To the Graduate Council:

I am submitting herewith a thesis written by Jeffrey Lee Hammond entitled "Daytime Effects of Raised Pavement Markers on Horizontal Curves." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Civil Engineering.

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and recommend its acceptance:

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Associate Vice Chancellor and
Dean of The Graduate School

DAYTIME EFFECTS OF RAISED PAVEMENT MARKERS ON HORIZONTAL CURVES

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Jeffrey Lee Hammond
December 1999

DEDICATION

"Be anxious for nothing, but in everything by prayer and supplication, with thanksgiving, let your requests be made known to God; and the peace of God, which surpasses all understanding, will guard your hearts and minds through Christ Jesus."

Philippians 4: 6,7

ACKNOWLEDGMENTS

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I would also like to thank the Southeastern Transportation Center whose generous financial support has enabled me to attain this educational goal.

Lastly, I owe the greatest thanks to my parents, Dr. Mike Hammond and Dr. Carol Hammond whose strong example and unfailing encouragement have brought the desire to attain excellence in all aspects of life.

ABSTRACT

A large number of vehicle crashes occur every year on the horizontal curves found on many of America's rural two-lane highways. Of these, a significant number can be attributed to the encroachment of a vehicle into the opposing lane of traffic. While multiple factors may contribute in forming these hazardous road segments, most are not corrected due to economic considerations. The purpose of this study is to note the driver response to the application of raised pavement markers by measuring the changes in speed and encroachment distance after varying the spacing intervals of these markers. All data was collected in dry, daylight conditions and thereby testing the "rumble effect" of the markers rather than their reflective delineation qualities. It is found here that daytime encroachment levels can be significantly reduced by an optimal marker spacing (40 feet) though operating speeds are generally not affected.

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Chapter I. Introduction

Background

High speeds and rapidly increasing vehicle volumes characterize America's rural two-lane arterial highways. These features, combined with mid- to short-radius horizontal curves and limited sight distances, can create hazardous road conditions for the motoring public. These highways may or may not exhibit high accident numbers or rates but are usually described by the road users as dangerous due to near misses or other experiences. Problems often occur on stretches characterized by yellow solid double-line striping on which no passing is allowed in either direction. In negotiating sudden and/or sharp horizontal curves, vehicles on the outside of the curve tend to encroach upon the opposing travel lane. If performed at an inopportune time, this action may prove to be the cause of crashes causing property damage, injury, or death. Roadway features or conditions such as poor striping visibility, narrow lanes, limited shoulder width, roadside hazards, and wet or polished pavement all tend to compound the likelihood and severity of these crashes. However, the implementation of a simple control measure on the curve to encourage speed reduction and less lane encroachment is a much needed safety improvement on many rural 2-lane, 2-way minor arterials.

Objective

This study attempts to characterize and modify motorist behavior upon encountering mid- to short-radius curves where sight distance is limited. More specifically, this research will note driver reaction to two variations on a single control measure (the use of raised pavement markers) and will be evaluated by changes, if any, in vehicle speed and encroachment distance on the curve. Two locations in rural Knox County, Tennessee will be used for the study.

Limitations

While the results and conclusions of this study may be generalized to many similar road locations, good judgement should be exercised in doing so due to the following research limitations:

- This study is limited to two sites on rural minor arterials. These sites display several differences, most notably different curve radii.
- Measured speeds may contain some relative error due to restrictions inherent to the sites.
- While some adjustment period was provided for the control measures, thereby eliminating the novelty effect of the changes, time constraints prohibit long-range evaluation of the sites.
- Sight distance inconsistencies due to seasonal vegetation may affect encroachment measurements.

Chapter II. A Review of the Pertinent Literature

History

In the past, many rural roadways were used primarily as farm-to-market routes with some inter-city travel occurring on larger highways. Though traffic volumes utilizing these roads continued to grow dramatically, the infrastructure did so sparingly or not at all. Today, these highways commonly are classified as major and minor rural arterials; nevertheless, their characteristics often do not reflect the advances made in the vehicles traveling them.

Accidents

In 1994 it was estimated that approximately 75 percent of all non-collision crashes occurred in rural areas, making up 88 percent of the non-collision fatalities that year (Martz, 1994). Ten years earlier, USDOT had published the following safety figures pertaining to two-lane rural highways in the United States (Brinkman et al, 1984).

- Two-lane rural highways represent 97 percent of rural mileage and 80 percent of all highway miles.
- 66 percent of all rural highway travel and 30 percent of all highway travel occurs on rural two-lane roads.
- An estimated 38 percent of rural two-lane roads have ADT volumes of less than 50 vpd, and some 80 percent have ADTs less than 400 vpd.

- These roads have higher percentages of head-on collisions and single-vehicle crashes than any other type of rural road.
- The likelihood of an accident is highest at intersections, horizontal curves, and bridges. However, compared to other rural roads, two-lane highways have a lower percentage of conflicts at intersections and a higher percentage on curves.

The FHWA's current highway statistics (1997) show that of the nation's 3.9 million miles, 137,500 (28%) are rural minor arterials (RMAs) (see Figure 1). The state of Tennessee classifies 3,400 of its 86,000 miles (25%) as RMAs (see Figure 2). Nationwide, these roads carry 157 billion (16%) of the total 2.5 trillion annual vehicle miles (see Figure 3). Tennessee estimates that 5.4 billion out of 58 billion (11%) annual vehicle-miles are traveled on minor arterials in rural areas (see Figure 4). Aside from high volumes, vehicle types negotiating these roadways also play an important role in accident occurrence. On Tennessee's RMAs, 92.6 percent of traffic consists of passenger cars and other 2-axle, 4 tired vehicles. Trucks with 6 or more tires make up 6.6 percent of the road users. While passenger vehicles are smaller, requiring less width in a traveled lane, their speeds tend to be higher, sometimes resulting in more severe opposing lane encroachment at horizontal curves.

Certainly, RMAs are some of the most accident-prone roads with many factors leading to these statistics. While a significant number of these crashes are collisions with fixed objects or other roadside features, improvements to the roadway itself may assist in

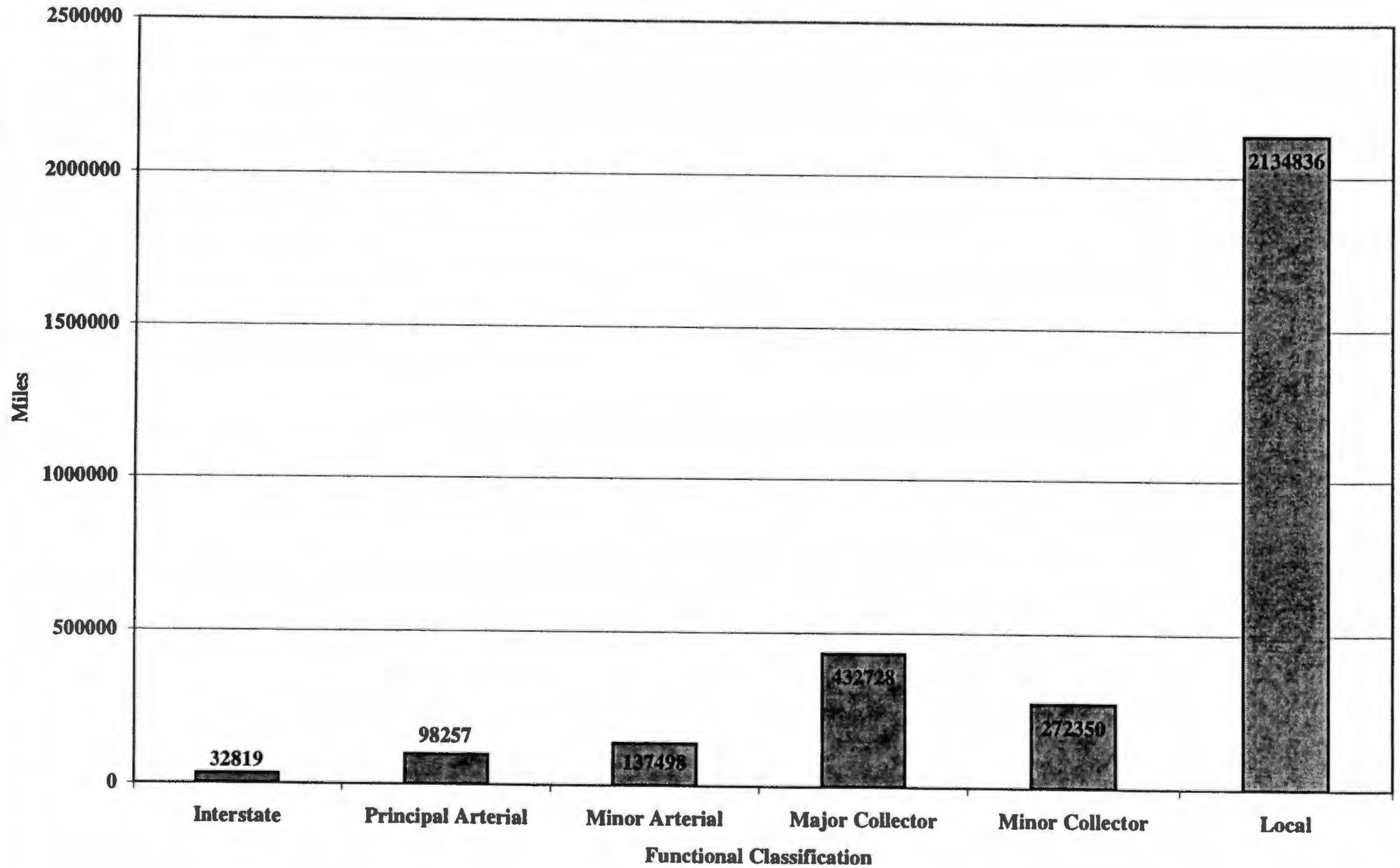

Figure 1. US Rural Roads - Miles by Functional Classification.
(Source: USDOT. Federal Highway Administration. Highway Statistics 1997. Office of Highway Information Management.)

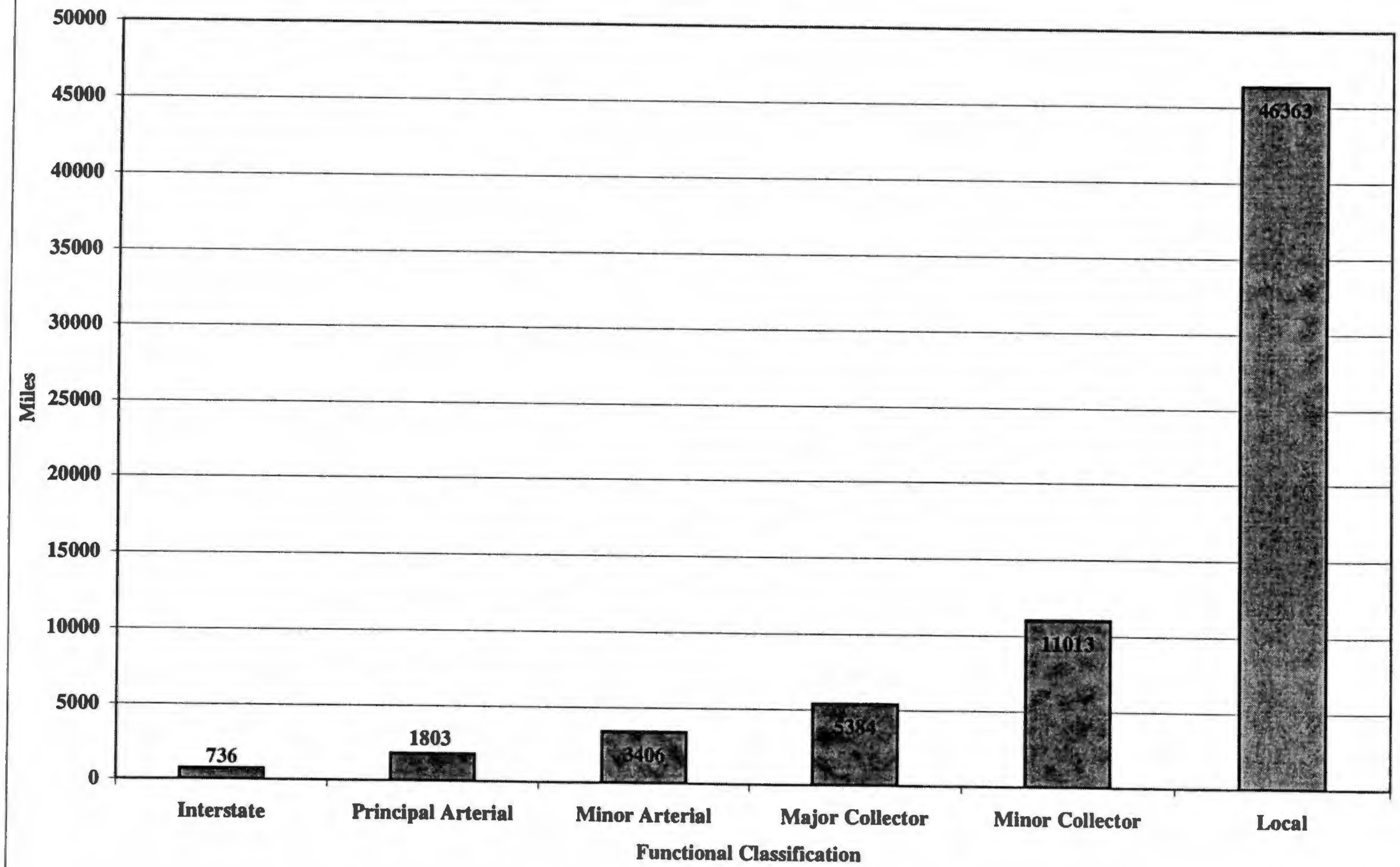

Figure 2. Tennessee Rural Roads - Miles by Functional Classification.
(Source: USDOT. Federal Highway Administration. Highway Statistics 1997. Office of Highway Information Management.)

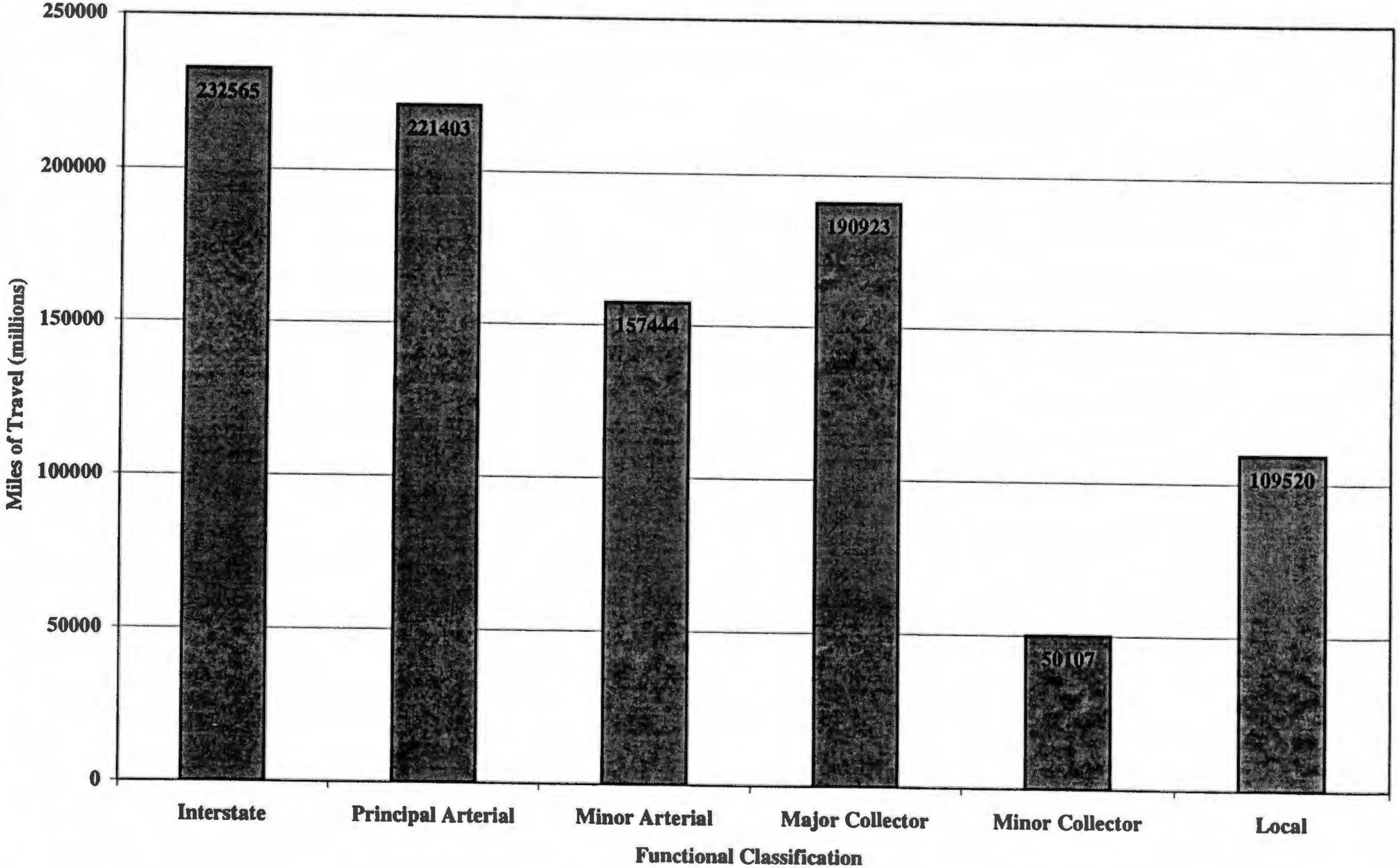

Figure 3. US Rural Roads - Annual Vehicle-Miles of Travel.
(Source: USDOT. Federal Highway Administration. Highway Statistics 1997. Office of Highway Information Management.)

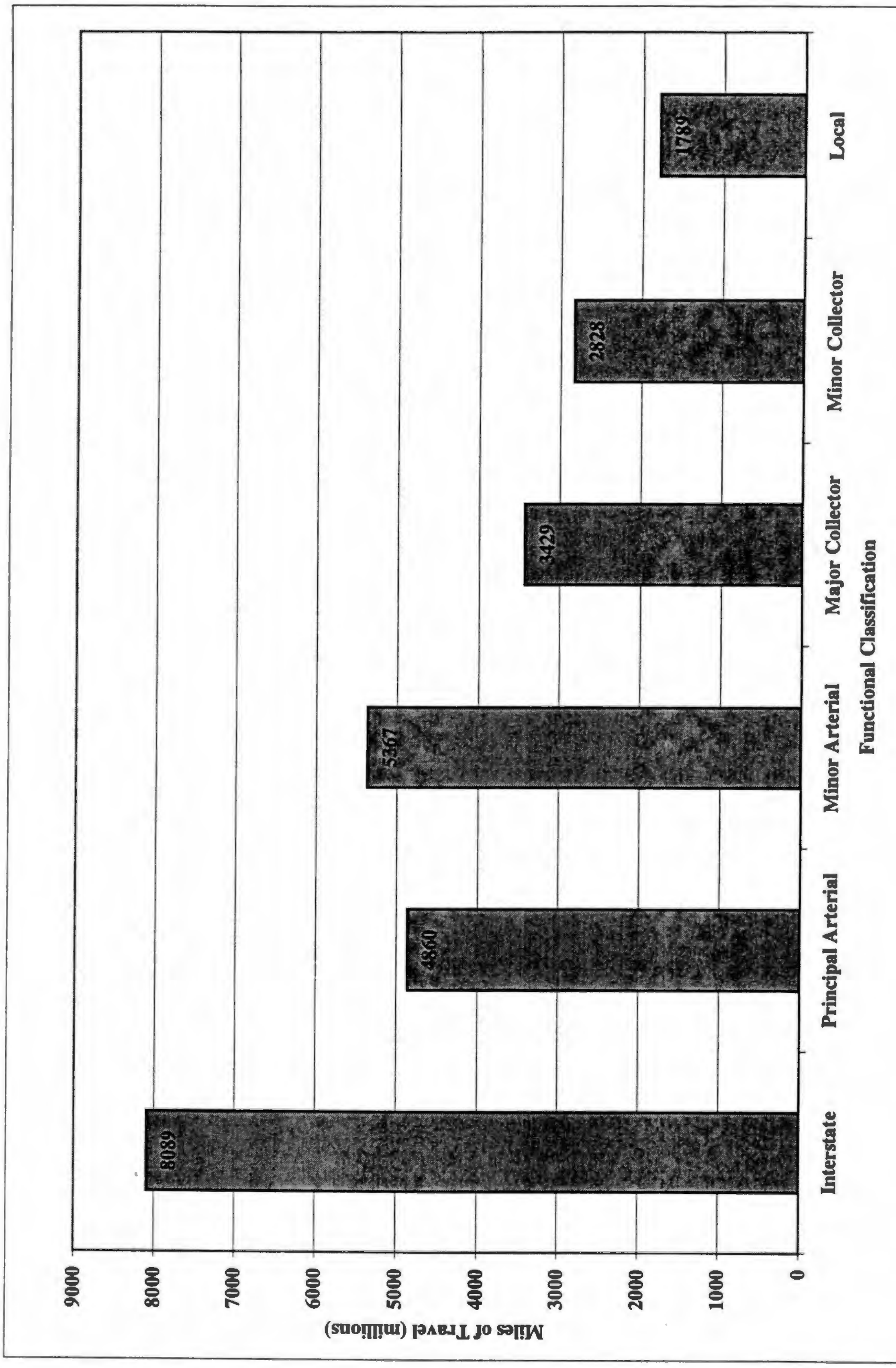

Figure 4. Tennessee Rural Roads - Annual Vehicle-Miles of Travel.
(Source: USDOT. Federal Highway Administration. Highway Statistics 1997. Office of Highway Information Management.)

lowering the accident numbers at hazardous road locations. In order to fully understand the performance of the driver-vehicle system in negotiating a curve, it is important to first understand the design criteria and current theory of operation at these locations.

Horizontal Curves

AASHTO's "A Policy on Geometric Design of Highways and Streets" (1990) states, "A smooth, flowing alinement is desirable on a rural arterial. Changes, in alinement, both horizontal and vertical, should be so gradual that the driver will not be surprised by any of the changes." The circular path of the vehicle around the curve is governed by the rate of roadway superelevation, the side friction factor, the speed of the vehicle, and the radius of curvature. Generally, however, the use of design speed on a given roadway is the primary vehicle control in the negotiation of horizontal curves (AASHTO, 1990). While alinement corrections to under-designed rural roadways would prove most beneficial, construction costs are often prohibitive.

The alinements of most RMAs have never been modified even though average operating speeds on the these roads have increased by as much as 5 miles per hour over the past fifteen years (Islam et al, 1994). These design inconsistencies have initiated many studies concerning speed-curvature relationships. While parameters such as those mentioned by AASHTO are major functions of the speed-curve relationship, research shows that speed differentials between tangent and curved sections play a crucial role in determining the relative safety and consistency of the roadway (Islam et al, 1994).

Road Markings

Several studies have been performed to evaluate the effectiveness of traditional pavement markings such as reflective paint while others involve the motorists' perception of and reaction to certain types of roadway delineation. Al-Masaeid and Sinha (1994) estimated that the application of painted markings at hazardous sites resulted in an accident reduction factor of 13.5%. The 1986 evaluation by Good and Baxter concluded that motorists favored continuous treatments such as a painted centerline over discrete ones such as chevrons. Relating to the current study, raised pavement markers guiding the motorists around a curve may prove more beneficial than painted lines, advance warning signs, speed advisories, or any combination of these.

Widespread use of raised pavement markings (RPMs) began in the 1950's and, though often modified, have been consistently used up to the present. While no guidelines currently mandate the use of RPMs, they have been utilized predominately on Interstate highways and have been shown to increase safety through added delineation where applied. Research on the subject has shown that markings on the roadway receive much more attention from the driver than do lateral signs (OECD, 1975) and provide more guidance than typical roadway markings.

Visual cues about the roadway are delivered by highly visible colored plastic casing and the retro-reflective lens of the reflective RPM. The color of these components depends on their placement and conforms to normal usage as defined by the MUTCD. Also, the rumble effect of the markers alerts the motorist that the vehicle has traveled outside of the assigned traffic lane.

Research involving the use of RPMs at high accident locations has been performed to evaluate both the additional delineation of the roadway provided by these markings and the effect of the markers on encroachment. Pigman and Agent in 1979 found that the RPM application resulted in a small decrease in mean operating speeds, while the 85th percentile speed remained constant. However, they also found that moderate and severe levels of daytime opposing-lane encroachment dropped significantly. Earlier research performed by Stimpson (1977) in evaluating various continuous delineation systems suggested that the application of RPMs decreased nighttime speeds by up to 35%.

Chapter III. Plan and Procedures of the Study

Research Hypotheses

A review of the pertinent literature has shown that hazardous horizontal curves may be improved by the application of additional delineation. Traditionally, these marking systems have been used either in advance of the curve to provide ample warning to the motorist who may not be aware of the changing alinement, or at the curve location with retro-reflective RPMs to increase the nighttime visibility of the changing alinement. It has also been stated that many characteristics of the driver-vehicle system combine to create a hazardous location, though possibly none more than the changes in operating speeds and travel paths that occur as the vehicle navigates the curve. Therefore, based on the proceeding research and on anticipated driver behavior, the following research hypotheses were generated:

General Research Hypothesis. There exists a strong relationship between roadway delineation and motorist behavior in negotiating horizontal curves on rural two-lane highways.

Specific Research Hypothesis I. By installing raised pavement markers at 40 ft. intervals, daytime encroachment into the opposing travel lane can be partially corrected by means of the "rumble effect" of the raised markers.

Specific Research Hypothesis II. By shortening the traditional 40-ft. RPM spacing interval to 20 ft., vehicle encroachment will be reduced further.

Specific Research Hypothesis III. The application of RPMs at horizontal curves will lower average operating speeds throughout the entire length of the curve.

Site Selection

For this study, two sites were selected based primarily upon their functional classification as minor arterials, average operating speeds, and observed encroachment occurring at specific spots. Both may be classified as rural as they are at least 10 miles outside of the city limits of Knoxville, TN, and both predominately serve residential traffic to and from rural collectors and local roads.

Site No. 1 ~ Hardin Valley Rd. (Figures 5, 6, 7, and 8)

Resident complaints here suggested that high speeds and travel outside of the prescribed lane were causing abnormally high accident numbers (9 in 8 months), most collisions causing only property damage, but some with minor injury. It was a concern that wet pavement was the chief cause of the crashes, however, in March of 1999 15-tons of skid-resistant surface mix was placed at the site then re-striped to ensure visibility.

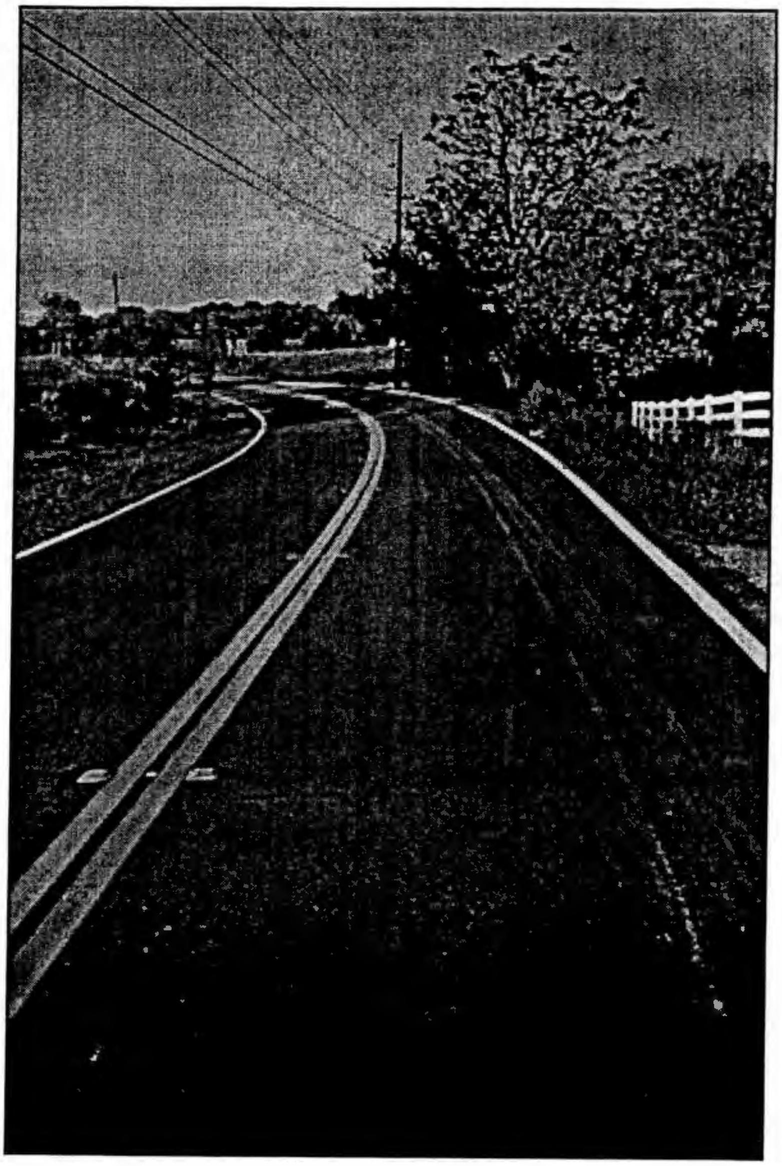

Figure 5. Horizontal curvature at the Hardin Valley Rd. site.

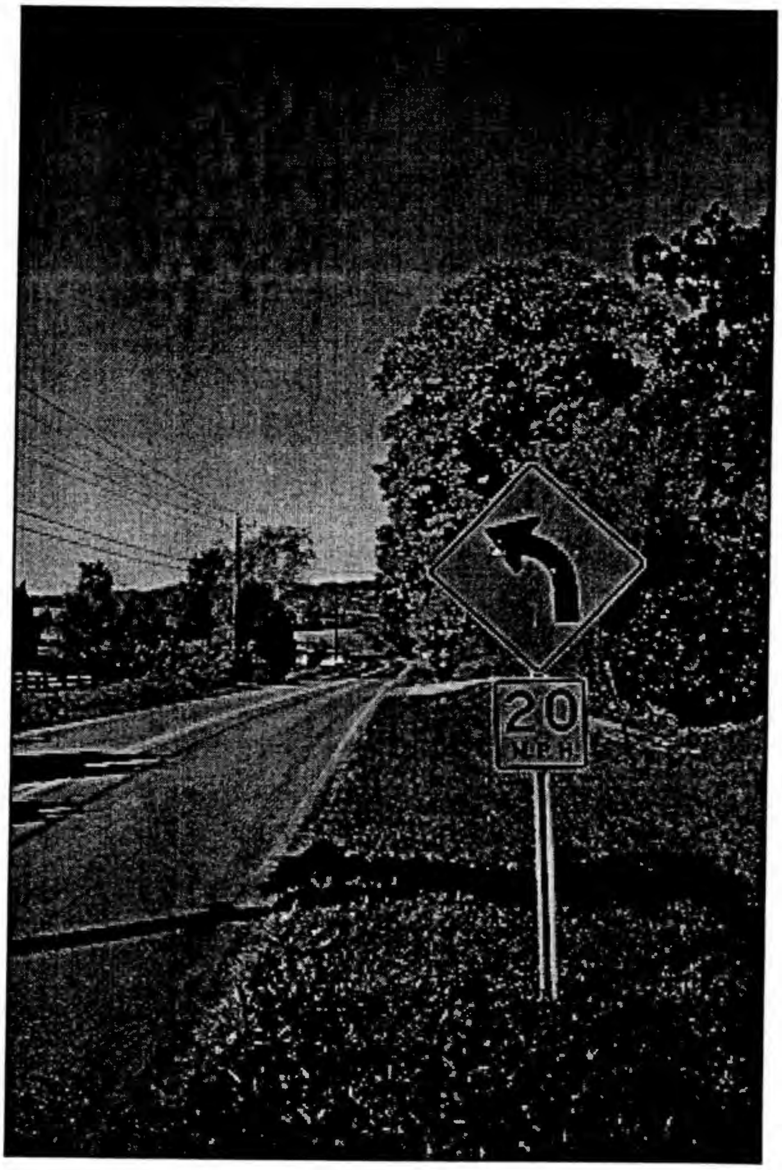

Figure 6. Signage at the Hardin Valley Rd. site. MUTCD guidelines state that a turn sign should be located here, not the existing curve sign.

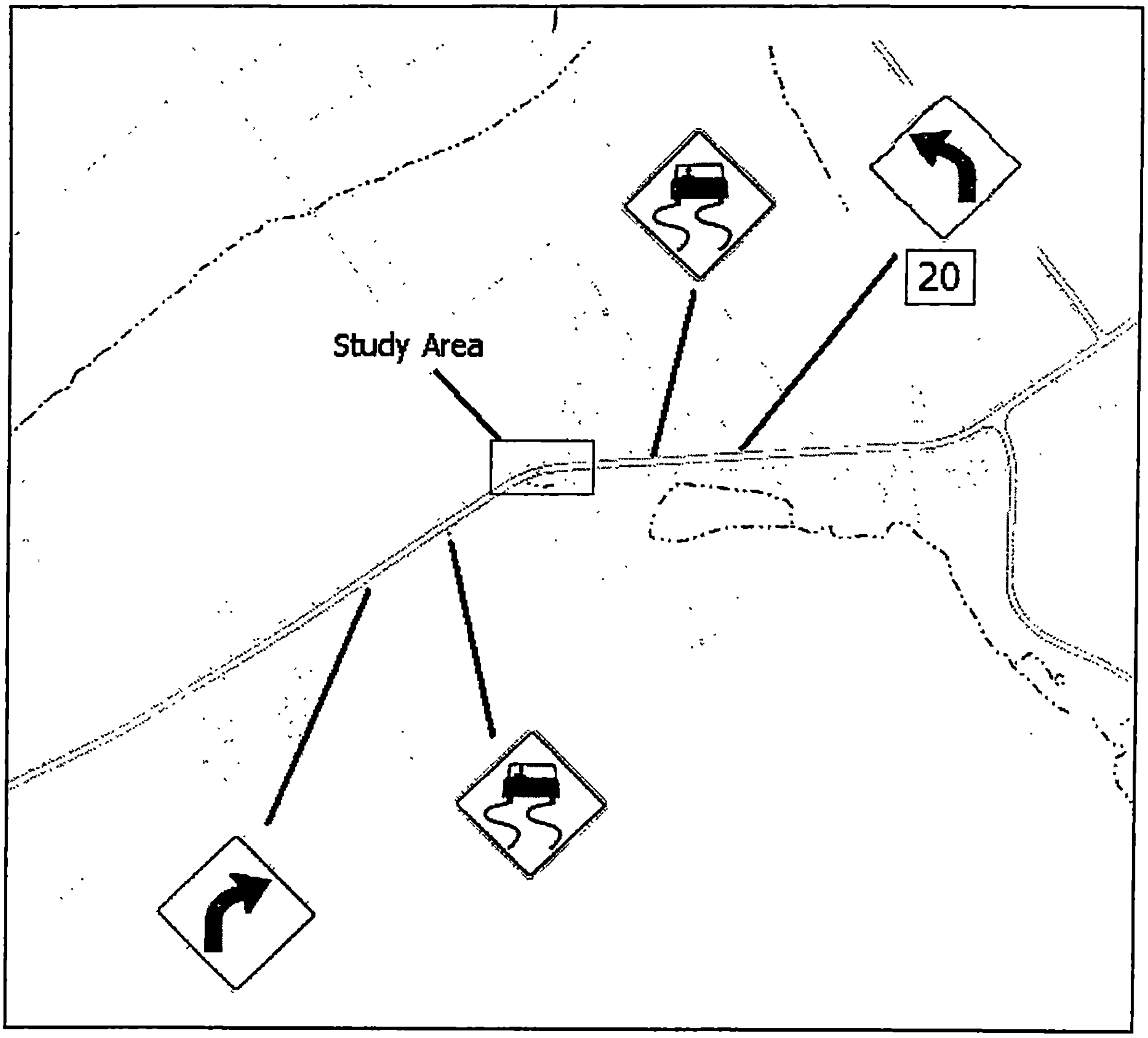

Figure 7. Warning Signs and Area of Investigation at the Hardin Valley Rd. Site.

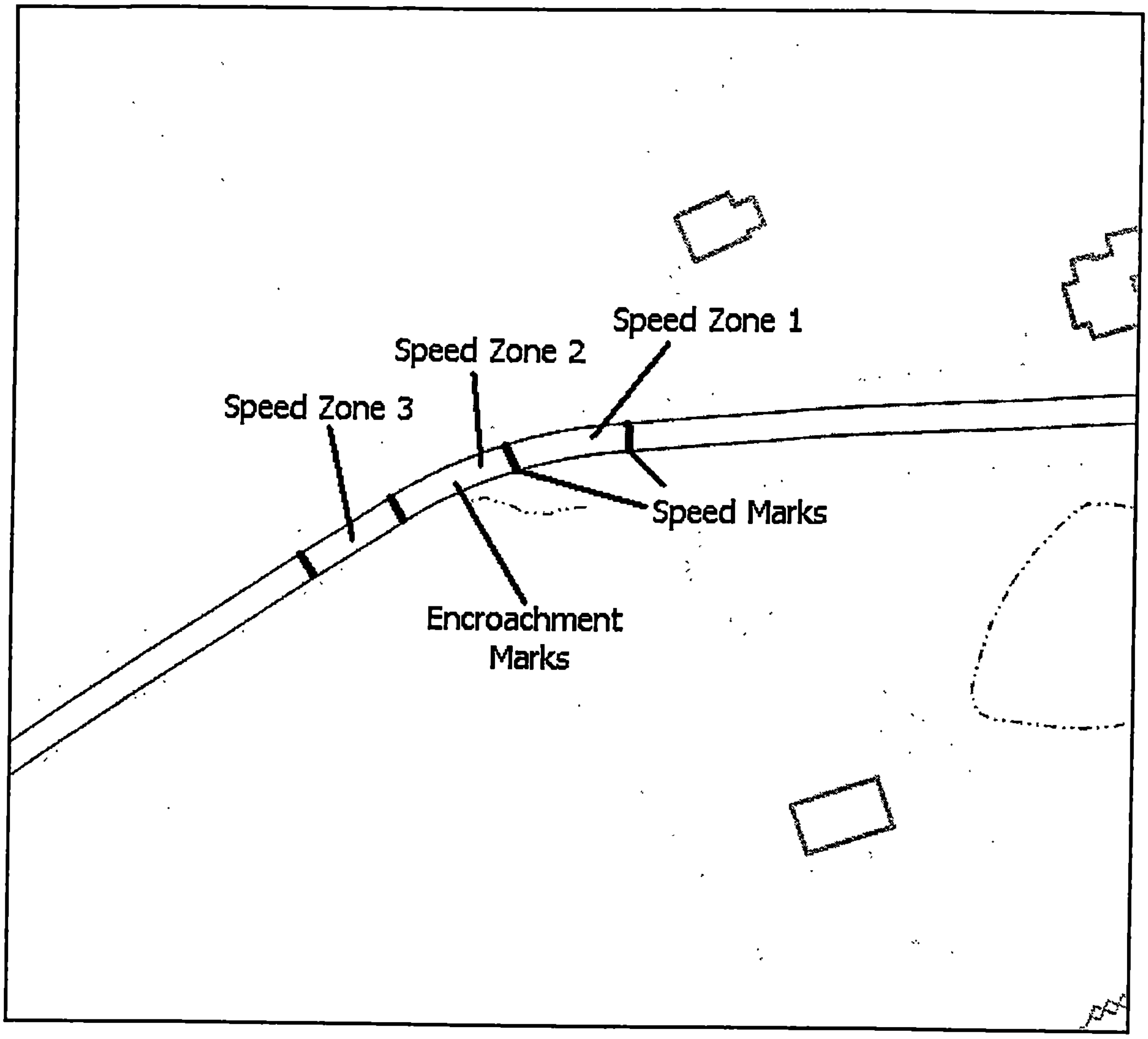

Figure 8. Study Area Configuration for the Hardin Valley Rd. Site.

Site No. 2 ~ East Emory Rd. (Figures 9, 10, 11, and 12)

An intersecting collector road in close proximity to the curve location makes vehicle conflicts here more likely. While the accident experience at this spot is not extremely high, resident concerns have been well voiced. The added vertical curvature here also makes this spot difficult to safely navigate at speeds over 30 mph.

Other features of each site are given in Table 1.

Data Collection Procedures

In evaluating the effect of the RPMs on motorist behavior, four data points were collected for each vehicle traveling through the test site. As the vehicle navigated the horizontal curve, its average speeds were calculated over three adjoining 100-ft. segments (Zones 1, 2, and 3); Zone 1 being the first segment traveled by the vehicle (see Figures 8 and 12). Upon entering and travelling at least 50 ft. into Zone 2, the distance of opposing-lane encroachment, if any, was measured. The results of these measurements are given in Chapter IV.

In order to obtain the speeds of the vehicles, four standard speed marks were placed at 100-ft. intervals around the curve. As the front wheel of the vehicle made contact with the mark, the computer program was activated to record the current time to the nearest 0.10 seconds. At the second mark, the time was again recorded; likewise for the other marks. With the distance and travel time being known, the average speed through the segments could be calculated and recorded.

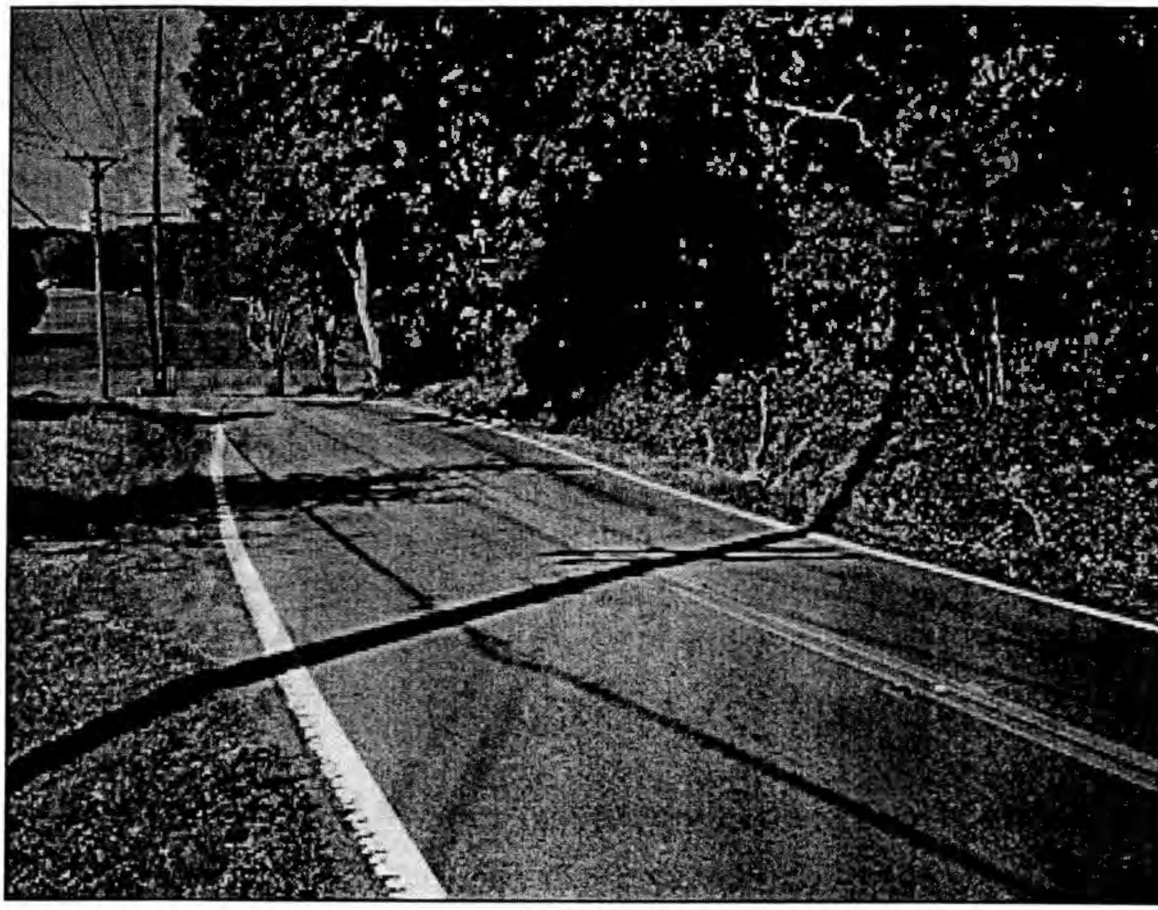

Figure 9. Horizontal curvature at the E. Emory Rd. site.

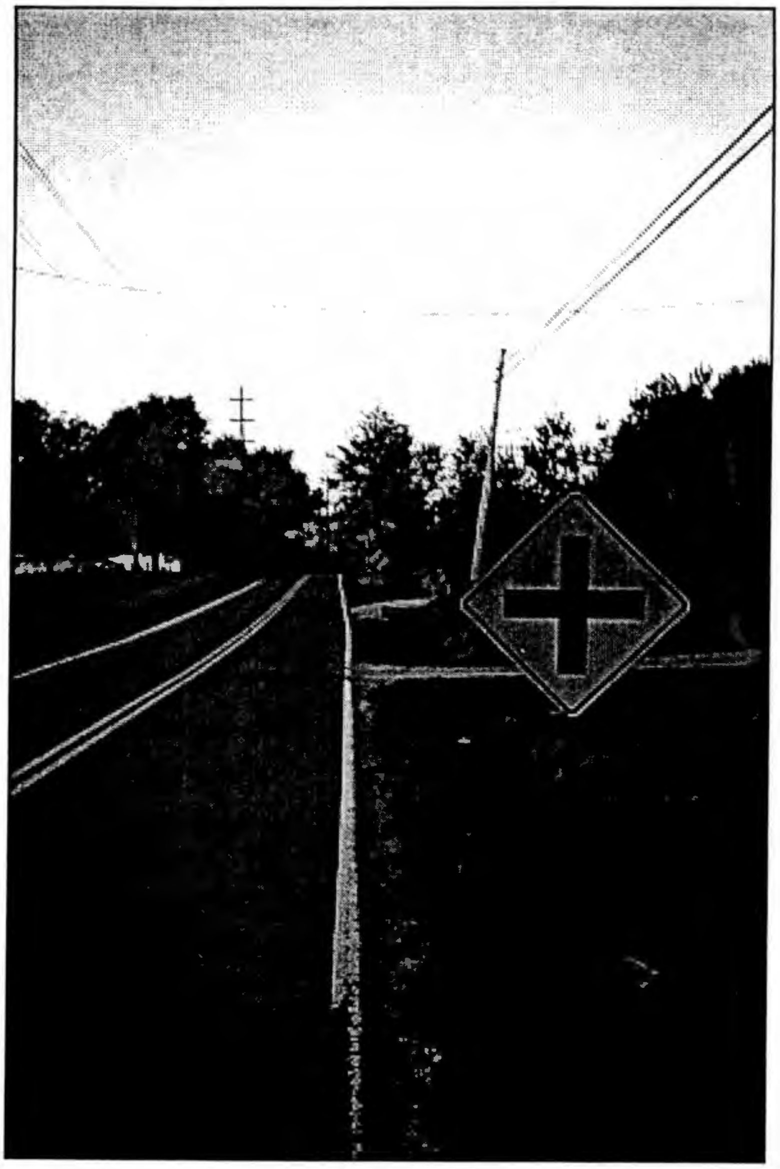

Figure 10. Signage at the E. Emory Rd. site. Note the Reverse Turn sign in the background.

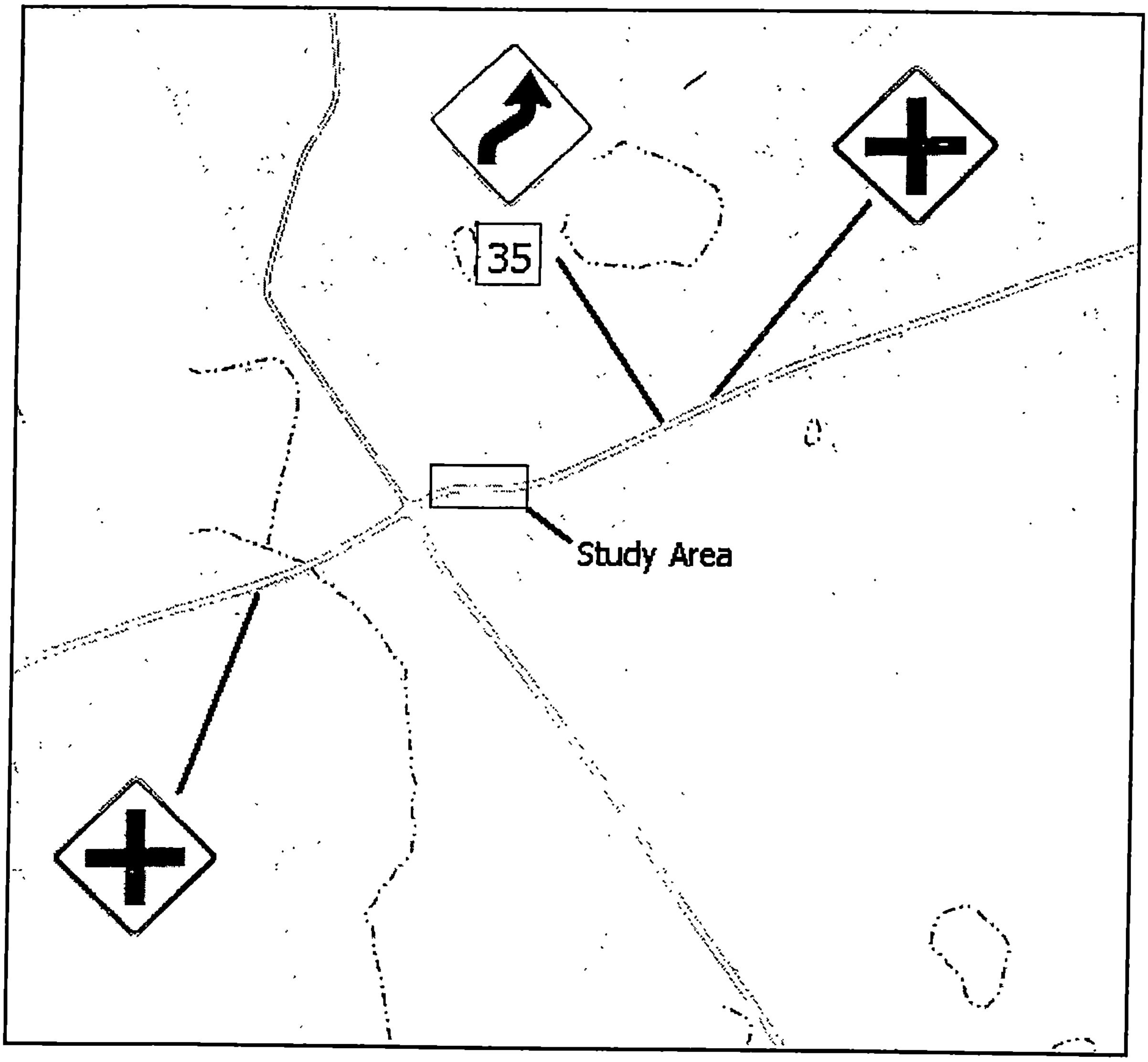

Figure 11. Warning Signs and Area of Investigation at the E. Emory Rd. Site.

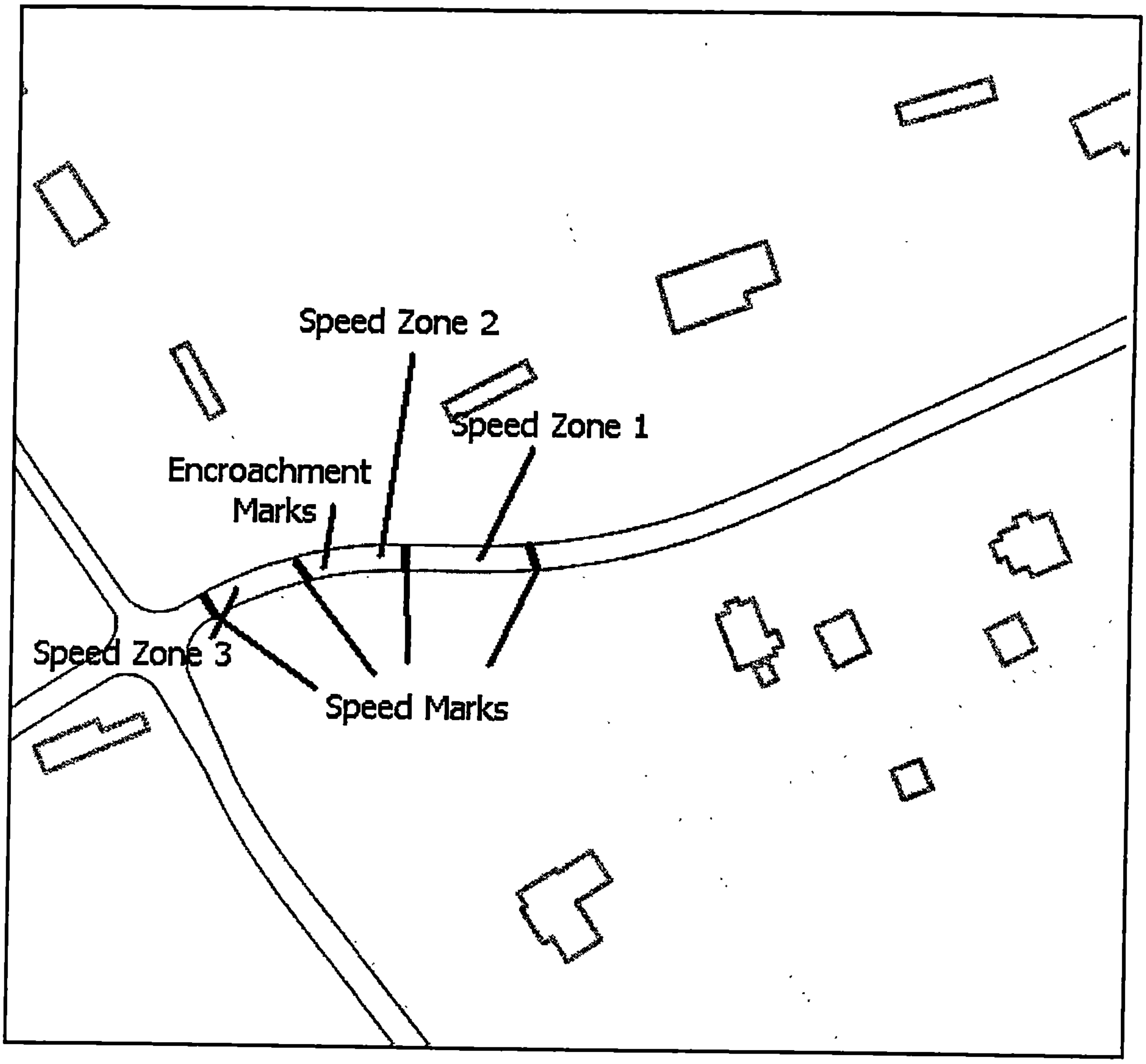

Figure 12. Study Area Configuration for the E. Emory Rd. Site.

Table 1. Relevant Features of Test Sites.

Feature	Hardin Valley Rd. Site	E. Emory Rd. Site
Length of Curve, ft.	168	270
Radius of Curve, ft.	290	425
Sight Distance[1], ft.	350	266
Lane Width, ft.	10	10
Average Daily Traffic, vpd	5400	3800
Posted Speed Limit, mph	40	40
Signage	See Figure	See Figure
Pavement Condition	Excellent	Good
Striping	Good condition, center and edge lines	Good condition, center and edge lines

[1] Measured at point of encroachment.

While speeds were being recorded, encroachment data was simultaneously captured for every vehicle. This was accomplished by a continuously running video camera focused on 3-ft. x 4-in. longitudinal marks spaced at 4-in. intervals from the painted centerline (see Fig. 13). A frame-by-frame analysis of this video clearly revealed the level of encroachment for each vehicle. By noting the exact point of contact with the front tire and the road (with respect to the longitudinal marks), errors due to parallax were non-existent.

Sampling Procedures

Data at the sites was not collected on weekends, holidays, or during peak hours of travel. All data collection and observations were made in dry conditions during daylight hours. Vehicles with headways less than three seconds were omitted as the follower speed may have been affected by the lead vehicle's speed; neither was data for vehicles slowing for turning movements onto adjacent roads or driveways recorded. Also, all data collection devices were placed in a discrete manner such that they did not influence the operation of the vehicle. The sample population per site per RPM application was no less than 100 vehicles, yielding a total of 600 analyzed data points.

Instruments

Two instruments were used at each site to accurately capture both the speeds of the vehicle and its wheelpath without inadvertently affecting the motorists' behavior. A speed calculation program was developed for an on-site laptop computer and used in

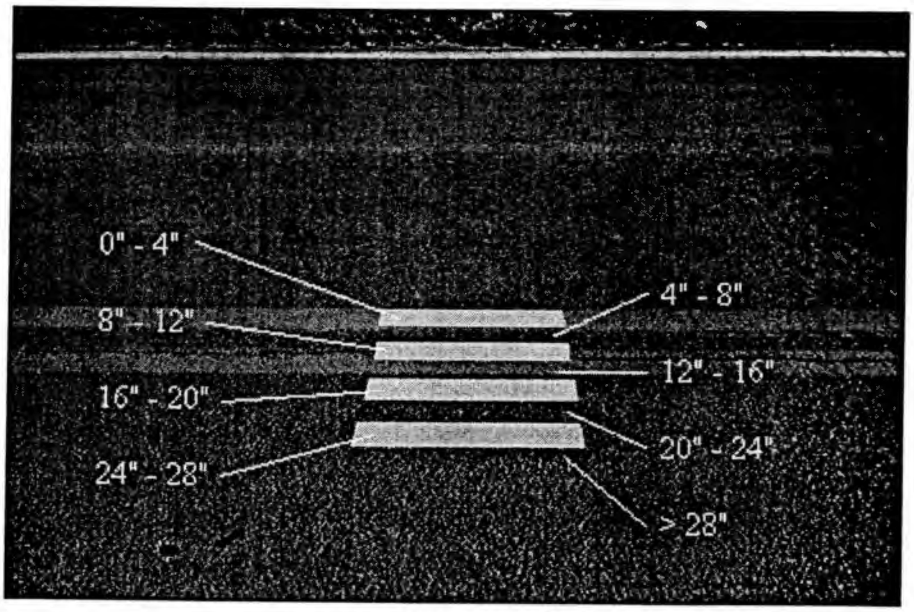

Figure 13. Arrangement of encroachment marks. These marks were used to measure the distance of travel into the opposing lane.

conjunction with standard speed markings to allow the researcher to capture average speeds over the three 100-ft. segments of the curve without using radar or road tubes that may be distracting to the driver. Also, the vehicle encroachment was measured by an analysis of film taken by a roadside video camera. Both the on-site laptop computer and camera were powered by constant supply sources.

The marker utilized in this study was a traditional non-plowable raised marker (Stimsonite LifeLite 88A). Its dimensions are 4 in. x 4 in. x 0.70 in. and is the standard amber color as prescribed by the MUTCD for centerline delineation. All markers were placed immediately outside of the painted centerline in accordance with current standard practice (see Fig. 14).

Variable

Following is the manner in which encroachment data was coded in the present study (see Figure 13 for the marking configuration). These measurements refer to distances outside of the proper travel lane:

No encroachment	0
0 in. – 4 in.	1
4 in. – 8 in.	2
8 in. – 12 in.	3
12 in. – 16 in.	4
16 in. – 20 in.	5
20 in. – 24 in.	6

Figure 14. Application of raised pavement markers.

24 in. – 28 in.	7
> 28 in.	8

The speed data calculated from measured time and known distance is presented in miles per hour. These speeds are accurate to approximately 1.0 mph as the precision of the timing device was limited to 0.10 seconds. Likewise, in test runs using a vehicle with known speed, data was generally accurate to 1 mph. The results of this study follow in Chapter IV.

Chapter IV. Results of the Study

In order to fully understand and quantify the effects of the RPM placements, the pertinent data has been analyzed using three distinct and well-recognized statistical procedures. By combining the results of both study sites, a response to the research hypotheses can be formed (see Tables 2 and 3). However, in order to more completely evaluate the driver response, the site results must be separated, thereby making differences inherent to each road segment of no effect.

Significance of the Data

In order to confirm the validity of the data, a standard variance ratio distribution (F-distribution) was performed across the four separate dependent variables (speed in Zones 1, 2, and 3 and vehicle encroachments), taking into account all 600 data points. The results of these analyses are given as Tables 4 through 7. While these tables are further explained later in this chapter, the small probability ($P<0.0001$) for all conditions should be noted here. This indicates that the probability that the speed variations experienced between sites are random occurrences is practically zero (less than a 0.01% chance). However, the F-test does not show a statistically significant difference in the speed variances with relation to the RPM applications. All vehicle encroachment data presented has been shown to be statistically important (Table 7).

Table 2. Combined Mean Results for Both Sites Under All Conditions.

			Zone 1 Speed		Zone 2 Speed		Zone 3 Speed		Encroachment	
Site	Condition	N	Mean (mph)	St. Dev.	Mean (mph)	St. Dev.	Mean (mph)	St. Dev.	Mean (levels)[1]	St. Dev.
HV	Ctrl	100	44.4	4.9326	41.3	4.4997	48.9	4.8829	4.02	3.2286
	40 ft RPM spacing	100	43.7	5.0458	41.6	5.0723	48.1	5.4881	3.01	2.9797
	20 ft RPM spacing	100	45.6	4.6385	41.9	4.6493	48.3	4.7379	2.78	3.1061
EE	Ctrl	100	38.0	4.4426	34.5	4.0051	34.8	5.4246	2.66	2.6409
	40 ft RPM spacing	100	38.6	4.5281	34.2	4.4855	33.4	4.4835	1.90	2.5995
	20 ft RPM spacing	100	38.3	4.4009	34.6	4.5157	33.6	4.4267	1.32	2.3693

[1] See Figure 13.

Table 3. Combined Statistical Results for Both Sites Under All Conditions.

Site	Condition	N	Zone 1 Speed Change	Zone 2 Speed Change	Zone 3 Speed Change	Encroachment Reduction
HV	Ctrl	100	Non-Significant	Non-Significant	Non-Significant	Significant
	40 ft RPM spacing	100	Non-Significant	Non-Significant	Non-Significant	Significant
	20 ft RPM spacing	100	Non-Significant	Non-Significant	Non-Significant	Non-Significant[1]
EE	Ctrl	100	Non-Significant	Non-Significant	Non-Significant	Significant
	40 ft RPM spacing	100	Non-Significant	Non-Significant	Non-Significant	Significant
	20 ft RPM spacing	100	Non-Significant	Non-Significant	Non-Significant	Non-Significant[1]

[1] Non-significant with respect to the 40-ft. spacing condition.

Table 4. Variance Ratio Distribution (F-distribution) for Zone 1 Speeds.

Dependent Variable: Zone 1 Speed (mph)			
F-value			55.67
Probability			<0.0001
Model Degrees of Freedom			5
Error Degrees of Freedom			594
Mean speed, Zone 1 (mph)			41.4
Population Variance	F-value	Probability	Degrees of Freedom
Between sites	269.42	<0.0001	1
Between conditions	1.77	0.1717	2

Table 5. Variance Ratio Distribution (F-distribution) for Zone 2 Speeds.

Dependent Variable: Zone 2 Speed (mph)			
F-value			75.01
Probability			<0.0001
Model Degrees of Freedom			5
Error Degrees of Freedom			594
Mean speed, Zone 2 (mph)			38
Population Variance	F-value	Probability	Degrees of Freedom
Between sites	373.77	<0.0001	1
Between conditions	0.42	0.6555	2

Table 7. Variance Ratio Distribution (F-distribution) for Vehicle Encroachment.

Dependent Variable: Encroachment Level (0 - 8)			
F-value			10.8
Probability			<0.0001
Model Degrees of Freedom			5
Error Degrees of Freedom			594
Mean Level of Encroachment			2.62
Population Variance	F-value	Probability	Degrees of Freedom
Between sites	31.98	<0.0001	1
Between conditions	10.81	<0.0001	2

Tukey Test Results

This test was likewise performed across the four dependant variables and includes all data points. The procedure defines the significant differences in the variable means in a side-by-side comparison. It may be obvious that characteristics inherent to each site will cause different driver reactions and for this reason the site comparison results are given only in the Appendix. However, it is interesting to note the mean comparisons between the control group and the different RPM spacings (Tables 8 and 9). These results will also be elaborated on further.

Analysis of Encroachment Data

By utilizing the chi-square statistic, which involves the difference between expected and observed value frequencies, an accurate evaluation of the effect of RPMs on opposing-lane encroachment can be attained. A complete analysis of the chi-square test is best undertaken by individual inspections of the various tests run; these are presented as Tables 10 through 15. These tables present total encroachment frequencies in two different forms. First, all levels of encroachment (LE) are displayed, 0 – 8, for combined sites (Table 10), Hardin Valley (Table 11), and E. Emory (Table 12). Secondly, these LEs are categorized into a "high" condition (LE 6 – 8), a "moderate" condition (LE 3 – 5), and a "low" condition (LE 0 – 2). Again, these results are given for combined sites (Table 13), Hardin Valley (Table 14), and E. Emory (Table 15). It should be noted that for the measurements taken at the E. Emory site, a relatively high probability indicates that there

Table 8. Tukey Range Test for Average Speeds (all zones).

	Zone 1 Speed (mph)		Zone 2 Speed (mph)		Zone 3 Speed (mph)	
Condition	Tukey Group[1]	Mean	Tukey Group[1]	Mean	Tukey Group[1]	Mean
Contol Data (existing road)	A	41.1810	A	37.8844	A	41.8770
40 ft. RPM spacing	A	41.1835	A	37.9168	A	40.7372
20 ft. RPM spacing	A	41.9428	A	38.2617	A	40.9656

	Zone 1 Speed (mph)	Zone 2 Speed (mph)	Zone 3 Speed (mph)
Alpha, a	0.05	0.05	0.05
Degrees of Freedom	594	594	594
Min. Significant Difference	1.0975	1.0688	1.1572

[1]Note: Means in the same zone with the same group letter are not significantly different.

Table 9. Tukey Range Test for Vehicle Encroachment Levels (0 - 8).

Condition	Tukey Group[1]	Mean
Contol Data (existing road)	A	3.34
40 ft. RPM spacing	B	2.46
20 ft. RPM spacing	B	2.05

Alpha, a	0.05
Degrees of Freedom	594
Min. Significant Difference	0.6666

[1]Note: Means in the same zone with the same group letter are not significantly different.

Table 10. Chi-Square Encroachment Frequencies for combined sites.

	lowest				Level of Encroachment				highest	
Condition	0	1	2	3	4	5	6	7	8	Value[1]
Control	55	22	20	16	17	13	10	11	36	Frequency
	80	21.333	18.667	16	11.667	7.667	9.667	6.667	28.333	Expected
	9.17	3.67	3.33	2.67	2.83	2.17	1.67	1.83	6	Percent
	27.5	11	10	8	8.5	6.5	5	5.5	18	Row Percent
	22.92	34.38	35.71	33.33	48.57	56.52	34.48	55	42.35	Column Percent
40 ft. spacing	83	17	26	16	11	5	13	5	24	Frequency
	80	21.333	18.667	16	11.667	7.667	9.667	6.667	28.333	Expected
	13.83	2.83	4.33	2.67	1.83	0.83	2.17	0.83	4	Percent
	41.5	8.5	13	8	5.5	2.5	6.5	2.5	12	Row Percent
	34.58	26.56	46.43	33.33	31.43	21.74	44.83	25	28.24	Column Percent
20 ft. spacing	102	25	10	16	7	5	6	4	25	Frequency
	80	21.333	18.667	16	11.667	7.667	9.667	6.667	28.333	Expected
	17	4.17	1.67	2.67	1.17	0.83	1	0.67	4.17	Percent
	51	12.5	5	8	3.5	2.5	3	2	12.5	Row Percent
	42.5	39.06	17.86	33.33	20	21.74	20.69	20	29.41	Column Percent

	DF	Value	Probability
Chi-Square	16	42.3955	0.0003

Sample Size : 600

[1]Frequency: number of times this level of encroachment (LE) was observed
Expected: number of expected occurrences for an even distribution across conditions (Σ LE freq/3)
Percent: frequency comparison to entire table (LE cond freq/sample size x 100)
Row Percent: percentage of occurrences for one condition across all LEs
Column Percent: percentage of occurrences for one LE across all conditions

Table 11. Chi-Square Encroachment Frequencies for the Hardin Valley Rd. site.

	lowest	Level of Encroachment							highest	
Condition	0	1	2	3	4	5	6	7	8	Value[1]
Control	24	11	6	4	7	10	4	7	27	Frequency
	32.333	10.333	7.333	8.333	6	5.667	5.667	4	20.333	Expected
	8	3.67	2	1.33	2.33	3.33	1.33	2.33	9	Percent
	24	11	6	4	7	10	4	7	27	Row Percent
	24.74	35.48	27.27	16	38.89	58.82	23.53	58.33	44.26	Column Percent
40 ft. spacing	35	6	12	9	6	4	11	2	15	Frequency
	32.333	10.333	7.333	8.333	6	5.667	5.667	4	20.333	Expected
	11.67	2	4	3	2	1.33	3.67	0.667	5	Percent
	35	6	12	9	6	4	11	2	15	Row Percent
	36.08	19.35	54.55	36	33.33	23.53	64.71	16.67	24.59	Column Percent
20 ft. spacing	38	14	4	12	5	3	2	3	19	Frequency
	32.333	10.333	7.333	8.333	6	5.667	5.667	4	20.333	Expected
	12.67	4.67	1.33	4	1.67	1	0.67	1	6.33	Percent
	38	14	4	12	5	3	2	3	19	Row Percent
	39.18	45.16	18.18	48	27.78	17.65	11.76	25	31.15	Column Percent

	DF	Value	Probability
Chi-Square	16	35.6160	0.0033

Sample Size : 300

[1]Frequency: number of times this level of encroachment (LE) was observed
Expected: number of expected occurrences for an even distribution across conditions (Σ LE freq/3)
Percent: frequency comparison to entire table (LE cond freq/sample size x 100)
Row Percent: percentage of occurrences for one condition across all LEs
Column Percent: percentage of occurrences for one LE across all conditions

Table 12. Chi-Square Encroachment Frequencies for the E. Emory Rd. site.

	lowest				Level of Encroachment				highest	
Condition	0	1	2	3	4	5	6	7	8	Value[1]
Control	31	11	14	12	10	3	6	4	9	Frequency
	47.667	11	11.333	7.667	5.667	2	4	2.667	8	Expected
	10.33	3.67	4.67	4	3.33	1	2	1.33	3	Percent
	31	11	14	12	10	3	6	4	9	Row Percent
	21.68	33.333	41.18	52.17	58.82	50	50	50	37.5	Column Percent
40 ft. spacing	48	11	14	7	5	1	2	3	9	Frequency
	47.667	11	11.333	7.667	5.667	2	4	2.667	8	Expected
	16	3.67	4.67	2.33	1.67	0.33	0.67	1	3	Percent
	48	11	14	7	5	1	2	3	9	Row Percent
	33.57	33.333	41.18	30.43	29.41	16.667	16.667	37.5	37.5	Column Percent
20 ft. spacing	64	11	6	4	2	2	4	1	6	Frequency
	47.667	11	11.333	7.667	5.667	2	4	2.667	8	Expected
	21.33	3.67	2	1.33	0.67	0.67	1.33	0.33	2	Percent
	64	11	6	4	2	2	4	1	6	Row Percent
	44.76	33.33	17.65	17.39	11.76	33.33	33.33	12.5	25	Column Percent

	DF	Value	Probability
Chi-Square	16	30.7169	0.0146

Sample Size : 300

[1]Frequency: number of times this level of encroachment (LE) was observed
Expected: number of expected occurrences for an even distribution across conditions (Σ LE freq/3)
Percent: frequency comparison to entire table (LE cond freq/sample size x 100)
Row Percent: percentage of occurrences for one condition across all LEs
Column Percent: percentage of occurrences for one LE across all conditions

Table 13. Categorized Chi-Square Encroachment Frequencies for combined sites.

Condition	Level of Encroachment[1] High	Med.	Low	Value[2]
Control	57	46	97	Frequency
	44.667	35.333	120	Expected
	9.5	7.67	16.17	Percent
	28.5	23	48.5	Row Percent
	42.54	43.4	26.94	Column Percent
40 ft. spacing	42	32	126	Frequency
	44.667	35.333	120	Expected
	7	5.33	21	Percent
	21	16	63	Row Percent
	31.34	30.19	35	Column Percent
20 ft. spacing	35	28	137	Frequency
	44.667	35.333	120	Expected
	5.83	4.67	22.83	Percent
	17.5	14	68.5	Row Percent
	26.12	26.42	38.06	Column Percent

	DF	Value	Probability
Chi-Square	4	17.8300	0.0013

Sample Size : 600

[1]Note: High = Levels of Encroachment (LE) 6 - 8.
Med. = LE 3 - 5
Low = LE 0 - 2

[2]Frequency: number of times this level of encroachment (LE) was observed
Expected: number of expected occurrences for an even distribution across conditions (Σ LE freq/3)
Percent: frequency comparison to entire table (LE cond freq/sample size x 100)
Row Percent: percentage of occurrences for one condition across all LEs
Column Percent: percentage of occurrences for one LE across all conditions

Table 14. Categorized Chi-Square Encroachment Frequencies for the Hardin Valley Rd. site.

	Level of Encroachment[1]			
Condition	High	Med.	Low	Value[2]
Control	38	21	41	Frequency
	30	20	50	Expected
	12.67	7	13.67	Percent
	38	21	41	Row Percent
	42.22	35	27.33	Column Percent
40 ft. spacing	28	19	53	Frequency
	30	20	50	Expected
	9.33	6.33	17.67	Percent
	28	19	53	Row Percent
	31.11	31.67	35.33	Column Percent
20 ft. spacing	24	20	56	Frequency
	30	20	50	Expected
	8	6.67	18.67	Percent
	24	20	56	Row Percent
	26.67	33.33	37.33	Column Percent

	DF	Value	Probability
Chi-Square	4	6.0867	0.1928

Sample Size : 300

[1]Note: High = Levels of Encroachment (LE) 6 - 8.
Med. = LE 3 - 5
Low = LE 0 - 2

[2]Frequency: number of times this level of encroachment (LE) was observed
Expected: number of expected occurrences for an even distribution across conditions (Σ LE freq/3)
Percent: frequency comparison to entire table (LE cond freq/sample size x 100)
Row Percent: percentage of occurrences for one condition across all LEs
Column Percent: percentage of occurrences for one LE across all conditions

Table 15. Categorized Chi-Square Encroachment Frequencies for the E. Emory Rd. site.

	Level of Encroachment[1]			
Condition	High	Med.	Low	Value[2]
Control	19	25	56	Frequency
	14.667	15.333	70	Expected
	6.33	8.33	18.67	Percent
	19	25	56	Row Percent
	43.18	54.35	26.67	Column Percent
40 ft. spacing	14	13	73	Frequency
	14.667	15.333	70	Expected
	4.67	4.33	24.33	Percent
	14	13	73	Row Percent
	31.82	28.26	34.76	Column Percent
20 ft. spacing	11	8	81	Frequency
	14.667	15.333	70	Expected
	3.67	2.67	27	Percent
	11	8	81	Row Percent
	25	17.39	38.57	Column Percent

	DF	Value	Probability
Chi-Square	4	16.8409	0.0021

Sample Size : 300

[1]Note: High = Levels of Encroachment (LE) 6 - 8.
Med. = LE 3 - 5
Low = LE 0 - 2

[2]Frequency: number of times this level of encroachment (LE) was observed
Expected: number of expected occurrences for an even distribution across conditions (Σ LE freq/3)
Percent: frequency comparison to entire table (LE cond freq/sample size x 100)
Row Percent: percentage of occurrences for one condition across all LEs
Column Percent: percentage of occurrences for one LE across all conditions

is less significant difference between two or more conditions. This is because of the small number of data points in the middle encroachment ranges.

Findings Concerning the Research Hypotheses

The general research hypothesis stated in Chapter III is again included here: There exists a strong relationship between roadway delineation and motorist behavior in negotiating horizontal curves on rural two-lane highways.

This statement has certainly been upheld and proven true through the data collected in this study. Below are listed the specific research hypotheses and the evidence from this study that either supports or fails to support them.

Specific Research Hypothesis I. By installing raised pavement markers at 40 foot intervals, daytime encroachment into the opposing travel lane can be partially corrected by means of the "rumble effect" of the raised markers.

- Simple mean results in Table 1 show a reduction in encroachment from LE 4 to LE 3 at the Hardin Valley site and from LE 2.7 to LE 1.9 at Emory Rd.

- The Tukey range test in Table 7 shows a significant difference in mean encroachment between the control and 40 ft. spacing conditions. The LE combined means for both sites were 3.34 (control) and 2.46 (40 ft.). This test predicts that a significant difference would be (0.67)*(LE 1).

- Overall, high LEs were dropped 7.5%, moderate LEs dropped 7%, and low LEs rose 14.5% (Table 13). This rise includes a 14% increase in vehicles with no encroachment at all (Table 10).

Specific Research Hypothesis II. By shortening the traditional 40 foot spacing interval to 20 feet, vehicle encroachment will be reduced further.

- While the average encroachment was lowered at both sites, the change was almost negligible.

- Table 9 showing the Tukey range test results indicates that no significant difference was found between the 40 ft. spacing (mean LE of 2.5) and the 20 ft. spacing (mean LE of 2.1).

- In combining both sites, the number of vehicles exhibiting no opposing-lane encroachment rose almost 10% when RPM spacings were shortened to 20 feet. The number of vehicles in the worst encroachment category, however, remained constant.

Specific Research Hypothesis III. The application of RPMs at horizontal curves will lower average operating speeds throughout the length of the curve.

- This hypothesis cannot be verified due to the lack of significance in any test through any speed zone. There is a significant difference in speed between the test sites, however, these a primarily due to variations in their respective environments and not due to any influence of the RPMs.

<u>Summary</u>

Statistical testing has shown there to be significant differences in encroachment levels after placement of the RPMs, but no difference in average operating speeds through the curves. Therefore, one of the three specific research hypotheses has been supported, one has some supporting evidence but remains inconclusive, and one has failed to be proven by this study.

Chapter V. Summary of the Study

This final chapter provides the essence of the research in brief form. First, an overview of the study, including the problem and the research procedures used in testing, will be summarily restated. Secondly, the major conclusions are outlined and given with respect to the research hypotheses tested. Finally, the implications of this research and suggestions for further study are discussed.

Procedure Overview

Statement of the Problem. This research investigated the relationship between pavement surface delineation and driver behavior on rural two-lane highways. Specific facets of tested driver behavior were (1) average operating speeds around the beginning, middle, and end of the curve and (2) the distance of encroachment into the opposing lane of travel.

Statement of the Procedures. To test the response to the raised pavement markers, three roadway conditions were evaluated at two different sites. These were:

Condition 1. No markers placed (control group).

Condition 2. RPMs placed at a 40-ft. spacing along the centerline.

Condition 3. RPMs placed at a 20-ft. spacing along the centerline.

Speeds for these three conditions were measured by standard speed markings and encroachment levels were measured by roadside film review. Data was only recorded in dry, daytime conditions.

Conclusions

Specific research hypothesis I concerning the initial placement of RPMs at a 40 ft. spacing was supported due to the significant decrease in encroachment at both sites. Approximately 15% of vehicles exhibiting "high" or "moderate" encroachment levels (> 8-in. into the opposing lane) were brought into the "low" (< 8-in. into the opposing lane) category (Table 13). More specifically, 9% of vehicles travelling more than 2 ft. across the painted centerline were corrected by the RPMs. Furthermore, this 40-ft. spacing increased the number of vehicles completely in the prescribed lane of travel by 14%.

Specific research hypothesis II, dealing with the shortened spacing of the RPMs to 20 ft., could not be adequately supported. Statistical analysis of encroachment data found no significant difference in the vehicle travel paths between the two RPM conditions. However, because some notable shift was made at one of the sites (an increase in the "low" category by 8% including a 6% increase in vehicles with no encroachment), this hypothesis cannot be completely rejected.

Specific research hypothesis III concerning the effect of RPMs on speed has failed to be supported by this study. Under no condition change has the difference in speed been significantly altered.

Implications

In promoting the increased safety of rural two-lane highways, the engineer is often faced with correcting multiple problems with limited tools, time, and budgets. When accident records indicate head-on collisions or off the road crashes where sudden movements were made to avoid an oncoming vehicle, it can logically be assumed that one or both vehicles were partly in the oncoming lane of travel. This study has shown that the proper use of RPMs can at least partially correct this behavior in locations where it is most prone to occur.

For most conditions, the results of this study recommend at least a 40-ft. spacing interval for these markings. Spacings below this have been shown to be no more effective in daylight conditions and are more costly and time consuming to install. Nevertheless, additional research on short-radius curves may prove a decreased interval more efficient. While speculative, it is the opinion of the researcher that spacings greater than 40 ft. are not as effective in nighttime delineation, particularly on short to moderate-radius curves.

Another important implication of these results comes in the type of RPM used. Here, the traditional 4-in. x 4-in. amber retro-reflective marker was evaluated (see Chapter III). However, many other types of markers, particularly plowable ones, are currently being utilized. While additional study using different types of markers may prove otherwise, it is the researcher's theory that smaller, less obtrusive markers may be less effective in wheel path control.

Suggested Further Research

In observing motorist behavior and analyzing the data of the study, several implications arose that might prove beneficial for future study. Following are some questions which, with researched answers, could be of great value:

1. Does the type of raised pavement marker play a critical role when attempting to control vehicle encroachment?
2. Do the RPMs cause drivers to shy away from them excessively toward the edge lines?
3. Is there significant impact on encroachment in nighttime/inclement weather conditions?
4. Are other rumble features located in the centerline equally or more effective in preventing opposing-lane encroachment?
5. What effect, if any, do RPMs have on roads carrying high volumes of large trucks?

Summary

This chapter has provided a summary of the study as well as its conclusions and implications. It was found that only the initial application of raised pavement markers had a significant effect on motorist behavior. This effect came in the decrease in the amount of opposing-lane encroachment on horizontal curves; no effect was had on vehicle operating speeds at either site. Certain ideas for future study in this area have been raised in conjunction with some notable implications of the results. It is here noted that, above all, roadway improvements should not be solely based on this or any other study, but on motorist safety and sound engineering judgement.

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REFERENCES

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APPENDICES

APPENDIX A

COMPREHENSIVE VEHICLE SPEED AND ENCROACHMENT DATA

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
1	1	37.87879	34.09091	34.09091	0	EE	40ft
2	2	42.61364	32.46753	35.88517	0	EE	40ft
3	3	40.10695	37.87879	34.09091	2	EE	40ft
4	4	34.09091	32.46753	32.46753	0	EE	40ft
5	5	34.09091	29.64427	27.27273	2	EE	40ft
6	6	42.61364	37.87879	35.88517	0	EE	40ft
7	7	42.61364	37.87879	37.87879	0	EE	40ft
8	8	37.87879	32.46753	30.99174	0	EE	40ft
9	9	37.87879	35.88517	32.46753	0	EE	40ft
10	10	48.7013	42.61364	45.45455	1	EE	40ft
11	11	45.45455	42.61364	40.10695	4	EE	40ft
12	12	26.22378	26.22378	29.64427	2	EE	40ft
13	13	34.09091	29.64427	25.25253	3	EE	40ft
14	14	48.7013	42.61364	37.87879	0	EE	40ft
15	15	37.87879	30.99174	29.64427	0	EE	40ft
16	16	48.7013	42.61364	40.10695	8	EE	40ft
17	17	42.61364	37.87879	35.88517	8	EE	40ft
18	18	37.87879	35.88517	34.09091	0	EE	40ft
19	19	37.87879	28.40909	26.22378	4	EE	40ft
20	20	35.88517	28.40909	27.27273	0	EE	40ft
21	21	37.87879	35.88517	32.46753	8	EE	40ft
22	22	42.61364	40.10695	37 87879	8	EE	40ft
23	23	35.88517	35.88517	34.09091	2	EE	40ft
24	24	37.87879	34.09091	34.09091	2	EE	40ft
25	25	35.88517	28.40909	27.27273	0	EE	40ft
26	26	35.88517	35.88517	34.09091	2	EE	40ft
27	27	35.88517	35.88517	32.46753	4	EE	40ft
28	28	40.10695	34.09091	28.40909	0	EE	40ft
29	29	35.88517	34.09091	34.09091	0	EE	40ft
30	30	37.87879	34.09091	34.09091	2	EE	40ft
31	31	48.7013	40.10695	35.88517	0	EE	40ft
32	32	34.09091	27.27273	27.27273	0	EE	40ft
33	33	32.46753	32.46753	34.09091	1	EE	40ft
34	34	27.27273	28.40909	26.22378	2	EE	40ft
35	35	35.88517	29.64427	30.99174	0	EE	40ft
36	36	37.87879	32.46753	32.46753	0	EE	40ft
37	37	32.46753	26.22378	20.66116	0	EE	40ft
38	38	35.88517	30.99174	30.99174	2	EE	40ft

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
39	39	42.61364	37.87879	35.88517	0	EE	40ft
40	40	37.87879	32.46753	29.64427	6	EE	40ft
41	41	37.87879	30.99174	32.46753	0	EE	40ft
42	42	34.09091	26.22378	29.64427	0	EE	40ft
43	43	45.45455	37.87879	35.88517	0	EE	40ft
44	44	35.88517	30.99174	30.99174	0	EE	40ft
45	45	40.10695	40.10695	37.87879	1	EE	40ft
46	46	37.87879	35.88517	35.88517	4	EE	40ft
47	47	35.88517	28.40909	26.22378	2	EE	40ft
48	48	40.10695	30.99174	29.64427	0	EE	40ft
49	49	35.88517	32.46753	30.99174	2	EE	40ft
50	50	42.61364	32.46753	30.99174	1	EE	40ft
51	51	37.87879	30.99174	32.46753	0	EE	40ft
52	52	32.46753	30.99174	30.99174	0	EE	40ft
53	53	35.88517	32.46753	34.09091	0	EE	40ft
54	54	34.09091	29.64427	32.46753	0	EE	40ft
55	55	42.61364	35.88517	37.87879	7	EE	40ft
56	56	42.61364	35.88517	32.46753	0	EE	40ft
57	57	40.10695	34.09091	34.09091	0	EE	40ft
58	58	37.87879	30.99174	30.99174	5	EE	40ft
59	59	42.61364	40.10695	37.87879	0	EE	40ft
60	60	34.09091	28.40909	29.64427	0	EE	40ft
61	61	42.61364	37.87879	35.88517	0	EE	40ft
62	62	35.88517	34.09091	32.46753	0	EE	40ft
63	63	42.61364	35.88517	35.88517	0	EE	40ft
64	64	34.09091	32.46753	32.46753	3	EE	40ft
65	65	34.09091	29.64427	29.64427	1	EE	40ft
66	66	32.46753	27.27273	25.25253	0	EE	40ft
67	67	40.10695	37.87879	40.10695	2	EE	40ft
68	68	34.09091	29.64427	28.40909	1	EE	40ft
69	69	35.88517	34.09091	35.88517	3	EE	40ft
70	70	37.87879	35.88517	34.09091	7	EE	40ft
71	71	37.87879	35.88517	35.88517	8	EE	40ft
72	72	48.7013	40.10695	42.61364	1	EE	40ft
73	73	40.10695	42.61364	37.87879	3	EE	40ft
74	74	42.61364	37.87879	37.87879	3	EE	40ft
75	75	35.88517	28.40909	30.99174	0	EE	40ft
76	76	35.88517	30.99174	28.40909	2	EE	40ft

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
77	77	42.61364	34.09091	34.09091	4	EE	40ft
78	78	28.40909	23.51097	25.25253	0	EE	40ft
79	79	45.45455	37.87879	35.88517	0	EE	40ft
80	80	40.10695	35.88517	37.87879	0	EE	40ft
81	81	37.87879	37.87879	37.87879	8	EE	40ft
82	82	42.61364	35.88517	34.09091	0	EE	40ft
83	83	34.09091	27.27273	28.40909	0	EE	40ft
84	84	42.61364	37.87879	32.46753	3	EE	40ft
85	85	35.88517	32.46753	30.99174	0	EE	40ft
86	86	37.87879	29.64427	27.27273	0	EE	40ft
87	87	37.87879	37.87879	37.87879	8	EE	40ft
88	88	42.61364	42.61364	42.61364	1	EE	40ft
89	89	42.61364	37.87879	37.87879	6	EE	40ft
90	90	42.61364	34.09091	34.09091	0	EE	40ft
91	91	42.61364	42.61364	40.10695	8	EE	40ft
92	92	42.61364	40.10695	37.87879	2	EE	40ft
93	93	48.7013	42.61364	45.45455	3	EE	40ft
94	94	40.10695	34.09091	34.09091	0	EE	40ft
95	95	37.87879	35.88517	37.87879	1	EE	40ft
96	96	37.87879	35.88517	34.09091	7	EE	40ft
97	97	37.87879	34.09091	34.09091	1	EE	40ft
98	98	37.87879	35.88517	32.46753	8	EE	40ft
99	99	37.87879	35.88517	32.46753	0	EE	40ft
100	100	34.09091	29.64427	29.64427	1	EE	40ft
101	1	27.27273	28.40909	27.27273	3	EE	Ctrl
102	2	42.61364	40.10695	40.10695	0	EE	Ctrl
103	3	42.61364	35.88517	42.61364	8	EE	Ctrl
104	4	37.87879	35.88517	32.46753	0	EE	Ctrl
105	5	28.40909	25.25253	20.66116	6	EE	Ctrl
106	6	40.10695	34.09091	34.09091	0	EE	Ctrl
107	7	40.10695	37.87879	40.10695	1	EE	Ctrl
108	8	34.09091	32.46753	34.09091	3	EE	Ctrl
109	9	40.10695	37.87879	40.10695	1	EE	Ctrl
110	10	35.88517	32.46753	34.09091	0	EE	Ctrl
111	11	37.87879	34.09091	35.88517	4	EE	Ctrl
112	12	32.46753	29.64427	32.46753	0	EE	Ctrl
113	13	32.46753	29.64427	29.64427	2	EE	Ctrl
114	14	34.09091	32.46753	34.09091	0	EE	Ctrl

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
115	15	37.87879	29.64427	30.99174	2	EE	Ctrl
116	16	42.61364	32.46753	37.87879	3	EE	Ctrl
117	17	32.46753	32.46753	34.09091	3	EE	Ctrl
118	18	34.09091	34.09091	34.09091	1	EE	Ctrl
119	19	29.64427	27.27273	27.27273	0	EE	Ctrl
120	20	37.87879	35.88517	37.87879	4	EE	Ctrl
121	21	35.88517	30.99174	34.09091	2	EE	Ctrl
122	22	35.88517	30.99174	30.99174	3	EE	Ctrl
123	23	35.88517	35.88517	35.88517	4	EE	Ctrl
124	24	35.88517	35.88517	34.09091	3	EE	Ctrl
125	25	40.10695	32.46753	29.64427	1	EE	Ctrl
126	26	37.87879	37.87879	37.87879	4	EE	Ctrl
127	27	32.46753	32.46753	34.09091	0	EE	Ctrl
128	28	35.88517	28.40909	21.99413	0	EE	Ctrl
129	29	34.09091	32.46753	32.46753	3	EE	Ctrl
130	30	45.45455	40.10695	40.10695	8	EE	Ctrl
131	31	32.46753	34.09091	34.09091	0	EE	Ctrl
132	32	35.88517	34.09091	34.09091	2	EE	Ctrl
133	33	30.99174	29.64427	29.64427	4	EE	Ctrl
134	34	37.87879	34.09091	34.09091	3	EE	Ctrl
135	35	40.10695	37.87879	37.87879	0	EE	Ctrl
136	36	35.88517	27.27273	21.30682	0	EE	Ctrl
137	37	42.61364	34.09091	37.87879	0	EE	Ctrl
138	38	37.87879	30.99174	32.46753	2	EE	Ctrl
139	39	42.61364	35.88517	42.61364	0	EE	Ctrl
140	40	42.61364	40.10695	42.61364	8	EE	Ctrl
141	41	37.87879	37.87879	37.87879	1	EE	Ctrl
142	42	37.87879	40.10695	35.88517	2	EE	Ctrl
143	43	42.61364	35.88517	40.10695	8	EE	Ctrl
144	44	52.44755	48.7013	52.44755	7	EE	Ctrl
145	45	34.09091	32.46753	35.88517	1	EE	Ctrl
146	46	35.88517	34.09091	34.09091	8	EE	Ctrl
147	47	37.87879	34.09091	30.99174	2	EE	Ctrl
148	48	37.87879	35.88517	34.09091	0	EE	Ctrl
149	49	35.88517	30.99174	32.46753	2	EE	Ctrl
150	50	40.10695	34.09091	34.09091	1	EE	Ctrl
151	51	35.88517	28.40909	19.48052	1	EE	Ctrl
152	52	45.45455	34.09091	35.88517	0	EE	Ctrl

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
153	53	35.88517	35.88517	37.87879	7	EE	Ctrl
154	54	45.45455	37.87879	45.45455	5	EE	Ctrl
155	55	34.09091	30.99174	29.64427	2	EE	Ctrl
156	56	42.61364	40.10695	42.61364	0	EE	Ctrl
157	57	34.09091	34.09091	34.09091	6	EE	Ctrl
158	58	34.09091	30.99174	35.88517	0	EE	Ctrl
159	59	37.87879	37.87879	37.87879	4	EE	Ctrl
160	60	42.61364	40.10695	37.87879	5	EE	Ctrl
161	61	42.61364	30.99174	30.99174	0	EE	Ctrl
162	62	37.87879	34.09091	32.46753	3	EE	Ctrl
163	63	30.99174	26.22378	25.25253	0	EE	Ctrl
164	64	40.10695	40.10695	42.61364	8	EE	Ctrl
165	65	32.46753	27.27273	21.30682	0	EE	Ctrl
166	66	42.61364	34.09091	27.27273	0	EE	Ctrl
167	67	34.09091	32.46753	32.46753	1	EE	Ctrl
168	68	34.09091	30.99174	32.46753	0	EE	Ctrl
169	69	37.87879	32.46753	34.09091	0	EE	Ctrl
170	70	37.87879	30.99174	34.09091	0	EE	Ctrl
171	71	37.87879	35.88517	37.87879	4	EE	Ctrl
172	72	35.88517	35.88517	35.88517	0	EE	Ctrl
173	73	42.61364	40.10695	37.87879	4	EE	Ctrl
174	74	37.87879	35.88517	35.88517	3	EE	Ctrl
175	75	45.45455	37.87879	37.87879	6	EE	Ctrl
176	76	35.88517	35.88517	35.88517	0	EE	Ctrl
177	77	35.88517	32.46753	32.46753	0	EE	Ctrl
178	78	34.09091	32.46753	28.40909	2	EE	Ctrl
179	79	35.88517	30.99174	32.46753	0	EE	Ctrl
180	80	40.10695	40.10695	40.10695	6	EE	Ctrl
181	81	42.61364	37.87879	34.09091	7	EE	Ctrl
182	82	40.10695	35.88517	34.09091	2	EE	Ctrl
183	83	42.61364	40.10695	42.61364	7	EE	Ctrl
184	84	40.10695	35.88517	37.87879	1	EE	Ctrl
185	85	35.88517	34.09091	30.99174	2	EE	Ctrl
186	86	45.45455	42.61364	45.45455	8	EE	Ctrl
187	87	35.88517	32.46753	32.46753	0	EE	Ctrl
188	88	40.10695	37.87879	37.87879	8	EE	Ctrl
189	89	35.88517	35.88517	35.88517	3	EE	Ctrl
190	90	34.09091	34.09091	35.88517	8	EE	Ctrl

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
191	91	34.09091	28.40909	28.40909	4	EE	Ctrl
192	92	48.7013	40.10695	40.10695	4	EE	Ctrl
193	93	32.46753	30.99174	34.09091	1	EE	Ctrl
194	94	40.10695	34.09091	34.09091	3	EE	Ctrl
195	95	42.61364	40.10695	40.10695	5	EE	Ctrl
196	96	42.61364	37.87879	37.87879	6	EE	Ctrl
197	97	40.10695	35.88517	37.87879	2	EE	Ctrl
198	98	35.88517	34.09091	35.88517	0	EE	Ctrl
199	99	45.45455	40.10695	42.61364	6	EE	Ctrl
200	100	42.61364	32.46753	35.88517	2	EE	Ctrl
201	.	.	.	.	.	EE	Ctrl
202	.	.	.	.	.	EE	Ctrl
203	.	.	.	.	.	EE	Ctrl
204	1	56.81818	45.45455	56.81818	8	HV	40ft
205	2	35.88517	34.09091	37.87879	1	HV	40ft
206	3	45.45455	42.61364	45.45455	8	HV	40ft
207	4	40.10695	34.09091	42.61364	0	HV	40ft
208	5	48.7013	48.7013	56.81818	3	HV	40ft
209	6	40.10695	37.87879	45.45455	0	HV	40ft
210	7	40.10695	37.87879	42.61364	0	HV	40ft
211	8	42.61364	42.61364	52.44755	0	HV	40ft
212	9	48.7013	42.61364	52.44755	2	HV	40ft
213	10	42.61364	45.45455	52.44755	8	HV	40ft
214	11	35.88517	32.46753	37.87879	8	HV	40ft
215	12	42.61364	42.61364	48.7013	8	HV	40ft
216	13	37.87879	34.09091	40.10695	0	HV	40ft
217	14	42.61364	42.61364	48.7013	8	HV	40ft
218	15	45.45455	40.10695	48.7013	5	HV	40ft
219	16	45.45455	40.10695	52.44755	2	HV	40ft
220	17	48.7013	42.61364	48.7013	1	HV	40ft
221	18	42.61364	40.10695	45.45455	0	HV	40ft
222	19	35.88517	34.09091	37.87879	6	HV	40ft
223	20	48.7013	52.44755	56.81818	3	HV	40ft
224	21	37.87879	40.10695	42.61364	2	HV	40ft
225	22	37.87879	35.88517	42.61364	0	HV	40ft
226	23	48.7013	45.45455	52.44755	6	HV	40ft
227	24	42.61364	40.10695	48.7013	0	HV	40ft
228	25	52.44755	48.7013	56.81818	7	HV	40ft

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
229	26	48.7013	48.7013	52.44755	4	HV	40ft
230	27	37.87879	37.87879	42.61364	2	HV	40ft
231	28	35.88517	35.88517	45.45455	2	HV	40ft
232	29	42.61364	45.45455	48.7013	8	HV	40ft
233	30	52.44755	52.44755	61.98347	6	HV	40ft
234	31	52.44755	48.7013	56.81818	6	HV	40ft
235	32	48.7013	45.45455	52.44755	6	HV	40ft
236	33	40.10695	42.61364	45.45455	4	HV	40ft
237	34	37.87879	34.09091	42.61364	0	HV	40ft
238	35	52.44755	45.45455	52.44755	8	HV	40ft
239	36	42.61364	42.61364	48.7013	3	HV	40ft
240	37	40.10695	40.10695	45.45455	0	HV	40ft
241	38	37.87879	35.88517	40.10695	0	HV	40ft
242	39	48.7013	42.61364	52.44755	5	HV	40ft
243	40	48.7013	48.7013	56.81818	2	HV	40ft
244	41	48.7013	42.61364	48.7013	5	HV	40ft
245	42	45.45455	40.10695	48.7013	6	HV	40ft
246	43	45.45455	42.61364	48.7013	7	HV	40ft
247	44	48.7013	48.7013	56.81818	6	HV	40ft
248	45	28.40909	29.64427	37.87879	0	HV	40ft
249	46	48.7013	42.61364	52.44755	0	HV	40ft
250	47	45.45455	42.61364	48.7013	8	HV	40ft
251	48	56.81818	52.44755	61.98347	8	HV	40ft
252	49	45.45455	45.45455	48.7013	0	HV	40ft
253	50	37.87879	35.88517	42.61364	0	HV	40ft
254	51	40.10695	37.87879	45.45455	3	HV	40ft
255	52	42.61364	40.10695	48.7013	0	HV	40ft
256	53	48.7013	45.45455	56.81818	4	HV	40ft
257	54	40.10695	35.88517	42.61364	3	HV	40ft
258	55	45.45455	42.61364	48.7013	0	HV	40ft
259	56	40.10695	40.10695	45.45455	2	HV	40ft
260	57	45.45455	45.45455	52.44755	8	HV	40ft
261	58	45.45455	40.10695	45.45455	0	HV	40ft
262	59	42.61364	37.87879	42.61364	0	HV	40ft
263	60	45.45455	45.45455	48.7013	6	HV	40ft
264	61	48.7013	45.45455	52.44755	6	HV	40ft
265	62	45.45455	42.61364	48.7013	2	HV	40ft
266	63	48.7013	42.61364	48.7013	8	HV	40ft

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
267	64	42.61364	42.61364	52.44755	1	HV	40ft
268	65	45.45455	35.88517	40.10695	2	HV	40ft
269	66	42.61364	40.10695	48.7013	3	HV	40ft
270	67	40.10695	40.10695	45.45455	0	HV	40ft
271	68	42.61364	35.88517	42.61364	4	HV	40ft
272	69	45.45455	45.45455	52.44755	3	HV	40ft
273	70	42.61364	35.88517	48.7013	2	HV	40ft
274	71	42.61364	40.10695	48.7013	5	HV	40ft
275	72	37.87879	37.87879	45.45455	0	HV	40ft
276	73	45.45455	45.45455	52.44755	4	HV	40ft
277	74	40.10695	37.87879	42.61364	1	HV	40ft
278	75	42.61364	40.10695	45.45455	0	HV	40ft
279	76	40.10695	35.88517	45.45455	6	HV	40ft
280	77	40.10695	37.87879	42.61364	2	HV	40ft
281	78	42.61364	42.61364	48.7013	3	HV	40ft
282	79	37.87879	37.87879	40.10695	0	HV	40ft
283	80	45.45455	45.45455	45.45455	0	HV	40ft
284	81	45.45455	42.61364	48.7013	3	HV	40ft
285	82	48.7013	48.7013	56.81818	8	HV	40ft
286	83	42.61364	42.61364	52.44755	0	HV	40ft
287	84	42.61364	34.09091	42.61364	0	HV	40ft
288	85	35.88517	35.88517	37.87879	0	HV	40ft
289	86	42.61364	42.61364	52.44755	0	HV	40ft
290	87	48.7013	45.45455	52.44755	6	HV	40ft
291	88	45.45455	37.87879	45.45455	0	HV	40ft
292	89	34.09091	34.09091	45.45455	0	HV	40ft
293	90	48.7013	52.44755	52.44755	0	HV	40ft
294	91	42.61364	42.61364	48.7013	8	HV	40ft
295	92	42.61364	42.61364	45.45455	0	HV	40ft
296	93	40.10695	37.87879	42.61364	0	HV	40ft
297	94	52.44755	48.7013	56.81818	8	HV	40ft
298	95	45.45455	42.61364	48.7013	4	HV	40ft
299	96	52.44755	56.81818	56.81818	0	HV	40ft
300	97	45.5	42.6	45.5	1	HV	40ft
301	98	42.6	45.5	42.6	0	HV	40ft
302	99	40.10695	37.87879	42.61364	1	HV	40ft
303	100	35.88517	35.88517	45.45455	2	HV	40ft
304	1	48.7013	42.61364	52.44755	7	HV	Ctrl

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
305	2	40.10695	35.88517	45.45455	5	HV	Ctrl
306	3	42.61364	40.10695	45.45455	0	HV	Ctrl
307	4	40.10695	37.87879	45.45455	8	HV	Ctrl
308	5	42.61364	40.10695	45.45455	4	HV	Ctrl
309	6	48.7013	45.45455	48.7013	7	HV	Ctrl
310	7	48.7013	40.10695	52.44755	8	HV	Ctrl
311	8	45.45455	42.61364	48.7013	6	HV	Ctrl
312	9	48.7013	45.45455	48.7013	8	HV	Ctrl
313	10	48.7013	45.45455	56.81818	8	HV	Ctrl
314	11	45.45455	45.45455	52.44755	8	HV	Ctrl
315	12	48.7013	48.7013	52.44755	8	HV	Ctrl
316	13	48.7013	45.45455	61.98347	8	HV	Ctrl
317	14	45.45455	42.61364	52.44755	7	HV	Ctrl
318	15	48.7013	45.45455	52.44755	8	HV	Ctrl
319	16	48.7013	40.10695	52.44755	8	HV	Ctrl
320	17	48.7013	48.7013	52.44755	0	HV	Ctrl
321	18	45.45455	45.45455	52.44755	7	HV	Ctrl
322	19	42.61364	37.87879	48.7013	1	HV	Ctrl
323	20	45.45455	40.10695	48.7013	0	HV	Ctrl
324	21	45.45455	45.45455	45.45455	0	HV	Ctrl
325	22	52.44755	42.61364	56.81818	4	HV	Ctrl
326	23	45.45455	42.61364	48.7013	0	HV	Ctrl
327	24	48.7013	48.7013	56.81818	5	HV	Ctrl
328	25	45.45455	40.10695	48.7013	1	HV	Ctrl
329	26	45.45455	45.45455	52.44755	8	HV	Ctrl
330	27	56.81818	45.45455	52.44755	3	HV	Ctrl
331	28	45.45455	42.61364	52.44755	0	HV	Ctrl
332	29	45.45455	45.45455	45.45455	3	HV	Ctrl
333	30	48.7013	37.87879	48.7013	5	HV	Ctrl
334	31	45.45455	42.61364	52.44755	8	HV	Ctrl
335	32	35.88517	34.09091	37.87879	2	HV	Ctrl
336	33	34.09091	34.09091	42.61364	8	HV	Ctrl
337	34	35.88517	35.88517	42.61364	4	HV	Ctrl
338	35	40.10695	37.87879	45.45455	7	HV	Ctrl
339	36	42.61364	37.87879	48.7013	8	HV	Ctrl
340	37	45.45455	48.7013	48.7013	4	HV	Ctrl
341	38	40.10695	37.87879	45.45455	2	HV	Ctrl
342	39	52.44755	45.45455	52.44755	3	HV	Ctrl

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
343	40	40.10695	37.87879	48.7013	2	HV	Ctrl
344	41	45.45455	42.61364	48.7013	1	HV	Ctrl
345	42	37.87879	40.10695	42.61364	7	HV	Ctrl
346	43	37.87879	42.61364	45.45455	1	HV	Ctrl
347	44	42.61364	40.10695	45.45455	1	HV	Ctrl
348	45	45.45455	42.61364	48.7013	5	HV	Ctrl
349	46	42.61364	37.87879	45.45455	6	HV	Ctrl
350	47	35.88517	37.87879	56.81818	8	HV	Ctrl
351	48	45.45455	40.10695	48.7013	0	HV	Ctrl
352	49	48.7013	42.61364	52.44755	8	HV	Ctrl
353	50	40.10695	35.88517	45.45455	0	HV	Ctrl
354	51	48.7013	45.45455	52.44755	1	HV	Ctrl
355	52	45.45455	42.61364	52.44755	8	HV	Ctrl
356	53	52.44755	45.45455	52.44755	5	HV	Ctrl
357	54	40.10695	37.87879	48.7013	4	HV	Ctrl
358	55	40.10695	37.87879	45.45455	0	HV	Ctrl
359	56	52.44755	45.45455	52.44755	8	HV	Ctrl
360	57	37.87879	35.88517	45.45455	0	HV	Ctrl
361	58	45.45455	45.45455	52.44755	8	HV	Ctrl
362	59	48.7013	45.45455	52.44755	6	HV	Ctrl
363	60	56.81818	52.44755	61.98347	2	HV	Ctrl
364	61	42.61364	40.10695	48.7013	5	HV	Ctrl
365	62	40.10695	37.87879	48.7013	0	HV	Ctrl
366	63	40.10695	35.88517	42.61364	0	HV	Ctrl
367	64	35.88517	29.64427	37.87879	0	HV	Ctrl
368	65	45.45455	45.45455	48.7013	0	HV	Ctrl
369	66	45.45455	40.10695	48.7013	0	HV	Ctrl
370	67	45.45455	37.87879	45.45455	0	HV	Ctrl
371	68	48.7013	42.61364	48.7013	5	HV	Ctrl
372	69	52.44755	45.45455	56.81818	8	HV	Ctrl
373	70	37.87879	34.09091	42.61364	1	HV	Ctrl
374	71	45.45455	40.10695	48.7013	4	HV	Ctrl
375	72	40.10695	35.88517	45.45455	1	HV	Ctrl
376	73	35.88517	32.46753	35.88517	0	HV	Ctrl
377	74	45.45455	42.61364	48.7013	0	HV	Ctrl
378	75	42.61364	35.88517	45.45455	5	HV	Ctrl
379	76	37.87879	37.87879	45.45455	0	HV	Ctrl
380	77	45.45455	42.61364	48.7013	0	HV	Ctrl

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
381	78	35.88517	34.09091	42.61364	0	HV	Ctrl
382	79	37.87879	35.88517	45.45455	2	HV	Ctrl
383	80	45.45455	45.45455	48.7013	8	HV	Ctrl
384	81	45.45455	45.45455	48.7013	8	HV	Ctrl
385	82	42.61364	42.61364	45.45455	5	HV	Ctrl
386	83	42.61364	37.87879	45.45455	6	HV	Ctrl
387	84	40.10695	40.10695	48.7013	1	HV	Ctrl
388	85	52.44755	45.45455	61.98347	8	HV	Ctrl
389	86	48.7013	45.45455	52.44755	5	HV	Ctrl
390	87	45.45455	37.87879	48.7013	3	HV	Ctrl
391	88	40.10695	37.87879	48.7013	1	HV	Ctrl
392	89	42.61364	42.61364	48.7013	0	HV	Ctrl
393	90	45.45455	40.10695	45.45455	8	HV	Ctrl
394	91	48.7013	48.7013	56.81818	8	HV	Ctrl
395	92	37.87879	35.88517	40.10695	1	HV	Ctrl
396	93	45.45455	45.45455	48.7013	8	HV	Ctrl
397	94	52.44755	48.7013	56.81818	8	HV	Ctrl
398	95	40.10695	37.87879	48.7013	0	HV	Ctrl
399	96	42.61364	37.87879	48.7013	0	HV	Ctrl
400	97	48.7013	45.45455	52.44755	8	HV	Ctrl
401	98	34.09091	30.99174	40.10695	7	HV	Ctrl
402	99	48.7013	48.7013	52.44755	4	HV	Ctrl
403	100	42.61364	42.61364	42.61364	2	HV	Ctrl
404	.	.	.	.	.	HV	Ctrl
405	.	.	.	.	.	HV	Ctrl
406	.	.	.	.	.	HV	Ctrl
407	.	.	.	.	.	HV	Ctrl
408	.	.	.	.	.	HV	Ctrl
409	1	34.09091	28.40909	26.22378	0	EE	20ft
410	2	40.10695	35.88517	34.09091	0	EE	20ft
411	3	42.61364	42.61364	42.61364	8	EE	20ft
412	4	40.10695	35.88517	34.09091	4	EE	20ft
413	5	35.88517	32.46753	32.46753	1	EE	20ft
414	6	37.87879	37.87879	35.88517	0	EE	20ft
415	7	45.45455	40.10695	37.87879	1	EE	20ft
416	8	42.61364	37.87879	32.46753	5	EE	20ft
417	9	45.45455	35.88517	34.09091	0	EE	20ft
418	10	37.87879	35.88517	32.46753	0	EE	20ft

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
419	11	37.87879	35.88517	32.46753	2	EE	20ft
420	12	42.61364	35.88517	32.46753	4	EE	20ft
421	13	37.87879	32.46753	32.46753	0	EE	20ft
422	14	48.7013	42.61364	40.10695	6	EE	20ft
423	15	34.09091	27.27273	26.22378	0	EE	20ft
424	16	37.87879	34.09091	28.40909	6	EE	20ft
425	17	40.10695	34.09091	34.09091	0	EE	20ft
426	18	42.61364	37.87879	32.46753	3	EE	20ft
427	19	35.88517	34.09091	32.46753	0	EE	20ft
428	20	37.87879	35.88517	35.88517	0	EE	20ft
429	21	37.87879	34.09091	29.64427	0	EE	20ft
430	22	35.88517	29.64427	30.99174	0	EE	20ft
431	23	48.7013	40.10695	37.87879	0	EE	20ft
432	24	40.10695	42.61364	40.10695	0	EE	20ft
433	25	37.87879	34.09091	32.46753	0	EE	20ft
434	26	30.99174	26.22378	25.25253	0	EE	20ft
435	27	45.45455	32.46753	34.09091	0	EE	20ft
436	28	42.61364	35.88517	32.46753	6	EE	20ft
437	29	34.09091	34.09091	35.88517	0	EE	20ft
438	30	35.88517	32.46753	30.99174	2	EE	20ft
439	31	42.61364	34.09091	34.09091	1	EE	20ft
440	32	42.61364	40.10695	42.61364	7	EE	20ft
441	33	37.87879	32.46753	32.46753	0	EE	20ft
442	34	37.87879	37.87879	37.87879	0	EE	20ft
443	35	37.87879	34.09091	32.46753	0	EE	20ft
444	36	32.46753	28.40909	29.64427	0	EE	20ft
445	37	37.87879	32.46753	34.09091	0	EE	20ft
446	38	35.88517	30.99174	32.46753	0	EE	20ft
447	39	37.87879	30.99174	29.64427	0	EE	20ft
448	40	40.10695	35.88517	35.88517	0	EE	20ft
449	41	35.88517	34.09091	34.09091	1	EE	20ft
450	42	35.88517	35.88517	34.09091	0	EE	20ft
451	43	35.88517	30.99174	30.99174	0	EE	20ft
452	44	45.45455	40.10695	32.46753	2	EE	20ft
453	45	40.10695	40.10695	37.87879	1	EE	20ft
454	46	42.61364	42.61364	40.10695	5	EE	20ft
455	47	40.10695	37.87879	35.88517	0	EE	20ft
456	48	45.45455	37.87879	37.87879	2	EE	20ft

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
457	49	42.61364	42.61364	35.88517	8	EE	20ft
458	50	35.88517	32.46753	34.09091	0	EE	20ft
459	51	35.88517	32.46753	28.40909	8	EE	20ft
460	52	40.10695	40.10695	42.61364	8	EE	20ft
461	53	28.40909	24.35065	24.35065	0	EE	20ft
462	54	29.64427	28.40909	30.99174	0	EE	20ft
463	55	34.09091	27.27273	23.51097	0	EE	20ft
464	56	32.46753	27.27273	28.40909	0	EE	20ft
465	57	40.10695	37.87879	35.88517	8	EE	20ft
466	58	37.87879	34.09091	32.46753	0	EE	20ft
467	59	35.88517	32.46753	30.99174	0	EE	20ft
468	60	35.88517	32.46753	32.46753	0	EE	20ft
469	61	40.10695	40.10695	37.87879	0	EE	20ft
470	62	30.99174	27.27273	23.51097	1	EE	20ft
471	63	45.45455	37.87879	35.88517	0	EE	20ft
472	64	40.10695	37.87879	37.87879	0	EE	20ft
473	65	35.88517	29.64427	28.40909	0	EE	20ft
474	66	35.88517	32.46753	34.09091	3	EE	20ft
475	67	45.45455	40.10695	34.09091	1	EE	20ft
476	68	34.09091	32.46753	30.99174	0	EE	20ft
477	69	37.87879	35.88517	35.88517	1	EE	20ft
478	70	34.09091	34.09091	34.09091	0	EE	20ft
479	71	35.88517	30.99174	30.99174	0	EE	20ft
480	72	35.88517	32.46753	34.09091	2	EE	20ft
481	73	35.88517	34.09091	30.99174	1	EE	20ft
482	74	34.09091	30.99174	32.46753	0	EE	20ft
483	75	35.88517	34.09091	32.46753	0	EE	20ft
484	76	42.61364	37.87879	37.87879	0	EE	20ft
485	77	42.61364	34.09091	35.88517	0	EE	20ft
486	78	35.88517	32.46753	34.09091	0	EE	20ft
487	79	35.88517	30.99174	29.64427	0	EE	20ft
488	80	37.87879	35.88517	34.09091	0	EE	20ft
489	81	37.87879	35.88517	40.10695	0	EE	20ft
490	82	42.61364	34.09091	34.09091	0	EE	20ft
491	83	32.46753	29.64427	28.40909	0	EE	20ft
492	84	34.09091	29.64427	30.99174	0	EE	20ft
493	85	42.61364	37.87879	40.10695	0	EE	20ft
494	86	45.45455	48.7013	42.61364	2	EE	20ft

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
495	87	42.61364	40.10695	42.61364	0	EE	20ft
496	88	37.87879	32.46753	34.09091	1	EE	20ft
497	89	35.88517	30.99174	32.46753	0	EE	20ft
498	90	42.61364	35.88517	35.88517	1	EE	20ft
499	91	35.88517	32.46753	30.99174	0	EE	20ft
500	92	37.87879	32.46753	28.40909	0	EE	20ft
501	93	34.09091	29.64427	27.27273	0	EE	20ft
502	94	27.27273	26.22378	26.22378	8	EE	20ft
503	95	45.45455	42.61364	45.45455	3	EE	20ft
504	96	42.61364	35.88517	35.88517	0	EE	20ft
505	97	29.64427	30.99174	30.99174	3	EE	20ft
506	98	37.87879	32.46753	34.09091	0	EE	20ft
507	99	40.10695	45.45455	42.61364	6	EE	20ft
508	100	32.46753	30.99174	32.46753	0	EE	20ft
509	1	48.7013	42.61364	52.44755	0	HV	20ft
510	2	35.88517	34.1	42.61364	2	HV	20ft
511	3	52.44755	45.45455	52.44755	0	HV	20ft
512	4	52.44755	52.44755	56.81818	3	HV	20ft
513	5	42.61364	40.10695	45.45455	0	HV	20ft
514	6	48.7013	42.61364	48.7013	3	HV	20ft
515	7	40.10695	34.09091	40.10695	1	HV	20ft
516	8	48.7013	45.45455	52.44755	0	HV	20ft
517	9	45.45455	42.61364	45.45455	0	HV	20ft
518	10	40.10695	37.87879	42.61364	8	HV	20ft
519	11	48.7013	42.61364	45.45455	7	HV	20ft
520	12	40.10695	35.88517	48.7013	3	HV	20ft
521	13	45.45455	42.61364	48.7013	4	HV	20ft
522	14	42.61364	40.10695	48.7013	7	HV	20ft
523	15	42.61364	40.10695	45.45455	8	HV	20ft
524	16	48.7013	40.10695	52.44755	8	HV	20ft
525	17	42.61364	40.10695	45.45455	8	HV	20ft
526	18	45.45455	40.10695	45.45455	0	HV	20ft
527	19	42.61364	34.09091	45.45455	0	HV	20ft
528	20	37.87879	34.09091	40.10695	3	HV	20ft
529	21	45.45455	45.45455	52.44755	8	HV	20ft
530	22	48.7013	45.45455	52.44755	8	HV	20ft
531	23	42.61364	40.10695	48.7013	3	HV	20ft
532	24	42.61364	40.10695	48.7013	1	HV	20ft

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
533	25	45.45455	42.61364	48.7013	0	HV	20ft
534	26	52.44755	45.45455	52.44755	0	HV	20ft
535	27	48.7013	42.61364	48.7013	4	HV	20ft
536	28	45.45455	35.88517	40.10695	1	HV	20ft
537	29	48.7013	45.45455	56.81818	0	HV	20ft
538	30	45.45455	37.87879	48.7013	3	HV	20ft
539	31	42.61364	42.61364	48.7013	1	HV	20ft
540	32	40.10695	34.09091	45.45455	1	HV	20ft
541	33	48.7013	42.61364	52.44755	8	HV	20ft
542	34	45.45455	42.61364	48.7013	6	HV	20ft
543	35	42.61364	34.09091	45.45455	1	HV	20ft
544	36	42.61364	40.10695	42.61364	8	HV	20ft
545	37	48.7013	42.61364	56.81818	3	HV	20ft
546	38	42.61364	42.61364	48.7013	3	HV	20ft
547	39	45.45455	45.45455	52.44755	4	HV	20ft
548	40	52.44755	48.7013	52.44755	8	HV	20ft
549	41	42.61364	34.09091	40.10695	0	HV	20ft
550	42	48.7013	42.61364	52.44755	8	HV	20ft
551	43	37.87879	35.88517	42.61364	0	HV	20ft
552	44	48.7013	40.10695	45.45455	0	HV	20ft
553	45	48.7013	48.7013	48.7013	8	HV	20ft
554	46	52.44755	52.44755	61.98347	8	HV	20ft
555	47	48.7013	42.61364	52.44755	0	HV	20ft
556	48	45.45455	42.61364	48.7013	0	HV	20ft
557	49	45.45455	45.45455	48.7013	8	HV	20ft
558	50	42.61364	37.87879	45.45455	1	HV	20ft
559	51	48.7013	40.10695	48.7013	0	HV	20ft
560	52	48.7013	48.7013	52.44755	0	HV	20ft
561	53	35.88517	37.87879	42.61364	4	HV	20ft
562	54	48.7013	45.45455	52.44755	3	HV	20ft
563	55	42.61364	37.87879	40.10695	5	HV	20ft
564	56	48.7013	42.61364	48.7013	2	HV	20ft
565	57	45.45455	40.10695	45.45455	0	HV	20ft
566	58	45.45455	42.61364	45.45455	1	HV	20ft
567	59	42.61364	40.10695	45.45455	0	HV	20ft
568	60	37.87879	37.87879	40.10695	8	HV	20ft
569	61	45.45455	45.45455	48.7013	0	HV	20ft
570	62	45.45455	40.10695	48.7013	1	HV	20ft

Obs	Veh_	Zone1	Zone2	Zone3	Enc_0_8_	where	cond
571	63	42.61364	37.87879	42.61364	4	HV	20ft
572	64	48.7013	45.45455	56.81818	5	HV	20ft
573	65	48.7013	45.45455	45.45455	1	HV	20ft
574	66	40.10695	35.88517	45.45455	0	HV	20ft
575	67	45.45455	42.61364	48.7013	0	HV	20ft
576	68	52.44755	48.7013	52.44755	0	HV	20ft
577	69	45.45455	45.45455	48.7013	0	HV	20ft
578	70	52.44755	48.7013	52.44755	0	HV	20ft
579	71	42.61364	40.10695	42.61364	8	HV	20ft
580	72	45.45455	45.45455	48.7013	0	HV	20ft
581	73	32.46753	28.40909	35.88517	0	HV	20ft
582	74	45.45455	45.45455	48.7013	8	HV	20ft
583	75	45.45455	45.45455	52.44755	0	HV	20ft
584	76	45.45455	42.61364	48.7013	0	HV	20ft
585	77	35.88517	40.10695	48.7013	0	HV	20ft
586	78	52.44755	45.45455	52.44755	0	HV	20ft
587	79	56.81818	52.44755	56.81818	1	HV	20ft
588	80	45.45455	35.88517	45.45455	0	HV	20ft
589	81	48.7013	40.10695	45.45455	3	HV	20ft
590	82	35.88517	34.09091	37.87879	0	HV	20ft
591	83	48.7013	48.7013	52.44755	8	HV	20ft
592	84	48.7013	48.7013	56.81818	0	HV	20ft
593	85	56.81818	45.45455	56.81818	1	HV	20ft
594	86	42.61364	37.87879	45.45455	8	HV	20ft
595	87	45.45455	48.7013	48.7013	6	HV	20ft
596	88	48.7013	40.10695	48.7013	0	HV	20ft
597	89	48.7013	45.45455	48.7013	1	HV	20ft
598	90	48.7013	45.45455	48.7013	2	HV	20ft
599	91	40.10695	37.87879	45.45455	3	HV	20ft
600	92	48.7013	48.7013	52.44755	3	HV	20ft
601	93	40.10695	40.10695	45.45455	7	HV	20ft
602	94	48.7013	42.61364	48.7013	0	HV	20ft
603	95	45.45455	40.10695	52.44755	0	HV	20ft
604	96	40.10695	37.87879	42.61364	2	HV	20ft
605	97	45.45455	42.61364	48.7013	8	HV	20ft
606	98	42.61364	40.10695	42.61364	1	HV	20ft
607	99	52.44755	48.7013	52.44755	5	HV	20ft
608	100	52.44755	42.61364	52.44755	0	HV	20ft

APPENDIX B

SAS PROGRAM USED IN STATISTICAL ANALYSIS

```
data oneb;set one;where='EE';cond='40ft';run;
data twob;set two;where='EE';cond='Ctrl';run;
data threeb;set three;where='HV';cond='40ft':run;
data threeb;set three;where='HV';cond='40ft';run;
data fourb;set four;where='HV';cond='Ctrl';run;
data fiveb;set one;where='EE';cond='20ft';run;
data sixb;set one;where='HV';cond='20ft';run;

data big;set oneb twob threeb fourb fiveb sixb;run;
proc print;run;


data big2;set big;if zone1=. and zone2=. and zone3=. then delete;run;proc print;run;


proc glm;class where cond;
model zone1 zone2 zone3 enc_0_8_=where cond where*cond;
means where cond where*cond /tukey;
run;


data big3;set big2;
if  enc_0_8_ ge 6 then encr='HI ';
if  enc_0_8_ ge 3 and  enc_0_8_ le 5 then encr='MED';
if  enc_0_8_ le 2 then encr='LOW';

proc freq;tables cond*encr/expected chisq;run;

proc sort;by where;

proc freq;by where;tables cond*encr /expected chisq;run;

proc freq;by where;tables cond*enc_0_8_ /expected chisq;run;
proc freq;;tables cond*enc_0_8_ /expected chisq;run;

data big4;set big3;
dv1_2=f2-f3;
dv2_3=f3-f4;

proc corr;
```

```
var f2 f3 f4 dv1_2 dv2_3;
with f5;run;


*/
```

APPENDIX C

ANALYSIS OF VARIANCE OUTPUT

The GLM Procedure

Class Level Information

Class	Levels	Values
where	2	EE HV
cond	3	20ft 40ft Ctrl

Number of observations 600

The GLM Procedure

Dependent Variable: Zone1 Zone1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	6073.29208	1214.65842	55.67	<.0001
Error	594	12960.55518	21.81912		
Corrected Total	599	19033.84726			

R-Square	Coeff Var	Root MSE	Zone1 Mean
0.319079	11.27309	4.671094	41.43577

Source	DF	Type I SS	Mean Square	F Value	Pr > F
where	1	5878.575487	5878.575487	269.42	<.0001
cond	2	77.121010	38.560505	1.77	0.1717
where*cond	2	117.595584	58.797792	2.69	0.0684

Source	DF	Type III SS	Mean Square	F Value	Pr > F
where	1	5878.575487	5878.575487	269.42	<.0001
cond	2	77.121010	38.560505	1.77	0.1717
where*cond	2	117.595584	58.797792	2.69	0.0684

The GLM Procedure

Dependent Variable: Zone2 Zone2

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	7759.85588	1551.97118	75.01	<.0001
Error	594	12290.23945	20.69064		
Corrected Total	599	20050.09533			

R-Square	Coeff Var	Root MSE	Zone2 Mean
0.387023	11.96366	4.548696	38.02096

Source	DF	Type I SS	Mean Square	F Value	Pr > F
where	1	7733.576421	7733.576421	373.77	<.0001
cond	2	17.490858	8.745429	0.42	0.6555
where*cond	2	8.788598	4.394299	0.21	0.8087

Source	DF	Type III SS	Mean Square	F Value	Pr > F
where	1	7733.576421	7733.576421	373.77	<.0001
cond	2	17.490858	8.745429	0.42	0.6555
where*cond	2	8.788598	4.394299	0.21	0.8087

The GLM Procedure

Dependent Variable: Zone3 Zone3

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	31575.34657	6315.06931	260.35	<.0001
Error	594	14407.85314	24.25565		
Corrected Total	599	45983.19971			

R-Square	Coeff Var	Root MSE	Zone3 Mean
0.686671	11.95583	4.925002	41.19330

Source	DF	Type I SS	Mean Square	F Value	Pr > F
where	1	31417.33121	31417.33121	1295.26	<.0001
cond	2	145.46436	72.73218	3.00	0.0506
where*cond	2	12.55100	6.27550	0.26	0.7721

Source	DF	Type III SS	Mean Square	F Value	Pr > F
where	1	31417.33121	31417.33121	1295.26	<.0001
cond	2	145.46436	72.73218	3.00	0.0506
where*cond	2	12.55100	6.27550	0.26	0.7721

The GLM Procedure

Dependent Variable: Enc_0_8_ Enc_0_8_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	434.755000	86.951000	10.80	<.0001
Error	594	4781.310000	8.049343		
Corrected Total	599	5216.065000			

R-Square	Coeff Var	Root MSE	Enc_0_8_ Mean
0.083349	108.4947	2.837136	2.615000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
where	1	257.4150000	257.4150000	31.98	<.0001
cond	2	174.0900000	87.0450000	10.81	<.0001
where*cond	2	3.2500000	1.6250000	0.20	0.8172

Source	DF	Type III SS	Mean Square	F Value	Pr > F
where	1	257.4150000	257.4150000	31.98	<.0001
cond	2	174.0900000	87.0450000	10.81	<.0001
where*cond	2	3.2500000	1.6250000	0.20	0.8172

APPENDIX D

TUKEY TEST OF MEANS OUTPUT

The GLM Procedure

Tukey's Studentized Range (HSD) Test for Zone1

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	594
Error Mean Square	21.81912
Critical Value of Studentized Range	2.77747
Minimum Significant Difference	0.749

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	where
A	44.5659	300	HV
B	38.3057	300	EE

The GLM Procedure

Tukey's Studentized Range (HSD) Test for Zone2

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	594
Error Mean Square	20.69064
Critical Value of Studentized Range	2.77747
Minimum Significant Difference	0.7294

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	where
A	41.6111	300	HV
B	34.4308	300	EE

The GLM Procedure

Tukey's Studentized Range (HSD) Test for Zone3

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	594
Error Mean Square	24.25565
Critical Value of Studentized Range	2.77747
Minimum Significant Difference	0.7898

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	where
A	48.4295	300	HV
B	33.9571	300	EE

The GLM Procedure

Tukey's Studentized Range (HSD) Test for Enc_0_8_

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	594
Error Mean Square	8.049343
Critical Value of Studentized Range	2.77747
Minimum Significant Difference	0.455

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	where
A	3.2700	300	HV
B	1.9600	300	EE

The GLM Procedure

Tukey's Studentized Range (HSD) Test for Zone1

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than **REGWQ**.

Alpha	0.05
Error Degrees of Freedom	594
Error Mean Square	21.81912
Critical Value of Studentized Range	3.32284
Minimum Significant Difference	1.0975

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	cond
A	41.9428	200	20ft
A			
A	41.1835	200	40ft
A			
A	41.1810	200	Ctrl

The GLM Procedure

Tukey's Studentized Range (HSD) Test for Zone2

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	594
Error Mean Square	20.69064
Critical Value of Studentized Range	3.32284
Minimum Significant Difference	1.0688

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	cond
A	38.2617	200	20ft
A			
A	37.9168	200	40ft
A			
A	37.8844	200	Ctrl

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The GLM Procedure

Tukey's Studentized Range (HSD) Test for Zone3

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	594
Error Mean Square	24.25565
Critical Value of Studentized Range	3.32284
Minimum Significant Difference	1.1572

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	cond
A	41.8770	200	Ctrl
A			
A	40.9656	200	20ft
A			
A	40.7372	200	40ft

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The GLM Procedure

Tukey's Studentized Range (HSD) Test for Enc_0_8_

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	594
Error Mean Square	8.049343
Critical Value of Studentized Range	3.32284
Minimum Significant Difference	0.6666

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	cond
A	3.3400	200	Ctrl
B	2.4550	200	40ft
B			
B	2.0500	200	20ft

APPENDIX E

CHI-SQUARE TEST OF FREQUENCY OUTPUT

The GLM Procedure

Level of where	Level of cond	N	Zone1 Mean	Zone1 Std Dev	Zone2 Mean	Zone2 Std Dev	Zone3 Mean	Zone3 Std Dev	Enc_0_8_ Mean	Enc_0_8_ Std Dev
EE	20ft	100	38.3028668	4.40088954	34.5978697	4.51570639	33.6491123	4.42671839	1.32000000	2.36933269
EE	40ft	100	38.6230453	4.52813289	34.2296449	4.48546030	33.3783259	4.48354570	1.90000000	2.59953376
EE	Ctrl	100	37.9910515	4.44261867	34.4648618	4.00512043	34.8439243	5.42461406	2.66000000	2.64085998
HV	20ft	100	45.5827115	4.63849944	41.9255170	4.64930751	48.2821855	4.73786768	2.78000000	3.10613599
HV	40ft	100	43.7439883	5.04578099	41.6039201	5.07231065	48.0960971	5.48807688	3.01000000	2.97971255
HV	Ctrl	100	44.3709595	4.93258949	41.3039370	4.49972102	48.9101259	4.88293321	4.02000000	3.22859697

The FREQ Procedure

Table of cond by encr

cond / encr Frequency Expected Percent Row Pct Col Pct	HI	LOW	MED	Total
20ft	35 44.667 5.83 17.50 26.12	137 120 22.83 68.50 38.06	28 35.333 4.67 14.00 26.42	200 33.33
40ft	42 44.667 7.00 21.00 31.34	126 120 21.00 63.00 35.00	32 35.333 5 33 16.00 30.19	200 33.33
Ctrl	57 44.667 9.50 28.50 42.54	97 120 16.17 48.50 26.94	46 35.333 7.67 23.00 43.40	200 33.33
Total	134 22 33	360 60.00	106 17.67	600 100.00

The FREQ Procedure

Statistics for Table of cond by encr

Statistic	DF	Value	Prob
Chi-Square	4	17.8300	0.0013
Likelihood Ratio Chi-Square	4	17.7734	0.0014
Mantel-Haenszel Chi-Square	1	0.1004	0.7514
Phi Coefficient		0.1724	
Contingency Coefficient		0.1699	
Cramer's V		0.1219	

Sample Size = 600

-- where=EE --

The FREQ Procedure

Table of cond by encr

cond / encr Frequency Expected Percent Row Pct Col Pct	HI	LOW	MED	Total
20ft	11 14.667 3.67 11.00 25.00	81 70 27.00 81.00 38.57	8 15.333 2.67 8.00 17.39	100 33.33
40ft	14 14.667 4.67 14.00 31.82	73 70 24.33 73.00 34.76	13 15.333 4.33 13.00 28.26	100 33.33
Ctrl	19 14.667 6.33 19.00 43.18	56 70 18.67 56.00 26.67	25 15.333 8.33 25.00 54.35	100 33.33
Total	44 14.67	210 70.00	46 15.33	300 100.00

-------------------- where=EE --------------------

The FREQ Procedure

Statistics for Table of cond by encr

Statistic	DF	Value	Prob
Chi-Square	4	16.8409	0.0021
Likelihood Ratio Chi-Square	4	16.7253	0.0022
Mantel-Haenszel Chi-Square	1	1.3457	0.2460
Phi Coefficient		0 2369	
Contingency Coefficient		0.2305	
Cramer's V		0.1675	

Sample Size = 300

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------------------------------- where=HV -------------------------------

The FREQ Procedure

Table of cond by encr

cond / encr Frequency Expected Percent Row Pct Col Pct	HI	LOW	MED	Total
20ft	24 30 8.00 24.00 26.67	56 50 18.67 56.00 37.33	20 20 6.67 20.00 33.33	100 33.33
40ft	28 30 9.33 28.00 31.11	53 50 17.67 53.00 35.33	19 20 6.33 19.00 31.67	100 33.33
Ctrl	38 30 12.67 38.00 42.22	41 50 13.67 41.00 27.33	21 20 7.00 21.00 35.00	100 33.33
Total	90 30.00	150 50.00	60 20.00	300 100.00

--- where=HV ---

The FREQ Procedure

Statistics for Table of cond by encr

Statistic	DF	Value	Prob
Chi-Square	4	6.0867	0.1928
Likelihood Ratio Chi-Square	4	6.0874	0.1927
Mantel-Haenszel Chi-Square	1	1.7187	0.1899
Phi Coefficient		0.1424	
Contingency Coefficient		0.1410	
Cramer's V		0.1007	

Sample Size = 300

-- where=EE --

The FREQ Procedure

Table of cond by Enc_0_8_

cond Enc_0_8_(Enc_0_8_)

Frequency / Expected / Percent / Row Pct / Col Pct	0	1	2	3	4	5	6	7	8	Total
20ft	64	11	6	4	2	2	4	1	6	100
	47.667	11	11.333	7.6667	5.6667	2	4	2.6667	8	
	21.33	3.67	2.00	1.33	0.67	0.67	1.33	0.33	2.00	33.33
	64.00	11.00	6.00	4.00	2.00	2.00	4.00	1.00	6.00	
	44.76	33.33	17.65	17.39	11.76	33.33	33.33	12.50	25.00	
40ft	48	11	14	7	5	1	2	3	9	100
	47.667	11	11.333	7.6667	5.6667	2	4	2.6667	8	
	16.00	3.67	4.67	2.33	1.67	0.33	0.67	1.00	3.00	33.33
	48.00	11.00	14.00	7.00	5.00	1.00	2.00	3.00	9.00	
	33.57	33.33	41.18	30.43	29.41	16.67	16.67	37.50	37.50	
Ctrl	31	11	14	12	10	3	6	4	9	100
	47.667	11	11.333	7.6667	5.6667	2	4	2.6667	8	
	10.33	3.67	4.67	4.00	3.33	1.00	2.00	1.33	3.00	33.33
	31.00	11.00	14.00	12.00	10.00	3.00	6.00	4.00	9.00	
	21.68	33.33	41.18	52.17	58.82	50.00	50.00	50.00	37.50	
Total	143	33	34	23	17	6	12	8	24	300
	47.67	11.00	11.33	7.67	5.67	2.00	4.00	2.67	8.00	100.00

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-- where=EE --

The FREQ Procedure

Statistics for Table of cond by Enc_0_8_

Statistic	DF	Value	Prob
Chi-Square	16	30.7169	0.0146
Likelihood Ratio Chi-Square	16	32.0433	0.0099
Mantel-Haenszel Chi-Square	1	13.3852	0.0003
Phi Coefficient		0.3200	
Contingency Coefficient		0.3048	
Cramer's V		0.2263	

WARNING: 33% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Sample Size = 300

-- where=HV --

The FREQ Procedure

Table of cond by Enc_0_8_

cond Enc_0_8_(Enc_0_8_)

Frequency / Expected / Percent / Row Pct / Col Pct	0	1	2	3	4	5	6	7	8	Total
20ft	38	14	4	12	5	3	2	3	19	100
	32.333	10.333	7.3333	8.3333	6	5.6667	5.6667	4	20.333	
	12.67	4.67	1.33	4.00	1.67	1.00	0.67	1.00	6.33	33.33
	38.00	14.00	4.00	12.00	5.00	3.00	2.00	3.00	19.00	
	39.18	45.16	18.18	48.00	27.78	17.65	11.76	25.00	31.15	
40ft	35	6	12	9	6	4	11	2	15	100
	32.333	10.333	7.3333	8.3333	6	5.6667	5.6667	4	20.333	
	11.67	2.00	4.00	3.00	2.00	1.33	3.67	0.67	5.00	33.33
	35.00	6.00	12.00	9.00	6.00	4.00	11.00	2.00	15.00	
	36.08	19.35	54.55	36.00	33.33	23.53	64.71	16.67	24.59	
Ctrl	24	11	6	4	7	10	4	7	27	100
	32.333	10.333	7.3333	8.3333	6	5.6667	5.6667	4	20.333	
	8.00	3.67	2.00	1.33	2.33	3.33	1.33	2.33	9.00	33.33
	24.00	11.00	6.00	4.00	7.00	10.00	4.00	7.00	27.00	
	24.74	35.48	27.27	16.00	38.89	58.82	23.53	58.33	44.26	
Total	97	31	22	25	18	17	17	12	61	300
	32.33	10.33	7.33	8.33	6.00	5.67	5.67	4.00	20.33	100.00

-- where=HV --

The FREQ Procedure

Statistics for Table of cond by Enc_0_8_

Statistic	DF	Value	Prob
Chi-Square	16	35.6160	0.0033
Likelihood Ratio Chi-Square	16	35.3746	0.0035
Mantel-Haenszel Chi-Square	1	7.7840	0.0053
Phi Coefficient		0.3446	
Contingency Coefficient		0.3258	
Cramer's V		0.2436	

Sample Size = 300

The FREQ Procedure

Table of cond by Enc_0_8_

cond	Enc_0_8_(Enc_0_8_)									
Frequency Expected Percent Row Pct Col Pct	0	1	2	3	4	5	6	7	8	Total
20ft	102	25	10	16	7	5	6	4	25	200
	80	21.333	18.667	16	11.667	7.6667	9.6667	6.6667	28.333	
	17.00	4.17	1.67	2.67	1.17	0.83	1.00	0.67	4.17	33.33
	51.00	12.50	5.00	8.00	3.50	2.50	3.00	2.00	12.50	
	42.50	39.06	17.86	33.33	20.00	21.74	20.69	20.00	29.41	
40ft	83	17	26	16	11	5	13	5	24	200
	80	21.333	18.667	16	11.667	7.6667	9.6667	6.6667	28.333	
	13.83	2.83	4.33	2.67	1.83	0.83	2.17	0.83	4.00	33.33
	41.50	8.50	13.00	8.00	5.50	2.50	6.50	2.50	12.00	
	34.58	26.56	46.43	33.33	31.43	21.74	44.83	25.00	28.24	
Ctrl	55	22	20	16	17	13	10	11	36	200
	80	21.333	18.667	16	11.667	7.6667	9.6667	6.6667	28.333	
	9.17	3.67	3.33	2.67	2.83	2.17	1.67	1.83	6.00	33.33
	27.50	11.00	10.00	8.00	8.50	6.50	5.00	5.50	18.00	
	22.92	34.38	35.71	33.33	48.57	56.52	34.48	55.00	42.35	
Total	240	64	56	48	35	23	29	20	85	600
	40.00	10.67	9.33	8.00	5.83	3.83	4.83	3.33	14.17	100.00

The FREQ Procedure

Statistics for Table of cond by Enc_0_8_

Statistic	DF	Value	Prob
Chi-Square	16	42.3955	0.0003
Likelihood Ratio Chi-Square	16	42.7910	0.0003
Mantel-Haenszel Chi-Square	1	19.1101	<.0001
Phi Coefficient		0.2658	
Contingency Coefficient		0.2569	
Cramer's V		0.1880	

Sample Size = 600

VITA

Jeff Hammond was born in Nashville, Tennessee on September 20, 1976. He attended schools in the Metropolitan Nashville Public School System, graduating from John Overton High School in 1994. He entered David Lipscomb University in Nashville the same year, then enrolled at the University of Tennessee, Knoxville in 1996 to pursue a degree in Civil Engineering. He received his Bachelor of Science degree in Civil Engineering in 1998 and his Master of Science degree in Civil Engineering in 1999, both from the University of Tennessee. He is currently working for Knox County's Department of Engineering and Public Works, and staying on his side of the road while doing it.