IMPLEMENTATION REPORT

INSTALLATION OF RAISED PAVEMENT MARKERS FOR REDUCING INCIDENCES OF WRONG-WAY DRIVING

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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ABSTRACT

On the basis of previous research, raised pavement markers were installed at two interstate off-ramps known to have experienced incidences of wrong-way driving to further evaluate their effectiveness in alerting motorists entering from the wrong-way of their mistake. Descriptions of these installations are given in the report along with the results of the evaluation, which included a subjective investigation of the visibility and alerting characteristics of the markers and a determination of their durability qualities. Based on the results it is felt that the configurations of markers used are effective in alerting drivers as a result of their viewing an unexpected phenomenon. It is recommended that the raised pavement markers, placed in configurations as noted in the report, be considered for placement in ramp areas or similar locations where wrong-way entries have been a problem.

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INTRODUCTION

In an attempt to stop drivers who enter an interchange ramp going the wrong way, a means of alerting them to their error is being sought. In view of the fact that a wrong-way driver must fail to see or properly interpret the directional signs, warning signs, and pavement markings placed in the intersection for his guidance, it is obvious that something beyond conventional concepts are needed. A concept which is believed to have merit involves the placement of raised pavement markers on off-ramps in such a configuration that the driver will be alerted as a result of viewing an unexpected phenomenon. Although such markers have been used for this purpose, they have been placed in the shape of an arrow, transverse line, or other configurations similar to markings normally seen by the motorist.

Recently completed research evaluated the feasibility of using such raised pavement markers to alert wrong-way drivers. Attention is called to the following conclusions and recommendations as presented in the final report on that research. (1)

Conclusions

1. The raised pavement marking system was effective in alerting drivers as a result of their viewing an unexpected phenomenon.

2. The marking system did help call attention to the in-place wrong-way signs and was thought to be effective in causing a wrong-way driver to realize his mistake and act accordingly.

3. A configuration consisting of 45 markers was preferred over a configuration with approximately one-half this number of markers. It was felt that the wrong-way signs should be toward the far end of the marker configuration as a wrong-way driver would view the system.

Recommendations

The working plan for this study noted that the research would be conducted in three phases, with the execution and design of each subsequent phase being dependent upon the results of the preceding one. Based on the results of this initial phase, which have indicated that the selected raised pavement markers exhibit good attention getting characteristics, it is recommended that the study be expanded by permanently placing raised pavement markers at two or three interchange off-ramps for further study. It is anticipated that this recommendation will be implemented in the near future.

OBJECTIVE AND SCOPE

Based on the results of the above mentioned research, the proposed raised pavement markers were installed at two locations known to have experienced incidences of wrong-way driving for further study of their effectiveness. Only one type of marker was installed, that being the Stimsonite Type 88 mono-directional red marker. The markers were installed in such a number and configuration thought to be most effective for the particular geometrics of the locations.

PROCEDURE

Sites

The sites chosen for installation of the pavement marking system were both on Route 44 in Virginia Beach. One is on the eastbound Lynnhaven off-ramp and the other at the end of Route 44 eastbound as it enters 21st Street. The sites are shown pictorially in Figures 1 and 2 and schematically in Figures 3 and 4. Both sites are on concrete pavements.

Installation of Markers

As previously stated, only Stimsonite Type 88 mono-directional red markers were installed. This type of marker was chosen since it has good reflective qualities. (2) This marker, shown in Figure 5, has a white opaque surface on one side and a red reflectorized surface on the other. All the markers were placed so that the red reflectorized face was parallel to the highway alignment facing potential wrong-way drivers. The driver going in the proper direction would see only an opaque surface, which is relatively inconspicuous as shown in the photograph of the 21st Street site in Figure 6.

A total of 49 markers were installed at each site in seven equally spaced lines perpendicular to the flow of traffic. Each line contained seven randomly spaced markers. Figures 7 and 8 show the marker configuration for the Lynnhaven and 21st Street installations, respectively.

All markers were attached to the pavement with an epoxy adhesive supplied with the markers. Half of the roadway was closed for approximately two hours while the markers were being installed, and the epoxy allowed to harden sufficiently for exposure to traffic. It is estimated that the purchase cost of marker and adhesive plus labor and equipment was $2/marker, or $98 per installation.

The length, width, and position of the marked area are dependent on the particular roadway geometrics and alignment; therefore, it is difficult to establish a criterion for placement, nonetheless, the markers were placed longitudinally to give the motorist a chance to turn completely into the ramp area before crossing the marked section. Also, it was felt that the termination of the marked section in the vicinity of the wrong-way sign would help call attention to the sign. Figures 9 and 10 show the Lynnhaven and 21st Street sites, respectively, as they would appear to the wrong-way driver at night with vehicle lights on high beam.

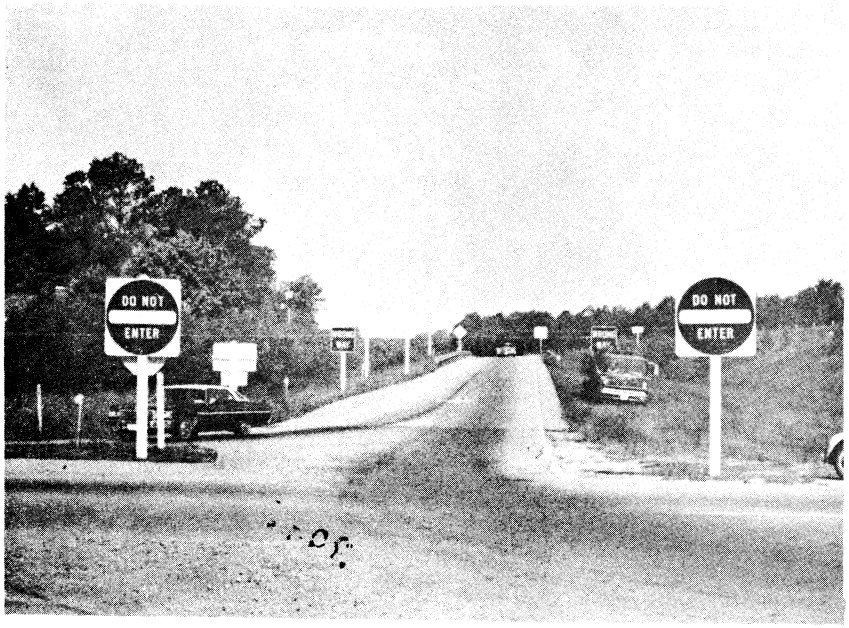


Figure 1. Lynnhaven off-ramp site.

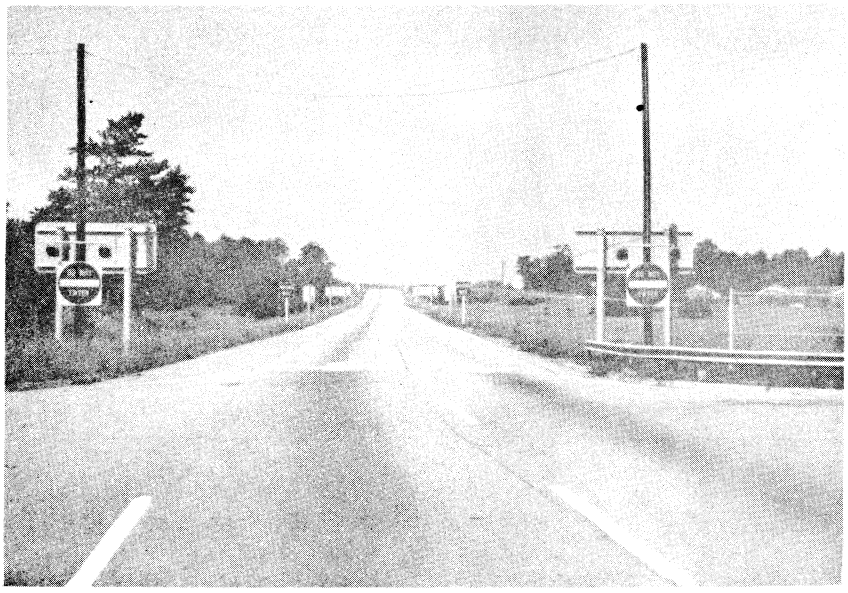


Figure 2. 21st Street site entering Virginia Beach.

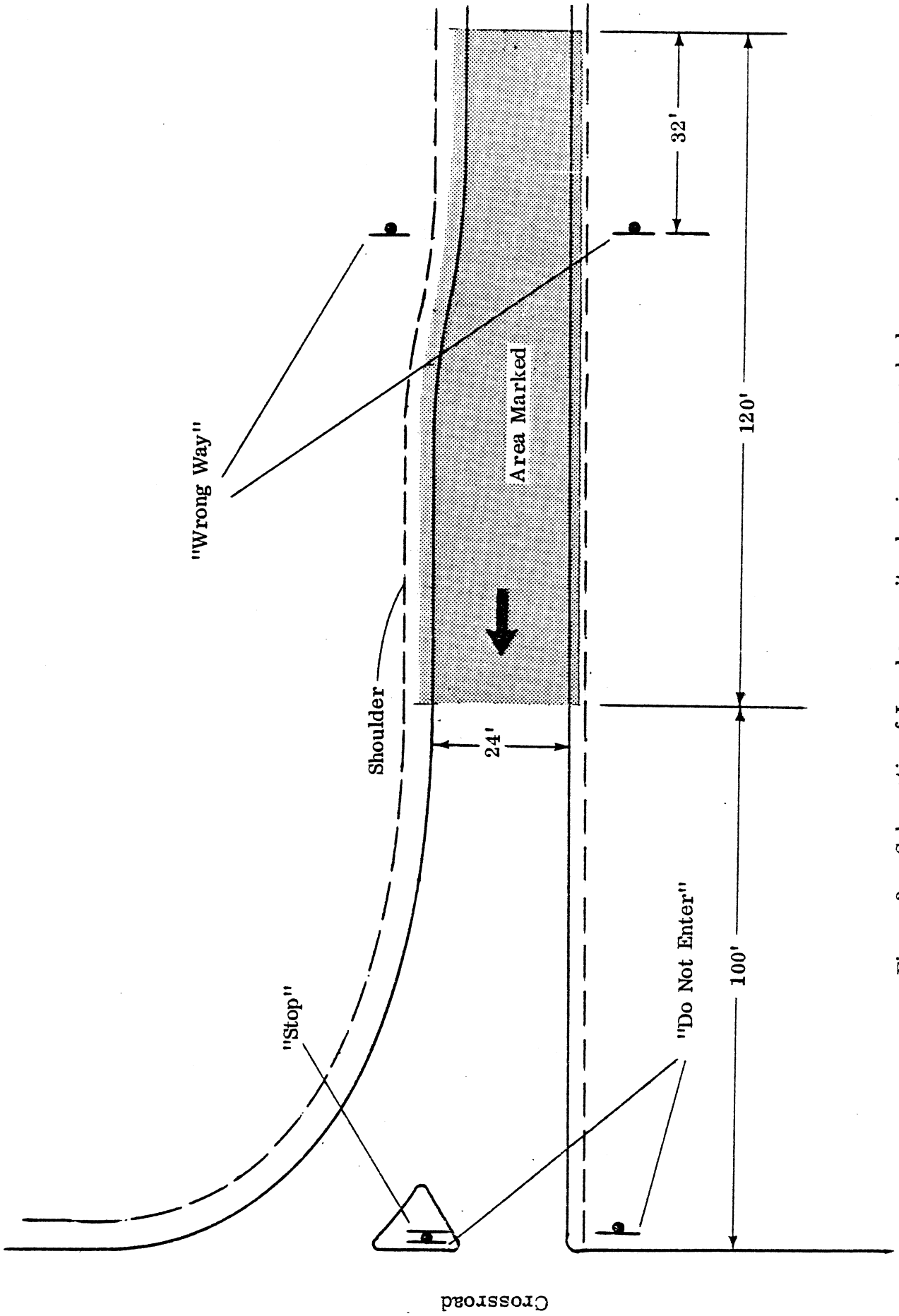


Figure 3. Schematic of Lynnhaven site showing area marked.
Note: 1 foot = 0.30 meter

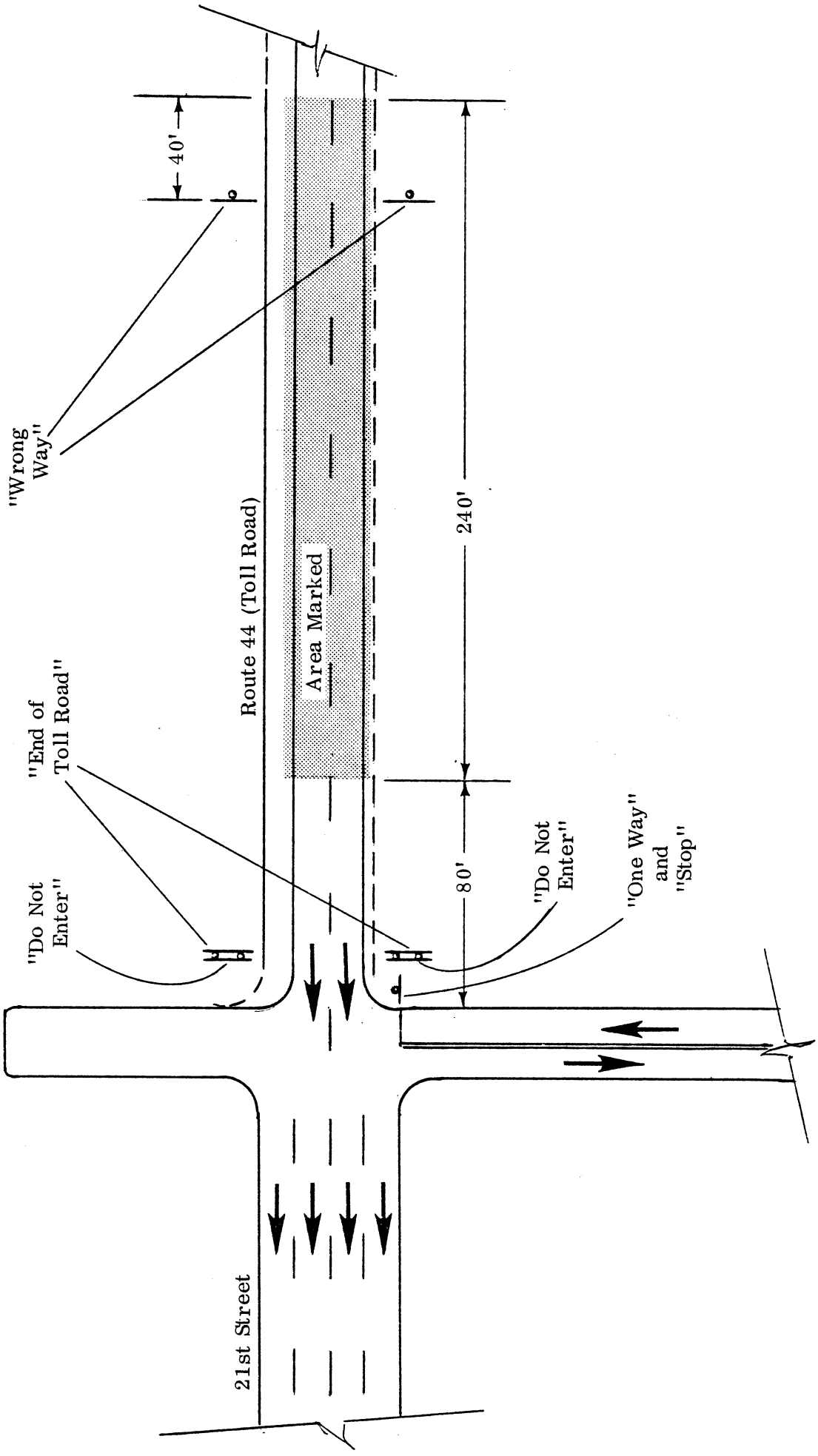


Figure 4. Schematic of 21st Street site showing area marked.
Note: 1 foot = 0.30 meter

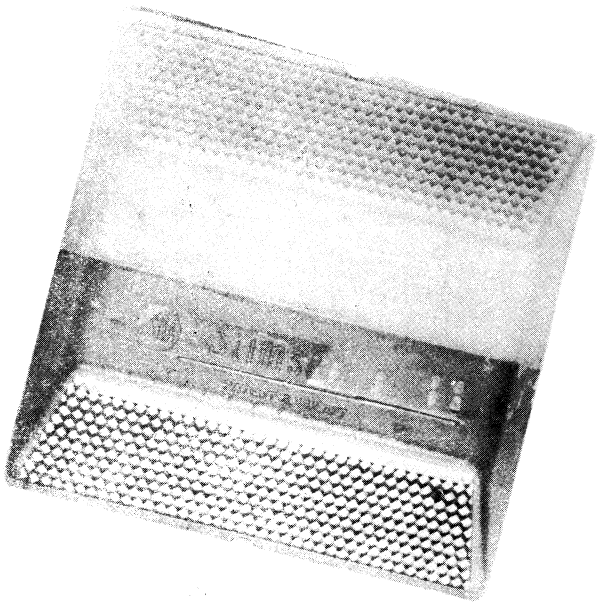


Figure 5. Mono-directional red marker.

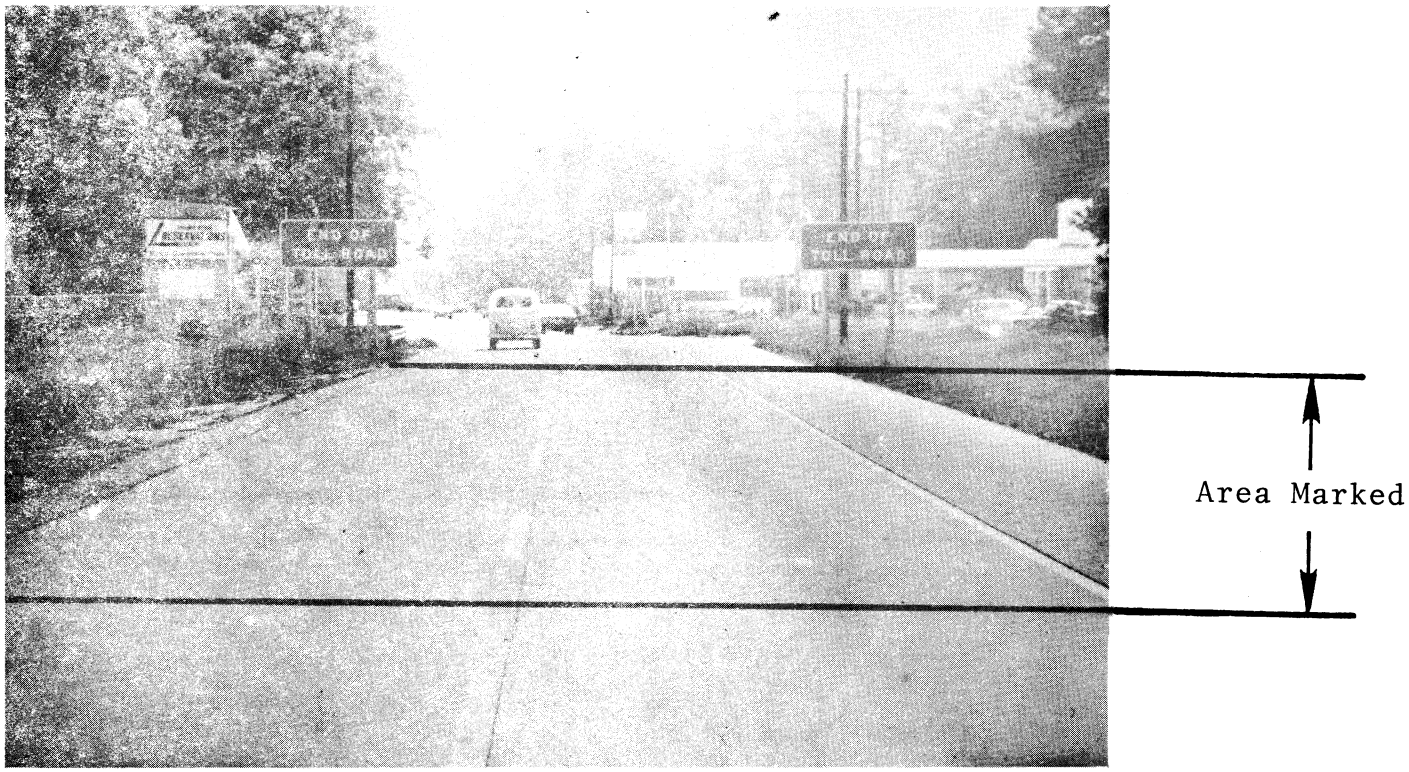


Figure 6. Markers as seen by drivers traveling in right direction.

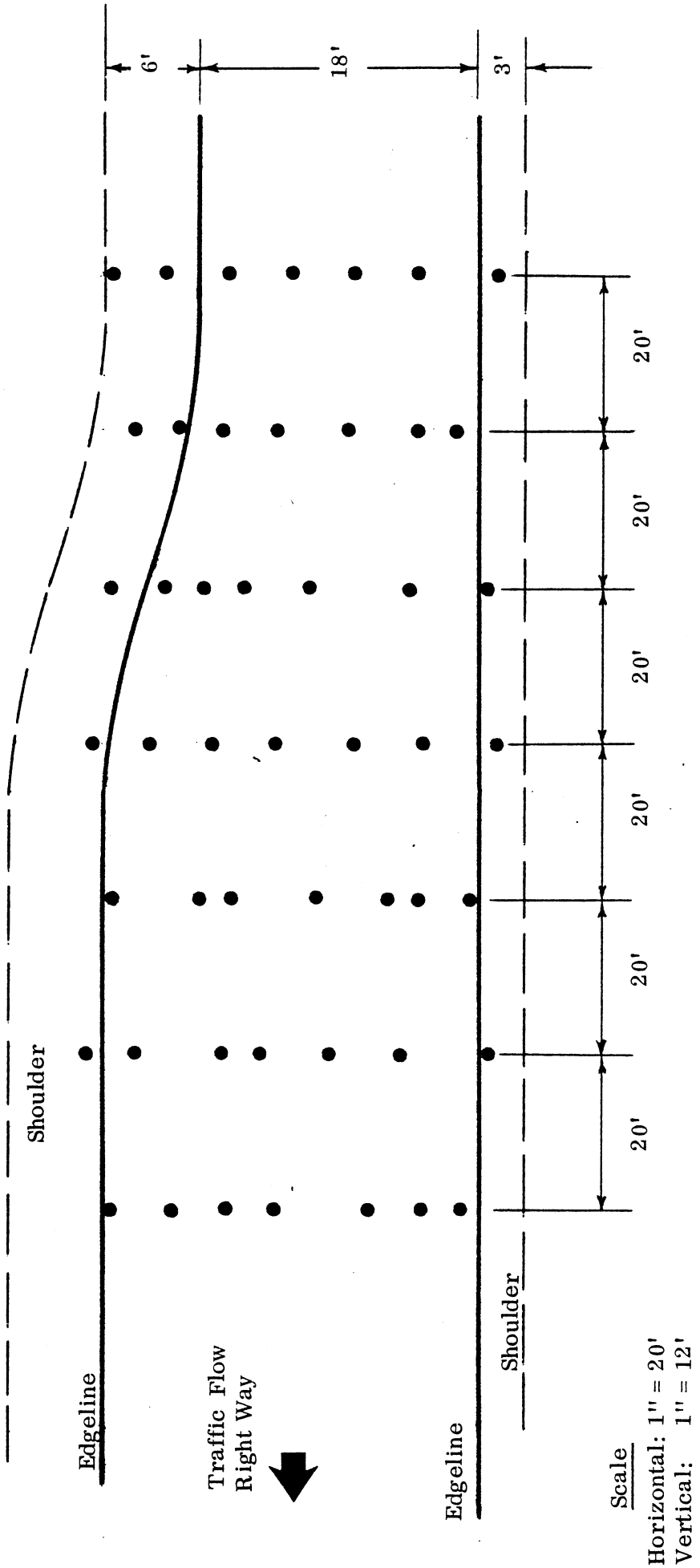
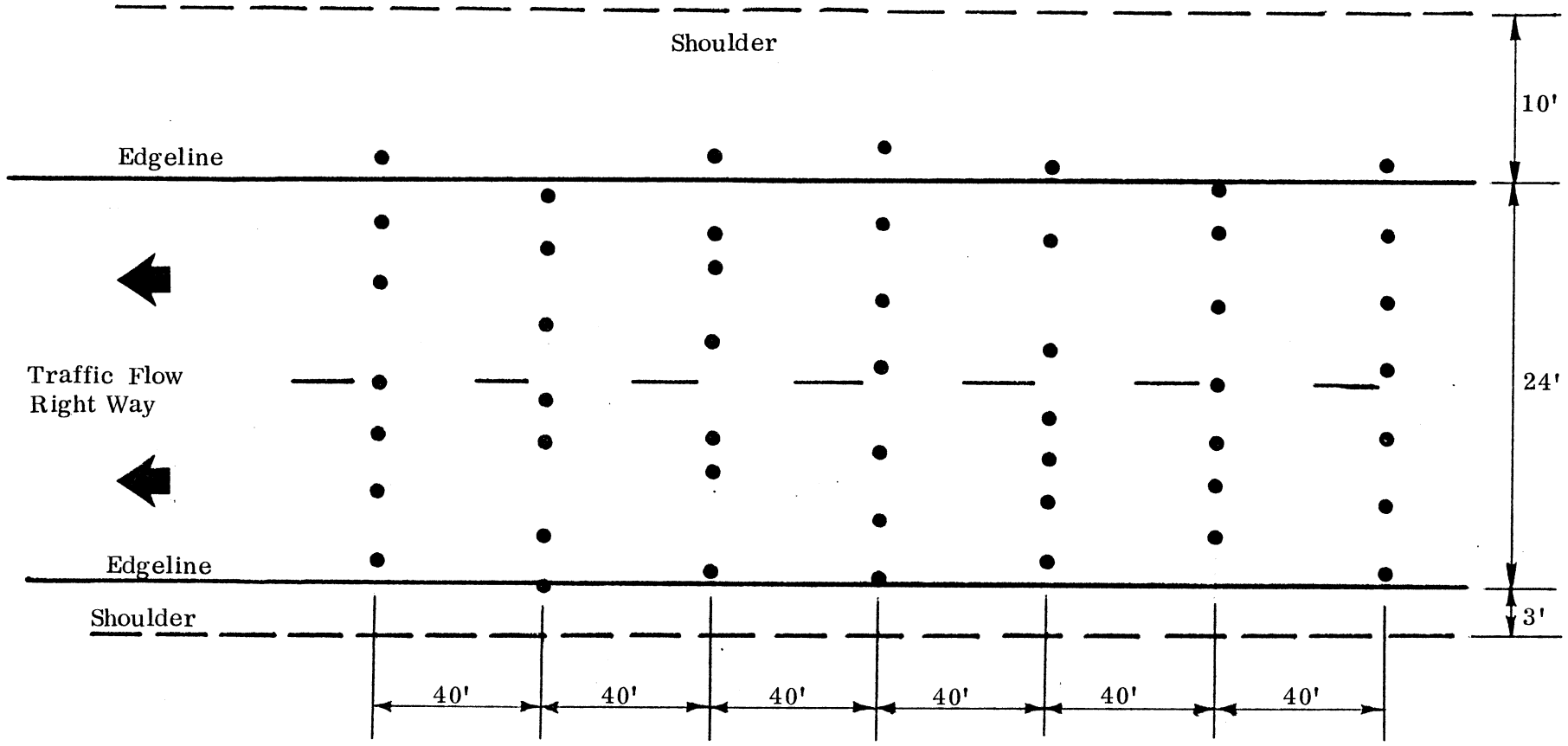


Figure 7. Marker configuration for the Lynnhaven site.
Note: 1 foot = 0.30 meter



Scale

Horizontal: 1" = 40'
Vertical: 1" = 12'

Figure 8. Marker configuration for the 21st Street site.
Note: 1 foot = 0.30 meter

Figure 9. Lynnhaven site from wrong-way approach.

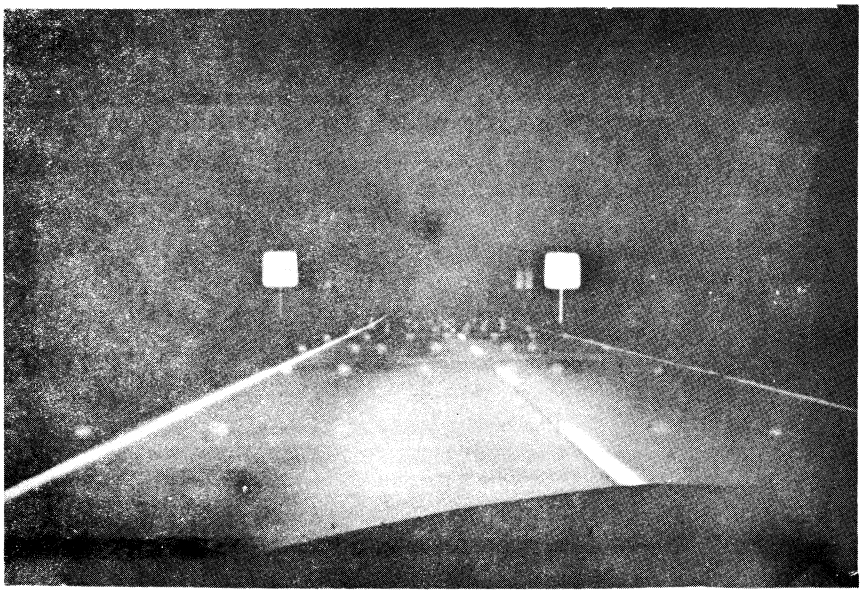


Figure 10. 21st Street site from wrong-way approach.

EVALUATION

The raised pavement marking systems were evaluated subjectively on the basis of their visibility and alerting characteristics and durability. Also, available wrong-way accident data were reviewed and consideration was given to any influence the marking systems might have had on the driver traveling in the proper direction. The visibility and durability were determined from periodic observations for one year after installation of the systems.

Throughout the evaluation, all existing pavement markings and signs were unaltered; the only difference was the addition of the raised markers.

Alerting Capabilities

Employees of the Research Council and the Virginia Department of Highways and Transportation served as test subjects by observing the installations from a vehicle in which the author was present. Also, opinions concerning the effectiveness of the installations in alerting wrong-way drivers were obtained from state and local police, rescue squad members, local traffic engineering personnel, etc. who had viewed a marking system upon request or on their own initiative. A total of 22 persons were either tested or questioned about the effectiveness of the installations.

All observations of the installations made by the test subjects and people interviewed were during darkness from a vehicle facing in the wrong direction. It should be noted that this procedure did not create a hazard as observations were made late at night when there was little traffic. Also, there was ample sight distance and shoulder-median space to allow time for the test vehicle to retreat when the light from an oncoming vehicle was sighted.

Visibility Characteristics

The visibility characteristics, or relative overall brightnesses of the installations, were rated by the author and a technician on a scale of 0 to 10, with 10 denoting the brightness or degree of retroreflection when the system is initially installed and 0 when the system has completely failed, ie., no light is reflected from the system. It is noted that the visibility rating is included as a means for judging the relative effectiveness of the system in serving its function of reflecting light. All ratings were made from a vehicle approaching the marking system from the wrong direction at night with headlights on both high beam and low beam.

Durability

The durability of the installations was determined by visually noting damage to the markers and the estimated percentage of the marker face obliterated. Also, observations were made of the resistance of the markers to snowplowing with rubber tipped blades over one winter.

Accident Analysis

Accidents resulting from incidences of wrong-way driving at the sites on which the marker installations were placed were tabluated for the period from January 1973 to May 1977.

Effect on Driver Traveling in Proper Direction

An indication of the influence of the marking system on the driver traveling in the right direction was evaluated by noting the percentage of vehicles showing brake lights in the area prior to and within the 21st Street installation. Data were collected during daylight for six hours before and six hours after the markers were installed.

Also, those persons who had been asked about the alerting capabilities of the markers were also questioned concerning any influence the markers had on the driver or vehicle traveling in the right direction.

RESULTS

Alerting Capabilities

Both the test subjects and the people interviewed were asked three basic questions concerning the system and its effectiveness, and the responses to each of the questions are commented upon below.

Question 1: Was the marking system effective in attracting attention, creating bewilderment?

All of the people responding to this question said they thought the marking system was effective in attracting attention and that it did create bewilderment. No one thought that the marking system would not have attracted their attention.

Question 2: Does the marking system help call attention to the "Wrong-Way" signs?

Ninety-one percent of the test subjects said the marking system was effective in directing attention to the wrong-way signs, while the remaining 9 percent were uncertain. Since the system would cause bewilderment as a result of viewing an unexpected and unusual phenomenon, the test subjects and those interviewed generally thought they would instinctively search for a reason for the unusual sight and thereby notice the wrong-way signs.

Question 3: Would the marking system be effective in causing a wrong-way driver to realize his mistake and react accordingly?

Ninety-one percent of those questioned thought the marking system would lead to corrective action by the driver, while the other 9 percent were uncertain.

Special note is made of a telephone call received by the district traffic engineer for the area where the installations were placed. The caller stated that they had entered the Lynnhaven ramp going the wrong way and immediately noticed the system of raised markers which alerted them to their mistake and led them to take corrective actions. The caller expressed the view that the system was very effective and wondered why it had not been placed at all ramps.

Visibility Characteristics

A rating of the relative visibility of each installation in terms of reflected light from a vehicle's headlights is shown in Table 1. After 48 weeks, both installations had a rating of 8, which is considered to be in the effective range. It is not known at what rating the system would be ineffective; however, it is surmised that a rating around 5 would be unsatisfactory.

Table 1.

Rating of System Effectiveness Related to Brightness

Site	Weeks After Installation					
	7	11	16	29	42	48
Lynnhaven Installation	10	10	10	9	8	8
21st Street, Virginia Beach Installation	10	10	10	9	8	8

Durability

The durability of the markers was evaluated by rating the surface abrasion, surface obliteration, and damage by chipping. Surface abrasion was taken as minute scratches and general wear over the surface, and those markers positioned in the tire tracking area exhibited the most wear of this type; however, in no case was the wear to the point where the markers were ineffective for their intended use.

During the summer it was noted that the reflecting faces of various markers were being obliterated or partially covered with a black, hard substance. This substance, shown on the face of the marker in Figure 11, is thought to be an accumulation of rubber from vehicle tires. Tables 2 and 3 give an estimation of the percentages of the marker faces still capable of reflecting light for the Lynnhaven and 21st Street installations, respectively.

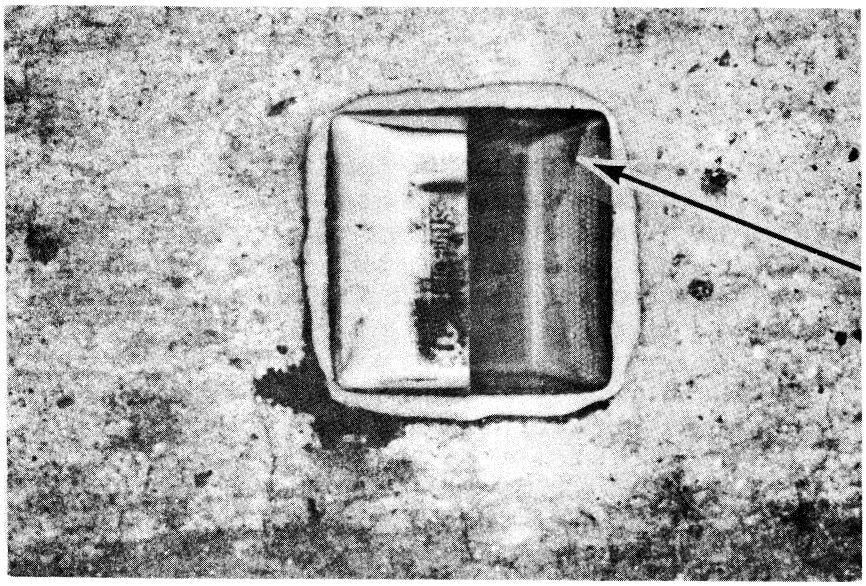


Figure 11. Marker face partially covered with black substance (arrow).

Table 2.

Percent of Marker Face Unobliterated—21st Street Site

Marker No.	Date 7/14/76	8/11/76	9/16/76	12/16/76	3/17/77	4/28/77
1	100	99	97	100	100	100
2	98	98	98	45	75	75
3	95	95	95	90	95	95
4	98	99	98	94	100	100
5	98	100	99	98	100	100
6	99	98	98	96	X**	X
7	99	100	99	99	100	97
8	98	98	96	97	100	100
9	96	96	97	88	100	100
10	100	99	98	98	100	100
11	99	98	85	99	100	100
12	99	98	98	95	100	100
13	99	98	100	97	100	100
14	98	99	99	100	100	100
15	100	95	96	99	X	X
16	95	80	90	89	100	94
17	98	97	96	93	100	98
18	99	100	97	98	100	100
19	96	99	99	96	100	100
20	97	98	99	99	X	X
21	100	100	99	100	100	98
22	99	100	96	100	X	X
23	97	98	94	90	99	99
24	99	99	97	98	100	98
25	99	98	98	96	100	98
26	98	97	99	97	100	100
27	99	97	99	96	X	X
28	100	100	100	100	X	X
29	97	99	98	99	X	X
30	98	97	97	97	100	100
31	100	99	98	95	100	100
32	98	99	99	97	100	100
33	100	98	98	96	40*	40*
34	100	99	98	96	100	100
35	100	100	98	98	100	100
36	100	100	98	97	40*	40*
37	100	99	100	91	100	95
38	100	98	98	98	100	100
39	98	97	98	99	100	100
40	100	96	97	98	100	100
41	99	98	90	98	X	X
42	99	98	99	97	100	100
43	100	100	100	100	X	X
44	99	100	94	97	100	100
45	99	99	95	98	100	100
46	97	99	96	99	100	100
47	99	99	98	98	100	100
48	99	96	96	98	X	X
49	99	98	98	100	100	100
Avg.	98.6	98.0	97.1	95.8	99.2	98.6

* Marker face chipped
** Marker missing

Table 3.

Percent of Marker Face Unobliterated—Lynnhaven Site

Marker No.	Date 7/14/76	8/11/76	9/16/76	12/16/76	3/17/77	4/28/77
1	98	92	97	98	80*	80*
2	95	93	90	86	83*	83*
3	98	99	92	99	80	80
4	55	60	55	70	55	55
5	60	60	65	65	75	50
6	95	96	90	65	55	65
7	99	99	99	99	100	100
8	100	100	99	98	100	100
9	97	98	96	98	96	96
10	90	91	82	99	90	85
11	85	84	80	85	92	78
12	95	80	80	80	70	70
13	85	76	70	80	86	86
14	100	100	100	99	100	100
15	100	99	96	99	100	100
16	97	97	98	99	96	80
17	98	99	96	99	80	80
18	90	77	80	90	80	85
19	93	96	98	99	100	100
20	93	95	97	90	X**	X
21	100	99	100	98	100	100
22	98	98	99	100	100	100
23	99	98	98	100	100	100
24	98	96	95	98	95	95
25	80	63	65	85	90	85
26	90	45	52	40	60	35
27	90	90	81	90	0*	0*
28	100	100	100	100	100	100
29	99	100	99	99	100	100
30	99	98	100	99	99	99
31	97	99	98	99	91	91
32	97	99	96	90	X	X
33	96	50	45	70	55	60
34	70	60	67	75	62	80
35	100	100	100	100	100	100
36	100	98	100	100	100	100
37	99	95	99	99	100	98
38	95	98	99	99	93	93
39	98	88	87	87	93	60
40	92	90	91	97	55	55
41	90	85	90	90	96	96
42	98	99	95	99	100	100
43	99	99	99	99	100	100
44	98	99	100	98	99	99
45	94	96	98	98	96	96
46	85	60	55	75	56	65
47	98	99	97	92	98	98
48	70	65	77	88	96	96
49	100	100	100	100	100	100
Avg.	92.9	88.9	88.2	91.0	88.4	86.6

* Marker face chipped
** Marker missing

Referring to Table 3, it is noted that the installation at the 21st Street site shows a higher percentage of unobliterated reflector faces than the Lynnhaven site for comparable observation periods. After one year the 21st Street system has an average of 98.6% of the faces of the reflectors available for reflecting light, whereas the Lynnhaven system has an average of 86.6%. This difference is attributed to the fact that the Lynnhaven site is on an off-ramp where vehicles had to stop, whereas vehicles had only to slow from 55 mph to 35 mph at the 21st Street site. The stopping action at the Lynnhaven site causes more tire friction and more accumulation of tire rubber on the markers. The markers showing the greatest amount of rubber were in the tire track area of the pavement. It is noted that the accumulation of rubber tended to increase with time; however, during the winter months, it decreased.

Damage by chipping or breaking was witnessed only after snowplowing. During the 1976-77 winter, the area encompassing the installations had two snow storms which led to six snowplow passes with a rubber tipped blade at the Lynnhaven site and eight passes at the 21st Street location. During the time of the two storms, the night temperatures were around 10°F (-12°C) and the day temperatures were in the low 20's°F (-6°C) when the installations were plowed. It is noted that there was more snowplowing in the region during the 1976-77 winter than there had been in several years. Referring to Tables 2 and 3, it is noted that 10 markers were completely lost and 2 chipped at the 21st Street installation while at the Lynnhaven location 2 markers were lost and 3 were damaged by chipping. As a result of the markers being positioned in a random orientation, the absence of the missing markers was not readily apparent.

Accident Analysis

Table 4 gives a tabulation of all wrong-way accidents involving drivers entering the wrong way at the site locations where the marking systems were installed. The infrequency of wrong-way accidents, especially within a certain location, along with the short period of time elapsed since the markers were installed (May 26, 1976), prohibits any statistical analysis of accidents; therefore, only a general discussion of available data is presented.

Table 4.

Wrong-Way Driving Accidents
January 1973-May 1977

Date	Time	Weather	Driver Condition
Wednesday, July 4, 1973	1:55 AM	Clear	Drunk
Tuesday, November 27, 1973	8:50 PM	Clear	Drinking
Saturday, January 26, 1974	1:00 AM	Cloudy	Drunk
Friday, May 3, 1974	12:25 AM	Cloudy	Normal
Thursday, July 3, 1975	2:07 AM	Clear	Drunk
Monday, August 11, 1975	12:10 AM	Cloudy	Drunk
Saturday, October 18, 1975	5:30 AM	Rain	Drinking

The frequency of accidents from January 1973 until the marking systems were installed was approximately one every six months; since the marking systems were installed, no wrong-way accidents have been reported. It is noted that because changes in signing had been made at the 21st Street location after the last wrong-way accident, yet before the marking systems were installed, it cannot be said that the marking system was entirely responsible for preventing wrong-way entries.

It is noted that all the accidents occurred during hours of darkness, the only time at which the marking system is effective.

Effect on Driver Traveling in Proper Direction

Based on a count of brake light indications for six hours before the markers were installed and six hours after installation, the percentages of drivers braking in the area just prior to the markers were 12.3% before and 13.3% after installation. Within the marking system 19.1% of the drivers were observed to brake their vehicles before the markers were installed and 20.7% were noted to do so after installation. The observations were made at the 21st Street site.

Those persons interviewed concerning the effectiveness of the installation were also questioned about the influence of the markers on right-way driving. All indicated that the markers had little influence on their driving, with the exception of a slight rumble effect which caused slowing in some cases. It is thought that any rumble effect from the marker is advantageous since the markers are placed in a location where vehicles should be slowing for a reduced speed limit or for stopping.

Maintenance

Since the initial installation, no maintenance has been required. Also, because of the random configurations it has not been necessary to replace the markers lost due to snowplowing. It is possible that the markers could accumulate enough of the black substance previously noted for them to become ineffective; however, this has not happened to date. Should this substance become a problem, methods of cleaning the markers could be investigated.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the evaluation of the marking systems described in this report, it is felt that this unique method of placing raised pavement markers for discouraging wrong-way driving is effective in alerting drivers as a result of their viewing an unexpected phenomenon.

It is realized that a degree of bias can be expected when testing subjects in the manner described in this report. The effect of the marking system on intoxicated or drowsy drivers cannot be surmised from the results of this evaluation, nor can the reactions of passengers to the markings be inferred. However, if only a small number of the subjects, all of whom thought the system to be effective, would actually have been prevented from going the wrong way, the system should be seriously considered because of its simplicity and low cost.

It is recommended that the system of raised pavement markers placed in configurations as noted in this report be seriously considered for placement in ramp

areas or similar locations where wrong-way entries have been a problem.

Since the markers used in the systems are not snowplowable with steel blades and can withstand only a limited exposure to rubber-tipped snowplow blades, it is recommended that further research into the adaptation of this system to areas where snowplowing is prevalent be undertaken. Also, observation of the sites noted in this report should continue for the purpose of determining the overall durability of the raised markers and the point at which the system becomes ineffective because of a loss in retroreflectivity.

References

1. Shepard, F. D., "Evaluation of Raised Pavement Markers for Reducing Incidences of Wrong-Way Driving", Virginia Highway and Transportation Research Council, June 1975.

2. Pigman, J. G., and Agent, K. R., "Raised Pavement Markers As a Traffic Control Measure at Lane Drops", Kentucky Bureau of Highways, February 1974.