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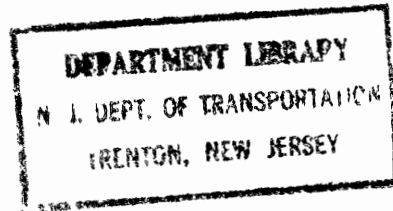
DIAGRAMMATIC SIGN STUDIES ON I-287 IN NEW JERSEY

FINAL REPORT

BY

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PREPARED BY



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16 Abstract  <p>Ninety-four freeway style diagrammatic signs were installed on I-287 in New Jersey, replacing 120 conventional signs at 22 interchanges. Traffic volumes and specific unusual maneuvers were counted and categorized for a seven-day period at each of 10 exit sites, both before and after the guide sign changes.</p> <p>The evaluation of the signs includes statistical comparisons of unusual maneuvers rates as well as visual observations. Diagrammatic or conventional signs were examined for their potential effectiveness according to the exiting situations.</p> <p>The effect of the separation by season and year on unusual maneuvers rates is shown from the results of nine, seven-day studies performed from 1969 to 1973 at one site.</p> <p>The adequacy of the diagram standards used for the study sign designs were reviewed and recommendations for further research are made for the sign designation of lane drops at exits, exit ramp geometry and the use of intermediate signing.</p>			
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## I. SUMMARY AND CONCLUSIONS

Driver exiting maneuvers at freeway ramps have been the subject of study for many years. The Blatnik Committee highlighted some of the difficulties that existed on the freeways during hearings held in 1968. Subsequently, research efforts were commenced to judge the effectiveness of the use of "diagrams" to supplement existing wording on freeway guide signs.

The diagrammatic sign is intended to present an image of the interchange, in its simplest form, to the approaching motorist. The conventional guide messages are placed on the same sign panel with the diagram.

Over 21 continuous miles on I-287, which included twenty-two interchanges, were signed with diagrammatic signs. This program was scheduled to allow the NJDOT to evaluate the new concept at a variety of different types of interchanges and on a roadway where the motorists had an opportunity to become accustomed to "continuous" signing of the same type.

The basic method used to evaluate the effectiveness of the new diagrammatic signs against the replaced conventional signing was the identification of a specific type of unusual maneuver by the exiting motorists.

Varying degrees of reliance are placed on the results of the studies performed at 10 sites, depending upon effects from certain bias sources operating at the time. The following summarizes the study findings that were conclusive:

- . At a split to a dualized road, an additional intermediate conventional type sign was shown to be more effective than a later conversion to diagrammatic signs.
- . At two loop exits within a clover leaf interchange, a conversion to diagrammatic effectively reduced stopping and backing maneuver

rates, but resulted in either no change or an increase in unusual exit gore maneuver rates. Grouping this data for a combined before and after analysis, results in a decrease of stopping and backing maneuver rates and an increase in unusual exit gore maneuvers rates.

- . At one right hand "tee" ramp, a conversion to diagrammatic signs reduced stopping and backing maneuver rates and resulted in no change in unusual exit gore maneuver rates.
- . At a right hand exit ramp terminating an auxiliary lane, the one and only sign used was shown to be more effective as a diagrammatic than as a conventional type.

The following summarizes the study findings that were inconclusive:

- . The data at another right hand "tee" ramp is not believed to be valid due to the biasing effects of upstream construction work during the after study.
- . The effectiveness of diagrammatic signs at a lane drop is not clear from the data collected. The data was most likely effected by a large relative increase in the percent exiting in the after study.
- . The effectiveness of diagrammatic signs at a left hand ramp exit is not clear from the data collected due to a large decrease in the percent exiting and a change in design in the after study. It is believed that the data relating to a second left hand ramp exit during the before study has been improperly collected and is thus disregarded as a finding. The results of using diagrammatic signs at a third left hand ramp exit were unclear due to a large decrease in the percent exiting in the after study. Several complaints relating to the very unusual diagrams at this location have been received.

## II. INTRODUCTION

Since the Blatnik Committee<sup>1</sup> advocated the trial of diagrammatic type guide signs at freeway interchanges, there have been several major developments in the evaluation of these signs. The Federal Highway Administration sponsored a national program to design and evaluate U.S. style diagrammatics aimed at reducing unusual maneuvers at high incidence exits. Several previous research efforts are worthy of mention. The effects of diagrammatic signs were shown in a field study at a left hand exit gore using a narrowly defined unusual maneuvers measure and a matched pairs statistical analysis of unusual maneuvers rates.<sup>2</sup> Diagrammatic sign concepts were evaluated in a laboratory setting and recommendations were made for specific applications and graphic design.<sup>3</sup> The inclusion of graphic lane lines in signed diagrams was evaluated in a field study.<sup>4</sup> The relevance of erratic maneuvers at several zones both upstream and downstream of the exit gore along with the results of driver interviews was shown in a diagrammatic sign evaluation.<sup>5</sup> The utility of unusual maneuvers, lane changes, speed changes, and headways in evaluating diagrammatic signs was demonstrated employing automated tape switches in several zones approaching exits, as well as driver interviews and learning curve detection.<sup>6</sup>

In pilot studies conducted at I-287 and U.S. 22 in New Jersey<sup>4</sup>, signs both with diagrammatics and with lane lines in the diagrams were considered to be successively more effective than conventional signs at that location. However, some doubt remained as to whether the improved performance found in unusual maneuvers was not due to the effects of novelty or sudden importance given to the signs. Hence, a study of diagrammatics over a continuous 22 mile section of I-287 was conducted to include a variety of geometric exit ramp configurations.

### III. AREA CHARACTERISTICS

I-287 in Somerset and Middlesex Counties was chosen for study, because of its varied geometry and its importance as part of a road system that encircles New York City.

The route in the study area is not yet connected to the rest of the encircling system, although extending sections of the route in the study area were constructed between the 1971 and 1973 studies. At the southern end, entrances from the Garden State Parkway and U.S. 9 were opened between the two main study years, extending the roadway approaching U.S. 1 from two to three and one-half miles and adding more entrances to the one already existing from U.S. 1, the New Jersey Turnpike, County Route 514, and Crows Mill Road. At the northern end, six miles of roadway was added with new access to N.J. 24, and County Route 510. A connecting interstate route, I-78, was constructed for seven miles to the east of I-287 during the 1971 studies, a total of twelve miles were constructed prior to the 1973 studies. Refer to Figure 1.

A noticeable amount of growth in shopping and industrial areas took place during the study years in the study area; the section of I-287 between U.S. 22 and County Route 527 was resurfaced and concrete center barriers were reconstructed just prior to and during the study in 1973. The repaving contract was coordinated with the diagrammatic sign study in such a manner as to keep studies and construction as far apart as possible. Although the cooperation in this respect was good, studies and repaving work were not a great distance away from each other at a few sites and effects on motorists behavior at the exit were bound to have occurred in some cases.

Volumes changed in an unbalanced manner at several sites suggesting a variation in driver navigational patterns. The most noticeable volume

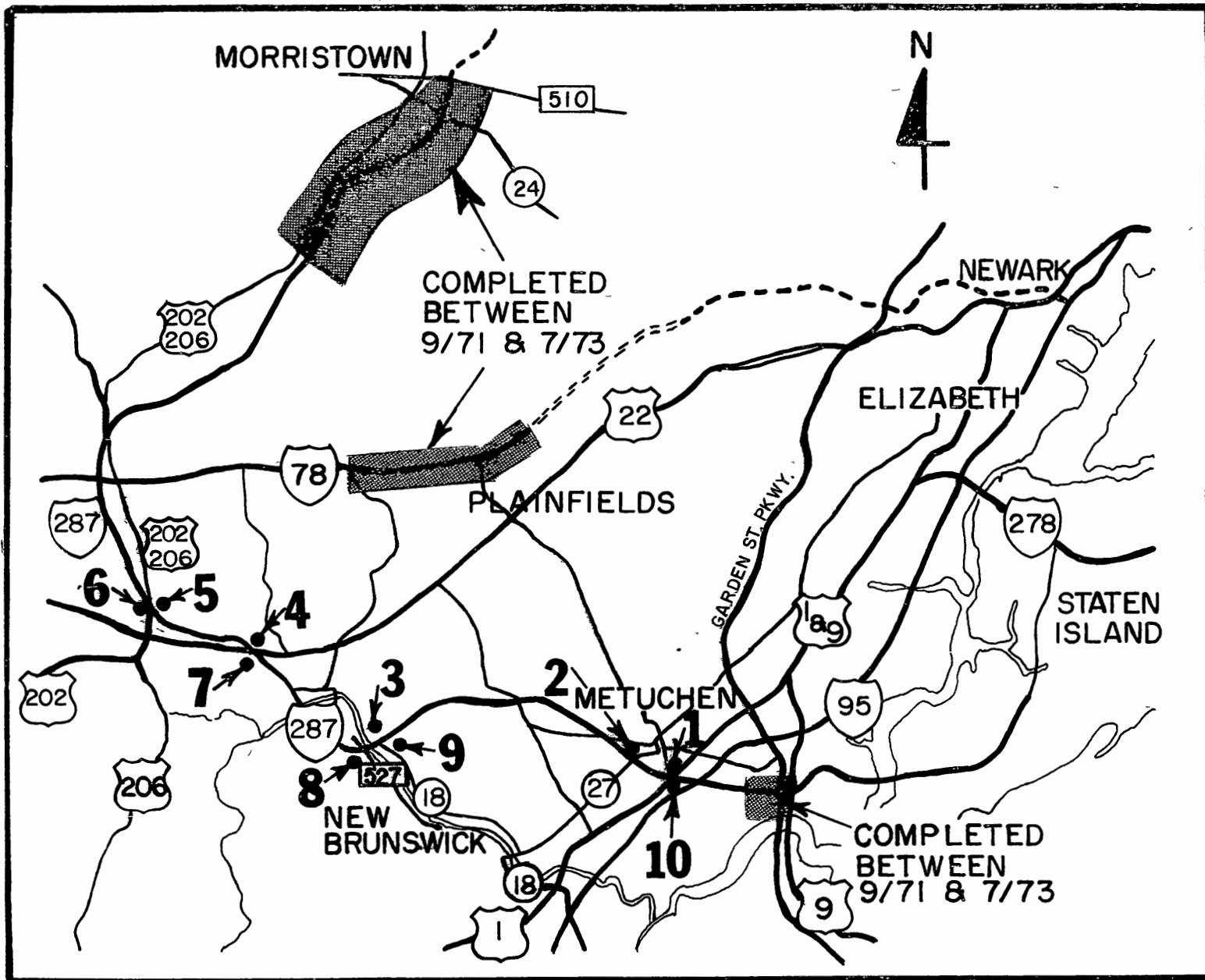


Figure 1 – Study Site Locations

changes were on the exit ramp from I-287 southbound to U.S. 1 northbound (Site 10) and on the exit ramp from I-287 southbound to U.S. 22 eastbound (Site 7). In 1973, many southbound motorists were apparently bypassing U.S. 1 for direct access with the Garden State Parkway instead of using U.S. 1 northbound for indirect access as was necessary in 1971. The southbound motorists on I-287 in 1973 were also apparently favoring the use of I-78 eastbound over U.S. 22 eastbound (Site 7). Although I-78 is not signed for the Plainfields, it is a faster and more direct route for southbound I-287 or eastbound I-78 motorists. New access with U.S. 9 and the Garden State Parkway is also the apparent cause for increased choice rate of the northbound exit ramp for N.J. 27 southbound (Site 2), the exit side to I-78 westbound of the northbound split (Site 5), and the increased percentage of southbound through traffic at the exit ramps for U.S. 202-206 southbound (Site 6), and U.S. 22 eastbound (Site 7).

#### IV. STUDY AND SIGN DESIGN PROCEDURES

##### Scope

The present study includes an evaluation of 30 signs spread over ten exit sites within a 22 mile section of I-287 and 95 in Somerset and Middlesex Counties (one of which is the left hand exit to westbound U.S. 22). The exit sites include both simple and complex geometric situations, among which are: left and right hand exits, semi-direct, indirect and direct ramps; left and right turn connections; and interchanges that have both one and two ramps exiting from a single direction. Exit sites were originally selected for their potential for unusual maneuvers occurrences. All the exit sites in the study route were initially studied for short periods to determine this potential.

A limitation was placed on the study, in that no new structures for mounting signs could be built. Within that limitation, several signs were modified to upgrade existing sign messages before formal data collection began. Unusual maneuvers and volume data were collected at each site during July and August of 1971, and also at a site number 5 during August 1972 after an additional sign had been erected at that location. (Refer to Figure 2).

All structures were analyzed for design wind load to determine maximum panel size for the increased area often required for diagrammatics on ground mounted signs. Less than standard layouts had to be resorted to on some ground mounted signs. Less overall area was usually needed in cases where one diagrammatic sign replaced two or more conventional signs.

Diagrammatic signs with breakaway posts on ground mounts replaced conventional signs in the spring of 1973 and studies at all ten sites

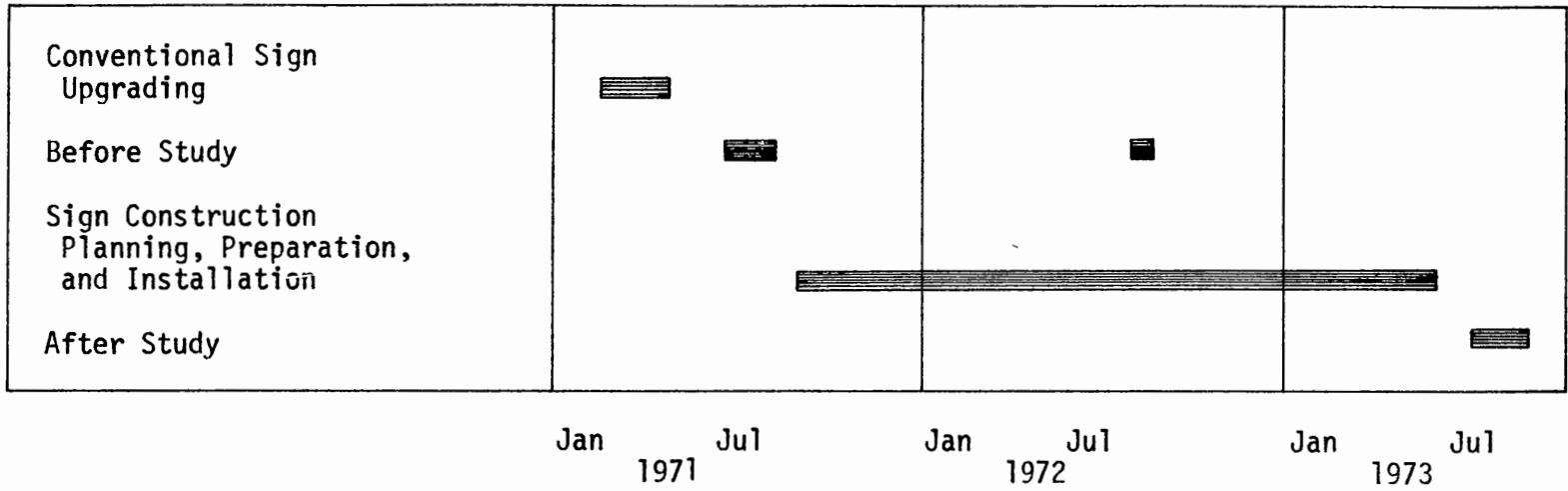


FIGURE 2  
 PROJECT ACTIVITY BAR CHART

were again made in July and August of 1973. One hundred and twenty conventional sign panels were replaced in the whole study section of I-287 by 94 diagrammatic sign panels. Twenty-two interchanges were involved in the change.

Letters, numbers, diagrams, and lane lines were reflectorized using cube corner reflex buttons, while high intensity beaded reflex sheeting was used for shield backgrounds. Both cube corner and bead sheeting had been tested for diagram visibility and recognizability at night from up to about one thousand feet.

The panel backgrounds were made from extruded aluminum coated with a polyvinylidene fluoride paint.

#### Sign Design Procedure

The diagram design methodology was aimed at satisfying the following requirements: 1) greater visibility to compensate for increased information content, 2) simplicity for ease of interpretation, 3) road-diagram relatability, 4) diagram continuity within each interchange, 5) message redundancy<sup>7</sup> for continued confirmation within exit approaches, and 6) uniform application among all interchanges for reliable driver recognition.

Diagram designs and sign layouts were developed with the use of a photo inventory film. Slides of signs on location were projected against a large screen. Alternate diagram and message layouts were superimposed on the scenes to review their adequacy from a driver's visual point of view. Opinions from engineering and non-engineering persons were solicited on an informal basis.

Both "plan view"<sup>3</sup> and a more symbolic style of diagram were simulated and reviewed. Refer to page 52 for illustration.

A practical set of standards enabling a consistent and reliable basis for designing a diagram for any geometric condition was arrived at using the more symbolic style of plan view.

Guidelines used in designing the sign panel messages and diagrams can be summarized as follows:

1. The lane widths on diagrams were varied according to exit proximity and function:
  - a. Advanced signs had 6-inch width lanes,
  - b. Exit direction signs had 8-inch lanes, and
  - c. Exit gore and overhead signs had 12-inch width lanes.
2. Lane lines were presented on signs with 12-inch width lanes only.
3. All main highway approaches to exits and through directions were shown with straight stems. Exit ramps were curved according to a symbolic plan view to the nearest 90-degree direction.
4. No more than two choices at a time were displayed diagrammatically for any gore (e.g., an exit and through arrow or a right and left arrow) even if the motorist is given two choices further down an exit ramp.
5. Messages and shields were placed so as to best locate them in relation to associated arrowheads.
6. Diagrams symbolically showed all major geometry at and downstream of its sign location except deceleration or auxiliary lanes added downstream.
7. A modified style of diagrammatics was employed for situations where the road diverges to parallel road-

ways, e.g., a dual split, slip ramp between dual road roadways, or main roads and service roads.

In general, when panels were replaced: (a) "EXIT" or "EXITS" was not used, (b) "KEEP RIGHT" or "LEFT," "RIGHT," or "LEFT LANE," and "EXIT ONLY" were not used, while (c) the same destinations, route numbers and cardinal directions were used.

Overhead signs were often easier to design than ground mounted signs, because less space was needed after organizing the messages from several signs onto one with a diagram.

### Data Collection

During each site study, unusual maneuvers and volumes were counted by hidden observers. Three observers counted all unusual maneuvers and two observers counted all volumes concurrently. An unusual maneuver was defined in this study as any stopping or backing in the exit gore section or driving on the gore line between the physical gore and a predetermined point upstream of it (Figure 3). At each site, unusual maneuvers and volumes were collected for both through and exit movements as well as for two axle and three or more axle vehicles in each hour from 2:00 to 5:00 p.m. on seven consecutive days.

Days when data were collected for "before" and "after" conditions were matched to the closest date from year to year.

### Analysis

The rates of unusual maneuvers (maneuvers per thousand vehicles) for the conventional and diagrammatic sign conditions were compared at each site. Only the rates for two-axle vehicles were compared since vehicles with extra axles perform a wider variation of unusual maneuvers.<sup>2</sup>

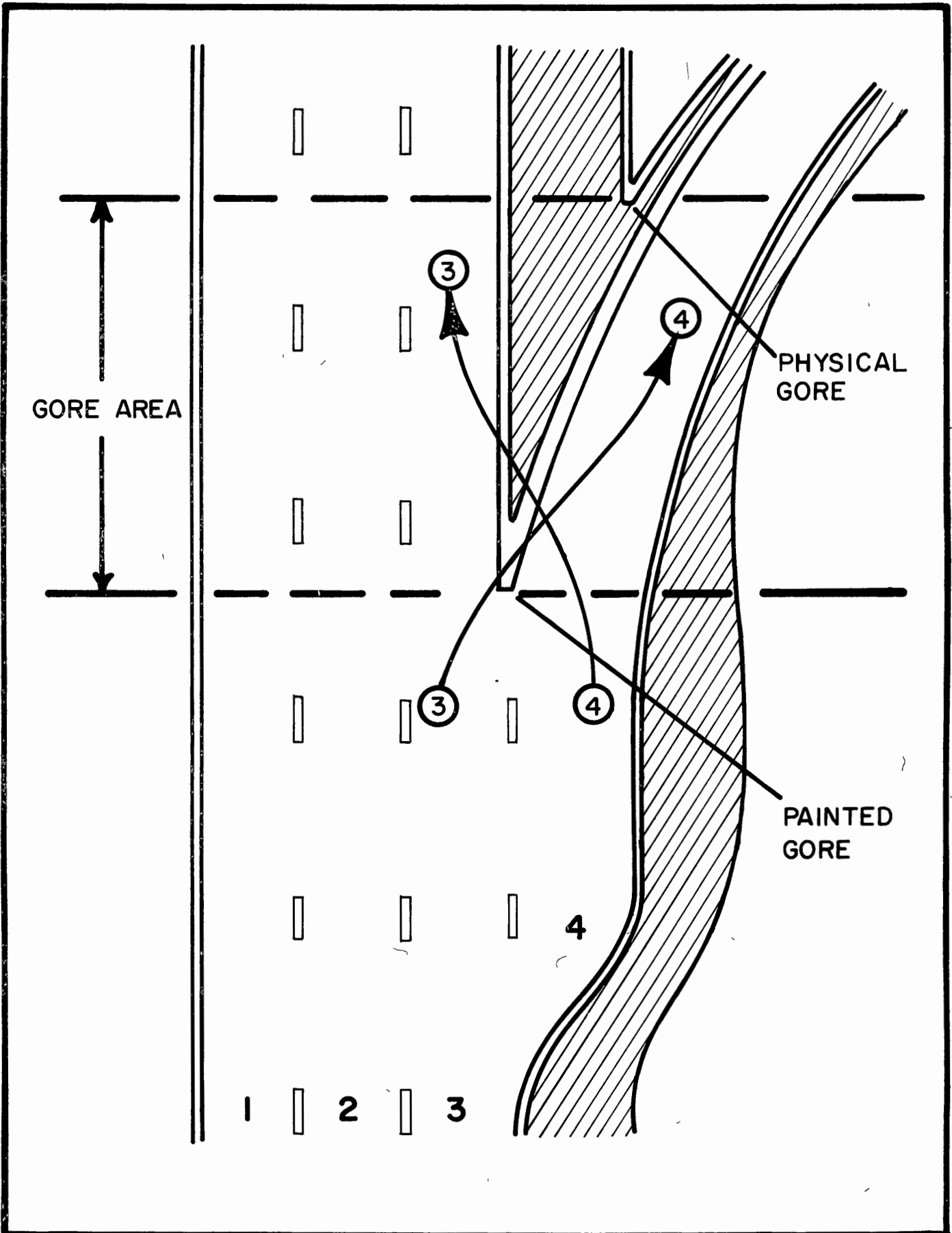


Figure 3- Typical Gore Weaves

Differences between studies were tested statistically by using the conservative, non-parametric, Wilcoxon matched pairs, signed ranks test.<sup>8</sup>

The following formula was used:

$$Z = (T - [N(N + 1)]/4) / \sqrt{[N(N + 1)(2N + 1)]/24}$$

Where: T = sum of positive ranks

N = number of qualified ranks

Z = normal standard deviation

Rates are paired by hour, day, and movement. Rates paired by movement are referred to in an abbreviated form as follows:

- a. EUR - exiting unusual maneuvers rates, e.g., a 3 to 4 maneuver in Figure 3.
- b. TUR - through unusual maneuvers rates, e.g., a 4 to 3 or 3 to 3 maneuver.
- c. SBR - stopping and backing unusual maneuvers rates for both exit and through movements.
- d. UR - total of both EUR and TUR.

A change is considered significant when it can be accepted at greater than the 95 percent level of confidence, using a one-tailed test.

The analysis of data for each site includes statements relating to:

1. Statistical comparisons pairing unusual maneuvers rates for each sign condition.
2. The sufficiency or validity of the data.
3. The possible or probable effects produced by extraneous factors, such as construction activity, new access, changed volume, accidents, and rain.

A stopping or backing maneuver can be considered to be more critical than a gore weaving maneuver. However, SBR's are included with the EUR or

UR totals, as well as separated for before and after comparisons. It is assumed their inclusion in EUR or UR totals has very little effect on the comparisons because SBR's are quite infrequent.

#### Non-Experimental Factors Control

Repaving and restriping, independent signing programs, new access, changing traffic volumes, changing travel patterns, and new industrial development are sources that can produce biasing effects on comparisons between before and after data.

In laboratory experiments, the effects from a particular change of condition on experimental individuals as a group is measured. A control group made up of the same kind of individuals, upon which no change is made, is often included in the experimental design. With this design, many of the biasing effects of unplanned or uncontrollable changes on the control group may be measured and approximated for the experimental group. Without this design, the effects from a particular change of condition are not exactly determinable because they are mixed with the effects from unplanned or uncontrollable changes.

In this diagrammatic sign study, motorists using an exit are the equivalent of an experimental group in the laboratory. Since all the signs were changed to diagrammatic versions within the study area and all the exits have different characteristics, control groups for each exit were not available.

Although control groups were not used, a large effort was made to reduce biasing effects from outside influences. For a repaving project that was conducted simultaneously with the "after" study, plans were prepared for repaving and restriping work so that exit striping was done in the same manner in both studies. This was accomplished by documenting the dimensions

of original gore stripes and entering them in restriping plans. The contractor was scheduled to conduct his work away from planned site studies. Requests were made to other agencies to refrain from making their own sign changes at locations relating to planned studies. Needed changes in destination names and exit numbering were mostly postponed. The one exception was at Site 6 where gore mounted supplemental signs were removed and a standard exit gore sign with a number was installed.

The method of analysis used enabled the minimization of effects from factors that were identified by hour of day or day of week. Loss of visibility during heavy rain is rare, but one hour of effected data was eliminated from the analysis. Effects from daily and weekly driver population mix variations were minimized with the matched-pairs, non-parametric analysis technique.

## V. STUDY SITE INFORMATION

### SITE 1 - I-287 NORTHBOUND TO U.S. 1 SOUTHBOUND

#### Background

As seen in Figure 4, the exit under observation is the second of two right hand exits for U.S. 1, a loop ramp for an indirect left turn. Five lanes approach the interchange. The right lane is dropped at the first exit; an 800 foot (240 meter) weaving lane is added for an entrance ramp and dropped at the loop ramp, while four lanes continue through.

There was about a 48% increase in the volume of traffic approaching the gore area during the two year period between before and after studies, which may be partially attributed to additional access at the southern end of the route.

#### Observations

Two of the four original overhead signs for through movement at the first exit gore displayed the word "SOUTH." The word "SOUTH" was intended for future shared routing of I-95 with I-287 traffic, but was potentially confusing to motorists without reference to a route number while shown alongside another panel with the word "NORTH" which referred to I-287.

It is believed that a greater degree of driver orientation could have been achieved with lane assignment (down-oriented) arrows, had they been used. Other signing differences may be seen in Figure 4.

Both signs and exit gore locations can be viewed from an adequate distance.

The choice of routes by some of the drivers was changed in this section of New Jersey because of extensions to I-287, made between studies. The increased use of this exit with these construction changes may account for some of the increase in the unusual maneuvers rates.



Only EUR were selected for analysis at this site, since most of the through unusual maneuvers were generated by entering motorists who would not have been exposed to the whole exit approach.

#### Remarks

There was a non-significant decrease in SBR and a significant increase in EUR after diagrammatic signs were installed. The change in SBR and EUR was conflicting for this site. (See Figure 14, page 45).

The diagrammatic sign system at this site appears to be more presentable than the conventional sign system, but based on the results of SBR and EUR comparisons alone, they are not more effective.

Both this site and Site 10 are similar in that they are both clover-leaf type interchanges, but in other small but important ways, they are different. The second exit gore sight distance is inadequate at Site 10, while the conventional signing was fairly straightforward. The reverse is true of Site 1. There were also different effects produced by changes in traffic between the study years. An increase in exiting volumes at Site 1 and a decrease in exiting volumes at Site 10 indicate an opposite effect from extensions of I-287 made between studies. The only aspect of the results that agree between studies at both sites are SBR comparisons, which show a decrease in both cases, although only SBR comparisons at Site 10 were significant.

## SITE 2 - I-287 NORTHBOUND TO N.J. 27 SOUTHBOUND

### Background

As seen in Figure 5, the exit under observation is the second of two right hand exits for N.J. 27, a semi-direct left turn ramp from a point beyond the actual interchange route. Four lanes approach the interchange. A deceleration lane is added for the first exit, and the right lane is dropped for the study exit, leaving three lanes for through traffic.

There was about a 29% increase in the volume of traffic approaching the gore area during the two year period between before and after studies, which may be partially attributed to additional access at the southern end of the route.

### Observations

The original overhead sign at the first gore that served as an exit direction sign for the second exit displayed two black-on-yellow "ONLY" signs that were not transferred to the new diagrammatic sign. The distinguishing feature given to the lane drop was in the diagram. The "ONLY" signs referred to the downstream lane drop at the study exit and are mutations of "EXIT ONLY", which is advised for this kind of situation in the MUTCD.<sup>9</sup>

All signs approaching the exits have adequate sight distances, except the exit gore sign for the study exit which is mounted on a cantilevered structure and placed in a manner that results in a reduced sight distance due to interfering light poles. More important, perhaps, is the drastically reduced sight distance of the second exit gore itself, produced by the cresting of a hill. The conventional overhead signing on the approach to this exit did not fully utilize the lane assignment principle with down pointing arrows for each lane.



The choice of routes by some of the drivers was changed in this section of New Jersey, because of extensions to I-287 made between studies. The increased use of this exit with these construction changes may account for some of the increase in the unusual maneuvers rates, as in the case of Site 1.

#### Remarks

There was a non-significant decrease in SBR and a significant increase in UR after diagrammatic signs were installed. Although there was a change in traffic using this exit as evidenced by the change of the percentage exiting and the assumed effects of the extensions to I-287 at the southern end, SBR and UR were not affected in the same manner. There was only one stopping and backing maneuver observed and it occurred during the study of conventional signs. Not only is there very little space to stop or back on the shoulder out of the way of traffic, but also it is very hazardous to do so because of frequent last instant weaving into the through lanes.

The diagrammatic signs at this location do not have more advantage than conventional signs. Lane drop symbolism could be more accentuated or the lane drop could be changed for improved performance. The results of SBR and UR comparison show that the diagrammatic signs do not appear to be more effective than the conventional signs.

This site is the only site in the study with the particular combination of short gore sight distance and exit lane drop characteristics.

SITE 3 - I-287 NORTHBOUND TO N.J. 18Background

As seen in Figure 6, the exit under observation is a right hand "tee" connection for N.J. 18. Three lanes approach the interchange and a deceleration lane is added on the right for the exit, while three lanes continue for through traffic.

There was about a 23% increase in the volume of traffic approaching the gore area during the two year period between before and after studies, which may be partially attributed to additional access at the southern end of the route.

Observations

The signs for this exit are well placed with simple and easy to read messages, and the exit gore can be seen from an adequate distance. There were no unusual influences known to have been operating during the studies, with the exception of one hour of very heavy rain and consequent atypical driving behavior, the data from which were not included in the analysis.

Remarks

There was a significant decrease in SBR and a non-significant decrease in UR after diagrammatic signs were installed.

The diagrammatic signs do not appear to be more informative for motorists using this particular exit, but the results of SBR comparisons alone present evidence that the diagrammatic signs are more effective.

The occurrence of unusual maneuvers of all types during both conventional and diagrammatic sign studies was infrequent at this site.

This site is somewhat similar to Site 8. Both sites are singular right-hand exits with deceleration lanes. The approach to Site 3 is on a tangent, while the approach to Site 8 is on a curve to the left.

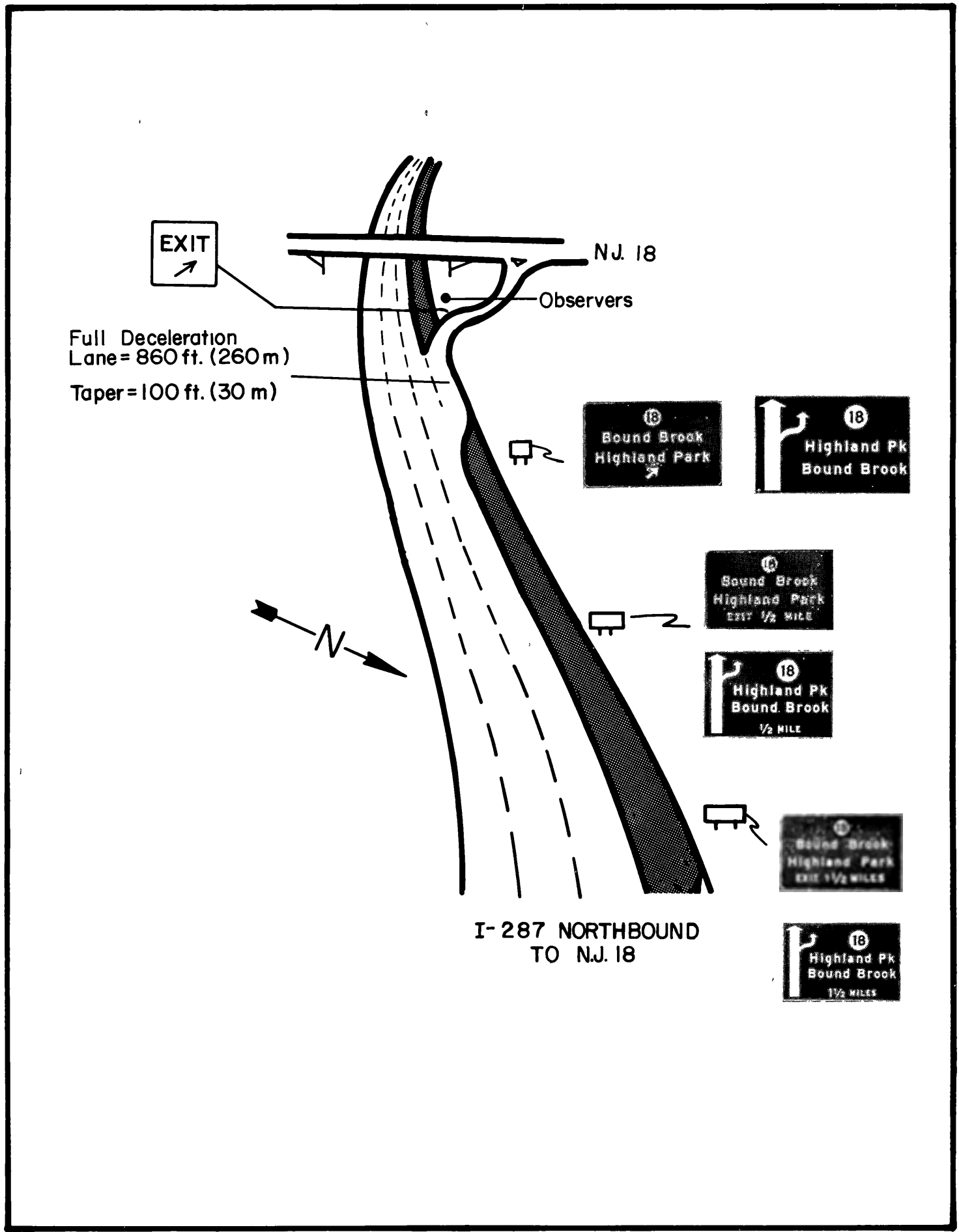


FIGURE 6 -STUDY SITE 3

## SITE 4 - I-287 NORTHBOUND TO U.S. 22 WESTBOUND

### Background

As seen in Figure 7, the exit under observation is the second of two exits, a left hand exit with a two lane ramp for a direct left turn following a right hand exit with a single lane ramp for a direct right turn. Three lanes approach the interchange. One lane is added at the overpass on the left for the second exit. Then, a deceleration lane is added on the right for the first exit. Another lane for the second exit is then added on the left beyond which three lanes continue through.

Repaving and restriping was just barely finished prior to the after study in 1973 and was active during the after study on the southbound roadway (in full sight of northbound motorists approaching the study location). Although a hill in the median cut off direct sight of construction in part of the approach, trucks were sometimes parked or active in the immediate median area near the second exit.

There was about a 21% increase in the volume of traffic approaching the gore area during the two year period between before and after studies.

### Observations

There are only slight visual differences between before and after sign messages. The after diagrams are thicker, include lane lines, and the diagrams on exit gore signs are reversed in relation to the associated messages.

The message and diagram layouts were well organized in both diagrammatic sign systems studied here, but the diagram displayed at the study exit gore could have been of greater length for better visual impact (refer to Figure 7).

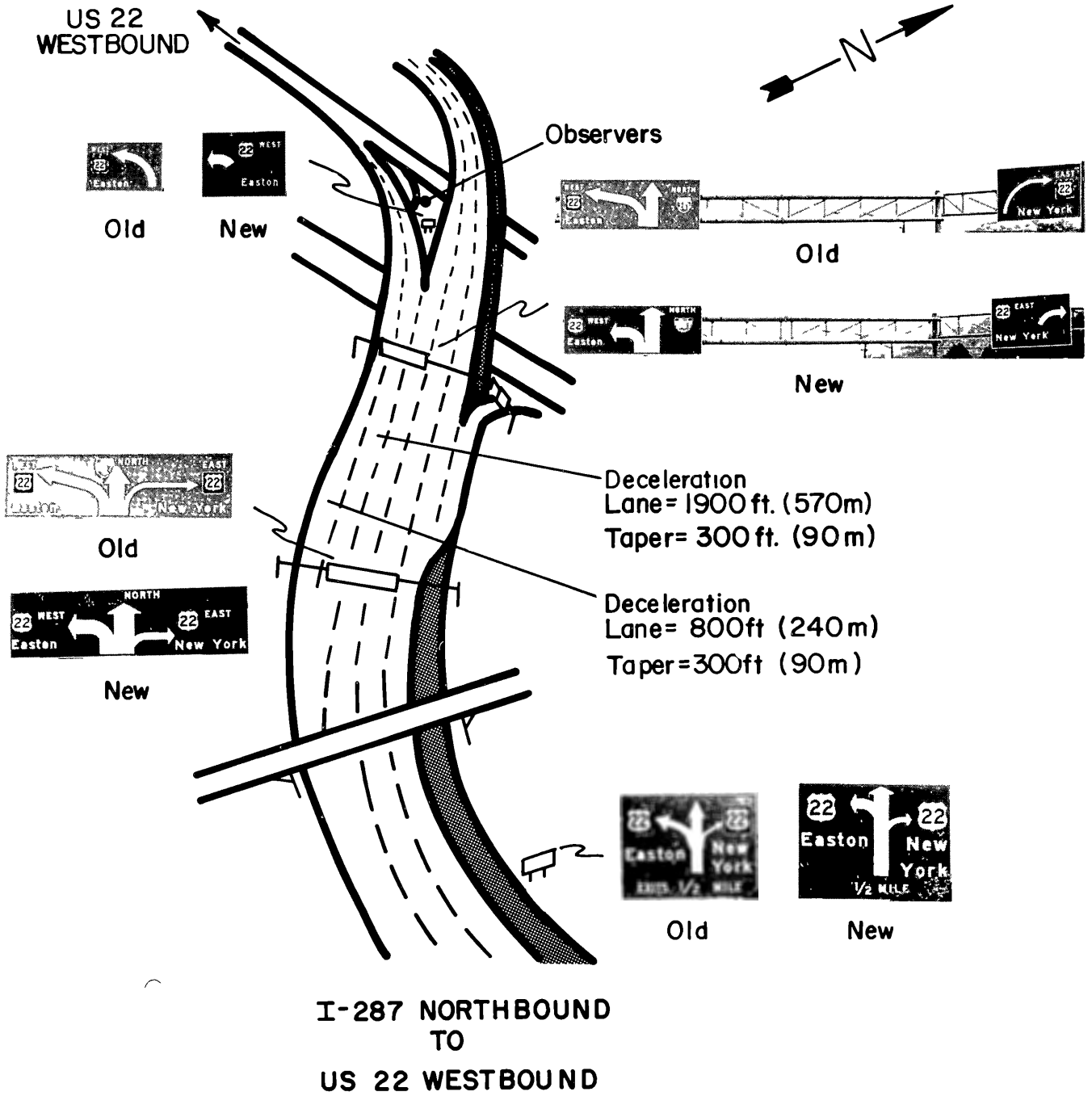


FIGURE 7 -STUDY SITE 4

Remarks

Unusual maneuvers rates (UR) in 1971 (old diagrammatic) were much below what was expected based on previous studies performed at this site (refer to Figure 15). Approximately 30 unusual maneuvers per thousand vehicles per hour on the average could have been expected, but less than five per thousand vehicles per hour occurred. The UR measured in 1973 averaged 26 per thousand vehicles per hour, which is in line with many previous studies. The unexplained occurrence in 1971 does not lend itself to a credible comparison of UR at this site and the before data are regarded as invalid and not included in this report. It is probable that the data collectors used an incorrect definition of the gore weaving area at this site in the before study.

The new diagrams at this site in 1973 are more informative than the older ones in that lane lines are included and a significant decrease in UR was expected along with the decrease in SBR found, based upon the results of a former study of nearly the same sign conditions performed in May and June of 1970.<sup>4</sup>

SITE 5 - I-287 NORTHBOUND SPLIT FOR I-78  
INTERCHANGE: THREE STUDIES

Background

As seen in Figure 8, the exit under observation is a split of lanes with the left hand side leading to both an exit to I-78 westbound and I-287 northbound. The right hand side, as the motorist can perceive by signing, leads to a through movement only (when, in fact, there is a downstream slip ramp for access to the left side). Future signing for the right hand side is planned for providing information on exiting to I-78 eastbound. Two lanes approach the site. One lane is added on the left, prior to the first overhead bridge. Then, the two left lanes are parted from the right lane, leaving a grass median between them.

Two separate changes were made to the signing, necessitating three studies at the site in 1971, 1972 and 1973. Between 1971 and 1972, two conventional signs were mounted on the first overhead bridge where none had existed before. Between 1972 and 1973, all the overhead signs were replaced with diagrammatic versions using the same messages. Conventional signs were added for the 1972 study because the sign system, as had existed at the site in 1971, was not regarded to have sufficient advance information to be used to represent the conventional standards adequately in a comparison with diagrammatic versions.

There was about a 23% increase in the volume of traffic approaching the gore area from July of 1971 to July of 1972 and about another 5% increase was indicated in July of 1973.

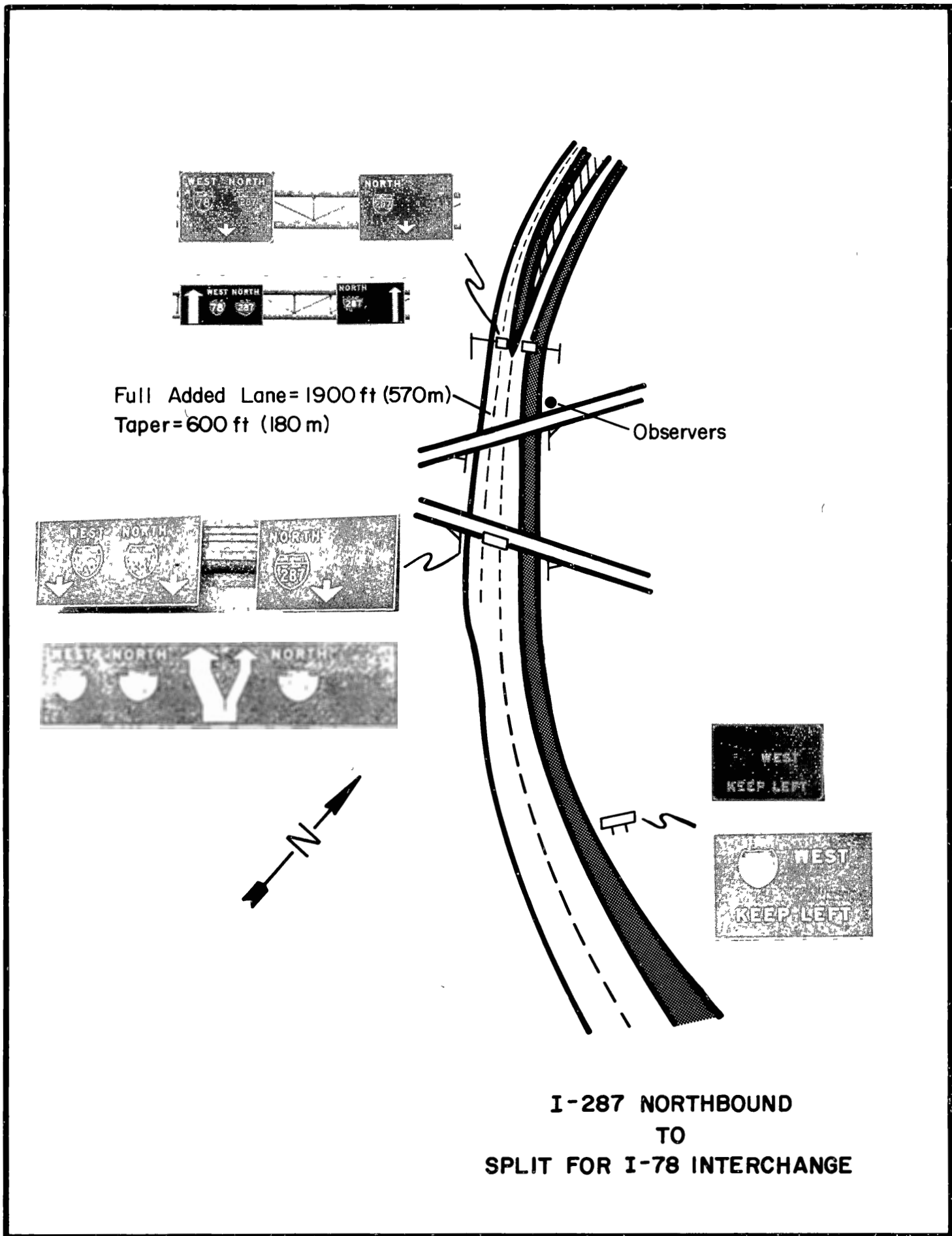


FIGURE 8 - STUDY SITE 5

### Observations

Prior to the addition of signs on the first bridge, the unfamiliar motorist was not fully aware of lane function at the split until the gore signs and physical split were in view. The motorists' view is blocked over part of the approach by the two overhead bridges and a curve to the right, as shown in Figure 8.

### Remarks

In 1972, after the addition of two conventional overhead signs at an intermediate location, there was a non-significant decrease in SBR and a significant decrease in UR. In 1973, after the change to diagrammatics, there was a significant increase in SBR and a significant increase in UR.

The additional conventional signs were considered to be necessary, and the statistical results show them to be more effective. The diagrammatic signs appear to be as informative, but the statistical results show them to be less effective than the improved conventional signs used at Site 5.

SITE 6 - I-287 SOUTHBOUND TO U.S. 202-206 SOUTHBOUNDBackground

As seen in Figure 9, the exit under observation is the left-hand and only exit from the left side of dualized I-287 for U.S. 202-206, a two lane ramp for a semi-direct right turn. Two lanes approach the study site and continue off the exit to the left while one tapered lane diverges to the right for through movement.

There was about a 27% increase in traffic volume during the two year study period.

Observations

The supplemental sign shown in Figure 9 that reads "SOMERVILLE KEEP LEFT" was in place during both "before" and "after" studies, but an "EXIT 13" tab was placed on top of the panel between the studies. The "EXIT 13" sign was installed in the exit gore between studies and replaced a supplemental sign that read "NEW YORK" and "SOMERVILLE".

The left-hand exit has the appearance of a through movement, while the through movement lane has the appearance of an exit. This site presents the most confusing exit and through geometry found in the entire study. Since the diagrams represent actual geometry, they are as unusual in appearance as the exit itself. During the studies, about ten times as many through movement motorists per 1,000 made weaves over the painted gore than exiting motorists. This was apparently due to the effect of reversed geometry.

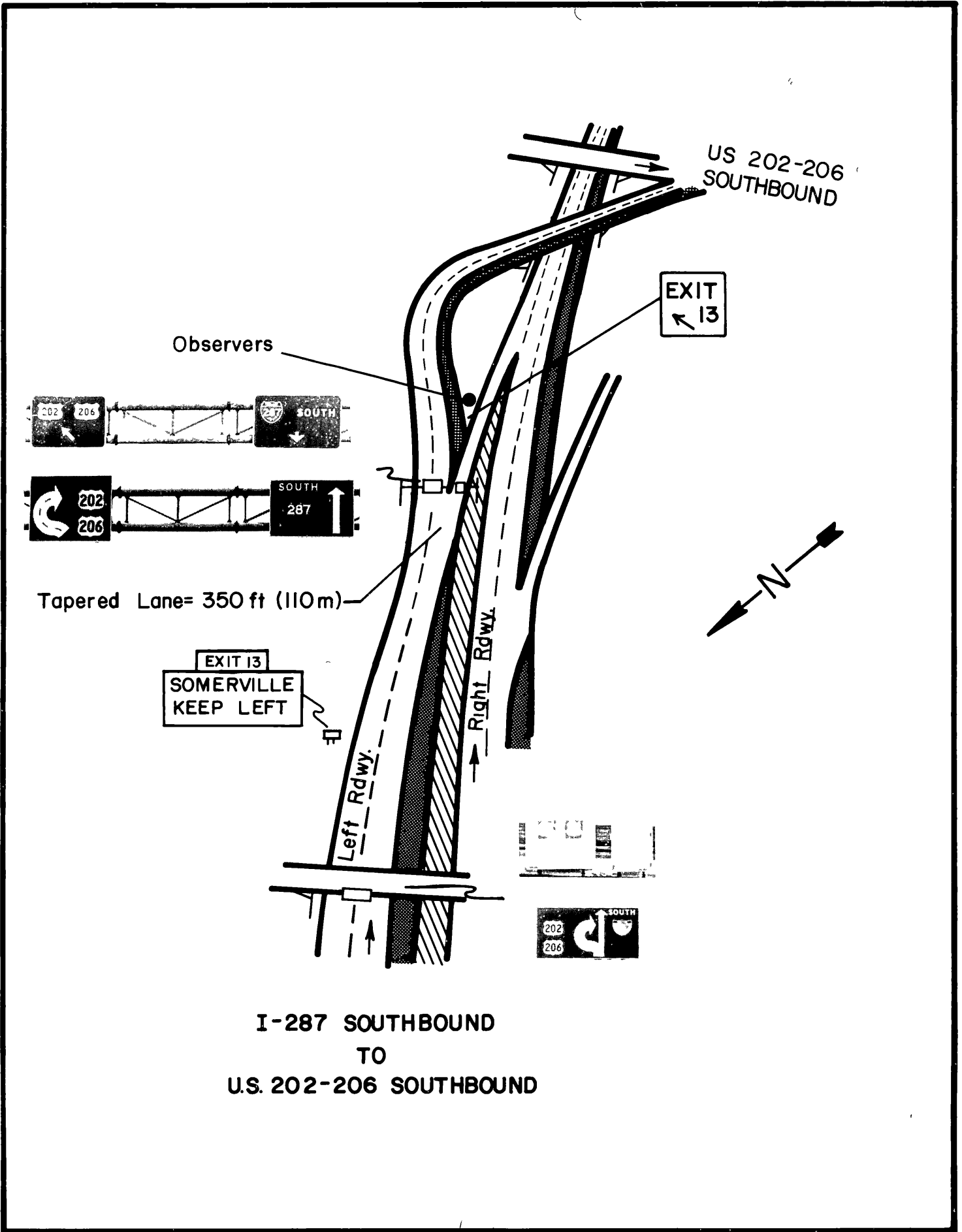


FIGURE 9 -STUDY SITE 6

Remarks

There was a non-significant decrease in SBR and a significant increase in UR after diagrammatic signs were installed.

Motorists may have difficulty accepting the confusing exit geometry as displayed diagrammatically on the signs. The statistical results of SBR and UR comparisons indicate that the diagrammatic signs used do not appear to be more effective than the conventional signs.

## SITE 7 - I-287 SOUTHBOUND TO U.S. 22 EASTBOUND

### Background

As seen in Figure 10, the exit under observation is the left hand and only exit for N.J. 22, a ramp for a direct left turn. Two lanes approach the interchange. Two lanes are added on the left, one for an additional through movement lane, and the other for exit deceleration. At the exit gore, three lanes are provided for through movement, beyond which an entrance lane is added on the right.

There was about a 6% increase in the volume of traffic approaching the gore area during the two year period between before and after studies which is the smallest increase among the ten study sites. Apparently, since I-78 has been extended to a location very close to U.S. 22 in Plainfield, east of this study site, many motorists have preferred to use it rather than this exit, because of the shorter distance involved.

### Observations

The "EXIT" sign positioned in the gore in 1971 was not present in 1973, neither was the white concrete gore point curbing. The white concrete gore point curbing was removed leaving dirt and grass prior to the study in 1973 as part of a repaving project.

The added lane on the left for the through movement requires the motorist to travel, laterally, 12 feet more than normal in order to get into the deceleration lane. This functional requirement tends to make the painted gore point more vulnerable to being traversed. This deviation may have been a greater problem to motorists in 1973 than in 1971 due to the loss of the exit sign and gore point curbing as targets.

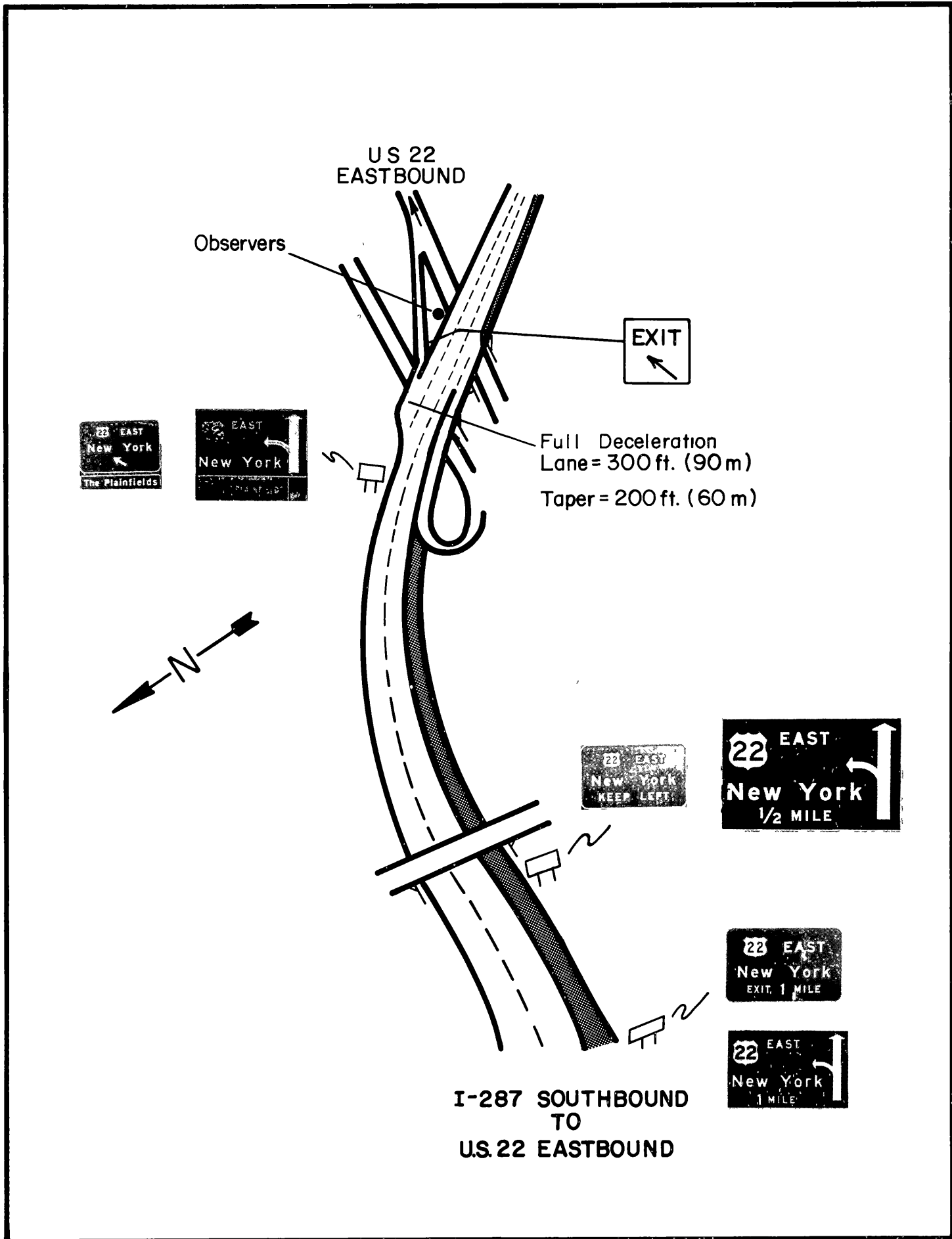


FIGURE 10-STUDY SITE 7

Remarks

There was a significant decrease in SBR and a significant increase in UR after diagrammatic signs were installed, resulting in a disagreement between the outcomes of statistical analysis of the two measures.

The diagrammatic signs present information about the exit being on the left side of the roadway. This additional piece of information would appear to be needed by motorists using the exit.

The lack of agreement in the statistical analysis may be the result of the missing "EXIT" sign in the gore during the 1973 studies.

A reduction in the percentage of exiting motorists indicates that a change in driver route choice had taken place between the before and after studies. The decreased use of this exit would not account for the increase in UR but may partially account for some of the decrease in SBR due to an assumed decrease in the proportion of "infrequent" drivers exiting at this point.

SITE 8 - I-287 SOUTHBOUND TO COUNTY ROUTE 527Background

As seen in Figure 11, the exit under observation is the right hand and only exit for County Route 527, a ramp for both a direct right and a semi-direct left turn. Three lanes approach the interchange on a curve to the left. A deceleration lane is added on the right for the exit, while three lanes continue through.

Repaving work with concrete median barrier replacement was in process about one mile upstream, during the study in 1973, with subsequent lane closures and frequently backed up traffic.

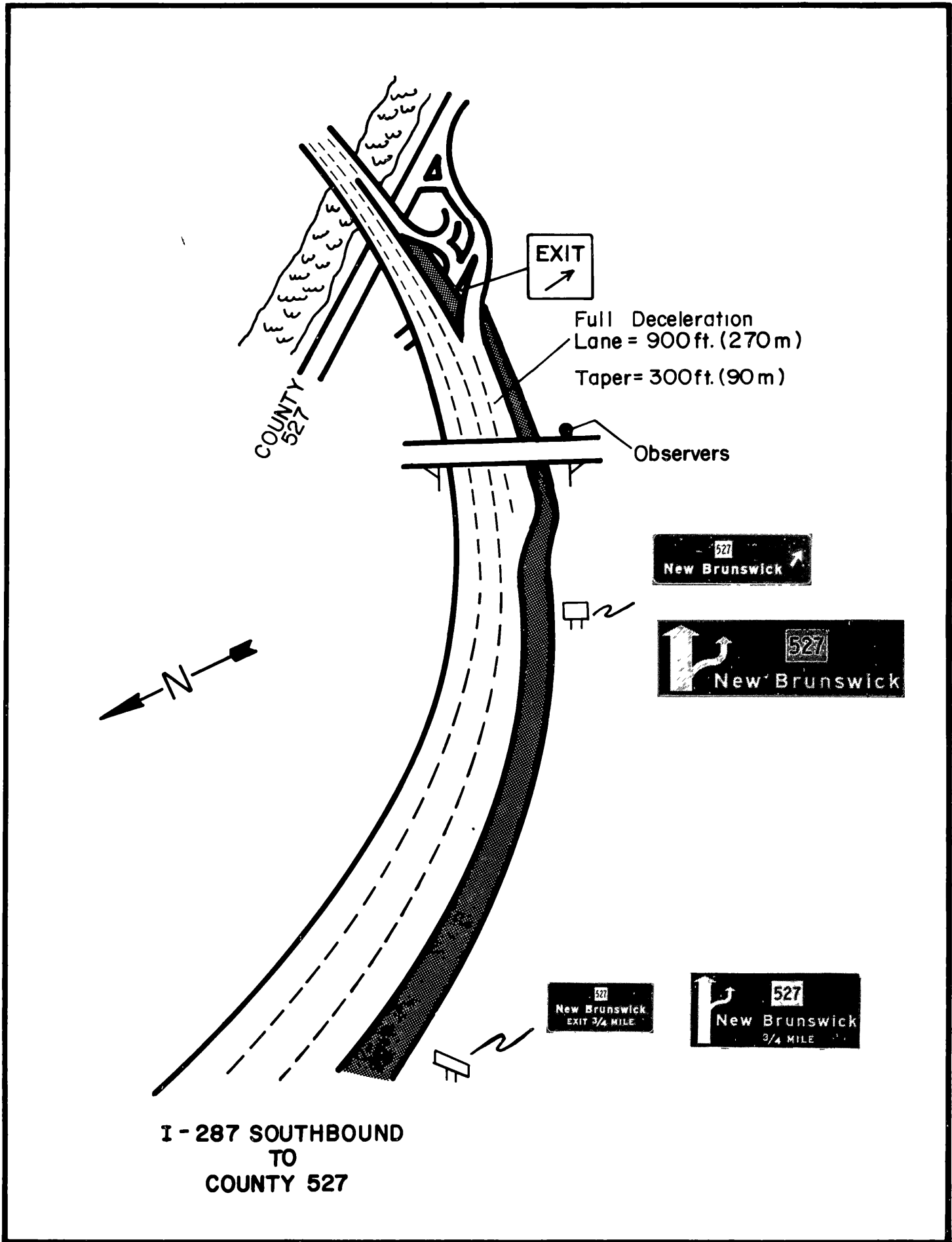
There was about a 25% increase in the volume of traffic approaching the gore area during the two year period between before and after studies, which may be partially attributed to additional egress at the southern end of the route.

Observations

There is an abrupt transition from the deceleration lane to the exit ramp on the right side of the roadway near the exit gore which, when combined with the left hand curve in the main roadway, encourages motorists to exit directly from the through movement lanes, rather than from the deceleration lane.

Remarks

The exit geometry is somewhat similar to Site 3 and the diagrammatic signs do not appear to be particularly more informative than the conventional signs studied here, as in the case of Site 3. At Site 8, the UR were unexpectedly high after the diagrammatic signs were installed.



I - 287 SOUTHBOUND  
TO  
COUNTY 527

FIGURE II-STUDY SITE 8

The lane closures and backed up traffic a mile upstream probably caused a bias in the 1973 data. Subsequent studies support the conclusion that the after study data taken in 1973 were invalid and they are not included in the report.

## SITE 9 - I-287 SOUTHBOUND TO N.J. 18

### Background

As seen in Figure 12, the exit under observation is the right hand and only exit for N.J. 18, a ramp for a direct right and semi-direct left turn. Three lanes approach the interchange and a deceleration lane is added on the right for the exit while three lanes continue through.

Repaving work with concrete median barrier replacement was in process about 1-1/2 miles upstream during the 1973 study, with subsequent lane closures and frequent traffic back ups.

There was about a 26% increase in the volume of traffic approaching the gore area during the two year period between before and after studies which may be partially attributed to additional egress at the southern end of the route.

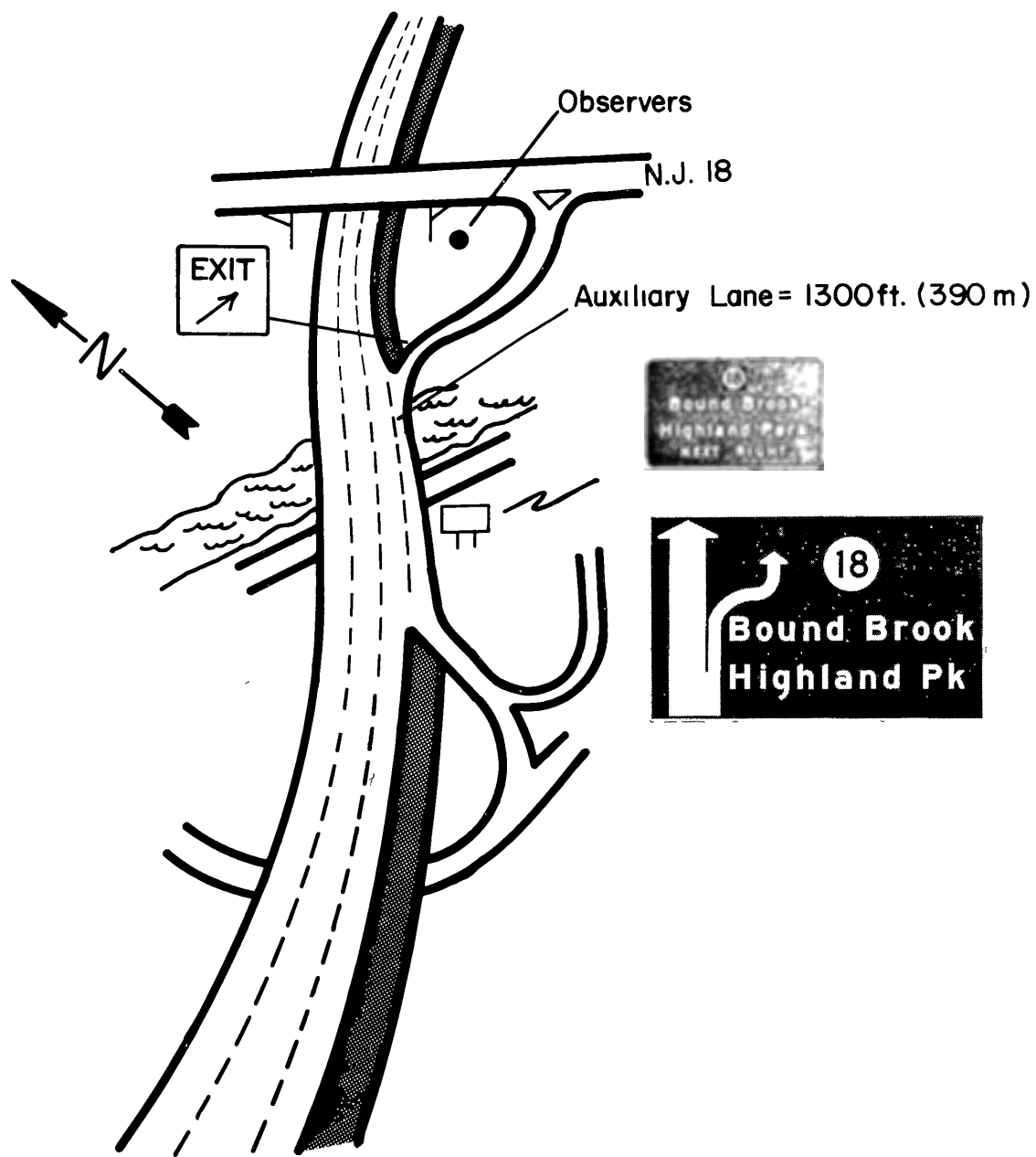
### Observations

Only one directional guide sign is provided for this exit and is located within the auxiliary lane. There should be an advanced guide sign as well as additional wording and special placement of the auxiliary lane sign that emphasizes the exit lane drop.

### Remarks

There was a significant decrease in SBR and a significant decrease in UR after diagrammatic signs were installed.

The diagrammatic sign at this study site appears to have an increased target value through the addition of the white diagrammatic symbol, although it does not seem to have added badly needed information. The statistical results indicated that the diagrammatic sign was more effective than the conventional sign.



I-287 SOUTHBOUND  
TO  
N.J. 18

FIGURE 12 - STUDY SITE 9

## SITE 10 - I-287 SOUTHBOUND TO U.S. 1 NORTHBOUND

### Background

As seen in Figure 13, the exit under observation is the second of two right hand exits for U.S. 1, a loop ramp for an indirect left turn. Five lanes approach the interchange. The right lane, an auxiliary lane for traffic coming from County Route 501, is dropped at the first exit ramp. A 730 foot (220 meter) weaving lane is provided between the second entrance ramp and the loop exit ramp, while four lanes continue through.

There was about a 40% increase in the volume of traffic approaching the gore area during the two year period between before and after studies, which may be partially attributed to additional access at the southern end of the route.

### Observations

The sign in the observed gore is the only one in the series of signs for this interchange that is not clearly visible at an adequate distance, since it is positioned far to the right and thus partially obscured by the underpass bridge rail and weaving traffic. The painted gore does not have an adequate sight distance, because of a crest at the underpass bridge. An exit direction sign should be added for the second exit to help compensate for problems associated with the unusual modification of the cloverleaf design, the subsequently greater distance between the first and second exits, and the shortened sight distance of the northbound exit gore and sign.

As in the case of Site 1, only EUR were selected for analysis at this site, since many of the through unusual maneuvers were generated by entering motorists who would not have been exposed to the whole exit approach.

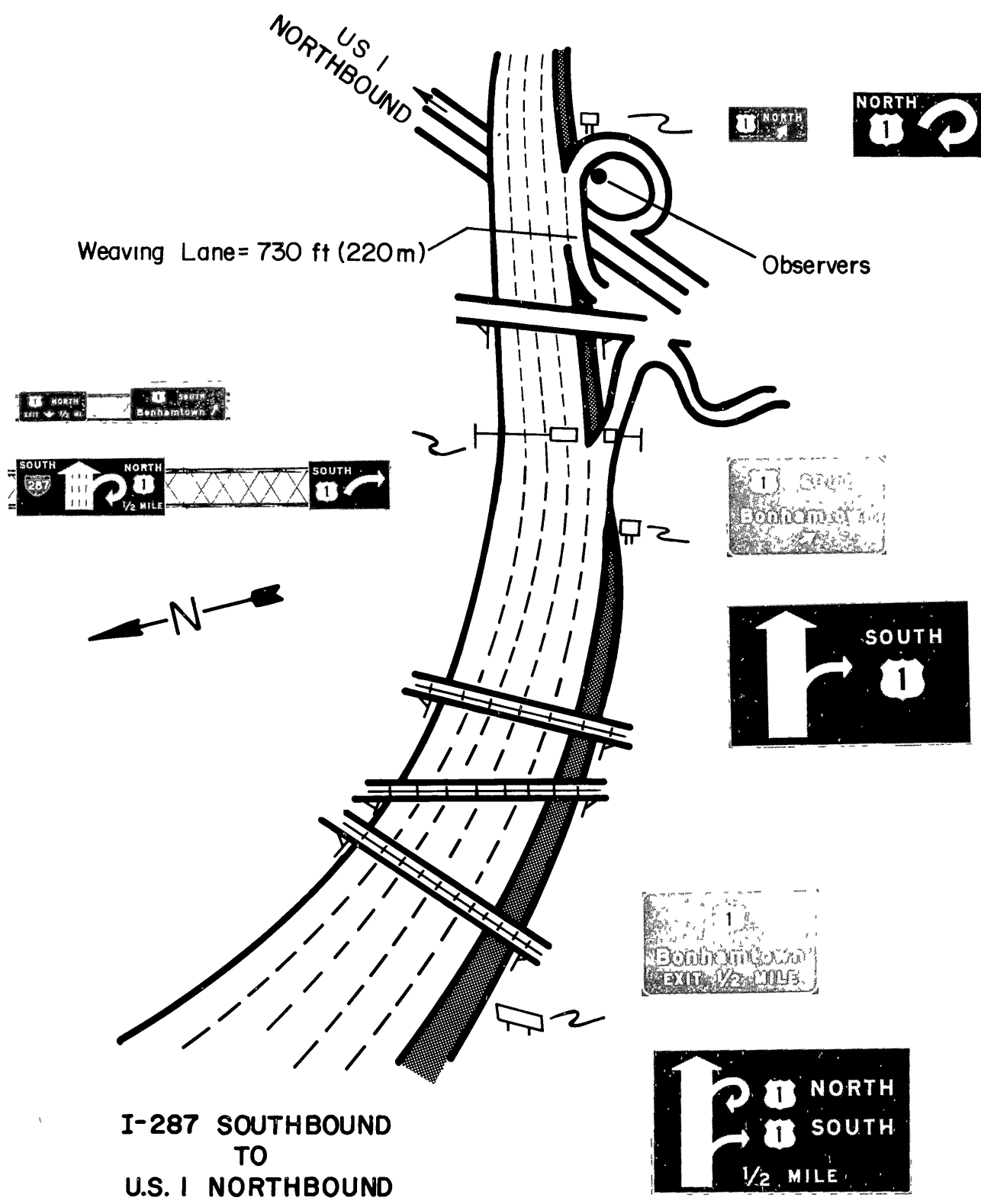


FIGURE 13 - STUDY SITE 10

Remarks

There was a significant decrease in SBR and a non-significant decrease in EUR after diagrammatic signs were installed. There was a decrease in the proportion of motorists exiting from 38 to 24 percent of the total approach volume. A decrease in the percentage of exiting motorists may indicate a lower proportion of "unfamiliar" motorists, which may in turn partially account for the lower UR found in 1973.

This site is similar to Site 1 in that they are both within clover-leaf interchanges, but unlike Site 1, the exit under observation has a short sight distance, lacks an exit direction sign, and had a decreased as opposed to an increased percentage of exiting motorists.

If there had been no change in driver route choices due to added connections at the southern end, the results of statistical comparison may have been more alike.

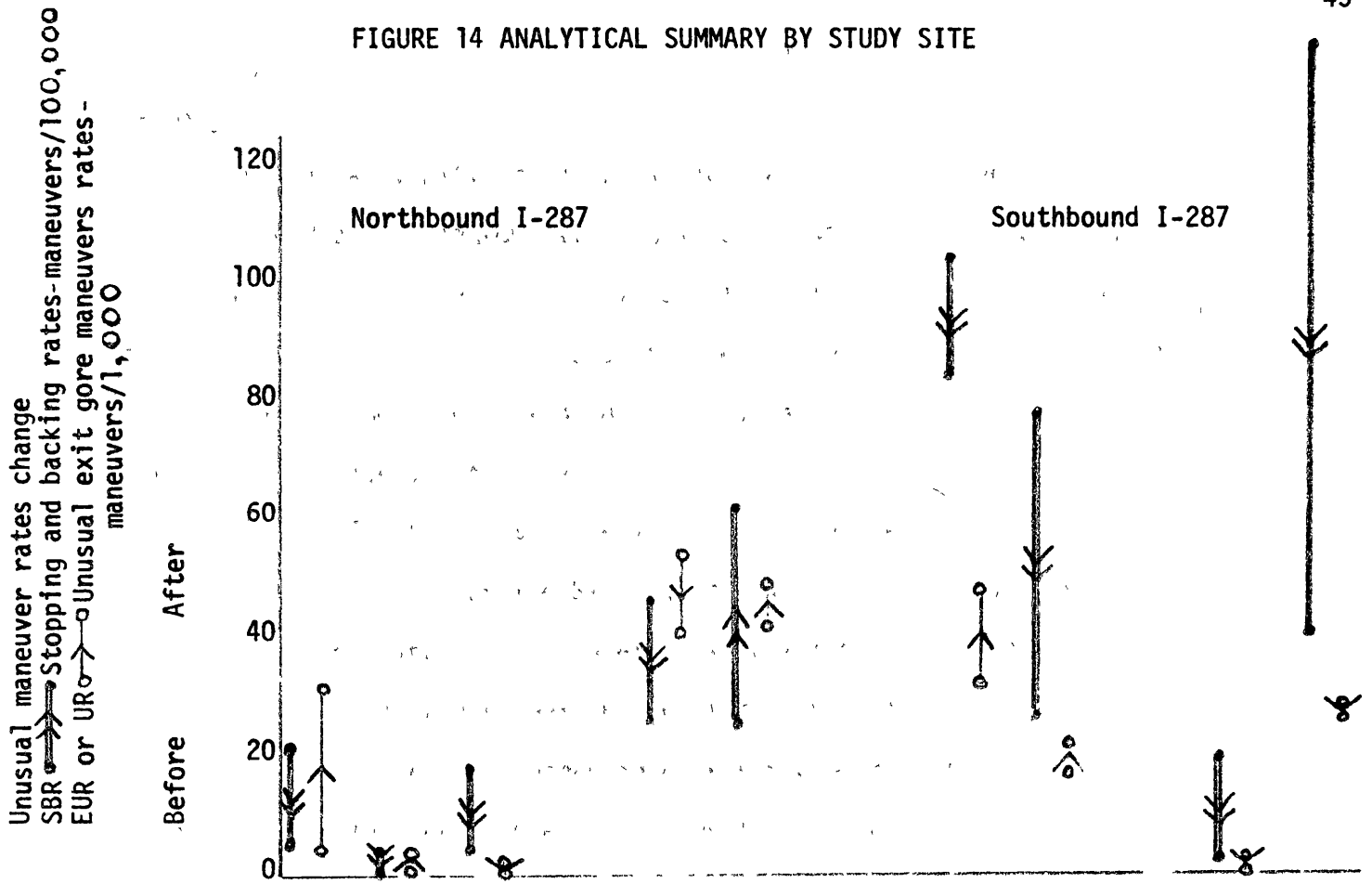
## VI. RESULTS

Table 1 summarizes the data collected and results of statistical analysis. Figure 14 visually summarizes the overall results of before and after comparisons of unusual maneuvers and the effect of bias at each study site. The direction and magnitude of change in rate from "before" to "after" conditions as well as the magnitude of each rate are shown graphically with arrows. The significance of the rate change is shown from the use of a Wilcoxon, nonparametric, matched pairs test. The change in rate from "before" to "after" conditions, representing twenty to twenty-one matched hourly pairs, is shown to be significant or not significant at the 95% level of confidence, in the direction of the change. If the direction of change of SBR and UR are not the same, or in other words conflict, this is shown within the row entitled "Change Conflict". In general, a conflict in direction is indicative of a weak or inconclusive difference, especially if the change in both SBR and UR are significant. The source of apparent bias effecting the data from the "after" studies is shown. The degree to which the bias affected the data cannot be accurately determined, but an assumption has been made for each site as to whether the bias source would tend to have made the after study rates higher or lower than they would have been without an operating bias.

As seen in Figure 14, Study Sites 3 and 5 were the only sites at which both the direction of SBR and UR change agreed and there was no observable source of bias. Conclusions may be based on the results of these studies without qualification.

Agreement between the SBR and UR direction of change in rates is shown

FIGURE 14 ANALYTICAL SUMMARY BY STUDY SITE



Site Number	1	2	3	4	5A	5B	6	7	8	9	10
Maneuver rate Category <sup>1</sup>	SBR EUR	SBR UR	SBR UR	SBR UR	SBR UR	SBR UR	SBR UR	SBR UR	SBR UR	SBR UR	SBR EUR
Significance of Change <sup>2</sup>	NS S	NS S	S NS		NS S	S S	NS S	S S		S S	S NS
Change Conflict <sup>3</sup>	C	C	A		A	A	C	C		A	A
Bias Source <sup>4</sup>	EP	EP		OB			EP	MS/EP	CW	CW	EP
Bias Direction <sup>5</sup>	H	H					L	H/L		H	L

1 - Categories are: stopping and backing (SBR); exiting maneuvers (EUR); both exiting and through maneuvers (UR).  
 2 - Rates compared on an hourly basis at the 95% confidence level are either: significant (S) or; not significant (NS) with one-tailed, nonparametric test.  
 3 - The direction of change of SBR and UR rates between before and after studies either conflict (C) or agree (A).  
 4 - Change of conditions between before and after studies may have a bias on the test results. The bias sources were: change in % exiting (EP); consistent observer error (OB); missing exit sign (MS); construction work upstream (CW).  
 5 - The bias source would tend to have made the after study rates higher(H) or lower (L) than they would have been without bias.

TABLE 1  
UNUSUAL MANEUVERS AND STATISTICAL  
SUMMARY BY STUDY SITE

Site Number		1	2	3	4	5A	5B	6	7	8	9	10
SBR	Before	19.0	3.7	16.2		44.7	23.0	103.6	74.1	35.7	23.6	134.6
	Mnvs./ 100,000 After	6.4	0.0	3.3	16.1	24.6	60.5	83.6	21.5		3.1	39.0
UR	Before	4.3**	1.1	1.0		52.0	38.7	28.7	14.4	3.6	1.1	23.2**
	Mnvs./ 1,000 After	30.8**	3.1	0.8	15.9	38.7	46.1	44.4	18.4		0.6	22.7**
AHV	Before	1002	1292	1232	1226	671	826	506	836	1335	1209	1309
	After	1483	1669	1528	1479	812	865	626	886	1670	1550	1833
% Vol. Exited	Before	7	8	10	49	47	50	46	20	22	19	38
	After	10	11	8	49	50	51	41	14	22	17	24
Z Value Wilcoxon Test*	SBR	1.21	1.00	1.75		0.97	1.78	0.85	2.04		2.02	3.33
		NS	NS	S		NS	S	NS	S		S	S
(Hourly Rates)	UR	3.75	4.01	1.04		3.64	2.85	2.40	3.94		2.50	0.14
		S	S	NS		S	S	S	S		S	NS

Abbreviations Used

SBR - Stopping and backing maneuver rate.

UR - Unusual exit gore maneuvers rate.

AHV - Average hourly volume of 2 axle vehicles approaching the gore area.

\* - Normal standard deviate, Non-Parametric Test.

NS - Not Significant

S - Significant

\*\* - Includes unusual exit gore maneuvers rates for exiting vehicles only.

NOTE: Tabulation or analysis of three or more axle vehicles is not included in this report.

for Study Sites 9 and 10 but a biasing factor was known to have been operating during the after studies of each of these sites. At Site 10, the effect of bias from a lower percent of approach volume that exited would tend to have made the reduction in rates appear to be greater than they would have been without bias, because the effect of bias would be to make the "after" study rates superficially low. The data at Sites 1 and 10 may be grouped for analysis since they are geometrically similar loop exits with the same interchange. The bias effects from a change in percent exited are in opposition and should hypothetically cancel. On applying the Wilcoxon Test for one direction at the 95% level of confidence, a significant decrease in SBR and a significant increase in EUR is found.

Conflict between the SBR and UR direction of change in rates is shown for Study Sites 1, 2, 6 and 7. A source of bias was known to have existed during the "after" studies at each of their sites. The effects of bias may be interpreted from Figure 14.

The before study data at Site 4 and the after study data at Site 8 are disregarded, and the results of including lane lines in the "Diagrammatic Sign Study" performed in 1970 should be reviewed and regarded as a somewhat liberal estimate.

The reduction of rates from Site 9 studies should be regarded as conservative, since effects of bias may tend to make the after study rates superficially high. At Site 9, bias from the effects of upstream construction activity would tend to have made the reduction in rates shown in Figure 14 to be less than without bias, because the "after" study rates tend to be superficially high.

At Site 2 both SBR and UR rates are very low, and in contradiction, as a result should be regarded as inconclusive.

Diagrammatic signs designed for the unusual left hand exit at Site 6 do not appear to be more effective than the conventional signs that were there.

The results of the Site 7 analysis are inconclusive, because of a missing exit sign in the gore during the after study in 1973.

## VII. FINDINGS FROM STUDIES AT SITE 4

In Figure 15, seven studies performed for six years at Site 4 are plotted by month according to the average unusual maneuvers per 1,000 vehicles for each study. A base curve is drawn between three studies performed with the same signs in different seasons within a 12 month period to illustrate the seasonal variation that was found. Variation found between years is also shown among studies performed with the same signs on the closest dates of the same month. Several conclusions can be made from these comparisons.

1. Seasonal variation can be greater than annual variation.
2. Declining gore weaving rates may be found for at least a year after installation of a diagrammatic sign.

Seasonal variation of unusual maneuvers rates may have a marked effect on "before" and "after" comparisons with a month between studies. The actual rate reduction found with the addition of lane lines in the old diagrams in June, 1970 may be seen in Figure 15 by directly comparing that point with the old diagrammatic rate from the curve directly above it, rather than with the rate actually found in May 1970.

A lower rate than the previous year with no change in signing was found in two occasions as can be seen in Figure 15 by comparing 1970 with 1971 in May and 1973 with 1974 in August. The reduced rates have not been found to be related to volume but may be related to driver familiarization.

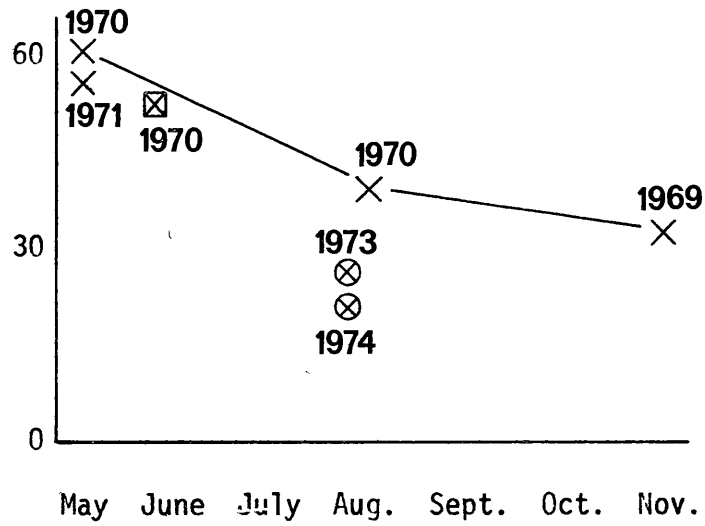
Comparisons between "before" and "after" conditions in future studies should take these possible variations in account when interpreting results.

### Comments on Unusual Maneuvers in Field Experiments

Unusual maneuvers can be used to measure the effect of sign and other types of changes. Rigid definitions of unusual maneuvers by category should

FIGURE 15  
UNUSUAL MANEUVERS RATES FOR SITE 4 STUDIES  
BY MONTH OF YEAR

Exiting Unusual Maneuvers  
(per thousand vehicles per hr.)



Sign Type Key

- × Old Diagrammatic
- ⊠ Old Diagrammatic with lane lines
- ⊗ New Diagrammatic

be required for field studies since they can occur almost anywhere on or near the road and can vary in degree of potential hazard and frustration to those involved.

In their use as measures in before and after type studies, a certain amount of experimental control can be obtained over unusual maneuvers. Extraneous variation in sign studies may be produced by changes in the motorists, the roadway, the vehicles, as well as by transient environmental events. Some basic analytical control may be easily attained over some of this variation by defining categories for comparison ahead of time, holding conditions as constant as possible, and noting all uncontrollable factors that might affect the data.

The data collection procedure for this project was designed for matched pair analysis, but does not, however, minimize the variation from changes in speed profiles or proportion of unfamiliar motorists that may occur after several years. The proportion of unfamiliar motorists in the traffic stream can be an especially important factor in affecting the number of unusual maneuvers at any given point in time, since motorists that are unfamiliar to a route interchange would tend to be more easily confused than a regular commuter.

In this study, the frequency of unusual maneuvers was divided by the volume to obtain an hourly rate with the theory that the number of unfamiliar motorists increases linearly with the number of vehicles. There is little evidence to support or deny this theory and its validity will probably not hold with a change in the driver population or a change in routing.

## VIII. DISCUSSION AND RECOMMENDATIONS FOR FUTURE RESEARCH

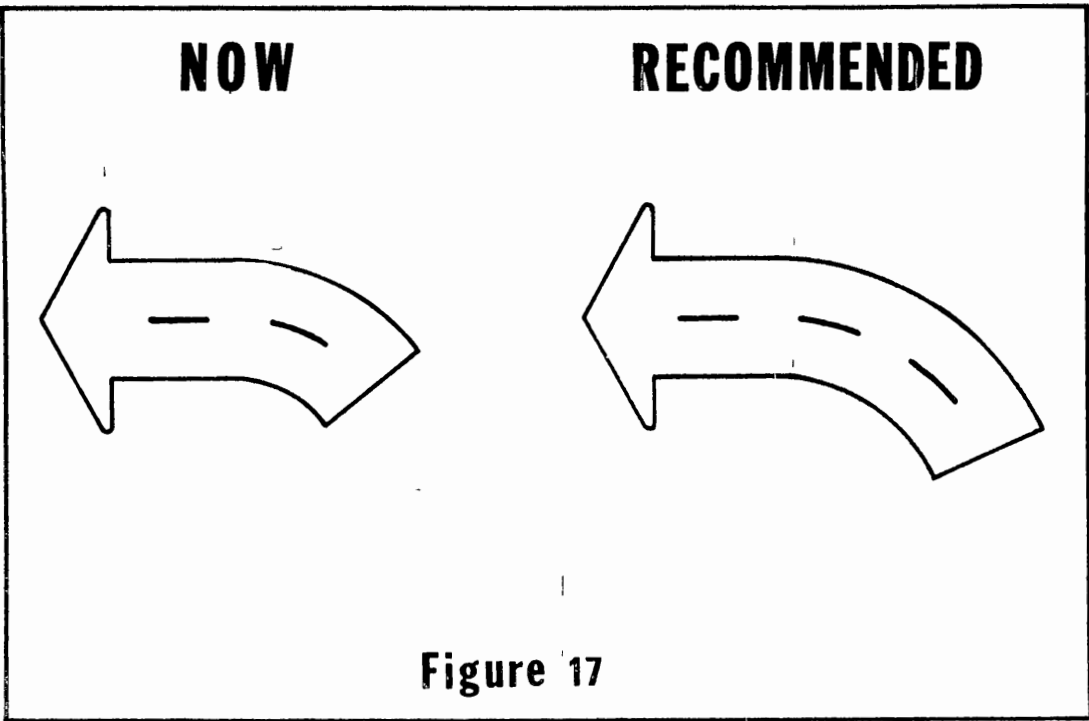
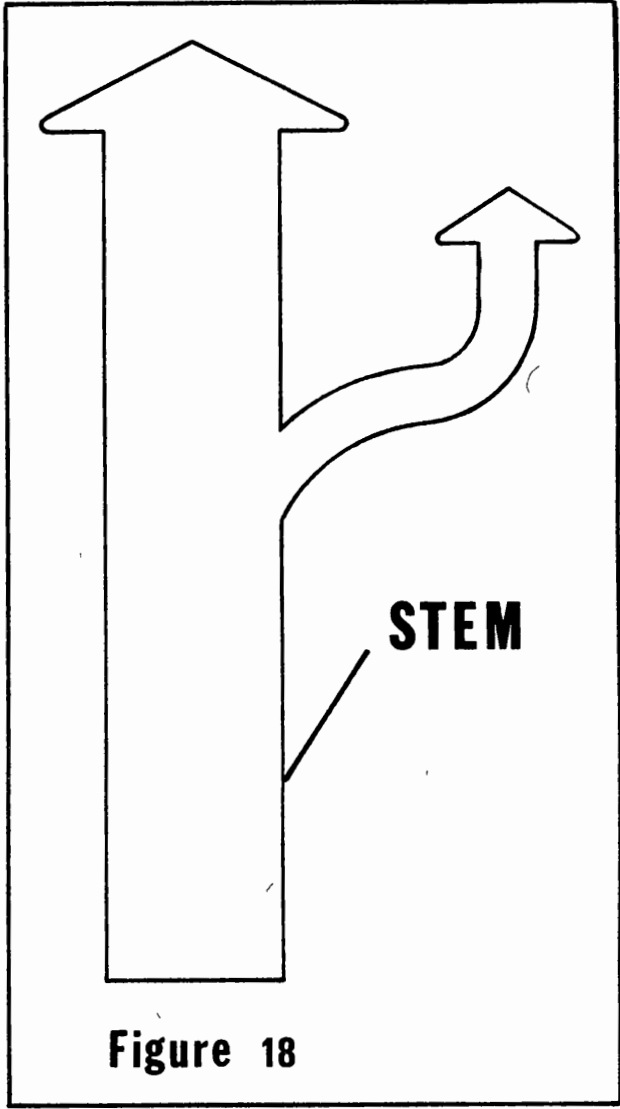
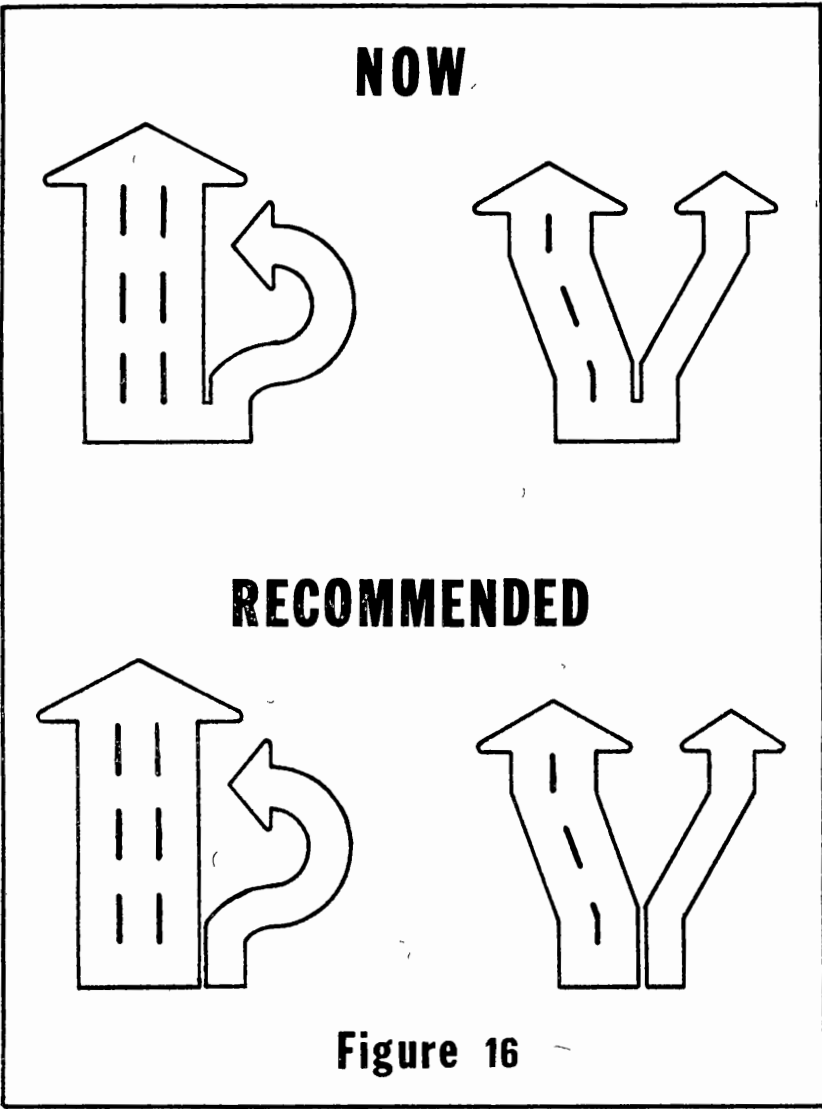
### Graphic Adequacy of I-287 Diagrams

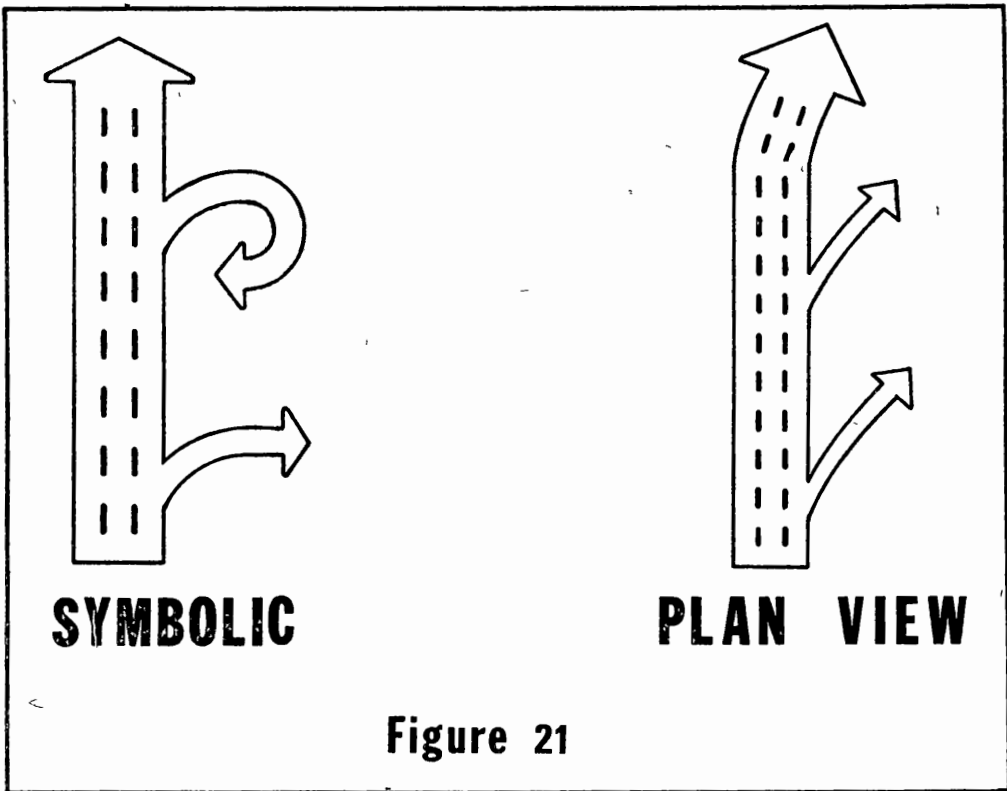
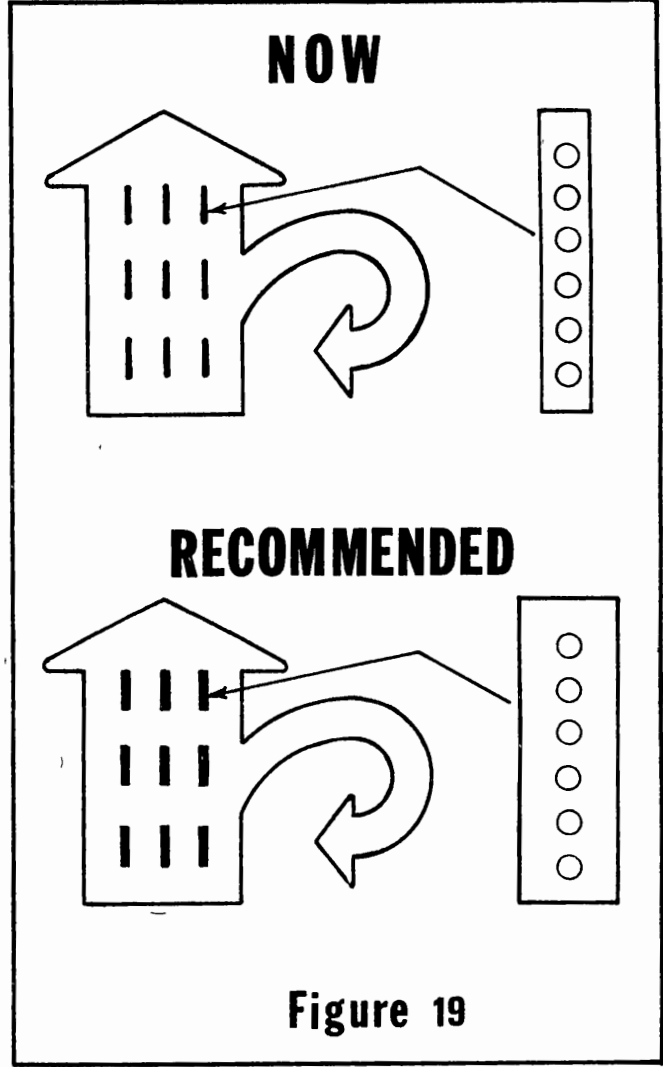
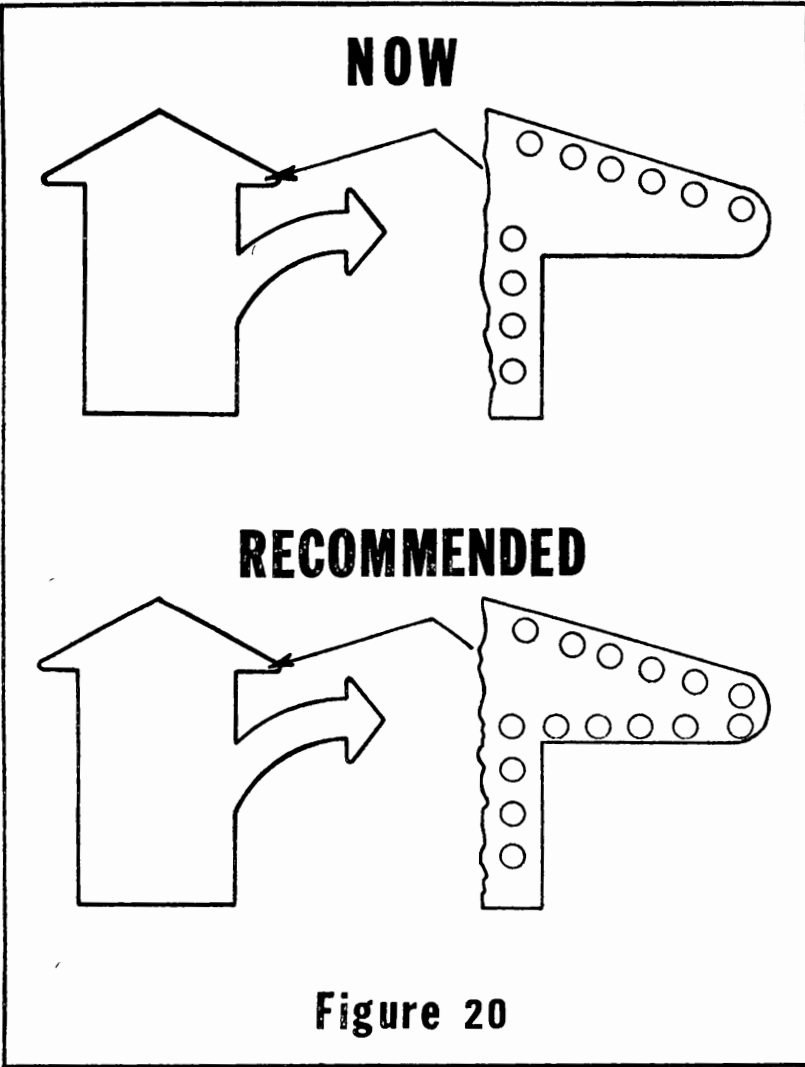
The method developed to design diagrams for I-287 could be improved upon to the benefit of the draftsman's ease and perhaps the motorist's perception. Modification to both the method and the diagrams that follow is recommended for evaluation:

- . complete separation between graphic movements for exit lane drops and splits (Figure 16)
- . extension of leading ends on gore located independent arrows that curve (Figure 17)
- . establishment of standard stem lengths for ground mounted advance guide and exit direction sign diagrams (Figure 18)
- . widening of lane lines to 3 inches instead of 2 inches (Figure 19)
- . heavier arrowhead overhand (Figure 20)

In general, more panel space should be considered for advance guide diagrammatic ground mounted signs than was used on I-287, since the addition of a diagram requires more space with given letter standards. Besides needing more space, diagrammatics require a greater degree of overall graphic organization than conventionals. In future work, design standards should be developed so incorrect message-to-diagram associations are minimized, correct associations are maximized, and diagram-to-message and message-to-message interfaces are organized so that they are in predictable locations. With the exception of sign panel space, these goals were accomplished on I-287 by means of standardization.

There is some uncertainty regarding the specific design of diagram symbols beyond the long narrow "plan view" I-495 type<sup>6</sup> and the short wide





more symbolic type<sup>4</sup> (I-287). Refer to Figure 21. The "plan view" type is a truer reproduction of the gore area approach in that main roadway curvature is shown. While the "plan view" type shows exiting sides, it does not show exit ramp turn directions. The more symbolic type is a symbolic reproduction of the gore area approach with all approach roadways shown vertically regardless of approach curvature. In the more symbolic type, exiting sides as well as exit ramp turn direction are displayed.

Although all drivers should profit from knowing the exiting sides in advance and the information should not be too hard to understand, graphically, there is some doubt as to the ability of all drivers to perceive the symbolic value of an implied exit ramp turn direction when it is semi-direct or indirect.

Further research is suggested to document the values of these differences in sign types in terms of exit performance since it has not been adequately documented with deliberate experimentation to date.

#### Exiting Problems and Freeway Characteristics

Advanced plan view perception of turn provisions was not as necessary in the past since speeds were slower and turn provisions were usually in plan view. If the motorist were to make an incorrect choice, he would just proceed to the next opportunity for a U-turn suffering little delay.

On the interstate freeways like I-287 in New Jersey and I-495 in Washington D.C., an incorrect choice could force a motorist into a half hour delay due to controlled access and long distances between exits where U-turns could be made. An advanced view of ramp sequences, exit sides, and ramp configurations prior to an interchange is not usually available

to the approaching motorist. This exit information deficiency is aggravated by truck interference and lane changing resistance. On I-287 some of these problems seemed to have been a result of difficulty in predicting 20 year volumes, geometric design and cost trade-offs, and lack of motorist information needs guidelines at the time of design.<sup>10</sup>

Unusual maneuvers at I-287 exits may be associated with misleading or unexpected geometry, lack of sign location space, short exit gore, sight distance, lane drops at exits, undersigning at critical route decision points, and perhaps unorganized exit located trailblazers.

As brought out in the report the use of diagrammatic signs shows potential in certain situations. It is also evident from the studies performed on I-287, that the following other types of improvements should be further investigated:

- . Accurate use of conventional lane assignments, when chosen.
- . Use of extra intermediate sign locations to emphasize important and unusual interchanges.
- . Alteration of existing lane drops at exits so that exiting and last instant merging are separated, longitudinally.
- . Special signing in auxiliary lanes to warn motorists of the lane drop at the exit.
- . Design of gore striping layouts to maximize exit gore sight distances.
- . Design of vertical/horizontal geometry to maximize exit gore sight distances.
- . Organization and functional placement of trailblazers to minimize decision conflicts at exits.

Parameters used in (6) and this report to evaluate diagrammatic type signing can also be used to field study lane drop at exit alterations, gore sight distance improvements, as well as the effect of trailblazers used at exit gores. These same parameters may be used to measure the values of improved conventional sign designs and placements as well.

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Department of Transportation, 1969.

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A P P E N D I X

TABLE 2

SITE 1 UNUSUAL MANEUVERS  
AND VOLUMES OF TWO AXLE VEHICLES ONLY  
(OBSERVER AVERAGES)

Conventional (Before)	DATES		Day	Hour	Total Maneuvers				Stopping and Backing		Volume			
	(C)	Diagrammatic (D) (After)			Exit	D	C	Thru	D	C	D	C	D	C
7/6/71		7/10/73	Tues.	2-3	0	2.0	0	4.6	0	0	37	105	727	1013
				3-4	0	9.0	1.0	7.0	0	1.0	79	160	872	1327
				4-5	0	3.7	0	7.0	0	0	140	198	1570	1953
7/7/71		7/11/73	Wed.	2-3	0	3.3	0	2.3	0	0	49	104	660	991
				3-4	1.0	3.3	1.0	.3	2.0	0	78	197	956	1293
				4-5	0	2.7	0	2.0	0	0	106	232	1285	1812
7/8/71		7/12/73	Thur.	2-3	2.0	5.0	0	3.0	0	0	54	123	659	1057
				3-4	0	5.0	0	2.0	0	0	74	156	888	1339
				4-5	1.0	4.6	1.0	11.3	0	0	141	229	1401	1990
7/9/71		7/13/73	Fri.	2-3	0	0	0	2.0	0	0	43	122	742	1218
				3-4	0	7.3	0	2.3	0	1.0	87	174	1087	1603
				4-5	0	7.0	3.0	3.0	0	0	139	227	1737	2126
7/10/71		7/14/73	Sat.	2-3	0	3.0	0	2.3	0	0	48	107	697	1059
				3-4	0	1.3	0	2.0	0	0	53	126	649	1003
				4-5	1.0	2.0	2.0	1.7	1.0	0	35	104	657	1139
7/11/71		7/15/73	Sun.	2-3	0	6.3	1.0	2.0	0	0	35	84	780	1122
				3-4	0	2.0	3.0	1.0	1.0	0	38	92	730	1002
				4-5	5.0	8.7	1.0	2.7	0	0	19	72	629	963
7/12/71		7/16/73	Mon.	2-3	1.0	2.7	0	2.0	0	0	51	128	604	976
				3-4	0	10.7	1.3	.3	0	0	111	146	818	1271
				4-5	0	5.7	1.0	3.7	0	0	105	212	1364	1786

TABLE 3  
SITE 2 UNUSUAL MANEUVERS  
AND VOLUMES OF TWO AXLE VEHICLES ONLY  
(OBSERVER AVERAGES)

Conventional (Before)	DATES		Day	Hour	Total Maneuvers				Stopping and Backing		Volume			
	(C)	Diagrammatic (D) (After)			Exit		Thru		C	D	Exit		Thru	
					C	D	C	D	C	D	C	D	C	D
7/16/71		7/20/73	Fri.	2-3	0	2.7	0	4.0	0	0	113	178	1007	1294
				3-4	0	3.3	2.0	8.0	0	0	123	243	1426	1802
				4-5	0	3.3	1.0	8.7	0	0	162	243	2128	2409
7/17/71		7/21/73	Sat.	2-3	0	2.0	0	4.0	0	0	80	96	1053	1217
				3-4	0	4.0	1.0	5.0	0	0	70	117	833	1311
				4-5	0	1.3	1.0	1.7	0	0	70	90	996	1230
7/18/71		7/22/73	Sun.	2-3	0	1.0	1.0	2.3	1.0	0	50	106	1120	1383
				3-4	1.0	2.3	0	6.0	0	0	50	81	962	1177
				4-5	0	2.3	1.0	2.3	0	0	30	56	870	1170
7/19/71		7/23/73	Mon.	2-3	0	6.3	0	2.7	0	0	107	199	855	1095
				3-4	0	5.3	1.0	3.3	0	0	118	198	1086	1345
				4-5	1.0	1.3	0	6.7	0	0	129	226	1568	2094
7/20/71		7/24/73	Tues.	2-3	1.0	2.7	1.0	1.0	0	0	109	201	820	1064
				3-4	1.0	2.7	3.0	4.0	0	0	116	220	1108	1464
				4-5	0	4.0	2.0	6.7	0	0	149	227	1811	2029
7/21/71		7/25/73	Wed.	2-3	0	2.0	2.0	4.0	0	0	98	179	884	1052
				3-4	0	3.0	2.0	3.0	0	0	111	232	1073	1387
				4-5	0	0	1.0	4.0	0	0	133	216	1567	2069
7/22/71		7/26/73	Thur.	2-3	0	1.7	0	3.0	0	0	104	183	833	1163
				3-4	1.0	2.7	1.0	10.3	0	0	131	238	1116	1440
				4-5	1.0	1.0	4.0	12.7	0	0	161	248	1805	2072

TABLE 4  
SITE 3 UNUSUAL MANEUVERS  
AND VOLUMES OF TWO AXLE VEHICLES ONLY  
(OBSERVED AVERAGES)

Conventional (Before)	DATES		Day	Hour	Total Maneuvers				Stopping and Backing		Volume				
	(C)	Diagrammatic (D) (After)			Exit	Thru	C	D	C	D	Exit	Thru	C	D	
7/26/71		7/30/73	Mon.	2-3	1.0	0	0	2.0	0	0	82	130	704	902	
				3-4	0	1.0	0	1.0	0	0	95	123	831	1229	
				4-5	0	0	2.0	1.0	0	0	156	122	1438	2131	
7/27/71		7/31/73	Tues.	2-3	0	0	1.7	0	0	0	0	100	132	696	932
				3-4	0	0	0	0.7	0	0	94	144	790	1236	
				4-5	0	0	1.0	1.0	0	0	351	167	1606	2077	
7/28/71		8/1/73	Wed.	2-3	1.0	0	2.0	1.5	1.0	0	100	120	794	936	
				3-4	0	0	0	2.0	0	0	127	129	1093	1258	
				4-5	0	0	0	1.0	0	0	151	157	1613	1898	
7/29/71		8/2/73	Thur.	2-3	0	1.0	0	1.0	0	0	111	154	817	1027	
				3-4	0	0	2.0	1.0	0	0	92	136	1104	1290	
				4-5	0	0	4.0	1.0	0	0	151	139	1543	1875	
7/30/71		8/3/73	Fri.	2-3	0	0	0	2.0	0	0	101	133	714	1351	
				3-4	0	0	1.0	3.0	0	1.0	153	143	1025	1610	
				4-5	1.0	0	1.0	1.0	0	0	207	209	1549	2291	
7/31/71		8/4/73	Sat.	2-3	1.0	1.0	1.0	0	1.0	0	94	126	1340	1325	
				3-4	0	0	1.0	1.0	1.0	0	97	114	1117	1191	
				4-5	1.0	1.0	1.0	0.5	1.0	0	105	106	1253	1149	
8/1/71		8/5/73	Sun.	2-3	1.0	0	1.0	1.0	0	0	63	78	992	980	
				3-4	0	0	1.0	0	0	0	61	65	1031	1015	
				4-5	1.0	0	0	1.0	0	0	43	122	1116	1167	

TABLE 5

SITE 4 UNUSUAL MANEUVERS  
AND VOLUMES OF TWO AXLE VEHICLES ONLY  
(OBSERVER AVERAGES)

Diagrammatic (Before)	DATES		Day	Hour	Total Maneuvers				Stopping and Backing		Volume			
	Diagrammatic (Old)	Diagrammatic (New)			Exit	Thru		DB	D	DB	D	Exit	Thru	
					DB	D	DB	D	DB	D	DB	D	DB	D
8/5/71		8/9/73	Thur.	2-3		12.0		2.7		1.0	465	513	435	536
				3-4		21.0		2.3		0	611	687	545	638
				4-5		23.0		2.7		0	1112	1151	1024	1025
8/6/71		8/10/73	Fri.	2-3		10.7		3.0		0	579	499	625	567
				3-4		12.0		8.7		1.0	793	926	835	1000
				4-5		19.3		9.7		0	846	1213	879	1412
8/7/71		8/11/73	Sat.	2-3		25.0		4.0		0	454	598	656	841
				3-4		20.3		5.7		1.0	462	555	588	696
				4-5		20.3		2.7		0	406	543	453	656
8/8/71		8/12/73	Sun.	2-3		27.0		4.7		1.0	691	656	945	917
				3-4		28.7		0		0	526	549	664	688
				4-5		17.3		33.0		0	376	433	575	775
8/9/71		8/13/73	Mon.	2-3		25.0		2.3		1.0	369	483	364	475
				3-4		22.3		.7		0	557	652	439	589
				4-5		18.3		1.0		0	460	1119	484	1002
8/10/71		8/14/73	Tues.	2-3		8.0		0		0	460	505	384	457
				3-4		12.7		2.0		0	571	644	523	628
				4-5		9.0		2.0		0	821	1065	1018	1035
8/11/71		8/15/73	Wed.	2-3		16.3		3.0		0	418	552	381	503
				3-4		8.0		1.3		0	718	686	554	550
				4-5		40.0		5.0		0	960	1088	723	942

TABLE 6  
SITE 5(A) UNUSUAL MANEUVERS  
AND VOLUMES OF TWO AXLE VEHICLES ONLY  
(OBSERVER AVERAGES)

Conventional (Before)	DATES		(M)	Day	Hour	Total Maneuvers				Stopping and Backing		Volume			
	(C)	Mod. Conv. (After)				Exit		Thru		C	M	Exit		Thru	
						C	M	C	M	C	M	C	M	C	M
8/15/71		8/20/72	Sun.	2-3		--	10.0	--	33.7	--	0	--	497	--	610
				3-4	14.3	8.7	34.7	25.3	1.0	0	349	412	429	506	
				4-5	12.7	8.3	25.7	23.7	1.0	0	290	380	313	466	
8/16/71		8/14/72	Mon.	2-3	7.0	5.0	15.0	13.2	0	1.0	190	243	221	260	
				3-4	8.7	11.5	10.0	9.0	0	0	304	299	268	275	
				4-5	12.7	16.4	13.0	16.6	0	0	315	547	287	443	
8/17/71		8/15/72	Tues.	2-3	8.7	2.3	15.3	19.0	0	0	219	262	228	246	
				3-4	18.0	9.7	14.0	18.3	0	0	312	356	271	284	
				4-5	10.7	18.0	14.7	6.3	0	0	373	598	326	435	
8/18/71		8/16/72	Wed.	2-3	24.3	4.7	25.0	15.3	0	0	273	274	230	254	
				3-4	19.0	12.7	18.7	14.7	0	1.0	328	351	368	302	
				4-5	19.0	31.0	15.0	18.3	0	0	313	603	376	478	
8/19/71		8/17/72	Thur.	2-3	10.3	8.7	11.0	9.0	1.0	0	228	275	237	271	
				3-4	13.6	8.7	20.3	17.7	1.0	0	280	361	286	341	
				4-5	27.0	25.7	20.6	17.7	1.0	0	367	602	304	502	
8/20/71		8/18/72	Fri.	2-3	12.7	13.0	13.7	21.7	0	1.0	266	342	443	461	
				3-4	13.7	14.7	22.7	21.6	0	0	354	410	561	566	
				4-5	29.7	35.3	16.0	23.0	0	0	500	670	736	775	
8/21/71		8/19/72	Sat.	2-3	10.3	9.3	19.0	17.6	0	1.0	341	424	447	488	
				3-4	37.0	23.0	35.0	40.7	0	0	320	351	424	406	
				4-5	21.0	4.0	22.0	9.0	1.0	0	357	368	381	360	

TABLE 7  
SITE 5(B) UNUSUAL MANEUVERS  
AND VOLUMES OF TWO AXLE VEHICLES ONLY  
(OBSERVER AVERAGES)

Mod. Conv. (Before)	DATES		Day	Hour	Total Maneuvers				Stopping and Backing		Volume			
	(M) Diagrammatic	(D) (After)			M	D	M	D	M	D	M	D	M	D
8/20/72		8/26/73	Sun.	2-3	10.0	23.3	33.7	15.3	0	1.0	497	627	610	541
				3-4	8.7	21.7	25.3	24.3	0	0	412	474	506	399
				4-5	8.3	12.0	23.7	16.3	0	0	380	453	466	364
8/14/72		8/27/73	Mon.	2-3	5.0	14.5	13.2	14.5	1.0	1.0	243	487	260	432
				3-4	11.5	20.5	9.0	14.0	0	0	299	497	275	453
				4-5	16.4	26.0	16.6	25.0	0	1.0	547	563	443	501
8/15/72		8/21/73	Tues.	2-3	2.3	13.7	19.0	14.7	0	1.0	262	300	246	293
				3-4	9.7	17.7	18.3	16.3	0	2.0	356	282	284	331
				4-5	18.0	30.3	6.3	14.0	0	0	598	434	435	559
8/16/72		8/22/73	Wed.	2-3	4.7	15.0	15.3	9.0	0	2.0	274	263	254	314
				3-4	12.7	17.0	14.7	16.0	1.0	0	351	327	302	337
				4-5	31.0	30.3	18.3	16.3	0	0	603	451	478	555
8/17/72		8/23/73	Thur.	2-3	8.7	16.7	9.0	17.0	0	1.0	275	295	271	293
				3-4	8.7	17.3	17.7	10.3	0	0	361	345	341	380
				4-5	25.7	31.7	17.7	12.3	0	0	602	426	502	530
8/18/72		8/24/73	Fri.	2-3	13.0	22.7	21.7	15.7	1.0	1.0	342	410	461	342
				3-4	14.7	36.0	21.6	21.3	0	0	410	534	566	455
				4-5	35.3	54.7	23.0	21.3	0	0	670	747	775	680
8/19/72		8/25/73	Sat.	2-3	9.3	19.0	17.6	20.3	1.0	1.0	424	473	488	418
				3-4	23.0	21.7	40.7	26.7	0	0	351	437	406	392
				4-5	4.0	16.7	9.0	19.0	0	0	368	403	360	374

TABLE 8  
 SITE 6 UNUSUAL MANEUVERS  
 AND VOLUMES OF TWO AXLE VEHICLES  
 (OBSERVER AVERAGES)

Conventional (C) (Before)	DATES		Day	Hour	Total Maneuvers				Stopping and Backing		Volume		Thru	
	(C) (Before)	Diagrammatic (D) (After)			Exit	D	C	D	C	D	C	D	C	D
8/5/71		8/9/73	Thur.	2-3	1.0	2.0	6.0	22.3	1.0	0	193	213	213	280
				3-4	2.0	1.0	9.0	34.0	0	0	212	209	227	342
				4-5	1.0	3.3	19.0	48.3	1.0	0	268	354	311	453
8/6/71		8/10/73	Fri.	2-3	0	4.0	4.3	20.7	0	1.0	165	222	261	332
				3-4	1.7	2.0	10.0	28.0	0	1.0	176	243	300	436
				4-5	0	1.0	15.7	36.0	1.0	1.0	315	346	370	462
8/7/71		8/11/73	Sat.	2-3	3.0	1.0	11.0	22.3	1.0	0	231	265	313	379
				3-4	3.0	3.0	15.0	18.0	0	1.0	208	225	314	381
				4-5	0	3.0	13.0	21.7	0	1.0	222	235	358	373
8/8/71		8/12/73	Sun.	2-3	4.0	2.0	16.7	26.3	1.0	0	360	304	246	386
				3-4	2.0	3.0	17.0	32.3	2.0	0	436	270	235	454
				4-5	3.7	1.0	24.3	58.7	0	1.0	474	251	222	591
8/9/71		8/13/73	Mon.	2-3	2.7	2.0	15.3	21.7	0	0	184	199	188	265
				3-4	4.7	2.0	18.3	24.0	1.0	0	184	248	203	331
				4-5	3.0	1.7	17.3	19.0	0	0	266	254	322	316
8/10/71		8/14/73	Tues.	2-3	2.0	1.0	13.3	14.7	1.0	1.0	146	205	173	273
				3-4	3.0	3.0	9.0	14.7	0	0	191	258	231	332
				4-5	2.0	1.0	5.0	14.7	0	0	248	291	290	377
8/11/71		8/15/73	Wed.	2-3	0	2.0	8.7	16.0	1.0	1.0	174	238	224	290
				3-4	0	1.3	10.0	24.7	1.0	2.0	196	249	234	331
				4-5	.7	0	8.3	25.7	0	1.0	263	317	273	403

TABLE 9

SITE 7 UNUSUAL MANEUVERS  
AND VOLUMES OF TWO AXLE VEHICLES  
(OBSERVER AVERAGES)

Conventional (Before)	DATES		Day	Hour	Total Maneuvers				Stopping and Backing		Volume			
	(C)	Diagrammatic (D) (After)			Exit	D	C	D	C	D	Exit	D	C	D
8/15/71		8/19/73	Sun.	2-3	12.0	22.0	7.0	0	1.0	3.0	230	149	863	974
				3-4	12.0	31.0	3.0	2.0	0	1.0	238	197	897	1068
				4-5	15.0	17.0	3.0	0	2.0	0	293	123	984	939
8/16/71		8/20/73	Mon.	2-3	6.7	15.3	1.0	1.0	0	0	114	101	493	670
				3-4	8.0	10.0	2.0	0	0	0	110	122	527	801
				4-5	7.0	15.3	3.0	.7	0	0	164	123	709	650
8/17/71		8/21/73	Tues.	2-3	7.0	9.0	1.0	1.0	1.0	0	148	65	572	491
				3-4	17.3	11.0	1.3	0	2.0	0	132	94	535	674
				4-5	7.0	12.0	3.0	0	0	0	139	136	584	847
8/18/71		8/22/73	Wed.	2-3	11.0	8.0	4.0	0	1.0	0	121	63	516	406
				3-4	4.7	21.0	1.0	0	0	0	138	117	559	721
				4-5	9.0	14.0	1.0	2.0	0	0	128	139	705	755
8/19/71		8/23/73	Thur.	2-3	7.0	17.7	0	0	1.0	0	124	88	552	512
				3-4	10.0	10.0	2.0	0	0	0	156	115	647	719
				4-5	9.0	11.0	1.0	1.0	0	0	199	119	715	851
8/20/71		8/24/73	Fri.	2-3	15.0	19.7	1.0	1.0	1.0	0	162	114	624	691
				3-4	9.7	16.0	1.0	0	1.0	0	169	154	714	974
				4-5	12.3	19.3	2.0	0	1.0	0	188	152	798	896
8/21/71		8/25/73	Sat.	2-3	9.0	23.7	1.0	1.0	0	0	140	136	726	797
				3-4	13.0	14.3	2.0	0	2.0	0	155	132	663	823
				4-5	8.5	14.0	2.0	1.0	0	0	202	122	722	792

## TABLE 10

SITE 8 UNUSUAL MANEUVERS  
AND VOLUMES OF TWO AXLE VEHICLES  
(OBSERVER AVERAGES)

Conventional (Before)	DATES		Day	Hour	Total Maneuvers				Stopping and Backing		Volume			
	(C)	Diagrammatic (D) (After)			Exit		Thru		C	D	Exit		Thru	
					C	D	C	D	C	D	C	D	C	D
7/26/71		7/30/73	Mon.	2-3	3.0		1.0	1.7	0	1.0	217	251	854	1030
				3-4	6.0		1.0	1.0	2.0	0	288	370	1019	1294
				4-5	4.0		0	0	0	1.0	415	530	1175	1702
7/27/71		7/31/73	Tue.	2-3	3.6		1.7	1.3	2.0	0	237	246	792	1001
				3-4	3.0		1.0	4.7	0	1.0	281	373	921	1210
				4-5	6.0		2.0	.7	1.0	0	387	490	1141	1369
7/28/71		8/1/73	Wed.	2-3	1.0		0	3.7	0	1.0	242	235	909	1055
				3-4	2.0		1.0	4.3	0	0	252	356	922	1245
				4-5	1.0		2.0	3.0	0	0	348	471	1149	1521
7/29/71		8/2/73	Thurs.	2-3	4.0		2.0	1.7	0	0	240	408	891	1305
				3-4	4.0		1.0	3.3	1.0	0	304	476	1113	1532
				4-5	8.0		1.0	4.7	1.0	1.0	398	486	1151	1485
7/30/71		8/3/73	Fri.	2-3	8.3		.7	3.3	0	1.0	230	366	941	1252
				3-4	3.0		1.0	1.3	1.0	0	317	496	1127	1466
				4-5	5.3		1.7	1.0	0	0	425	580	1217	1691
7/31/71		8/4/73	Sat.	2-3	3.0		.7	1.7	1.0	0	240	256	1004	1276
				3-4	2.0		2.0	1.0	1.0	0	264	286	1041	1304
				4-5	2.0		0	2.3	0	0	259	235	1015	1188
8/1/71		8/5/73	Sun.	2-3	4.7		2.3	0	0	0	259	205	1101	1107
				3-4	4.0		0	2.0	0	1.0	229	235	1143	1196
				4-5	2.0		.3	0	0	0	262	210	1308	1280

TABLE 11  
SITE 9 UNUSUAL MANEUVERS  
AND VOLUMES OF TWO AXLE VEHICLES  
(OBSERVER AVERAGES)

Conventional (Before)	DATES		Day	Hour	Total Maneuvers				Stopping and Backing		Volume			
	(C)	Diagrammatic (D) (After)			Exit	D	C	Thru	D	C	D	C	Thru	D
7/16/71		7/20/73	Fri.	2-3	2.0	0	0	0	0	0	241	188	1071	956
				3-4	2.0	0	0	1.0	0	0	316	233	1351	1598
				4-5	0	0	0	0	0	0	368	435	1280	2275
7/17/71		7/21/73	Sat.	2-3	2.0	1.0	2.0	0	2.0	0	263	275	1085	898
				3-4	0	0	0	1.0	0	0	244	290	1114	1120
				4-5	0	1.0	0	1.0	0	0	261	350	1056	1410
7/18/71		7/22/73	Sun.	2-3	2.0	.3	1.0	.7	1.0	0	184	176	822	953
				3-4	2.0	0	0	0	0	0	197	227	880	1143
				4-5	2.0	1.0	0	0	0	0	230	215	985	1327
7/19/71		7/23/73	Mon.	2-3	2.0	0	1.0	2.0	1.0	1.0	214	236	863	961
				3-4	1.0	0	1.0	0	0	0	200	252	964	1173
				4-5	1.0	0	0	1.0	0	0	261	295	975	1545
7/20/71		7/24/73	Tues.	2-3	0	1.0	0	0	0	0	171	210	721	989
				3-4	1.0	0	2.0	0	1.0	0	196	254	896	1240
				4-5	1.0	1.0	0	1.0	0	0	268	323	1031	1617
7/21/71		7/25/73	Wed.	2-3	0	0	0	3.0	0	0	202	220	777	983
				3-4	0	0	0	0	0	0	178	276	1015	1172
				4-5	0	0	0	0	0	0	238	341	994	1525
7/22/71		7/26/73	Thur.	2-3	0	0	0	0	0	0	203	255	773	1039
				3-4	1.0	0	1.0	2.0	1.0	0	215	258	838	1204
				4-5	0	0	0	0	0	0	208	356	1040	1766

TABLE 12  
SITE 10 UNUSUAL MANEUVERS  
AND VOLUMES OF TWO AXLE VEHICLES  
(OBSERVER AVERAGES)

Conventional (Before)	DATES		Day	Hour	Total Maneuvers				Stopping and Backing		Volume			
	(C)	Diagrammatic (D) (After)			Exit		Thru		C	D	Exit		Thru	
					C	D	C	D	C	D	C	D	C	D
7/6/71		7/10/73	Tues.	2-3	6.0	8.0	2.0	2.0	2.0	2.0	361	347	607	892
				3-4	22.0	9.0	3.7	0	2.0	0	538	469	760	1402
				4-5	6.7	16.0	4.0	1.0	2.0	0	658	629	1008	2158
7/7/71		7/11/73	Wed.	2-3	4.0	7.0	0	3.0	0	0	356	343	575	954
				3-4	10.0	24.0	3.0	5.0	2.0	1.0	531	470	796	1499
				4-5	15.0	18.7	7.0	7.0	1.0	0	838	609	1240	2274
7/8/71		7/12/73	Thur.	2-3	11.7	7.0	5.0	1.0	3.0	1.0	360	331	612	1019
				3-4	16.3	6.0	2.3	3.0	3.0	0	601	538	815	1420
				4-5	22.0	8.0	2.0	4.0	3.0	1.0	821	634	1189	2228
7/9/71		7/13/73	Fri.	2-3	9.0	17.3	1.0	0	1.0	1.0	353	358	714	1129
				3-4	15.0	15.3	6.7	1.0	2.0	2.0	572	485	896	1722
				4-5	15.0	8.0	0	1.0	2.0	0	839	654	1302	2345
7/10/71		7/14/73	Sat.	2-3	6.0	9.7	5.0	5.0	3.0	3.0	367	367	594	930
				3-4	6.3	10.0	3.0	2.0	2.0	1.0	377	372	701	1081
				4-5	9.0	8.3	1.0	4.0	2.0	1.0	318	299	638	1060
7/11/71		7/15/73	Sun.	2-3	15.3	3.3	7.0	2.0	3.0	0	285	274	655	989
				3-4	10.0	3.0	1.0	0	0	1.0	316	290	751	929
				4-5	7.7	4.0	2.3	2.0	4.0	0	292	315	768	1173
7/12/71		7/16/73	Mon.	2-3	7.0	6.0	2.0	0	0	0	400	339	563	896
				3-4	9.0	11.5	1.0	1.5	0	0	593	466	759	1285
				4-5	6.0	7.0	0	3.0	0	1.0	747	542	1025	1984