FINAL REPORT

TRAFFIC FLOW EVALUATION OF PAVEMENT INSET LIGHTS FOR USE DURING FOG

by

Frank D. Shepard
Research Engineer

(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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MR. F. D. SHEPARD, Research Engineer, VH&TRC

SUMMARY

Reduced visibility resulting from fog presents a very hazardous condition on the highway because of the inability of motorists to readily observe pavement markings and signs and the movement of traffic. Afton Mountain, which is traversed by I-64, often is the site of such reduced visibility because of the low cloud covering the mountain top during periods of rain. An awareness of the fog problem on Afton Mountain led to a decision to install a lighting system consisting of pavement inset lights to aid motorists during periods of fog on a 5.8-mile (9.4-km) section of I-64 encompassing the top of the mountain.

The purpose of this research was to investigate the characteristics of the traffic flow with the system of pavement inset lights during fog through the collection and analysis of data before and after the lights were installed. The traffic flow parameters evaluated were vehicle speeds, headways, queues, and lateral placement. A before and after accident analysis was made also.

Overall, the lighting system led to higher nighttime speeds, an increase in speed differentials for various cases during both daytime and nighttime, and a decrease in nighttime headways and queuing. These changes in traffic flow characteristics may be construed as producing an increase in the potential for accidents; however, they are thought by the author to be a result of the inset lighting system providing improved delineation for the guidance of motorists. This improvement in guidance, especially during fogs at night, should provide safer driving conditions than hitherto existed.

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INTRODUCTION

Reduced visibility resulting from fog presents a very hazardous condition on the highway because of the inability of motorists to readily observe pavement markings and signs and the movement of traffic. Afton Mountain, which is traversed by I-64, often is the site of such reduced visibility because of the low cloud cover on the mountain top during rainy periods.

An acute awareness of the fog problem on Afton Mountain led to a decision by the Virginia Department of Highways and Transportation to install a lighting system consisting of pavement inset lights and low level illumination lights to aid motorists during periods of fog.

The installation was made on a 5.8-mile (9.4-km) section of highway encompassing the top of Afton Mountain. Since fog often occurs on only a portion of the mountain, the installation was divided into three sections, with each section being separated at points observed to most often correspond with the fog patterns. Each section is controlled by two fog detectors which are located at or close to the endpoints of the section and are capable of detecting five levels of fog density. The intensity of the guidance lights within each section is controlled by the density of the fog at each detector.

The fog guidance system consists of unidirectional airport runway lights installed in the pavement edge line along each side of the roadway in both directions, spaced at 200-ft. (61-m) intervals on tangent sections and 100-ft. (30.5-m) on curved sections. Figure 1 shows the inset lights operating during daylight fog conditions and Figure 2 shows nighttime conditions. In addition to the white inset lights on the main line, amber lights are installed on one side of the off-ramps. Also, low level illumination lights are installed on a short section of an on-ramp.

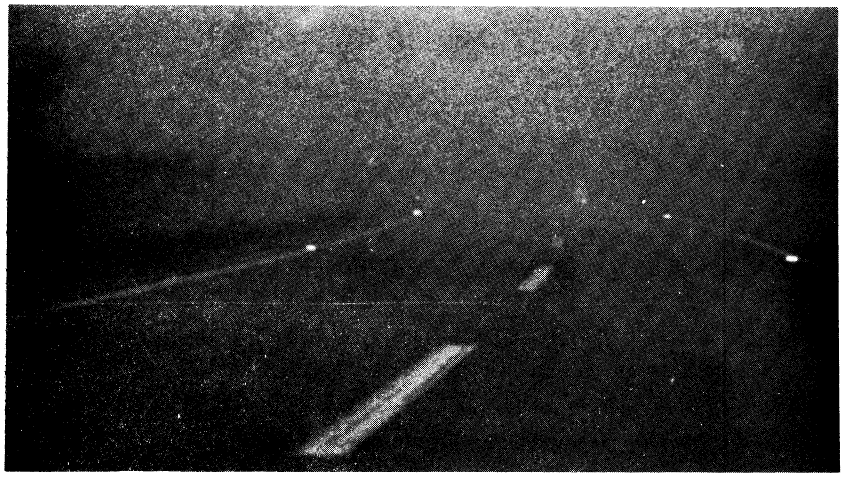

Figure 1. Inset lights during daytime fog conditions.

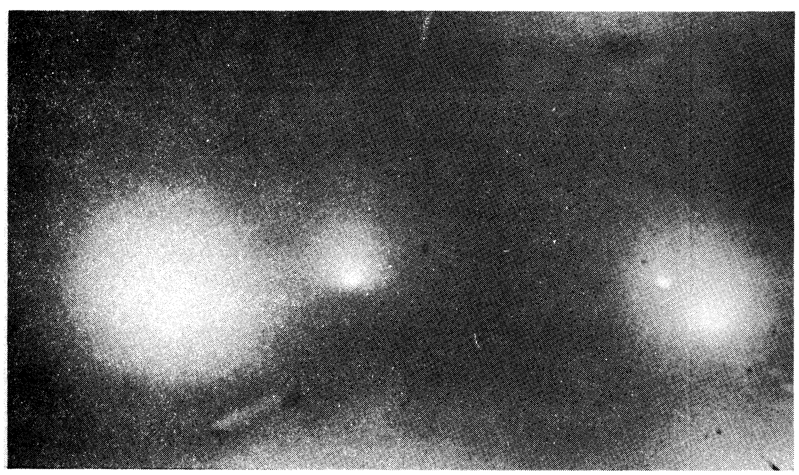

Figure 2. Inset lights during nighttime fog conditions.

It was felt that the lighting system would help delineate the highway and thus lead to an improvement in traffic operations. However, it was not known how the system of lights would affect vehicle speeds, headways, and placement. Also, there was some concern that the system might promote a false sense of security and lead to higher speed and greater differentials in speed that would increase the possibility of accidents.

PURPOSE AND SCOPE

It was, therefore, the purpose of this research to investigate the traffic flow characteristics during fog within the system of pavement inset lights installed on I-64 across Afton Mountain.

The scope of the study included the collection and analysis of traffic flow data before and after the inset lights were installed. The traffic flow parameters evaluated were vehicle speeds, headways, queues, and lateral placement. A before and after accident analysis was also made. Because of the variability of fog densities for the period of study, and project time, personnel, and funding limitations, it was not possible to collect traffic flow data for all fog conditions on Afton Mountain. Although the data anticipated and thought possible to collect under the work plan(1) would be inadequate for the purpose of deciding the success or failure of the lighting system, it would add to the data base concerning traffic flow during fog conditions for the type of delineation used; namely, pavement inset lights.

EVALUATION OF TRAFFIC FLOW

The effect of the system of pavement inset lights on the traffic flow characteristics was determined by comparing data collected before and after the system was installed. Data were collected for all fog conditions (day and night) occurring within the time frame allowed for collection. Also, data collection was limited to weekdays during off-peak hours.

Site

One location on the two westbound lanes of I-64 over Afton Mountain just east of the Blue Ridge Parkway was chosen for data collection. This location, which had an annual average daily traffic count of approximately 5,000 vehicles for the period 1973-1976, is on the level section of the mountain top with a slight horizontal curve to the right. There are no interchanges prior to the site for a distance of 7 miles (11.3 km). Data were collected at only one site because of the difficulty encountered in monitoring equipment and fog conditions for more than one site.

Collection of Traffic Flow Data

Data were collected before (11/27/73-5/1/75) and after (1/26/76-9/30/76) installation of the lighting system using a system of tapeswitches placed in the configuration shown in Figure 3. The tapeswitches were placed on the highway using one of two methods, depending upon the weather conditions. Under clear, dry conditions they were attached to the road surface with double-faced tape over which 6-in. (15.24 cm) of tape was placed. During adverse weather, i.e., rain, fog, etc., the tapeswitches were attached to thin (0.022-in. [0.56 mm]) metal ribbons stretched across the highway and fastened to metal anchors in the shoulder and the median. These methods allowed the quick, safe installation of the switches under any weather conditions. Also, switches placed by the latter method proved to be the most durable and reliable during adverse weather conditions.

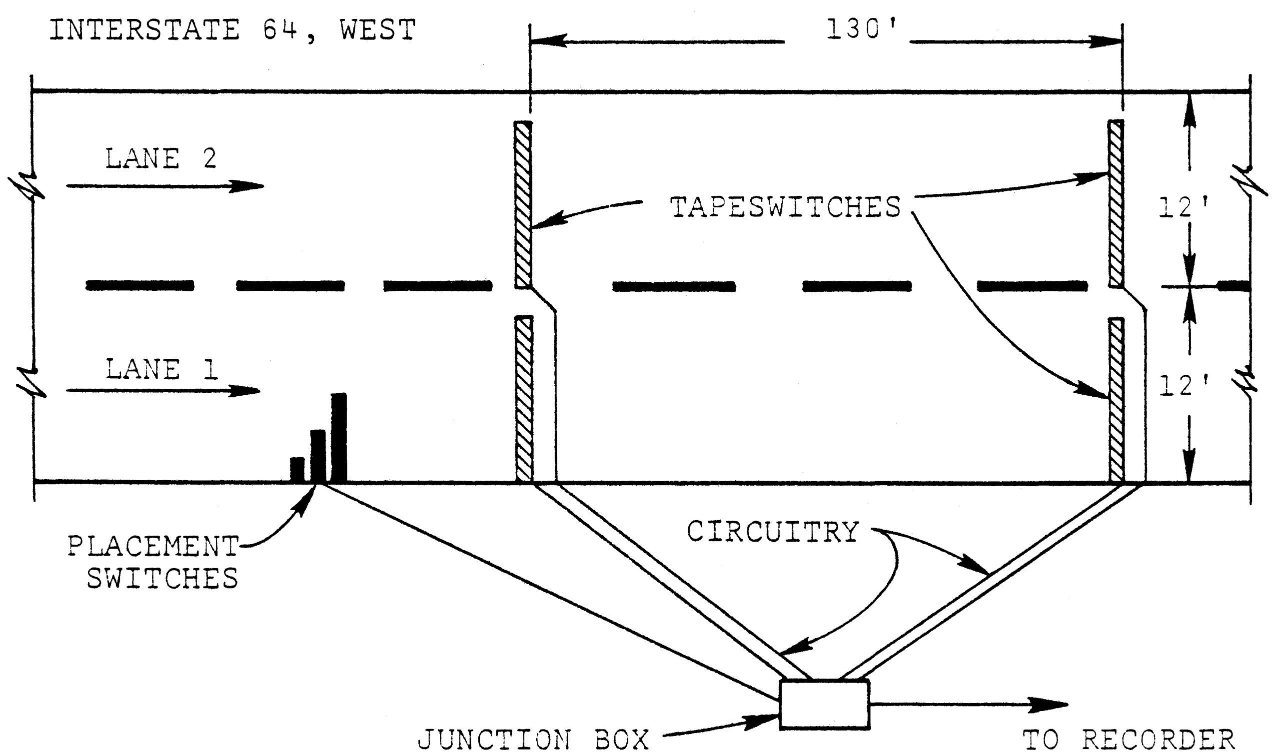

Figure 3. System of tapeswitches used for data collection.
Note: 1 ft. = 0.30 m.

Data from all the tapeswitches were recorded simultaneously on a 4-channel chart recorder with each particular switch being identified by assigning different voltages. By knowing the distance between the tapeswitches on the road and the speed of the chart recorder, vehicular speeds and headways were determined by measuring the distances between impulses on the chart.

Vehicle placements were obtained by installing tapeswitches of different lengths on the right edge of the traffic lane (lane 1) and noting which switch combinations were activated.

The chart recorder used for data collection was placed in a vehicle parked approximately 1,000 ft. (304.8 m) past the site to eliminate any influence the parked vehicle may have had on traffic flow. Also, the switches were not conspicuous to motorists.

Weather Conditions

The fog problem considered here is caused by low cloud cover in the mountainous areas. The fogs are relatively dense and uniform. However, variable fog conditions, fog banks, etc., do occur at the edges of the cloud cover and in areas under broken clouds resulting from clearing weather.

It should be noted that data were taken only during uniform fog conditions extending at least 500 ft. (152.4 m) to 1,000 ft. (304.8 m) in advance of the test site.

Fog Density

It is very important that a relative measure of fog density be obtained as it influences traffic flow characteristics. The density was determined by noting the number of visible centerline stripes on the pavement during daylight hours and the number of reflectorized shoulder delineators during hours of darkness. These distances were used to identify relative fog densities in the analysis of the data. It should be noted that vehicles are visible for distances greater than those shown, with the distance depending on the type of vehicle and size of the taillight and its intensity when illuminated.

Since the tapeswitches were approximately 1,000 ft. (304.8 m) from the data recorders, the fog densities and uniformity of the fog were monitored by driving through the site at regular intervals.

RESULTS

The numerous variables associated with the project, problems encountered in data collection during adverse weather conditions, and the time frame in which it was possible to collect the data limited the quantity of data collected for analysis. Therefore, the study results reflect only those data for which comparable before-after conditions were available.

The collection of traffic flow data during fog presented a situation in which one variable — the density of the fog, or sight distance — could change instantaneously, and it was difficult to detect and consider small changes. As a result, sight distances were broken into six categories: 50-80 ft. (15.2-24.4 m), 80-110 ft. (24.4-33.6 m), 110-150 ft. (33.6-45.8 m), 150-200 ft. (45.8-61.0 m), 200-300 ft. (61.0-91.2 m) and 300-500 ft. (91-2-152.5 m). These categories encompassed the fog densities encountered during the study.

Traffic flow data were classified within these sight distances and are presented accordingly. The traffic flow and sight distance data are further categorized into off-peak hours during weekdays for daylight and darkness. Table 1 gives the numbers of hours for which before and after data were accumulated along with the associated traffic volumes and sight distances. For these volumes, the traffic flow conditions were well within uncongested or "free flow" conditions.

Speeds

Vehicular speeds were obtained from lanes 1 and 2 for cars, trucks, and tractor-trailers. Table 2 gives a summary of speeds for cars and tractor-trailers and the associated standard deviations and volumes; trucks were not included because of the low volume encountered.

Table 1

Hours of Data Collected with Associated Traffic Volumes

Time	Sight Distance, ft.	Hours of Data		Traffic Volumes			
		Before	After	Before		After	
				Total	Veh./hr.	Total	Veh./hr.
DAYLIGHT	50-80	3.72	-	667	179	-	-
	80-110	7.95	-	2,041	257	-	-
	110-150	6.58	8.13	1,891	288	2,324	286
	150-200	3.12	6.93	782	250	2,016	291
	200-300	1.25	3.00	299	240	884	294
	300-500	-	1.45	-	-	511	352
NIGHT	50-80	2.35	4.53	322	137	497	110
	80-110	2.72	6.65	305	112	756	114
	110-150	-	0.58	-	-	77	133

NOTE: 1 ft. =0.30m

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Table 2

Summary of Vehicle Speeds and Associated Standard Deviations and Volumes

TIME	Veh. Type	Sight Distance, ft.	50-80						80-110						110-150					
		Lane	1			2			1			2			1			2		
		Number	B[b]	A[c]	Sig.[a]	B	A	Sig.	B	A	Sig.	B	A	Sig.	B	A	Sig.	B	A	Sig.
DAY	Car	Speed	41.0			46.7			40.0			45.2			43.1	38.5	x	49.3	42.9	x
		Std.Dev.	6.6			7.9			6.6			6.0			7.2	7.8	x	6.0	7.4	x
		Vol.	150			56			1172			476			1176	1328		382	467	
	T-T	Speed	32.0						34.0						34.9	33.7				
		Std.Dev.	5.7						6.7						7.4	7.0				
		Vol.	26						170						158	235				
			150-200						200-300						300-500					
DAY	Car	Speed	44.9	42.1	x	49.7	46.5	x	48.2	45.5	x		50.0			48.9			53.0	
		Std.Dev.	6.4	7.6	x	6.2	6.5		7.7	7.1			6.2			7.7			5.8	
		Vol.	419	1236		45	357		246	537			144			346			77	
	T-T	Speed								36.2						37.4				
		St.Dev.								8.5						8.8				
		Vol.								94						40				
			50-80						80-110						110-150					
NIGHT	Car	Speed	25.7	29.9	x	32.2	35.9	x	30.6	36.4	x	36.2	40.7	x		40.9				
		Std.Dev.	5.7	7.5	x	7.4	8.0		7.1	8.0	x	7.2	8.5			7.1				
		Vol.	168	291		73	79		185	412		60	98			9				
	T-T	Speed	28.3	30.6					30.0	34.7	x									
		Std.Dev.	5.8	5.3					4.9	5.8										
		Vol.	15	69					31	123										

(a) Significant at 95% confidence interval.

(b) Before

(c) After

Note: 1 ft. = 0.30 m.

Daylight

For daylight hours, comparable before-after data were available in the 110-150 ft. (33.6-45.8 m), 150-200 ft. (45.8-61.0 m) and 200-300 ft. (61.0-91.2 m) sight distance categories and showed a significant decrease in mean speeds in both lane 1 and lane 2. The only comparison for tractor-trailers showed speeds to be slightly lower in the after condition for lane 1 and a 110-150 ft. (33.6-45.8 m) sight distance; however, the difference was not significant. A plot of the average speeds for cars in lanes 1 and 2 and sight distances for which data were available is shown in Figure 4.

An analysis of variance was used to judge if the differences between speed variances for the before and after conditions were significant. From the results in Table 2 it can be seen that there was a significant difference for cars in lanes 1 and 2 for the 110-150 ft. (33.6-45.8 m) sight distance, while only lane 1 showed a significant difference for the 150-200 ft. (45.8-61.0 m) range. No difference was found in the variability for lane 1 and the 200-300 ft. (61.0-91.2 m) sight distance. Available data for tractor-trailers indicated no significant difference for lane 1 in the 110-150 ft. (33.6-45.8 m) category.

Darkness

During nighttime off-peak hours, there was a significant increase in average speeds for cars in lane 1 and lane 2 and sight distance in the 50-80 ft. (15.2-24.4 m) and 80-110 ft. (24.4-33.6 m) categories after the lights were installed. For these sight distances, speeds increased for tractor-trailers in lane 1; however, the difference was significant for only the 80-110 ft. (24.4-33.6 m) sight distance. A comparison of the car speeds in lanes 1 and 2 is shown in Figure 5.

There was a significant increase in the speed variance for cars within the 50-80 ft. (15.2-24.4 m) and 80-110 ft. (24.4-33.6 m) sight distances for lane 1; however, there was no significant difference for cars in lane 2 nor tractor-trailers in lane 1.

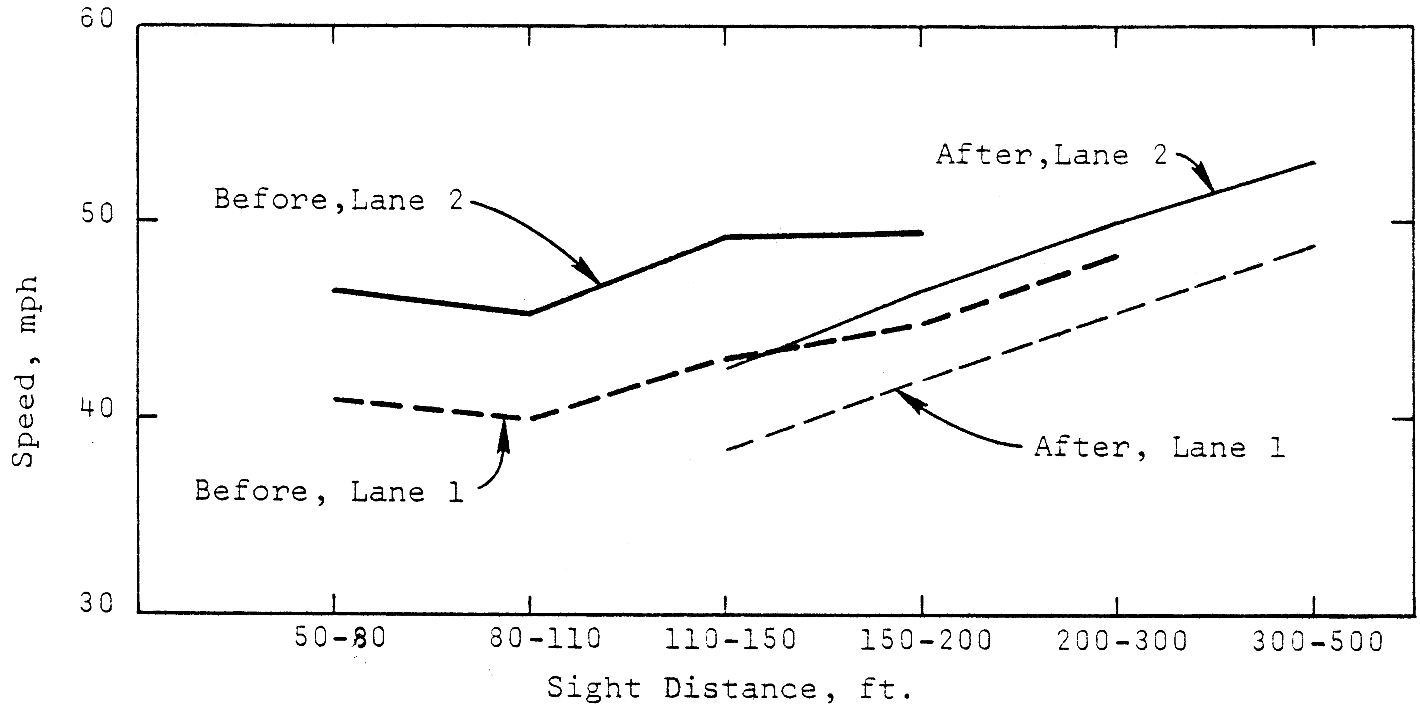

Figure 4. Mean car speed versus sight distance for daylight fog conditions. (Note: 1 mph = 1.6 kmh; 1 ft. = 0.30 m)

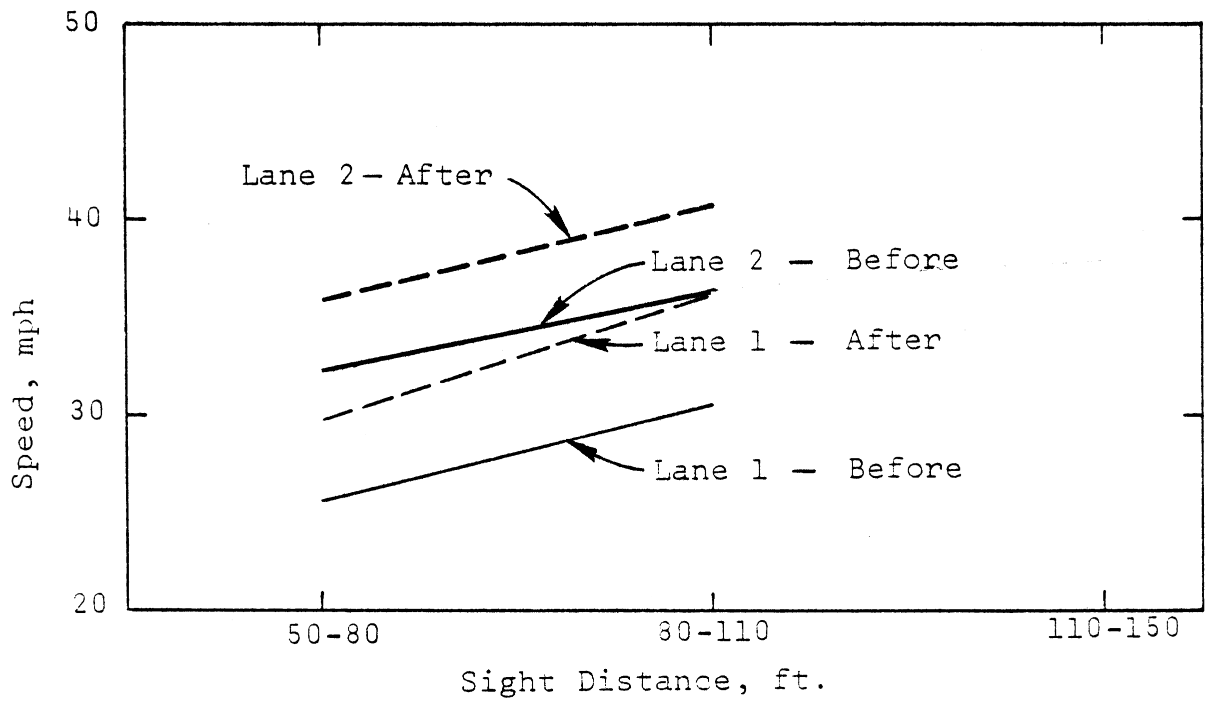

Figure 5. Mean car speed versus sight distance for nighttime fog conditions. (Note: 1 mph = 1.6 kmh; 1 ft. = 0.30 m)

Safe Stopping Distance

The minimum safe stopping distance includes both the distance the vehicle travels while the driver reacts to the situation requiring a stop and the distance it travels after the brakes are applied. In fog, the distance at which the driver can see an object requiring him to stop is related to the density of the fog. Therefore, for a safe stop, the sight distance should be greater than the minimum safe stopping distance for a given vehicle speed. To give an indication of the relationship of sight distances in fog to the minimum safe stopping distance, the curves in Figure 6 show speed vs. safe stopping distances for cars on wet pavement with zero grade. The upper limit of the sight distance for each sight distance category in fog is also shown. It should be noted that the upper limit is increased by 50-80 ft. (15.2-24.4 m) as an estimation of the sight distance of a vehicle, since vehicles are visible for distances greater than the centerline skips used for categorizing the fog densities; that is, the distance for the 50-80 ft. (15.2-24.4 m) category increased to 130 ft. (39.6 m); and that for the 150-200 ft. (45.8-61.0 m) category became 280 ft. (85.5 m). An example of the differences in safe stopping distances for different speeds is given by plotting before-after car speeds for the 50-80 ft. (15.2-24.4 m) sight distance category in nighttime fog and those for the 110-150 ft. (33.6-45.8 m) category in daytime fog. In all cases the actual sight distance was less than the safe stopping distances. This condition indicates that drivers tend to go too fast for sight distances in fog.

Headways

A summary of headway data, including mean headway, volume and the percentage of vehicles within various headway intervals, is given in Table 3. It should be noted that headways were measured from front axle to front axle of successive vehicles with only headways below 58 seconds being considered.

Although all headways below 58 seconds were recorded, the primary concern was with headways where vehicles were in visual contact, because only then were headways likely to be influenced by vehicle interactions.

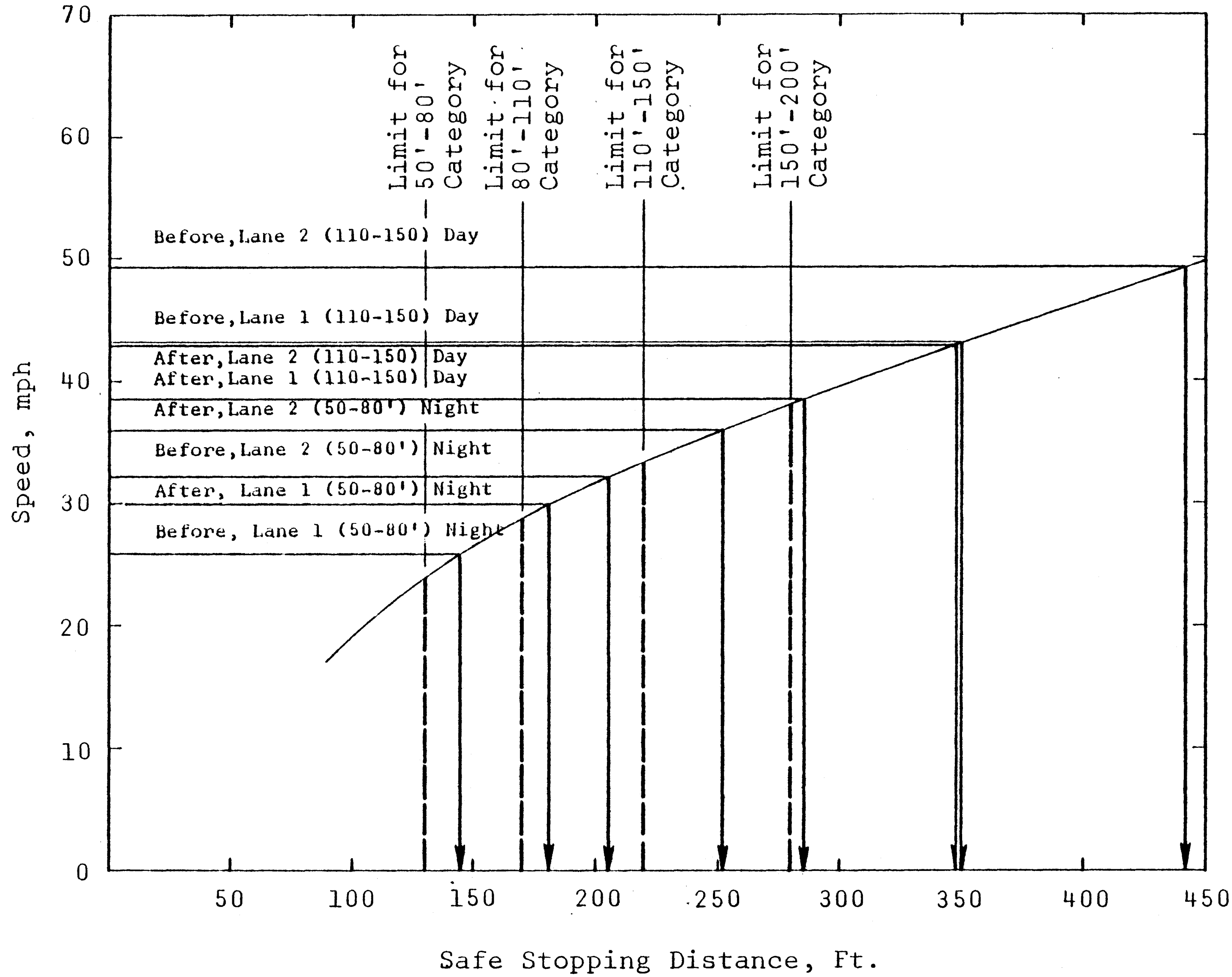

Figure 6. Safe stopping distances for various speeds.
(Note: 1 mph - 1.6 kmh; 1 ft. - 0.30 m)

Table 3

Summary of Vehicle Headway Data

TIME		Sight Distance, ft.	50-80				80-110				110-150				150-200 (a)		200-300 (a)		300-500 (a)	
		Lane No.	1		2		1		2		1		2		1		1		1	
		Condition	B (b)	A (c)	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
DAY		Mean Headway	15.8		28.4		15.3		18.5		13.3	13.2	18.1	19.0	14.8	13.2		13.3		11.4
		Volume	540		35		1453		343		1407	1688	280	308	554	1551		68 5		424
		Vol./15 min.	36.3		6.5		50.5		11.9		53.5	52.2	10.6	9.8	44.5	56.0		57.0		73.0
	% of Veh.	0-1 Sec.	0		0		0		0		0	0	1	1	1	0		0		0
		1-2 Sec.	12		14		11		14		15	10	17	15	8	8		3		4
		2-3 Sec.	13		2		13		9		12	13	8	10	10	11		9		10
NIGHT		Mean Headway	14.7	17.4			15.4	19.5	16.0											
		Volume	182	308			167	467												
		Vol./15 min.	19.4	17.0			15.4	17.6												
	% of Veh.	0-1 Sec.	0	0			0	0												
		1-2 Sec.	8	4			8	3												
		2-3 Sec.	14	14			14	7												

(a) No data collected for lane 2.

(b) Before

(c) After

Headways were, therefore, broken down into 1-second time intervals and the percentages of vehicles within the time intervals. Using the average speeds given in Table 2 and the sight distances in fog, the time intervals in which headways are influenced by vehicle interactions can be determined. In the majority of cases only those headways within the 0-3 second range are relevant since beyond 3 seconds the sight distances prevent interactions for those speeds shown in Table 2.

Figures 7 and 8 show the percentages of vehicles below 3-second headways for lanes 1 and 2 during daylight. For lane 1 there was a decrease in the percentage of vehicles in the after condition at the 110-150 ft. (33.6-45.8 m) sight distance; however, there was no difference between the before and after condition for the 150-200 ft. (45.8-61.0 m) sight distance. The one sight distance category (110-150 ft. [33.6-45.8 m]) for which lane 2 before-after data were comparable revealed no difference in vehicle percentages.

Lane 1 headways below 3 seconds for nighttime conditions are shown in Figure 9. For both sight distances observed for fog the percentages of headways below 3 seconds were less in the after condition than the before, with the greater difference being found in the 80-110 ft. (24.4-33.6 m) sight distance category.

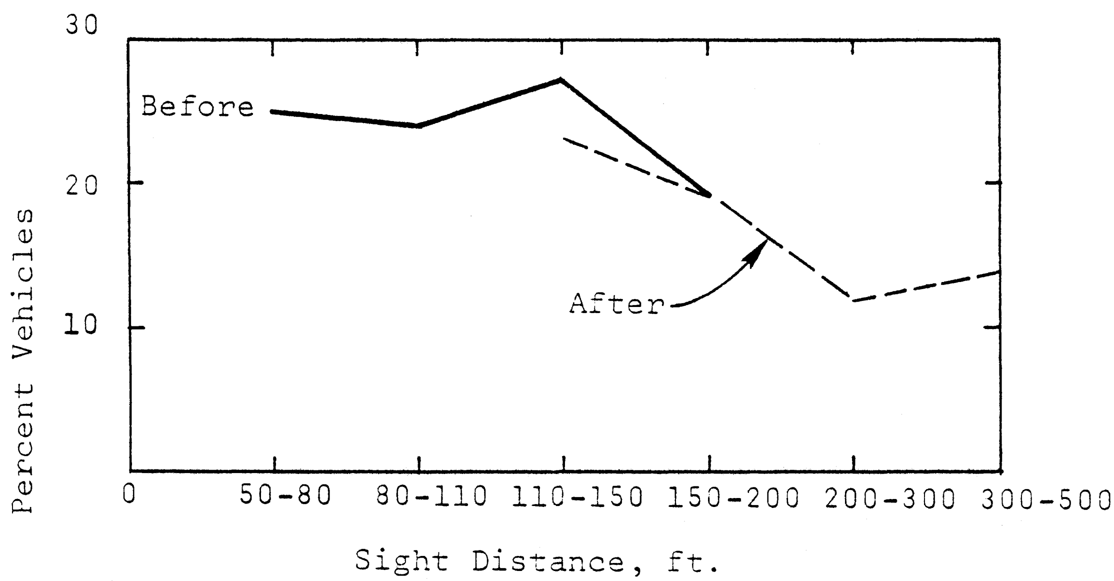

Figure 7. Percentage of vehicles in lane 1 below 3 seconds, daylight. (1 ft. = 0.30 m)

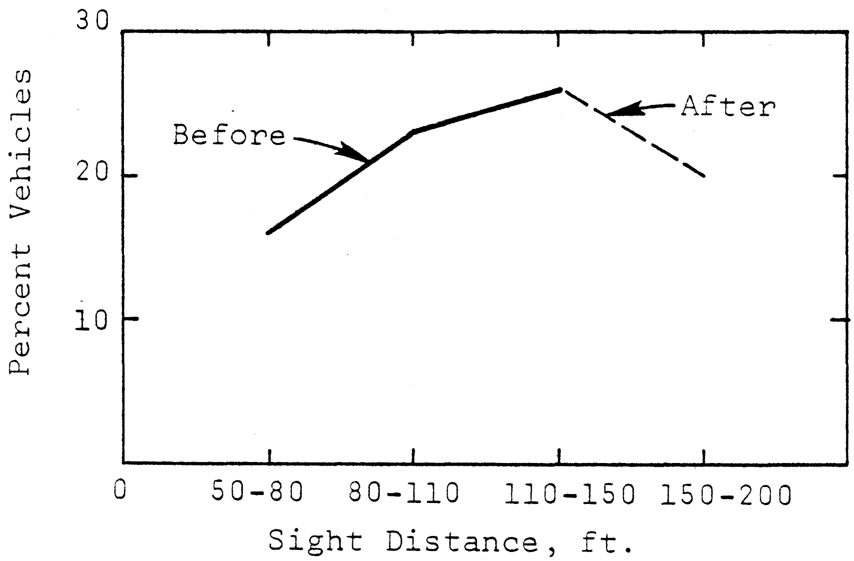

Figure 8. Percentage of vehicles in lane 2 below 3 seconds, daylight. (1 ft. = 0.30 m)

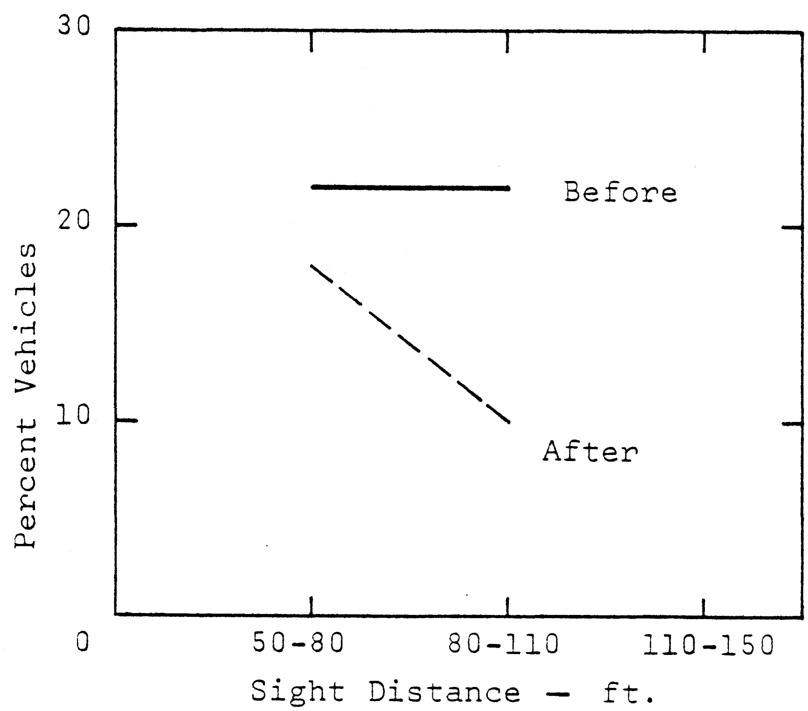

Figure 9. Percentage of vehicles in lane 1 below 3 seconds, darkness. (1 ft. = o.30 m)

Vehicle Queuing

Data concerning the queuing of vehicles for the sight distances in fog for which comparable data were available are shown in Figures 10 and 11 for daytime and nighttime conditions, respectively. A queue was considered as two or more vehicles with the headway times being less than those times shown in the figures. The number of queues per 100 vehicles was plotted as a function of the headway time. It should be noted that beyond 3 seconds headway time there was very little visual contact between vehicles because of the restricted sight conditions; therefore, only those queues with vehicle headways less than 3 seconds were included.

Vehicle queuing during daylight hours was less in the after condition than the before for the 110-150 ft. (33.6-45.8 m) sight distance; however, there was little difference for the 150-200 ft. (45.8-61.0 m) sight distance.

There was a decrease in nighttime vehicle queuing for both the 50-80 ft. (15.2-24.4 m) and 80-110 ft. (24.4-33.6 m) sight categories in the after condition, with the difference being much less for the former than for the latter.

For both daytime and nighttime conditions (before and after) the average number of vehicles in each queue was in the 2.1-2.5 vehicle range.

Lateral Placement

The placement of vehicles with reference to the right pavement edge was rounded into intervals of 0-1.3 ft. (0-0.39 m), 1.3-3.1 ft. (0.39-0.95 m), 3.1-5.2 ft. (0.95-1.59 m), or 5.2 ft. (1.59 m) or more from the edge. Figure 12 shows the placement of cars for the before and after conditions for unimpaired and 150-200 ft. (45.8-61.0 m) sight distances. Vehicles tended to be further from the pavemdnt edge in the after condition than in the before for the 150-200 ft. (45.8-61.0 m) sight distance. A comparison of the clear and 150-200 ft. (45.8-61.0 m) sight distances showed that cars traveled further from the edge line in both the before and after periods for the 150-200 ft. (45.8-61.0 m) sight distance.

Figures 13 and 14 show the placement of cars and tractor-trailers, respectively, for nighttime under the after condition. Figure 13 shows there was very little difference between the 50-80 ft. (15.2-24.4 m) and 80-110 ft. (24.4-33.6 m) sight distance categories for cars; however, for unimpaired sight distances, cars drove closer to the right edge line. Figure 14 shows that as the nighttime sight distances decreased, tractor-trailers were further from the right edge line.

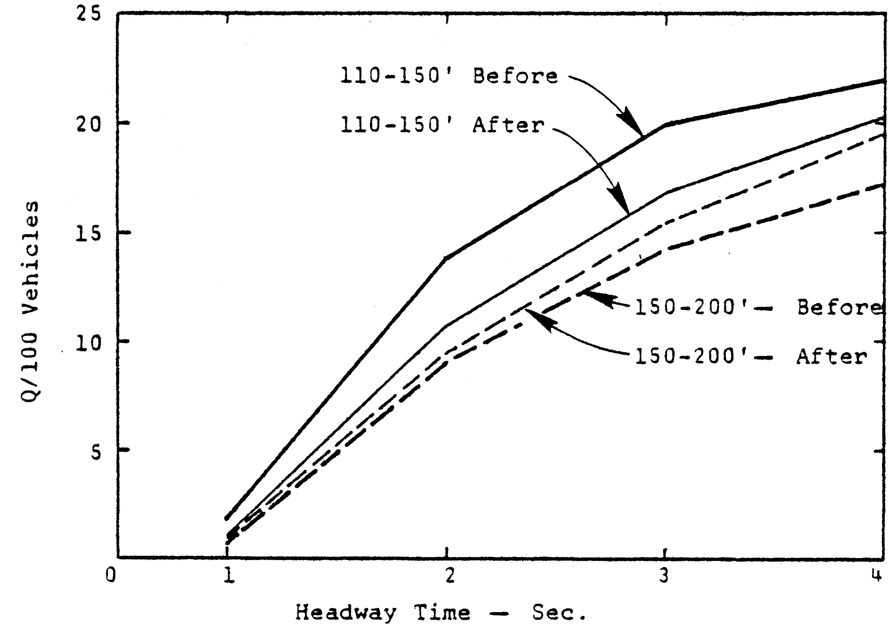

Figure 10. Vehicle queuing for headway cutoff time shown — daytime. (1 ft. = 0.30 m).

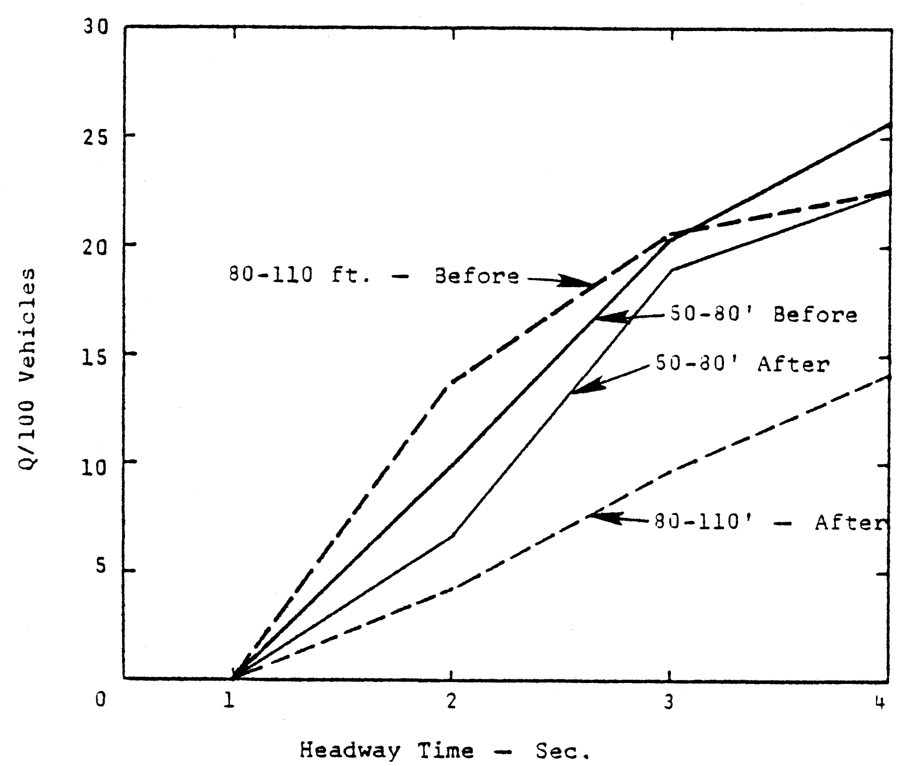

Figure 11. Vehicle queuing for headway cutoff time shown — nighttime (1 ft. = 0.30 m).

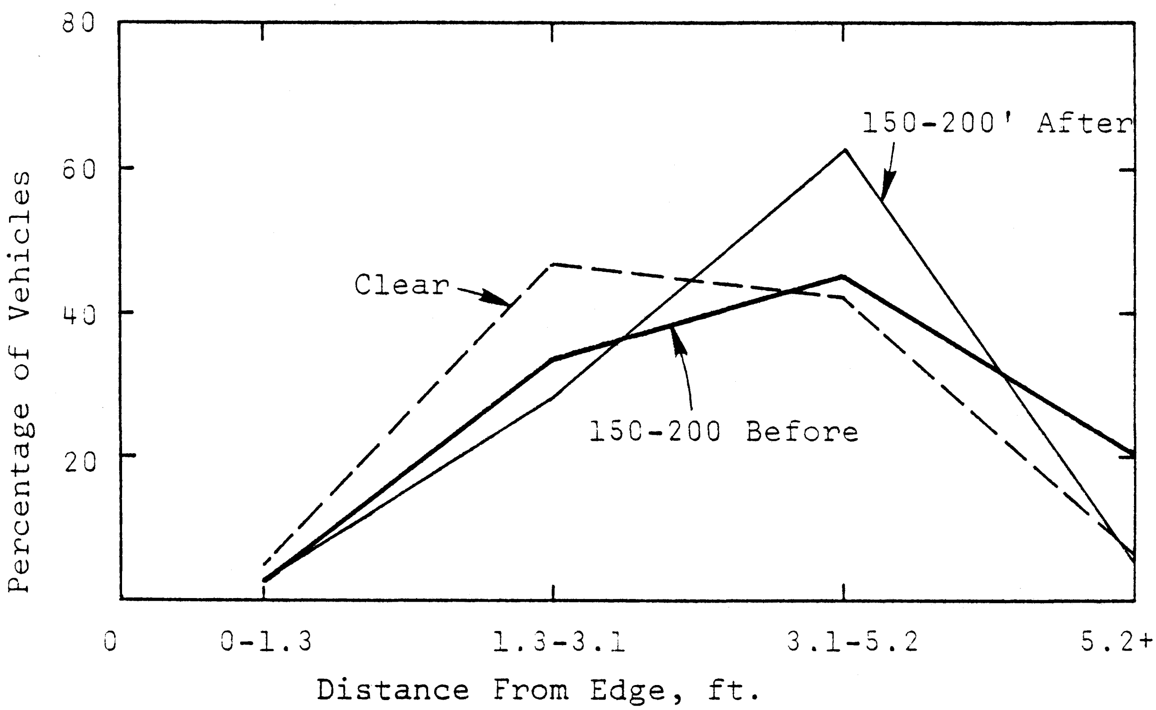

Figure 12. Placement interval from pavement edge for cars during daylight. (1 ft. - 0.30 m)

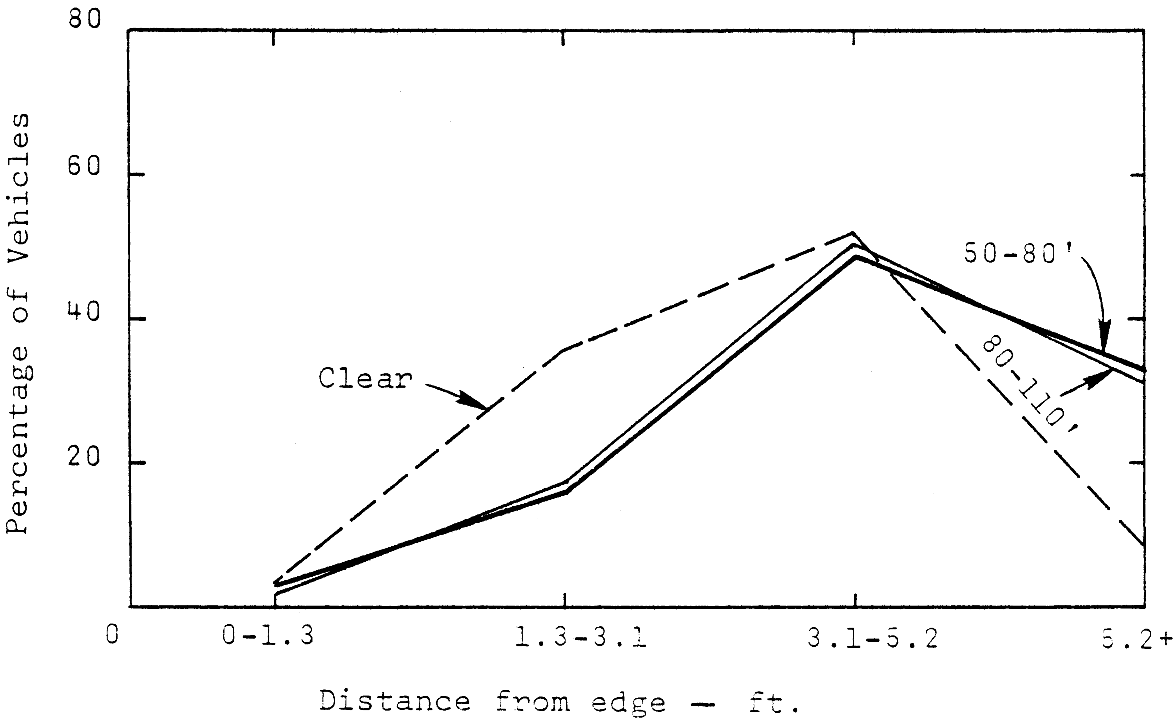

Figure 13. Placement interval from pavement edge for cars at night — after period. (1 ft. = 0.30 m)

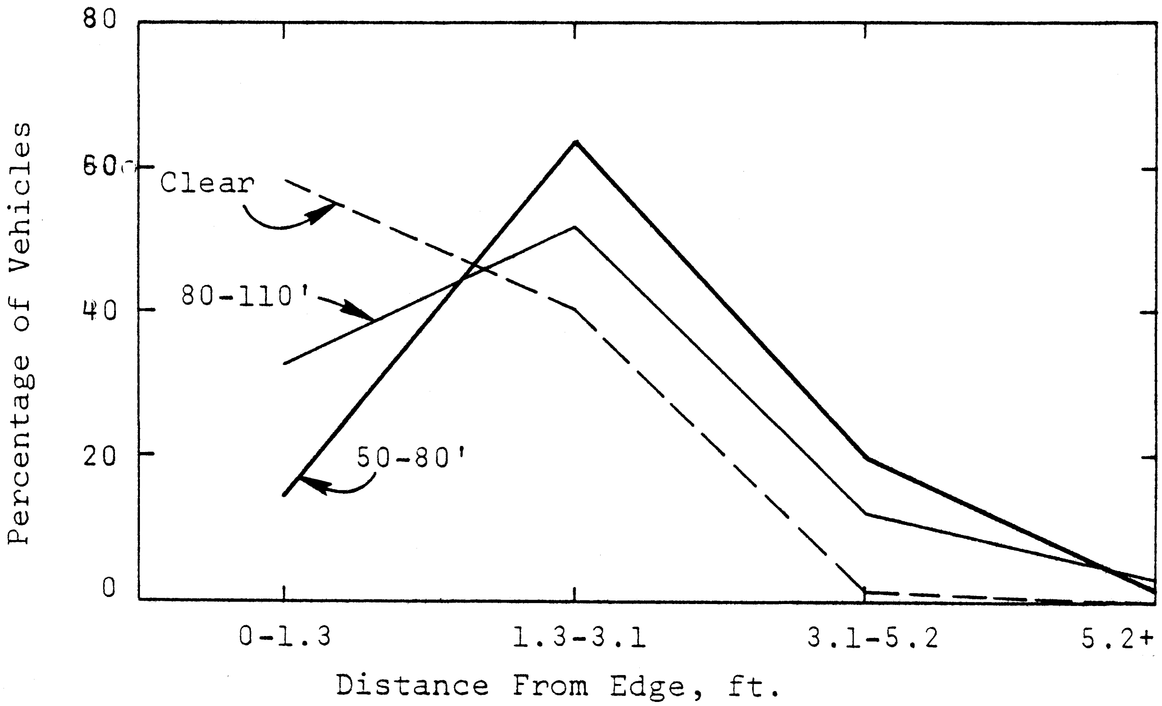

Figure 14. Placement interval from pavement edge for tractor-trailers at night — after condition. (1 ft. = 0.30 m)

Accidents

Information on all accidents occurring within the section of pavement inset lights from December 22, 1972, when the highway was opened, until September 30, 1976, was obtained from the Division of Motor Vehicles. Table 4 gives a summary of the accident data for the before (2/28/73-9/30/74) and after (2/28/75-9/30/76) periods.

Four accidents occurred in fog during the before period, and only 1 accident occurred during the after period. The infrequency of accidents during fog prohibits any statistical analysis; therefore, a general breakdown of the available data is presented in Table 5 and is followed by specific comments concerning each accident.

Table 4

Summary of Accident Analysis, All Accidents

	Before (2/28/73-9/30/74)	After (2/28/75-9/30/76)
Total Accidents	40	31
Injury Accidents	8	13
Fatal Accidents	1	0
Weather Conditions		
Clear	18	20
Cloudy	9	7
Ice, Snow, and Sleet	6	3
Rain	3	0
Fog	4	1
Daylight	22	15
Darkness	18	16

Table 5

Summary of Accidents, Fog Related Only

	Before	After
Total Accidents	4	1
Injury Accidents	0	0
Fatal Accidents	0	0
Daylight	2	0
Darkness	2	1

Before Accidents

1. Vehicle stopped on roadway was hit by two others. Road covered with ice.

2. Vehicle went out of control on ramp. Driver charged with reckless driving.

3. Vehicle hit truck when attempting to pass (dawn).

4. Vehicle trailer started to sway and overturned.

After

1. Deer ran in front of vehicle.

DISCUSSION OF RESULTS

As indicated previously the limited time during which it was possible to collect the data, along with the infrequency of fog at various density levels, limited the quantity of data that could be collected for analysis, and the study results represent only those data for which comparable before-after conditions were available.

Speeds

It is interesting to note that the speeds decreased after the system was installed during daylight fog conditions. This decrease is explained by the fact that during daylight hours, within the range of sight distances encountered in fog, the motorist can see at least two or three centerline skips (40 ft. [12.2 m] intervals; 15 ft. [4.9 m] painted line); however, the uniqueness of the system, in addition to some glare associated with the lights, causes the motorist to slow down. It is felt that when the data were accumulated the inset lights were a little brighter than they needed to be, which caused the glare and deceleration, and that once experience allows a realistic coordination between the sight distances in fog and light intensities, speeds will tend to be closer to those found in the before conditions.

Daytime fog creates restrictive driving conditions; however, it is during nighttime fog that driving becomes difficult, primarily because of the inability of the driver to see pavement markings and delineators whose retroreflectivity is significantly reduced under night-wet weather conditions. Also, the reflection of the vehicle headlights from the fog seriously restricts the motorist's visibility. The significant increases in speeds during nighttime fog give strong support to the contention that the inset lighting system provides additional delineation for guidance. However, it should be noted that the increase in speed at night for the after condition increases the accident potential, since even the nighttime-before speeds exceed those required for a safe stopping distance.

There was concern from the onset of the project that vehicle speeds would increase as a result of the improved delineation; therefore, a system of matrix type fog warning and advisory speed signs has been proposed for regulating speeds within the system of guidance lights. It is anticipated that the signs will be operable by 1979.

Safe Stopping Distance

It is noted above that the increase in nighttime speeds after the lights were installed raises the accident potential as a result of the increased stopping distances required. However, the low traffic volume encountered on this rural section of interstate highway, especially at night, leads to a decrease in vehicle interaction that lessens the significance associated with the safe stopping distance. Also, the improved delineation is thought to help prevent vehicle stoppages along the roadway.

Headways

A review of the headway data showed little difference in headways between the before and after conditions during the hours of daylight. However, available data show a decrease in nighttime headways (below 3 seconds) after the inset lights were installed. This finding, coupled with results showing less vehicle queuing in the after condition, indicates that motorists were using the inset lights for guidance rather than relying on car-following.

Queuing

The decrease in headways and vehicle queuing at night might indicate a reduction in the potential for accidents after the system was installed. However, it should be noted that for severely restricted sight distances before the guidance system was installed, vehicles tended to form queues for the purpose of being led through the fog, which may be thought of as being safer than having no one to follow.

Accidents

It would be difficult to surmise what, if any, increase in accident potential would result from the differences noted in traffic flow parameters. There has been only one accident during fog conditions since the system of lights was installed. Also, in a recent subjective evaluation of the system, over 95% of the motorists interviewed indicated that they were aided by the system and 90% reported that the lights reduced their anxiety while driving in fog.[2]

SUMMARY OF FINDINGS

Overall, the lighting system led to higher nighttime speeds, an increase in speed differentials for various cases during both daytime and nighttime, and to an increase in nighttime headways and a decrease in queuing. These changes in traffic flow characteristics may be construed as producing an increase in the potential for accidents; however, they are thought by the author to be a result of the inset lighting system providing improved delineation for the guidance of motorists. This improvement in guidance, especially during fogs at night, may provide safer driving conditions than hitherto existed. A summary of the findings is given below.

1. The installation of the pavement inset lights has resulted in a decrease in daytime speeds and an increase in nighttime speeds.

2. For the sight distances in fog during daytime and nighttime, there was a significant increase in the variability of speeds for cars in lane 1 in the after period. Results for the remainder of the comparisons showed no differences for cars or tractor-trailers, with the exception of cars in lane 2 for the 110-150 ft. (33.6-45.8 m) sight distance category.

3. For all conditions investigated (before and after) the actual sight distances were less than the safe stopping distances, a condition which indicates that drivers tend to go too fast for sight distances in fog.

4. There was little difference in vehicle headways during daylight hours between the before and after periods; however, there was an increase in nighttime headways in the after period.

5. There was a decrease in daytime vehicle queuing for the 110-150 ft. (33.6-45.8 m) sight distance, but little difference within the 150-200 ft. (45.8-61.0 m) range. At night, for both sight distances considered, there was a decrease in vehicle queuing. There was little difference in the numbers of vehicles in the queues.

6. During daylight the lateral placement of cars was further from the right edge line after the lights were installed. Also, the placement of cars was further from the edge line during fog for both the before and after periods as compared to clear weather conditions. Both cars and tractor-trailers were positioned further from the edge line for nighttime fog conditions as compared with clear conditions.

REFERENCES

1. Shepard, F. D., "Traffic Flow Evaluation of Pavement Inset Lights for Use During Fog," Working Plan, Virginia Highway and Transportation Research Council, February 1974.

2. Creech, M. F., and T. A. Chrisman, "Evaluation of the 5.8-Mile Highway Light System for Guidance in Fog on Afton Mountain," Virginia Highway and Transportation Research Council, September 1976.