A Positive Guidance Evaluation of a Diagrammatic Signing System

Report TSD-473-81

TRAFFIC and SAFETY DIVISION

MICHIGAN DEPARTMENT OF TRANSPORTATION

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By

William H. Opland, P.E.
Safety Programs Unit

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Abstract

This report is an evaluation of a freeway diagrammatic signing system installed as part of a Positive Guidance demonstration project. The location of the project was the eastbound I-96 approach to the I-96/US-131 freeway split in the city of Walker, Michigan.

A before-and-after study showed statistically significant reductions of two of the measures of effectiveness used; erratic maneuvers and brake applications. The reductions were greatest during the Sunday evening study period and least during the Monday morning study period. Presumably, Sunday drivers were making primarily social and recreational trips and passed through the freeway split infrequently. Monday morning drivers were presumed to be making primarily job-related trips and passed through the freeway split more frequently. Thus, the signing project appeared to be of greater assistance to those passing the site infrequently.

Lane changes and lane volumes were also investigated, but few patterns were apparent. Left-lane traffic heading towards the left-side split increased but the last second lane change from the far left lane to the right-side split also increased in the after period.

The timing of this report did not permit a statistically valid before-and-after accident study, however, 32 accidents occurred in the four years prior to project implementation (1974-1977). The measures of effectiveness studied cannot be directly correlated to accidents, thus it is not possible to directly quantify the benefits of this project. Erratic maneuvers and brakelight applications often indicate confusing conditions which may lead to accidents. However, without those accidents actually being counted, the actual benefits attributable to a decrease in these measures of effectiveness remain qualitative in nature.

Introduction

The Positive Guidance methodology is designed to provide high-payoff, short-range solutions to safety and operational problems. It is based on the premise that drivers are most likely to perform properly when they are given sufficient information in a usable form.

Highway engineering and human factors technologies are combined to produce an information system best suited to driver capabilities. The resulting procedure consists of six major functions:

- A Collection of Data
- B Specification of Problems
- C Definition of Driver Performance Factors
- D Definition of Information Requirements
- E Determination of Positive Guidance Information (includes plan implementation)
- F Evaluation

A more detailed description of these functions may be found in "A User's Guide to Positive Guidance" published by the FHWA in June, 1977.

In October, 1977, Mr. Gerson Alexander of the Federal Highway Administration's (FHWA) Office of Traffic Operations invited the Michigan Department of Transportation to participate in a Positive Guidance demonstration project. The FHWA wanted to apply their newly developed Positive Guidance procedures at hazardous and/or confusing highway locations. $75,000 in demonstration funds were offered to help finance the project. Michigan thus became one of three states to initially participate in a federally-funded Positive Guidance demonstration project.

Once the department agreed to conduct the Positive Guidance project, potential study locations were requested from its district traffic and safety engineers. After reviewing suggested locations, the eastbound I-96 freeway split at M-37 and US-131 in the city of Walker in Kent County was selected as the study site.

A Positive Guidance plan was then developed for the project. The plan outlined the experimental design and the measures of effectiveness (MOE's) to be used. It also included the data collection plan, statistical analysis techniques, and implementation costs. The plan was subsequently approved by the FHWA, and a contract to carry out the Positive Guidance project was signed on May 17, 1978.

Positive Guidance Functions A (Collect Data) through E-2 (Design Positive Guidance Plan) were carried out in the summer and fall of 1978 (see appendix for the list of Positive Guidance functions). The interim report containing this information was submitted to the FHWA in December, 1978.

After approval of the interim report, a signing contract was awarded in September, 1979, to carry out the Positive Guidance plan. The contract was completed in July, 1980, and "after" data was collected in August, 1980.

This report evaluates the revised signing system that was developed and installed. This evaluation is the last step (Function F) in the Positive Guidance process.

Site Description

The Positive Guidance study zone was located along eastbound I-96 in the city of Walker, located northwest of Grand Rapids (Figure 1). The eastbound portion of the freeway is a 2-lane roadway that becomes a 3-lane roadway with the addition of an entrance ramp from M-37. The 3-lane section splits into two 2-lane roadways about 1,000 feet downstream of the entrance ramp from M-37 (Figure 2).

The total length of the study zone from the Walker Road overpass on the west to the bifurcation point where the freeway splits on the east is 2.0 miles. The major area of conflict occurs in the 3-lane weave zone between the M-37 entrance ramp and the freeway split. In this area, ramp vehicles have a difficult time merging into the middle lane. To add to the difficulty of the short weave zone, motorists must decide which path to select at the freeway split. In short, the geometrics of the interchange make it difficult for motorists to maneuver effectively within the weave zone.

Positive Guidance Plan

The Positive Guidance plan developed for the freeway split involved the use of a diagrammatic signing system. Figures 3a through 3e show the newly installed diagrammatic signing system as well as the former signing system. The drawings on the right side of the page show the new signs while the drawings on the left side show the former signs.

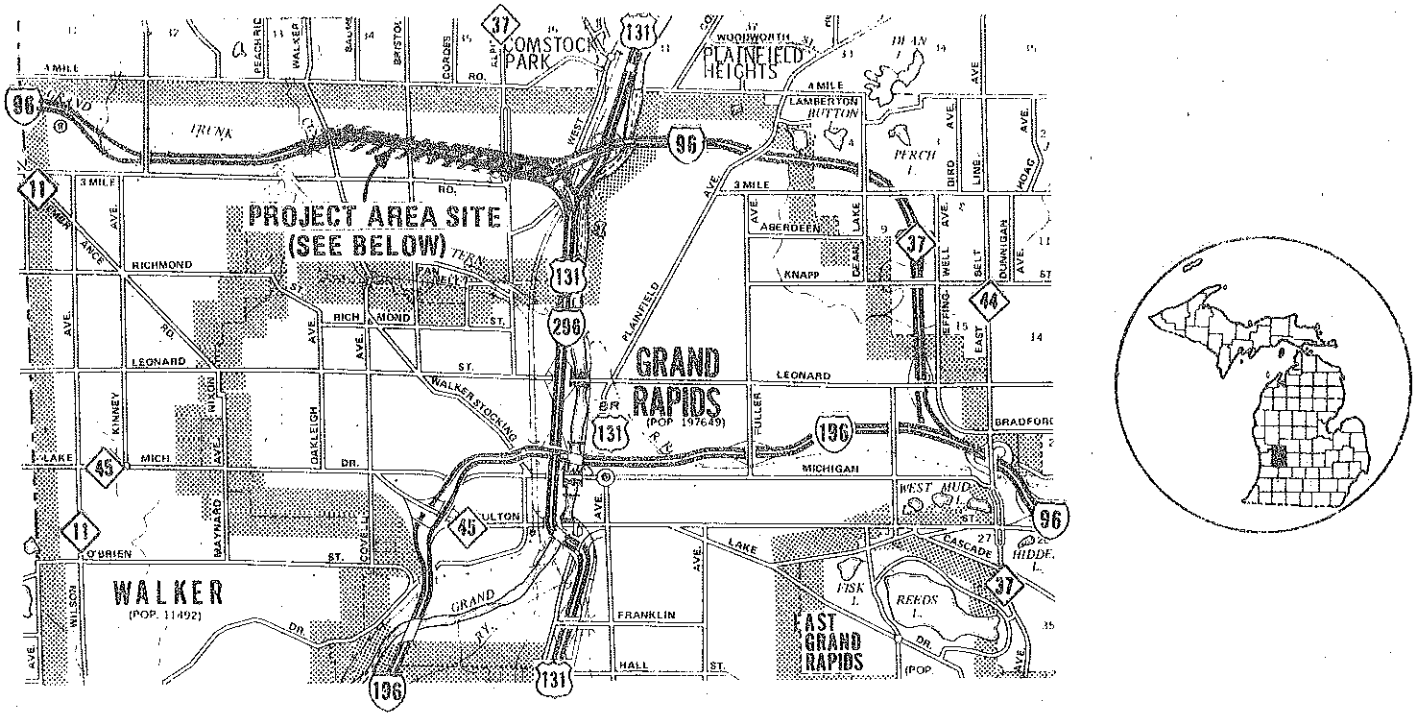
The first revised signs confronted by eastbound I-96 motorists are the two overhead signs mounted on the Walker Avenue overpass (Figure 3a). These signs provide advance notification of the upcoming M-37 NORTH and US-131 SOUTH exits. The left-hand sign is new and it gives the same basic information as the old sign. The I-296 shield was eliminated, the word JCT was added, and Grand Rapids was abbreviated to Gd. Rapids. The size of the sign was reduced in response to these changes. The right-hand sign was not changed.

The new Grand Rapids Exit sign is next in sequence and located at Station 265 (Figure 3b). This sign replaces one formerly located at Station 275 and provides advance notification of the upcoming two exits, as well as the Plainfield Avenue exit four miles to the east. The former sign may have led some motorists to believe that only two Grand Rapids exits existed. The new sign points out that it is not necessary to exit immediately in order to go to Grand Rapids.

The M-37 SOUTH/FOLLOW I-96 sign at Station 273 allowed removal of the M-37 shield from the overhead diagrammatic signs. However, the M-37 shield at the freeway split was included to provide confirmation for on-ramp traffic destined onto M-37. M-37 duals with I-96 from Alpine Avenue easterly to East Belt Line Avenue on the east side of Grand Rapids (Figure 1).

The first overhead diagrammatic sign is located one mile in advance of the freeway split at Station 282 (Figure 3b). This sign details the layout of the

EASTBOUND I-96 AT THE M-37, US-131 INTERCHANGE
KENT COUNTY
CITY OF WALKER



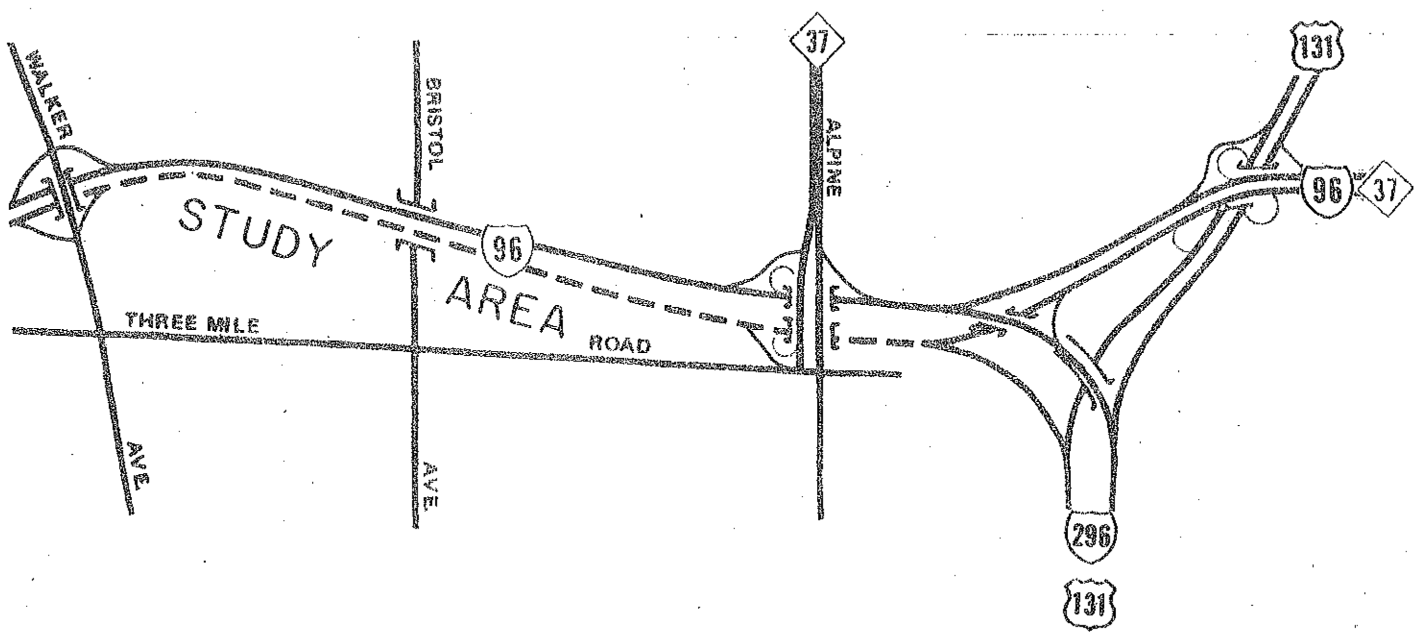


FIGURE 1
POSITIVE GUIDANCE STUDY
SITE

EASTBOUND I-96 AT THE M-37, US-131 INTERCHANGE

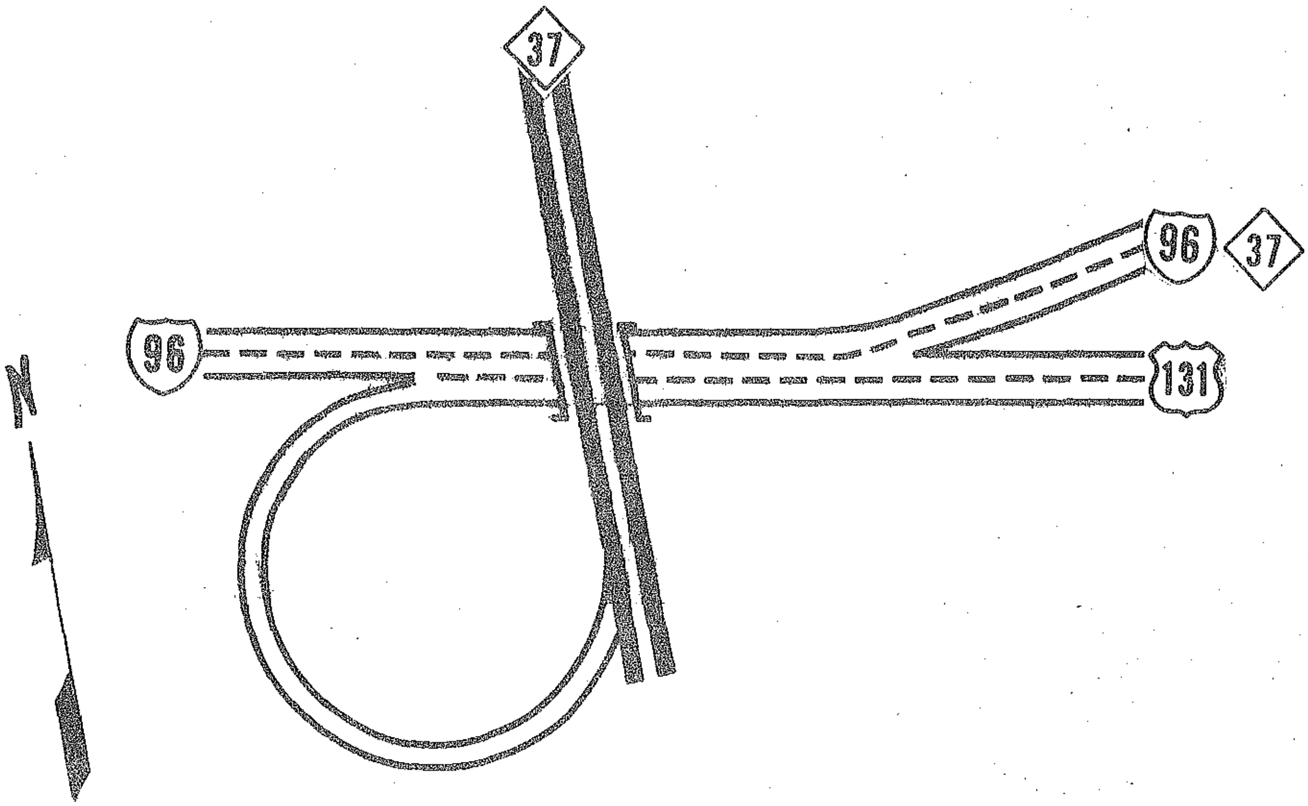


FIGURE 2
POSITIVE GUIDANCE STUDY
ZONE

interchange that lies ahead and allows time to maneuver as traffic approaches the interchange. The sign is located at the end of a 3,000-foot tangent and is readily visible. The little "tail" near the bottom of the sign communicates the upcoming entrance ramp and weave zone.

The FOOD-LODGING sign at Station 282 was removed.

Several changes incidental to the project focus were also initiated as follows:

The former advance notification sign for M-37/Alpine Avenue at Station 289 was removed (Figure 3c).

The previous "Sparta" sign at Station 1471 was replaced with a new sign (Figure 3c).

A new FOOD-LODGING sign was installed at Station 1479 (Figure 3c).

The former overhead signs at Station 1487 were replaced with the cantilever sign at Station 1488+50 (Figure 3d). The diagrammatic signing system eliminated the need for the ½ mile advance notification to Grand Rapids - Kalamazoo.

The entrance ramp to eastbound I-96 from M-37 is located at the end of a long downhill horizontal curve. A flashing beacon and floodlight were installed on the Merge sign at Station 1499 to help motorists detect the sign, particularly at night.

The former lane assignment signs on the Alpine Avenue overpass were replaced by a second diagrammatic sign (Figures 3d and 3e). Elimination of both the I-296 and M-37 shields from the sign gives the motorist less information to assimilate. The former lane assignment signs gave the motorist five route shields while the new sign uses only three.

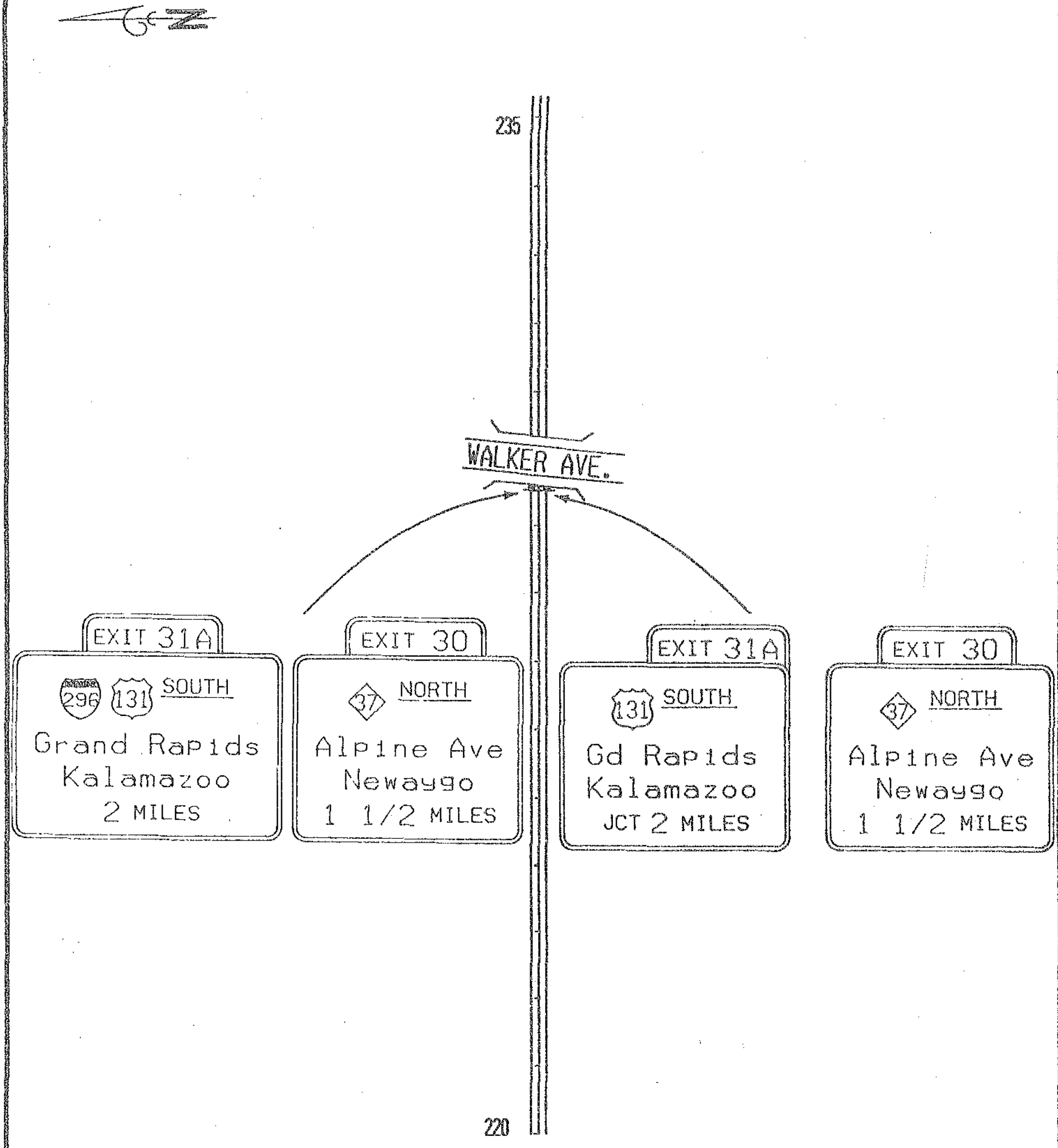
The last signs in the diagrammatic sequence occur at the freeway split at Station 1510 (Figure 3e). The new signs are basically the same as those which were replaced; up arrows on the Grand Rapids-Kalamazoo sign were changed to down arrows and the I-296 shield was eliminated. On the left sign, the positions of US-131 NORTH and M-37 were reversed. The curved-up arrows were retained since they help to reinforce the idea conveyed by the diagrammatic signs. A new and longer sign truss allowed removal of the former protective guardrail.

In the before period, there was no lane line present to distinguish the right lane from the middle lane between Stations 1504 and 1510. Only the joint line served to differentiate the two lanes, and it curved to the left at the gore area. The addition of a new lane line was intended to counter the effect of the joint line. In addition, the pavement markings through the gore area now conform with the standards for the existing geometrics.

Elimination of I-296 Route Markers

Review of the route marking system, as part of this Positive Guidance project, indicated that the I-296 markers were confusing and unnecessary. The red, white, and blue interstate shields for I-96 and I-296 were easily confused. In addition, the previous signing system included shields for US-131 NORTH, US-131 SOUTH, and M-37 (Figure 3d). The five route markers may have resulted in an information "overload"; elimination of the I-296 and M-37 markers resulted in a simpler signing system.

I-296 formerly dualed with US-131 for a 3-mile segment between I-96 and I-196 (Figure 1). Since US-131 is the major north/south freeway in the area, the I-296 designation served no useful purpose other than to designate an interstate routing. With concurrence from the FHWA and AASHTO (American Association of State Highway and Transportation Officials), the I-296 designation was eliminated from all road signs, as well as from the official transportation map. However, the 3-mile segment of US-131 remains as part of the official interstate system even though it is not so designated on the signs.



BEFORE

AFTER

FIGURE 3a	POSITIVE GUIDANCE
PAGE 7	DIAGRAMMATIC SIGNING SYSTEM

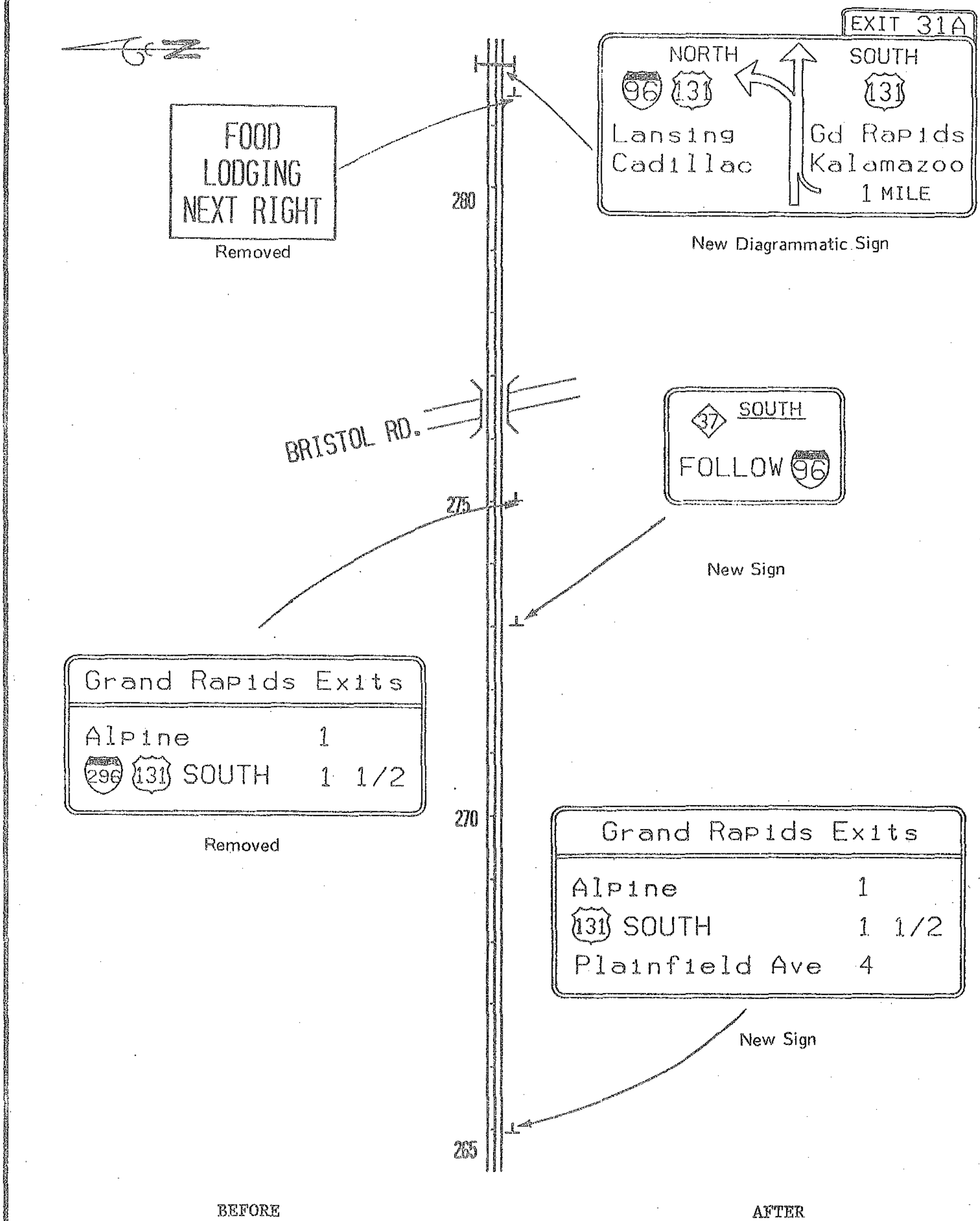


FIGURE 3b	POSITIVE GUIDANCE DIAGRAMMATIC SIGNING SYSTEM
PAGE 8	

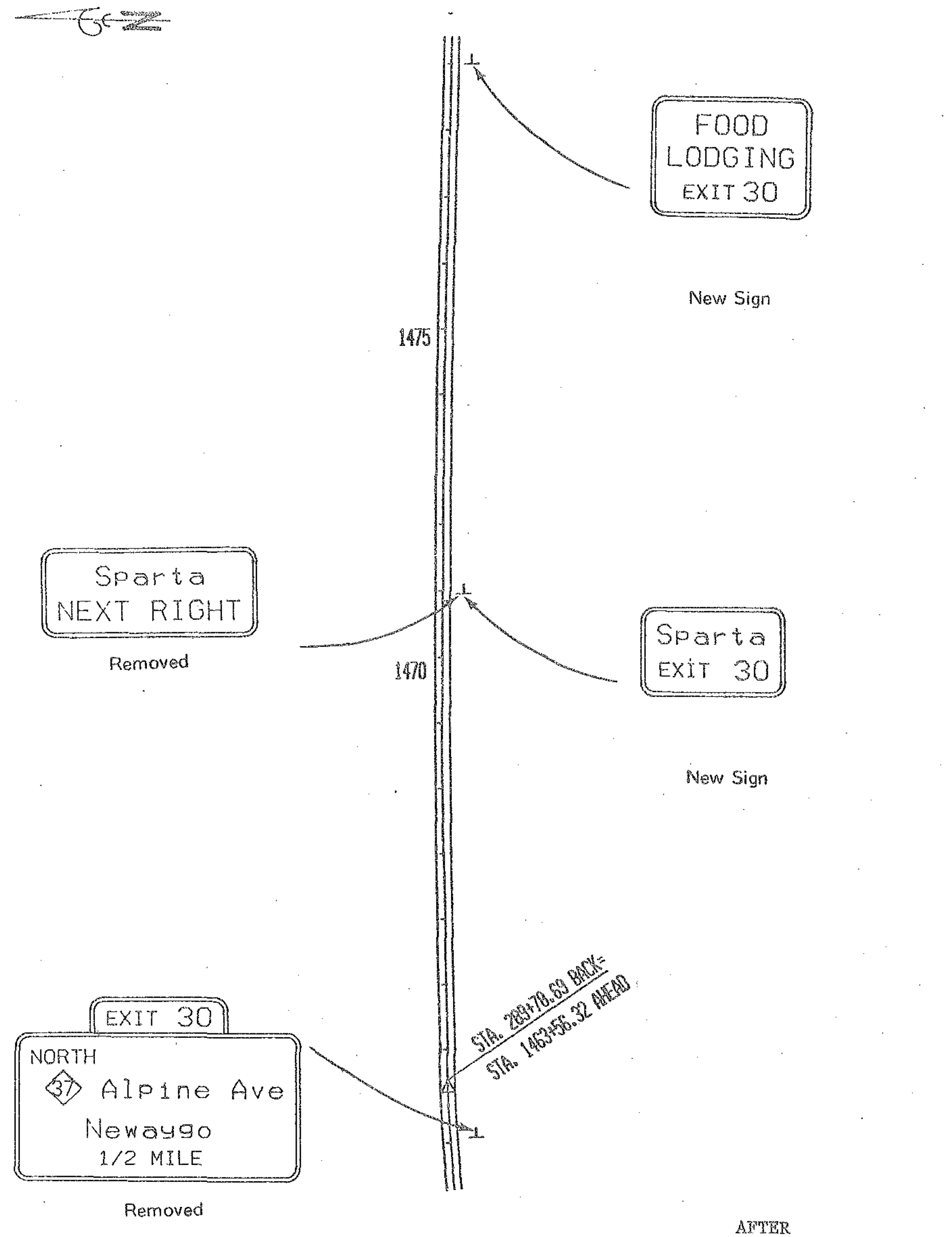


FIGURE 3c	POSITIVE GUIDANCE
PAGE 9	DIAGRAMMATIC SIGNING SYSTEM

41026S 12058014 M

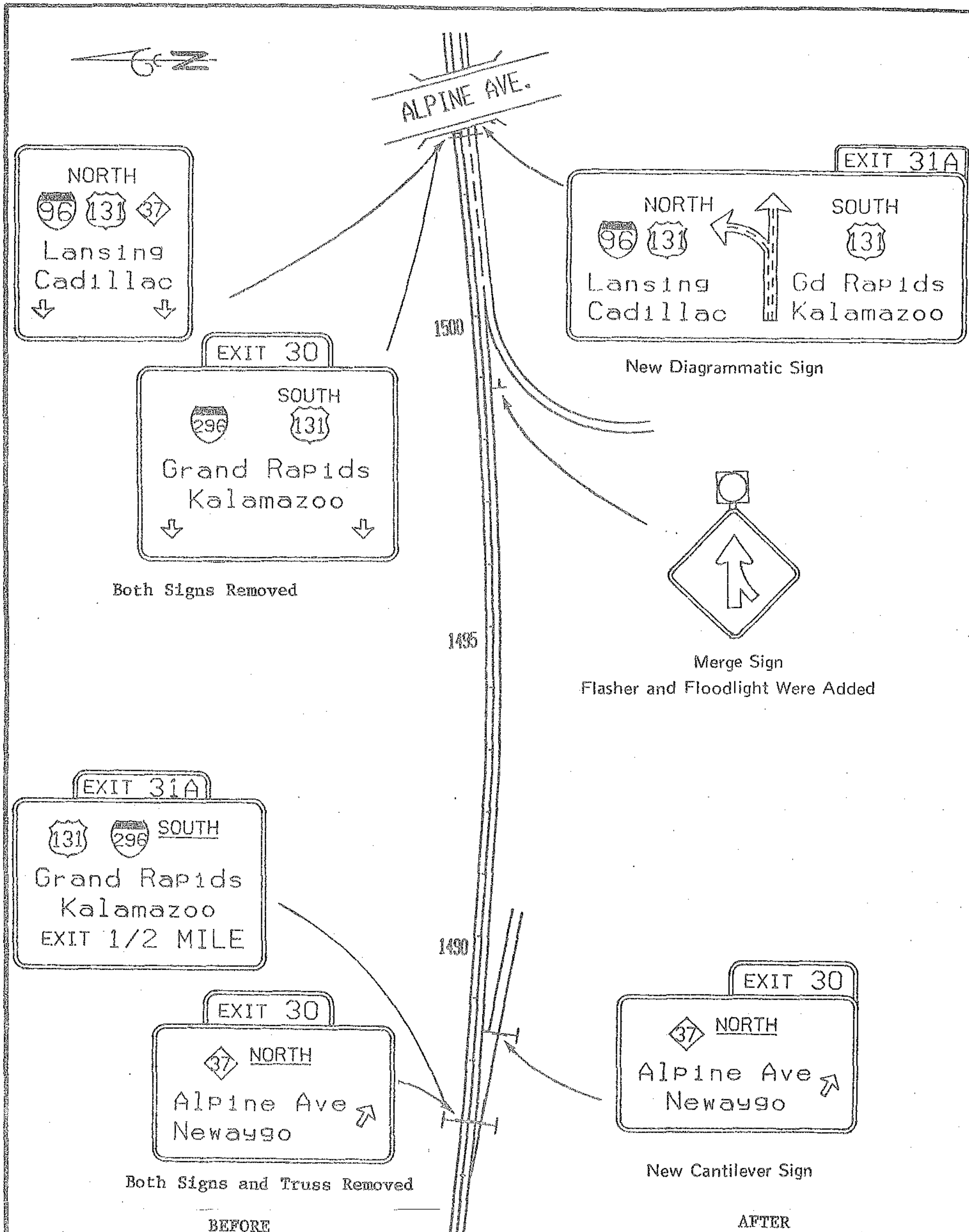


FIGURE 3d	POSITIVE GUIDANCE DIAGRAMMATIC SIGNING SYSTEM
PAGE 10	

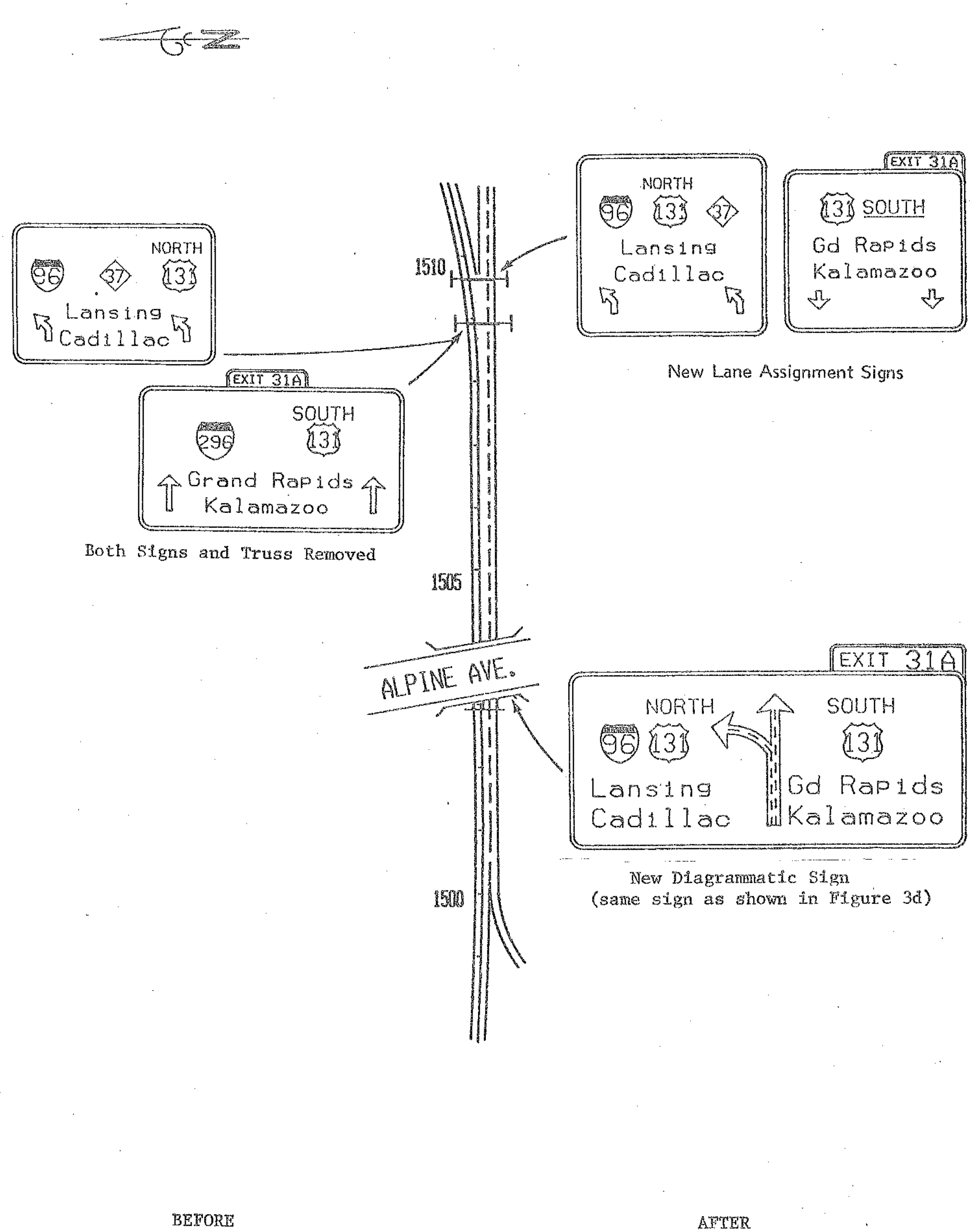


FIGURE 3e	POSITIVE GUIDANCE
PAGE 11	DIAGRAMMATIC SIGNING SYSTEM

Data Collection Plan

Before and after data were collected during the following periods:

- Sunday evening (4:30 p.m. to 6:30 p.m.)
- Weekday morning peak (7 a.m. to 9 a.m.)
- Weekday off-peak (11:30 a.m. to 1:30 p.m.)

The Sunday evening time period was chosen to reflect primarily social or recreational driving. The weekday morning period was chosen to reflect primarily commuting and work-related driving, and the weekday off-peak period was chosen to reflect a mix of all varieties of driving.

Measures of Effectiveness

The measures of effectiveness (MOE's) used to evaluate the project were:

- Erratic maneuvers
- Brake applications
- Lane changes
- Lane usage (volumes)

All data was collected with two video recorders. The video equipment was set up on the M-37 overpass so that both upstream and downstream operations could be viewed and recorded (Figures 5 and 6).

Erratic Maneuvers - Figure 4 shows the number of erratic maneuvers which occurred at the downstream location in the before and after periods.

Figure 4. Before and After Erratic Maneuvers

	Volumes		Erratic Maneuvers		
	Before	After	Before	After	Percent Change
Sunday Evening (2 hrs)	3057	3794	15	9*	- 40.0
Monday Morning (2 hrs)	3240	3159	7	6	- 14.3
Monday Mid-Day (2 hrs)	2590	2620	13	9	- 30.7
Total (6 hrs)	8887	9573	35	24*	- 31.4

*The reduction is significant at the 90 percent confidence level (chi-square).

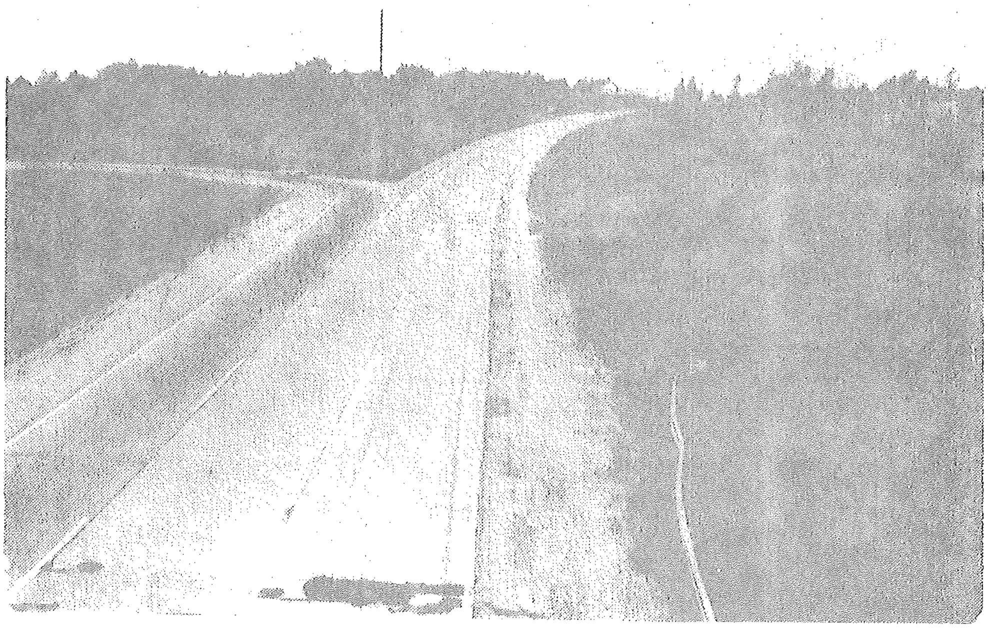


Figure 5. Looking westerly (from the M-37 overpass) at upstream location.

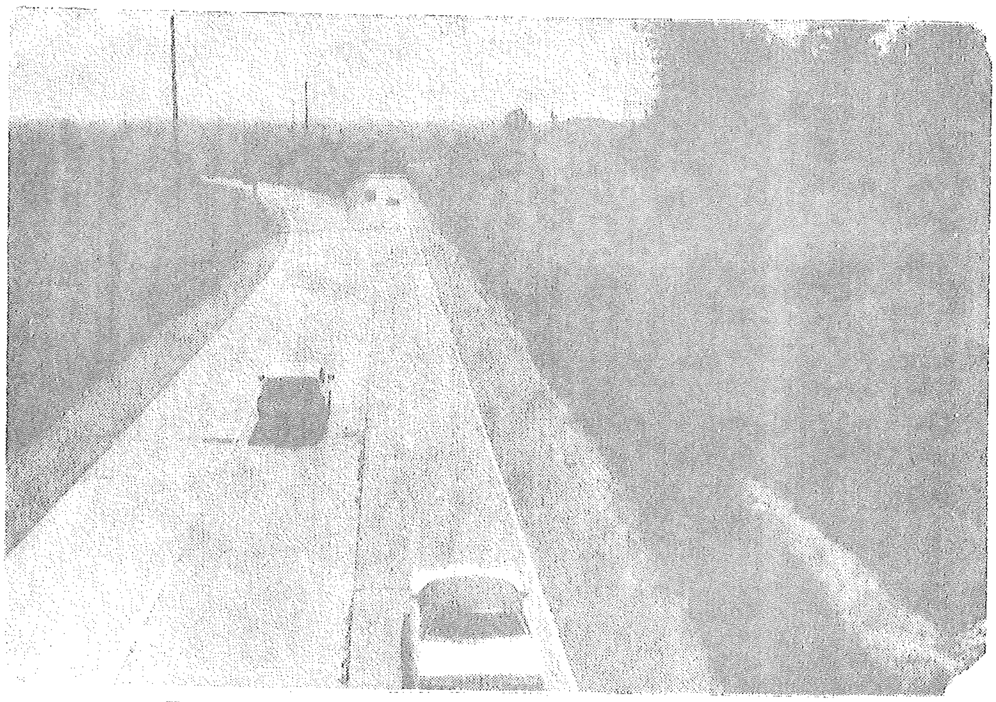


Figure 6. Looking easterly (from the M-37 overpass) at downstream location.

For study purposes, an erratic maneuver was defined as any vehicular movement through the gore area or involving a sudden lane change just in advance of the gore area. While Figure 4 shows a large reduction in erratic maneuvers, some erratic maneuvers continued. Many of these are probably due to the complex geometrics of the interchange. To eliminate all erratic maneuvers, the interchange would have to be redesigned.

The Sunday evening period experienced the biggest reduction in erratic maneuvers. Erratic maneuvers were reduced 40 percent (from 15 to 9) even though traffic volumes increased 24 percent. A chi-square test utilizing a 2X2 contingency table was used to test the significance of the reductions. This reduction was significant at the 90 percent confidence level.

The reductions during the Monday morning and Monday mid-day periods were not statistically significant.

For the combined 6-hour study period, erratic maneuvers were reduced 31.4 percent (from 35 to 24). This was significant at the 90 percent confidence level.

Brake Applications - Figure 7 shows the number of brake applications in the before and after periods.

Figure 7. Before and After Brake Applications

		Volumes		Brake Applications		
		Before	After	Before	After	Percent Change
Sunday Evening	(2 Hrs)	3057	3794	41	15+	- 63.0
Monday Morning	(2 Hrs)	3240	3159	34	31	- 8.8
Monday Mid-day	(2 Hrs)	2590	2620	30	23	- 23.3
Total	(6 Hrs)	8887	9573	105	69+	- 34.3

+The reduction is significant at the 95 percent confidence level (chi-square).

The Sunday evening period experienced the biggest reduction in brake applications. Even with a 24 percent increase in traffic volumes, brake applications were reduced 63 percent (from 41 to 15). A chi-square test utilizing a 2X2 contingency table was used to test the significance of the reductions. This reduction was significant at 95 percent confidence level.

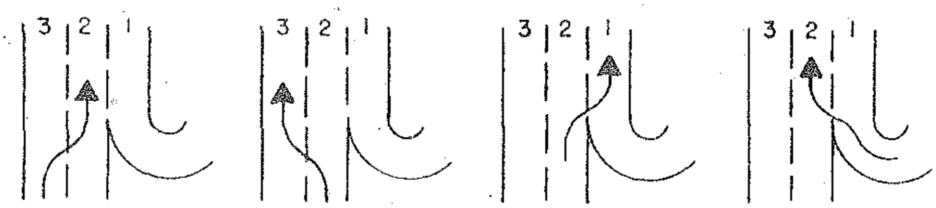
Although both the Monday morning and Monday mid-day periods experienced reductions, they were not statistically significant.

The total 6-hour period experienced a reduction in brake applications from 105 to 69, or 34%. This reduction was significant at the 95 percent confidence level.

Lane Changes - Lane changes were recorded at both the upstream and downstream locations. The upstream location is at the beginning and the downstream location at the end of the weave zone. Chi-square tests utilizing 2X2 contingency tables and the actual numbers of lane changes were used to test the significance of these changes.

Upstream Location: Figure 8 shows the before and after lane change percentages at the upstream location.

Figure 8. Percent Lane Changes at Upstream Location



	Lane 3 to 2		Lane 2 to 3		Lane 2 to 1		Lane 1 to 2	
	Before	After	Before	After	Before	After	Before	After
Sunday Evening	2.6	2.1	1.8	4.4+	2.8	2.1	11.5	8.9*
Monday Morning	1.5	4.7+	0.8	5.7+	1.5	1.8	8.2	11.2+
Monday Mid-day	5.4	6.6	0.4	13.5+	3.3	4.0	14.0	14.2

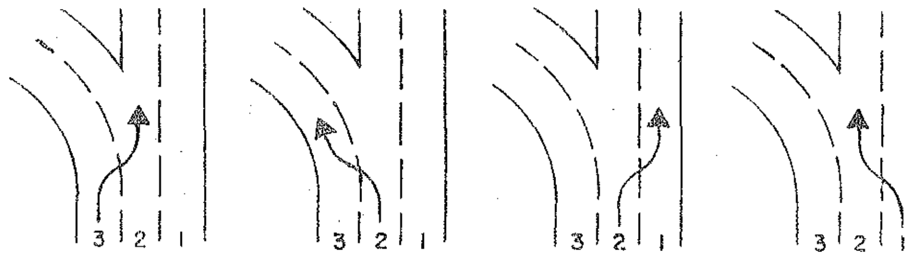
+The increase is significant at the 99 percent confidence level (chi-square).

*The reduction is significant at the 95 percent confidence level (chi-square).

On Sunday evening, there was a significant increase in the change from Lanes 2 to 3 and a significant decrease in the change from Lanes 1 to 2. On Monday morning, there were significant increases in the changes from Lanes 3 to 2, 2 to 3, and 1 to 2. On Monday at mid-day, there was a significant increase in the change from Lanes 2 to 3.

Downstream Location: Figure 9 shows the percentage of lane changes at the downstream location. The Sunday evening period experienced significant increases for changes from Lanes 3 to 2 and 2 to 1. The Monday morning period had a significant increase for the change from Lanes 2 to 1. The Monday mid-day period had significant increases in changes from Lanes 2 to 3 and 2 to 1 and a significant decrease for the change from Lanes 1 to 2.

Figure 9. Percent Lane Changes at Downstream Location



	Lane 3 to 2		Lane 2 to 3		Lane 2 to 1		Lane 1 to 2	
	Before	After	Before	After	Before	After	Before	After
Sunday Evening	1.6	4.4+	0.6	0.9	2.8	5.9+	7.6	6.5
Monday Morning	2.3	3.5	0.5	0.5	2.3	7.3+	6.2	4.5*
Monday Mid-day	2.3	3.3	0.8	2.0+	3.9	6.3+	8.7	6.2*

+The increase is significant at the 95 percent confidence level (chi-square).
*The reduction is significant at the 95 percent confidence level (chi-square).

Lane Usage (Volumes) - Figures 10 and 11 show the individual lane volumes at the downstream and upstream locations, respectively. These volumes represent the 2-hour counts for each time period.

Downstream Location: The Sunday evening after period volume increased 24 percent over the before period volume. The Monday morning volume decreased 2.5 percent and the Monday mid-day volume increased by 1.2 percent. The percentage of vehicles using Lane 3 increased for the three time periods. The percentage of vehicles using Lane 1 decreased for the three periods.

Figure 10. Lane Volumes at Downstream Location

Lane	3	2	1a	1	Total
Sunday Evening					
Before	731 (23.0)	688 (22.5)	448 (14.7)	1190 (38.9)	3057 (100)
After	1092 (28.8)	725 (19.1)	692 (18.2)	1285 (33.9)	3794 (100)
Monday Morning					
Before	395 (12.2)	569 (17.6)	755 (23.3)	1521 (46.9)	3240 (100)
After	487 (15.4)	582 (18.4)	690 (21.8)	1400 (44.3)	3159 (100)
Monday Midday					
Before	384 (14.8)	581 (22.4)	469 (18.1)	1156 (44.6)	2590 (100)
After	454 (17.3)	578 (22.1)	447 (17.1)	1141 (43.5)	2620 (100)

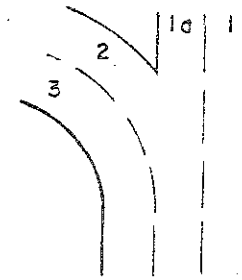
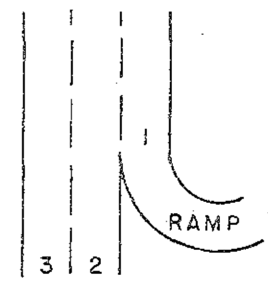


Figure 11. Lane Volumes at Upstream Location

Lane	3	2	1 (Ramp)	Total
Sunday Evening				
Before	768 (24.9)	896 (29.0)	1423 (46.1)	3087 (100)
After	1263 (32.7)	1141 (29.6)	1453 (37.7	3857 (100)
Monday Morning				
Before	453 (13.9)	1057 (32.4)	1748 (53.7)	3258 (100)
After	530 (16.9)	999 (31.8)	1611 (51.3)	3140 (100)
Monday Midday				
Before	410 (15.6)	815 (31.0)	1403 (53.4)	2628 (100)
After	438 (16.5)	799 (30.0)	1425 (53.5)	2662 (100)



Upstream Location: The Sunday evening after period volume increased 24.9 percent over the before period volume. The Monday morning volume decreased by 3.6 percent and the Monday mid-day volume increased by 1.3 percent.

The only consistent change which occurred at the upstream location was an increase in the percentage of vehicles using Lane 3.

Conclusions

The measures of effectiveness (MOE) evaluated in this study were erratic maneuvers, brakelight applications, lane changes, and lane usage (volumes). Erratic maneuvers appear to be the best MOE for evaluating confusing conditions. The other MOEs may not consistently indicate confusion. For example, brakelight applications may indicate merely congestion. Therefore, the reduction in erratic maneuvers was considered the most significant MOE in this study.

An analysis of the video tapes used to record lane changes and lane volumes revealed a problem with the evaluation procedures. It was not possible, with the taping method used, to note a vehicle as it encountered the first of the diagrammatic signs and follow it through the entire project site. Probably many early lane changes were missed. A trace analysis, while costly and time consuming, may have remedied this situation.

The before-and-after data indicated an overall reduction in erratic maneuvers of 31.4 percent. The greatest percentage reduction occurred in the Sunday evening period. Most driving during this period was assumed to be non-work related (i.e. social and recreational). The lowest percentage reduction occurred during Monday morning, a period when most driving is assumed work related. Presumably, drivers travelling to work repeatedly and familiar with the route are less likely to respond to sign changes than those travelling for social or recreational purposes, whose trips are less frequent.

The overall reduction in brake applications was 34.3 percent. The reduction pattern was identical to the pattern described above for erratic maneuvers (i.e. the greatest percentage reduction occurred on Sunday evening and the lowest percentage reduction occurred on Monday morning).

An analysis of the lane changes revealed few patterns. The lane change from Lanes 2 to 3 increased for all time periods at the upstream location. The lane change from Lanes 2 to 1 increased for all time periods at the downstream location. These changes indicated that drivers staying on eastbound I-96 were moving to the far left lane and drivers staying on southbound US-131 were moving to the far right lane. The lane change from Lanes 3 to 2 at the downstream location should have decreased after installation of the diagrammatic signs. Unfortunately, the percentage of cars making this lane change increased during all three time periods, although only Sunday evening's increase was significant.

An analysis of lane volumes indicated an increase in Lane 3 volumes for all time periods at both locations. This substantiates the conclusion that drivers staying on eastbound I-96 were moving into the left lane.

The cost of the contract for this project was $110,000. It is difficult to quantify the benefits attributable to this project. The timing of this report did not permit a statistically valid before-and-after accident study, however, there were 32 accidents in the four years before project implementation (1974-1977). A future study should look into the after period accident experience. Although the MOEs studied cannot be directly correlated to accidents, they often indicate confusing situations which may lead to accidents. However, the reduction of erratic maneuvers cannot be quantified directly. In spite of this difficulty, the Positive Guidance principles and diagrammatic signs tested here appear promising. Further applications may be warranted in other confusing situations or in situations where signs require replacement for maintenance and could therefore be economically converted to a diagrammatic display.

APPENDIX

Positive Guidance Tasks

FUNCTION A - Collection of Data

(A-1) Review all historical data
(A-2) Conduct site survey and operations review
(A-3) Collect performance data
(A-4) Describe location characteristics

FUNCTION B - Specification of Problems

(B-1) Identify, describe, and rank hazards

FUNCTION C - Definition of Driver Performance Factors

(C-1) Analyze speed and path
(C-2) Characterize expectancies
(C-3) Assess detection and recognition factors
(C-4) Analyze information load

FUNCTION D - Definition of Information Requirements

(D-1) Determine information handling zones
(D-2) Determine information needs
(D-3) Assign primacies to needs
(D-4) Assess current information system

FUNCTION E - Determination of Positive Guidance Information

(E-1) Identify applicable control devices
(E-2) Design positive guidance plan
(E-3) Meet with FHWA officials to discuss plan
(E-4) Implement positive guidance plan

FUNCTION F - Evaluation

(F-1) Develop evaluation plan
(F-2) Conduct data collection
(F-3) Analyze and interpret data

4-22-81
WHO(57F-63)-12
Safety Programs Unit