INTERIM REPORT

EVALUATION OF WIDE EDGELINES ON TWO-LANE RURAL ROADS

by

B. H. Cottrell, Jr.
Research Scientist

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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ABSTRACT

This interim report presents the results of an evaluation of 4-in and 8-in wide edgelines on the lateral placement and speeds of vehicles on two-lane rural roads. Data were collected at twelve locations on sections of roadway covering 55.2 mi. Two methods of painting the 8 in width were also analyzed.

It was concluded from analyses of variance of lateral placement, lateral placement variance, encroachments by cars and trucks, mean speed, and the speed variance that, overall, there were no statistically significant differences between the 4-in and 8-in wide edgelines. The mean lateral placement was significantly lower for the 8-in line. However, changes in lateral placement and speed were neither statistically nor practically significant.

SI CONVERSION FACTORS

To convert

From	To	Multiply by
in	cm	2.54
mi	km	1.609 344
mi/h	km/h	1.609 344 E + 00
Degrees	Radians	1.745 E-02
gal	m^3	3.785 412 E-03
gal/mi	m^3/km	2.352 146 E-03
lb/mi	kg/km	2.818 493 E-01

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INTRODUCTION

Problem Statement

There are a high number of run-off-the-road (ROR), drunken driving, and night accidents in rural areas. In 1980, there were 18,792 ROR accidents in rural areas in Virginia.(1) Of this total, 269, or 1.4%, were fatal accidents; 8,367, or 44.6%, injury accidents; and 10,417, or 54.0%, property damage accidents. ROR accidents accounted for 31.9% of all rural accidents, 38.5% of the fatalities in rural accidents (the largest percentage for any type of accident), and 35.1% of the persons injured in rural accidents. Drinking drivers -- persons driving under the influence of alcohol (DUI) -- were involved in 12,025, or 20.4%, of all rural accidents. Accidents involving DUI accounted for 31.7% of fatal accidents, 27.1% of personal injury accidents, and 16.3% of property damage accidents in rural areas. There were 25,621 accidents during nighttime, which constituted 43.5% of all accidents in rural areas.

To provide guidance to motorists on two-lane rural roads, edgelines are used to delineate the right edge of the roadway. The edgeline is one element in a pavement marking system that provides warning and guidance information to the driver without diverting his attention from the roadway.(2) Reflectorized pavement markings are the most common form of delineation at night when the reduced visibility creates a greater need for guidance information.

Edgelines 8 in wide have the potential to reduce the probability of a driver running off the road and increase the probability of a driver positioning his vehicle close to the centerline. However, since wide edgelines have the potential to influence the lateral position of the vehicle in this manner, the probability of centerline encroachment may increase. The Virginia Department of Highways and Transportation currently uses wide edgelines and centerlines in special circumstances, viz., in gore areas on interstate routes, tunnel entrances, and approaches to narrow bridges.

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Objectives and Scope

The objectives of the research reported here, which was requested by the Highway and Traffic Safety Division, were to evaluate the effect of wide edgelines on (1) accidents, especially those involving ROR and DUI, and (2) on the lateral placement and speed of vehicles.

The Governor's Task Force to Combat Drunk Driving addressed highway edgelines in its action plan, and recommended that the "Virginia Department of Highways and Transportation should investigate the use of wide (8-inch) edgelines on secondary roads as a measure for reducing accidents involving DUI."(3)

The scope was limited to two-lane rural roads. Primary routes were selected because accident data are more detailed and more readily available for them than for secondary routes.

This interim report documents the evaluation of lateral placement and speed. The final report will address accidents.

Report Format

The remainder of this report is divided into 5 major sections as follows:

1. Literature review
2. Study Design
3. Analysis of Lateral Placement and Speed Data
4. Analysis of Wide Edgeline Painting
5. Conclusions

LITERATURE REVIEW

An HRIS literature review did not identify any completed research efforts on the effect of wide edgelines on accidents. Two research projects on the use of edgelines as a countermeasure for DUI were identified. Both projects were conducted on a controlled test section.

Research was conducted by Nedas et al. on the use of no edgelines and 4-, 6-, and 8-in wide edgelines as an alcohol countermeasure.(4) It was concluded that the effect of increasing the edgeline width was to move drivers from the edgeline toward the centerline, for drivers with a zero blood alcohol concentration (BAC) as well as those with 0.05% and 0.08% BAC levels. The shift toward the centerline was not accompanied by an increase in centerline encroachments. The range was compressed against the centerline, which resulted in more driving in the lane and a more centralized position of vehicles. Based on previous research which had indicated that a compressed range of vehicle positions and the positioning of vehicles in the center of the lane are measures of good driving, it was concluded that the 8-in wide edgelines provided benefits compared to those 4-in wide for both impaired and unimpaired drivers. Furthermore, since alcohol impairment may be related to other types of impairment such as fatigue, drugs, and reduced visual ability, the beneficial effects may extend to other impairments.

In his research on the effects of roadway delineation on curve negotiation by both sober and drinking drivers, Johnson concluded the following:

1. The major determinant of curve negotiation performance is the geometry of the road being driven. The proportion of the ratios of the instantaneous vehicle curve radius to the curve radius, IC/CR, that is equal to or less than 0.85 was used as the major dependent performance measure. The higher the proportion, the better the performance.

2. Drivers generally use a corner-cutting strategy when negotiating horizontal curves. In a corner-cutting technique, drivers seek to drive a path with a radius larger than the curve radius. This is generally performed by driving at the outside of the curve at the beginning of the curve, near the inside at the curve apex, and near the outside of the curve near the end of the curve.

3. Alcohol leads to extreme corner-cutting behavior.

4. Edgelines generally add little to driver performance, except that 6-in wide lines, the widest edgeline tested, reduce the incidence of extreme lateral placement, particularly for alcohol-affected drivers (0.05% BAC level).

5. The combination of chevron alignment signs and 6-in wide edgelines offers the greatest potential as an accident countermeasure.(5)

No information is available on the impact of wide edgelines on lateral placement nor on accidents, especially the ROR and DUI types, under road conditions.

STUDY DESIGN

The experimental plan for evaluating the wide edgelines was a before and after study. Field data were collected for a before period with standard width edgelines and for an after period following the installation of wide edgelines. It is assumed that any differences in the measures of performance, lateral placement, and speeds between the before and after periods were attributable to the wide edgelines. The primary measure of performance was lateral placement. Because previous research by Nedas et al. had concluded that increasing the edgeline width moved the driver closer to the centerline, the effect of edgeline width on lateral placement was of much concern. It was believed important to determine if such a shift resulted in safety and operational problems.

Study Sections

Two sections of roadway were selected for the study: a 36.3-mile section of Route 20 from Route 53 near Charlottesville south to U.S. Route 15 in Albemarle and Buckingham counties, and 18.9 miles of Route 501 in Bedford (from Route 761 north to county line) and Rockbridge (5.4 miles northward from county line) counties. In selecting these sections, the accident data on 11 road sections were reviewed and these 2 were ranked 1st and 2nd for the percentage of ROR accidents and alcohol-drug related accidents.

Study Sites for Field Data Collection

A sampling method based on the following criteria was developed to select sites for field data collection along the study sections.

1. Ideally, study sites should be located at 5-mile intervals along the study section (intervals of 3 to 7 miles were acceptable).

2. The direction of travel of the traffic volume to be studied should be alternated (e.g., northbound, southbound, northbound, etc.).

3. The posted speed limit should be 55 mi/h.

4. The sites should be representative of the overall geometrics of the roadway (e.g., a road section with many horizontal curves should have curve study sites).

5. Interference from intersections and driveways should be avoided.

6. The total sample should include left and right horizontal curves and tangent sections.

7. For curves, the study site should be located midway between the beginning and middle of the curve.

8. A convenient parking area should be available for the vehicle transporting the data collection equipment.

Using these criteria, 12 study sites were selected. Descriptive data on these sites are shown in Table 1. It is noted that some of the edgelines intended to be 8 in wide were not that wide.

Data Collection Procedure

Lateral placement and speed data were collected for a 24-hour period at the study sites using a Leupold and Stevens traffic data recorder (TDR).

Use of Leupold and Stevens TDR for Lateral Placement Data (6)

The configuration for collecting lateral placement data with the Leupold and Stevens TDR is illustrated in Figure 1. Two TDR detector channels were used for each lane: one to measure the vehicle's speed, the other to measure its position relative to the edge line. The speed detector consisted of two sensor cables placed perpendicular to the edge line and 6 ft apart. The position detector consisted of two sensor cables placed 6 ft apart at the edge of the pavement, but the trailing cable was laid at an angle other than 90° to the edge of the pavement. A typical angle for the trailing detector was 45°. Vinyl tape was used to secure the sensor cables to the pavement.

Traffic data were recorded on a magnetic cassette tape that was brought in from the field, read, and filed on a computer. The raw data were printed and screened for recording errors. Summary data on lateral placement and speeds such as the mean, standard deviation, and frequency distribution were printed using TDR report generator programs and programs developed at the Research Council.

Table 1

Data on the Study Sites

Site No.	Approach	Geometrics	Lane Width (ft) (inside lane markings)	24-hr Traffic Count	Wide Edgeline (in)
Route 20 - Albemarle County					
1	Southbound	Left Curve 6°	10.92	2,307	7.0
2	Northbound	Left Curve 11°	9.58	1,982	7.5
3	Southbound	Straight	11.00	1,420	8.0
4	Northbound	Left Curve 10°	8.92	1,379	7.0
Route 20 - Buckingham County					
5	Southbound	Right Curve 5°	9.00	911	7.0
6	Northbound	Straight	8.71	631	8.0
7	Southbound	Straight	8.79	534	7.8
8	Northbound	Straight	9.00	1,028	7.5
Route 501 - Bedford County					
9	Southbound	Left Curve 10°	9.75	688	10.0
10	Northbound	Straight	8.46	559	10.0
11	Southbound	Right Curve 7°	8.17	390	10.0
Route 501 - Rockbridge County					
12	Northbound	Left Curve 3°	9.83	1,482	7.0

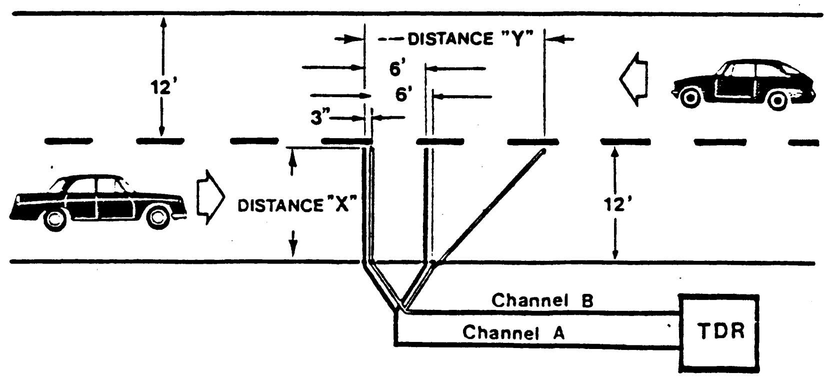

Figure 1. Configuration for lateral placement data collection.

ANALYSIS OF LATERAL PLACEMENT AND SPEED

The analysis of the lateral placement and speed data was performed for individual sites and for all sites. The objective was to determine if there were any significant differences in lateral placement or speed for 4-in lines as compared to those for the 8-in line. The measures of performance and statistical tests are discussed below.

Analysis of Variance of Lateral Placement

The analysis of variance is a statistical procedure for testing the equality of means of two or more samples by analyzing the variation both within and between samples.(7) A significance level of 0.05 was used.

The results of the analysis are shown in Table 2. During the day, for all 12 sites the lateral placement means for the 4-in and 8-in lines were significantly different. At night, 7 of the 12 sites had statistically equal means. For the total period, the means for the 4-in and 8-in wide lines were significantly different for 10 of the 12 sites.

Based on the analysis of variance, it was concluded that the means of the lateral placement for the 4- and 8-in wide edgelines were significantly different during the day and total time periods.

Comparison of the Variances of Lateral Placement

The variance of the lateral placement of 4- and 8-in wide edgelines were compared using a chi-square test under the hypothesis that the variance in lateral placement of the 8-in lines equals a specified value; that is, the variance of the 4-in wide line.(8) Normal distributions were assumed for both variances. The alternative hypothesis is that the variance of the 8-in wide edgeline is either greater than or less than the variance of the 4-in line. A significance level of 0.05 was used.

Research by Stimpson et al. concluded that longitudinal changes in lateral placement variance is one of the two most sensitive indicators of hazard,(9) and Taylor et al. noted a strong correlation between the lateral placement variance and accident experience.(10) In other words, the higher the variance in the lateral placement, the higher the hazard potential and number of accidents. Consequently, it was concluded that the lower the variance in lateral placement, the better the edgeline performs.

Table 2

Results of the Analysis of Variance of Lateral Placement

	Statistically Different Lateral Placement		
Site No.	Day	Night	Total
1	X	X	X
2	X	X	X
3	X	X	X
4	X		
5	X		X
6	X		
7	X	X	X
8	X		X
9	X		X
10	X		X
11	X		X
12	X	X	X
Total	12	5	10
Percent	100	41.7	83.3

The results of the chi-square test are shown in Table 3. For the day, night, and total time periods, 8 (or 66.7%), 9 (or 75%), and 9 (or 75%), respectively, of the 12 sites showed no significant difference in the lateral placement variance.

The Wilcoxon matched-pairs signed rank test was employed to determine whether the variance in lateral placement variance was significantly different for the 4- and 8-in wide edgelines for all 12 sites. This is a two-sample, nonparametric test (no assumptions are made on the distribution of the variances) for comparing two populations (4- and 8-in wide lines) on the basis of a paired sample (4- and 8-in lines lateral placement variance measure at a site).(8) For the three time periods, it was concluded that there was no significant difference in the variance of the lateral placement for 4-in and 8-in lines at a 0.05 level of significance.

Table 3

Results of the Comparison of Lateral Placement Variances by Chi-square Test

Site No.	Preferred Lateral Placement								
	Day			Night			Total		
	4 in	8 in	No Diff.	4 in	8 in	No Diff.	4 in.	8 in	No Diff.
1			X	X					X
2		X			X			X	
3		X				X			X
4			X			X			X
5			X			X			X
6	X					X	X		
7			X		X				X
8			X			X			X
9		X				X		X	
10			X			X			X
11			X			X			X
12			X			X			X
Total	1	3	8	1	2	9	1	2	9
Percent	8.3	25.0	66.7	8.3	16.7	75.0	8.3	16.7	75.0

Comparison of Means of Lateral Placement

The means of the lateral placements were compared using a t-test under the hypothesis that the mean lateral placements of the two edgelines are equal. A significance level of 0.05 was used.

It is noted that good or preferred lateral placement is controversial. Research by Johnson, as well as others, has concluded that a corner-cutting strategy is used on curves.(5) Other researchers have recommended driving in the center of the lane.(4,9,10)

In a telephone conversation, one of the three driving supervisors for the Commonwealth of Virginia Division of Motor Vehicles stated that the Division's policy on driver position in the lane is that (1) the center of the lane is the predominantly recommended driver position in Virginia, (2) on left curves, drivers should stay to the left when there is no opposing traffic to avoid gravel near the shoulder which may cause skidding -- otherwise, they should drive in the center of the lane, and (3) on right curves, they should always drive in the center of the lane. Gravel near the shoulder did not appear to be a problem at the study sites. Therefore, in general, good lateral placement was considered to be synonomous with driving in the center of the lane. The preferred edgeline width is the one that results in a mean lateral placement closest to the center of the lane. For all sites, the mean lateral placements of both edgeline widths were greater (or closer to the centerline) than the lateral placement of a standard size vehicle positioned in the center of the lane. Consequently, the lower mean lateral placement was preferred.

As can be seen in Table 4, for 10 (91.7%), 7 (58.4%), and 9 (75%) of the 12 sites, the mean lateral placement for the 8-in wide edgeline was significantly lower than the mean for the 4-in line for the day, night, and total time periods, respectively.

Similarly, the Wilcoxon matched-pairs signed rank test revealed that the mean lateral placement for the 4-in wide edgeline was significantly greater at a level of significance of 0.01 for all three time periods. Therefore, from a statistical standpoint the 8-in wide line results in significantly better lateral placement positioning than does the 4-in line.

Table 4

Results of the Comparison of the Mean Lateral Placements

Site No.	Preferred Mean Lateral Placement								
	Day			Night			Total		
	4 in	8 in	No Diff.	4 in	8 in	No Diff.	4 in	8 in	No Diff.
1		X			X			X	
2		X			X			X	
3		X			X			X	
4		X				X			X
5		X				X		X	
6		X				X		X	
7		X			X			X	
8		X				X		X	
9	X					X	X		
10		X			X			X	
11		X			X			X	
12		X			X			X	
Total	1	11	0	0	7	5	1	10	1
Percent	8.3	91.7	0	0	58.4	41.6	8.3	83.4	8.3

Encroachments on Opposing Lane

Encroachments on the opposing lane were compared using a chi-square test under the hypothesis of independence of edgeline width and encroachments. A significance level of 0.05 was used. The alternative hypothesis is that the edgeline width causing the lower percentage of encroachments is preferred.

Encroachments were measured using a lateral placement zone system consisting of 10 zones, with each zone being 10 in wide. The zones of encroachment are the zone in which the average vehicle would be crossing the centerline and all zones to the left of this zone as illustrated in Figure 2. The average widths of 6 ft and 8 ft were used for cars and trucks, respectively. Data from Consumer Report show that the widths of 1984 model cars range from a 63.8-in mean for small cars to a mean of 76.6 in for large cars.(11) The mean for medium cars is 70.8 in. Since data were not available on the distribution of car ownership by car size, the medium cars were selected as the average vehicle and the average car width of 72 in was used. The American Association of State Highway and Transportation Officials (AASHTO) design widths for cars and trucks are 7.0 and 8.5 ft, respectively.(12) An average truck width of 8 ft was selected, since the design vehicles are larger than the actual vehicles.

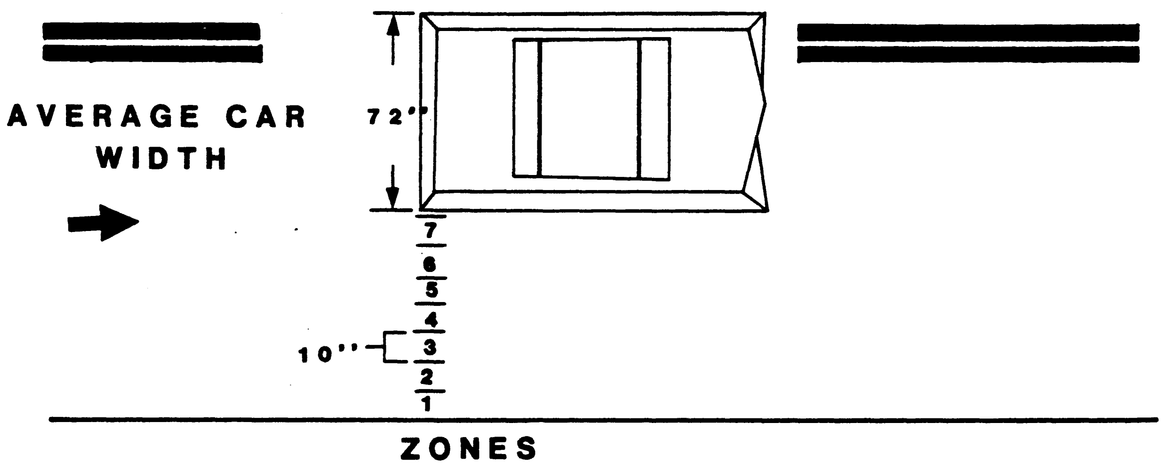

Figure 2. Example of zones of encroachment.

The zones of encroachment were determined as follows: (1) the average vehicle width is subtracted from the lane width to determine the minimum lateral placement for encroachment; (2) the associated zone is identified, and (3) if this position is in the half of the zone closest to the edgeline, then this zone and all higher zones represent the zones of encroachment; otherwise, all higher zones represent the zone of encroachment.

The encroachment results are shown in Table 5. For all time periods, and for both cars and trucks, neither edgeline appeared to perform consistently better than the other. This is supported by the Wilcoxon matched-pairs signed rank tests, which concluded that there were no significant differences in the encroachments for the two edgeline widths for all time periods for both cars and trucks, with one exception. For trucks at night, the encroachments were significantly greater for 4-in wide edgelines.

Distribution of the Lateral Placement of Cars and Trucks by Zones

The distribution of the lateral placement of cars and trucks by zones is displayed in the Appendix for all sites for the total period. In general, there were no noticeable changes in the position or range of lateral placements of cars. These data are consistent with the earlier findings on the means and variance of lateral placement.

Comparison of the Variances in Speed

The variances in the speed for the 4-in and 8-in wide edgelines were compared using a chi-square test under the hypothesis that the variance in speed for the 8-in edgelines equals a specified value; that is, the variance in speed for the 4-in line. Normal distributions were assumed and a level of significance of 0.05 was used. The preferred speed variance was the lower speed variance since uniform driving tends to promote safety.[4,9] The chi-square test results are shown in Table 6. For the day, night, and total time periods, the data show that the variance in speed was significantly lower for the 4-in line at 6 (50%), 3 (25%), and 7 (58.3%) of the 12 sites. At night, for 8 (66.7%) of the 12 sites there was no significant difference in the speed variance.

Use of the Wilcoxon matched-pairs signed rank test showed that there was no significant difference for the day and night periods. For the total period, the variance for the 8-in wide edgeline was significantly greater than that for the 4-in line at the 0.05 level of significance.

Table 5

Results of Comparison of Encroachments on Opposing Lane

Site No.	Preferred Encroachment																	
	Day						Night						Total					
	Cars			Trucks			Cars			Trucks			Cars			Trucks		
	4 in	8 in	No Diff.	4 in	8 in	No Diff.	4 in	8 in	No Diff.	4 in	8 in	No Diff.	4 in	8 in	No Diff.	4 in	8 in	No Diff.
1		X		X					X			X		X		X		
2		X			X				X			X		X			X	
3		X				X		X				X		X				X
4	X					X	X					X	X					X
5	X				X		X					X	X				X	
6		X				X			X			X		X				X
7		X				X			X			X		X				X
8	X					X			X			X	X					X
9	X				X				X		X				X		X	
10		X		X					X			X		X		X		
11	X					X	X					X	X					X
12	X				X		X				X		X				X	
Total	6	6	0	2	4	6	4	1	7	0	2	10	5	6	1	2	4	6
Percent	50.0	50.0	0	16.7	33.3	50.0	33.3	8.3	58.4	0	16.7	83.5	41.7	50.0	8.3	16.7	33.3	50.0

Table 6

Comparison of the Variances of Speed

Site No.	Statistically Lower Speed Variance								
	Day			Night			Total		
	4 in	8 in	No Diff.	4 in	8 in	No Diff.	4 in	8 in	No Diff.
1	X			X			X		
2	X					X	X		
3	X					X	X		
4			X		X				X
5			X			X	X		
6	X					X	X		
7	X					X			X
8		X		X				X	
9	X					X	X		
10		X				X		X	
11			X			X			X
12			X	X			X		
Total	6	2	4	3	1	8	7	2	3
Percent	50.0	16.7	33.3	25.0	8.3	66.7	58.3	16.7	25.0

Comparison of the Mean Speeds

The mean speeds were compared using the t-test under the hypothesis that the mean speeds are equal at a 0.05 significance level. The preferred speed was the lower speed.

As shown in Table 7, for the day, night, and total periods, 8 (66.7%), 11 (91.7%), and 9 (75.0%), respectively, of the 12 sites showed no significant differences.

Thus, the Wilcoxon matched-pairs signed rank test concluded that at a 0.05 level of significance, the mean speeds of the 4- and 8-in wide edgelines were equal for all three time periods.

Table 7

Comparison of the Mean Speeds

Site No.	Statistically Lower Mean Speed: Day 4 in	Day 8 in	Day No Diff.	Night 4 in	Night 8 in	Night No Diff.	Total 4 in	Total 8 in	Total No Diff.
1			X			X			X
2		X				X		X	
3		X				X		X	
4			X			X			X
5			X			X			X
6		X				X		X	
7		X				X			X
8			X		X				X
9			X			X			X
10			X			X			X
11			X			X			X
12			X			X			X
Total	0	4	8	0	1	11	0	3	9
Percent	0.0	33.3	66.7	0.0	8.3	91.7	0.0	25.0	75.0

Summary of the Statistical Analysis

A summary of the findings from all the statistical tests except the analysis of variance of lateral placement is shown in Table 8. The lateral placement mean indicates a statistically better performance by the 8-in wide edgeline for all three time periods. The superior performance in the Wilcoxon matched-pairs signed rank test for truck encroachments at night and speed variance for the total period results from two sites having large differences between the 4- and 8-in lines for these measures. In the Wilcoxon matched-pairs signed rank tests, large differences between the matched pairs are ranked higher, and, consequently, one or two sites with large differences between the matched pairs may result in statistically significant differences while the remaining sites indicate little or no differences. These two sites, when compared to the other ten sites, are exceptions that favor the 8-in wide edgeline. The variance in lateral placement, car encroachments, and mean speed are statistically equal for 4- and 8-in lines for all time periods.

Table 8

Summary of Analysis for All Sites

Measure of Performance	Preferred Line Width								
	Day			Night			Total		
	4 in	8 in	No Diff.	4 in	8 in	No Diff.	4 in	8 in	No Diff.
Lateral placement variance	3(25)	1(8.3)	8(66.7)*	2(16.7)	1(8.3)	9(75.0)*	2(16.7)	1(8.3)	9(75.0)*
Lateral placement mean	1(8.3)	10(83.4)*	1(8.3)	0(0)	7(58.7)*	4(33.3)	1(8.3)	9(75.0)*	2(16.7)
Encroachment, cars	6(50)	6(50)	0(0)*	4(33.3)	1(8.3)	7(58.4)*	5(41.7)	6(50)	1(8.3)*
Encroachment, trucks	2(16.7)	4(33.3)	6(50)*	0(0)	2(16.7)*	10(83.3)	2(16.7)	4(33.3)	6(50)*
Speed variance	6(50)	2(16.7)	4(33.3)*	3(25.0)	1(8.3)	8(66.7)*	7(58.3)	2(16.7)*	3(25)
Mean speed	0(0)	4(33.3)	8(66.7)*	0(0)	1(8.3)	11(91.7)*	0(0)	3(25)	9(75)*

Note: Percentages shown in parentheses.

*Results of the Wilcoxon matched-pairs signed rank test.

Therefore, the lateral placement mean is the only measure of performance that shows a statistically significant difference between the 4- and 8-in wide lines. The difference suggests that 8-in wide edgelines are preferred.

The study sites were grouped by road geometrics and lane width to examine performance trends related to these factors. However, no significant relationships were observed.

Practical Significance of Differences Between 4- and 8-in Edgelines

The statistical significance of differences between performance measures for the 4- and 8-in wide edgelines must be examined for practical significance, because statistical significance does not necessarily reflect a practical significance. In other words, given that there is a statistically measurable effect, Is the change effective in improving traffic safety and operations? This question will be thoroughly addressed in the final report on this research project. The practical significance based on engineering judgement is discussed below.

In Table 9, the numerical differences between the measures of performance for the total period are given for the 12 sites. The values for the 4-in wide edgeline and the statistical results are also shown.

Only the mean lateral placement consistently showed a statistically significant difference, with the 8-in edgeline being preferred. A lateral placement shift of 8 in is practical. With a tire width of about 8 in, the tire path will not overlap with a lateral placement shift of 8 in or more. Also, it is believed that a shift is visibly noticeable at 8 in. Based on this, only site 3 displayed a practically significant lateral placement shift. Consequently, it was concluded that overall there was no practically significant shift in lateral placement.

No other measure was closely examined for practical significance, since there were no overall statistically significant differences.

Table 9

Differences Between 4- and 8-in Wide Edgelines for the Total Period

Site No.	Lateral Placement				Encroachment (%)				Speed			
	Mean (ft)		Variance (ft^2)		Cars		Trucks		Mean (mi/h)		Variance (mi/h^2)	
	4 in	4-8 in	4 in	4-8 in	4 in	4-8 in	4 in	4-8 in	4 in	4-8 in	4 in	4-8 in
1	4.44	0.38(8)	1.35	0.0	32.3	7(8)	61.0	-21.5(4)	39.76	-0.04	20.78	-2.59(4)
2	3.43	0.44(8)	1.04	-0.27(8)	54.3	28(8)	89.2	28.3(8)	51.43	0.68(8)	31.03	-4.53(4)
3	3.76	0.71(8)	1.12	-0.06	15.8	11(8)	37.5	- 2.9	53.56	1.21(8)	39.22	-3.77(4)
4	2.85	0.05	1.01	0.06	33.3	-17.9(4)	94.0	1.1	39.39	-0.06	25.02	-0.23
5	2.38	0.17(8)	0.96	0.05	19.7	- 8(4)	86.7	29.8(8)	51.57	-0.44	42.04	-6.10(4)
6	2.20	-0.08(8)	0.78	0.07(4)	41.2	14.9(4)	81.5	-14.0	54.37	0.84(8)	33.33	-5.12(4)
7	2.96	0.48(8)	1.13	0.03	72.1	30.1(8)	90.1	- 9.9	57.82	0.57	35.07	-0.23
8	2.09	0.11(8)	0.94	0.05	9.9	- 9.4(4)	81.0	- 3.6	53.87	0.05	52.43	4.07(8)
9	2.90	-0.23(4)	1.10	-0.17(8)	10.4	- 3.5	88.3	29.8(8)	44.59	-0.09	27.56	-4.15(4)
10	2.27	0.32(8)	1.17	0.07	40.7	7.6(8)	90.8	- 9.2(4)	48.62	0.06	63.41	6.24(8)
11	2.31	0.23(8)	1.15	0.06	45.0	-26.6(4)	100.0	4.0	45.67	0.01	36.74	0.65
12	2.94	0.46(8)	1.09	-0.01	13.7	- 7.6(4)	75.3	35.3(8)	52.64	-0.31	34.09	-0.62(4)
Mean Difference		.25		-0.02		- 2.2		5.6		0.21		-2.04
Std. Dev.		.26		.11		17.4		19.8		0.50		3.42
Range of Diff.		0.05-0.71		0-0.17		3.5-30.1		1.1-35.3		0.01-1.21		0.23-6.24

4-8 in = difference between the 2 edgelines

(8) = 8-in line statistically preferred.

(4) = 4-in line statistically preferred.

ANALYSIS OF WIDE EDGELINE PAINTING

The analysis of the painting of wide edgelines consisted of a review of the methods of painting and a cost analysis. The discussion under Methods of Painting Edgelines examines the alternative methods and the variables considered. The purposes of the cost analysis were to examine (1) the differences in cost for painting 4-in and 8-in wide edgelines, and (2) differences in costs for painting the 8-in wide edgelines by two methods. To aid in the analysis, time and motion studies were conducted during the painting of wide edgelines on two road sections on Route 501: one section in each of Bedford (Salem District) and Rockbridge (Staunton District) counties. The time required for the paint crews' activities and the amount of material used were recorded. Data were also reported for the 8-in edgeline painting on Route 20.

Methods of Painting Edgelines

A 4-in wide edgeline is painted using one paint gun and at a speed of 6 to 8 mi/h. One method of painting an 8-in wide edgeline is to raise the gun above the level of a 4-in line and proceed at a slower speed of about 4 mi/h. The Staunton District paint crew employed this method. A second method, which was used by the Salem District paint crew, is to use two guns and maintain the same speed (about 6 mi/h). A wet paint thickness of 15 mils (0.015 in) should be maintained for both methods. In both cases, the additional line width was on the inside of the old 4-in line, that is, in the travel lane. The use of two guns permits a higher speed; however, caution must be used to avoid excessive overlays where the sprays from the two guns meet. The Staunton District preferred raising the gun in lieu of using two guns because of the possible overlap problem. On the other hand, observations of the wide edgeline painted with two guns revealed that two lines were visible.

Three variables that influence the painting time are the design of the paint gun, the method used to reload the tanks, and number of tanks used for white paint. Use of a high quality gun enables the paint truck to travel at a higher speed than when a lower quality gun is used. It is more convenient and quicker to reload the paint truck tank from a supply truck equipped with a pressurized tank than from 55-gal cans. Moreover, if both paint tanks instead of one tank are used for white paint, then the distance that can be painted before reloading doubles and the number of reloadings are halved.

Cost Analysis

In Table 10, data are provided on the quantity per mile and cost per mile of the items involved in edgeline painting. The four items are white paint, beads, labor, and equipment. The four data groups are (1) planning estimate for 4-in edgelines, (2) planning estimate for 8-in edgelines, (3) data for Rte. 501 - Salem District, and (4) data for Rte. 501 - Staunton District.

Planning Estimates

The quantity per mile of paint and beads for an 8-in wide edgeline is double that for a 4-in wide line and the labor and equipment time increases 33%. The time difference is primarily due to the increase in the number of refills and, depending on the method of painting, lower speeds. Consequently, the total cost per mile is 90.0% greater for an 8-in wide line than for a 4-in line.

Rte. 501, 8-in Wide Edgelines

When comparing the two-gun and the raised-gun methods, the paint and bead quantities per mile are lower for the raised gun method by 10.8% and 23.8%, respectively, because of differences in the thickness and width of the lines. Samples of the edgeline widths painted with two guns and a raised gun method were noted to be 10 in and 7 in, respectively. The labor and equipment time was 32% greater for the raised-gun method. This is due to the slower paint speed 4.0 mi/h compared to 5.9 mi/h (32% slower) -- and the greater average refill time -- 28 minutes compared to 20 minutes (40% longer). It is noted that the Staunton District crew used a higher quality gun. The Salem District crew refilled from a pressurized tank, whereas the Staunton District crew refilled from 55-gal drums. Furthermore, the labor and equipment costs varied because of a difference in the sizes of the work crews (5 for Salem, 6 for Staunton) and wage rates, and the type of equipment used. The total cost per mile was 7% lower for the raised-gun method.

Ideally, it is expected that the paint and bead costs would be the same for both methods and that differences in the costs of labor and equipment due to differences in speed would account for the major cost differences.

Cost Data for 8-in Wide Edgelines on Rte. 20

The cost data for painting the wide edgelines on Rte. 20 are shown in Table 11.

Table 10

Data on Edgeline Painting

Items	Planning Estimates			Data for Rte. 501 8-in Edgelines			
	4-in edgeline	8-in edgeline (2 guns)	% diff. from 4-in estimate	two guns (Salem)	% diff. with 8-in edgeline estimate	raised gun (Staunton)	% diff. with two guns
Quantity/mi							
paint, gal	16.5	33.0	100.0	31.6	- 4.5	28.2	-10.8
beads, lb	99.5	199.0	100.0	168.2	-15.5	128.2	-23.8
labor & equip. (h)	0.18	0.24	33.0	0.25	4.8	0.33	+32.0
Labor and Equipment[a]							
labor cost/h	$ 59.15	$ 59.15		$ 52.60[b]		$ 61.85[c]	
equip. cost/h	33.35	33.35		36.70		31.30	
Total	$ 92.50	$ 92.50		$ 89.30		$ 93.15	
Total Cost/mi							
paint	$ 66.00	$132.00	100.0	$126.08	- 4.5	$112.52	-10.8
beads	17.43	34.86	100.0	29.47	-15.5	22.46	-23.8
labor & equip.	16.65	23.13	33.0	22.33	4.8	30.53	32.0
Total	$100.08	$189.99	90.0	$177.88	- 6.7	$165.51	- 7.0

[a] - Labor and equipment costs for estimates are the mean costs for the data for Rte. 501.

[b] - Based on 5-man crew.

[c] - Based on 6-man crew.

Table 11

Cost Data for 8-in Wide Edgelines on Rte. 20

Cost Per Mile	Raised-Gun Method (Culpeper District)	Using a Raised-Gun Over Two Adjacent 4-in Edgelines (Lynchburg District)
paint	$124.12	$151.39
beads	29.79	42.46
labor and equipment	31.58	96.29
Total	$185.49	$290.14

The total cost per mile for the Culpeper District is between the values of the Salem District ($177.88) and the planning estimate ($189.99). The Lynchburg District total cost per mile is higher because it includes three passes in the painting of the edgelines: (1) painting over the existing 4-in edgeline, (2) painting a 4-in wide edgeline adjacent to the existing edgeline, and (3) painting an 8-in wide edgeline over the two 4-in lines. Three passes were used to provide added durability to the 8-in wide line by providing uniform thickness across the width.

Labor and Equipment Costs

In the above data, the labor and equipment cost represents the cost for the painting operations only. In many cases, travel time and preparation and cleanup at the district shop are also included. For example, when labor and equipment costs for an 8-hr day are considered for painting the 8-in wide edgelines on Rte. 20 in the Culpeper District, the labor and equipment cost per mile is $46.06. This is $14.48 per mile, or 45.8%, higher than the actual painting operations cost per mile.

Moreover, the difference in labor and equipment cost per mile for painting a 4-in versus an 8-in line is decreased when considering travel time and preparation.

CONCLUSIONS

The following conclusions were drawn from the data presented in this report.

Analysis of Wide Edgeline Painting

1. Based on planning estimates, for the 8-in wide edgeline, the costs per mile for materials (paint and beads), and labor and equipment, were 100% and 33% greater, respectively, than the costs for the 4-in line. The total costs per mile were 90% greater for the 8-in wide edgeline.

2. The total cost per mile for the raised-paint-gun method was 7% lower than that for the two-paint-gun method of painting wide edgelines.

Analysis of Lateral Placement and Speed

1. Overall, there were no statistically significant differences between the 4- and 8-in wide edgelines from the analysis of variance of lateral placement, lateral placement variance, encroachments by cars and trucks, mean speed, and speed variance.

2. The mean lateral placement was significantly lower for the 8-in wide edgeline. However, the difference was of a small magnitude and of no practical significance.

3. Lateral placement and speed were neither significantly nor practically affected by a change from a 4-in to an 8-in wide edgeline.

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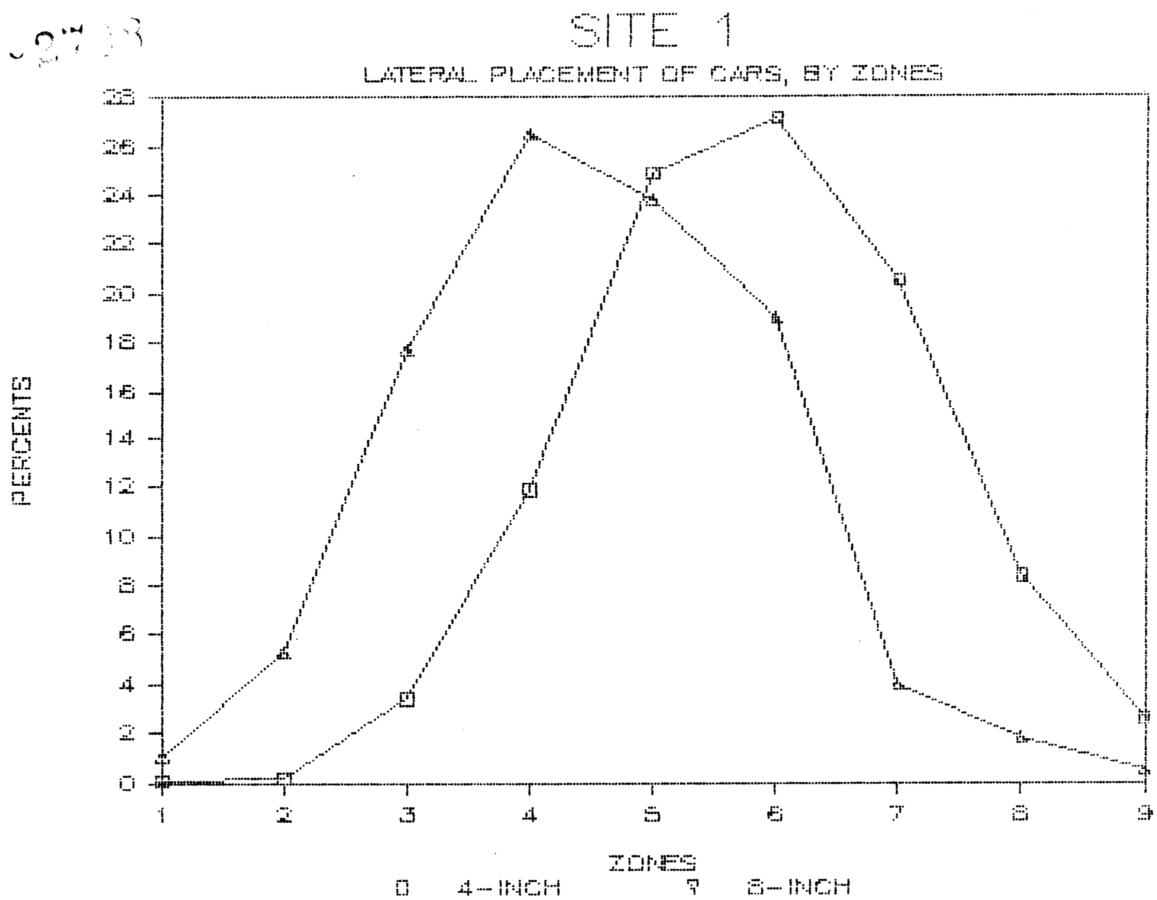
APPENDIX

DISTRIBUTION OF THE LATERAL PLACEMENT OF CARS (pp. A-2 through A-7) AND TRUCKS (pp. A-8 through A-13) BY ZONES FOR THE TOTAL PERIOD

Figure A-1



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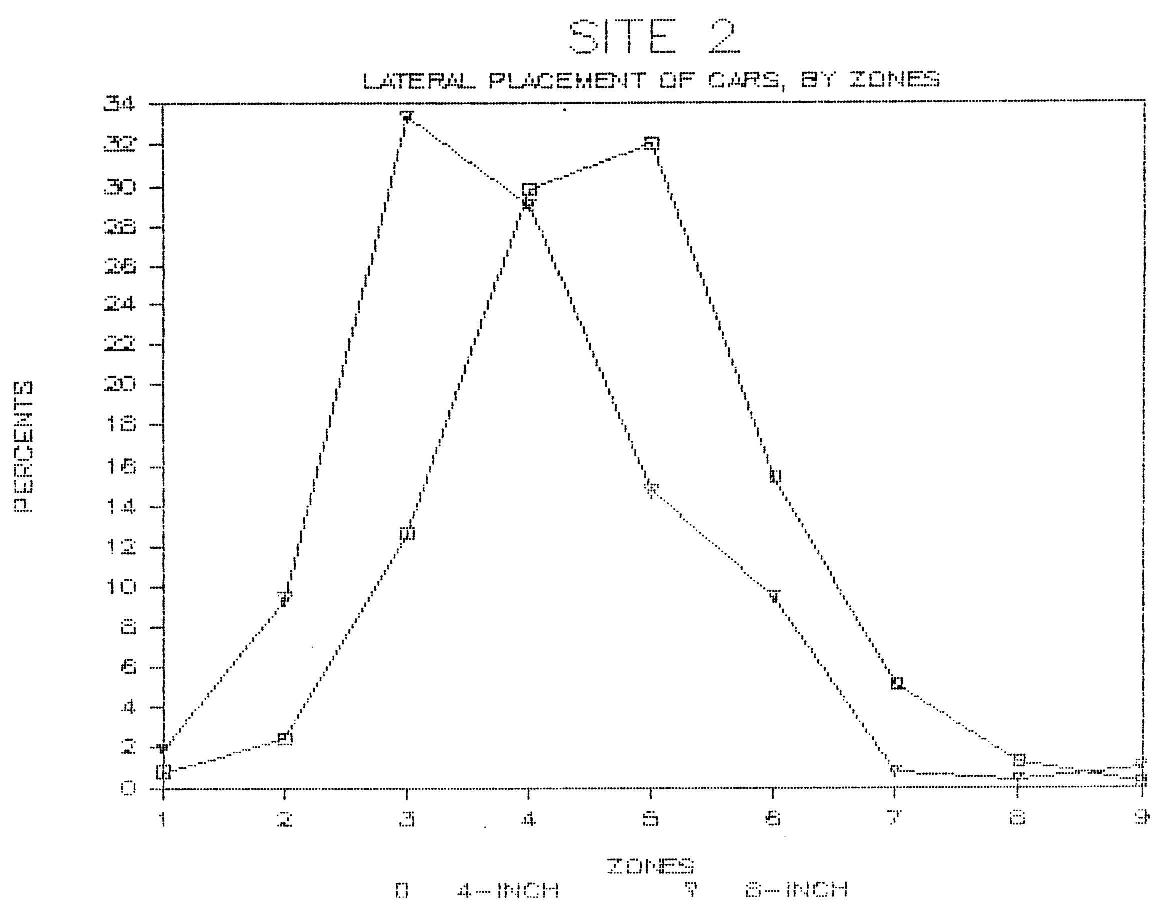

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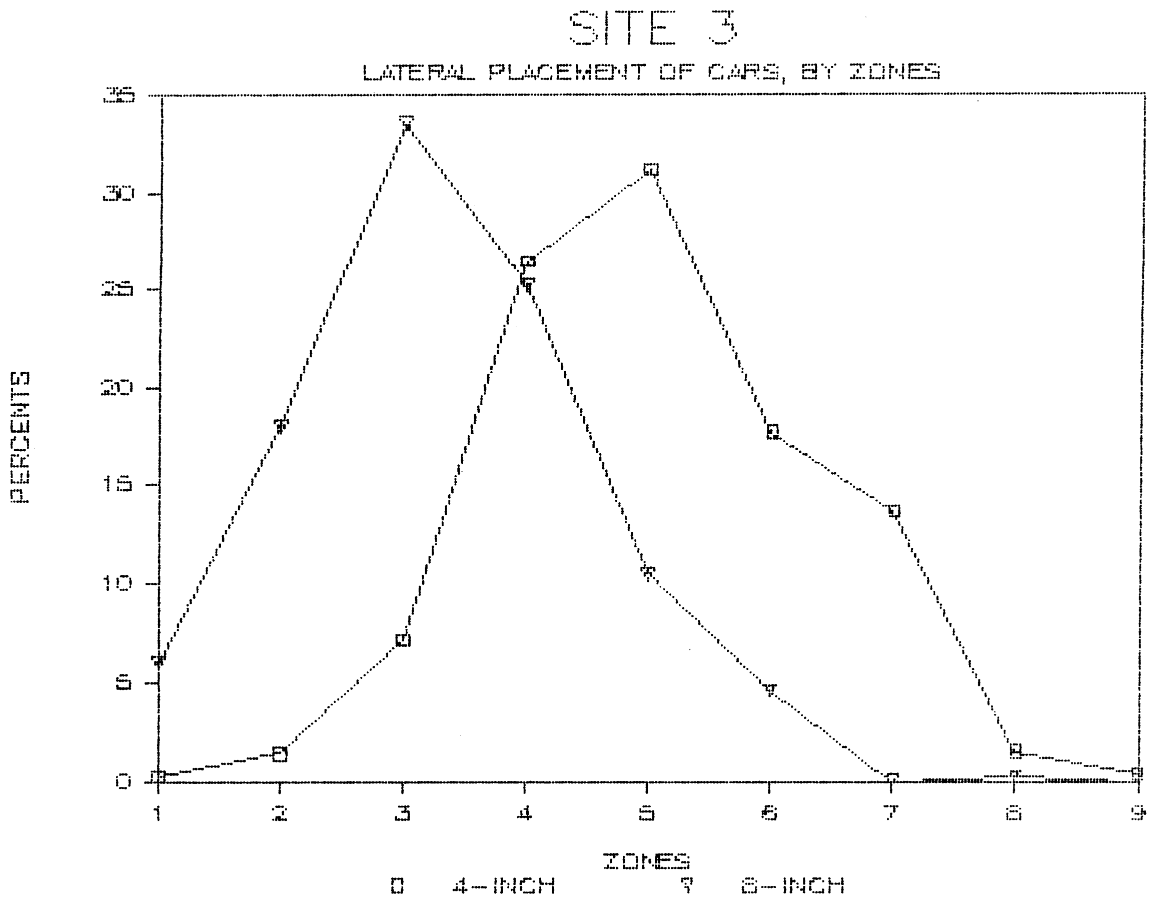

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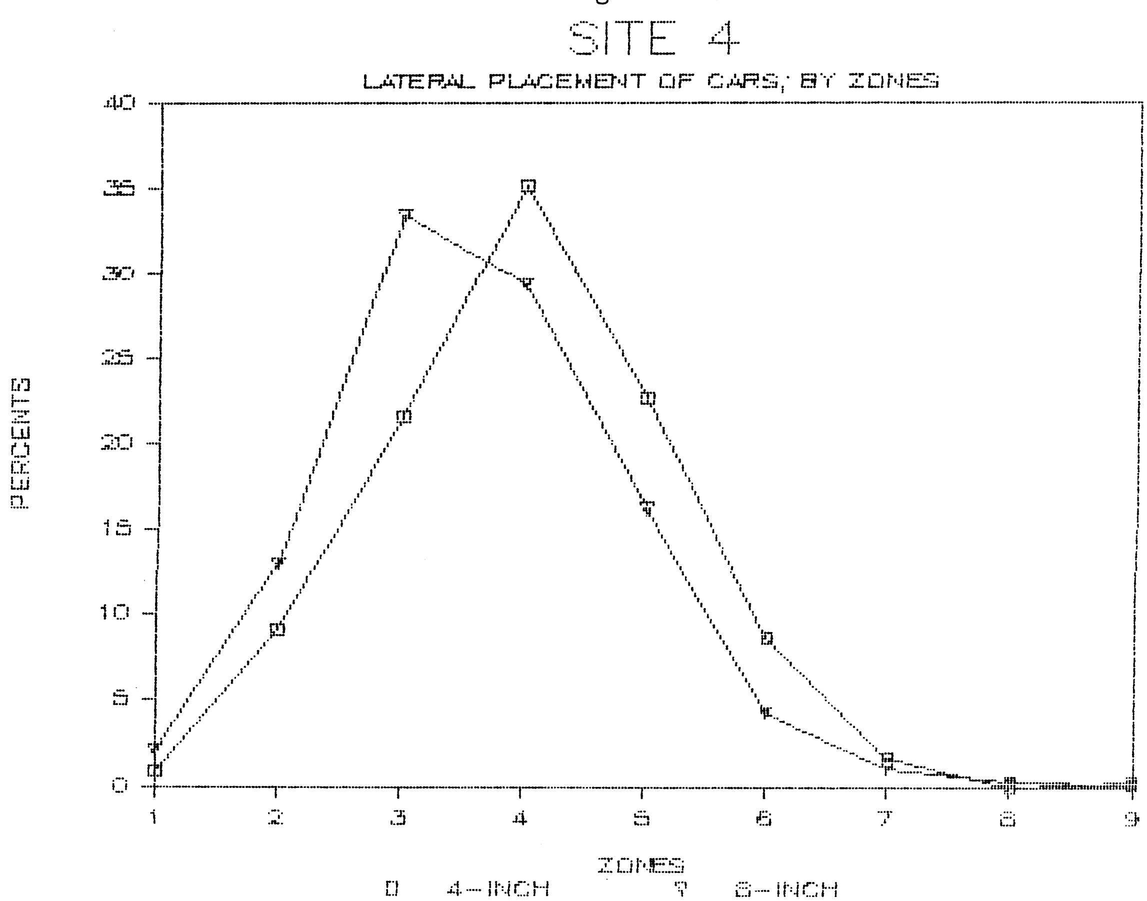

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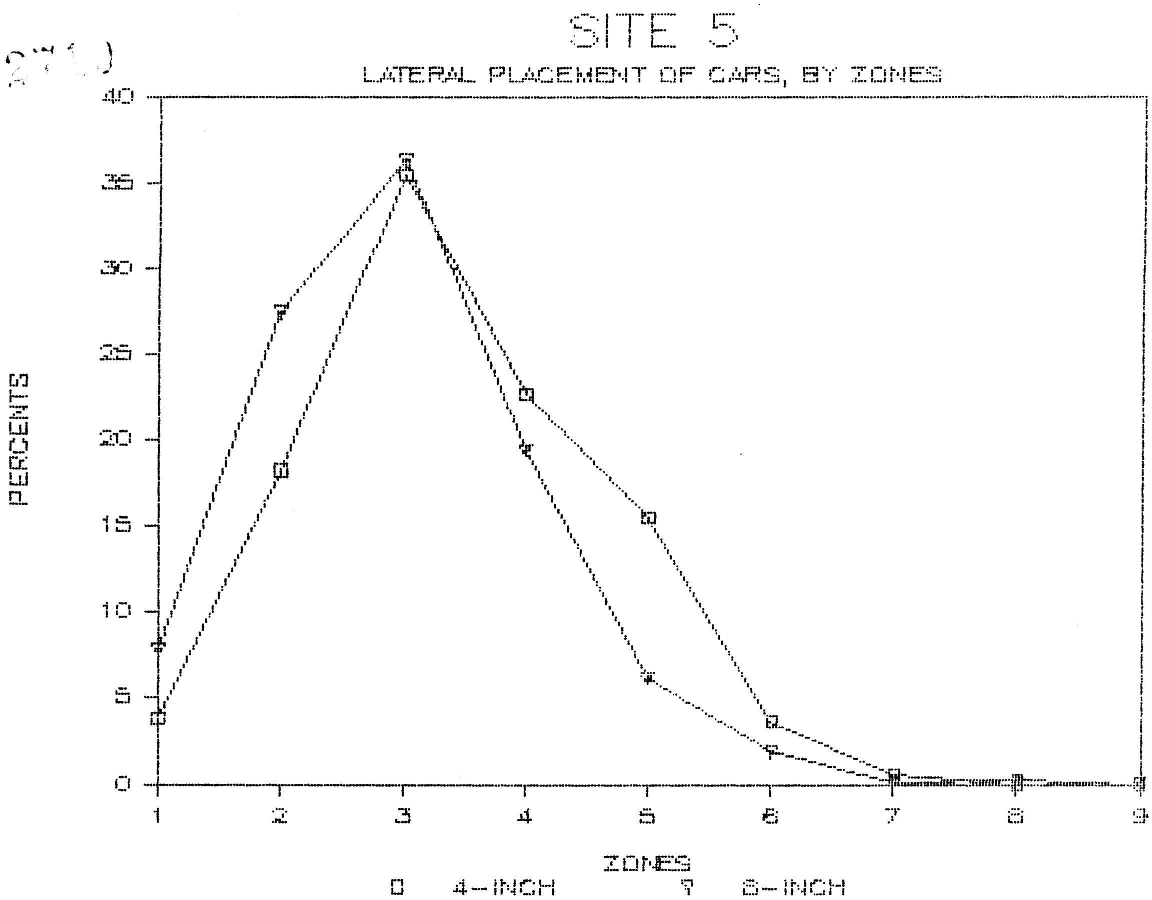

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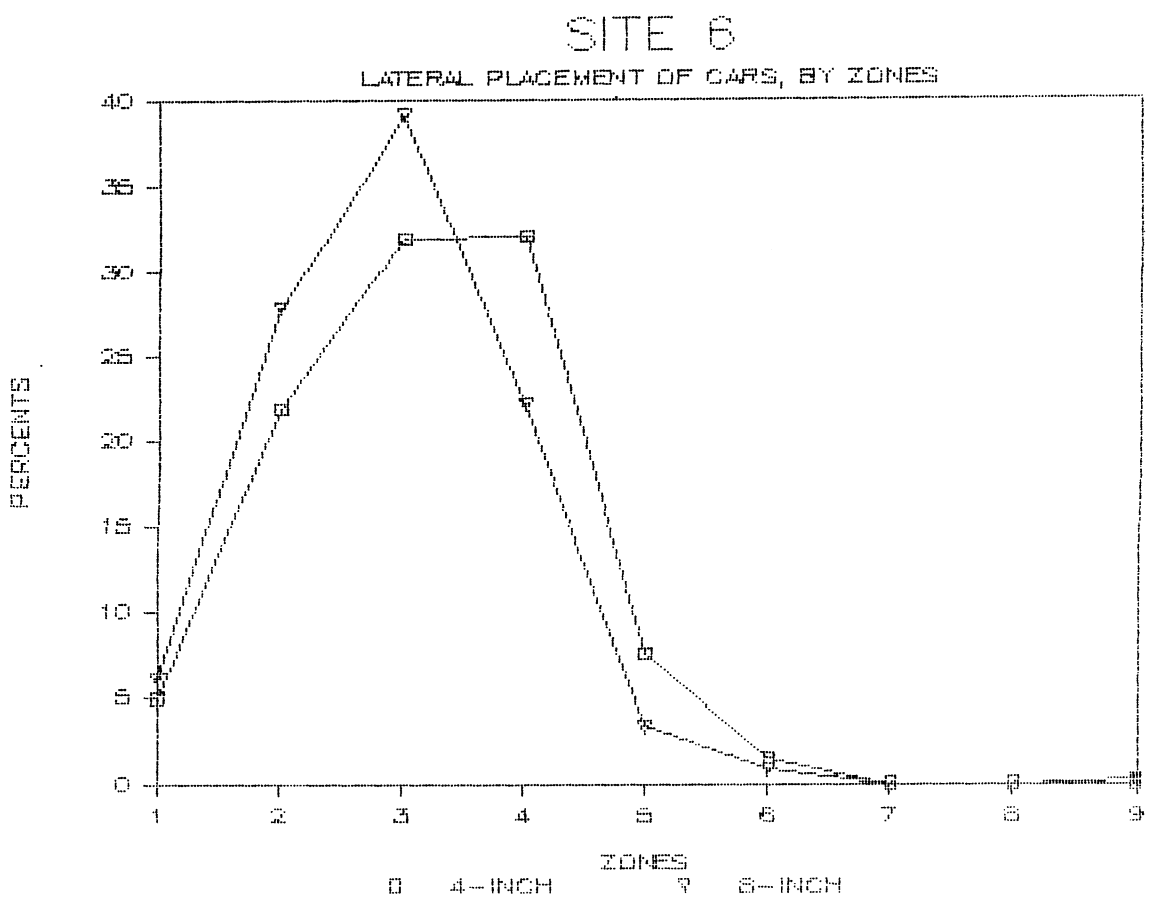

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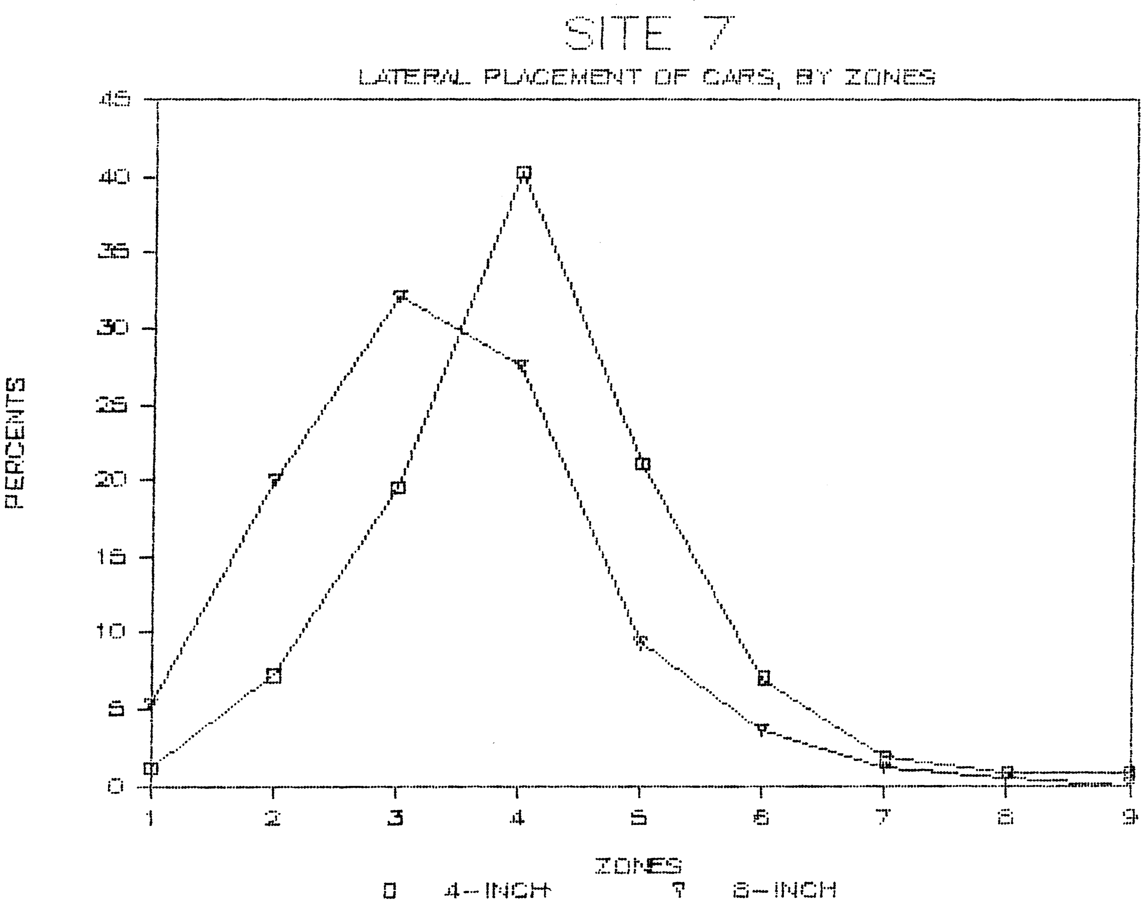

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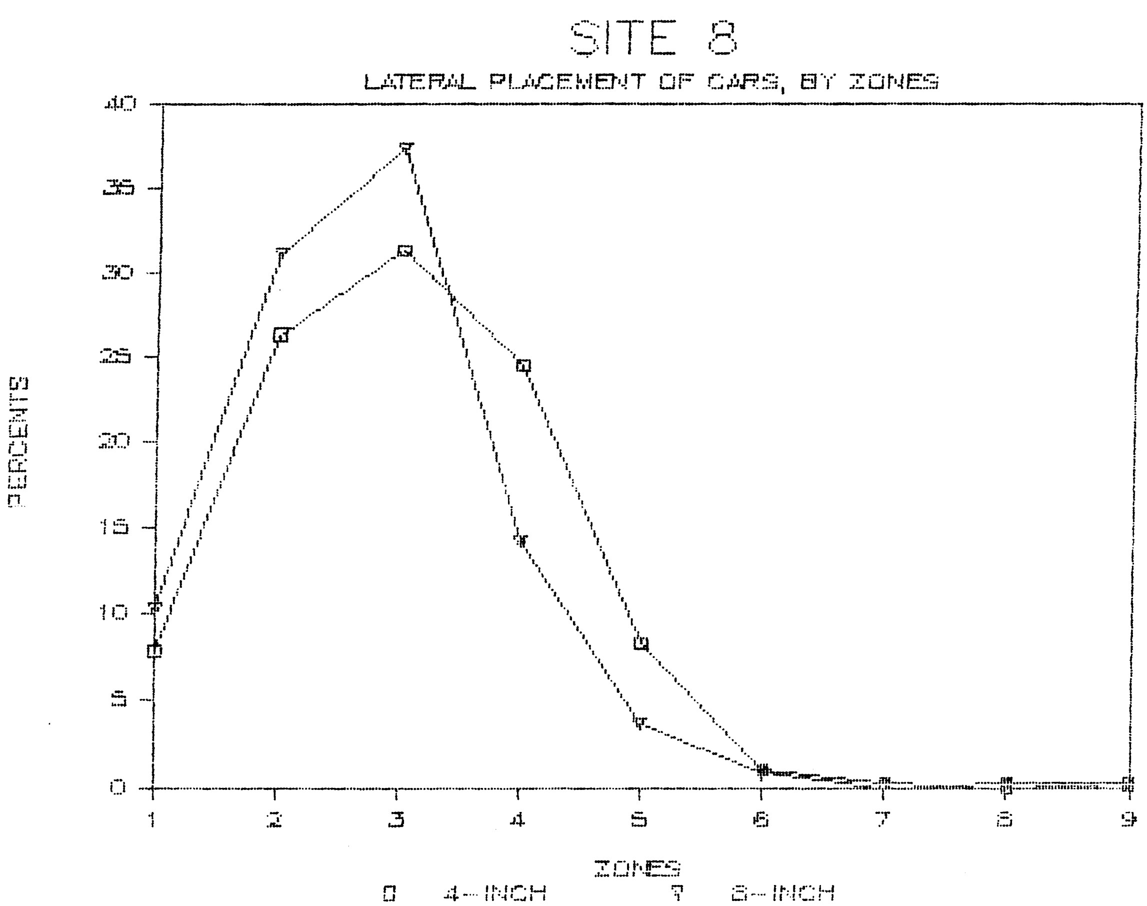

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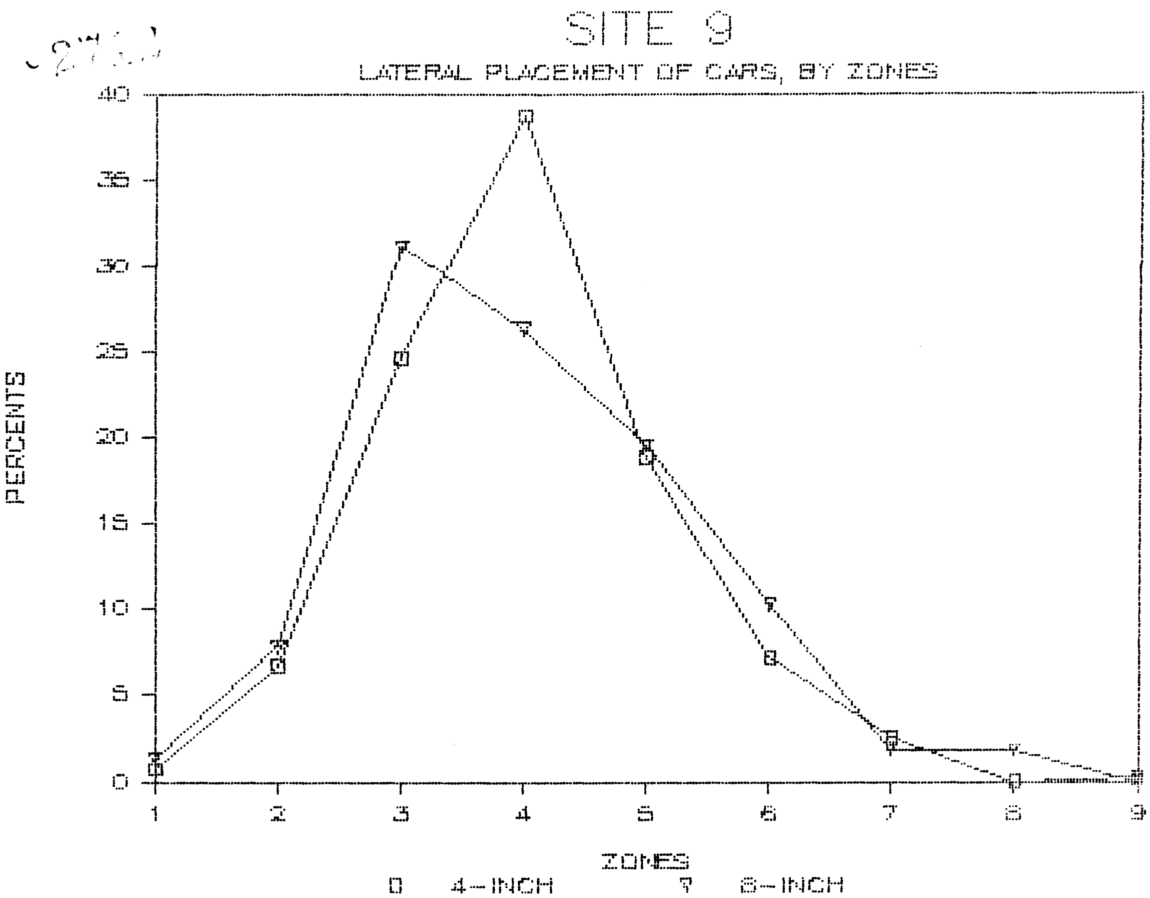

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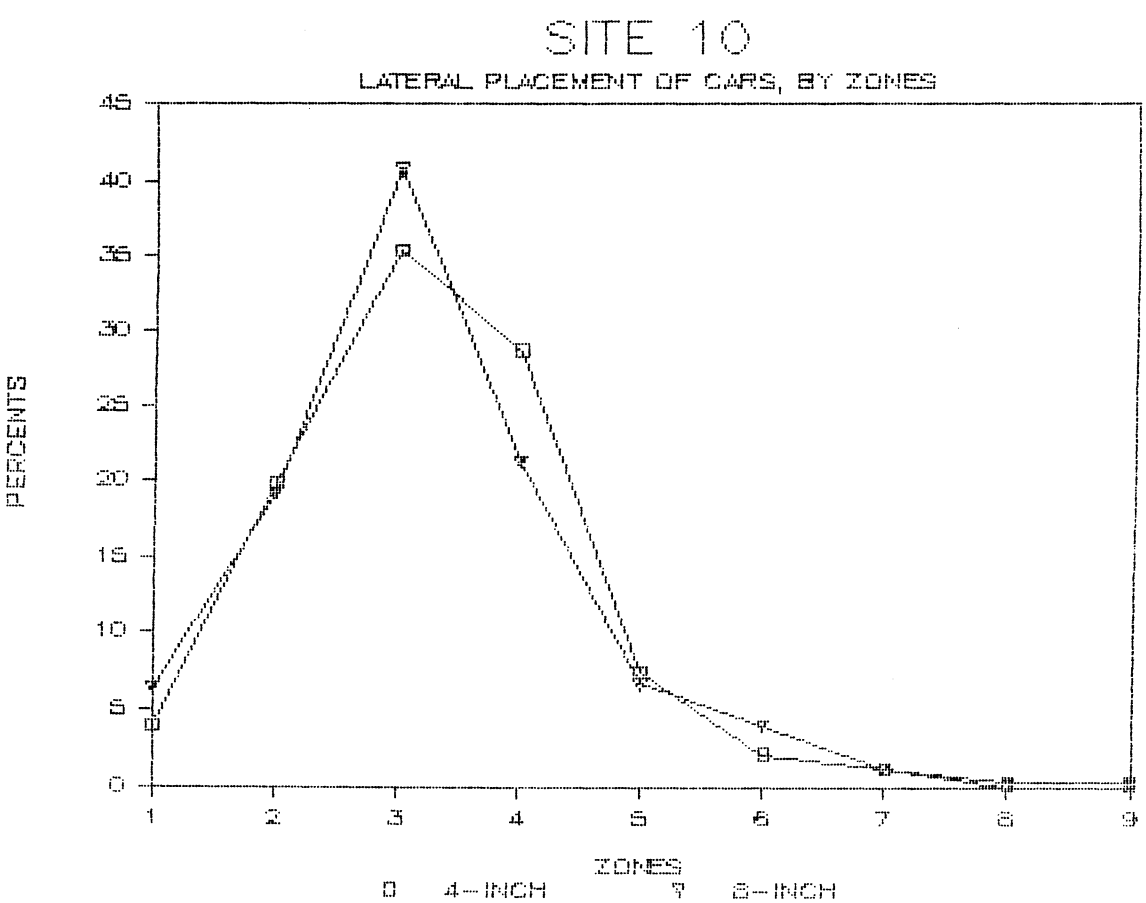

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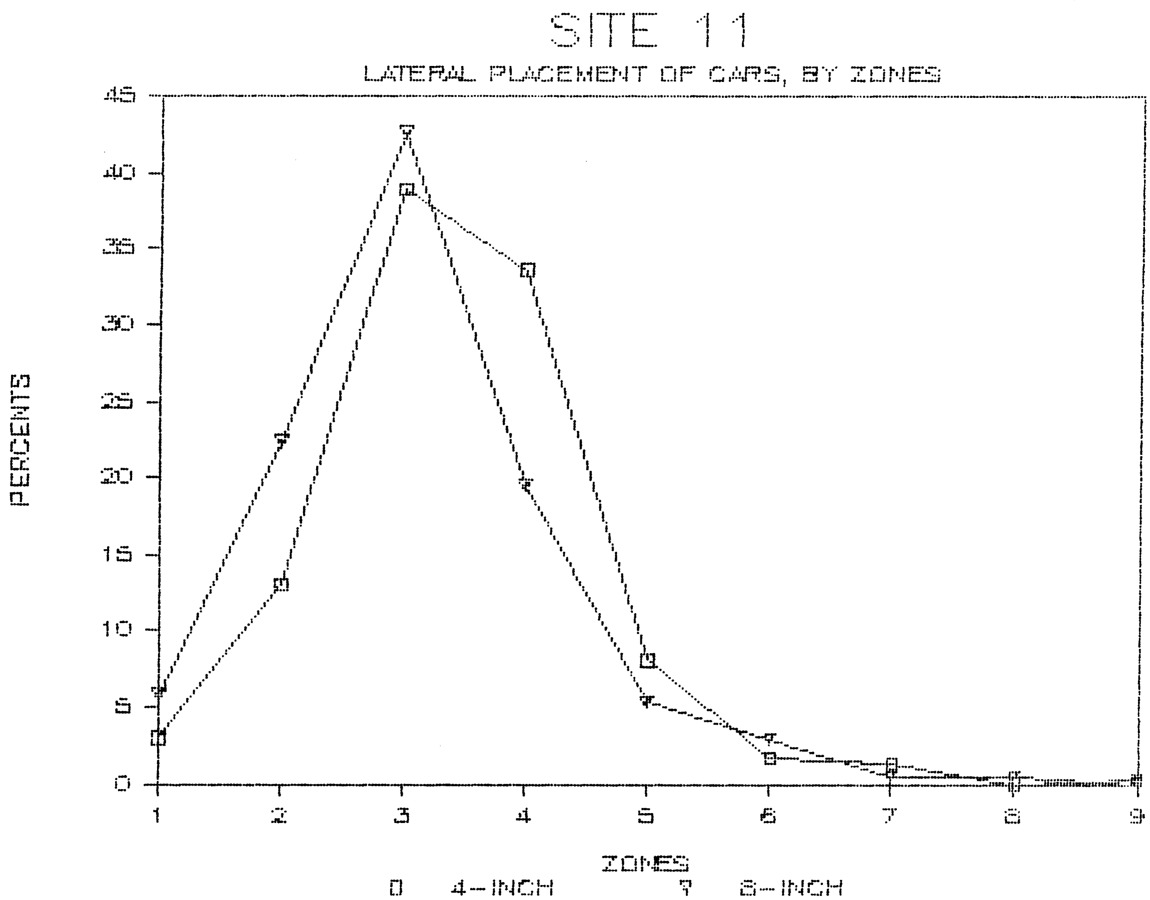

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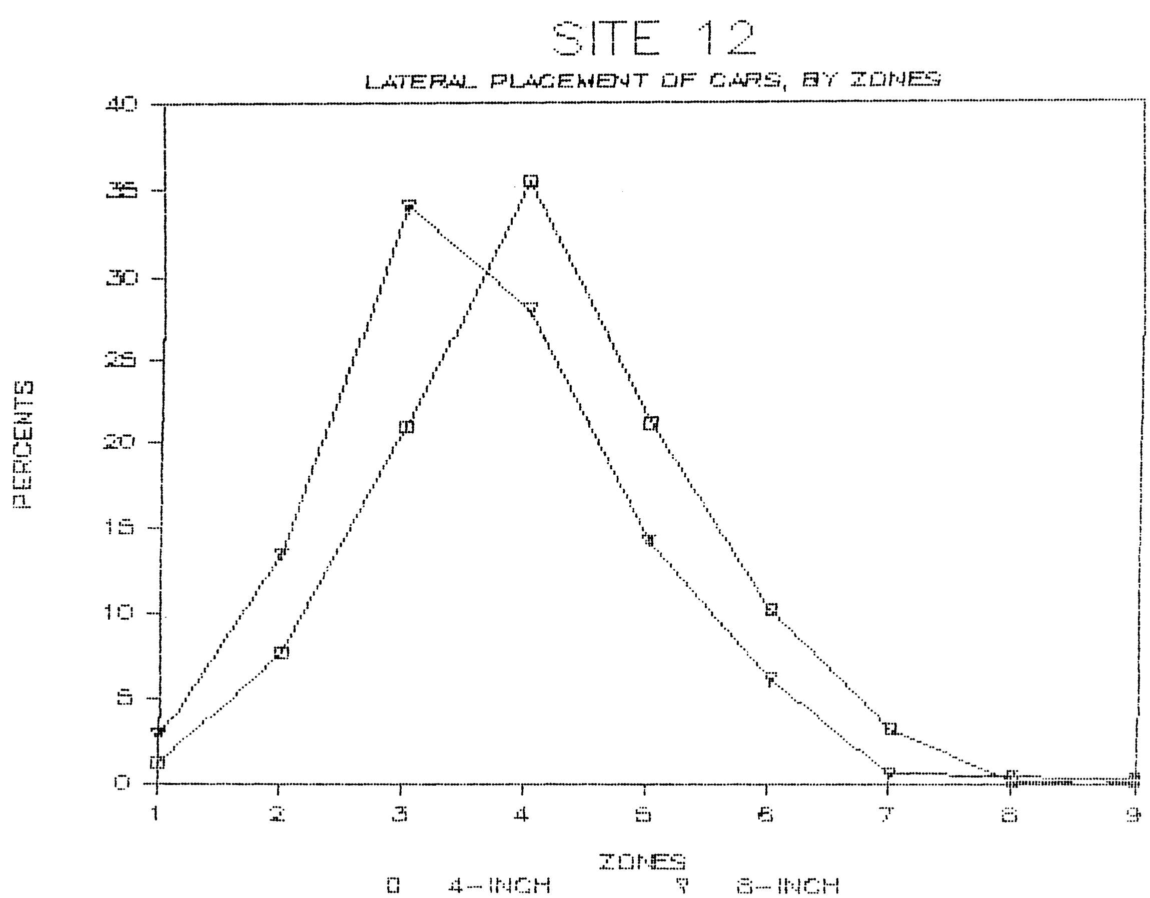

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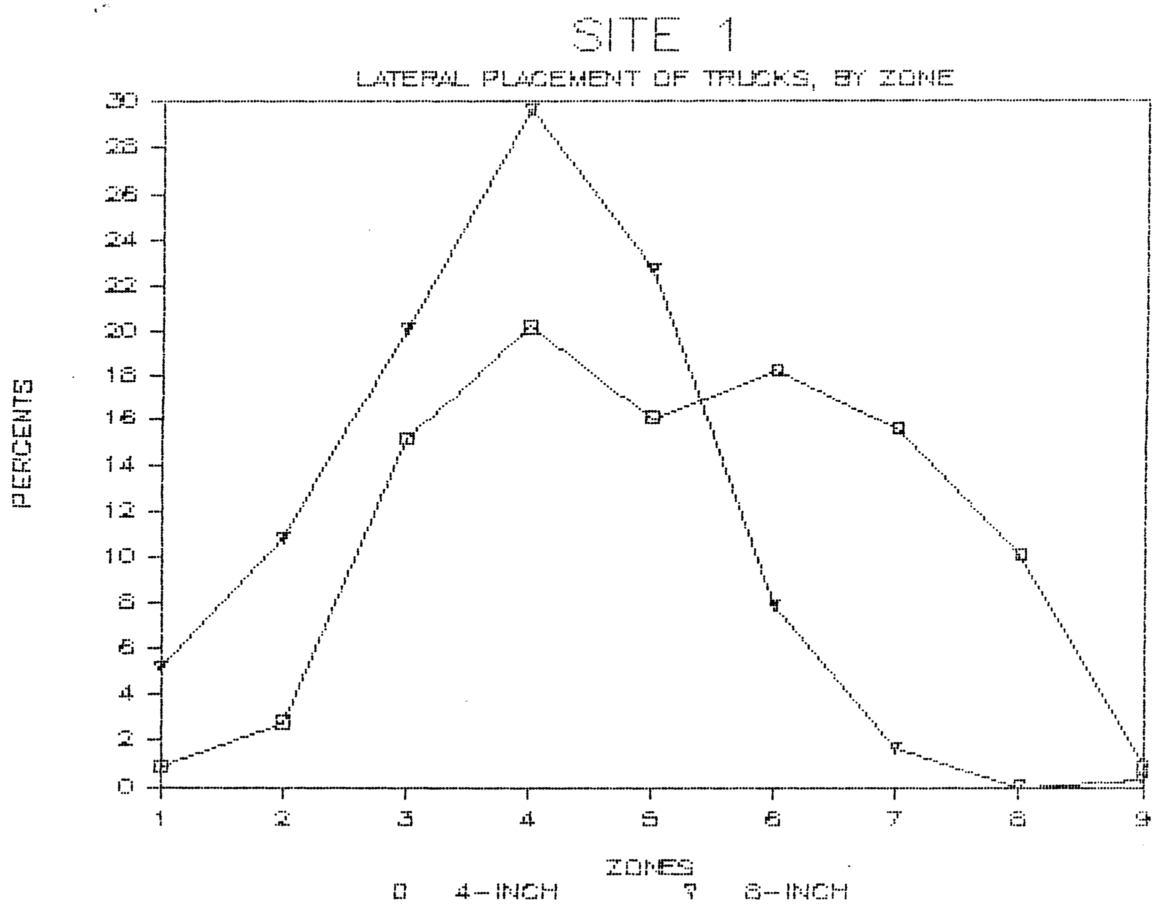

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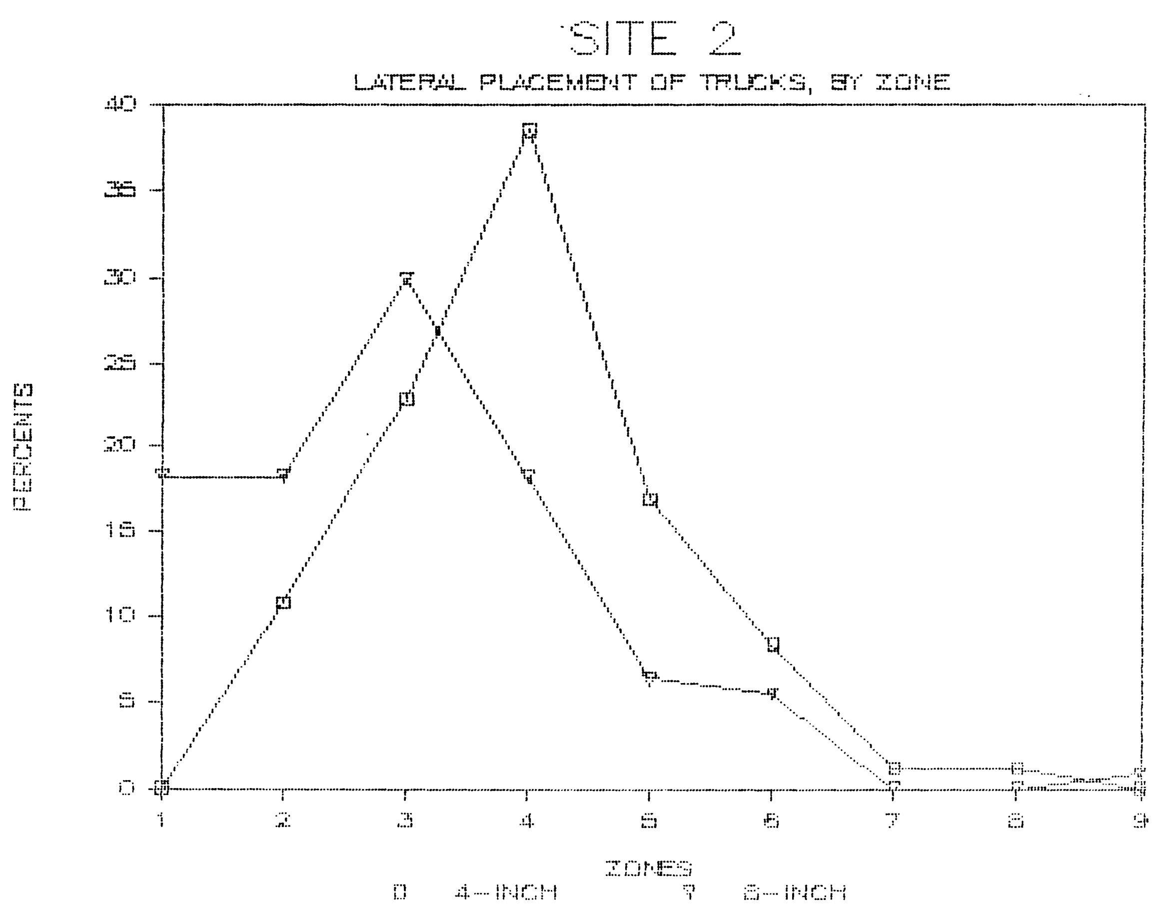

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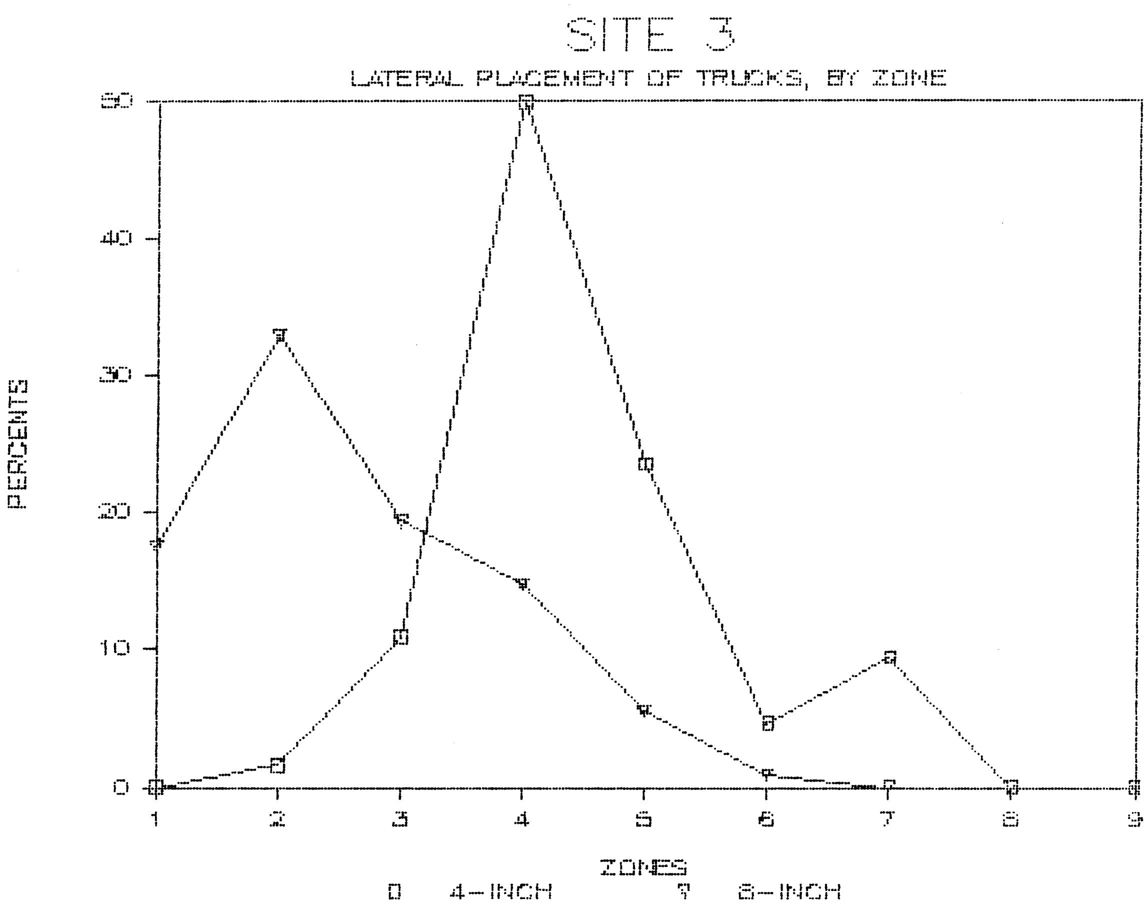

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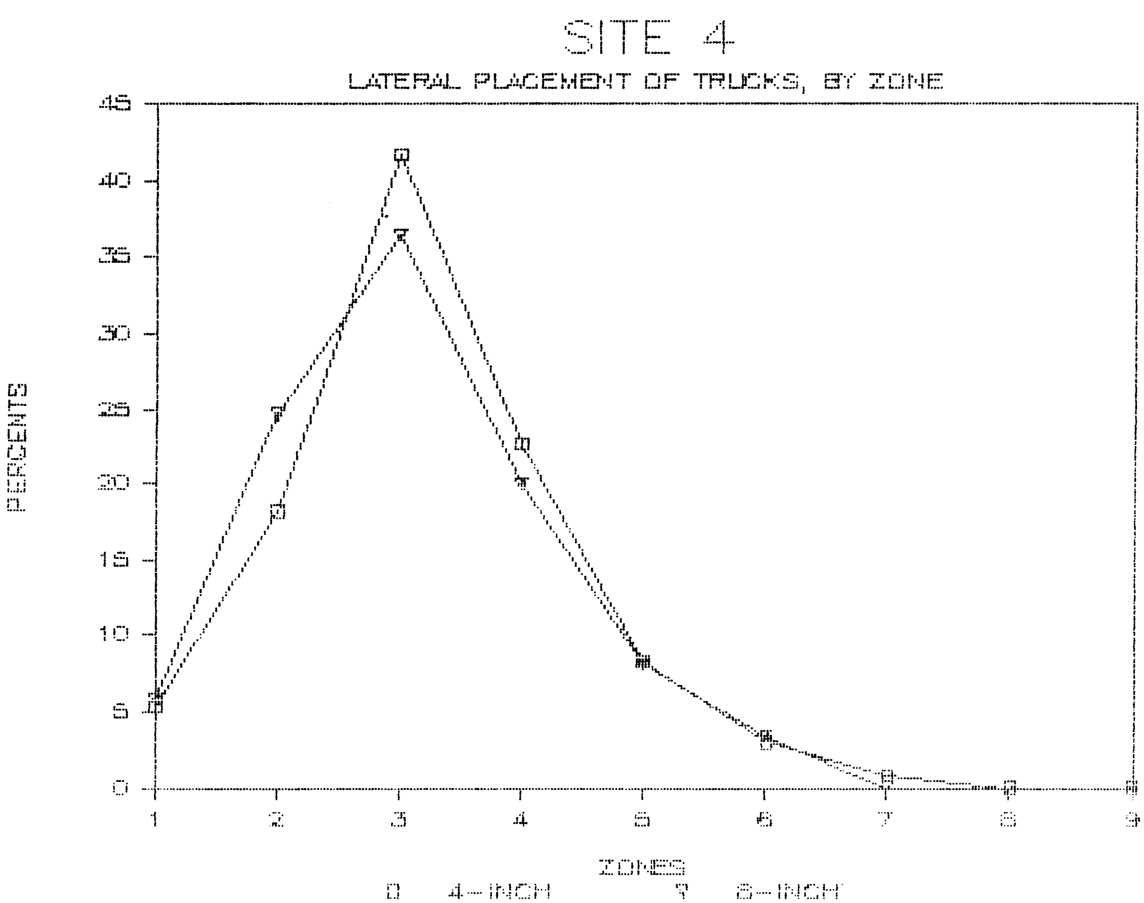

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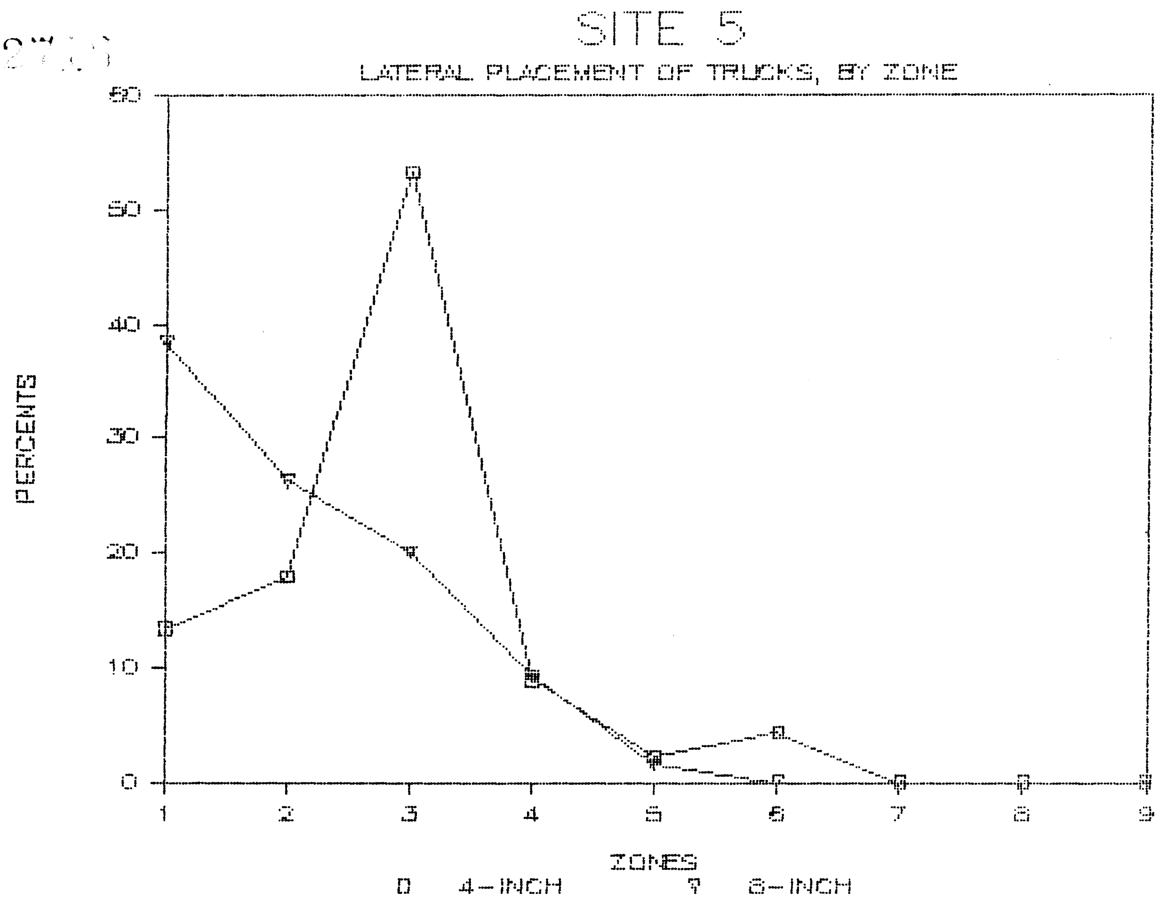

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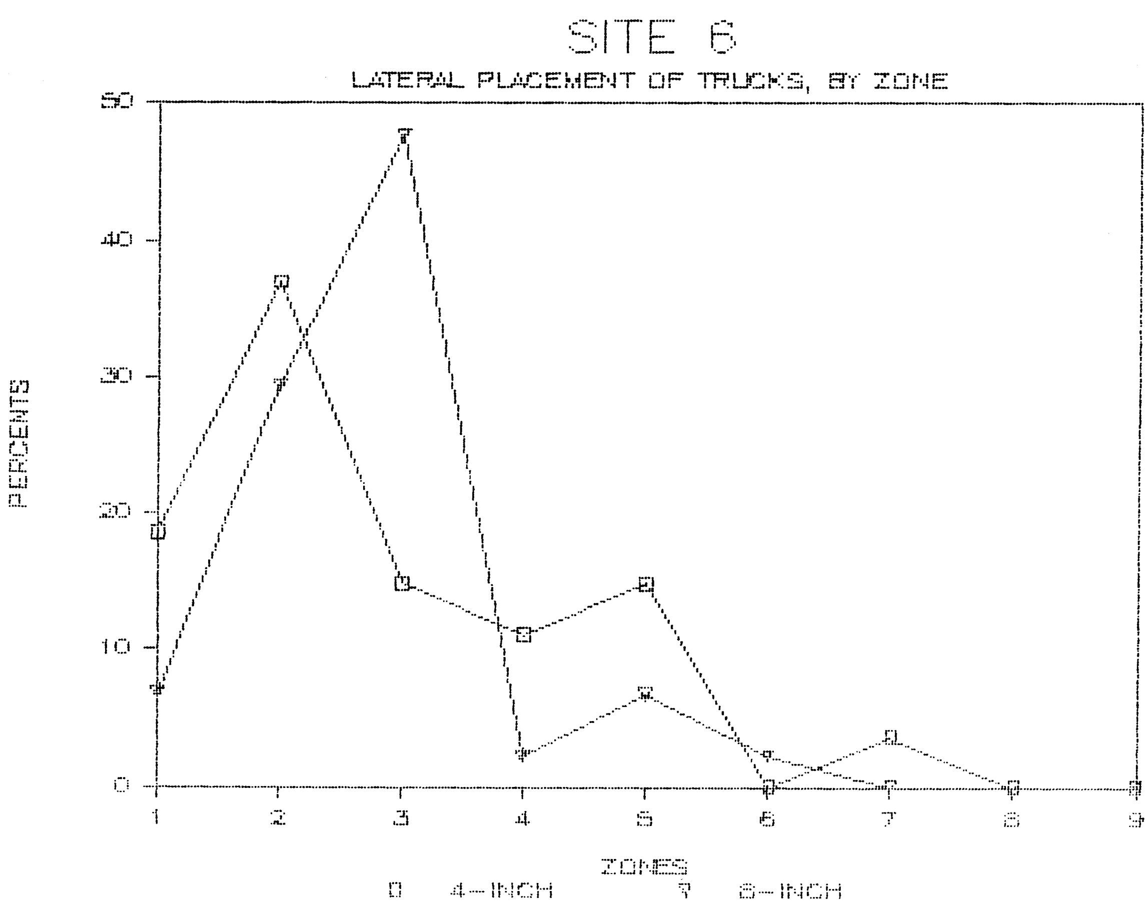

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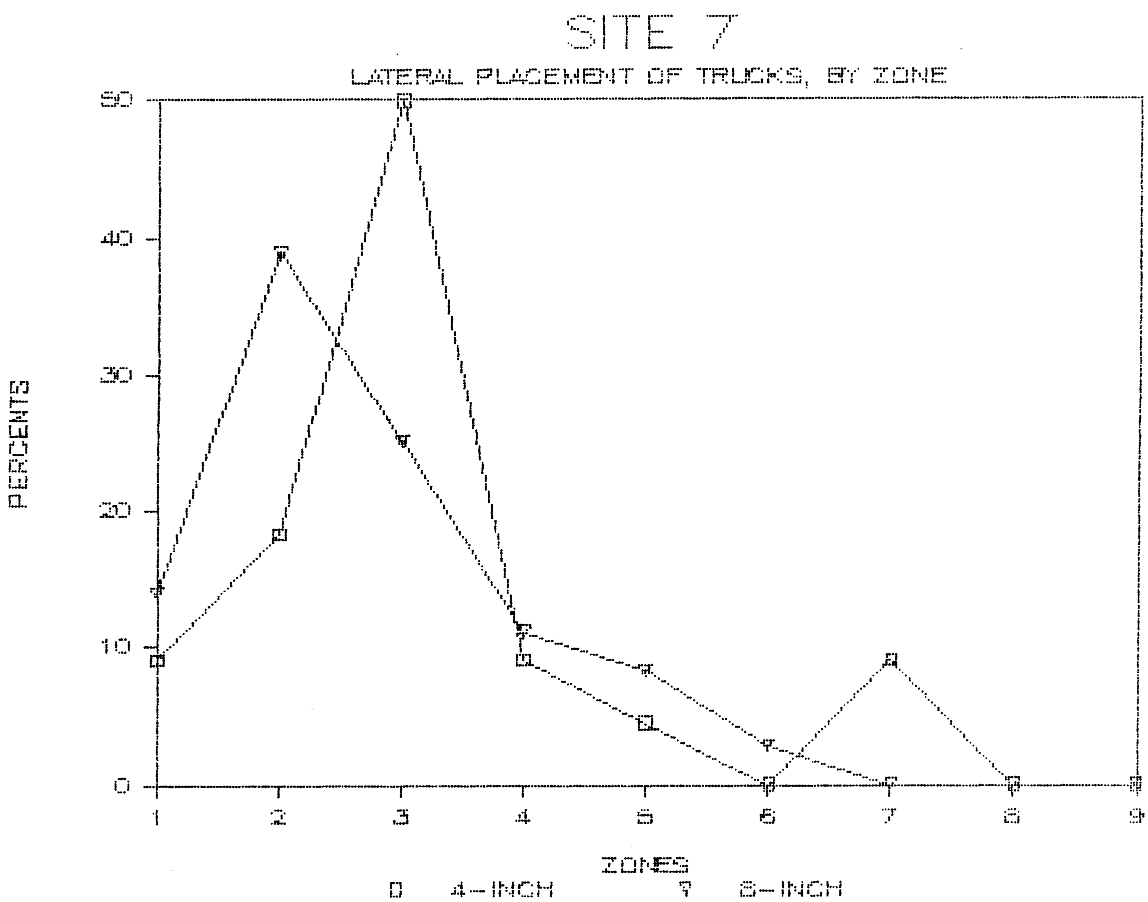

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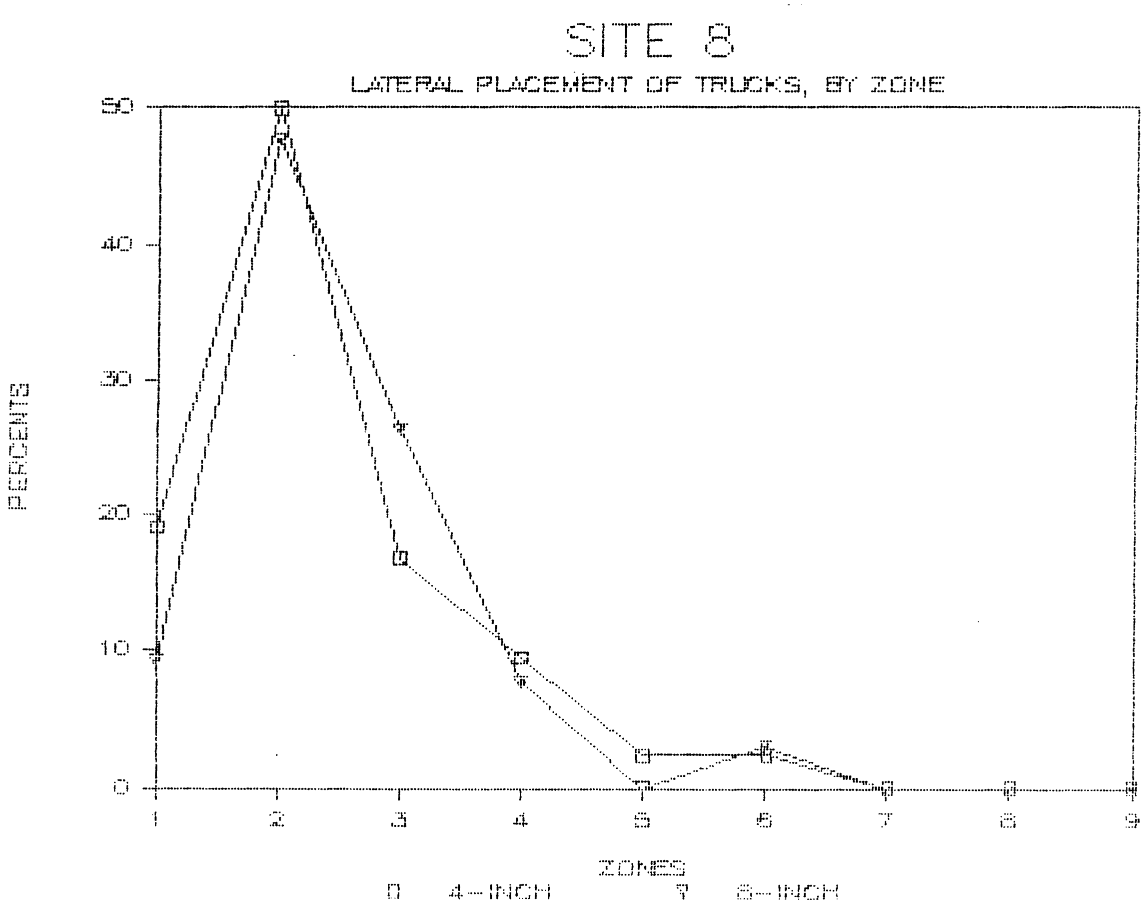

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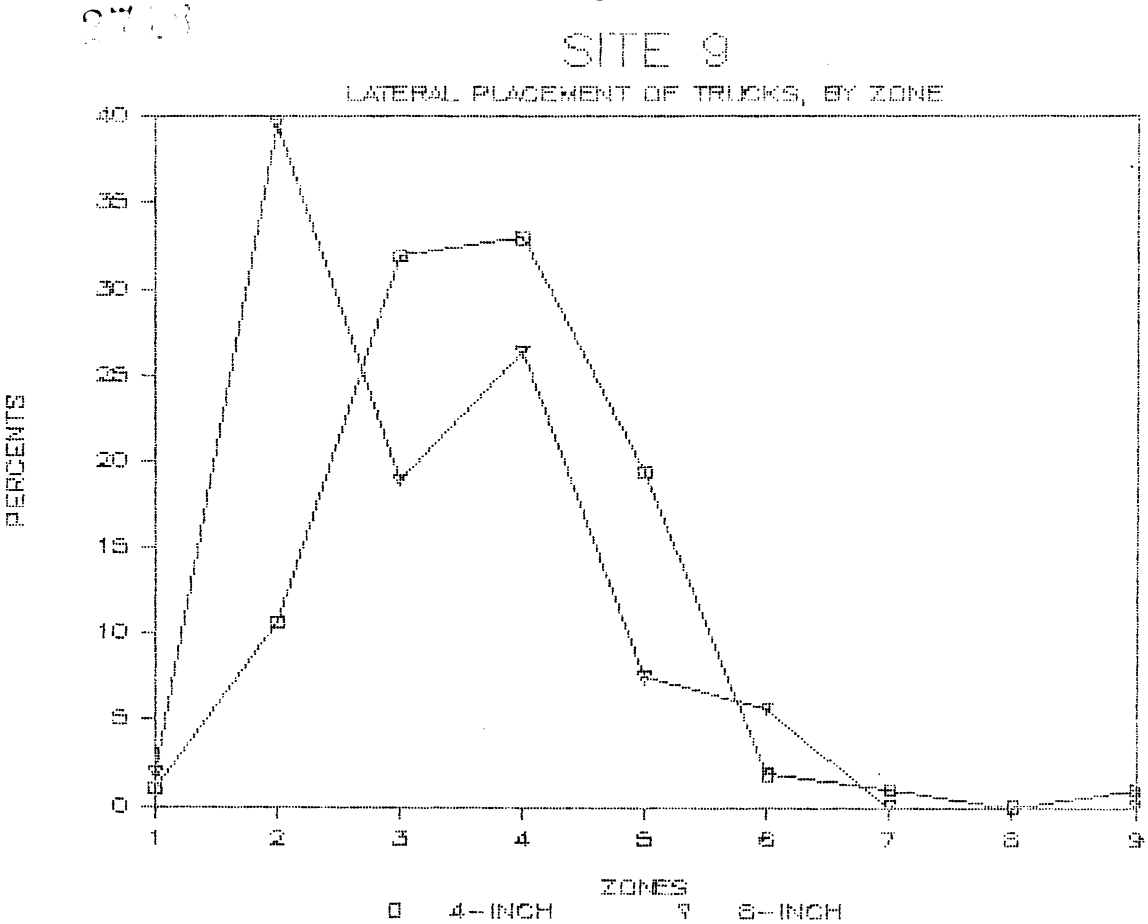

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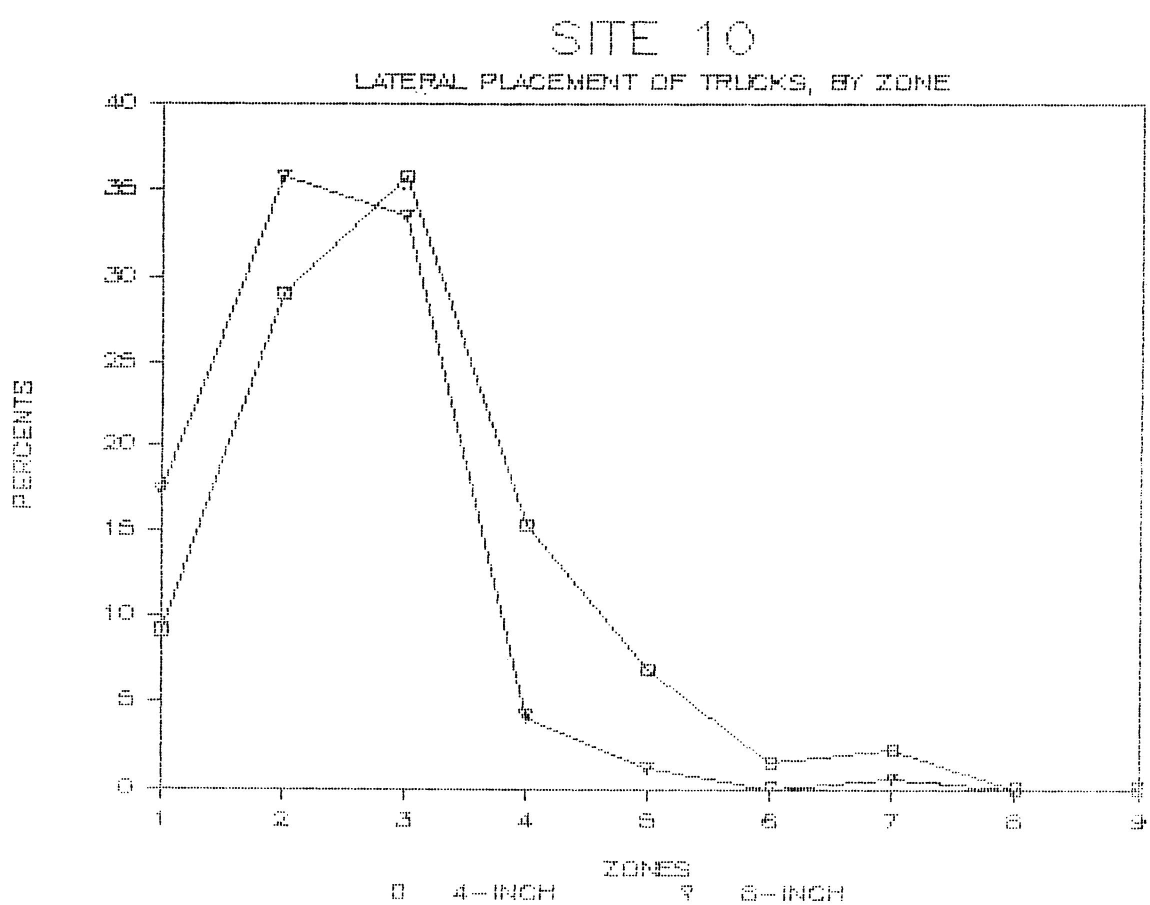

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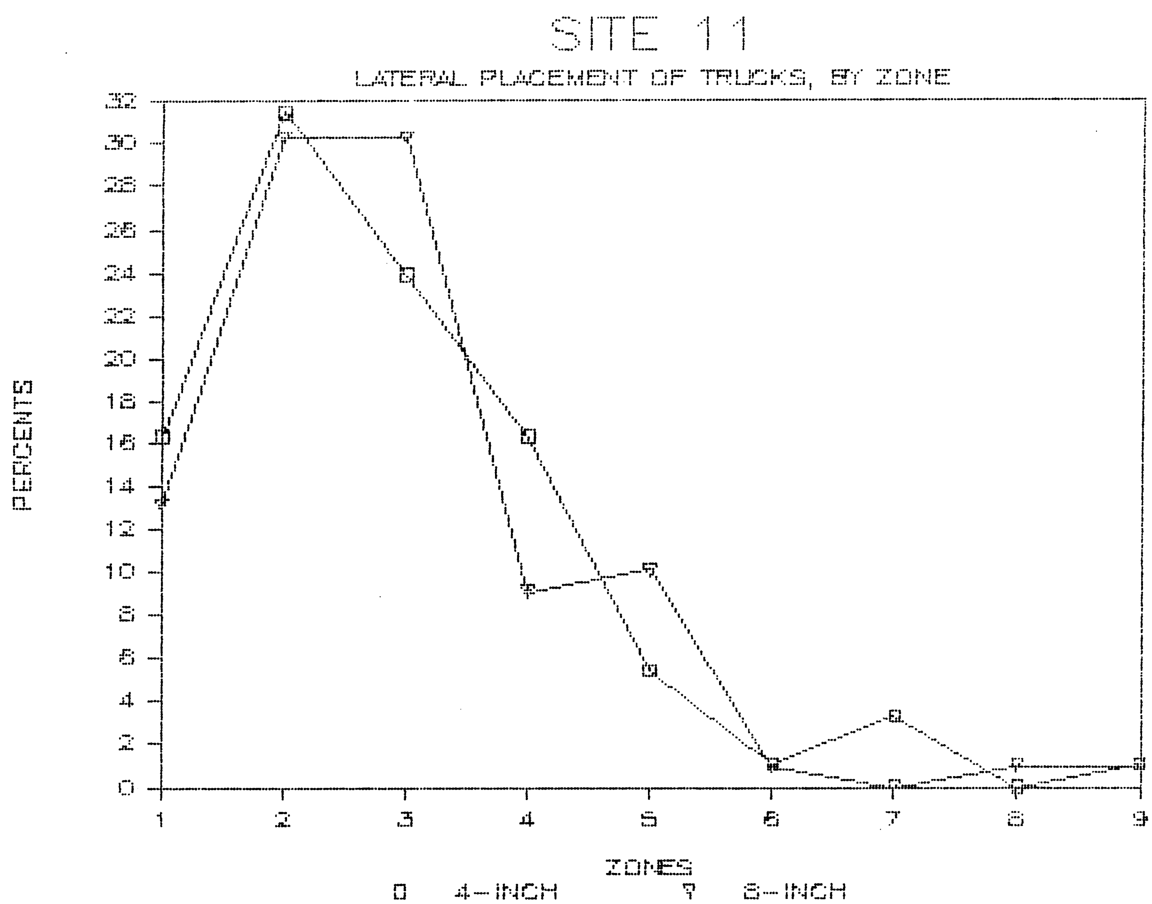

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