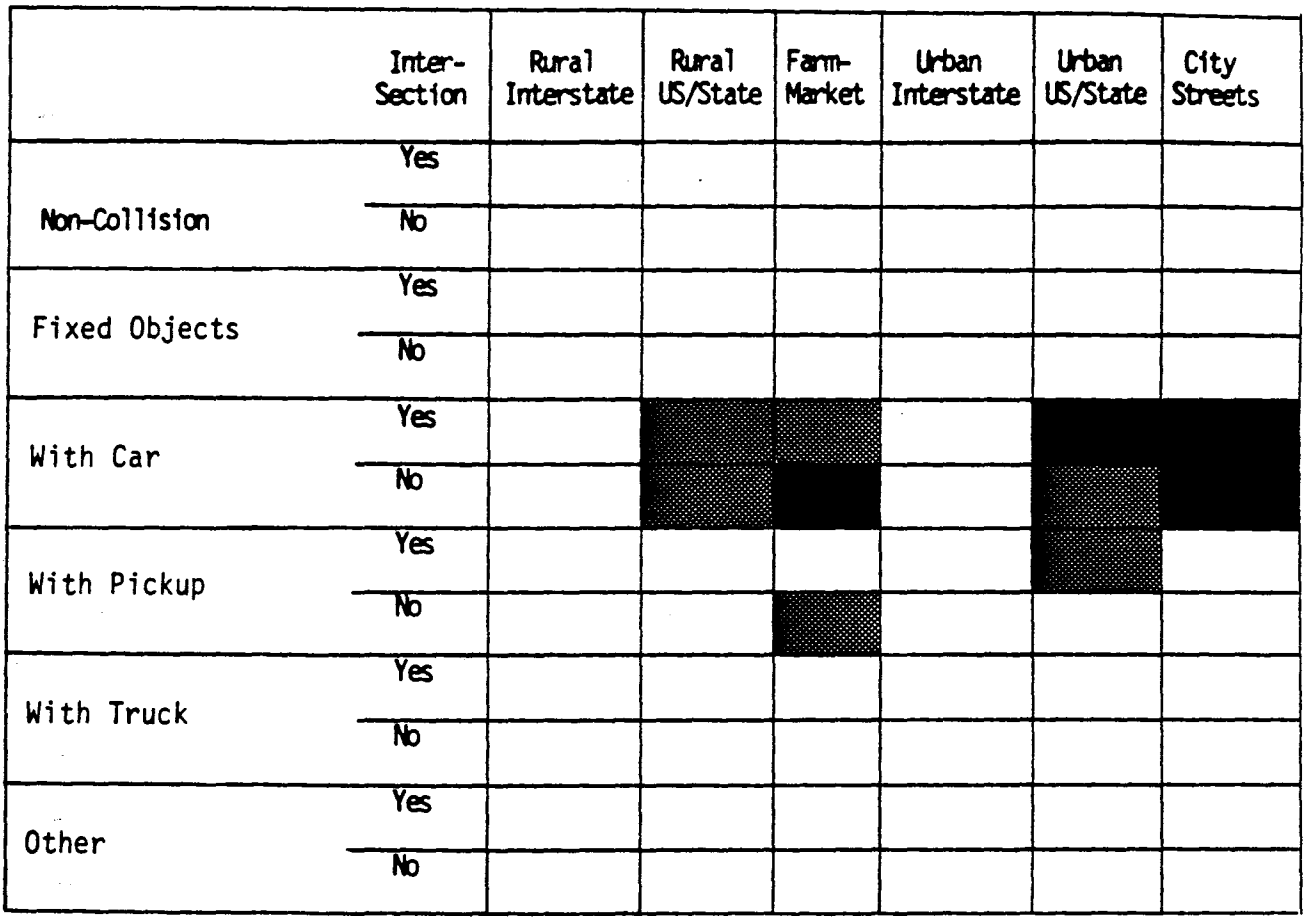
	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes						
	No						
Fixed Objects	Yes						
	No						
With Car	Yes				▓	■	■
	No				▓	▓	■
With Pickup	Yes					▓	▓
	No						
With Truck	Yes						
	No						
Other	Yes						
	No						■

■ ≥ 5.0 %

▓ 3.0 to 4.9 %

□ < 3.0 %

Figure 9: Prevalence of Accident Involvements for Tank Single-Unit

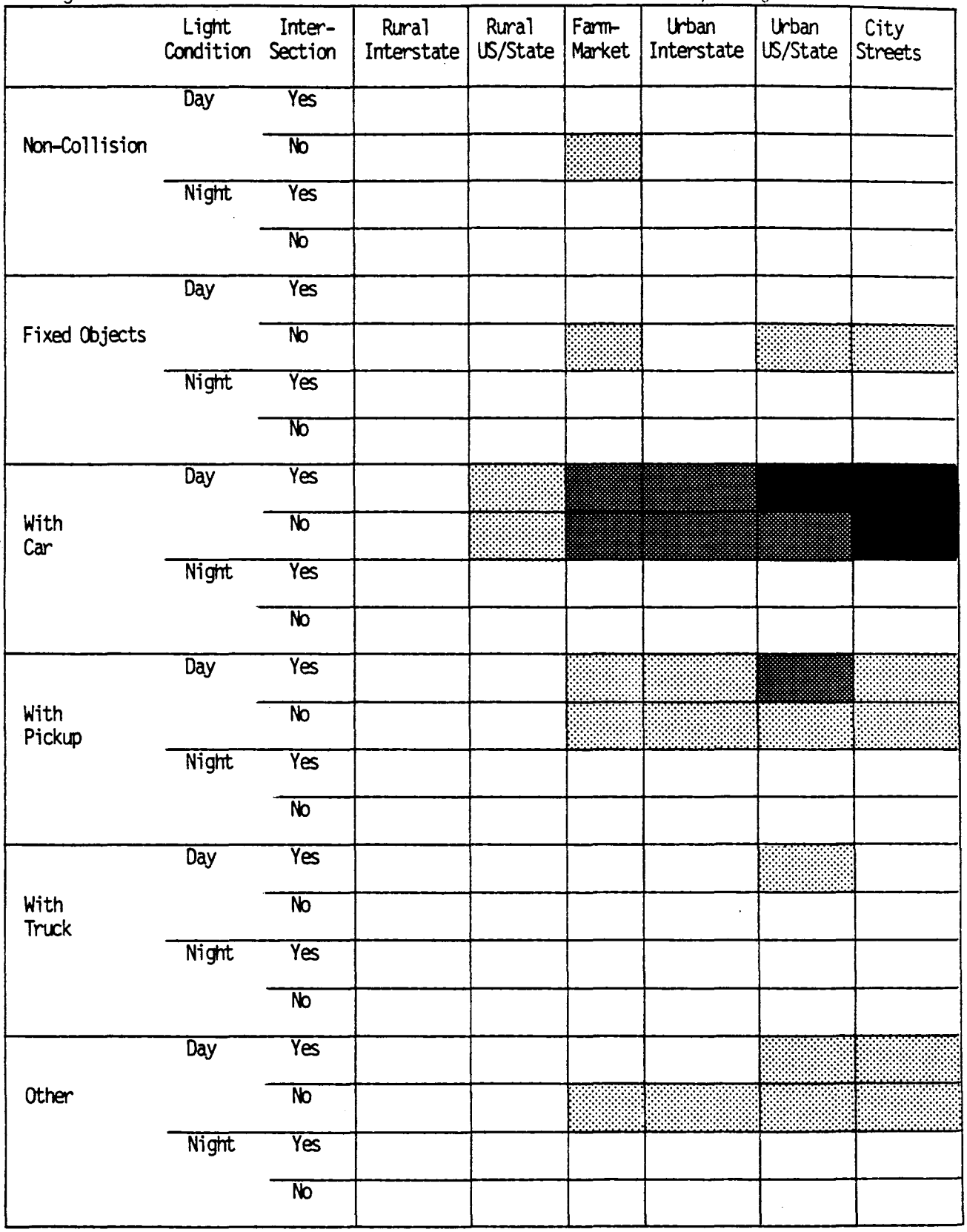


■ ≥ 5.0 %

▩ 3.0 to 4.9 %

□ < 3.0 %

Figure 10: Prevalence of Accident Involvements for Dump Single-Unit



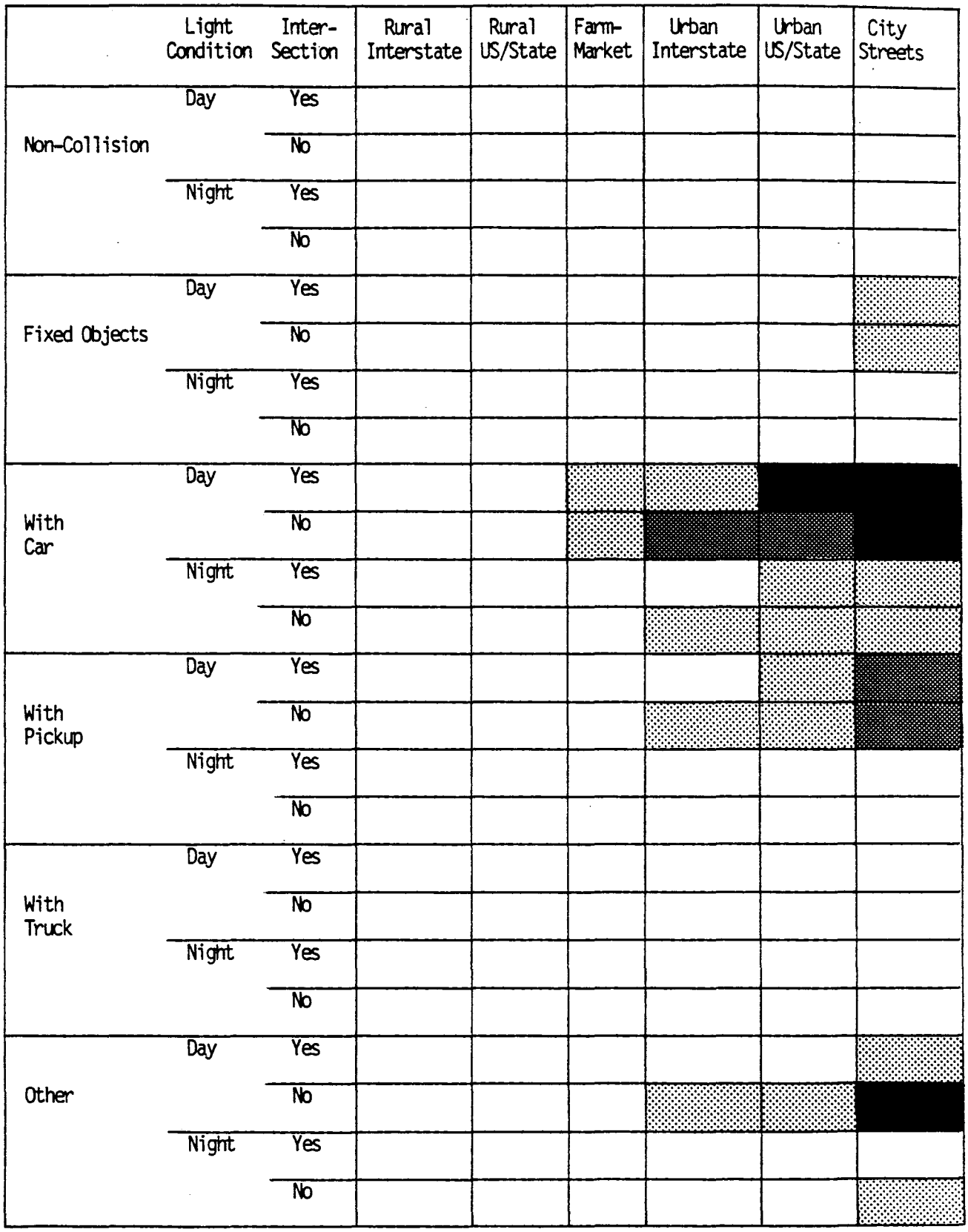
■ ≥5.0 %

▩ 3.0 to 4.9 %

▨ 1.0 to 2.9 %

□ <1.0%

Figure 11: Prevalence of Accident Involvements for Garbage/Wrecker Single-Unit



■ ≥ 5.0 %
▩ 3.0 to 4.9 %
▨ 1.0 to 2.9 %
□ < 1.0 %

Figure 12: Prevalence of Accident Involvements for Mixer/Cement Single-Unit

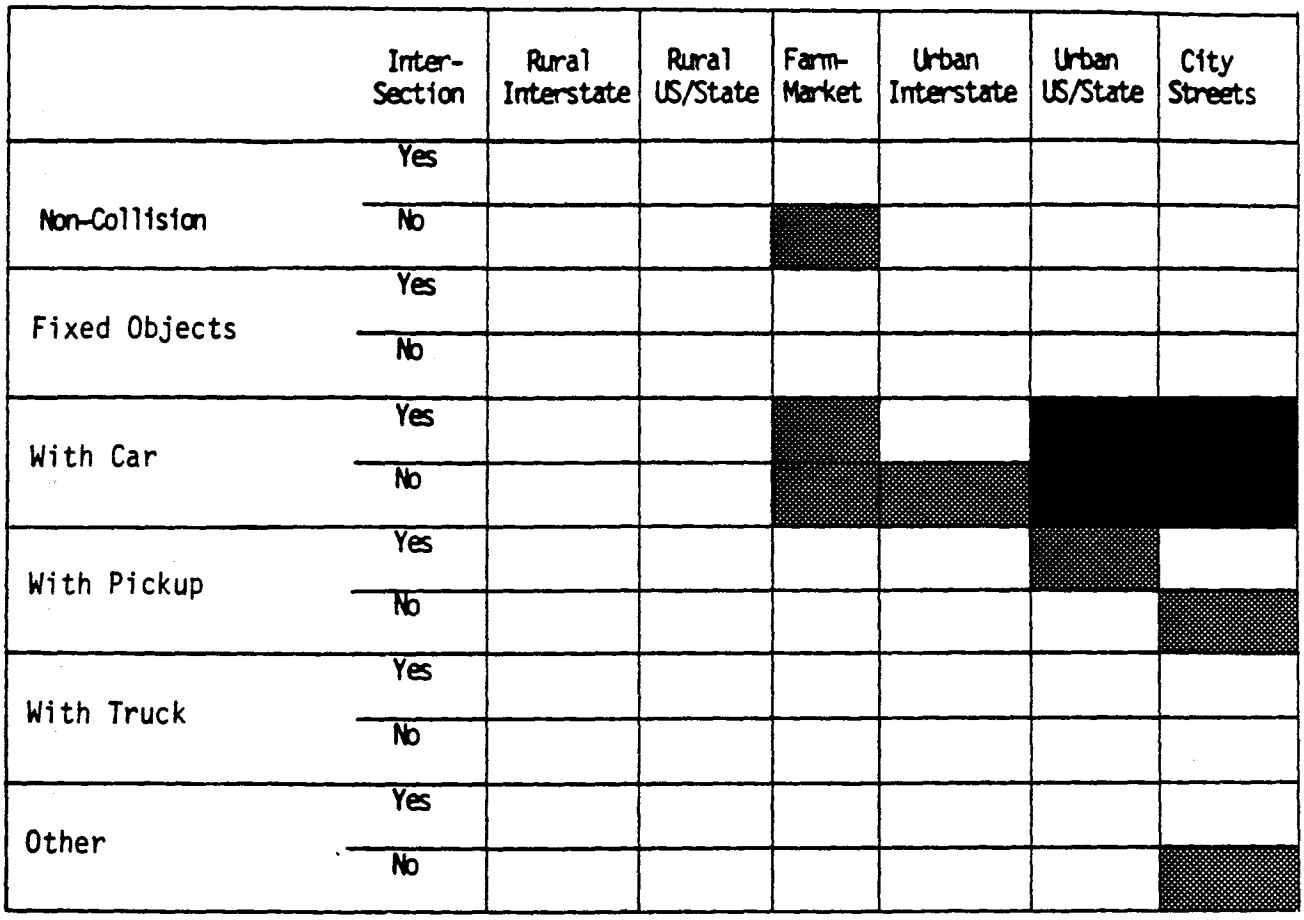


Figure 13: Prevalence of Accident Involvements for Bobtails

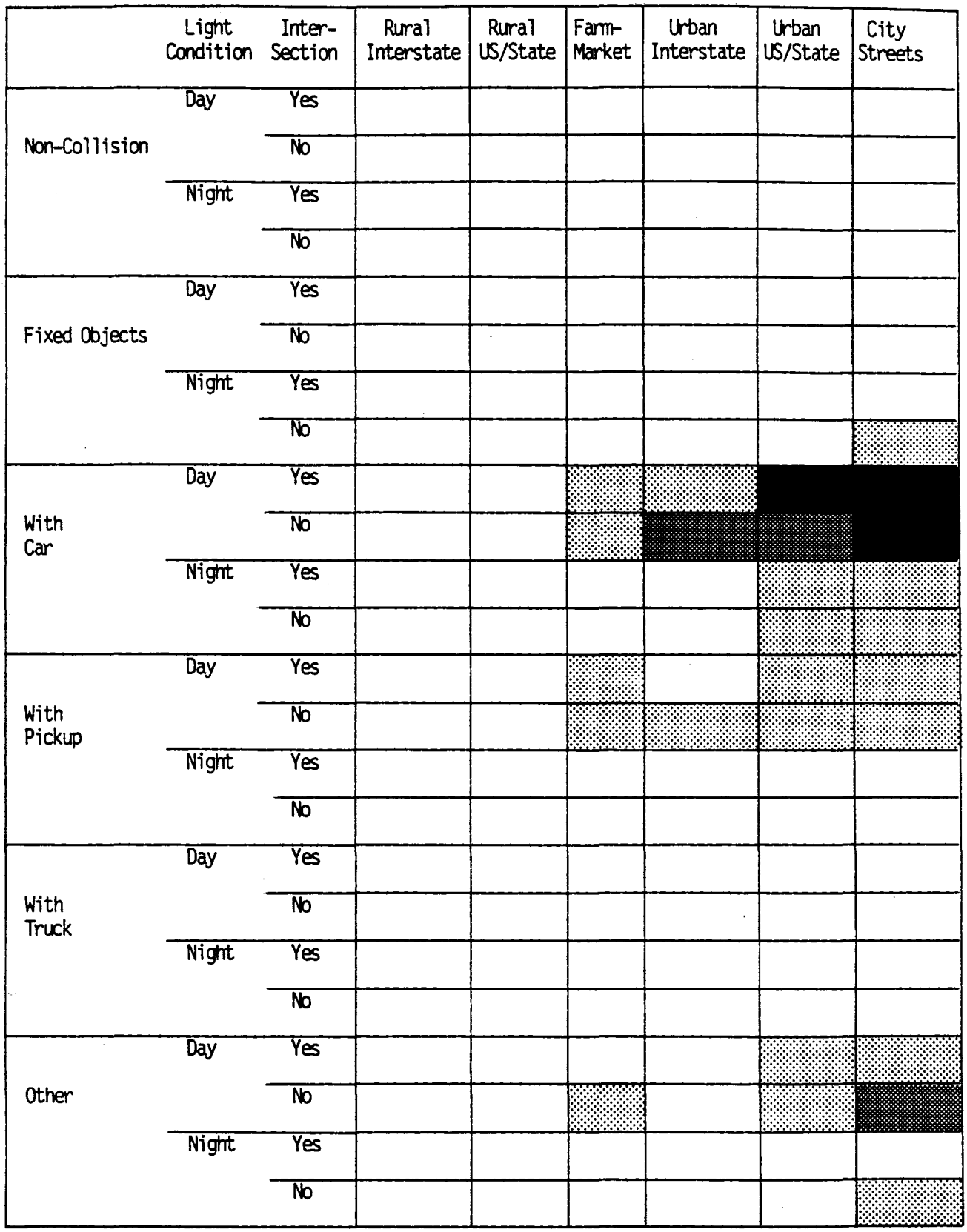
	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes						
	No						
Fixed Objects	Yes						
	No						
With Car	Yes				■	■	■
	No				■	■	■
With Pickup	Yes						▒
	No						▒
With Truck	Yes						
	No						
Other	Yes						
	No						▒

■ ≥ 5.0 %

▒ 3.0 to 4.9%

□ < 3.0 %

Figure 14: Prevalence of Accident Involvements for "Mixed" Single-Unit



■ ≥ 5.0 %
▩ 3.0 to 4.9 %
▨ 1.0 to 2.9 %
□ < 1.0 %

Table 6

Estimated Probabilities By Road Class (Flatbed Semitrailers)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	3.27	3.49	2.93	1.84	2.85	2.60
		No	7.84	11.56	9.27	6.13	4.28	2.60
	Night	Yes	1.96	0.27	0.98	0.92	0.53	0.37
		No	12.42	6.45	1.95	0.92	1.07	0.37
Fixed Objects	Day	Yes	0.65	1.88	3.41	2.15	6.60	7.43
		No	8.50	10.22	12.68	7.36	8.20	8.18
	Night	Yes	0	0.81	1.46	0	1.25	3.72
		No	5.23	6.18	1.46	2.76	2.67	0.74
With Car	Day	Yes	5.23	7.53	15.12	14.42	21.57	20.82
		No	9.15	10.75	8.78	21.17	11.05	17.10
	Night	Yes	0.65	4.03	0.98	2.45	4.81	1.49
		No	9.80	3.49	3.90	9.20	3.39	1.86
With Pickup	Day	Yes	0	3.23	6.83	4.29	8.73	8.55
		No	6.54	5.65	9.76	6.13	5.70	4.09
	Night	Yes	0	1.34	0.49	0.61	1.78	0.74
		No	6.54	4.03	3.90	3.37	1.07	0.74
With Truck	Day	Yes	0	2.96	0.49	0.92	2.32	0.74
		No	1.31	4.30	2.44	5.52	1.60	0.74
	Night	Yes	0	0	0	0	0.89	0
		No	7.19	1.08	0.98	0	0	0
Other	Day	Yes	0	1.08	2.93	1.23	4.28	7.81
		No	2.61	4.84	6.34	6.44	4.10	7.06
	Night	Yes	0.65	0.54	0.49	0	0.18	0
		No	10.46	4.30	2.44	2.15	1.07	2.23
Total			100	100	100	100	100	100

Table 7

Estimated Probabilities by Road Class (Van Semitrailers)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	0.86	2.28	2.53	0.64	1.70	0.44
		No	12.57	18.52	8.19	3.04	3.36	1.03
	Night	Yes	0.68	1.53	0.72	0.20	0.52	0.06
		No	13.88	17.47	3.13	1.34	1.43	0.21
Fixed Objects	Day	Yes	0.63	1.22	2.77	1.53	3.20	4.57
		No	7.98	8.23	7.47	6.09	5.22	8.97
	Night	Yes	0.59	0.99	0.84	0.57	1.16	0.80
		No	10.59	9.31	3.37	3.19	2.68	2.21
With Car	Day	Yes	1.40	2.69	16.02	14.90	24.22	23.46
		No	8.29	8.63	20.72	27.82	18.64	21.69
	Night	Yes	0.72	1.16	2.77	2.95	4.67	2.18
		No	5.81	5.20	4.94	7.77	5.08	2.83
With Pickup	Day	Yes	0.81	1.26	6.27	3.37	6.60	5.28
		No	5.59	4.76	9.52	7.43	6.03	5.81
	Night	Yes	0.41	0.54	1.08	0.69	1.32	0.50
		No	4.01	2.96	2.41	2.13	1.70	0.77
With Truck	Day	Yes	0.81	0.37	0	1.76	1.61	0.62
		No	3.97	0.99	0	2.72	1.04	0.47
	Night	Yes	0.36	0.14	0	0.30	0.27	0.06
		No	2.48	0.54	0	0.67	0.25	0.06
Other	Day	Yes	0.59	0.71	1.45	1.58	2.54	5.40
		No	6.08	4.01	3.25	5.15	3.40	8.70
	Night	Yes	0.72	0.75	0.60	0.74	1.16	1.18
		No	10.18	5.74	1.93	3.42	2.20	2.69
Total			100	100	100	100	100	100

Table 8

Estimated Probabilities by Road Class (Tank Semitrailers)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	5.02	4.45	7.56	1.34	4.31	1.93
		No	10.37	8.82	13.53	2.60	2.60	2.99
	Night	Yes	1.84	1.80	2.08	0.32	0.89	0.19
		No	7.86	7.42	7.72	1.26	1.07	0.68
Fixed Objects	Day	Yes	2.01	1.84	2.08	2.37	4.80	3.76
		No	5.18	4.69	4.74	5.91	3.67	7.52
	Night	Yes	0.67	0.76	0.59	0.55	0.98	0.39
		No	3.85	3.93	2.72	2.92	1.53	1.74
With Car	Day	Yes	5.18	6.90	8.20	18.30	30.17	22.28
		No	7.36	9.54	10.28	24.92	12.61	24.49
	Night	Yes	1.84	2.81	2.24	4.34	6.09	2.51
		No	5.52	8.02	5.86	12.38	5.29	5.69
With Pickup	Day	Yes	3.51	5.21	5.70	3.94	9.76	4.92
		No	3.85	5.61	5.54	4.10	3.15	4.15
	Night	Yes	1.34	2.13	1.60	0.95	1.99	0.58
		No	3.01	4.73	3.14	2.05	1.32	0.96
With Truck	Day	Yes	2.34	1.48	0.43	0.63	1.77	0.68
		No	3.85	2.37	0.64	1.03	0.86	0.87
	Night	Yes	0.84	0.60	0.11	0.16	0.37	0.10
		No	3.01	2.00	0.37	0.55	0.37	0.19
Other	Day	Yes	2.68	1.84	2.34	1.42	2.33	2.89
		No	10.20	6.66	7.61	5.13	2.54	8.29
	Night	Yes	1.00	0.76	0.64	0.32	0.46	0.29
		No	7.69	5.61	4.31	2.52	1.07	1.93
Total			100	100	100	100	100	100

Table 9

Estimated Probabilities by Road Class (Dump Semitrailers)

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	1.58	5.87	6.17	1.51	5.26	4.12
	No	8.95	16.15	19.04	4.05	5.43	5.15
Fixed Objects	Yes	1.05	1.19	1.22	1.51	2.74	2.89
	No	14.74	8.90	10.09	11.19	7.52	9.48
With Car	Yes	7.37	11.47	9.57	16.43	31.84	26.70
	No	24.21	16.97	15.65	24.05	17.74	17.63
With Pickup	Yes	2.11	8.26	5.65	5.87	9.53	7.63
	No	8.42	16.51	12.61	11.59	7.14	6.80
With Truck	Yes	0.53	1.74	2.09	2.22	1.32	1.65
	No	4.74	5.60	7.48	7.30	1.67	2.47
Other	Yes	3.16	1.74	2.26	3.41	4.44	6.39
	No	23.16	5.60	8.17	10.87	5.38	9.07
Total		100	100	100	100	100	100

Table 10

Estimated Probabilities by Road Class (Livestock/Pole Semitrailers)

Accident Type	Inter-section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Single-Vehicle	Yes	8.42	10.15	8.89	1.33	4.00	4.21
	No	33.68	41.36	35.56	5.33	16.00	16.84
Multi-Vehicle	Yes	23.16	14.70	23.33	42.00	36.50	17.89
	No	24.21	15.61	24.81	44.67	38.50	18.95
Other	Yes	2.11	3.94	1.48	1.33	1.00	8.95
	No	8.42	14.24	5.93	5.33	4.00	33.16
Total		100	100	100	100	100	100

Table 11

Estimated Probabilities by Road Class ("Mixed" Semitrailers)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	0.62	2.42	2.99	0.79	1.45	0.45
		No	8.81	9.36	9.70	2.22	2.14	1.02
	Night	Yes	0.44	1.03	0.49	0.25	0.40	0.07
		No	9.15	5.83	2.30	1.03	0.87	0.23
Fixed Objects	Day	Yes	0.47	0.98	2.07	1.11	3.40	5.63
		No	6.11	6.96	7.32	5.51	3.55	6.04
	Night	Yes	0.50	0.48	0.54	0.31	0.98	1.18
		No	7.87	4.02	2.24	1.83	1.21	1.49
With Car	Day	Yes	4.76	7.85	10.38	15.13	27.39	26.44
		No	16.14	13.31	15.97	30.36	17.53	19.49
	Night	Yes	1.50	2.33	2.05	2.56	4.46	2.81
		No	9.07	7.04	5.60	9.16	5.08	3.69
With Pickup	Day	Yes	1.86	5.74	7.25	4.14	9.78	6.60
		No	5.37	7.80	8.40	8.39	5.50	4.90
	Night	Yes	0.74	1.32	1.53	0.79	1.78	0.81
		No	3.89	3.27	3.25	2.92	1.83	1.09
Other	Day	Yes	1.43	2.68	3.77	3.15	5.88	6.04
		No	8.33	8.16	9.10	7.46	4.34	9.52
	Night	Yes	0.76	1.01	0.67	0.39	0.80	0.47
		No	12.16	8.41	4.37	2.49	1.62	2.02
Total			100	100	100	100	100	100

Table 12

Estimated Probabilities by Road Class (Flatbed Single-Unit)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	0.84	1.58	1.28	0.27	0.54	0.12
		No	7.93	8.91	4.40	1.05	1.02	0.35
	Night	Yes	1.04	1.27	0.78	0.05	0.20	0.05
		No	8.98	7.03	2.73	0.24	0.36	0.15
Fixed Objects	Day	Yes	0.42	0.79	1.45	1.05	1.24	1.30
		No	4.38	4.91	5.40	4.19	2.50	3.94
	Night	Yes	0.42	0.67	0.92	0.24	0.44	0.52
		No	5.01	3.94	3.37	0.97	0.88	1.59
With Car	Day	Yes	6.68	9.33	18.13	22.29	31.19	25.46
		No	19.62	16.48	19.66	26.14	18.51	22.68
	Night	Yes	2.30	2.30	3.51	1.59	3.38	3.17
		No	6.89	4.06	3.82	1.86	2.02	2.82
With Pickup	Day	Yes	3.55	5.94	8.24	9.60	13.30	7.90
		No	10.23	10.36	8.83	11.13	7.82	6.96
	Night	Yes	1.25	1.58	1.70	0.73	1.54	1.06
		No	3.76	2.73	1.84	0.86	0.91	0.92
With Truck	Day	Yes	0.42	1.33	1.06	3.15	2.62	1.16
		No	1.46	3.21	1.59	5.06	2.13	1.43
	Night	Yes	0	0.06	0.06	0.05	0.07	0.04
		No	0.21	0.18	0.08	0.08	0.07	0.04
Other	Day	Yes	1.04	1.70	2.20	2.10	3.09	4.57
		No	7.93	7.52	6.04	6.24	4.65	10.35
	Night	Yes	0.63	0.73	0.78	0.27	0.62	1.04
		No	5.01	3.39	2.14	0.81	0.93	2.37
Total			100	100	100	100	100	100

Table 13

Estimated Probabilities by Road Class (Van Single-Unit)

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	2.50	1.67	2.05	0.15	1.03	0.05
	No	30.83	25.00	10.77	1.34	3.28	0.49
Fixed Objects	Yes	0	0.33	0.26	0.15	0.34	0.16
	No	8.33	19.67	10.00	5.82	5.69	4.78
With Car	Yes	3.33	8.00	29.74	24.18	32.76	34.29
	No	5.00	12.00	16.41	28.06	11.21	23.96
With Pickup	Yes	3.33	6.67	11.28	9.55	16.55	8.63
	No	5.00	10.00	6.67	11.34	5.86	6.21
With Truck	Yes	1.67	0.67	1.03	1.64	2.84	0.44
	No	6.67	2.67	1.54	4.33	2.33	0.66
Other	Yes	6.67	2.67	4.10	3.28	9.40	7.03
	No	26.67	10.67	6.15	10.15	8.71	13.30
Total		100	100	100	100	100	100

Table 14

Estimated Probabilities by Road Class (Tank Single-Unit)

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	1.69	3.52	2.00	2.01	4.53	3.79
	No	5.08	3.23	4.50	4.52	1.92	2.73
Fixed Objects	Yes	1.69	3.52	2.00	2.01	4.53	3.79
	No	5.08	3.23	4.50	4.52	1.92	2.73
With Car	Yes	16.95	26.98	16.17	15.58	35.67	29.44
	No	33.90	24.05	34.83	35.68	15.36	21.70
With Pickup	Yes	6.78	9.97	6.00	5.53	13.17	10.93
	No	13.56	8.80	13.00	13.07	5.76	8.04
With Truck	Yes	1.69	3.23	2.00	2.01	4.39	3.49
	No	3.39	2.93	4.17	4.52	1.92	2.58
Other	Yes	3.39	5.57	3.50	3.02	7.54	6.22
	No	6.78	4.99	7.33	7.54	3.29	4.55
Total		100	100	100	100	100	100

Table 15

Estimated Probabilities by Road Class (Dump Single-Unit)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	3.68	2.39	4.12	0.62	2.51	1.26
		No	11.71	7.02	10.55	1.75	3.09	2.64
	Night	Yes	0	0.07	0.15	0.03	0.09	0.05
		No	1.00	0.65	0.96	0.17	0.28	0.24
Fixed Objects	Day	Yes	0	1.23	1.07	1.05	1.54	1.26
		No	0	6.15	4.80	5.20	3.28	4.56
	Night	Yes	0	0.07	0.04	0.03	0.05	0.05
		No	0	0.58	0.44	0.48	0.30	0.42
With Car	Day	Yes	19.06	17.89	17.00	24.10	32.15	26.61
		No	24.75	22.16	18.42	29.15	16.82	23.64
	Night	Yes	0.67	0.65	0.61	0.85	1.15	0.95
		No	2.34	2.03	1.69	2.68	1.54	2.18
With Pickup	Day	Yes	8.70	7.97	8.77	6.86	12.59	7.05
		No	13.38	11.66	11.16	9.77	7.76	7.35
	Night	Yes	0.33	0.29	0.31	0.25	0.46	0.26
		No	1.34	1.09	1.03	0.90	0.71	0.68
With Truck	Day	Yes	0	2.75	2.50	2.06	3.28	2.35
		No	0	4.06	3.25	2.97	2.06	2.50
	Night	Yes	0	0.07	0.09	0.08	0.11	0.08
		No	0	0.36	0.31	0.28	0.19	0.23
Other	Day	Yes	4.01	3.48	4.43	3.47	5.23	6.16
		No	8.36	6.66	7.46	6.53	4.24	8.48
	Night	Yes	0	0.14	0.15	0.11	0.19	0.23
		No	0.67	0.58	0.68	0.59	0.39	0.77
Total			100	100	100	100	100	100

Table 16

Estimated Probabilities by Road Class (Garbage/Wrecker Single-Unit)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	0	0.54	1.61	0.34	0.68	0.46
		No	0	1.63	3.10	1.13	1.13	0.93
	Night	Yes	0	0	0.58	0.10	0.16	0.11
		No	0	0.27	1.16	0.34	0.29	0.20
Fixed Objects	Day	Yes	0.62	1.63	0.90	1.23	2.03	2.64
		No	2.48	4.89	1.42	3.25	2.80	4.33
	Night	Yes	0.62	0.27	0.32	0.39	0.51	0.59
		No	3.11	1.09	0.52	1.03	0.74	0.96
With Car	Day	Yes	3.11	20.65	21.69	19.56	26.63	23.21
		No	8.07	29.89	16.91	25.22	18.08	18.70
	Night	Yes	3.73	4.89	8.07	6.06	6.88	5.11
		No	9.94	7.07	6.26	7.83	4.70	4.13
With Pickup	Day	Yes	1.86	3.26	7.62	4.73	9.52	6.81
		No	6.21	5.71	7.42	7.68	8.11	6.86
	Night	Yes	2.48	0.82	2.84	1.48	2.48	1.50
		No	8.07	1.36	2.78	2.36	2.09	1.51
With Truck	Day	Yes	0	3.80	1.68	1.43	2.25	0.37
		No	0	4.89	1.16	1.58	1.32	0.26
	Night	Yes	0	0.82	0.65	0.44	0.58	0.08
		No	0	1.09	0.45	0.49	0.35	0.06
Other	Day	Yes	3.11	0.82	3.16	2.41	2.54	5.75
		No	18.63	3.53	6.20	7.73	4.34	11.60
	Night	Yes	3.73	0.27	1.16	0.74	0.68	1.27
		No	24.22	0.82	2.32	2.41	1.13	2.56
Total			100	100	100	100	100	100

Table 17

Estimated Probabilities by Road Class (Mixer/Cement Single-Unit)

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	16.67	7.69	4.58	5.71	6.25	1.52
	No	16.67	10.26	16.79	0	2.27	6.09
Fixed Objects	Yes	0	0	0.76	2.86	2.28	1.02
	No	0	7.69	6.87	7.14	2.27	2.54
With Car	Yes	33.33	23.08	17.56	25.71	33.52	30.46
	No	33.33	20.51	19.85	30.00	22.73	23.86
With Pickup	Yes	0	5.13	9.16	1.43	14.77	8.12
	No	0	12.82	9.16	15.71	5.68	9.64
With Truck	Yes	0	2.56	1.53	0	0.57	0
	No	0	5.13	2.29	4.29	1.70	2.03
Other	Yes	0	5.13	6.87	0	5.68	3.55
	No	0	0	4.58	7.14	2.28	11.17
Total		100	100	100	100	100	100

Table 18

Estimated Probabilities by Road Class (Bobtails)

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	10.00	7.08	4.36	2.76	0.29	0.60
	No	13.08	9.58	5.90	3.54	0.43	0.78
Fixed Objects	Yes	2.31	1.25	0.51	1.02	1.07	1.06
	No	13.08	7.08	2.05	5.28	5.36	5.37
With Car	Yes	10.77	13.75	27.69	24.41	27.86	27.80
	No	12.31	15.42	31.28	27.56	31.43	31.38
With Pickup	Yes	8.46	6.67	11.03	9.45	10.50	10.23
	No	6.92	5.83	9.49	7.87	8.79	8.58
With Truck	Yes	0	9.17	1.79	1.50	2.14	1.01
	No	0	15.83	3.33	2.44	3.57	1.74
Other	Yes	7.69	2.92	0.77	4.88	2.93	3.94
	No	15.38	5.42	1.79	9.29	5.64	7.52
Total		100	100	100	100	100	100

Table 19

Estimated Probabilities by Road Class ("Mixed" Single-Unit)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	1.40	1.34	0.81	0.35	0.43	0.17
		No	10.68	7.82	4.87	0.99	0.53	0.48
	Night	Yes	0.29	0.37	0.42	0.11	0.22	0.14
		No	8.41	4.44	3.76	0.49	0.46	0.59
Fixed Objects	Day	Yes	1.16	0.69	0.78	0.78	0.84	0.70
		No	4.64	4.65	3.95	2.58	1.49	2.11
	Night	Yes	0.53	0.44	0.97	0.73	0.68	0.86
		No	5.99	4.38	5.27	2.69	1.44	2.65
With Car	Day	Yes	10.17	12.58	17.76	21.80	29.26	28.69
		No	10.12	14.98	16.72	25.27	17.45	19.40
	Night	Yes	2.39	3.31	5.00	5.65	7.87	6.55
		No	5.82	5.19	4.47	6.52	5.03	4.04
With Pickup	Day	Yes	4.86	6.06	6.39	5.14	9.36	6.08
		No	4.08	9.24	7.45	7.55	6.22	4.75
	Night	Yes	1.67	1.46	1.66	1.36	2.05	1.33
		No	3.16	2.70	1.69	1.83	1.35	0.88
Other	Day	Yes	4.88	3.66	4.66	5.48	6.88	6.23
		No	10.82	8.14	7.44	6.64	4.97	8.69
	Night	Yes	0.92	1.48	1.72	1.36	1.54	1.84
		No	8.02	7.09	4.23	2.66	1.94	3.81
Total			100	100	100	100	100	100

trailers and passenger cars on farm-to-market roads were 36.74 percent during the day and 7.71 percent at night. These probabilities for collisions between van semi-trailers and pickups were 15.79 percent and 3.49 percent for day and night, respectively. This implies that about 64 percent of total accident involvements of van semi-trailers on farm-to-market roads might be expected to be collisions with passenger cars or pickups. This might indeed be a potential safety problem if the number of van semi-trailers on this road class increased substantially.

The following are some of the findings from Tables 6 through 19.

a) On rural interstate highways, van semi-trailers showed the highest probability of single-vehicle accidents (i.e., non-collision accidents or fixed-object accidents), among all semi-trailers--a 48 percent chance. Flatbed semi-trailers and tank semi-trailers showed similar probabilities of single-vehicle accidents--a 37 to 39 percent chance; "mixed" semi-trailers showed a 34 percent chance; and dump semi-trailers showed a 26 percent chance. Night time showed slightly higher probabilities of single-vehicle accidents than did day-time for most semi-trailers, except for tank semi-trailers which showed the day-time probability to be almost twice the night-time probability. On rural interstate highways, "mixed" semi-trailers and dump semi-trailers showed the highest probabilities of collision with passenger vehicles--43 percent, followed by flatbed semi-trailers (38 percent), tank semi-trailers (32 percent) and van semi-trailers (27 percent). Note that van semi-trailers were the only semi-trailers subset which showed a considerably higher probability of single-vehicle accidents (1.8 time) than the probability of collisions with passenger vehicles. For all semi-trailers, the probability of collisions with passenger vehicles was about 1.4 to 2.0 times higher during the day time than at night.

b) On rural US/State highways, van semi-trailers showed the highest probability of single-vehicle accidents among all semi-trailers--a 60 percent chance. They were followed by flatbed semi-trailers (a 41 percent chance), and tank, dump, and "mixed" semitrailers (a 32 percent chance). For most semi-trailers, this probability was higher during the day than at night, except for van semi-trailers which showed similar probabilities for day and

night. On rural US/State highways, dump semi-trailers, and "mixed" semi-trailers showed about a 50 percent chance of collisions with passenger vehicles. They were followed by tank semi-trailers (a 45 percent chance), flatbed semi-trailers (a 40 percent chance), and van semi-trailers (a 27 percent chance). Notice that van semi-trailers, again, were the only semi-trailer type which showed the probability of single-truck accidents to be much higher (more than twice) than the probability of collisions with passenger vehicles on this road class. For all semi-trailers, the probability of collisions with passenger vehicles was about 1.5 to 2.5 times higher during the day than at night.

c) On farm-to-market roads, tank semi-trailers showed the highest probability of single-vehicle accidents among all semi-trailers--a 41 percent chance. They were followed by flatbed semi-trailers and dump semi-trailers (about a 35 percent chance), and van semi-trailers and "mixed" semi-trailers (about a 28 percent chance). On farm-to-market roads, van semi-trailers showed the highest probability of collisions with passenger vehicles among all semi-trailers (a 64 percent chance). They were followed by "mixed" semi-trailers (a 55 percent chance), and tank and dump semi-trailers (a 44 percent chance). These multiple-vehicle collision probabilities were particularly high during the day time. Note that for all semi-trailers the probability of collisions with passenger vehicles was higher than the probability of single-vehicle accidents on this road class.

d) On urban interstate highways, flatbed semi-trailers showed the highest probability of single-vehicle accidents among all semi-trailers (a 22 percent chance). Tank, van, and dump semi-trailers showed similar probabilities of single-vehicle accidents (a 16 to 18 percent chance), while "mixed" semi-trailers showed the lowest probability of 13 percent. Unlike on rural highways or farm-to-market roads, the probability of single-vehicle accidents on this class of urban highways was relatively small. Day-time consistently showed a much higher probability of single-vehicle accidents than did night-time for all semi-trailers. On urban interstate highways, tank and "mixed" semitrailers showed the highest probabilities of collisions with passenger vehicles among all semi-trailers (about a 72 percent chance). They were followed by van semi-trailers (a 67 percent chance), flatbed semi-

trailers (a 62 percent chance), and dump semi-trailers (a 58 percent chance). These probabilities were considerably higher than those on rural highways or farm-to-market roads. Day-time showed at least a 2.5 times higher probability of collisions with passenger vehicles than did night-time for all semi-trailers.

e) On urban US/State highways, flatbed semi-trailers showed the highest probability of single-vehicle accidents among all semi-trailers (a 27 percent chance). Tank, van, and dump semitrailers showed similar probabilities of single-vehicle accidents (a 19 to 21 percent chance), while "mixed" semi-trailers showed the lowest probability of 14 percent. Single-vehicle accident probability during the day was considerably higher than the probability at night for all semi-trailers. On urban US/State highways, tank and "mixed" semi-trailers showed the probabilities of collisions with passenger vehicles of about 71 percent, followed by van and dump semi-trailers (67 percent) and flatbed semi-trailers (58 percent). Unlike the 4 previous road classes discussed, the probabilities of collisions with passenger vehicles on urban US/State highways for all semi-trailers were higher for intersections than for non-intersections, particularly during the day. As expected, the probabilities of collisions with passenger vehicles were much higher during the day than at night for all semi-trailers.

f) On city streets, the probabilities of non-collision accidents for all semi-trailers were very small--3 percent for flatbed, van, and "mixed" semi-trailers; 6 percent for tank semi-trailers and 9 percent for dump semitrailers. The probabilities of fixed-object accidents were somewhat higher for all semi-trailers--20 percent for flatbed semitrailers, 15 percent for van, tank, and "mixed" semi-trailers, and 12 percent for dump semi-trailers. Day-time showed higher values of single-vehicle accident probabilities than did night-time for all semi-trailers. On city streets, the probabilities of collisions with passenger vehicles did not vary much among all semi-trailers. Tank and "mixed" semi-trailers showed a 65 percent chance, van and dump semi-trailers a 60 percent chance, and flatbed a 55 percent chance. For all semi-trailers, the day-time probabilities were 7 to 10 times those for night-time.

g) For SU trucks, with very few exceptions, the probabilities of single-vehicle accidents on all 6 road classes were usually lower than the same probabilities for semi-trailers of comparable vehicle body styles. In general, the probabilities of single-vehicle accidents on urban interstate highways, urban US/State highways, farm-to-market roads, and city streets, were relatively low. On rural interstate highways and rural US/State highways, van SU, cement/mixer SU, flatbed SU, bobtails, and "mixed" SU trucks showed the probabilities of single vehicle accidents ranging from 15 to 33 percent. Tank SU trucks and garbage/wrecker trucks showed consistently low probabilities of single-vehicle accidents on all road classes.

h) For SU trucks, with only one exception, the probabilities of collision with passenger vehicles on all road classes were usually higher than those for semi-trailers of comparable vehicle body styles. These probabilities usually ranged from about 55 to 80 percent. The one exception was van SU trucks on rural interstate highway, which showed only a 16 percent chance of collisions with passenger vehicles, compared with a 27 percent chance by van semi-trailers.

3.3 Truck Accident Involvements on Highway Ramps

As shown in Table 5(d), truck accident involvements on ramps accounted for only 1 percent of total truck accident involvements. There were a total of 776 reported truck accident involvements occurring on highway ramps in Texas in a period of two years between 1983 and 1984. Of these, 218 (or 28.1 percent) were reported for entrance ramps and 558 (or 71.9 percent) for exit ramps. Because the number of accident involvements on exit ramps was 2.5 times that on entrance ramps, attempts were made to identify factors that might be associated with this difference. To this end, the associations between entrance/exit ramp accidents and truck type, light condition, time-of-day, road surface condition, ramp curvature, driver age, accident type and accident severity, were examined. These were accomplished by testing each of these independent variables with entrance/exit ramp. The results for all variables are shown in Table 20.

Table 20

Associations Between Entrance/Exit Ramp and Independent Variables

Variables			Chi-Square	D.F.	p-value
entrance/exit	x	truck type	3.27	5	.66
entrance/exit	x	accident type	4.95	7	.66
entrance/exit	x	light condition	1.24	1	.27
entrance/exit	x	road surface condition	0.02	1	.89
entrance/exit	x	time-of-day	5.27	7	.63
entrance/exit	x	accident severity	5.58	2	.06
entrance/exit	x	driver age	1.65	3	.65
entrance/exit	x	ramp curvature	.08	1	.77

Table 21

Accident Frequency by Accident Type (1983-1984)

Accident Type	Entrance Ramps	Exit Ramps
Overturn	34	73
Other Non-Collision	8	14
Fixed-Object	31	83
Collision With Car	85	243
Collision With Pickup	25	66
Collision With Truck	2	10
Collision With Other Vehicle	30	58
Other	3	11
Total	218	558

It can be seen that none of the variables considered showed statistically significant chi-square statistics. This implies that given a truck accident involvement on a highway ramp, the probability that it would happen on an entrance ramp was about 28 percent versus 72 percent on an exit ramp. This was true regardless of truck type, light condition, time-of-day, road surface condition, ramp curvature, driver age, accident type, and accident severity.

Tables 21 and 22 show the frequencies of truck accident involvements on ramps by accident type and by ramp curvature for 1983-1984.

3.4 Severity of Truck Accidents

Based on truck accident involvements in Texas in 1984, Table 23(a) shows the distributions of accident severity for SU trucks and semi-trailers. The table indicates that for semi-trailers, the proportion of total accidents that were fatal was about two percent. The proportion of incapacitating-injury accidents was also quite small (about five percent). The majority of semi-trailers' accident involvements were PDO accidents (70 percent) and non-incapacitating-injury accidents (23 percent). For SU trucks, the proportion of fatal accidents was less than one percent, incapacitating-injury accidents about four percent, non-incapacitating-injury accidents 25 percent, and PDO accidents 70 percent.

Chira-Chavala, et. al. (2) reported that the odds of fatal accidents and the odds of injury accidents in accidents involving the Interstate Commerce Commission (ICC-authorized) heavy trucks were influenced by the independent and the interaction effects of the following variables: accident type, road class, environmental conditions (day/night and wet/dry pavements), loading status and truck type. Of these, the most dominant factor was reported to be accident type: single-vehicle accidents, collisions with passenger vehicles, or collisions with large trucks. This led to conducting four separate analyses for four subsets of truck accidents as follows:

a) single-vehicle accidents of semi-trailers (i.e. overturns, other non-collision accidents, and fixed-object accidents);

Table 22

Accident Frequency by Ramp Curvature (1983-1984)

Ramp Curvature	Entrance Ramps	Exit Ramps
Less than 4 Degrees	199	510
Greater than 4 Degrees	12	34
Missing	7	14
Total	218	588

Table 23(a)

Distribution of Severity of Truck Accident Involvements in Texas for 1984

Truck Configuration	Number of Accident Involvements				
	Fatal	Incapacitating Injury	Possible or Non-Incapacitating Injury	P.D.O.	Total
Single-Unit	270 (0.75)	1393 (3.86)	9054 (25.11)	25336 (70.27)	36053 (100.00)
Semi-trailers	408 (2.04)	1130 (5.65)	4542 (22.72)	13912 (69.59)	19992 (100.00)
Total	678	2523	13596	39248	56045

b) collisions between semi-trailers and passenger vehicles;

c) single-vehicle accidents of SU trucks; and

d) collisions between SU trucks and passenger vehicles.

Collisions with other large trucks were not analyzed here due to their relatively infrequent occurrences. This class of accidents only accounted for about one percent of total truck accident involvements in 1984. Accidents involving combination trucks other than semi-trailers were also excluded due to a very small sample size.

The preliminary examination of truck accidents led to defining the dependent and candidate independent variables for each of the above four subsets, as shown in Table 23(b).

The results of the severity analysis in terms of the model parameters are summarized in Table 24. Detail of the data input and the analysis results for the four subsets are described in Appendix E. It was noted that in all four subsets, all seven candidate variables mentioned above were analyzed for their potential effects on the severity of truck accidents. However, in the variable selection stage, driver age, vehicle body style, and intersection related were found to be non-significant for the two subsets designating single-vehicle accidents involving semi-trailers and single-vehicle accidents involving SU trucks. Driver age, vehicle body style, and object struck were found to be non-significant for the other two subsets designating collisions between semi-trailers and passenger vehicles, as well as those between SU trucks and passenger vehicles. Since object struck for the collision subsets was defined as passenger cars or pickups, this result implied that, on the average, occupants of passenger cars and pickups were expected to have similar severity when they were involved in accidents with trucks.

The results of the severity analysis are summarized in Tables 25 through 28. These tables were cross-classified by the variables similar to those

Table 23(b). Variables for Severity Analysis

Variable	Level
Dependent: Severity	o Accident involvements that resulted in fatalities or incapacitating injuries o Accident involvements that resulted in non-incapacitating or possible injuries but not fatalities or incapacitating injuries o P.D.O. accidents
Independent: Object Struck	Single-Vehicle Accidents: o Overturn, other single-vehicle o Fixed-object Multi-Vehicle Collisions: o Collisions with passenger cars o Collisions with pickups
Vehicle Body Style	o Flatbed o Van o Tank o Dump o Other
Road Class	o Rural Interstate o Rural US/State o Farm-to-Market o Urban Interstate o Urban US/State o City Streets
Light Condition	o Daylight (Day) o Other (Night)
Pavement Surface Condition	o Dry o Wet, snowy, icy (to be called "wet")
Intersection Related	o Yes o No
Driver Age	o Less than 25 o 25 - 55 o Over 55

Table 24: Summary of Effects of Variables on the Two Severity Odds

SUBSET	Road (R)	Intersection (I)	Light (L)	Pavement Surface (P)	Object Struck (O)	R x O	R x P	R x I	R x L	I x O	I x P	P x O	P x L
Semitrailers, Single-Veh Accidents	● X			● X	X	X	●					X	
Semitrailers, Single-Veh Accidents on Urban US/State highways		● X		●	● X					● X			
Collisions between Semitrailers and Passenger Vehicles	● X	X	● X					X					
S-U Trucks, Single-Veh Accidents	● X		● X		● X	X							
Collisions between S-U Trucks and Passenger Vehicles	● X	● X	● X	● X				● X	X		● X		X

● Odds of fatal and incapacitating-injury accidents

X Odds of non-incapaciatating-injury accidents

The first five columns represent the main effects of the variables while the next eight columns represent two-variable interactions.

Table 26

Summary of Estimated Odds of Non-Incapacitating

Injury Accidents for Semitrailers

Accident Type	Light Condition	Inter-Section	Pavement Surface Condition	Road Class					
				Rural Interstate	Rural US/State	FM	Urban Interstate	Urban US/State	City Street
Non-Collision	Day	Yes	Dry	.488	.514	.714	.503	.407	.266
			Wet	.356	.375	.523	.367		.190
		No	Dry	*	*	*	*	.456	*
			Wet						
	Night	Yes	Dry	*	*	*	*	*	*
			Wet						
		No	Dry	*	*	*	*		*
			Wet						
Fixed-Object	Day	Yes	Dry	.347	.322	.167	.506	.068	.057
			Wet	.479	.443	.228	.696		.078
		No	Dry	*	*	*	*	.245	*
			Wet						
	Night	Yes	Dry	*	*	*	*	*	*
			Wet						
		No	Dry	*	*	*	*		*
			Wet						
Collisions With Pass. Vehicles	Day	Yes	Dry	.300	.475	.322	.204	.288	.222
			Wet						
		No	Dry	.381	.438	.438	.395	.295	.230
			Wet						
	Night	Yes	Dry	.496	.780	.526	.333	.472	.364
			Wet						
		No	Dry	.623	.717	.719	.646	.482	.376
			Wet						

* Same as above entries.

Table 25

Summary of Estimated Odds of Fatal and Incapacitating

Injury Accidents for Semitrailers

Accident Type	Light Condition	Inter-Section	Pavement Surface Condition	Road Class: Rural Interstate	Rural US/State	FM	Urban Interstate	Urban US/State	City Street
Non-Collision	Day	Yes	Dry	.170	.126	.107	.068	.097	.004
			Wet	.086	.079	.095	.090	.031	.046
		No	Dry	*	*	*	*	.106	*
			Wet					.031	
	Night	Yes	Dry	*	*	*	*	*	*
			Wet						
		No	Dry	*	*	*	*		*
			Wet						
Fixed-Object	Day	Yes	Dry	.170	.126	.107	.068	0[a]	.004
			Wet	.086	.079	.095	.090	0[a]	.046
		No	Dry	*	*	*	*	.066	*
			Wet					.020	
	Night	Yes	Dry	*	*	*	*	*	*
			Wet						
		No	Dry	*	*	*	*		*
			Wet						
Collisions With Pass. Vehicles	Day	Yes	Dry	.084	.194	.084	.031	.048	.019
			Wet						
		No	Dry						
			Wet						
	Night	Yes	Dry	.250	.382	.253	.092	.145	.056
			Wet						
		No	Dry						
			Wet						

* Same as above entries.
a A very small value.

Table 27

Summary of Estimated Odds of Fatal and Incapacitating

Injury Accidents for Single-Unit Trucks

Accident Type	Light Condition	Inter-Section	Pavement Surface Condition	Road Class					
				Rural Interstate	Rural US/State	FM	Urban Interstate	Urban US/State	City Street
Non-Collision	Day	Yes	Dry	.225	.209	.174	.132	.080	.073
			Wet						
		No	Dry	*	*	*	*	*	*
			Wet						
	Night	Yes	Dry	.379	.353	.293	.222	.134	.123
			Wet						
		No	Dry	*	*	*	*	*	*
			Wet						
Fixed-Object	Day	Yes	Dry	.147	.138	.116	.088	.053	.049
			Wet	*	*	*	*	*	*
		No	Dry	*	*	*	*	*	*
			Wet						
	Night	Yes	Dry	.250	.234	.195	.148	.090	.082
			Wet						
		No	Dry	*	*	*	*	*	*
			Wet						
Collisions With Pass. Vehicles	Day	Yes	Dry	.106	.091	.059	.021	.032	.025
			Wet	.071	.060	.039	.014	.021	.016
		No	Dry	.100	.128	.052	.028	.030	.011
			Wet	.111	.143	.059	.031	.033	.012
	Night	Yes	Dry	.187	.161	.105	.038	.057	.044
			Wet	.111	.111	.069	.024	.038	.029
		No	Dry	.176	.226	.093	.050	.053	.020
			Wet	.194	.256	.104	.055	.059	.022

* Same as above entries.

Table 28

Summary of Estimated Odds of Non-Incapciatating

Injury Accidents for Single-Unit Trucks

Accident Type	Light Condition	Inter-Section	Pavement Surface Condition	Road Class					
				Rural Interstate	Rural US/State	FM	Urban Interstate	Urban US/State	City Street
Non-Collision	Day	Yes	Dry	.580	.620	.957	1.103	1.402	.942
			Wet						
		No	Dry	*	*	*	*	*	*
			Wet						
	Night	Yes	Dry	.739	.787	1.216	1.405	1.787	1.196
			Wet						
		No	Dry	*	*	*	*	*	*
			Wet						
Fixed-Object	Day	Yes	Dry	.646	.506	.515	.543	.314	.331
			Wet						
		No	Dry	*	*	*	*	*	*
			Wet						
	Night	Yes	Dry	.831	.640	.654	.690	.398	.420
			Wet						
		No	Dry	*	*	*	*	*	*
			Wet						
Collisions With Pass. Vehicles	Day	Yes	Dry	.222	.427	.336	.348	.353	.344
			Wet	.250	.491	.388	.403	.407	.397
		No	Dry	.322	.333	.305	.358	.297	.219
			Wet	.429	.440	.404	.473	.392	.287
	Night	Yes	Dry	.242	.846	.585	.471	.486	.477
			Wet	.250	.786	.540	.436	.448	.439
		No	Dry	.349	.660	.531	.484	.409	.301
			Wet	.379	.699	.559	.509	.432	.317

* Same as above entries.

used to cross-classify the results of truck accident involvements of Tables 6 through 19.

The estimated odds of fatal or incapacitating injury accidents represented a ratio of the number of fatal or incapacitating injury accident involvements to the number of all other accident involvements. For example, Table 25 shows that the estimated odds of fatal or incapacitating injury accidents for collisions between semi-trailers and passenger vehicles at night on rural US/State highways was 0.382. This implies that for every 100 semi-trailers involved in such collisions that did not result in fatalities or incapacitating injuries, there would be another 38 semi-trailers involved in such collisions that resulted in fatalities or incapacitating injuries. The chance of fatal or incapacitating injury accidents for these collisions was therefore one out of 3.6 accident involvements. The estimated odds of non-incapacitating injury accidents represented a ratio of the number of non-incapacitating injury or possible injury accident involvements to the number of PDO accident involvements. For example, Table 26 shows that the estimated odds of non-incapacitating injury accidents for intersection-related collisions between semi-trailers and passenger vehicles at night on rural US/State highways was 0.780. This implies that about one out of every 2.3 such accident involvements that did not result in fatalities or incapacitating injuries might still be expected to result in non-incapacitating or possible injuries.

Table 25 summarizes the estimated odds of fatal or incapacitating injury accidents for semi-trailers, cross-classified by road class, pavement surface condition, intersection related, light condition, and accident type. The table reveals the following:

a) Among all three accident types, collisions between semi-trailers and passenger vehicles at night resulted in the highest likelihood of fatalities or incapacitating injuries, particularly on rural US/State highways, rural interstate highways, and farm-to-market roads. As many as one out of every three to four such night-time collisions might be incapacitating injurious or fatal. On all road classes, the night-time collisions would result in the

odds of fatal or incapacitating injury accidents to be up to three times the odds for day-time collisions.

b) For collisions between semi-trailers and passenger vehicles, the odds of fatal or incapacitating injury accidents on rural highways were about 2.5 to 3 times those on urban freeways. Although these odds increased with decreasing degree of urbanization, they did not appear to be influenced by roadway design standards (roadway design standards in rural areas were considered to be the highest for interstate highways, followed by US/State highways, and farm-to-market roads; in urban areas, the standards were the highest for interstate highways, followed by US/State highways, and city streets).

c) For non-collision and fixed-object accidents involving semi-trailers, the odds of fatal or incapacitating injury accidents were influenced by interactions involving factors such as roadway design standards, pavement surface condition, and rural/urban environment. For example, in dry conditions, the odds of fatal or incapacitating injury accidents increased with decreasing degree of urbanization; this trend was not observed in wet conditions. In rural areas and in dry conditions, the odds of fatal or incapacitating injury accidents increased with increasing roadways design standards.

d) For non-collision and fixed-object accidents involving semi-trailers on rural highways, the odds of fatal or incapacitating injury accidents on dry pavements might be up to twice the odds on wet pavements. This, however, was not true for urban highways or city streets. This finding suggested that those single-venicle accidents in wet conditions on rural highways might have involved lower energy than those in dry conditions. This, in turn, suggested a lower stability threshold of semi-trailers in wet conditions. One probable cause for this might have been hydroplaning of truck tires for empty or lightly loaded semi-trailers which was shown in (4, 5) to be likely at speeds attainable on most highways.

e) For non-collision and fixed-object accidents involving semi-trailers, those occurred on rural interstate highways showed the highest

likelihood of fatalities or incapacitating injuries. Up to one out of every seven such accidents might be incapacitating injurious or fatal.

Table 26 summarizes the estimated odds of non-incapacitating injury accidents for semi-trailers. The table indicates the following:

a) Collisions between semi-trailers and passenger vehicles at night showed very high odds of non-incapacitating injury accidents on all road classes, even on city streets. Up to one out of every two to three such night-time collisions that did not result in fatalities or incapacitating injuries might still be expected to result in non-incapacitating or possible injuries.

b) Collisions between semi-trailers and passenger vehicles during the day showed lower odds of non-incapacitating injury accidents than did those at night, for all road classes. The odds during the day were about 0.60 times the odds at night. These odds did not appear to be affected by roadway design standards but might increase with decreasing degree of urbanization.

c) For semi-trailers involved in non-collision accidents, the odds of non-incapacitating injury accidents were similar during the day and at night. On rural highways, these odds increased with decreasing roadway design standards. However, on urban roadways, the odds increased with increasing roadway design standards.

d) For fixed-object accidents involving semi-trailers, the odds of non-incapacitating injury accidents were similar for day and night. The odds did not appear to be influenced by rural/urban environment. However, they appeared to increase with increasing roadway design standards.

e) Urban interstate highways which had shown relatively low odds of fatal or incapacitating injury accidents for single-vehicle accidents involving semi-trailers, showed relatively high odds of non-incapacitating injury accidents for these single-vehicle accidents.

Tables 25 and 26 strongly indicate that collisions between semi-trailers and passenger vehicles were considerably more serious at night than during the day on all road classes, in terms of causing fatalities and/or incapacitating injuries. This was indicated by much higher odds of fatal or incapacitating injury accidents (as well as higher odds of non-incapacitating injury accidents) at night. Further investigations of these accidents reveal that the manners of collision were different during the day and at night (Appendix F). For example, the percentage of night-time collisions that were rear-end was always higher than the percentage of day-time collisions that were rear-end on all road classes. Night-time collisions also involved proportionally more angle collisions than did day-time collisions (except on rural interstate highways). For other manners of collision, the differences in their relative frequencies during the day and at night depended on road classes. Appendix G shows the severity extents associated with the 6 different collision manners -- angle, rear-end, sideswipe in the same direction, other collision manners in the same direction, opposite-direction collisions, and other. Each table of Appendix G represents each of the 6 road classes. It can be seen that given a manner of collision, almost without exceptions, night-time was associated with a higher proportion of fatal or incapacitating-injury collisions than was day-time. This was consistent for all manners of collision and road classes.

In addition, a further investigation of the vehicle damage scales of passenger cars and pickups, as defined by the National Safety Council (6), was also conducted. It was revealed that for those collisions which resulted in either front damage, back damage, or side damage to the passenger vehicles, the vehicle damage scales of these passenger vehicles were always higher at night than during the day-time. This was true for all 6 road classes. This finding implies that the energy level involved in night-time collisions was higher than that in day-time collisions, probably due to higher speeds prior to collisions at night than during the day. Poorer driver reaction at night to attempt evasive maneuvers, due to lower visibility and fatigue, might also worsen the problems.

Table 27 summarizes the odds of fatal or incapacitating injury accidents for SU trucks. The table reveals the following:

a) Unlike the semi-trailer population, SU trucks showed that non-collision accidents indicated the highest odds of fatal or incapacitating injury accidents, followed by fixed-object accidents and collisions between SU trucks and passenger vehicles. This was true for all road classes.

b) For non-collision and fixed-object accidents involving SU trucks, the odds of fatal or incapacitating injury accidents increased with increasing roadway design standards and decreasing degree of urbanization. Rural interstate and rural US/State highways showed high likelihood of fatalities or incapacitating injuries. On these two road classes, up to about one out of every four non-collision accidents at night, and one out of every six during the day, might be fatal or incapacitating injurious.

c) For non-collision and fixed-object accidents involving SU trucks, the odds of fatal or incapacitating injury accidents at night were about 1.7 times those during the day for all road classes.

d) For collisions between SU trucks and passenger cars, the odds of fatal or incapacitating injury accidents were the highest on rural interstate and rural US/State highways among all six road classes. Up to one out of every five such collisions at night and one out of every eight during the day might be fatal or incapacitating injurious on these two road classes. These odds increased with decreasing degree of urbanization.

e) For collisions between SU trucks and passenger vehicles, the odds of fatal or incapacitating injury accidents at night were considerably higher than those during the day. The magnitude of the difference depends on road classes, pavement surface conditions, and whether the accidents were intersection related.

Table 28 summarizes the estimated odds of non-incapacitating injury accidents for SU trucks. The table reveals the following:

a) For non-collision accidents involving SU trucks, the odds of non-incapacitating injury accidents increased with increasing degree of urbanization and, for rural highways, with decreasing roadway design standards. This

trend was the exact opposite to that for the odds of fatal or incapacitating injury accidents. Urban US/State highways and city streets (which had shown low odds of fatal or incapacitating injury accidents), as well as urban inter-state highways (which had shown only moderate odds of fatal or incapacitating injury accidents), showed much higher odds of non-incapacitating injury accidents than did rural interstate and rural US/State highways.

b) For fixed-object accidents involving SU trucks, the odds of non-incapacitating injury accidents increased with decreasing degree of urbanization but did not appear to be affected by roadway design standards. Overall, the odds for fixed-object accidents were smaller than the odds for non-collision accidents, except on rural interstate highways for which the reverse was true.

c) For collisions between SU trucks and passenger vehicles, the odds of non-incapacitating injury accidents were considerably higher at night than for the day on all road classes except rural interstate highways where the odds for night and day were quite similar. The odds did not appear to be influenced by roadway design standards or degree of urbanization.

4. SUMMARY AND DISCUSSION

The statistical analysis of truck accidents was aimed at describing the following truck accident problems:

(i) The prevalence of truck accident involvements on the Texas highway system which was represented by the estimated percentages (distribution) of truck accident involvements under various conditions for each truck type.

(ii) The accident propensity on individual road classes for each truck type. This was measured by the estimated probabilities of accident involvements within each road class independent of other road classes.

(iii) Severity of truck accidents as measured by the estimated odds of fatal or incapacitating injury accidents and the estimated odds of non-incapacitating injury accidents.

The analyses involved were based on multivariate modeling techniques for contingency tables. Model estimations were very desirable because large contingency tables made up of observed frequencies of truck accident involvements tended to have cell sizes ranging from very small to very large values. Cells with small frequencies were particularly subjected to erratic cell-to-cell changes due solely to the random nature of accident occurrences. Therefore, computation of accident statistics directly from the observed data with small cell sizes might result in unstable statistics. Model estimations such as those carried out in this study would, among other things, compute "smoothed" statistics in each cell, thus eliminating or minimizing the erratic cell-to-cell occurrences in the observed data. In this way, stable estimates might be obtained and the resulting accident statistics might be more reliable than those directly derived from the observed data.

Table 29 summarizes the prevalence of accident involvements by selected types of semi-trailers and SU trucks. This summary table was obtained by combining the estimated percentages of accident involvements from the appropriate cells in each table of Appendix D. For example, the estimated proportion of flatbed semi-trailers that were single-vehicle accidents on

Table 29: **Summary of Estimated Percentages of Accident Involvements by Selected Truck Types**

Truck Type	Single-Vehicle Accidents					Collisions with Cars or Pickups				
	Rural IH	Rural US/State	FM	Urban Highways	City Streets	Rural IH	Rural US/State	FM	Urban Highways	City Streets
Flatbed Semi-Trailer	3.2	8.1	3.7	12.0	3.7	3.1	7.9	5.4	28.0	7.9
Van Semi-Trailer	5.9	9.8	1.4	8.5	3.5	3.4	4.5	3.1	32.1	11.9
Tank Semi-Trailer	2.1	8.0	7.3	8.2	1.9	1.8	10.6	7.6	30.4	6.5
Dump Semi-Trailer	0.7	5.0	6.0	10.3	3.0	1.2	8.3	7.1	32.6	8.1
"Mixed" Semi-Trailer	2.9	4.6	2.2	7.1	2.6	3.7	7.2	4.4	38.4	10.7
Flatbed SU	0.6	2.1	3.2	3.2	2.6	1.1	3.8	10.2	33.3	23.0
Van SU	1.1	3.1	2.0	3.8	2.2	0.4	2.5	5.6	28.2	29.8
Tank SU	0.3	1.8	3.0	4.6	3.3	1.6	9.2	16.4	25.1	17.9
Dump SU	0.2	1.1	4.5	4.7	2.9	1.0	4.0	12.0	32.7	19.1
"Mixed" SU	0.5	1.3	3.0	2.6	3.2	0.6	3.0	8.7	28.9	29.9

Percentages were fractions within each particular truck type. Percentages in each row do not sum to 100 because only major, but not all, accident types are shown.

rural interstate highways was found to be 3.2 percent. This was obtained by adding all involvements percentages of flatbed semi-trailers (Table D1; Appendix D) which were non-collision and fixed-object accidents, regardless of day/night or whether they were intersection related. In Table 29, urban interstate hignways and urban US/State highways were combined as urban highways. The table indicates the following:

a) Collisions between trucks and passenger vehicles on urban highways dominated the accident distributions of all truck types.

b) Percentages of single-vehicle accidents involving semi-trailers were significant, particularly on urban highways and rural US/State highways.

The prevalence of truck accident involvements was sensitive to the amount of truck traffic or truck miles of travel (i.e., truck exposure). For example, the prevalence of accident involvement for tank semi-trailers indicated that about 13 percent of their total involvements were collisions with cars during the day on urban US/State highways (Table D3, Appendix D). This relatively high prevalence of accident involvements might be attributable to tank semi-trailers' high mileage on this highway class during the day, or other inherent (traffic, roadway) conditions during the day on this highway class, or a combination of both. The usefulness of the prevalence of accident involvements, therefore, was limited to providing a description of the current extent of accident involvements for each truck type on the highway system.

To neutralize the effect of truck exposure by road class, the probabilities of accident involvements under various conditions conditional on each road class were computed. These probabilities, expressed as percentages within each road class, indicate the accident propensity on individual road classes for each truck type. Accident characteristics on individual road classes with particularly high probabilities of occurrences (at least a 25 percent probability) were listed in Table 30 in a descending order of the probability values for selected truck types. Each probability value used to order the accident characteristics was based on the results of Tables 6 through 19. For example, the probability associated with collisions

Table 30. Summary of Accident Characteristics on Individual Road Classes With Particularly High Probabilities of Occurrence by Truck Type

Truck Type	Characteristics With High Probabilities of Occurrence
Flatbed Semi-Trailers	(1) Collisions with cars on urban IH (particularly during the day) (2) Collisions with cars on city streets (particularly during the day) (3) Collisions with cars on urban US/State (particularly during the day or at intersections) (4) Collisions with cars on FM roads (particularly during the day or at intersections) (5) Collisions with cars on rural US/State (6) Collisions with cars on rural IH (7) Non-collision accidents on rural IH
Van Semi-Trailers	(1) Collisions with cars on urban IH (particularly during the day) (2) Collisions with cars on urban US/State (particularly during the day) (3) Collisions with cars on city streets (particularly during the day) (4) Collisions with cars on FM roads (particularly during the day) (5) Non-collision accidents on rural US/State (6) Non-collision accidents on rural IH
Tank Semi-Trailers	(1) Collisions with cars on urban IH (2) Collisions with cars on city streets (particularly during the day) (3) Collisions with cars on urban US/State (particularly during the day or at intersections) (4) Non-collision accidents on FM roads (5) Collisions with Cars on rural US/State (6) Collisions with Cars on FM roads (7) Non-collision accidents on rural IH (8) Non-collision accidents on rural US/State
Dump Semi-Trailers	(1) Collisions with cars on urban IH (particularly at intersections) (2) Collisions with cars on city streets (3) Collisions with cars on urban IH (4) Collisions with cars on rural IH (5) Collisions with cars on rural US/State (6) Collisions with cars on FM roads (7) Collisions with pickups on rural US/State (8) Non-collision accidents on rural US/State
"Mixed" Semi-Trailers	(1) Collisions with cars on urban IH (particularly during the day) (2) Collisions with cars on urban US/State (particularly during the day or at intersections) (3) Collisions with cars on city streets (particularly during the day or at intersections) (4) Collisions with cars on FM roads (5) Collisions with cars on rural IH (6) Collisions with cars on rural US/State

Table 30. Summary of Accident Characteristics on Individual Road Classes With Particularly High Probabilities of Occurrence by Truck Type (Cont.)

Truck Type	Characteristics With High Probabilities of Occurrence
Flatbed SU	(1) Collisions with cars on urban US/State (particularly during the day or at intersections) (2) Collisions with cars on city streets (particularly during the day) (3) Collisions with cars on urban IH (particularly during the day) (4) Collisions with cars on FM roads (particularly during the day) (5) Collisions with cars on rural IH (particularly during the day) (6) Collisions with cars on rural US/State (particularly during the day)
Van SU	(1) Collisions with cars on city streets (particularly at intersections) (2) Collisions with cars on urban IH (3) Collisions with cars on FM roads (particularly at intersections) (4) Collisions with cars on urban US/State (particularly at intersections) (5) Non-collision accidents on rural IH (6) Non-collision accidents on rural US/State
Tank SU	(1) Similar and high probabilities were found for collisions with cars on all 6 road classes
Dump SU	(1) Collisions with cars on urban IH (particularly during the day) (2) Collisions with cars on city streets (particularly during the day) (3) Collisions with cars on urban US/State (particularly during the day or at intersections) (4) Collisions with cars on rural IH (particularly during the day) (5) Collisions with cars on rural US/State (particularly during the day) (6) Collisions with cars on FM roads (particularly during the day) (7) Collisions with pickups on rural IH (particularly during the day)
Mixed SU	(1) Collisions with cars on urban US/State (particularly during the day or at intersections) (2) Collisions with cars on city streets (particularly during the day or at intersections) (3) Collisions with cars on urban IH (particularly during the day) (4) Collisions with cars on FM roads (particularly during the day) (5) Collisions with cars on rural US/State (6) Collisions with cars on rural IH

between flatbed semi-trailers and cars on urban interstate highways was a sum of four probabilities from Table 6 over day/night and intersection-related/non-intersection related (i.e. 14.42 + 21.17 + 2.45 + 9.20 = 47.24 percent). This probability was higher than the probability values associated with the other six listed accident characteristics for flatbed semi-trailers.

Unlike truck accident involvements, severity of accidents involving trucks significantly differed by truck configuration (SU trucks or semi-trailers) but not by vehicle body style. The severity levels of accidents involving semi-trailers and those involving SU trucks were found to be associated with a number of factors, but particularly road class, day/night and accident type. The findings on the severity of truck accidents suggested many trends concerning the specific factors which were strongly associated with increased odds of fatal or incapacitating injury accidents, as well as increased odds of non-incapacitating injury accidents. These trends are summarized in Table 31. Roadway design standards were considered to be the highest for interstate highways, followed by US/State highways and farm-to-market roads. In urban areas, urban interstate highways were considered to be of the highest design standard, followed by urban US/State highways and city streets.

Finally, the problems associated with the DPS accident file must be acknowledged. The amount of information pertaining to truck accidents and the description of trucks involved in accidents were very limited. Of the basic information reported about trucks such as vehicle body style, the proportion of missing data was found to be very high. Significant inconsistency of reporting truck configurations, vehicles makes and models was also evident; so were the reporting inconsistencies for other variables contained in the file. Other problems associated with accident reporting practices in Texas had been studied and documented (10, 11). All these limitations and anomalies in the DPS file could significantly affect the quality of truck accident statistics. Because the DPS accident file is the only data base which has the most complete coverage of accidents for the entire state, improvements in the accident reporting forms, practices, and thresholds should be considered so that detail of important accident information, and higher degrees of data reliability and consistency may be obtained. Such

Table 31

Summary of Factors Associated With Increased Severity of Truck Accidents

Accident Type	Measure of Severity	Factors Associated with Increased Severity*
Non-collisions involving semi-trailers	Odds of fatal or incapacitating injury accidents	Decreased degree of urbanization; increased road design standards* (for rural highway on dry pavements only); dry condition (for rural highways).
	Odds of non-incapacitating injury accidents	Decreased road design standards (for rural highways); increased road design standards (for urban roadways); dry condition.
Fixed-object accidents involving semi-trailers	Odds of fatal or incapacitating injury accidents	Decreased degree of urbanization; increased road design standards (for rural highway on dry pavements only); dry condition (for rural highways).
	Odds of non-incapacitating injury accidents	Increased road design standards; wet condition.
Collisions between semi-trailers and passenger vehicles	Odds of fatal or incapacitating injury accidents	Night-time; decreased degree of urbanization.
	Odds of non-incapacitating injury accidents	Night-time; decreased degree of urbanization.
Non-collisions involving SU trucks	Odds of fatal or incapacitating injury accidents	Night-time; decreased degree of urbanization; increased road design standards.
	Odds of non-incapacitating injury accidents	Night-time; increased degree of urbanization; decreased road design standard (for rural highways).
Fixed-object accidents involving SU trucks	Odds of fatal or incapacitating injury accidents	Night-time; increased degree of urbanization; increased road design standards.
	Odds of non-incapacitating injury accidents	Night-time; decreased degree of urbanization.
Collisions between SU trucks and passenger vehicles	Odds of fatal or incapacitating injury accidents	Night-time; decreased degree of urbanization.
	Odds of non-incapacitating injury accidents	Night-time; wet condition.

* The hierarchy of road design standards was interstate highways, US/State highways, and FM roads in rural areas; interstate highways, US/State highways, and city streets in urban areas.

improvements are likely to be long-term. In the mean time, accident statistics particularly those pertaining to truck accidents should be applied with these shortcomings in mind.

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APPENDIX A

MODEL ESTIMATION METHODS

APPENDIX A

I. Model Estimation for Accident Involvements Using Log-Linear Model

Log-linear models are statistical models that can be applied to determine associations among a number of variables. They are particularly suitable for frequency or count data with nominal (discrete) variables. A log-linear model can be generally expressed as follows (7).

For a contingency table of accident frequency, which is cross-classified by 3 variables, A, B, and C,

$$\text{Log } (m_{ijk}) = u + u_A + u_B + u_C + u_{AB} + u_{AC} + u_{BC} + u_{ABC} \quad \ldots\ldots \text{(a)}$$

where m_{ijk} is the estimated cell counts

u is the overall mean

u_A is the main effect of A

u_B is the main effect of B

u_C is the main effect of C

u_{AB} is the two-way interaction between A and B, and so on.

Equation (a) can be estimated using an iterative proportional fitting (IPF) procedure. The statistical goodness-of-fit is an asymptotic chi-square which is expressed as:

$$G^2 = -2 \sum_i X_i \log (m_i / X_i)$$

where m_i is the estimated cell counts.

X_i is the observed cell counts

Once the estimated cell frequencies were obtained, the cell probabilities and the probabilities conditional on each road class can be computed. A computer program, BMDP (8), can be used to estimate a log-linear model and its parameters.

II. Model Estimation for Accident Severity

The model form selected for the severity analysis was a pair of logit models for a polytomous severity variable whose levels had a natural order from the most to the least severe. Continuous ratios, such as the odds of fatal or incapacitating injury accidents and the odds of non-incapacitating injury accidents, have been shown by Fienberg (3) to possess the asymptotic properties that allow two logit models to be estimated independently while retaining the basic structure of the data set.

The two logit models for the two odds can be represented by:

Log (Odds of fatal or incapacitating injury accidents)

$= \text{Log } (m_1/(m_2 + m_3))$

$= W + W_A + W_B + W_{AB} + \cdots\cdots$

Log (Odds of non-incapacitating injury accidents)

$= \text{Log } (m_2/m_3)$

$= W' + W'_A + W'_B + W'_{AB} + \cdots\cdots$

where m_1, m_2, m_3 are the cell frequencies by the 3 severity levels;

- W is the overall mean
- W_A is the main effect of variable A
- W_B is the main effect of variable B
- W_{AB} is the interaction between A and B, and so on.

Computer programs such as BMDP (8) or SAS (9) can be used for estimating the logit models.

APPENDIX B

FREQUENCY OF TRUCK ACCIDENT INVOLVEMENTS

Table B-1
Accident Involvements of Flatbed Semitrailers

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	5	13	6	6	16	7
		No	12	43	19	20	24	7
	Night	Yes	3	1	2	3	3	1
		No	19	24	4	3	6	1
Fixed Object	Day	Yes	1	7	7	7	37	20
		No	13	38	26	24	46	22
	Night	Yes	0	3	3	0	7	10
		No	8	23	3	9	15	2
With Car	Day	Yes	8	28	31	47	121	56
		No	14	40	18	69	62	46
	Night	Yes	1	15	2	8	27	4
		No	15	13	8	30	19	5
With Pickup	Day	Yes	0	12	14	14	49	23
		No	10	21	20	20	32	11
	Night	Yes	0	5	1	2	10	2
		No	10	15	8	11	6	2
With Truck	Day	Yes	0	11	1	3	13	2
		No	2	16	5	18	9	2
	Night	Yes	0	0	0	0	5	0
		No	11	4	2	0	0	0
Other	Day	Yes	0	4	6	4	24	21
		No	4	18	13	21	23	19
	Night	Yes	1	2	1	0	1	0
		No	16	16	5	7	6	6
Total			153	372	205	326	561	269

Total for all road classes was 1886.

Table B-2

Accident Involvements of Van Semitrailers

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	3	4	3	5	7	0
		No	32	56	5	10	14	3
	Night	Yes	1	4	0	2	3	0
		No	26	53	4	4	7	3
Fixed Objects	Day	Yes	0	2	3	6	16	14
		No	16	26	5	25	23	33
	Night	Yes	3	2	0	3	5	4
		No	25	28	4	12	10	5
With Car	Day	Yes	6	11	13	59	99	80
		No	19	26	17	112	87	71
	Night	Yes	0	3	1	8	26	12
		No	11	12	6	37	20	7
With Pickup	Day	Yes	2	6	6	12	26	18
		No	9	14	8	31	31	19
	Night	Yes	0	4	1	4	4	2
		No	13	4	1	8	8	3
With Truck	Day	Yes	2	0	--	8	5	3
		No	8	5	--	12	4	1
	Night	Yes	0	0	--	0	5	0
		No	7	1	--	2	0	0
Other	Day	Yes	2	3	2	9	18	14
		No	11	5	3	18	12	37
	Night	Yes	0	1	0	2	2	4
		No	26	24	1	15	9	6
Total			222	294	83	404	441	339

Total for all road classes was 1783

Table B-3

Accident Involvements of Tank Semitrailers

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	7	12	14	2	13	1
		No	4	27	28	3	7	4
	Night	Yes	1	2	3	0	4	0
		No	3	15	13	2	5	1
Fixed Objects	Day	Yes	0	2	5	2	14	5
		No	3	11	8	8	12	7
	Night	Yes	1	3	1	0	5	2
		No	3	12	5	5	5	0
With Car	Day	Yes	3	18	15	22	104	20
		No	6	23	19	31	44	26
	Night	Yes	0	9	4	7	15	4
		No	3	18	12	16	14	7
With Pickup	Day	Yes	4	12	10	5	26	4
		No	2	14	8	5	11	6
	Night	Yes	1	4	5	2	12	0
		No	0	14	7	2	4	1
With Truck	Day	Yes	0	6	1	1	8	1
		No	5	8	2	2	3	1
	Night	Yes	0	0	0	0	0	0
		No	1	2	0	0	0	0
Other	Day	Yes	0	6	5	3	7	5
		No	3	9	14	7	8	8
	Night	Yes	0	2	0	0	1	0
		No	10	20	9	2	5	1
Total			60	249	188	127	327	104

Total for all road classes was 1055

Table B-4

Accident Involvements of Dump Semitrailers

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	1	6	8	3	10	4
	No	1	18	21	4	15	5
Fixed Objects	Yes	1	0	1	2	8	2
	No	2	11	12	14	16	10
With Car	Yes	1	14	12	14	77	28
	No	5	17	17	37	39	15
With Pickup	Yes	0	10	7	12	17	7
	No	2	17	14	10	22	7
With Truck	Yes	0	1	2	5	3	1
	No	1	7	9	7	4	3
Other	Yes	0	2	1	3	14	6
	No	5	6	11	15	9	9
Total		19	109	115	126	234	97

Total for all road classes was 700

Table B-5

Accident Involvements of Livestock/Pole Semitrailers

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Single-Vehicle	Yes	2	5	2	0	4	1
	No	6	29	10	1	8	2
Multi-Vehicle	Yes	3	5	3	6	31	4
	No	6	15	10	7	14	3
Other	Yes	0	1	1	0	1	3
	No	2	11	1	1	2	5
Total	Yes	19	66	27	15	60	18

Total for all road classes was 205

Table B-6

Accident Involvements of "Mixed" Semitrailers

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	7	54	32	27	59	10
		No	109	195	114	77	85	24
	Night	Yes	6	19	8	9	15	2
		No	112	126	24	35	36	5
Fixed Objects	Day	Yes	7	24	24	35	137	129
		No	74	144	84	193	142	142
	Night	Yes	5	7	6	14	39	29
		No	98	88	26	60	49	33
With Car	Day	Yes	58	166	117	519	1105	613
		No	199	281	186	1049	697	453
	Night	Yes	19	49	26	91	173	66
		No	111	149	62	313	210	85
With Pickup	Day	Yes	28	118	84	143	395	148
		No	61	168	96	289	218	119
	Night	Yes	4	31	17	27	69	24
		No	53	66	38	101	76	20
With Truck	Day	Yes	0	1	0	3	1	0
		No	0	1	0	0	0	1
	Night	Yes	0	0	0	0	0	0
		No	0	0	2	0	0	0
Other	Day	Yes	24	63	40	111	233	131
		No	96	166	108	255	177	230
	Night	Yes	3	15	11	11	35	20
		No	156	184	47	88	62	38
Total			1230	2115	1152	3450	4013	2322

Total for all road classes was 14282

Table B-7

Accident Involvements of Flatbed Single-Unit Trucks

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	1	4	6	2	2	2
		No	5	13	10	4	8	3
	Night	Yes	0	1	2	0	0	0
		No	3	13	15	0	3	0
Fixed Objects	Day	Yes	0	1	9	4	6	9
		No	3	9	19	13	16	29
	Night	Yes	1	0	3	0	2	5
		No	1	7	9	7	7	12
With Car	Day	Yes	4	20	69	78	194	191
		No	8	22	66	100	116	169
	Night	Yes	0	4	12	6	15	24
		No	5	7	15	9	14	21
With Pickup	Day	Yes	1	8	25	42	81	65
		No	5	19	38	36	45	48
	Night	Yes	1	1	3	2	12	6
		No	2	6	8	3	7	7
With Truck	Day	Yes	0	0	4	11	18	8
		No	1	8	6	20	9	12
	Night	Yes	0	0	0	0	3	0
		No	0	0	0	0	0	0
Other	Day	Yes	1	5	9	9	24	31
		No	2	10	20	24	26	78
	Night	Yes	0	1	2	0	1	6
		No	4	6	9	2	6	22
Total			48	165	359	372	615	748

Total for all road classes was 2307

Table B-8

Accident Involvement of Van Single-Unit Trucks

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	0	1	0	0	2	0
	No	4	7	5	1	3	1
Fixed Objects	Yes	0	0	0	0	1	0
	No	1	6	4	4	6	9
With Car	Yes	1	2	13	18	36	61
	No	0	4	5	17	15	45
With Pickup	Yes	0	1	4	6	20	17
	No	1	4	3	8	6	10
With Truck	Yes	0	1	1	2	2	0
	No	1	0	0	2	4	2
Other	Yes	1	1	1	0	12	14
	No	3	3	3	9	9	23
Total		12	30	39	67	116	182

Total for all road classes was 446

Table B-9

Accident Involvement of Tank Single-Unit Trucks

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	0	3	4	0	1	0
	No	1	2	4	0	1	1
Fixed Objects	Yes	0	0	0	1	1	1
	No	0	3	6	3	1	1
With Car	Yes	1	8	10	4	30	28
	No	1	2	17	6	11	14
With Pickup	Yes	1	3	2	0	11	7
	No	1	5	6	3	6	4
With Truck	Yes	0	1	2	0	3	0
	No	0	1	4	0	2	3
Other	Yes	0	3	1	1	5	2
	No	1	3	4	2	1	5
Total		6	34	60	20	73	66

Total for all road classes was 259

Table B-10

Accident Involvements of Dump Single-Unit

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	2	2	19	0	19	6
		No	2	10	47	9	17	20
	Night	Yes	0	0	3	0	0	0
		No	1	2	3	0	2	0
Fixed Objects	Day	Yes	0	0	3	4	7	12
		No	0	9	22	17	21	24
	Night	Yes	0	0	0	0	3	0
		No	0	2	4	3	2	3
With Car	Day	Yes	6	28	74	90	195	175
		No	6	27	92	97	114	147
	Night	Yes	0	0	3	3	7	2
		No	2	4	3	11	13	7
With Pickup	Day	Yes	3	11	43	18	82	44
		No	4	16	51	39	46	45
	Night	Yes	0	0	1	1	5	1
		No	0	2	2	5	4	5
With Truck	Day	Yes	0	3	15	7	22	11
		No	0	7	11	10	14	21
	Night	Yes	0	0	0	2	0	0
		No	0	0	2	0	0	0
Other	Day	Yes	0	7	18	15	34	35
		No	4	7	37	19	24	53
	Night	Yes	0	0	0	0	4	1
		No	0	1	3	4	2	8
Total			30	138	456	354	637	620

Total for all road classes was 2235.

Table B-11

Accident Involvements of Garbage/Wrecker Single-Unit

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	0	0	2	0	2	3
		No	0	1	5	3	3	7
	Night	Yes	0	0	0	1	2	1
		No	0	0	3	0	0	0
Fixed Objects	Day	Yes	0	0	2	1	7	14
		No	0	2	0	6	6	21
	Night	Yes	0	0	0	1	3	7
		No	1	1	3	4	3	13
With Car	Day	Yes	1	9	36	41	79	154
		No	1	10	22	50	61	124
	Night	Yes	1	2	14	7	19	33
		No	1	2	10	21	16	20
With Pickup	Day	Yes	1	1	11	10	30	50
		No	1	3	14	16	24	44
	Night	Yes	0	0	2	5	7	5
		No	1	0	5	2	8	9
With Truck	Day	Yes	0	1	4	3	8	3
		No	0	1	1	4	5	0
	Night	Yes	0	0	1	0	1	0
		No	0	2	0	1	0	2
Other	Day	Yes	0	1	6	7	12	31
		No	3	1	10	14	10	79
	Night	Yes	0	0	0	3	1	9
		No	5	0	4	3	4	18
Total			16	37	155	203	311	647

Total for all road classes was 1369

Table B-12

Accident Involvements of Mixer/Cement Single-Unit

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	1	3	6	4	11	3
	No	1	4	22	0	4	12
Fixed Objects	Yes	0	0	1	2	4	2
	No	0	3	9	5	4	5
With Car	Yes	2	9	23	18	59	60
	No	2	8	26	21	40	47
With Pickup	Yes	0	2	12	1	26	16
	No	0	5	12	11	10	19
With Truck	Yes	0	1	2	0	1	0
	No	0	2	3	3	3	4
Other	Yes	0	2	9	0	10	7
	No	0	0	6	5	4	22
Total		6	39	131	70	176	197

Total for all road classes was 619

Table B-13

Accident Involvements of Bobtails

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	2	1	1	4	0	2
	No	1	3	3	4	1	1
Fixed Objects	Yes	1	0	0	2	1	2
	No	1	2	1	6	8	12
With Car	Yes	1	1	11	27	46	60
	No	2	6	12	39	37	69
With Pickup	Yes	0	1	7	9	18	21
	No	2	2	1	13	9	20
With Truck	Yes	0	2	0	1	3	4
	No	0	4	2	4	5	2
Other	Yes	0	1	1	3	8	8
	No	3	1	0	15	4	17
Total		13	24	39	127	140	218

Total for all road classes was 561

Table B-14
Accident Involvements of "Mixed" Single-Unit

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	6	22	29	15	30	18
		No	44	117	198	32	37	58
	Night	Yes	1	4	20	1	15	18
		No	35	69	147	20	32	68
Fixed Objects	Day	Yes	6	9	32	18	61	89
		No	18	72	157	100	102	241
	Night	Yes	1	8	38	35	45	94
		No	26	65	212	85	103	317
With Car	Day	Yes	39	185	716	767	2053	3352
		No	45	233	664	884	1207	2283
	Night	Yes	13	56	195	196	538	778
		No	21	73	184	231	362	464
With Pickup	Day	Yes	21	89	254	185	651	714
		No	16	143	300	260	436	555
	Night	Yes	6	25	68	43	145	155
		No	14	38	66	69	92	104
Other	Day	Yes	21	64	185	192	469	734
		No	44	115	299	233	358	1015
	Night	Yes	3	14	70	48	119	212
		No	34	116	168	93	124	450
Total*			414	1518	4006	3508	6981	11719

Total for all road classes was 28146

* Total included collisions with trucks (a very small number) not shown here.

APPENDIX C

ESTIMATED MODELS FOR TRUCK ACCIDENT INVOLVEMENTS BY TRUCK TYPE

APPENDIX C

ESTIMATED MODELS FOR TRUCK ACCIDENT INVOLVEMENTS BY TRUCK TYPE

Semitrailers

Subset	Estimated Model
Flatbed Semitrailers	Saturated Model **
Van Semitrailers	RI, RL, RA, IL, IA, LA
Tank Semitrailers	RI, RL, RA, IL, IA
Dump Semitrailers*	RI, RA, IA
Livestock/Pole Semitrailers*	RA, IA
"Mixed" Semitrailers	RIA, RLA, ILA

Single-Unit Trucks	Estimated Model
Flatbed Single-Unit	RI, RL, RA, IA, LA
Van Single-Unit*	RI, RA, IA
Tank Single-Unit*	A, RI
Dump Single-Unit	RI, RA, IA, IL
Cement/Mixer*	Saturated Model **
Garbage/Wrecker	RI, RA, RL, IA
Bobtail*	RA, IA
"Mixed" Single-Unit	RIL, RIA, RLA, ILA

R = Road Class L = Light Condition

I = Intersection/Non-Intersection A = Accident Type

* Light condition was not analyzed due to small sample size

** Saturated model implies that the observed contingency table is the best fitted model

APPENDIX D

ESTIMATED DISTRIBUTIONS OF ACCIDENT INVOLVEMENTS

Table D-1

Estimated Distribution of Accident Involvements (Flatbed Semitrailers)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	0.27	0.69	0.32	0.32	0.85	0.37
		No	0.64	2.28	1.01	1.06	1.27	0.37
	Night	Yes	0.16	0.05	0.11	0.16	0.16	0.05
		No	1.01	1.27	0.21	0.16	0.32	0.05
Fixed Objects	Day	Yes	0.05	0.37	0.37	0.37	1.96	1.06
		No	0.69	2.01	1.38	1.27	2.44	1.17
	Night	Yes	0	0.16	0.16	0	0.37	0.53
		No	0.42	1.22	0.16	0.48	0.80	0.11
With Car	Day	Yes	0.42	1.48	1.64	2.49	6.42	2.97
		No	0.74	2.12	0.95	3.66	3.29	2.44
	Night	Yes	0.05	0.80	0.11	0.42	1.43	0.21
		No	0.80	0.69	0.42	1.59	1.01	0.27
With Pickup	Day	Yes	0	0.64	0.74	0.74	2.60	1.22
		No	0.53	1.11	1.06	1.06	1.70	0.58
	Night	Yes	0	0.27	0.05	0.11	0.53	0.11
		No	0.53	0.80	0.42	0.58	0.32	0.11
With Truck	Day	Yes	0	0.58	0.05	0.16	0.69	0.11
		No	0.11	0.85	0.27	0.95	0.48	0.11
	Night	Yes	0	0	0	0	0.27	0
		No	0.58	0.21	0.11	0	0	0
Other	Day	Yes	0	0.21	0.32	0.21	1.27	1.11
		No	0.21	0.95	0.69	1.11	1.22	1.01
	Night	Yes	0.05	0.11	0.05	0	0.05	0
		No	0.85	0.85	0.27	0.37	0.32	0.32
Total			8.11	19.72	10.87	17.27	29.75	15.02

Table D-2

Estimated Distribution of Accident Involvements (Van Semitrailers)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	0.11	0.38	0.12	0.15	0.42	0.08
		No	1.56	3.06	0.38	0.69	0.83	0.20
	Night	Yes	0.08	0.25	0.03	0.04	0.13	0.01
		No	1.73	2.88	0.15	0.30	0.35	0.04
Fixed Objects	Day	Yes	0.08	0.20	0.13	0.35	0.79	0.87
		No	0.99	1.36	0.35	1.38	1.29	1.71
	Night	Yes	0.07	0.16	0.04	0.13	0.29	0.15
		No	1.32	1.54	0.16	0.72	0.66	0.42
With Car	Day	Yes	0.17	0.44	0.75	3.38	5.99	4.46
		No	1.03	1.42	0.96	6.30	4.61	4.12
	Night	Yes	0.09	0.19	0.13	0.67	1.16	0.42
		No	0.72	0.86	0.32	1.76	1.26	0.54
With Pickup	Day	Yes	0.10	0.21	0.29	0.76	1.63	1.00
		No	0.70	0.79	0.44	1.68	1.49	1.10
	Night	Yes	0.05	0.09	0.05	0.16	0.33	0.10
		No	0.50	0.49	0.11	0.48	0.42	0.15
With Truck	Day	Yes	0.10	0.06	0	0.40	0.40	0.12
		No	0.49	0.16	0	0.62	0.26	0.09
	Night	Yes	0.04	0.02	0	0.07	0.07	0.01
		No	0.31	0.09	0	0.15	0.06	0.01
Other	Day	Yes	0.07	0.12	0.07	0.36	0.63	1.03
		No	0.76	0.66	0.15	1.17	0.84	1.65
	Night	Yes	0.09	0.12	0.03	0.17	0.29	0.22
		No	1.27	0.95	0.09	0.77	0.54	0.51
Total			12.45	16.50	4.66	22.66	24.73	19.01

Table D-3

Estimated Distribution of Accident Involvements (Tank Semitrailers)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	0.28	1.05	1.35	0.16	1.34	0.19
		No	0.59	2.09	2.41	0.31	0.81	0.29
	Night	Yes	0.10	0.43	0.37	0.04	0.28	0.02
		No	0.45	1.75	1.38	0.15	0.33	0.07
Fixed Objects	Day	Yes	0.11	0.44	0.37	0.28	1.49	0.37
		No	0.29	1.11	0.84	0.71	1.14	0.74
	Night	Yes	0.04	0.18	0.10	0.07	0.30	0.04
		No	0.22	0.93	0.48	0.35	0.47	0.17
With Car	Day	Yes	0.29	1.63	1.46	2.20	9.35	2.19
		No	0.42	2.26	1.83	3.00	3.91	2.41
	Night	Yes	0.10	0.66	0.40	0.52	1.89	0.25
		No	0.31	1.90	1.04	1.49	1.64	0.56
With Pickup	Day	Yes	0.20	1.23	1.01	0.47	3.03	0.48
		No	0.22	1.33	0.99	0.49	0.98	0.41
	Night	Yes	0.08	0.50	0.28	0.11	0.62	0.06
		No	0.17	1.12	0.56	0.25	0.41	0.09
With Truck	Day	Yes	0.13	0.35	0.08	0.08	0.55	0.07
		No	0.22	0.56	0.11	0.12	0.27	0.09
	Night	Yes	0.05	0.14	0.02	0.02	0.11	0.01
		No	0.17	0.47	0.07	0.07	0.11	0.02
Other	Day	Yes	0.15	0.44	0.42	0.17	0.72	0.28
		No	0.58	1.57	1.36	0.62	0.79	0.82
	Night	Yes	0.06	0.18	0.11	0.04	0.14	0.03
		No	0.44	1.33	0.77	0.30	0.33	0.19
Total			5.67	23.64	17.80	12.02	30.98	9.83

Table D-4

Estimated Distribution of Accident Involvements (Dump Semitrailers)

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	0.04	0.91	1.01	0.27	1.76	0.57
	No	0.24	2.51	3.13	0.73	1.81	0.71
Fixed Objects	Yes	0.03	0.19	0.20	0.27	0.91	0.40
	No	0.40	1.39	1.66	2.01	2.51	1.31
With Car	Yes	0.20	1.79	1.57	2.96	10.64	3.70
	No	0.66	2.64	2.57	4.33	5.93	2.44
With Pickup	Yes	0.06	1.29	0.93	1.06	3.19	1.06
	No	0.23	2.57	2.07	2.09	2.39	0.94
With Truck	Yes	0.01	0.27	0.34	0.40	0.44	0.23
	No	0.13	0.87	1.23	1.31	0.56	0.34
Other	Yes	0.09	0.27	0.37	0.61	1.49	0.89
	No	0.63	0.87	1.34	1.96	1.80	1.26
Total		2.71	15.57	16.43	18.00	33.43	13.86

Table D-5

Estimated Distribution of Accident Involvements (Livestock/Pole Semitrailers)

Accident Type	Inter-section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Single-Vehicle	Yes	0.78	3.25	1.17	0.10	1.17	0.39
	No	3.11	13.25	4.66	0.39	4.66	1.55
Multi-Vehicle	Yes	2.14	4.71	3.06	3.06	10.63	1.65
	No	2.23	5.00	3.25	3.25	11.21	1.75
Other	Yes	0.19	1.26	0.19	0.10	0.29	0.83
	No	0.78	4.56	0.78	0.39	1.17	3.06
Total		9.22	32.04	13.11	7.28	29.13	9.22

Table D-6

Estimated Distribution of Accident Involvements ("Mixed" Semitrailers)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	0.05	0.36	0.24	0.19	0.41	0.07
		No	0.76	1.39	0.78	0.54	0.60	0.17
	Night	Yes	0.04	0.15	0.04	0.06	0.11	0.01
		No	0.79	0.86	0.18	0.25	0.25	0.04
Fixed Objects	Day	Yes	0.04	0.15	0.17	0.27	0.96	0.92
		No	0.53	1.03	0.59	1.33	1.00	0.98
	Night	Yes	0.04	0.07	0.04	0.08	0.28	0.19
		No	0.68	0.59	0.18	0.44	0.34	0.24
With Car	Day	Yes	0.41	1.16	0.84	3.65	7.70	4.30
		No	1.39	1.97	1.29	7.33	4.93	3.17
	Night	Yes	0.13	0.34	0.17	0.62	1.25	0.46
		No	0.78	1.04	0.45	2.21	1.43	0.60
With Pickup	Day	Yes	0.16	0.85	0.58	1.00	2.75	1.07
		No	0.46	1.15	0.68	2.03	1.54	0.80
	Night	Yes	0.06	0.19	0.12	0.19	0.50	0.13
		No	0.34	0.48	0.26	0.71	0.51	0.18
Other	Day	Yes	0.12	0.40	0.30	0.76	1.65	0.98
		No	0.72	1.21	0.73	1.80	1.22	1.55
	Night	Yes	0.07	0.15	0.05	0.09	0.23	0.08
		No	1.05	1.24	0.35	0.60	0.45	0.33
Total*			8.62	14.80	8.06	24.15	28.11	16.26

* Total included small percentages of collisions with trucks which are not shown.

Table D-7

Estimated Distribution of Accident Involvements (Flatbed Single-Unit)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	0.02	0.11	0.20	0.04	0.14	0.04
		No	0.16	0.64	0.68	0.17	0.27	0.11
	Night	Yes	0.02	0.09	0.12	0.01	0.05	0.02
		No	0.19	0.50	0.42	0.04	0.10	0.05
Fixed Objects	Day	Yes	0.01	0.06	0.23	0.17	0.33	0.42
		No	0.09	0.35	0.84	0.68	0.67	1.28
	Night	Yes	0.01	0.05	0.14	0.04	0.12	0.17
		No	0.10	0.28	0.52	0.16	0.23	0.52
With Car	Day	Yes	0.14	0.67	2.82	3.59	8.32	8.26
		No	0.41	1.18	3.06	4.21	4.94	7.36
	Night	Yes	0.05	0.16	0.55	0.26	0.90	1.03
		No	0.14	0.29	0.59	0.30	0.54	0.91
With Pickup	Day	Yes	0.07	0.42	1.28	1.55	3.55	2.56
		No	0.21	0.74	1.37	1.79	2.08	2.26
	Night	Yes	0.03	0.11	0.26	0.12	0.41	0.34
		No	0.08	0.20	0.29	0.14	0.24	0.30
With Truck	Day	Yes	0.01	0.10	0.16	0.51	0.70	0.38
		No	0.03	0.23	0.25	0.81	0.57	0.46
	Night	Yes	0	0	0.01	0.01	0.02	0.01
		No	0	0.01	0.01	0.01	0.02	0.01
Other	Day	Yes	0.02	0.12	0.34	0.34	0.82	1.48
		No	0.16	0.54	0.94	1.01	1.24	3.35
	Night	Yes	0.01	0.05	0.12	0.04	0.16	0.34
		No	0.10	0.24	0.33	0.13	0.25	0.77
Total			2.08	7.15	15.56	16.12	26.67	32.42

Table D-8

Estimated Distribution of Accident Involvements (Van Single-Unit)

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	0.07	0.11	0.18	0.02	0.27	0.02
	No	0.83	1.68	0.94	0.20	0.85	0.20
Fixed Objects	Yes	0	0.02	0.02	0.02	0.09	0.07
	No	0.22	1.32	0.87	0.87	1.48	1.95
With Car	Yes	0.09	0.54	2.60	3.63	8.52	13.99
	No	0.13	0.81	1.43	4.22	2.91	9.78
With Pickup	Yes	0.09	0.45	0.99	1.43	4.30	3.52
	No	0.13	0.67	0.58	1.70	1.52	2.53
With Truck	Yes	0.04	0.04	0.09	0.25	0.74	0.18
	No	0.18	0.18	0.13	0.65	0.61	0.27
Other	Yes	0.18	0.18	0.36	0.49	2.44	2.87
	No	0.72	0.72	0.54	1.52	2.26	5.43
Total		2.69	6.73	8.74	15.02	26.01	40.81

Table D-9

Estimated Distribution of Accident Involvements (Tank Single-Unit)

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	0.04	0.46	0.46	0.15	1.28	0.97
	No	0.12	0.43	1.04	0.35	0.54	0.70
Fixed Objects	Yes	0.04	0.46	0.46	0.15	1.28	0.97
	No	0.12	0.43	1.04	0.35	0.54	0.70
With Car	Yes	0.39	3.56	3.75	1.20	10.05	7.50
	No	0.77	3.17	8.08	2.74	4.33	5.53
With Pickup	Yes	0.15	1.31	1.39	0.43	3.71	2.78
	No	0.31	1.16	3.02	1.01	1.62	2.05
With Truck	Yes	0.04	0.43	0.46	0.15	1.24	0.89
	No	0.08	0.39	0.97	0.35	0.54	0.66
Other	Yes	0.08	0.73	0.81	0.23	2.13	1.58
	No	0.15	0.66	1.70	0.58	0.93	1.16
Total		2.27	13.19	23.17	7.69	28.19	25.49

Table D-10

Estimated Distribution of Accident Involvements (Dump Single-Unit)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	0.05	0.15	0.84	0.10	0.72	0.35
		No	0.16	0.43	2.15	0.28	0.88	0.73
	Night	Yes	0	0	0.03	0	0.03	0.01
		No	0.01	0.04	0.20	0.03	0.08	0.07
Fixed Objects	Day	Yes	0	0.08	0.22	0.17	0.44	0.35
		No	0	0.38	0.98	0.82	0.94	1.27
	Night	Yes	0	0	0.01	0	0.01	0.01
		No	0	0.04	0.09	0.08	0.09	0.12
With Car	Day	Yes	0.26	1.11	3.47	3.82	9.16	7.38
		No	0.33	1.37	3.76	4.62	4.79	6.56
	Night	Yes	0.01	0.04	0.13	0.13	0.33	0.26
		No	0.03	0.13	0.34	0.43	0.44	0.60
With Pickup	Day	Yes	0.12	0.49	1.79	1.09	3.59	1.96
		No	0.18	0.72	2.28	1.55	2.21	2.04
	Night	Yes	0	0.02	0.06	0.04	0.13	0.07
		No	0.02	0.07	0.21	0.14	0.20	0.19
With Truck	Day	Yes	0	0.17	0.51	0.33	0.94	0.65
		No	0	0.25	0.66	0.47	0.59	0.69
	Night	Yes	0	0	0.02	0.01	0.03	0.02
		No	0	0.02	0.06	0.04	0.05	0.06
Other	Day	Yes	0.05	0.21	0.90	0.55	1.49	1.71
		No	0.11	0.41	1.52	1.03	1.21	2.35
	Night	Yes	0	0.01	0.03	0.02	0.05	0.06
		No	0.01	0.04	0.14	0.09	0.11	0.21
Total			1.34	6.18	20.40	15.84	28.49	27.75

Table D-11

Estimated Distribution of Accident Involvements (Garbage/Wrecker Single-Unit)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	0	0.01	0.18	0.05	0.15	0.22
		No	0	0.04	0.35	0.17	0.26	0.44
	Night	Yes	0	0	0.07	0.01	0.04	0.05
		No	0	0.01	0.13	0.05	0.07	0.09
Fixed Objects	Day	Yes	0.01	0.04	0.10	0.18	0.46	1.25
		No	0.03	0.13	0.16	0.48	0.64	2.05
	Night	Yes	0.01	0.01	0.04	0.06	0.12	0.28
		No	0.04	0.03	0.06	0.15	0.17	0.45
With Car	Day	Yes	0.04	0.56	2.45	2.90	6.05	10.97
		No	0.09	0.80	1.91	3.74	4.11	8.84
	Night	Yes	0.04	0.13	0.91	0.90	1.56	2.42
		No	0.12	0.19	0.71	1.16	1.07	1.95
With Pickup	Day	Yes	0.02	0.09	0.86	0.70	2.16	3.22
		No	0.07	0.15	0.84	1.14	1.84	3.24
	Night	Yes	0.03	0.02	0.32	0.22	0.56	0.71
		No	0.09	0.04	0.31	0.35	0.47	0.72
With Truck	Day	Yes	0	0.10	0.19	0.21	0.51	0.18
		No	0	0.13	0.13	0.23	0.30	0.12
	Night	Yes	0	0.02	0.07	0.07	0.13	0.04
		No	0	0.03	0.05	0.07	0.08	0.03
Other	Day	Yes	0.04	0.02	0.36	0.36	0.58	2.72
		No	0.22	0.09	0.70	1.15	0.99	5.49
	Night	Yes	0.04	0.01	0.13	0.11	0.15	0.60
		No	0.28	0.02	0.26	0.36	0.26	1.21
Total			1.18	2.69	11.31	14.83	22.71	47.28

Table D-12

Estimated Distribution of Accident Involvements (Mixer/Cement Single-Unit)

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	0.16	0.48	0.97	0.65	1.78	0.48
	No	0.16	0.65	3.55	0	0.65	1.94
Fixed Objects	Yes	0	0	0.16	0.32	0.65	0.32
	No	0	0.48	1.45	0.81	0.65	0.81
With Car	Yes	0.32	1.45	3.72	2.91	9.53	9.69
	No	0.32	1.29	4.20	3.39	6.46	7.59
With Pickup	Yes	0	0.32	1.94	0.16	4.20	2.58
	No	0	0.81	1.94	1.78	1.62	3.07
With Truck	Yes	0	0.16	0.32	0	0.16	0
	No	0	0.32	0.48	0.48	0.48	0.65
Other	Yes	0	0.32	1.45	0	1.62	1.13
	No	0	0	0.97	0.81	0.65	3.55
Total		0.97	6.30	21.16	11.31	28.45	31.81

Table D-13

Estimated Distribution of Accident Involvements (Bobtails)

Accident Type	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Yes	0.23	0.30	0.30	0.62	0.07	0.23
	No	0.30	0.41	0.41	0.80	0.11	0.30
Fixed Objects	Yes	0.05	0.05	0.04	0.23	0.27	0.41
	No	0.30	0.30	0.14	1.19	1.34	2.09
With Car	Yes	0.25	0.59	1.93	5.53	6.95	10.80
	No	0.29	0.66	2.17	6.24	7.84	12.19
With Pickup	Yes	0.20	0.29	0.77	2.14	2.62	3.98
	No	0.16	0.25	0.66	1.78	2.19	3.33
With Truck	Yes	0	0.39	0.12	0.34	0.53	0.39
	No	0	0.68	0.23	0.55	0.89	0.68
Other	Yes	0.18	0.12	0.05	1.11	0.73	1.53
	No	0.36	0.23	0.12	2.10	1.41	2.92
Total		2.32	4.28	6.95	22.64	24.96	38.86

Table D-14

Estimated Distribution of Accident Involvements ("Mixed" Single-Unit)

Accident Type	Light Condition	Inter-Section	Rural Interstate	Rural US/State	Farm-Market	Urban Interstate	Urban US/State	City Streets
Non-Collision	Day	Yes	0.02	0.07	0.11	0.04	0.11	0.07
		No	0.16	0.42	0.69	0.12	0.13	0.20
	Night	Yes	0	0.02	0.06	0.01	0.05	0.06
		No	0.12	0.24	0.53	0.06	0.11	0.25
Fixed Objects	Day	Yes	0.02	0.04	0.11	0.10	0.21	0.29
		No	0.07	0.25	0.56	0.32	0.37	0.88
	Night	Yes	0.01	0.02	0.14	0.09	0.17	0.36
		No	0.09	0.24	0.75	0.34	0.36	1.10
With Car	Day	Yes	0.15	0.68	2.53	2.72	7.26	11.95
		No	0.15	0.81	2.38	3.15	4.33	8.08
	Night	Yes	0.04	0.18	0.71	0.70	1.95	2.73
		No	0.09	0.28	0.64	0.81	1.25	1.68
With Pickup	Day	Yes	0.07	0.33	0.91	0.64	2.32	2.53
		No	0.06	0.50	1.06	0.94	1.54	1.98
	Night	Yes	0.02	0.08	0.24	0.17	0.51	0.56
		No	0.05	0.15	0.24	0.23	0.33	0.37
Other	Day	Yes	0.07	0.20	0.66	0.68	1.71	2.60
		No	0.16	0.44	1.06	0.83	1.23	3.62
	Night	Yes	0.01	0.08	0.24	0.17	0.38	0.77
		No	0.12	0.38	0.60	0.33	0.48	1.59
Total			1.47	5.39	14.22	12.46	24.80	41.65

APPENDIX E

DETAILED RESULTS OF SEVERITY ANALYSIS

APPENDIX E

DETAILED ANALYSIS RESULTS OF TRUCK ACCIDENT SEVERITY

The results of the severity analyses for the four subsets in terms of the estimated model parameters are summarized in Figure E1. For example it was found that for single-vehicle accidents involving semi-trailers, the odds of fatal or incapacitating injury accidents were significantly affected by the main effects of road class and pavement surface condition, as well as the interaction between road class and pavement surface condition.

Detail of the analyses involved and the results obtained are presented below for each of the four subsets.

Subset I: Severity of Single-Vehicle Accidents Involving Semitrailers

In 1984, there were 4,343 reported single-vehicle accidents involving semitrailers which were not on entrance or exit ramps. Of these, 323 (7.4 percent) were fatal or incapacitating accidents, 994 (22.9 percent) were non-incapacitating-injury accidents, and 3,026 (69.7 percent) were PDO accidents.

Of the seven candidate independent variables considered, the variable selection process indicated that the following significantly affected the severity distribution of this subset. They were:

1. Road Class
2. Pavement Surface Condition
3. Object Struck (None, fixed object)

On the other hand, those which were found to be non-significant were:

1. Driver Age
2. Vehicle Body Style
3. Light Condition
4. Intersection Related

Figure E1: Summary of Effects of Variables on the Two Severity Odds

SUBSET	Road (R)	Intersection (I)	Light (L)	Pavement Surface (P)	Object Struck (O)	R x O	R x P	R x I	R x L	I x O	I x P	P x O	P x L
Semitrailers, Single-Veh Accidents	● X			● X	X	X	●					X	
Semitrailers, Single-Veh Accidents on Urban US/State highways		● X		●	● X					● X			
Collisions between Semitrailers and Passenger Vehicles	● X	X	● X					X					
S-U Trucks, Single-Veh Accidents	● X		● X		● X	X							
Collisions between S-U Trucks and Passenger Vehicles	● X	● X	● X	● X				● X	X		● X		X

● Odds of fatal and incapacitating-injury accidents

X Odds of non-incapaciatating-injury accidents

It was noted that intersection-related did not show significant effect on accident severity with one notable exception--it appeared, at this variable-selection stage, to be significant for single-vehicle accidents involving semitrailers on Urban US/State highways. This led to two sets of model estimation for this subset in order to appropriately account for the effect of intersection-related. These are described below.

Model Estimation Excluding Urban US/State Highways

Table E1 is a contingency table of single-vehicle accidents involving semi-trailers, cross-classified by severity, road class, object struck, and pavement surface condition. Urban US/State highways were not included in this table due to their exceptional difference from other five road classes as noted above. Model estimation for Urban US/State highways was therefore conducted separately.

The estimated odds of fatal or incapacitating injury accidents, as well as the estimated odds of non-incapacitating injury accidents are shown in Table E2. The estimated odds of fatal or incapacitating injury accidents represented a ratio of the number of fatal or incapacitating injury accidents to the number of all other accidents. For example, the estimated odds of fatal or incapacitating injury accidents for non-collision accidents on dry pavements on rural interstate highways were 0.17. This implied that for every 100 such accidents that did not result in fatalities or incapacitating injuries, there were another 17 such accidents that did. Therefore, approximately one out of every 7 non-collision accidents on dry pavements on rural interstate highways might be expected to result in fatalities or incapacitating injuries. The estimated odds of non-incapacitating injury accidents for the same accidents were found to be 0.488. This implied that for those accidents that did not involve fatalities or incapacitating injuries, about 49 might still be expected to result in non-incapacitating injuries while another 100 might be expected to cause property damage only.

Table E-1

Single-Vehicle Accidents of Semitrailers

Pavement Surface Condition	Object Struck	Road Class	Number of Accident Involvements		
			Fatal or Incap. Injury (m_1)	Non-Incap. Injury (m_2)	P.D.O. (m_3)
Dry	None	Rural Interstate	29	58	113
		Rural US/State	41	114	229
		FM	28	97	134
		Urban Interstate	10	33	71
		City Streets	2	14	46
	Fixed-Object	Rural Interstate	29	43	127
		Rural US/State	32	64	173
		FM	14	25	135
		Urban Interstate	14	76	169
		City Streets	0	21	394
Wet	None	Rural Interstate	10	37	111
		Rural US/State	23	81	207
		FM	5	15	31
		Urban Interstate	5	19	45
		City Streets	1	1	14
	Fixed-Object	Rural Interstate	7	17	33
		Rural US/State	12	41	113
		FM	4	7	42
		Urban Interstate	12	58	68
		City Streets	2	5	46

Model Estimation for Urban US/State Highways

Table E3 shows single-vehicle accidents of semitrailers on urban US/State highways, cross-classified by severity, object struck, pavement surface condition, and intersection-related. Table E4 shows the estimated odds of fatal or incapacitating injury accidents, as well as the estimated odds of non-incapacitating injury accidents.

Subset II: Collisions Between Semitrailers and Passenger Vehicles

In 1984, there were 12,235 reported collisions between semi-trailers and passenger vehicles which were not on entrance or exit ramps. Passenger vehicles included passenger cars and pickups. There were 923 (7.5 percent) fatal or incapacitating-injury accidents, 2,914 (23.8 percent) non-incapacitating injury accidents, and 8,398 (68.6 percent) PDO accidents.

Of the seven independent variables considered, the following were found to be significant in the variable-selection stage:

1. Light Condition
2. Road Class
3. Intersection Related

On the other hand, those which were found to be non-significant were driver age, object struck (cars or pickups), vehicle body style, and pavement surface condition.

Table E5 shows accident involvements of semi-trailers in collisions with passenger vehicles, crossed classified by severity, road class, intersection-related, and light condition. Table E6 shows the estimated odds of fatal or incapacitating injury accidents, as well as the estimated odds of non-incapacitating injury accidents.

Table E-2

Estimated Severity Odds for Single-Vehicle Accidents of Semitrailers

Pavement Surface Condition	Object Struck	Road Class	$\frac{m_1}{m_2 + m_3}$	$\frac{m_2}{m_3}$
Dry	None	Rural Interstate	0.170	.488
		Rural US/State	0.126	.514
		FM	0.107	.714
		Urban Interstate	0.068	.503
		City Streets	0.004	.266
	Fixed-Object	Rural Interstate	*	.347
		Rural US/State	*	.322
		FM	*	.167
		Urban Interstate	*	.506
		City Streets	*	.057
Wet	None	Rural Interstate	0.086	.356
		Rural US/State	0.079	.375
		FM	0.095	.523
		Urban Interstate	0.090	.367
		City Streets	0.046	.190
	Fixed-Object	Rural Interstate	*	.479
		Rural US/State	*	.443
		FM	*	.228
		Urban Interstate	*	.696
		City Streets	*	.078

* Same as above entries

$m_1/(m_2+m_3)$ is the odds of fatal or incapacitating injury accidents

m_2/m_3 is the odds of non-incapacitating injury accidents

Table E-3

Single-Vehicle Accidents of Semitrailers on Urban US/State Highways

Intersection	Pavement Surface Condition	Object Struck	Number of Accident Involvements		
			Fatal or Incap. Injury (m_1)	Non-Incap. Injury (m_2)	P.D.O. (m_3)
Yes	Dry	None	10	29	65
		Fixed-Object	0	11	209
	Wet	None	0	6	21
		Fixed-Object	0	6	40
No	Dry	None	11	31	69
		Fixed-Object	13	37	178
	Wet	None	2	25	54
		Fixed-Object	3	23	67

Table E-4

Estimated Severity Odds for Single-Vehicle Accidents of Semitrailers on Urban US/State Highways

Intersection	Pavement Surface Condition	Object Struck	$\frac{m_1}{m_2 + m_3}$	$\frac{m_2}{m_3}$
Yes	Dry	None	.097	.407
		Fixed-Object	0 [a]	.068
	Wet	None	.031	*
		Fixed-Object	0 [a]	*
No	Dry	None	.106	.456
		Fixed-Object	.066	.245
	Wet	None	.031	*
		Fixed-Object	.020	*

* Same as above entries

a Very small odds

$m_1/(m_2+m_3)$ is the odds of fatal or incapacitating injury accidents

m_2/m_3 is the odds of non-incapacitating injury accidents

Table E-5

Collisions Between Semitrailers and Passenger Vehicles

Light Condition	Intersection	Road Class	Number of Accident Involvements: Fatal or Incap. Injury (m_1)	Non-Incap. Injury (m_2)	P.D.O. (m_3)
Day	Yes	Rural Interstate	4	24	83
		Rural US/State	69	99	227
		FM	28	88	253
		Urban Interstate	22	135	662
		Urban US/State	88	436	1497
		City Streets	15	174	809
	No	Rural Interstate	33	81	217
		Rural US/State	119	152	352
		FM	30	108	268
		Urban Interstate	44	467	1125
		Urban US/State	50	274	918
		City Streets	14	135	626
Night	Yes	Rural Interstate	4	8	14
		Rural US/State	34	45	44
		FM	11	12	37
		Urban Interstate	12	35	105
		Urban US/State	54	92	206
		City Streets	10	33	73
	No	Rural Interstate	42	68	106
		Rural US/State	99	85	115
		FM	33	55	61
		Urban Interstate	51	166	299
		Urban US/State	50	100	216
		City Streets	7	41	83

Table E-6

Estimated Severity Odds for Collisions Between Semitrailers and Passenger Vehicles

Light Condition	Intersection	Road Class	$\frac{m_1}{m_2 + m_3}$	$\frac{m_2}{m_3}$
Day	Yes	Rural Interstate	.084	.300
		Rural US/State	.194	.475
		FM	.084	.322
		Urban Interstate	.031	.204
		Urban US/State	.048	.288
		City Streets	.019	.222
	No	Rural Interstate	*	.381
		Rural US/State	*	.438
		FM	*	.438
		Urban Interstate	*	.395
		Urban US/State	*	.295
		City Streets	*	.230
Night	Yes	Rural Interstate	.250	.496
		Rural US/State	.382(a)	.780
		FM	.253	.526
		Urban Interstate	.092	.333
		Urban US/State	.145	.472
		City Streets	.056	.364
	No	Rural Interstate	*	.623
		Rural US/State	*	.717
		FM	*	.719
		Urban Interstate	*	.646
		Urban US/State	*	.482
		City Streets	*	.376

* Same as above entries

(a): outlier, the value shown is the observed odds.

$m_1/(m_2+m_3)$ is the odds of fatal or incapacitating injury accidents

m_2/m_3 is the odds of non-incapacitating injury accidents

Subset III: Severity of Single-Vehicle Accidents Involving SU Trucks

In 1984, there were 3,930 reported single-vehicle accidents involving SU trucks which were not on entrance or exit ramps. Of these, 452 (11.50 percent) were fatal or incapacitating-injury accidents, 1,300 (33.02 percent) were non-incapacitating-injury accidents, and 2,178 (55.42 percent) were PDO accidents.

Of the seven independent variables considered, the following were identified as significant variables in the variable-selection stage:

1. Road Class
2. Light Condition
3. Object Struck

Those variables which were found to be non-significant in the variable selection were driver age, pavement surface condition, vehicle body style, and intersection-related.

Table E7 shows single-vehicle accidents involving SU trucks cross-classified by severity, road class, object struck, and light condition. Table E8 shows the estimated odds of fatal or incapacitating injury accidents, as well as the estimated odds of non-incapacitating injury accidents.

Subset IV: Severity of Collisions Between SU Trucks and Passenger Vehicles.

In 1984, there were 25,384 reported collisions between SU trucks and passenger vehicles which were not on entrance or exit ramps. Of these, 879 (3.46 percent) were fatal or incapacitating-injury accidents, 6,294 (24.80 percent) were non-incapacitating injury accidents, and 18,211 (71.74 percent) were PDO accidents.

Of the seven independent variables considered, the following were found to be significant in the variable-selection stage:

Table E-7

Single-Vehicle Accidents of Single-Unit Trucks

Light Condition	Object Struck	Road Class	Number of Accident Involvements: Fatal or Incap. Injury (m_1)	Non-Incap. Injury (m_2)	P.D.O. (m_3)
Day	None	Rural Interstate	15	19	33
		Rural US/State	29	60	101
		FM	56	156	145
		Urban Interstate	8	30	27
		Urban US/State	9	74	55
		City Streets	16	63	58
	Fixed-Object	Rural Interstate	2	13	13
		Rural US/State	19	30	62
		FM	28	77	160
		Urban Interstate	9	66	103
		Urban US/State	12	51	179
		City Streets	15	101	350
Night	None	Rural Interstate	12	12	16
		Rural US/State	23	32	37
		FM	37	79	81
		Urban Interstate	3	11	8
		Urban US/State	4	34	17
		City Streets	13	36	38
	Fixed-Object	Rural Interstate	4	9	17
		Rural US/State	16	29	43
		FM	48	91	130
		Urban Interstate	23	38	71
		Urban US/State	18	48	107
		City Streets	31	137	288

Table E-8

Estimated Severity Odds of Single-Vehicle Accidents for Single-Unit Trucks

Light Condition	Object Struck	Road Class	$\frac{m_1}{m_2 + m_3}$	$\frac{m_2}{m_3}$
Day	None	Rural Interstate	.225	.580
		Rural US/State	.209	.620
		FM	.174	.957
		Urban Interstate	.132	1.103
		Urban US/State	.080	1.402
		City Streets	.073	.942
	Fixed-Object	Rural Interstate	.147	.646
		Rural US/State	.138	.506
		FM	.116	.515
		Urban Interstate	.088	.543
		Urban US/State	.053	.314
		City Streets	.049	.331
Night	None	Rural Interstate	.379	.739
		Rural US/State	.353	.787
		FM	.293	1.216
		Urban Interstate	.222	1.405
		Urban US/State	.134	1.787
		City Streets	.123	1.196
	Fixed-Object	Rural Interstate	.250	.831
		Rural US/State	.234	.640
		FM	.195	.654
		Urban Interstate	.148	.690
		Urban US/State	.090	.398
		City Streets	.082	.420

$m_1/(m_2+m_3)$ is the odds of fatal or incapacitating injury accidents

m_2/m_3 is the odds of non-incapacitating injury accidents

1. Light Condition
2. Road Class
3. Intersection-related
4. Pavement Surface Condition

On the other hand, those which were found to be non-significant were driver age, object struck, and vehicle body style.

Table E9 shows accident involvements of SU trucks in collisions with passenger vehicles, cross classified by severity, road class, intersection-related, pavement surface condition, and light condition. Table E10 shows the estimated odds of fatal or incapacitating injury accidents, as well as the estimated odds of non-incapacitating injury accidents.

Table E-9

Collisions Between Single-Unit Trucks and Passenger Vehicles

Light Condition	Pavement Surface Condition	Intersection	Road Class	# of Accident Involvements: Fatal or Incap. Injury (m_1)	Non-Incap. Injury (m_2)	P.D.O. (m_3)
Day	Dry	Yes	Rural Interstate	9	10	56
			Rural US/State	26	93	212
			FM	68	259	778
			Urban Interstate	26	268	809
			Urban US/State	98	744	2162
			City Streets	96	1029	2918
		No	Rural Interstate	8	19	50
			Rural US/State	52	98	276
			FM	51	241	825
			Urban Interstate	37	349	951
			Urban US/State	47	421	1376
			City Streets	25	528	2468
	Wet	Yes	Rural Interstate	1	0	5
			Rural US/State	5	16	25
			FM	3	59	137
			Urban Interstate	0	54	108
			Urban US/State	15	159	395
			City Streets	16	254	688
		No	Rural Interstate	2	5	9
			Rural US/State	5	13	58
			FM	16	59	125
			Urban Interstate	3	65	149
			Urban US/State	11	90	211
			City Streets	13	135	461
Night	Dry	Yes	Rural Interstate	0	6	13
			Rural US/State	10	30	37
			FM	22	78	140
			Urban Interstate	7	68	128
			Urban US/State	26	208	374
			City Streets	34	228	524
		No	Rural Interstate	6	7	27
			Rural US/State	25	41	46
			FM	23	79	142
			Urban Interstate	17	92	189
			Urban US/State	25	96	294
			City Streets	11	118	381
	Wet	Yes	Rural Interstate	1	1	1
			Rural US/State	1	1	9
			FM	3	21	38
			Urban Interstate	1	15	43
			Urban US/State	6	44	107
			City Streets	7	77	144
		No	Rural Interstate	0	1	7
			Rural US/State	2	8	18
			FM	3	19	34
			Urban Interstate	3	16	40
			Urban US/State	8	34	71
			City Streets	5	34	96

Table E-10

Estimated Severity Odds for Collisions Between Single-Unit Trucks and Passenger Vehicles

Light Condition	Pavement Surface Condition	Intersection	Road Class	$\frac{m_1}{m_2 + m_3}$	$\frac{m_2}{m_3}$
Day	Dry	Yes	Rural Interstate	.106	.222
			Rural US/State	.091	.427
			FM	.059	.336
			Urban Interstate	.021	.348
			Urban US/State	.032	.353
			City Streets	.025	.344
		No	Rural Interstate	.100	.322
			Rural US/State	.128	.333
			FM	.052	.305
			Urban Interstate	.028	.358
			Urban US/State	.030	.297
			City Streets	.011	.219
	Wet	Yes	Rural Interstate	.071	.250
			Rural US/State	.060	.491
			FM	.039	.388
			Urban Interstate	.014	.403
			Urban US/State	.021	.407
			City Streets	.016	.397
		No	Rural Interstate	.111	.429
			Rural US/State	.143	.440
			FM	.059	.404
			Urban Interstate	.031	.473
			Urban US/State	.033	.392
			City Streets	.012	.287
Night	Dry	Yes	Rural Interstate	.187	.242
			Rural US/State	.161	.846
			FM	.105	.585
			Urban Interstate	.038	.471
			Urban US/State	.057	.486
			City Streets	.044	.477
		No	Rural Interstate	.176	.349
			Rural US/State	.226	.660
			FM	.093	.531
			Urban Interstate	.050	.484
			Urban US/State	.053	.409
			City Streets	.020	.301
	Wet	Yes	Rural Interstate	.111	.250
			Rural US/State	.111	.786
			FM	.069	.540
			Urban Interstate	.024	.436
			Urban US/State	.038	.448
			City Streets	.029	.439
		No	Rural Interstate	.194	.379
			Rural US/State	.256	.699
			FM	.104	.559
			Urban Interstate	.055	.509
			Urban US/State	.059	.432
			City Streets	.022	.317

APPENDIX F

MANNERS OF COLLISION BETWEEN SEMITRAILERS AND PASSENGER VEHICLES

COLLISION TYPES BETWEEN SEMITRAILERS AND PASSENGER VEHICLES ON RURAL INTERSTATE HIGHWAYS

	DAY	NIGHT	TOTAL
ANGLE	45 10.18	17 7.02	62
REAR-END	116 26.24	101 41.74	217
SIDESWIPE	169 38.24	71 29.34	240
OTHER-SAME DIREC	81 18.33	25 10.33	106
OPPOSITE DIRECTI	29 6.56	24 9.92	53
OTHER	2 0.45	4 1.65	6
TOTAL	442	242	684

COLLISION TYPES BETWEEN SEMITRAILERS AND PASSENGER VEHICLES ON RURAL US/STATE HIGHWAYS

	DAY	NIGHT	TOTAL
ANGLE	216 21.22	102 24.17	318
REAR-END	167 16.40	76 18.01	243
SIDESWIPE	138 13.56	43 10.19	181
OTHER-SAME DIREC	328 32.22	92 21.80	420
OPPOSITE DIRECTI	167 16.40	107 25.36	274
OTHER	2 0.20	2 0.47	4
TOTAL	1018	422	1440

COLLISION TYPES BETWEEN SEMITRAILERS AND PASSENGER VEHICLES ON FARM TO MARKET

	DAY	NIGHT	TOTAL
ANGLE	208 26.84	76 36.36	284
REAR-END	64 8.26	27 12.92	91
SIDESWIPE	34 4.39	5 2.39	39
OTHER-SAME DIREC	262 33.81	55 26.32	317
OPPOSITE DIRECTI	197 25.42	45 21.53	242
OTHER	10 1.29	1 0.48	11
TOTAL	775	209	984

COLLISION TYPES BETWEEN SEMITRAILERS AND PASSENGER VEHICLES ON URBAN INTERSTATE HIGHWAYS

	DAY	NIGHT	TOTAL
ANGLE	291 11.85	83 12.43	374
REAR-END	433 17.64	162 24.25	595
SIDESWIPE	952 38.78	287 42.96	1239
OTHER-SAME DIREC	651 26.52	104 15.57	755
OPPOSITE DIRECTI	122 4.97	30 4.49	152
OTHER	6 0.24	2 0.30	8
TOTAL	2455	668	3123

COLLISION TYPES BETWEEN SEMITRAILERS AND PASSENGER VEHICLES ON URBAN US/STATE HIGHWAYS

	DAY	NIGHT	TOTAL
ANGLE	715 21.91	199 27.72	914
REAR-END	282 8.64	120 16.71	402
SIDESWIPE	565 17.32	116 16.16	681
OTHER-SAME DIREC	1317 40.36	203 28.27	1520
OPPOSITE DIRECTI	342 10.48	78 10.86	420
OTHER	42 1.29	2 0.28	44
TOTAL	3263	718	3981

COLLISION TYPES BETWEEN SEMITRAILERS AND PASSENGER VEHICLES IN CITY STREETS

	DAY	NIGHT	TOTAL
ANGLE	419 23.63	68 27.53	487
REAR-END	63 3.55	15 6.07	78
SIDESWIPE	182 10.27	28 11.34	210
OTHER-SAME DIREC	724 40.83	88 35.63	812
OPPOSITE DIRECTI	327 18.44	44 17.81	371
OTHER	58 3.27	4 1.62	62
TOTAL	1773	247	2020

APPENDIX G

SEVERITY BY MANNERS OF COLLISION BETWEEN SEMITRAILERS AND PASSENGER VEHICLES

Severity by Collision Type and Day/Night
on Rural Interstate Highways

Collision Type	Time	% Severity			Total
		Fatal	Incapacitating Injury	Other	
Angle	Day	0	6.7	93.3	45
	Night	5.9	5.9	88.2	17
Rear-end	Day	1.7	12.9	85.3	116
	Night	5.9	18.8	75.2	101
Sideswipe : same dir.	Day	0	5.9	94.1	169
	Night	0	8.5	91.5	71
Other : same dir.	Day	1.2	1.2	97.6	81
	Night	4.0	8.0	88.0	25
Opposite	Day	13.8	3.4	82.8	29
	Night	12.5	20.8	66.7	24
Other	Day	0	0	100.0	2
	Night	0	50.0	50.0	4

Severity by Collision Type and Day/Night
on Rural US/State Highways

Collision Type	Time	% Severity			Total
		Fatal	Incapacitating Injury	Other	
Angle	Day	9.7	19.4	70.8	216
	Night	10.8	26.5	62.7	102
Rear-end	Day	1.2	10.2	88.6	167
	Night	0	27.6	72.4	76
Sideswipe : same dir.	Day	2.2	8.0	89.8	138
	Night	0	7.0	93.0	43
Other : same dir.	Day	1.5	10.7	87.8	328
	Night	10.9	10.9	78.3	92
Opposite	Day	15.0	16.2	68.9	167
	Night	25.2	22.4	52.3	107
Other	Day	0	0	100.0	2
	Night	0	0	100.0	2

Severity by Collision Type and Day/Night
on Farm-to-Market Roads

Collision Type	Time	% Severity			Total
		Fatal	Incapacitating Injury	Other	
Angle	Day	1.9	8.2	89.9	208
	Night	2.6	17.1	80.3	76
Rear-end	Day	1.6	0	98.4	64
	Night	3.7	14.8	81.5	27
Sideswipe : same dir.	Day	0	0	100.0	34
	Night	0	20.0	80.0	5
Other : same dir.	Day	0.4	5.0	94.6	262
	Night	6.0	14.5	80.0	55
Opposite	Day	4.1	7.1	88.8	197
	Night	8.9	15.6	75.5	45
Other	Day	0	0	100.0	10
	Night	100.0	0	0	1

Severity by Collision Type and Day/Night
on Urban Interstate Highways

Collision Type	Time	% Severity			Total
		Fatal	Incapacitating Injury	Other	
Angle	Day	1.4	4.5	94.2	291
	Night	4.8	9.6	85.5	83
Rear-end	Day	0.9	2.3	96.8	433
	Night	3.1	14.2	82.7	162
Sideswipe : same dir.	Day	0.2	1.9	97.9	952
	Night	0.3	2.4	97.2	287
Other : same dir.	Day	0	1.8	98.2	651
	Night	1.9	4.8	93.3	104
Opposite	Day	0.8	1.6	97.5	122
	Night	10.0	16.7	73.3	30
Other	Day	0	0	100.0	6
	Night	0	0	100.0	2

Severity by Collision Type and Day/Night
on Urban US/State Highways

Collision Type	Time	% Severity			Total
		Fatal	Incapacitating Injury	Other	
Angle	Day	3.5	6.3	90.2	715
	Night	6.0	13.1	80.9	199
Rear-end	Day	0.7	1.8	97.5	282
	Night	1.7	19.2	79.2	120
Sideswipe : same dir.	Day	0.4	1.9	97.7	565
	Night	0.8	4.3	95.9	117
Other : same dir.	Day	0.3	1.5	98.2	1317
	Night	0	7.4	92.6	202
Opposite	Day	2.6	4.4	93.0	342
	Night	11.5	14.1	74.4	78
Other	Day	0	0	100.0	42
	Night	0	0	100.0	2

Severity by Collision Type and Day/Night
on City Streets

Collision Type	Time	% Severity			Total
		Fatal	Incapacitating Injury	Other	
Angle	Day	0.5	2.1	97.4	419
	Night	0	8.8	91.2	68
Rear-end	Day	0	1.6	98.4	63
	Night	5.9	5.9	88.2	17
Sideswipe : same dir.	Day	0	0.5	99.5	182
	Night	0	0	100.0	28
Other : same dir.	Day	0	0.8	99.2	724
	Night	0	3.4	96.6	88
Opposite	Day	1.5	1.5	97.0	327
	Night	2.3	11.4	86.4	44
Other	Day	0	0	100.0	58
	Night	0	0	100.0	4