E-20-624

GEORGIA DEPARTMENT OF TRANSPORTATION

CONTRACT RESEARCH

GDOT RESEARCH PROJECT NO. 7703

FINAL REPORT

WRONG-WAY TRAFFIC MOVEMENTS ON FREEWAY RAMPS

SCHOOL OF CIVIL ENGINEERING
GEORGIA INSTITUTE OF TECHNOLOGY

1979

Contract Research

GDOT Research Project No. 7703

Final Report

WRONG-WAY TRAFFIC MOVEMENTS ON FREEWAY RAMPS

by

Peter S. Parsonson
Associate Professor
School of Civil Engineering
and
James R. Marks

Georgia Institute of Technology

Contract with

Department of Transportation
State of Georgia

In cooperation with

U.S. Department of Transportation
Federal Highway Administration

September 19, 1979

ABSTRACT

Special cameras purchased from the California DOT were used by Georgia Tech to monitor the wrong way traffic movements at 45 representative off-ramps in the Greater Atlanta freeway system. Countermeasures were installed and evaluated at nine of these locations. Recommendations for a statewide program of countermeasures were presented.

The report includes an annotated bibliography summarizing wrong-way research performed to date by California, Virginia, Georgia, etc.

It was concluded that high rates of wrong-way entries are found in the Atlanta area at incomplete interchanges (where such entries are often intentional); and at loop off-ramps that have their crossroad terminal adjacent to the on-ramp.

The main recommendations offered to the Georgia DOT were as follows:

- State policy should discourage the construction of these two types of design
- The California DOT's standard sign package, supplemented by a painted stopbar, should be implemented statewide
- Where loop off-ramps have their crossroad terminal adjacent to the on-ramp, an additional countermeasure is recommended: a crossroad median divider consisting of a row of ceramic buttons.

KEY WORDS: wrong-way, off-ramp, freeway accidents, driver limitations, freeway operations, freeway signing, interchange design

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The authors are grateful to Archie C. Burnham, Jr., P.E., State Traffic and Safety Engineer, and Percy B. Middlebrooks, Jr., Associate Research Engineer, both with the Georgia DOT, for their advice and assistance on this project. Mr. Middlebrooks is the project monitor for the GDOT.

The Georgia Tech students who assisted the authors on this project included Michael Melder, Joseph Yesbeck and Perfecto Ocasio.

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The purpose of this project is to monitor the wrong-way traffic movements currently occurring at representative off-ramps in the District 7 (Greater Atlanta) freeway system; to identify countermeasures; and to evaluate the effectiveness of these countermeasures after their installation by the GDOT at a few typical locations.

This Final Report was preceded by Interim Progress Reports Nos. 1 and 2, dated June and August, 1978, respectively (1 and 2); and by an instruction manual (3) to assist field personnel in using the California wrong-way counters. Also transmitted prior to this Final Report was a special report by student Michael Melder dated March, 1979, and updated to April by the project staff (4). This report presented data obtained since August, 1978, and included an annotated bibliography.

Prior to this project considerable research on wrong-way ramp movements had already been performed. Appendix A is an annotated bibliography describing briefly all of the references found by the project staff.

This introduction describes a few key research projects performed by the Georgia DOT, the California DOT and by Georgia Tech. These were of particular importance in bringing about the present project.

GDOT's Freeway Wrong-Way Entry Study

In December, 1976, the Georgia DOT published the final report of Project No. 3-75, entitled "Freeway Wrong Way Entry Study" (5). Mr. Percy B. Middlebrooks, Jr., a GDOT Associate Research Engineer, was the Principal Investigator and author of the report.

This report cited statistics from DeKalb County, Georgia, and from California, Virginia and Texas regarding the frequency and severity of accidents caused by wrong-way driving. For example, from 1.4 percent to 10 percent of freeway fatalitites are attributable to these movements. In California 19 percent of wrong-way accidents result in fatalities and another 46 percent produce injuries. The GDOT report concluded that it appears that a significant number of fatalities can be prevented by identifying problem ramps and taking steps to reduce the number of wrong-way entries at these ramps.

In that project the GDOT did not attempt to identify the problem ramps in the Atlanta area, but instead tested a particular countermeasure at a single ramp that was notorious for wrong-way movements.

One of the principal recommendations of the final report was that wrong-way counters similar to those developed by California should be constructed and used to identify ramps prone to wrong-way entries.

California DOT's Wrong-Way Cameras

In 1961 the California legislature authorized a general study of wrong-way movements on freeways. A study subsequently showed that over a 4-year period there were 988 such accidents, killing 268 persons. About 80 percent of these accidents occur after dark, and three accidents in four were attributed to the drinking driver (6).

In 1967 the California DOT developed and used throughout the state a "wrong-way camera" which, when installed on an off-ramp, will count and take a snapshot of every wrong-way vehicle. The camera is a simple Kodak Instamatic and is housed by a steel box that rests on the ground, chained to a pole. The camera is triggered by a pair of closely space road tubes stretched across the ramp. Right-way vehicles crossing the tubes in the correct sequence are ignored by the camera. However, a wrong-way vehicle crosses the tubes in a sequence that triggers the camera and a digital counter. At first glance the equipment appears to be an ordinary volume-count station. Only the small glass window for the camera, and the presence of two tubes instead of one, distinguish the installation from one commonly encountered by all motorists. The next subsection of this report includes photos and additional details of the hardware and its operation.

In the late 1960's California refined the design of the wrong-way camera, and from 1971-1977 used 150 of them to monitor almost every off-ramp in the state. California has found them to be consistent, reliable and accurate in detecting wrong-way entries (6). An interim report of their results was published in 1974 (7) and a final report in 1978 (8). The latter report is summarized herein in the annotated bibliography (Appendix A). The report is the result of at least 30 days of camera surveillance at each of 4000 off-ramps, and experience with a wide variety of countermeasures. Because of their wrong-way effort over a number of years, wrong way accidents have not increased despite a sharp increase in the miles of freeway and freeway travel.

About 7 percent of the ramps monitored (257 out of 3,954) had a significant wrong-way entry problem (five or more wrong-way entries per month). Entries were reduced to an acceptable level (less than two per month) at 90 percent of these ramps by the installation of a standard sign package and, where necessary, the application of one or more special countermeasures. The standard sign package, instituted in 1973, is reproduced herein as Appendix B.

The wrong-way cameras built by the California DOT are currently stored in a warehouse, inasmuch as the monitoring program is now finished. They are available for purchase by agencies interested in pursuing monitoring programs of their own (9).

California also developed a Super 8 movie camera as a companion the the snapshot model. The movie model uses an inexpensive Instamatic camera, housed in a simple box that rests on the ground. The camera is triggered by the electronics in the snapshot unit, using a 100-foot-long interconnecting cable. The movie camera is oriented to record the course of the wrong-way vehicle once it reaches the freeway. About a dozen of these units were constructed for the monitoring of unusually interesting ramps. Like the snapshot cameras, the movie models are idle at present, available for purchase.

Georgia Tech's Pilot Study at Central Avenue/I-75

In early 1977 the Georgia DOT made known to Georgia Tech its interest in monitoring off-ramps for wrong-way movements. Tech immediately purchased from the California DOT one of its snapshot camera units, for $300, and also purchased a quantity of accessories and supplies. On April 14, 1977, the camera was installed by Tech on the northbound off-ramp from Interstate 75 to Central Avenue (U.S.19-41) near Hapeville. This location, a type AB partial cloverleaf, was recommended by the Georgia DOT for Tech's pilot study because it was known to experience a relatively high incidence of wrong-way movements. The location is shown in Figure 1.

The camera and road tubes were placed approximately 160 feet from the Central Avenue end of the off-ramp, past all Wrong-Way and Do Not Enter signs. The camera set-up and road-tube installation are shown in Figures 2,3, and 4.

The road tubes are of semi-circular cross-section, flat on the bottom, in order that they will remain 3 to 4 inches apart. Double-faced carpet tape was placed between the tubes and the road, to minimize movement and to maximize the life of the hose. Industrial tape (Nashua 200) was applied to the tops of the tubes for the same reasons.

The study site was visited twice a week to check road tubes and equipment, record the number of wrong-way actuations,

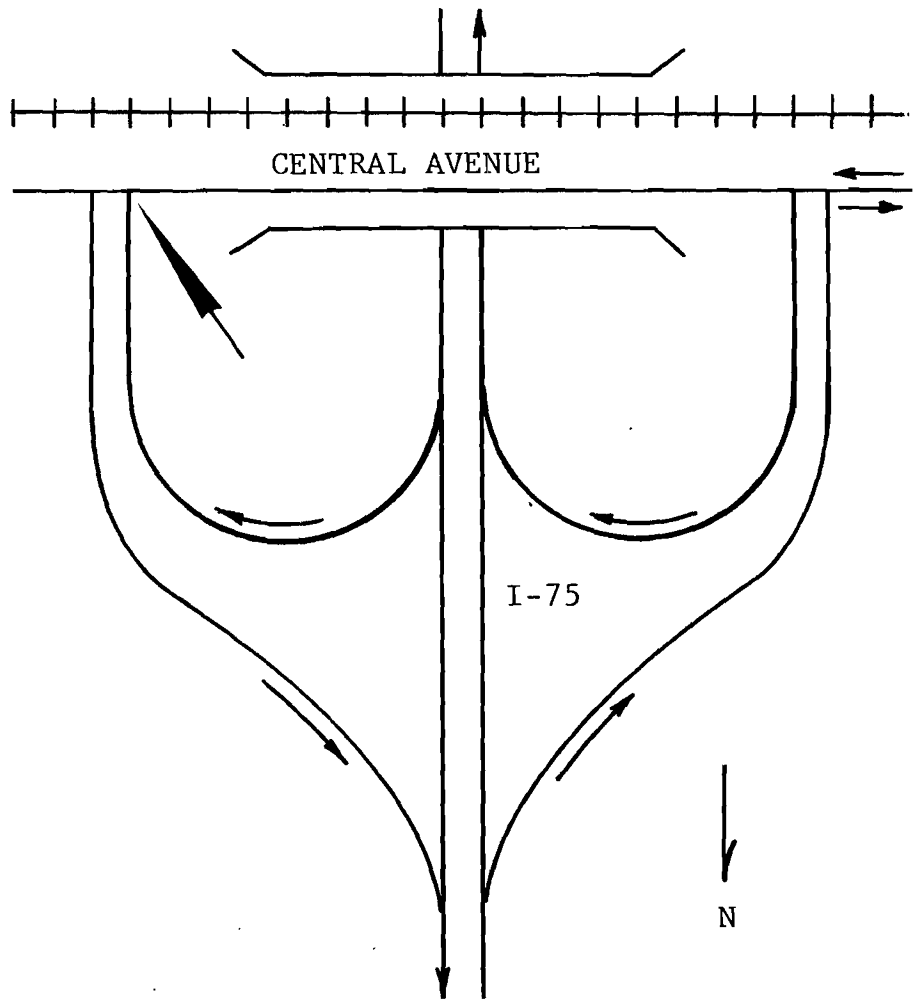


Figure 1. Type AB partial cloverleaf selected for pilot study

Figure 2. The wrong-way camera unit, installed and chained to light standard

Figure 3. The road-tube installation, and its position relative to the camera. Gore area for this ramp is in background.

Figure 4. View of the camera and road-tube from the Central Avenue end of the ramp

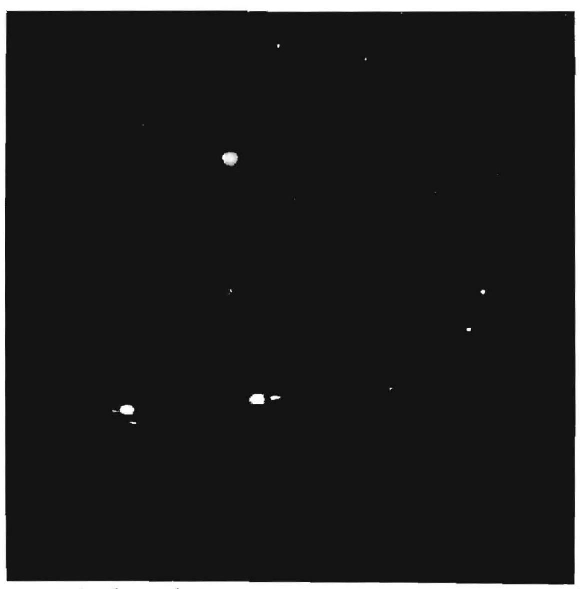


Figure 5. Nighttime wrong-way movement. Note rectangular headlights, easily distinguished from taillights.

and replace the film. A log was kept, indicating counter readings, film usage, and any retaping or other repairs.

In the first three weeks of operation 68 actuations, resulting in 57 photographs, were registered. (On several occasions the actuations exceeded the 12-exposure capacity of the camera). A wrong-way rate of approximately 3 per day is suggested by these data. However, the frequency varies widely from day to day. For example, seven wrong-way movements were recorded in the first 24 hours of camera operation. The average rate of three per day or 90 per month is very high by California standards. It was mentioned above that a problem ramp in California is characterized by a rate of over five month. Reference 8 seems to say that 50 to 60 wrong-way entries per month were the highest levels ever recorded anywhere in the state.

Three sample photographs are shown as Figures 5,6 and 7. Figure 5 shows a night-time wrong-way movement. It is easy to see that the vehicle's lights are headlights, not tail-lights, thereby confirming that the vehicle is in fact moving in the wrong direction on the ramp. Figure 6 shows a vehicle firmly committed to making a wrong-way movement in broad daylight. Such a photo is the exception rather than the rule, as most such movements occur at night. Figure 7 shows a right-way vehicle rolling back across the tubes and causing a wrong-way movement to be registered. It is not uncommon for a car waiting in a queue on an upgrade to roll back a foot or two, especially if it has manual transmission.

Figure 6. Daylight wrong-way movement

Figure 7. False actuation caused by vehicle roll-back

Therefore it is important that the equipment include a camera, not just a digital counter. Of the 57 photos obtained at I-75 and Central Avenue, five were of cars rolling back.

The high wrong-way rate at I-75 and Central Avenue led to a larger program, sponsored by the GDOT and performed by Georgia Tech, to research wrong-way movements and several countermeasures at a number of freeway off-ramps throughout Greater Atlanta. This document is the final report for that larger project. Concurrently the GDOT installed several countermeasures involving signs, markings and ceramic buttons at I-75 and Central Ave. Georgia Tech continued to give informal assistance at that location by evaluating these countermeasures. The results were reported by Parsonson et al. in 1978 (10) and are summarized herein. Subsequently the GDOT tested a further countermeasure, a steel "flapper" device set into the pavement to jolt a wrong-way vehicle. An earlier installation of the device at another location was described by Middlebrooks (5). The description of its effectiveness at I-75 and Central Ave. is beyond the scope of this report.

Purpose and Scope of Project

It was agreed that the project purchase 18 wrong-way snapshot cameras from California and install them for a month at each of 44 of District 7's freeway off-ramps.

In a pre-proposal conference it was agreed that not all of the ramps in District 7 need to be monitored for wrong-way movements. Many are simple diagonal ramps, such as at diamond and cloverleaf interchanges, and need not be monitored in large number [California had found that full cloverleaf interchanges have the fewest wrong-way movements, and the left-hand off-ramp has the most. The parclo AB design, as at I-75 and Central Avenue, also is reported by California to be troublesome (8)]. It was agreed that the project would be based on a sampling of the various off-ramp types, including a few ordinary diagonal ramps, a few off-ramps with close frontage roads, etc. The purpose would be to monitor just enough of each type of off-ramp to permit an evaluation of the associated hazard. Tech would then recommend appropriate countermeasures, such as improved signing, marking, channelization, changes in curb radii, addition of median islands on the cross-road, etc. The Georgia DOT would at that time determine the countermeasures that appear to hold the most promise in terms of costs and effectiveness, and would implement these at a few representative locations. Tech would return the monitoring equipment to these sites to evaluate the effectiveness of the countermeasures in reducing the frequency of wrong-way movements.

The details of the selection of off-ramps, the program to monitor existing movements, and the program to evaluate the countermeasures are discussed in the following sections.

PROCEDURE

This section explains in detail how the 44 sites in Greater Atlanta were selected; how they were monitored for wrong-way movements; the selection of countermeasures; and how the installed countermeasures were evaluated.

Selection of Off-Ramps in District 7

The Georgia DOT furnished to Georgia Tech maps of Fulton, DeKalb, Cobb, Douglas, Clayton and Rockdale Counties with an identification of the locations of all of the off-ramps that could possibly be susceptible to wrong-way movements. These counties comprise the DOT's District 7, and the identified ramps are 218 in number. Georgia Tech classified these ramps by type, as shown in Table 1, according to the AASHO ramp classification (see Figure 8, from Reference 11) and the classification scheme prepared by the well known geometric-design authority Jack Leisch (12). (Figure 9). The table omits a number of directional ramps, primarily in Cobb County, considered by Tech to be of little interest in the proposed research. Table 1 shows that of the 218 off-ramps, less than half (only 103) are simple diagonal ramps at diamond interchanges. The table also shows that, in Fulton County in particular, there is a myriad of interchange types and ramp configurations. There are 23 in all. Although each type and configuration was dictated by the circumstances of its site, there are so many different layouts that the unfamiliar driver understandably could find it easy to make a wrong turn.

Table 1

Classification of Freeway Off-Ramps in District 7

TYPE	COUNTY Fulton	DeKalb	Cobb	Douglas	Clayton	Rockdale
Diamond interchange, simple diagonal ramp	48	34	14	4	1	2
Diamond, diagonal ramp, close frontage road*	1	8	1	2	1	6
Half diamond, diagonal ramp*	11	4	0	2	0	0
Quarter diamond, diagonal ramp*	4	0	0	0	0	0
Split diamond, diagonal ramp*	3	1	2	0	0	0
Split diamond, diagonal ramp, close frontage road*	0	7	0	0	0	0
Full diamond, diagonal ramp, unusual or confusing design*	6	0	0	0	0	0
Partial cloverleaf (parclo) diagonal ramp*	4	0	0	0	0	0
Parclo, loop ramp*	5					
Parclo, one quadrant, diagonal ramp	1	2	0	0	0	0
Same but with close frontage road*	0	3	0	0	0	0
Parclo, 1 quad, loop ramp*	3	0	0	0	0	0
Same but with close frontage road*	0	2	0	0	0	0
Parclo A, 4 quad, diagonal ramp	2	0	0	0	0	0
Parclo B, 1 quad, diagonal ramp	0	0	1	0	0	0
Parclo B, 1 quad, loop ramp*	0	0	1	0	0	0

Table 1 (Continued)

TYPE	Fulton	DeKalb	Cobb	Douglas	Clayton	Rockdale
	COUNTY					
Parclo with CD road and loop ramp*	0	0	1	0	0	0
Parclo AB with diagonal ramp*	3	0	0	0	3	0
Parclo AB with loop ramp*	3	0	0	0	3	0
Parclo AB, 3 quad, diagonal ramp(*)	2	0	0	0	0	0
Parclo AB, 3 quad, loop ramp*	1	0	0	0	0	0
Parclo AB, 4 quad, diagonal ramp (*)	2	0	0	0	0	0
Parclo AB, 4 quad, loop ramp*	1	0	0	0	0	0

Note: * indicates that wrong-way movements could well be a problem.
(*) indicates that some ramps of this type could well be a problem.

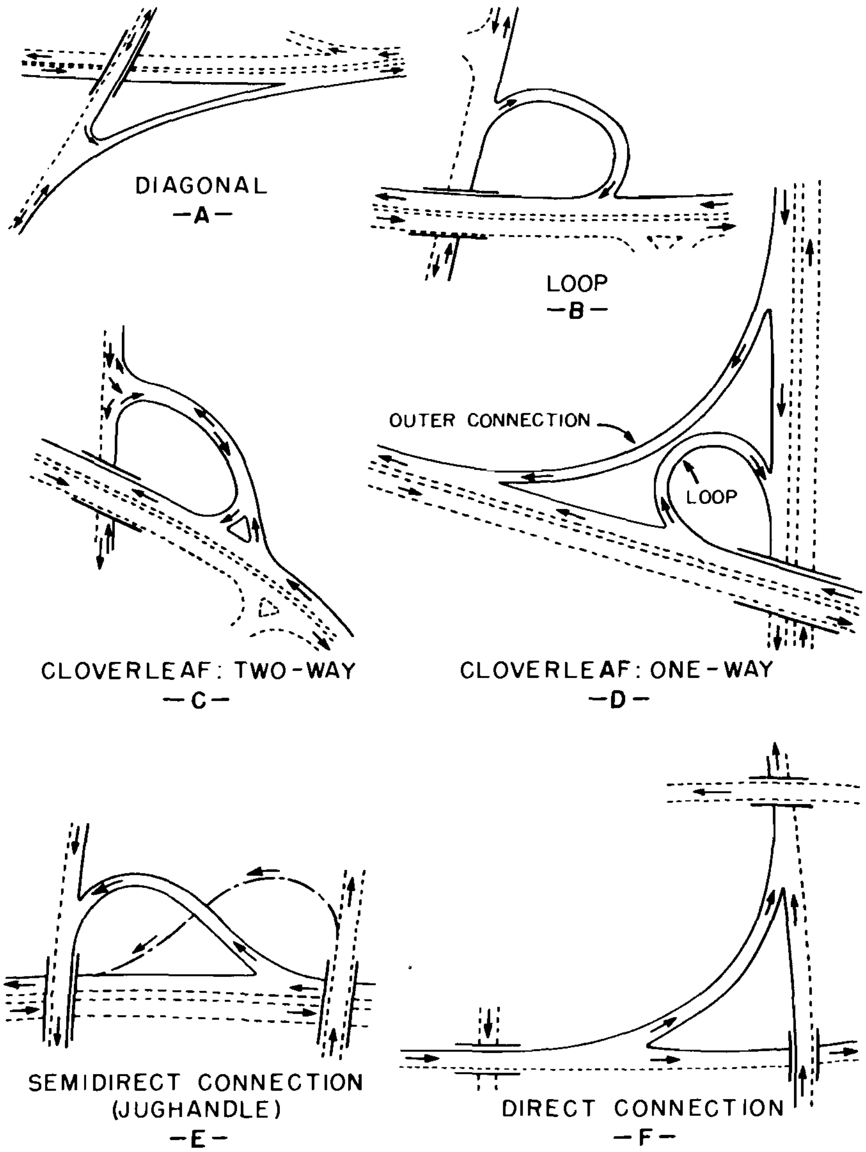


Figure 8. AASHO Classification of Ramps (from Reference 11)

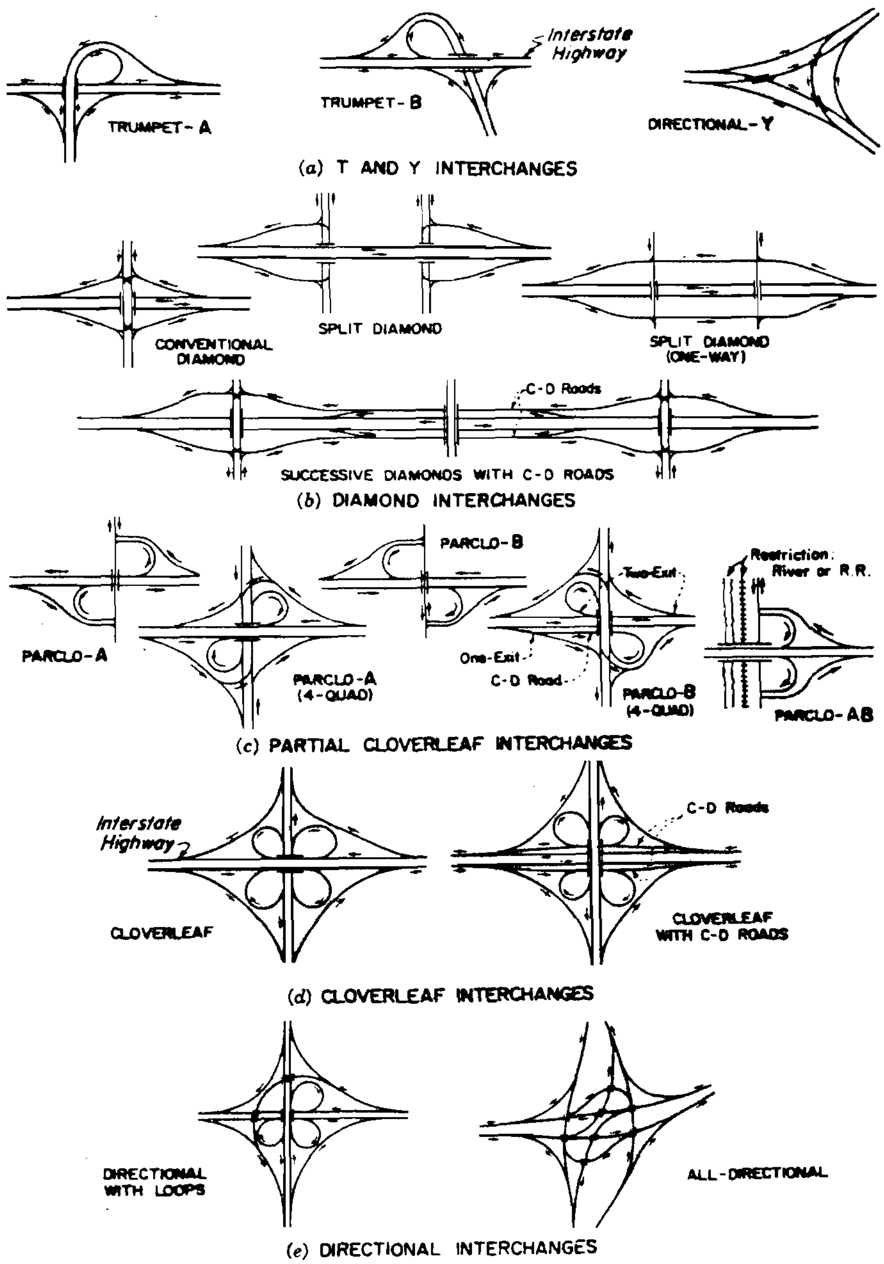


Figure 9. Leisch Classification of Interchanges (from Reference 12)

The configurations considered by Tech to be susceptible to a wrong-way problem are marked in Table 1 with an asterisk. There are 19 such configurations. A ramp-by-ramp study of the 218 locations resulted in the selection of 87 susceptible ramps. This number does not include any ramps from those categories not marked with an asterisk.

In summary, of the 23 ramp layouts identified, 19 are considered susceptible and 4 are not. Of the 19, the following 6 are probably not worth studying, either because there is only one such ramp in the area, or else only one in the area is considered to be susceptible:

Parclo B, 1 quad, loop ramp

Parclo with CD road and loop ramp

Parclo AB, 3 quad, diagonal ramp

Parclo AB, 3 quad, loop ramp

Parclo AB, 4 quad, diagonal ramp

Parclo AB 4 quad, loop ramp

Therefore there are 13 layouts that appeared worth studying. They are shown in Figure 10, along with the simple diamond (Type XIV). It was agreed to monitor 2 to 4 locations of each of these types for a total of 39 sites. With respect to the 4 layouts that are not susceptible to wrong-way movements, it was agreed to monitor two simple diamond ramps and one of each of the other 3 types, for a total of 5. Therefore 44 sites in all were slated for monitoring in this stage of the project.

Of the 44 sites, it was agreed to select one of each

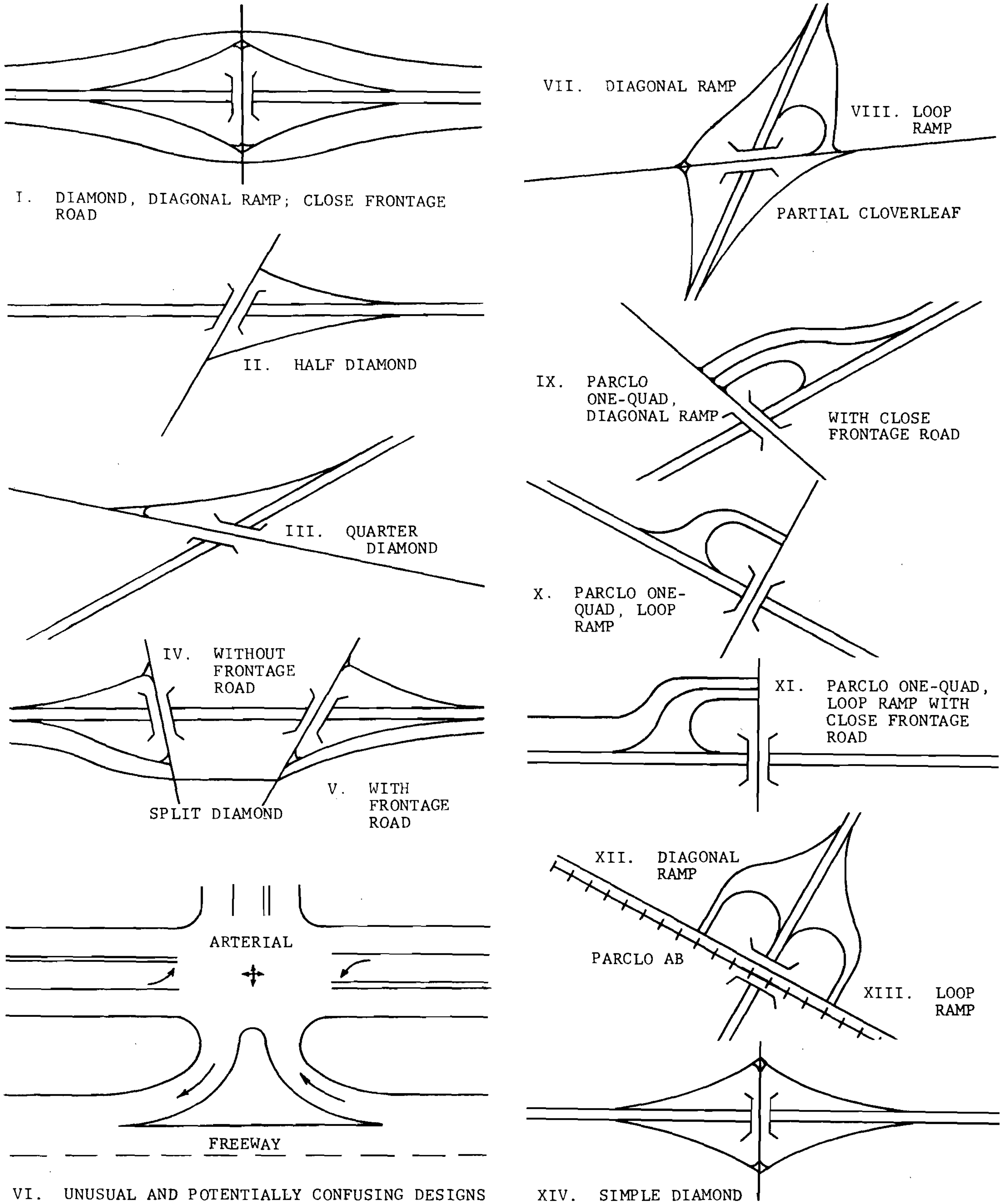


Figure 10. Ramp types studied in Greater Atlanta

of the 13 types of layouts for follow-up monitoring using Tech's California movie camera. These same 13 sites would also serve as test beds for the evaluation of countermeasures.

Program to Monitor Existing Movements

It was agreed to monitor the 44 sites using snapshot cameras for a period of one month each, based on California experience (8). It turned out to be necessary to monitor many of the ramps for more than a month, in an effort to get 30 days of good data. The counters were periodically checked (usually once a week) and if anything was malfunctioning then the data back to the previous check was ignored.

This phase of the project was completed by the end of June 1978. Additional "before" data was obtained for several months thereafter, while waiting for the installation of the recommended countermeasures. At some locations extra counters were deployed to determine the direction in which the wrong-way drivers were turning.

Program to Evaluate Countermeasures

It was agreed that Tech would recommend specific countermeasures for each of these 13 sites. The GDOT would make the final decision as to the countermeasures to be installed, and would proceed to install them with their own forces. Tech would then re-deploy its monitoring cameras at these 13 locations, for lengths of time comparable to the initial monitoring of the existing movements.

Tech's recommendations for countermeasures were presented at a meeting with the GDOT on June 7, 1978. The agreed-upon recommendations were confirmed in Interim Report No. 1, June 30, 1978 (1). Because there were relatively few ramps with a high incidence of wrong-way entries, only nine were recommended for countermeasures. During the summer of 1978 all nine were further monitored to obtain additional "before" data, while awaiting the installation of countermeasures. One location was eliminated on the basis of these additional data, leaving eight ramps for the installation of countermeasures during the fall of 1978, primarily. (Certain locations were improved in phases that extended the period of countermeasure installation to June, 1979). Wrong-way cameras immediately were returned to these locations, and monitoring of "after" wrong-way movements was completed by June of 1979 except at one location.

FINDINGS

This section presents the results of the Georgia Tech research at Central Avenue and I-75 and in the Greater Atlanta project. As mentioned above, the experience with the wrong-way "flapper" device installed by the GDOT at Central Avenue/I-75 is beyond the scope of this report.

<u>Central Avenue/I-75 Results</u>

Figure 11 shows the original signing plan used at this off-ramp, and the locations of the wrong-way cameras. The lower star in the figure, next to the road-tubes, is the still-camera unit, which was aimed southeast toward any wrong-way vehicles entering from Central Avenue. The upper star, closer to Central Avenue, is the movie-camera unit. It was pointed northwest, toward the gore area of the off-ramp, in order to monitor the movement of a wrong-way vehicle once it reached the freeway. The road tubes were placed approximately 160 feet from the Central Avenue end of the ramp, past all the DO NOT ENTER and WRONG WAY signs. Any driver reaching the road tubes was firmly committed to the wrong-way movement.

Figure 12 shows the improvements that were made to the original countermeasure plan. These were implemented in the following sequence:

Phase 1: An I-75 NORTH trailblazer was installed to direct the left-turning traffic into the on-ramp. Coincident with this phase, the Central Avenue centerline was extended further

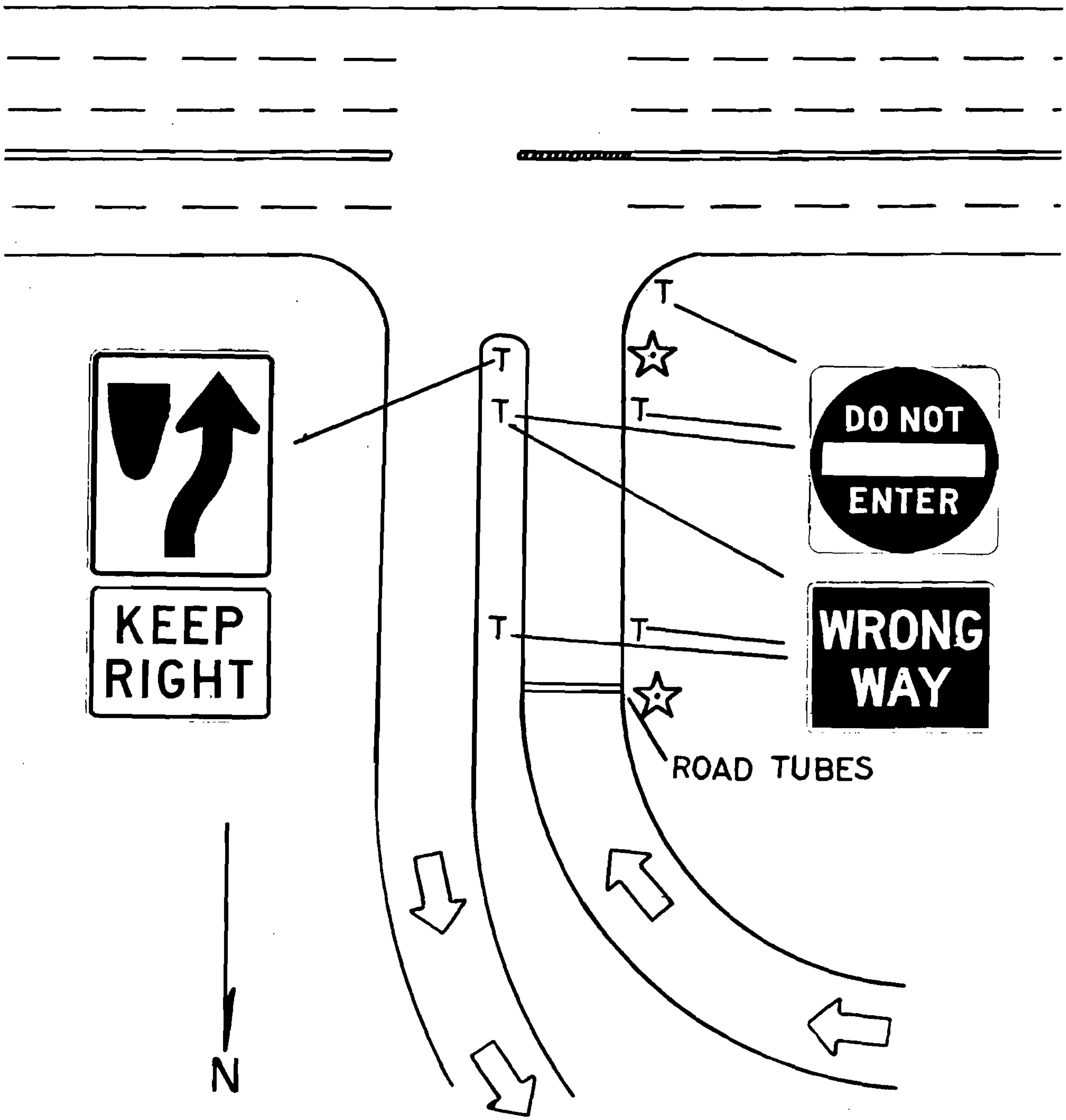


Figure 11. Initial signing plan at Central Avenue/I-75

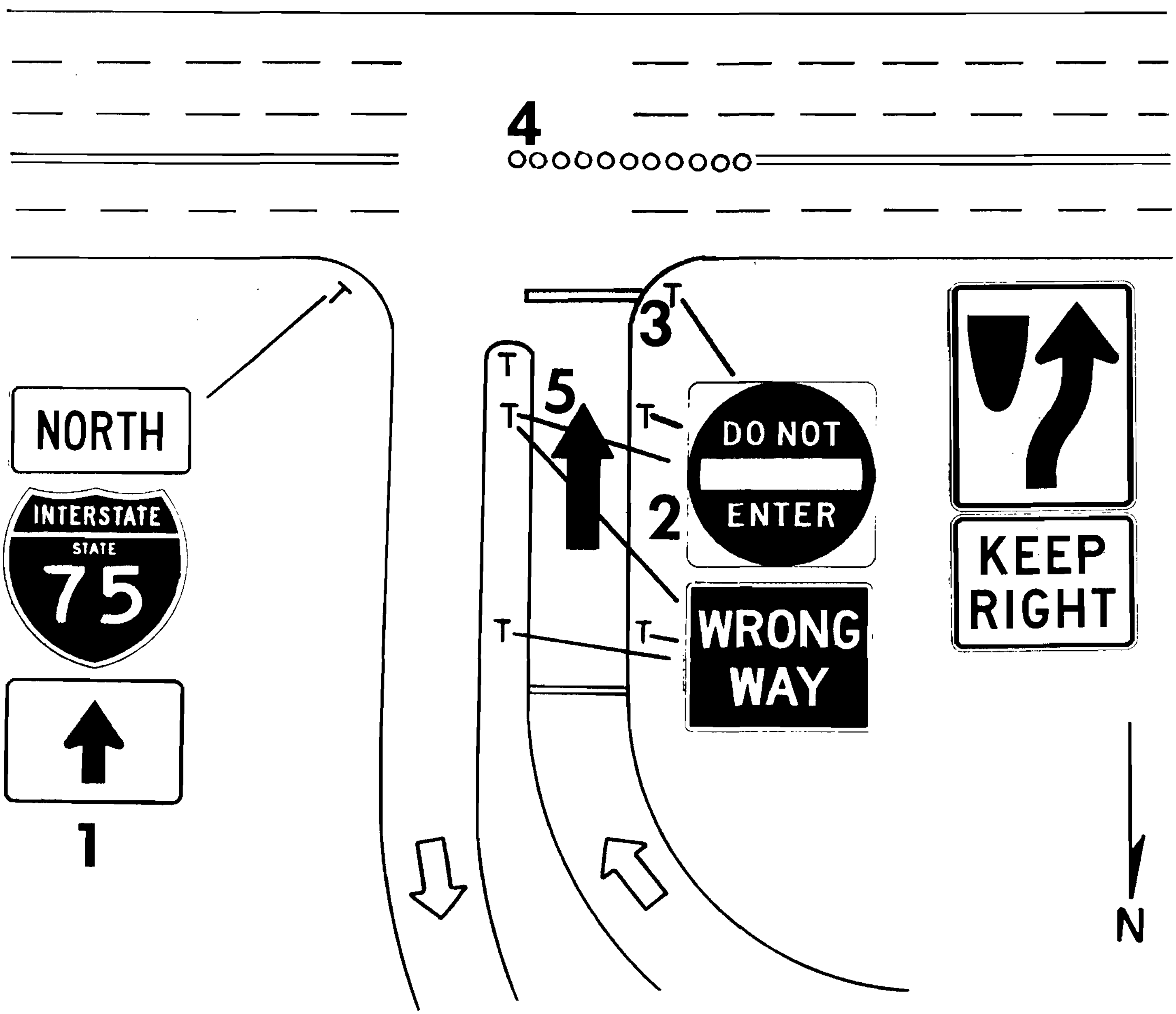


Figure 12. Phased improvements at Central Avenue/I-75

inside the intersection with the ramps, as shown in Figure 11.

Phase 2: The WRONG WAY and DO NOT ENTER signs located on the ramp median were lowered to 18 inches above the pavement in order to place them more directly in the path of headlight beams at night.

Phase 3: Phases 1 and 2 were removed, returning the intersection to its original condition. Then an 18-inch-wide stop line was to aid a driver on Central Avenue to determine the correct direction of flow of the off-ramp.

Phase 4: The phase 3 stop line was removed and yellow ceramic buttons of 8-inch diameter were installed on an extension of the centerline of Central Avenue. These buttons were intended to physically prevent drivers on Central Avenue eastbound from turning left into the off-ramp.

Phase 5: The buttons were left in place and a long (18-foot) arrow was painted on the off-ramp where it could be seen by Central Avenue drivers.

Table 2 shows the results obtained for each improvement over the data-recording period. The table shows that phases 1, 2, and 3 were each, individually, able to reduce the wrong-way incidence to about one-third to one-half of its original rate. The ceramic buttons were about as effective as any one of the first three improvements.

The finding that the buttons alone were an insufficient countermeasure came as a surprise. It had been hypothesized that practically all of the wrong-way movements were by eastbound drivers who were taking their first left (after the bridge) as they were accustomed to doing at the familiar diamond interchange.

Table 2

Effectiveness of Phased Improvements at Central Ave/I-75

Phase	Description	Length of Recording Period, days	Wrong-Way Entries Per Month
	Original Signing Plan*	22	89
1	Trailblazer sign	15	45
2	Lower "DO NOT ENTER" and "WRONG WAY" signs	14	36
3	18"-wide stop line	22	49
4	8"-diameter yellow ceramic buttons	40	40
5	18-foot-long painted pavement arrow	41	8.5

*The Central Avenue centerline was extended further inside the intersection with the ramps coincident with this phase.

It was thought that closely-spaced buttons would surely cause the wrong-way movements to virtually disappear. That did not turn out to be the case. It is important that the buttons be installed touching one another, and that they be extended toward the freeway (to the right. or west, in Fig. 11) far enough to prevent left-turning vehicles from avoiding them by starting the turn early.

The detailed data from this location are included herein as Appendix C.

Greater Atlanta Results

Forty-four off-ramps in the Greater Atlanta area were selected for monitoring, as explained earlier. They represented 13 types considered especially susceptible to wrong-way movements, plus the diamond configuration (Figure 10, above). This section presents the "before" results, obtained by monitoring wrong-way entries before any countermeasures were installed; and the "after" results at the ramps selected for countermeasures.

"Before" Results. The initial monitoring was essentially completed by June, 1978. The nine ramps selected at that time for countermeasures were further monitored during that summer to strengthen their "before" data records. Table 3, taken from an appendix of Interim Progress Report No. 1 (1), shows the final "before" data. Table 3 classifies them according to their geometric type (from Figure 10).

Table 3 shows that there are several ramp types that are particularly susceptible to wrong-way movements, as follows:

Type II: Half diamond (3.9 per month)

Table 3. "Before" Data for Greater Atlanta Project

Type	Location	Days	WW	Rate
I	I-85 @ Peachtree St. SB (U)	28	1	1.1
	I-285 @ Riverdale Rd. (S)	42	4	2.9
	I-20 @ SR 20 (R)	30	1	1.0
	I-20 @ SR 92 (R)	38	0	0.0
	I-20 @ Wesley Chapel (S)	70	4	1.7
	Overall	208	10	1.4
II	I-20 @ Chapel Hill Road (R)	97	15	4.6
	SR 166 @ Lakewood Ave. EB (U)	18	0	0.0
	Overall	115	15	3.9
III	I-75/85 @ Butler Street (W)	49	3	1.8
	I-75/85 @ Decatur Street (W)	51	6	3.5
	Overall	100	9	2.7
IV	I-20 @ Six Flags Rd. WB (S)	23	2	2.6
	I-20 @ Six Flags Dr. EB (S)	29	2	2.1
	I-285 @ E. Ponce de Leon (S)	*	*	*
	Overall	52	4	2.3
V	I-85 @ Pleasantdale Rd. (S)	20	0	0.0
VI	SR 166 @ Lakewood Ave. WB (U)	93	4	1.3
VII	I-285 @ Martin Luther King Dr. (S)	29	1	1.0
	SR 400 @ Holcomb Br. Rd. SB (R)	59	16	8.1
	SR 400 @ Haynes Br. Rd. NB (R)	28	0	0.0
	Overall	116	17	4.4
VIII	SR 400 @ Holcomb Br. Rd. NB (R)	25	1	1.2
	SR 400 @ Haynes Br. Rd. SB (R)	79	37	14.1
	Overall	104	38	11.0
IX	I-85 @ N. Druid Hills Rd. SB (S)	36	1	0.8
	I-285 @ Lawrenceville Hwy. SB (S)	42	0	0.0
	Overall	78	1	0.4
X	I-75/85 @ Peachtree (U)	*	*	*
	I-85 @ Piedmont (U)	28	0	0.0
XI	I-85 @ N. Druid Hills (S)	36	0	0.0
XII	I-85 @ Sylvan Road (S)	72	3	1.2
	I-75 @ Moores Mill Road (S)	34	0	0.0
	I-285 @ US 19/41 (S)	28	3	3.2

Table 3 (cont'd.)

	I-75 @ Jonesboro Road (R)	29	0	0.0
	I-285 @ Clark Howell (S)	29	0	0.0
	Overall	192	6	0.9
XIII	I-85 @ Central Avenue (S)	21	0	0.0
	I-20 @ Hightower (S)	35	2	1.7
	I-285 @ Clark Howell (S)	*	*	*
	I-285 @ US 19/41 (S)	76	30	11.8
	I-75 @ SR 54 (R)	29	4	4.1
	Overall	161	36	6.7
XIV	I-75 @ University (U)	14	1	2.1
	I-285 @ SR 42 (S)	8	0	0.0
	I-285 @ SR 54 (S)	*	*	*
	I-85 @ SR 74 (R)	59	0	0.0
	I-285 (Bouldercrest) (S)	30	0	0.0
	Overall	111	1	0.3

* - Indicates Ramps for which the data are questionable.

(U) - Indicates ramp in an urban area.

(S) - Indicates ramp in a suburban area.

(R) - Indicates ramp in a rural area.

These area classifications are relative and based on the judgment of the investigator.

Type VIII: Partial cloverleaf loop ramp (11.0 per month)

Type XIII: Parclo AB loop ramp (6.7 per month)

Types VIII and XIII share the same problem: entrance and exit ramps in close proximity. The half diamond is susceptible because it is an incomplete interchange; drivers may make intentional wrong-way entries. This is probably the case at the Douglas County ramp at I-20 and Chapel Hill Road. Here local residents have to go two or three miles out of their way to make a legal westbound entry at Georgia 92. The problem would be less in urban areas, where access points are closely spaced.

The average rates reported above need to be interpreted in light of the dispersions from the mean within each of these three groups. An analysis of variance (13) detailed in Appendix D shows that there is so much variation within the ramp types that the differences between types are not statistically significant. This finding means that wrong-way problems in Atlanta tend to be location-specific rather than a consequence of only the geometric configuration. It follows that there needs to be a standard countermeasure, such as California's standard sign package (Appendix B), that would be applied system-wide. Then, special countermeasures would be tailored to solve any remaining problems at specific locations.

These specific locations would be identified by 30-day monitoring with a wrong-way camera. The problem in this is that the occurrences of wrong-way movement are not uniformly distributed in time. The chronological raw data from this project show that wrong-way entries tend to occur in flurries that may be weeks or months apart.

Because of this, at three locations the initial 30-day data indicated rates that turned out to be too high after several months of additional data were obtained. These locations were Ga. 166 at Lakewood Ave.; I-85 at Sylvan/Central Ave.; and I-20 at Wesley Chapel. More confidence can be placed, probably, in data that indicates about the same number of wrong-way entries during each one-week period. Our finding is that a ramp experiencing between two and five wrong-way movements per month is on the hazy borderline of a wrong-way problem. California, also, recognizes this range by specifying that a "problem" ramp has more than five and a corrected one less than two (8).

Another difficulty is that there is not necessarily any correlation between the frequency of wrong-way entries and the incidence of wrong-way accidents at that location. A low wrong-way-entry rate does not necessarily mean a safe ramp. After all, only one movement is necessary for a fatal accident. For example, on November 12, 1977, a state trooper was killed in a wrong-way accident on I-85 just south of Monroe Dr. (14). The most likely entry point was the interchange at Peachtree St. The project staff studied this location in the spring of 1978 and found a low rate of 1.1 per month. Of course, in view of the time-variation problem we may be understimating the rate here. Nevertheless, it appears that a wrong-way entry at this ramp led to a fatality.

The GDOT and project staff mutually agreed on the following eight locations to receive the countermeasures listed:

I-285 at Riverdale Road

1. Large pavement arrows
2. 24" stop bar
3. DO NOT ENTER sign; R 5-1
4. Guide sign

I-285 at U. S. 19/41 (Old Dixie Highway)

1. 24" stop bar
2. Large pavement arrow
3. Trailblazer
4. Ceramic buttons

I-20 at Chapel Hill Road

1. Standard MUTCD arrows (5)
2. WRONG WAY sign; R 5-9
3. DO NOT ENTER sign; R 5-1
4. NO RIGHT TURN sign; R 3-1
5. NO LEFT TURN sign; R 3-2

GA. 400 at Holcomb Bridge Road

1. Large pavement arrows
2. 24" stopbar
3. DO NOT ENTER sign; R 5-1, on island facing partially toward westbound traffic on Holcomb Bridge Rd.

I-75/85 at Decatur St.

1. Large pavement arrows
2. KEEP RIGHT sign; R 4-7

I-75 at Ga. 54 (NB exit)

1. Short dotted "elephant tracks" to guide left-turning traffic into the correct ramp (there is an exclusive left-turn lane here);
2. Large pavement arrows;
3. Replace missing DO NOT ENTER sign, and replace a length of striping on Ga. 54 that was removed by a patching operation.

Ga. 400 at Haynes Bridge Road

Phased improvements in the following sequence:

Phase 1
1. Standard pavement arrows
2. Adjust centerline opening
3. Trailblazer

Phase 2
4. 24" stopbar

Phase 3
5. Enlarge pavement arrows

Phase 4 (Only if necessary)
6. Ceramic buttons

I-20 at Wesley Chapel Road

1. Large pavement arrows
2. Extend pavement edge line
3. DO NOT ENTER; R 5-1
4. KEEP LEFT; R 4-8

Appendix E is a series of scale drawings of these ramps and their countermeasures.

"After" Results. The "after" monitoring was completed in May, 1979, except for Ga. 400 at Haynes Bridge Road. (The Phase 2 stopbar was monitored there in the summer.) The wrong-way rates per month, detailed in Appendix F, are summarized as follows:

I-285 at Riverdale Rd.	1.4
I-285 at U. S. 19/41	1.8
I-20 at Chapel Hill Road	2.4
Ga. 400 at Holcomb Bridge Road	0.0
I-75, 85 at Decatur Street	2.0
I-75 at Ga. 54	2.9
Ga. 400 at Haynes Bridge Road	22.3
I-20 at Wesley Chapel Road	0.7

These results show that the countermeasures were successful except at Ga. 400 and Haynes Bridge Road. I-20 at Chapel Hill is a half-diamond where many wrong-way movements are intentional; they are not susceptible of correction by measures short of reconstruction. I-75, 85 at Decatur Street, also, is known to be used intentionally in the wrong-way by emergency vehicles responding to an incident on the freeway.

Results at Ga. 400 and Haynes Bridge Road indicate that standard pavement arrows, trailblazer signs, and a 24" painted stop bar are not sufficient at a parclo AB. Large pavement arrows, and ceramic buttons on the crossroad, are required.

Comments on the Wrong-Way Counters

The project staff produced an interim report (3) on the operation and maintenance of the wrong-way counters. On the whole, Georgia Tech's experience with these counters was satisfactory. However, there are a few negative comments, as follows:

- It is not unusual for the digital counter to record a value greatly in excess of the number of photograph-confirmed wrong-way movements.
- Similarly, it is not unusual for a wrong-way activation to advance the digital counter, and light the test lights, but not actuate the solenoid. A weak battery is not necessarily the cause.
- The counter was designed to use an unusual, 7.5-volt battery that must be special-ordered. It is not a rechargeable type.
- The counter will fail to operate when the battery has lost just a few tenths of a volt. Frequent replacements are costly.

o The electronic technicians at Georgia Tech believe that the wrong-way counter would be more reliable if the circuitry were replaced by a "chip". The cost would not be excessive.

o The movie camera is particularly unreliable in subfreezing temperatures. We suspect that the cold is reducing battery voltage just enough to prevent operation.

CONCLUSIONS

The following conclusions are drawn:

1. A California report (8) issued after this project began concluded that wrong-way movements can be reduced to an acceptable level at 90 percent of their problem locations by the installation of their standard sign package and, where necessary, the application of one or more of their low-cost special techniques.

2. The same California report concluded that as much effort should be spent on good signing, delineation, lighting, and geometric design of the on-ramp entrance as is expended in warning the driver he is entering the off-ramp. Positive direction is as important as negative warning.

3. Our experience at Central Ave./I-75, which is a parclo AB interchange, leads to the conclusion that each of the following is an effective, inexpensive countermeasure:

- o Trailblazer signs on the on-ramp
- o Lowering of DO NOT ENTER and WRONG WAY signs
- o Painted stopline, 18" wide, at end of off-ramp
- o Yellow ceramic buttons to form a median divider on the cross-road
- o Painted 18-foot-long painted pavement arrow on the off-ramp.

4. Our experience in the Greater Atlanta study of 44 ramps leads to the following conclusions:

- o Half-diamonds, partial cloverleaf loop ramps, and parclo AB loop ramps may be particularly susceptible to wrong-way movements, but the data are not sufficient for us to be sure. However, California came to the same conclusion (Reference 8, Table 1).

o Many, if not most, of the wrong-way movements at half-diamonds and other incomplete interchanges are believed to be intentional. There is no countermeasure short of reconstruction.

o Aside from the half-diamond, the only type of ramp design that displays alarmingly high rates of wrong-way movements is the loop off-ramp that has its crossroad terminal adjacent to the on-ramp. (Types VIII and XIII in Fig. 10). Examples are Ga. 400 at Haynes Bridge Road and I-285 at U. S. 19,41 (and I-75 at Central Ave.).

o Regarding Types VIII and XIII it is concluded from experience at Haynes Bridge Road that standard pavement arrows and trailblazer signs are not sufficient. Experience at U. S. 19/41 and Central Ave. leads to the conclusion that a 24" stop bar, large pavement arrows, and ceramic buttons are needed in addition. The DO NOT ENTER and WRONG WAY signs should be mounted low as recommended originally by California (App. B).

o Experience at the other ramps receiving countermeasures shows that these same improvements (except the ceramic buttons) are effective. These are similar to the California standard sign package (Appendix B) with the addition of the 24" stopbar.

o Experience at both Central Ave/I-75 and in the Greater Atlanta project leads to the conclusion that the 24" stopbar is an effective countermeasure.

5. It is concluded that the GDOT should not undertake a large-scale monitoring of off-ramps elsewhere in the state until improvements in the electronic design of the wrong-way counter have been considered.

RECOMMENDATIONS

It is recommended that the Georgia DOT:

1. Include in its policies on geometric design the following statements:

   - o From the standpoint of preventing wrong-way movements, it is preferred to provide all movements to and from the freeway at each interchange location. Conventional, easily recognized interchange patterns are preferred.
   - o Loop off-ramps that have their crossroad terminals adjacent to an on-ramp entrance have higher-than-average rates of wrong-way entry.

2. Adopt statewide the California standard sign package detailed in Appendix B, with the addition of a 24"-wide painted stopbar at the crossroad end of the off-ramp. (Appendix E shows several examples of this stopbar). The standard sign package includes the 24-foot, painted arrow pavement marking in the new, two-piece design.

The recommendation of the 24" painted stopbar is considered to be fully cost-effective. At Central Ave/I-75 this one countermeasure, alone, reduced wrong-way entries by almost half. In the Greater Atlanta phase of the project it was visually apparent to the staff members that the stopbar greatly reduces the attractiveness of the opening to wrong-way drivers.

3. Implement the second recommendation first at those

interchanges where there is a loop off-ramp with its crossroad terminal adjacent to an on-ramp entrance. Concurrent with the placement of the sign package and stopbar at these priority locations, install on the crossroad a median divider consisting of a row of 8" diameter, yellow ceramic buttons. The buttons should touch each other to form a continuous, unbroken barrier, and should extend far enough toward the interchange structure (the freeway) to prevent a wrong-way driver from avoiding the buttons by turning left early. The length of divider required for this is typically 100 feet, as shown in the example for Ga. 400 and Haynes Bridge Road (Appendix E).

There are 19 such locations in the Greater Atlanta area (including the four studied in this project), as follows:

	County			
	Fulton	DeKalb	Cobb	Clayton
Parclo, loop ramp (Type VIII)	5	0	0	0
Parclo, 1 quad, loop ramp (Type X)	3	0	0	0
Parclo, 1 quad, loop ramp with close frontage road	0	2	0	0
Parclo B, 1 quad, loop ramp	0	0	1	0
Parclo AB with loop ramp (Type XIII)	3	0	0	3
Parclo AB, 4 quad, loop ramp	1	0	0	0

The program of recommended countermeasures is so strong that we do not believe that the GDOT needs to go to the considerable expense of evaluating these locations with the wrong-way counters.

4. Implement the second recommendation at all other interchanges statewide.

5. Actively solicit the aid of the Georgia Highway Patrol to identify, on a continuing basis, those interchanges at which wrong-way movements are still a problem. Install a wrong-way camera at each such location, and design and implement special countermeasures.

Wrong way accidents are rare events, so it is difficult to estimate the expected benefit from the implementation of the recommendations. In the Greater Atlanta area alone, the annual number of wrong-way entries can be expected to drop by approximately 3000 to 4000. Fully one-third of this benefit will occur at the 19 locations described above, we believe. These 19 off-ramps should experience a reduction in wrong-way entries from seven to eight to only two to three per month. The other 200 off-ramps probably will average a reduction of about one wrong-way entry per month, as a result of the proposed improvements.

REFERENCES

1. Marks, James R., Interim Progress Report No. 1, GDOT Research Project 7703, Georgia Institute of Technology, School of Civil Engineering, June 30, 1978.

2. Marks, James R., Interim Progress Report No. 2, GDOT Research Project 7703, Georgia Institute of Technology, School of Civil Engineering, August 31, 1978.

3. Marks, James R., Recommendations and Manual for Use of Wrong-Way Traffic Counters, GDOT Research Project 7703, Georgia Institute of Technology, School of Civil Engineering, August 31, 1978.

4. Melder, Michael, Wrong-Way Traffic Movement on Freeway Ramps, GDOT Research Project 7703, Georgia Institute of Technology, School of Civil Engineering, March, 1979, updated to April by project staff.

5. Middlebrooks, Percy B., Freeway Wrong-Way Entry Study, GDOT Research Assistance Project 3-75, Final Report, Office of Materials and Research, Georgia DOT, Atlanta, December, 1976, 68 pages.

6. Weaver, Richard P., "Hidden Cameras to Detect Wrong-Way Driving on Freeway Ramps", Photo-Optical Instrumentation: A Tool for Solving Traffic and Highway Engineering Problems, Proceedings of the Society of Photo-Optical Instrumentation Engineers, Vol.30, November, 1971, pp. 39-44.

7. Gabriel, Jerry D., "Wrong-Way Driving on California Freeways", Traffic Quarterly, April, 1974, pp. 227-240.

8. Rinde, E.A., Off-Ramp Surveillance; Wrong-Way Driving, California DOT, Office of Traffic, Sacramento, August, 1978, 119 pages.

9. Weaver, Richard P., Assistant District Traffic Engineer, California DOT, 2829 Juan St., P.O. Box 81406, San Diego, CA. 92138, Telephone (714) 294-5082.

10. Parsonson, Peter S., et al., "Wrong-Way Traffic Movements on Freeway Ramps in Atlanta", Compendium of Technical Papers, Institute of Transportation Engineers 48th Annual Meeting, Atlanta, Georgia, August 6-10, 1978, pp. 143-147.

11. American Association of State Highway Officials, A Policy on Geometric Design of Rural Highways, 1965, Washington, D.C. p. 527.

12. Leisch, Jack E., "Adaptability of Interchanges to Interstate Highways", ASCE Transactions, 1959, Vol. 124, p. 588.

13. Montgomery, Douglas C., Design and Analysis of Experiments, John Wiley and Sons, 1976

14. The Atlanta Journal and Constitution, "Trooper Killed in I-85 Collision", November 13, 1977, p. 8A

Appendix A

Annotated Bibliography

ANNOTATED BIBLIOGRAPHY

Burns, E.N., "Safety Benefits from Effective Directional Signing for Freeway Entrance Ramps", Compendium of Technical Papers, 44th Annual Meeting, Institute of Traffic Engineers, (Sept. 1974), pp. 66-75

This paper recommends that positive directional signing to freeway entrance ramps should be placed on local approaches.

Estep, A.C., "Wrong-Way Driving on California Freeways, 1961-1972", American Association of State Highway Officials, 1972 Summer Meeting of the Operating Committee on Traffic Engineering, Dearborn, Michigan, July 16-18, 1972, 29 pages.

This paper reviews the reports by Tamburri. The appendices include a sample ramp inspection form.

Friebele, John D., *et al.*, State-of-the-Art of Wrong-Way Driving on Freeways and Expressways, Research Report 139-7, Texas Transportation Institute, Texas A&M University, College Station, June, 1971, 34 pages.

This is a review of 20 references considered to represent the state of knowledge of wrong-way driving. Unspecified additional research and studies were recommended.

Gabriel, Jerry D., "Wrong-Way Driving on California Freeways", Traffic Quarterly, April, 1974, pp. 227-240

This is an interim report after three years of an accelerated program to reduce wrong-way accidents. California has discontinued the construction of

- Left-hand off ramps
- Cul-de-sac off-ramps that end as a two-way road,

using jug-handle left turns to attempt to avoid wrong-way movements
- Scissors off-and on-ramp combinations

A 24-foot, two-piece arrow pavement marking is described. "Problem" ramps with optical illusions or confusing geometry are discussed. The camera surveillance program is summarized. The annual number of wrong-way accidents remained the same from 1967 to 1974 despite increases in freeway mileage and travel.

Gillespie, Hugh M., Ed., "California Explores Methods of Fighting Continuing Problem of Wrong-Way Driving", Highway Research News, Highway Research Board, Washington, D.C., Summer, 1971, pp. 31-33.

This news article announced the beginning of a 5-point program to attack this problem:
- Evaluation of small bumps, skull-and-crossbones signs, warning lights in the pavement, positive directions to the on-ramp
- Review of work in other states
- Enlist aid of Highway Patrol to identify active locations
- Investigation teams to conduct trials at select locations
- Place a wrong-way counter at every off-ramp for at least one month

The article points out that the major factors associated with this problem are alcohol, darkness, and old age, over which the Division has no control.

Hulbert, S. and J. Beers, "Wrong-Way Driving: Off-Ramp Studies". Record 122, Highway Research Board, Washington, D.C., 1966, pp. 35-49

Laboratory evaluations indicated that red-and-white signs elicit an earlier response than black-and-white signs. Standard arrows were found not to be as detectable as two different styles when viewed as would a wrong-way driver.

Lew, Alan, Final Report on Wrong-Way Driving (Phase III), State of California Division of Highways, Traffic Department, Sacramento, February, 1971, 33 pages

The various reports by Tamburri are summarized. As a result of Phase III research the design standards for California were revised to

- Prefer the provision of all movements in the design
- Prefer conventional, easily recognized interchange patterns
- Recognize that cul-de-sac, scissors and direct connection off-ramps have higher-than-average rates of wrong-way entry.

Manual on Uniform Traffic Control Devices, U.S.D.O.T., Federal Highway Administration, 1971

This edition did not expressly deal with wrong-way movements until changed in December, 1977 (as described in the next entry of this bibliography)

Manual on Uniform Traffic Control Devices, "Official Rulings on Requests for Interpretations, Changes, and Experimentations, Vol. VIII", U.S.D.O.T., Federal Highway Administration, December, 1977, pp. 6-8

Approval was given to add two new sections to the MUTCD, 2A-31 and 2E-44, both entitled Wrong-Way Traffic Control. They are essentially the same as the Federal-Aid Highway Program Manual Sec. 6.8.3.1, adopted in 1974. They cover the use of ONE WAY, DO NOT ENTER and WRONG WAY signs, and the use of double solid yellow lines on the crossroad. Directional arrow pavement markings of standard size (9'4") are required to be placed in each lane of an exit ramp near the crossroad terminal, where it would clearly be in sight of a wrong-way driver. They may also be placed elsewhere, as needed.

Manual on Uniform Traffic Control Devices, U.S.D.O.T., Federal Highway Administration, 1978

Section 2A-31, Wrong-Way Traffic Control, describes the use of ONE WAY, DO NOT ENTER and WRONG-WAY signs. Section 2E-41, of the same title, but applying specifically to expressway quide signs, also covers these three signs. These provisions are almost identical to those added to the previous edition in 1977 (see the preceding item in this bibliography) except that the 1978 edition uses the new, two-piece arrow described by Tamburri and Theobald in 1966.

Messer, Carroll J., et al., A Qualitative Analysis of Wrong-Way Driving in Texas, Research Report 139-6, Texas Transportation Institute, Texas A&M University, College Station, May, 1971, 16 pages.

A questionnaire survey of engineers and police showed that drugs and alcohol are perceived to be the greatest problem in wrong-way driving. Countermeausures involving engineering, enforcement and education were determined to be needed.

Middlebrooks, Percy B., Freeway Wrong-Way Entry Study, GDOT Research Assistance Project 3-75, Final Report, Office of Materials and Research, Georgia DOT, Atlanta, December, 1976, 68 pages

A spring-mounted, collapsing curb set into the pavement was installed at one location and evaluated. It is a steel "flapper" device that depresses when struck by a right-way vehicle but delivers a warning jolt to a driver moving in the wrong direction. It was concluded that the device is sufficiently durable and should be considered where less-expensive methods of preventing wrong-way entries are not effective.

Parsonson, Peter S., et al.,"Wrong-Way Traffic Movements on Freeway Ramps in Atlanta", Compendium of Technical Papers, Institute of Transportation Engineers 48th Annual Meeting, Atlanta, Georgia, August 6-10, 1978, pages 143-147.

A number of wrong-way cameras purchased from the California DOT were used to monitor a parclo AB interchange and 44 others in Atlanta. The effectiveness of various signs, a stop line, ceramic buttons and an 18-foot long painted pavement arrow is described.

Richard, Charles L., "Analysis of Wrong-Way Incidents on Michigan Freeways", Abridgment, Record 279, Highway Research Board, Washington, D.C., 1969, p. 156

This report analyzes 200 wrong-way incidents and 44 wrong-way accidents on rural freeways. Characteristics of wrong-way drivers are given; 42 percent of the incidents occurred at diamond interchanges; 80 percent of accidents occurred at night.

Shepard, Frank D., Installation of Raised Pavement Markers for Reducing Incidences of Wrong-Way Driving, Virginia Highway and Transportation Research Council, Charlottesville, Report 77-R58, PB-275 739/1WX, June, 1977, 23 pages.

It is recommended, on the basis of tests at two locations, that raised pavement markers, placed in configurations as noted in the report, be considered for placement where wrong-way entries are a problem.

Rinde, E.A., Off-Ramp Surveillance; Wrong-Way Driving, California DOT, Office of Traffic, Sacramento, August, 1978, 119 pages.

Approximately 4000 off-ramps have been monitored for at least 30 days each. This has led to a reduction in the number of wrong-way entries.

Since 1963, when the wrong-way effort first began, the miles of freeway and expressway travel have about tripled. However, fatal and injury wrong-way accidents have increased only 25 percent. Since 1971, when the camera surveillance program began, accidents have leveled off.

The improved standard wrong-way sign package for off-and on-ramps instituted in 1973 in itself has been effective in reducing wrong-way entries.

Careful original positioning of the signs in the standard package is required. Even so, it is often necessary to reposition signs as many as three or four times to solve the problem at some locations.

As much effort should be spent on good signing, delineation, lighting and geometric design of the on-ramp entrance as is expended in warning the driver he is entering the off-ramp. Positive direction is as important as negative warning.

A number of special techniques have been developed to use at locations where signing is not enough. The better of these include painted islands and channelization; cat-tracking using reflective pavement markers; pathfinder signs in the median of the crossroad; trailblazing signs; internally illuminated FREEWAY ENTRANCE signs; changing signal heads to directional arrows; sign-and-light installations saying GO BACK-YOU ARE GOING WRONG WAY; pavement lights; off-ramp throat reduction using dikes, curbs, delineator posts and paint; and lighting of on-ramps.

California is aware of Georgia's flapper device but does not appear to be receptive to it. They quote the Middlebrooks report that some right-way drivers went around the device to avoid hitting it.

California reduced wrong-way entries to an acceptable level at 90 percent of their problem locations by the installation of the standard sign package and, where necessary, the application of one or more of the special techniques. The last resort is the installation of pavement lights and, finally, major reconstruction.

Tamburri, T.N., and D.J. Theobald, "Wrong-Way Driving (Phase III)", Record 151, Highway Research Board, Washington, D.C., 1966, pp. 41-95

This paper summarizes a report of the same title and authors issued by the State of California Division of Highways, Traffic Department, in February, 1965.

It presents statistics on wrong-way incidents and describes the effectiveness of better signing and pavement marking; an actuated warning device will illuminated sign, lights, and horns; and spike barriers designed to disable the wrong-way vehicle.

It was concluded that spike barriers are inadequate but painted arrows are effective in reducing daylight wrong-way incidents.

Tamburri, Thomas N., Interim Report on Wrong-Way Driving, (Phase III), State of California Division of Highways, Traffic Department, Sacramento, February, 1966, 16 pages.

This report describes which specific geometric details and traffic control devices on the ramp and on the crossroad are effective in preventing wrong-way movements. The recent statewide reduction in wrong-way incidents was attributed to the painting of white pavement arrows at all off-ramps. Entry rates considerably above the average were found for trumpet direct-connecting

off-ramps, off-ramps to cul-de-sac local roads, scissor-type off-ramps, and direct-connecting off-ramps (left and right side).

Tamburri, T.N. and P.R. Lowden, Jr., Interim Report No. 2 on Wrong-Way Driving (Phase III), State of California Division of Highways, Traffic Department, Sacramento, June, 1968, 73 pages.

It was reported that wrong-way incidents and fatalities had been reduced by two-thirds, and accidents by one-third, by the use of signs reading DO NOT ENTER; WRONG WAY; and GO BACK - YOU ARE GOING WRONG WAY; and by white pavement arrows.

Interchanges should allow all possible movements and use median dividers on the crossroads. Off-ramps should intersect crossroads at the flattest possible angle. Left-hand off-ramps should be avoided.

Tamburri, Thomas N., "Wrong-Way Driving Accidents are Reduced", Record 292, Highway Research Board, Washington, D.C., 1969, pp. 24-50.

Wrong-way driving on freeways can be reduced perhaps two-thirds by using

- White-on-red WRONG WAY signs with black-on-white DO NOT ENTER signs at off-ramps
- White-on-green FREEWAY ENTRANCE signs at on-ramps
- Large (24-foot) white pavement arrows at all off ramps and on ramps.

Further reductions can be achieved by

- Proper choice of off-ramp type
- Flat angles of intersection of off-ramp and crossroad
- Dividing the crossroad
- Eliminating left-side off-ramps
- Providing for all possible turning movements
- Providing a minimum of 1200 feet of sight distance (3.75-ft right-way-driver eye height to 2.0-ft headlight height)

"Traffic Control Devices on Federal-Aid and other Streets and Highways", Federal-Aid Highway Program Manual, Sec. 6.8.3.1, Federal Highway Administration (Oct. 17, 1974).

This manual covers the signing of exit ramps at those locations where the exit ramp intersects a crossroad in such a manner that wrong-way entry could be made. The use of ONE WAY and DO NOT ENTER signs is set forth, as well as the application of arrow pavement markings.

Transportation Research Board, Design and Control of Freeway Ramp Terminals, National Cooperative Highway Research Program, Synthesis of Highway Practice Number 35, Washington, D.C., 1976, 61 pages.

This report briefly reviews the standard countermeasures such as the use of a concrete median on the crossroad, better signs, and the avoidance of confusing layouts. It summarizes the reports by Estep (1972), Burns (1974) and "Traffic Control Devices on Federal-Aid and Other Streets and Highways" (referenced in this bibliography).

Vaswani, N.K., Measures for Preventing Wrong-Way Entries on Highways, Virginia Highway Research Council, Charlottesville, Report 72-R41, 41 pages.

A two-year survey of incidents in Virginia showed that most of them occurred at diamond interchanges.
Investigations at four interchanges produced recommendations involving channelization of tbe left lane of the exit ramp; proper location of signs; diagrammatic signs at four-lane divided highways; and supplemental signs with pavement markings and spotlighting to make entry ramps conspicious and exit ramps inconspicious.
Other countermeasures recommended were double yellow lines without full openings; continuation of pavement edge lines across exit ramps; and bringing stop lines closer to pavement edge lines.

Vaswani, N.K., "Case Studies of Wrong-Way Entries at Highway Interchanges in Virginia" Record 514, Transportation Research Board, Washington, D.C., 1974, pp. 16-28.

This paper is essentially identical to the one entitled "Measures for Preventing Wrong-Way Entries on Highways" by the same author.

Vaswani, N.K., "Virginia's Crash Program to Reduce Wrong-Way Driving", Record 644, Transportation Research Board, Washington, D.C., 1978, pp. 84-90/

This paper recommends

- Using two 19-foot reflectorized pavement arrows on ramps, one five feet from the stopline and the other 100 feet from it
- Eliminating pavement flares. The left edge of the left lane of the exit ramp should not be flared (with a turning radius) into the right pavement edge of a crossroad.
- Providing stop lines across exit ramps near junctions with crossroads
- Continuing the pavement edge line across exit ramps
- Continuing double yellow lines on two-lane divided crossroads opposite exit ramps
- Extending medians to reduce the width of the crossover
- Adding guidance to local drivers on new interchange
- Informing the driver of the geometry of the intersection
- Providing guidance at T intersection without a crossover.

Weaver, Richard P., "Hidden Cameras to Detect Wrong-Way Driving on Freeway Ramps", Photo-Optical Instrumentation: A Tool for Solving Traffic and Highway Engineering Problems, Proceedings of the Society of Photo-Optical Instrumentation Engineers,Vol. 30, November, 1971, pp. 39-44.

The California Division of Highways developed a camera-in-box unit that can be set on the ground on an off-ramp to photograph vehicles moving in the wrong direction. The camera is triggered by crossing a pair of rubber hoses (fastened to the pavement) in the wrong sequence. The camera must be used (as well as a digital counter) to assure that an actuation is truly a wrong-way vehicle, not a false call or malfunction, and to determine characteristics such as night vs. day, car vs. truck, etc.

Appendix B

California's Standard Sign Package

STATE OF CALIFORNIA DEPARTMENT OF PUBLIC WORKS DIVISION OF HIGHWAYS **CIRCULAR LETTER**	FILE CLASSIFICATION Highway Project Development Traffic Department No. 165	NO. 73-18

TO: **ALL DISTRICTS AND HEADQUARTERS**	DATE ISSUED: March 19, 1973	DATE EXPIRED: March 19, 1976

SUBJECT:
Roadside Signs - Ramp Terminal Details
(Expires Upon Publication of Traffic Manual Section 4-05)

REFERENCE:
Supplements Chapter 4, Signs, of the Traffic Manual
Supersedes Standard Plan Sheet S45-3, June 15, 1970

Purpose

These instructions and the attached details A through J set forth the standards for freeway ramp terminal signing to prevent wrong-way driving. The details supersede standard plan sheet S45, Roadside Signs, Minor, Typical Location Details which was deleted from the January 1973 edition of the California Standard Plans.

Discussion

Analysis of wrong-way driving accidents has shown that over 70% occur during hours of darkness. Signing to decrease wrong-way movements should, therefore, be at its best at night. In order to be most responsive to headlights, DO NOT ENTER and FREEWAY ENTRANCE packages should be mounted with the bottom of the lower sign two feet above the edge of pavement. ONE-WAY arrows (R10) should be mounted 1½ feet above the pavement. Standard mounting height for all other signs in the ramp terminal area will remain at five feet. In locations subject to deep snow, sign heights may be adjusted in accordance with the judgment of the District Traffic Engineer.

Pedestrian prohibition signs (R43 and R44) if installed should be placed far enough up the ramp to avoid conflict with the signs near the terminal; generally 75 to 100 feet will be sufficient. At least two large (24-foot) painted pavement arrows should be placed in the center of each ramp lane.

The sign locations on the attached details are approximate. All ramp terminals must be reviewed under both day and night conditions by experienced signing personnel to determine exact locations.

On-Ramp Signing

Care must be taken to insure that arrows on directional signs cannot be misinterpreted as pointing into off-ramps or other inappropriate roadways. Freeway entrance packages (FREEWAY ENTRANCE, Route Shields, Cardinal Direction, and Down Diagonal Arrows) should be placed as near the intersection of the on-ramp and cross street as possible. Large FREEWAY ENTRANCE signs (48" x 30") should be used. The down diagonal arrow should always point toward the on-ramp pavement. The location of the sign package should not be controlled by the use of the larger signs. If proper placement requires the smaller (36" x 21") FREEWAY ENTRANCE sign, it should be used.

Off-Ramp Signing

At least one DO NOT ENTER package should be placed to fall within the area covered by a car's headlights and visible to the driver from the decision point on each likely approach.

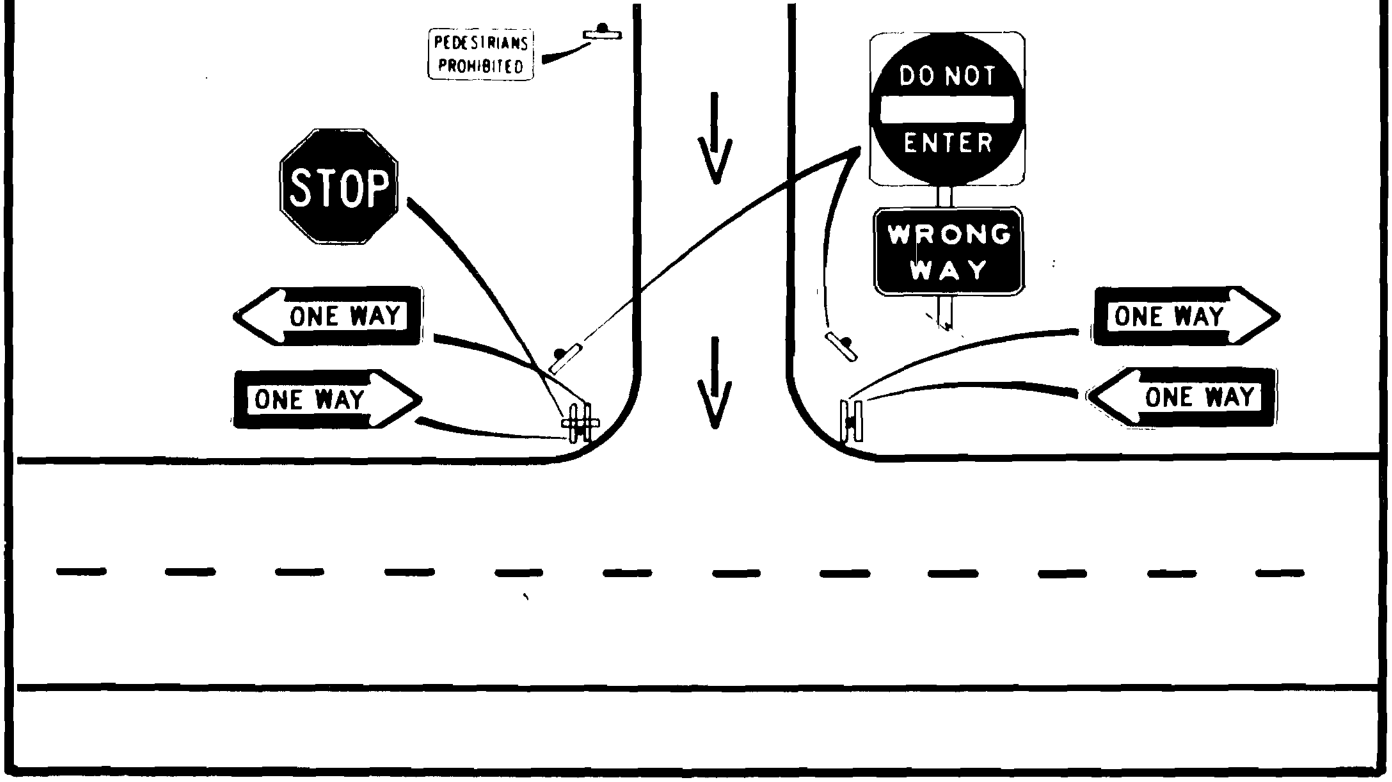
A field decision will have to be made whether to use three DO NOT ENTER packages or four if the off-ramp is split by a traffic island. Generally, curbed islands larger than 1,000 square feet in area indicate the use of four packages. Painted islands may be somewhat larger and still be adequately signed with three packages. Refer to details "E", "H", and "I".

ONE-WAY arrows (R10) should be placed as close to the crossing street as possible. If there are sidewalks immediately adjacent to the cross street, these signs should be located behind the sidewalk to avoid conflicting with pedestrians. A less desirable alternate is relocating the signs above the pedestrian level.

At skewed ramp intersections, where the angle approaches 90°, a second ONE-WAY arrow should be added on the obtuse side when it would be visible to approaching traffic. Refer to detail "B".

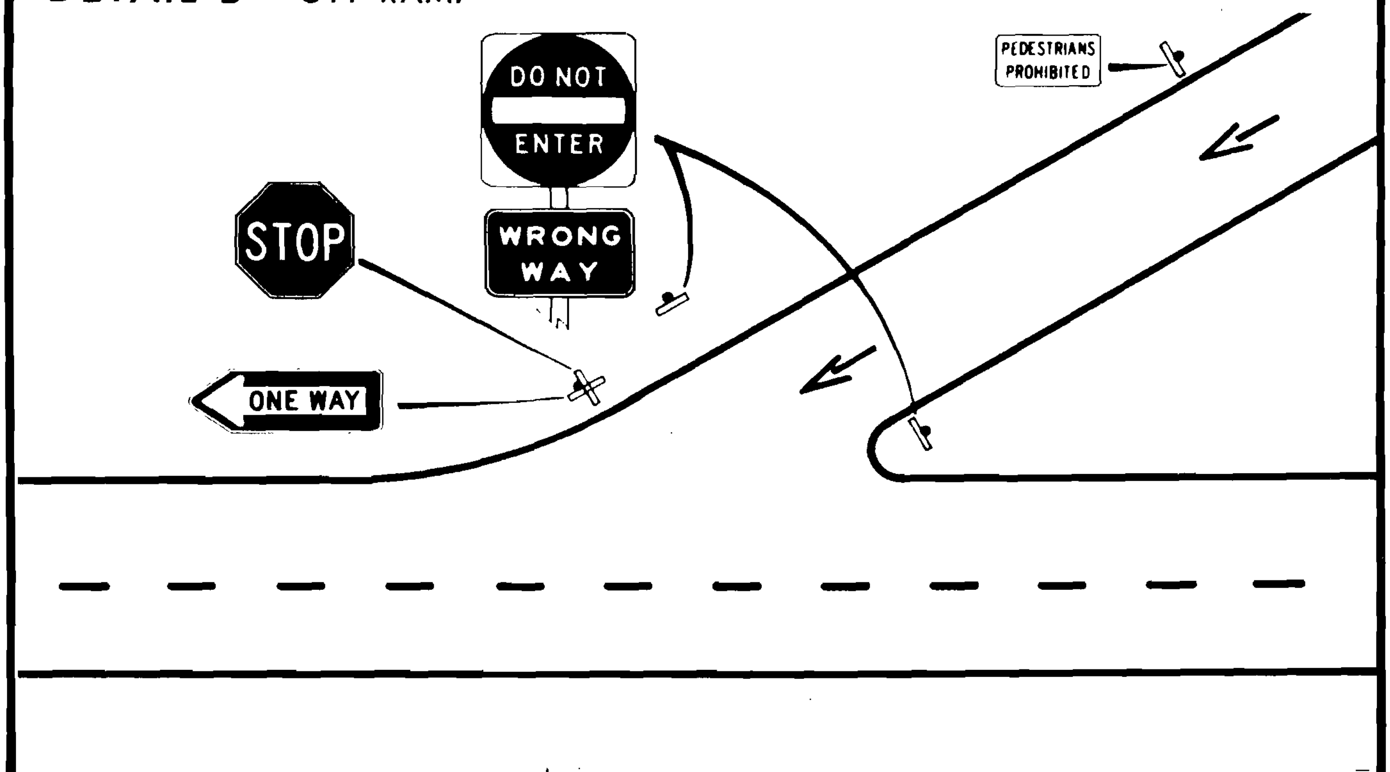
Word message R16A and R17A turn prohibition signs shall be placed in suitable locations on the crossing street in advance of the off-ramp. Symbol-type turn prohibition signs shall <u>not</u> be used at ramp terminals.

DETAIL A OFF-RAMP

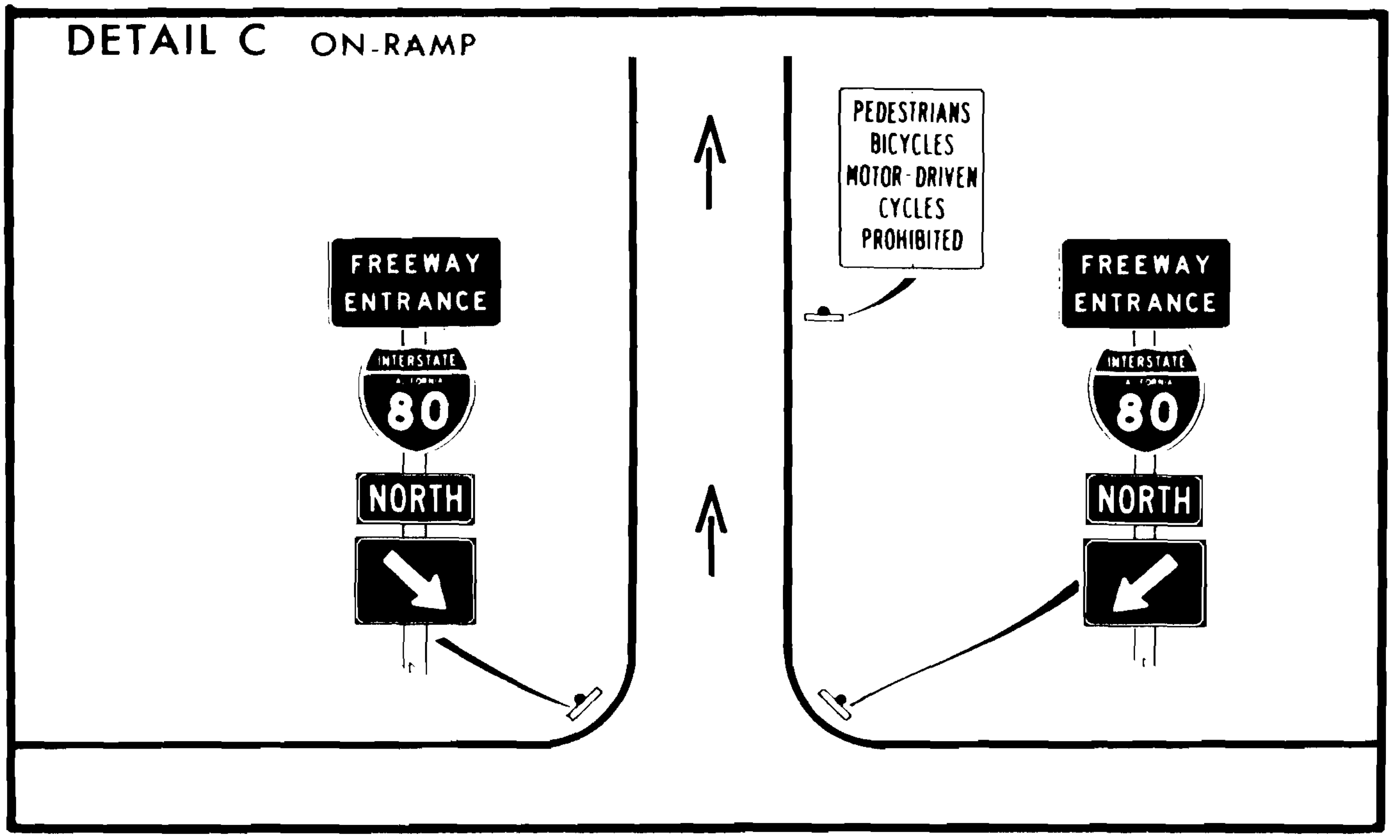


No Scale

DETAIL B OFF-RAMP

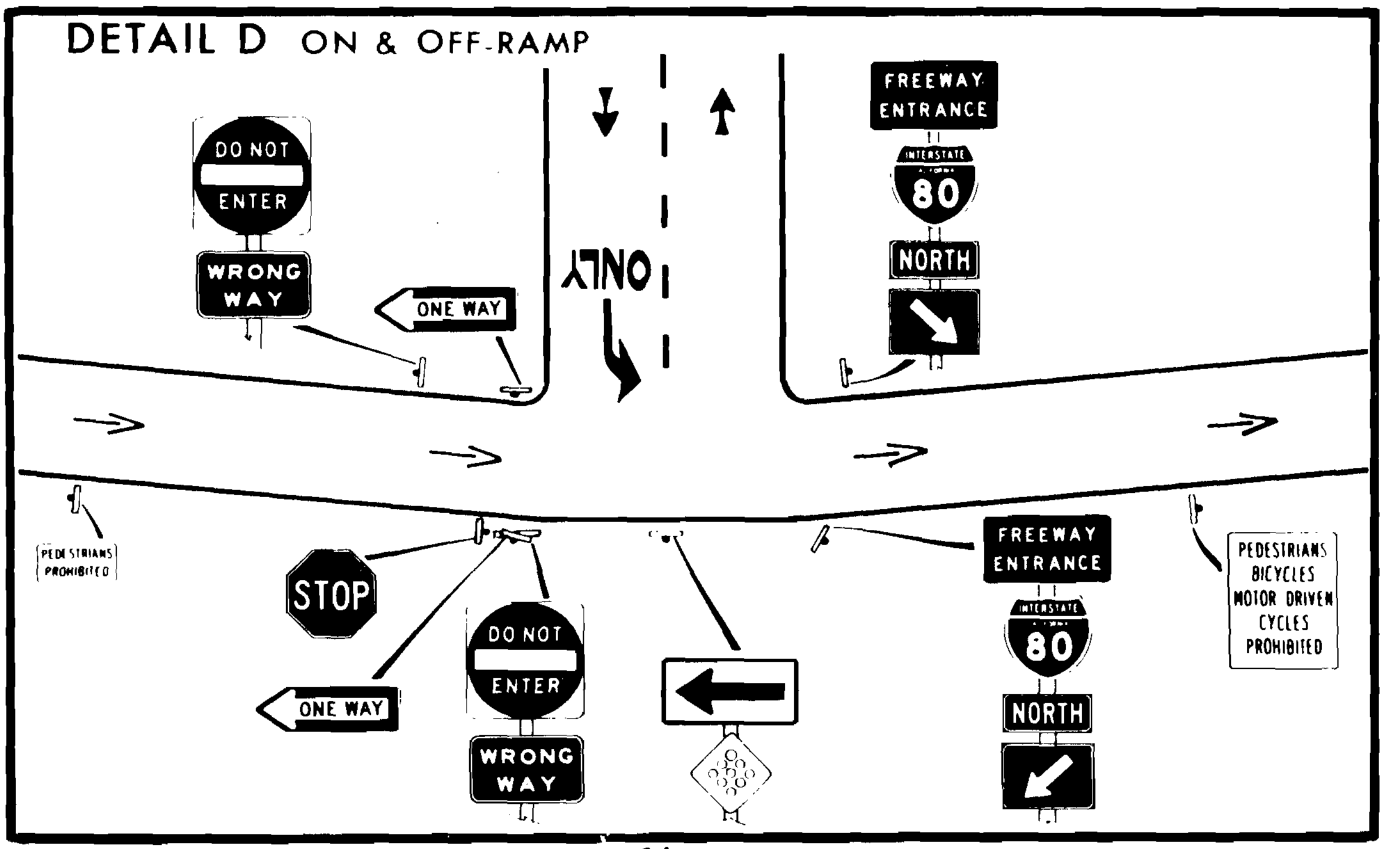


DETAIL C ON-RAMP

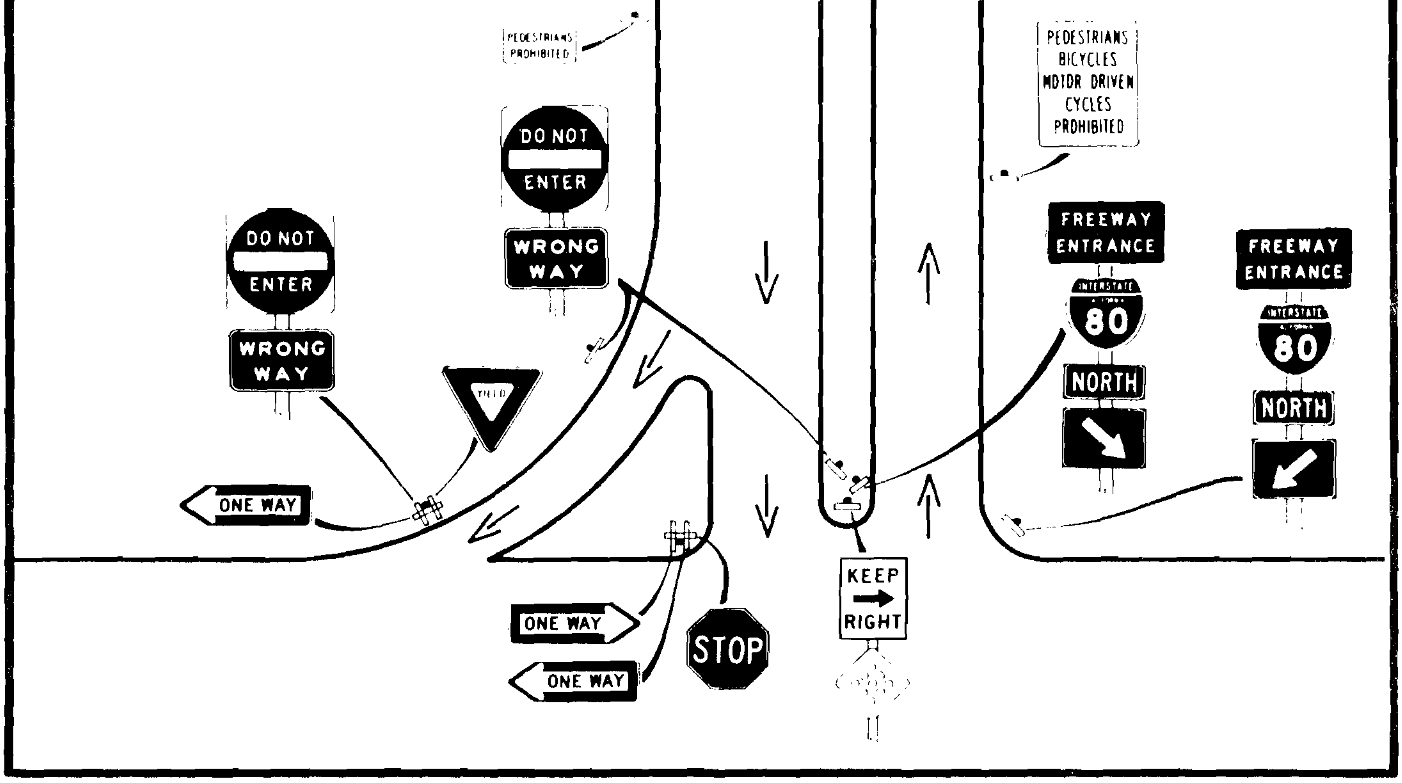


No Scale

DETAIL D ON & OFF-RAMP

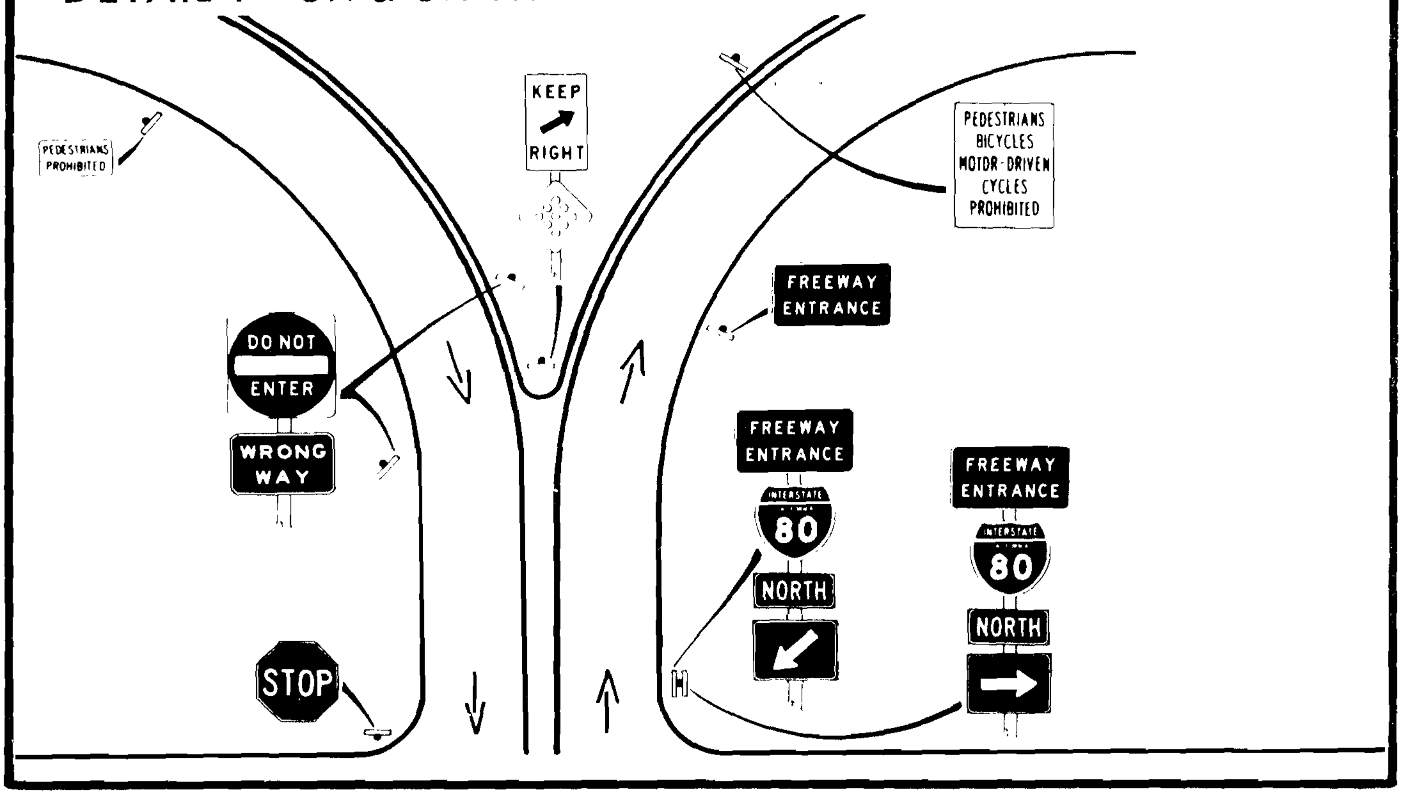


DETAIL E ON & OFF-RAMP

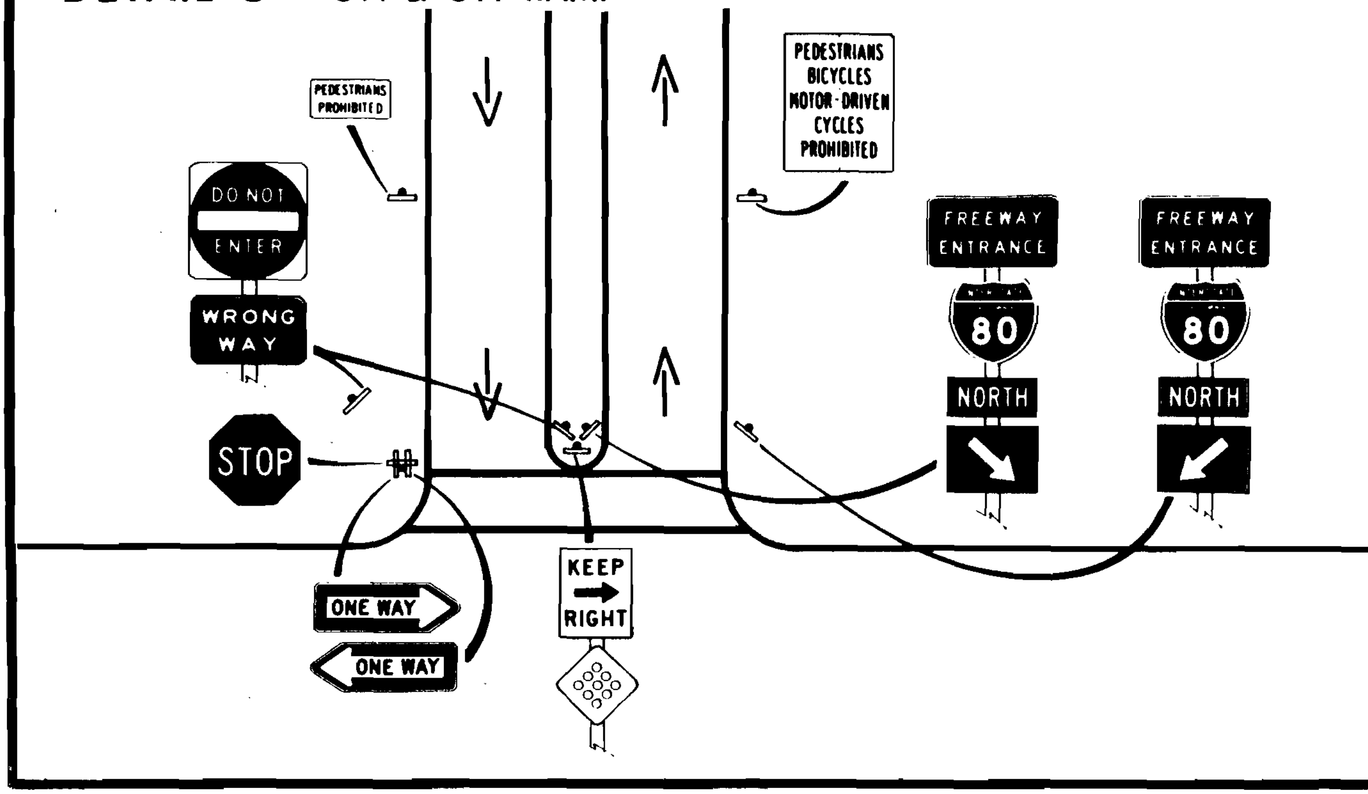


No Scale

DETAIL F ON & OFF-RAMP

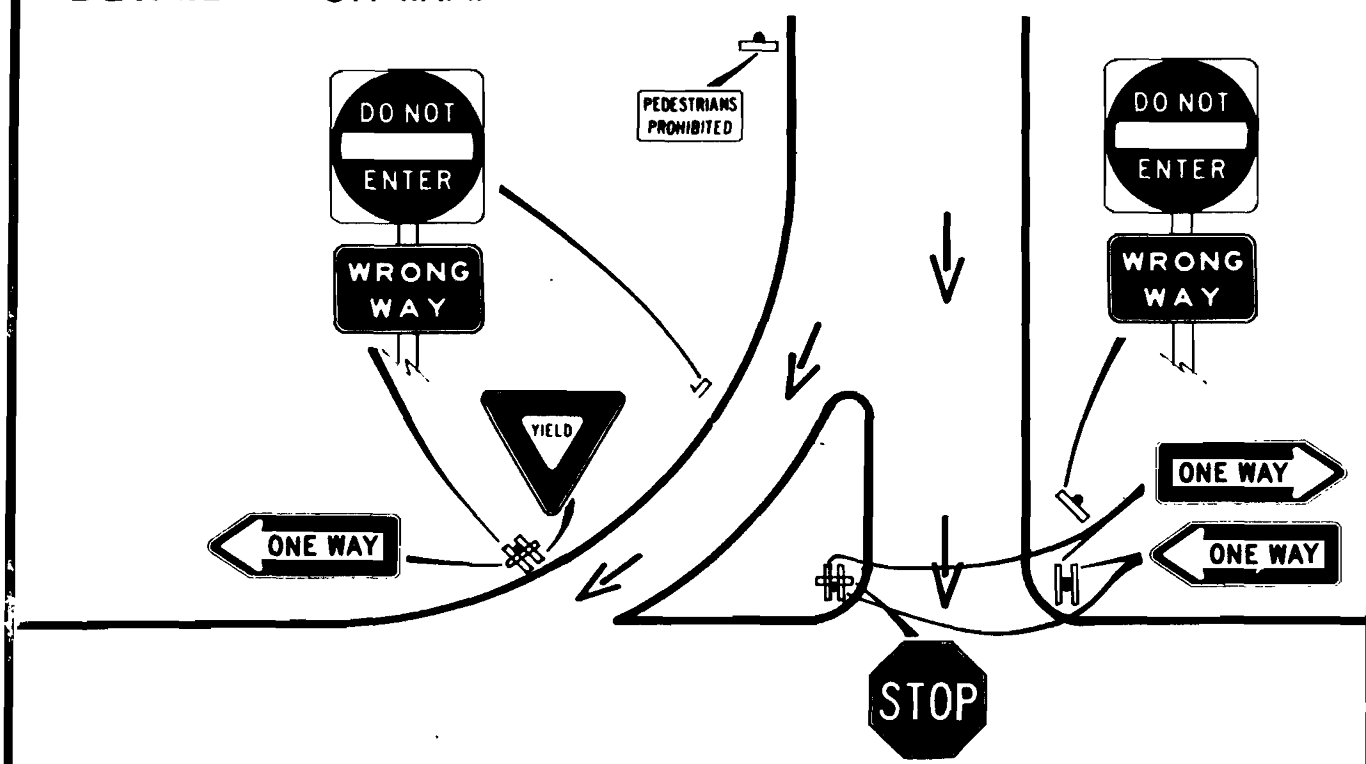


DETAIL G ON & OFF-RAMP

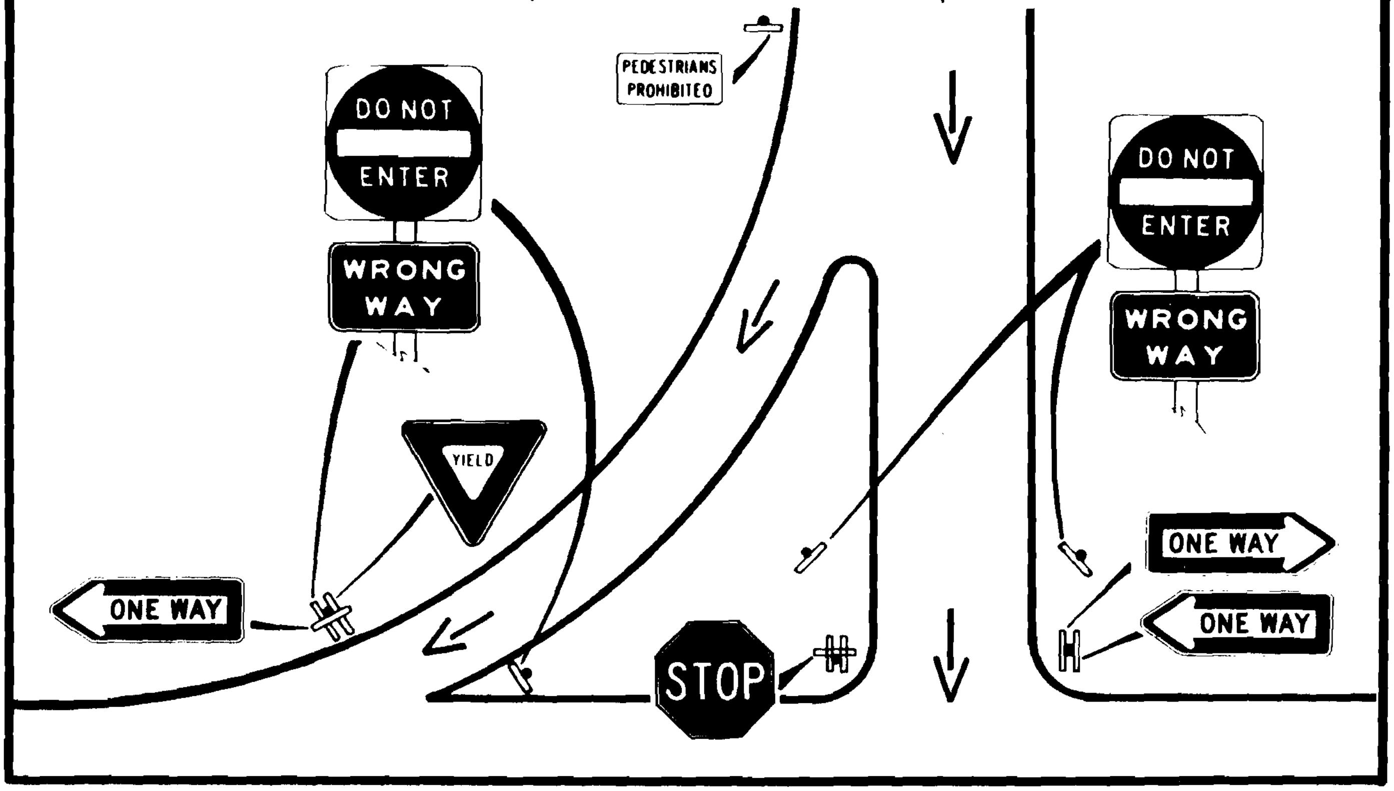


No Scale

DETAIL H OFF-RAMP

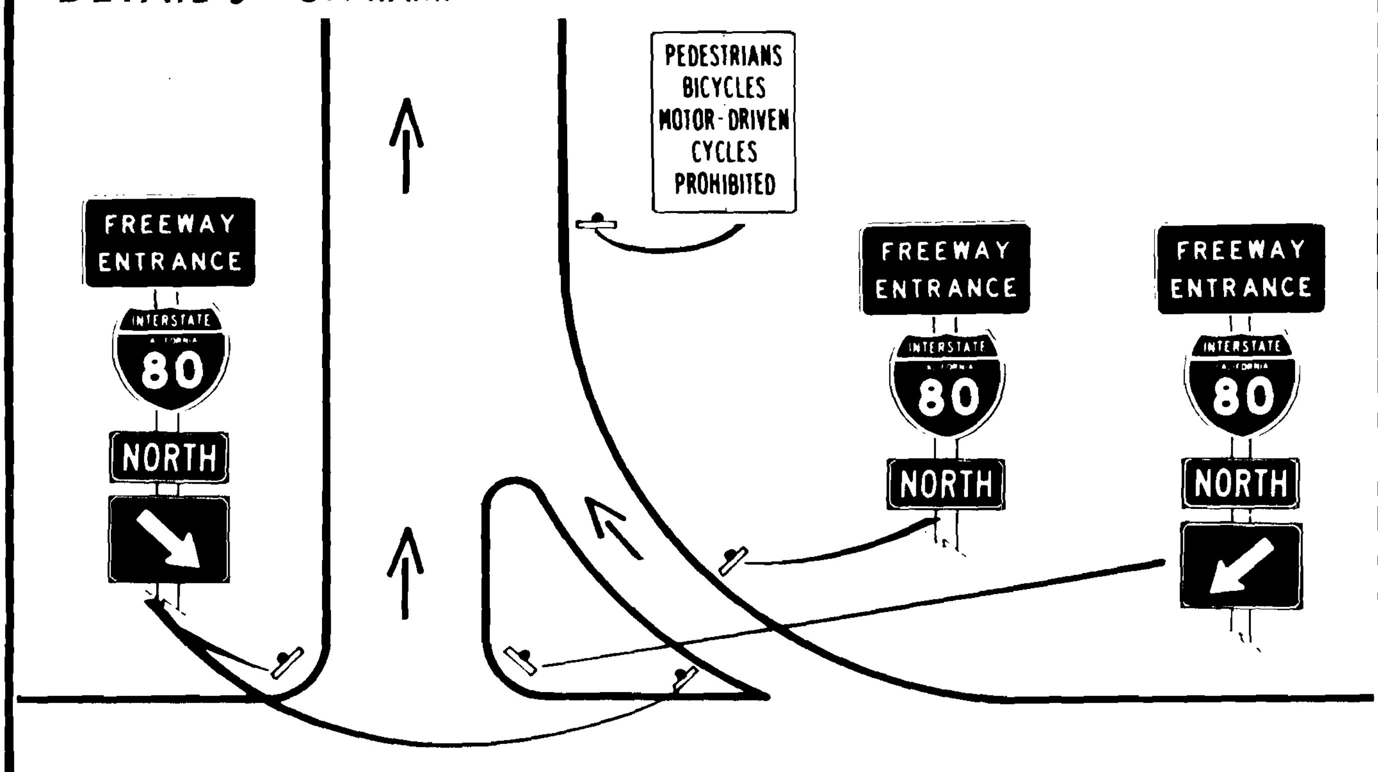


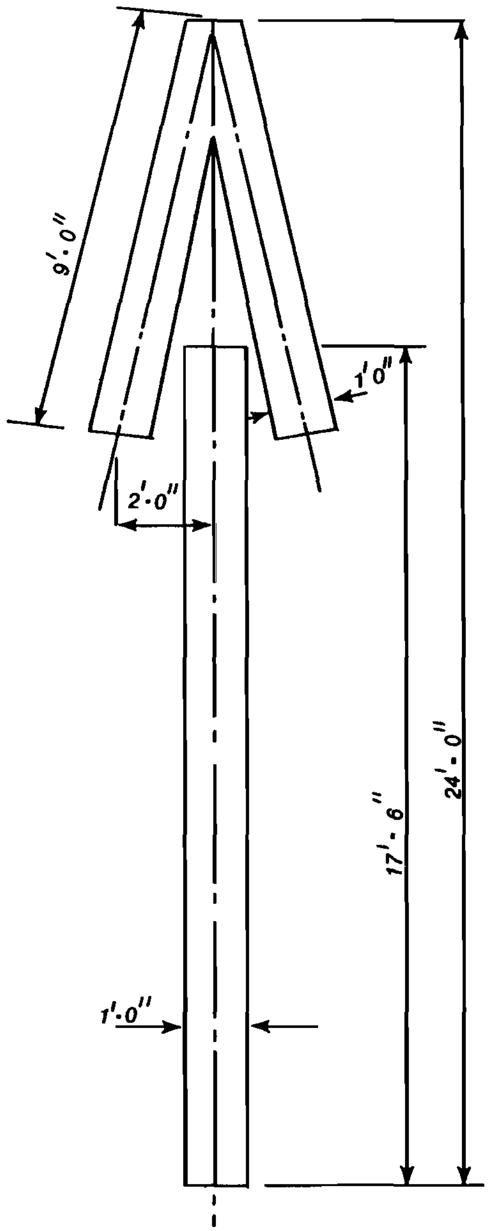
DETAIL I OFF-RAMP (LARGE CURBED ISLAND)



No Scale

DETAIL J ON-RAMP





Dimensions of the Arrow Pavement Marking Used by the California Division of Highways (Reference 7)

Appendix C

Data from Central Avenue/I-75

WRONG-WAY MONITORING RECORD

Location I-75 NB Exit 85 (Central Ave)

Sketch(show interchange and indicate ramp studied)

DATES	ACTUATIONS	WRONG-WAY PHOTOS Day	Night	of (number shot)	WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
BEFORE							
4/14-4/15	7	6	**	7	6	1	180.0
4/15-4/19	14	8	**	9	12	4	90.0
4/19-4/22	8	8	**	8	8	3	80.0
4/22-4/25	11	10	**	10	11	3	110.0
4/25-4/29	9	9	**	9	9	4	67.5
4/29-5/2	10	10	**	10	10	3	100.0
5/2-5/6	9	4	**	4	9	4	67.5
5/6-5/11	MALF.						
PHASE I							
5/11-6/28	INACTIVE						
6/28-7/1	2	2	**	2	2	3	20.0
7/1-7/5	9	9	**	9	9	4	67.5
7/5-7/8	4	4	**	4	4	3	40.0
7/8-7/11	MALF.						
7/11-7/13	INACTIVE						
PHASE II							
7/13-7/18	6	6	**	6	6	5	36.0
7/18-7/22	3	2	**	2	3	4	22.5
7/22-7/25	5	4	**	4	5	3	50.0
7/25-7/27	3	3	**	3	3	2	45.0
PHASE III							
7/27-7/29	5	-	-	-	-	-	-
7/29-8/1	3	-	-	-	-	-	-
8/1-8/5	4	2	**	2	4	4	30.0
8/5-8/12	9	8	**	8	9	7	38.6
8/12-8/16	12	10	**	10	12	4	90.0
8/16-8/19	4	4	**	4	4	3	40.0
8/19-8/23	7	7	**	7	7	4	52.5

DATES	ACTUATIONS	WRONG-WAY PHOTOS Day	Night	of (number shot)	WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
PHASE IV							
8/23-8/30	MALF.						
8/30-9/3	6	6	**	6	6	4	45.0
9/3-9/10	MALF.						
9/10-9/14	INACTIVE						
9/14-9/22	MALF.						
9/22-9/27	2			*	2	5	12.0
9/27-10/4	8	1	5	8	6	7	25.7
10/4-10/10	12	1	1	2	12	6	60.0
10/10-10/25	MALF.						
10/25-2/24	INACTIVE						
2/24-3/4	15	2	6	12	10	8	37.5
3/4-3/14	20	2	9	12	18	10	54.0
3/14-4/25	INACTIVE						
PAVEMENT ARROW INSTALLED 4/22/78							
4/25-5/1	MALF.						
5/1-5/2	INACTIVE						
5/2-5/12	MALF.						
5/12-5/15	INACTIVE						
5/15-5/22	1	0	1	1	1	6	5.0
5/22-5/31	MALF.						
5/31-6/6	0	0	0	0	0	6	0.0
6/6-6/16	133	0	0	0	0	10	0.0
6/16-6/24	MALF.						
6/24-6/28	INACTIVE						
6/28-7/1	5	0	0	5	0	3	0.0
7/1-7/7	5	0	2	5	2	6	10.0
7/7-7/14	4	0	3	4	3	7	12.9
7/14-7/17	2	0	1	2	1	3	10.0
7/17-7/19	0	0	0	0	0	2	0.0
7/19/7/22	1	1	0	1	1	3	10.0
7/22-7/25	1	0	1	1	1	3	10.0
7/25-7/27	3	0	2	3	2	2	30.0
WRONG-WAY CAR STOP ACTIVATED 7/27/78							
7/27-7/31	1	0	0	1	0	4	0.0

PAGE TWO

WRONG-WAY MONITORING
RECORD

Location I-75 NB Exit 85 (Central Ave.)

Sketch (show interchange and indicate ramp studied)

DATES	ACTUATIONS	WRONG-WAY PHOTOS Day	Night	of (number shot)	WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
7/31-8/2	0	0	0	0	0	2	0.0
8/2-8/5	2	0	0	2	0	3	0.0
8/5-8/7	1	1	0	1	1	2	15.0
8/7-8/9	1	0	0	1	0	2	0.0
WRONG-WAY CAR STOP DEACTIVATED 8/8/78							
8/9-8/11	1	0	1	1	1	2	15.0
8/11-8/14	2	0	1	2	1	3	10.0
8/14-8/19	3	1	1	3	2	5	12.0

SUMMARY OF DATA FROM CENTRAL AVE./I-75

	Activations	Photos	Movements*	Days	Rate
BEFORE	68	55 of 56	65	22	88.6
PHASE I	15	15 of 15	15	10	45.0
PHASE II	17	15 of 15	17	14	36.4
PHASE III	36	31 of 31	36	22	49.1
PHASE IV	63	33 of 40	54	40	40.5
ARROW	22	11 of 22	11	41	8.5
CAR STOP	5	1 of 5	1	13	2.3

*Wrong-Way movements of this location frequently exceed the 12-exposure capacity of a roll of film. It was necessary for the project staff to factor up the actual number of photos to reflect this.

Appendix D

Statistical Evaluation of "Before" Data

in Greater Atlanta Study

STATISTICAL EVALUATION

A rough statistical analysis was made on the Phase 1 data. Analysis of variance (ANOVA) was used to test whether the rates for the different ramp types were significantly different. Each ramp observed was considered as one observation, no matter how long it was observed.

The method involves calculating a corrected sum of squares for each variance component, here the ramp types and error (random variance). These are found as follows:

$$SS_{TREATMENT(RAMP\ TYPE)} = \sum_i \frac{X_i^2}{n_i} - \frac{X..^2}{N}$$

$$SS_{TOTAL} = \sum_j \sum_i X_{ij}^2 - \frac{X..^2}{N}$$

$$SS_{ERROR} = SS_{TOTAL} - SS_{TREAT}$$

where X_{ij} = individual observations

X_i = sum for each ramp types

n_i = number of observations for that ramp type

N = total number of observations

These are then inserted into the ANOVA table. Degrees of freedom for the treatment is equal to the number of treatments minus one. For error it is the total number of observations minus the number of treatments. The mean square is the sum of squares divided by its degrees of freedom. The ANOVA table is as follows:

Source	SS	DOF	MS	F
Ramp Types	66.42	12	5.54	<1
Error	136.22	21	6.49	
Total	202.64	33		

The F-ratio measures how much greater the variance due to the treatment is than is the random error. Here it is less than one, so we conclude that the ramp type is not statistically significant at this level of analysis.

Appendix E

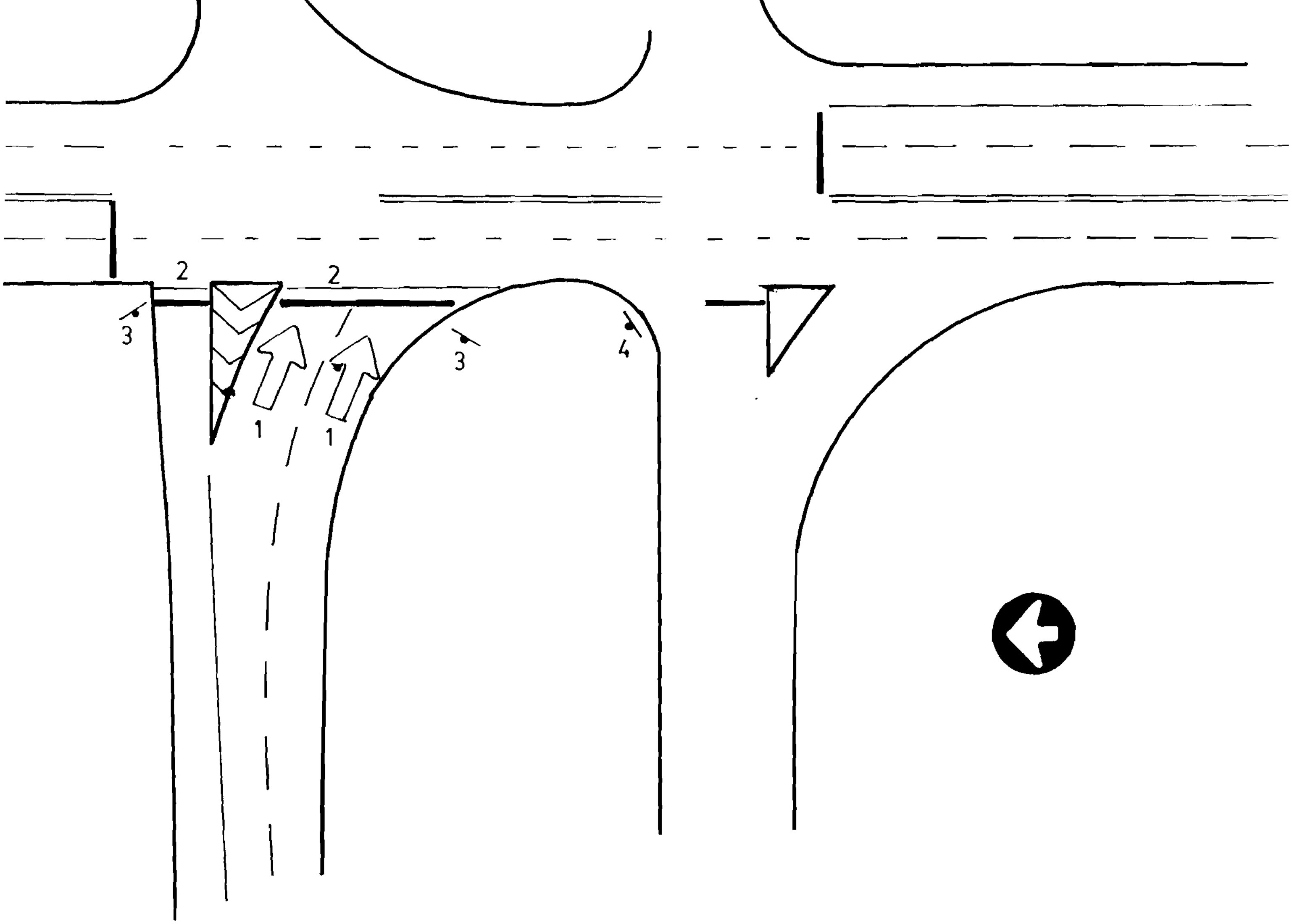
Countermeasures Evaluated

in Greater Atlanta Study

I - 285 & RIVERDALE RD

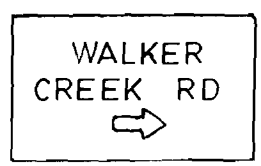
DIAMOND WITH CLOSE FRONTAGE ROAD

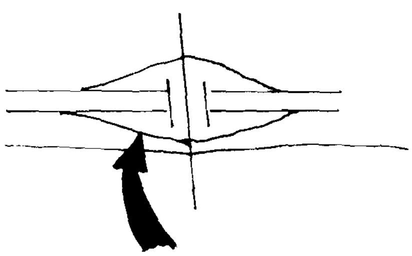
APP SCALE : 1"=40'



COUNTERMEASURES :

1 Large pavement arrows
2 24" stop bar, 8' from curb (or 4' from crosswalk)
3 DO NOT ENTER ; R 5-1
4 Guide sign

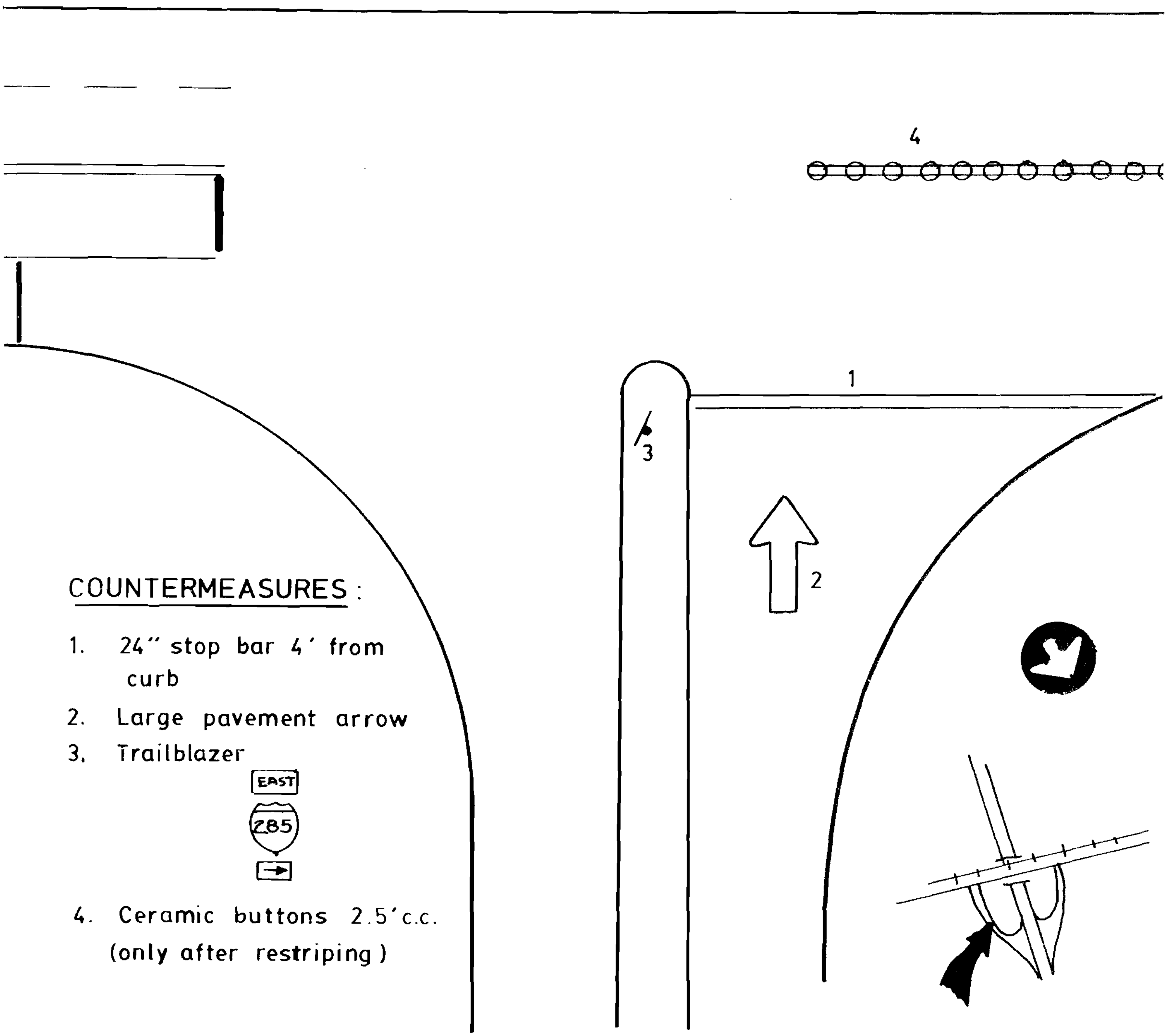




I-285 & US 19/41

PARCLO AB LOOP RAMP

APP SCALE : 1"=20'



COUNTERMEASURES :

1. 24" stop bar 4' from curb
2. Large pavement arrow
3. Trailblazer

   EAST

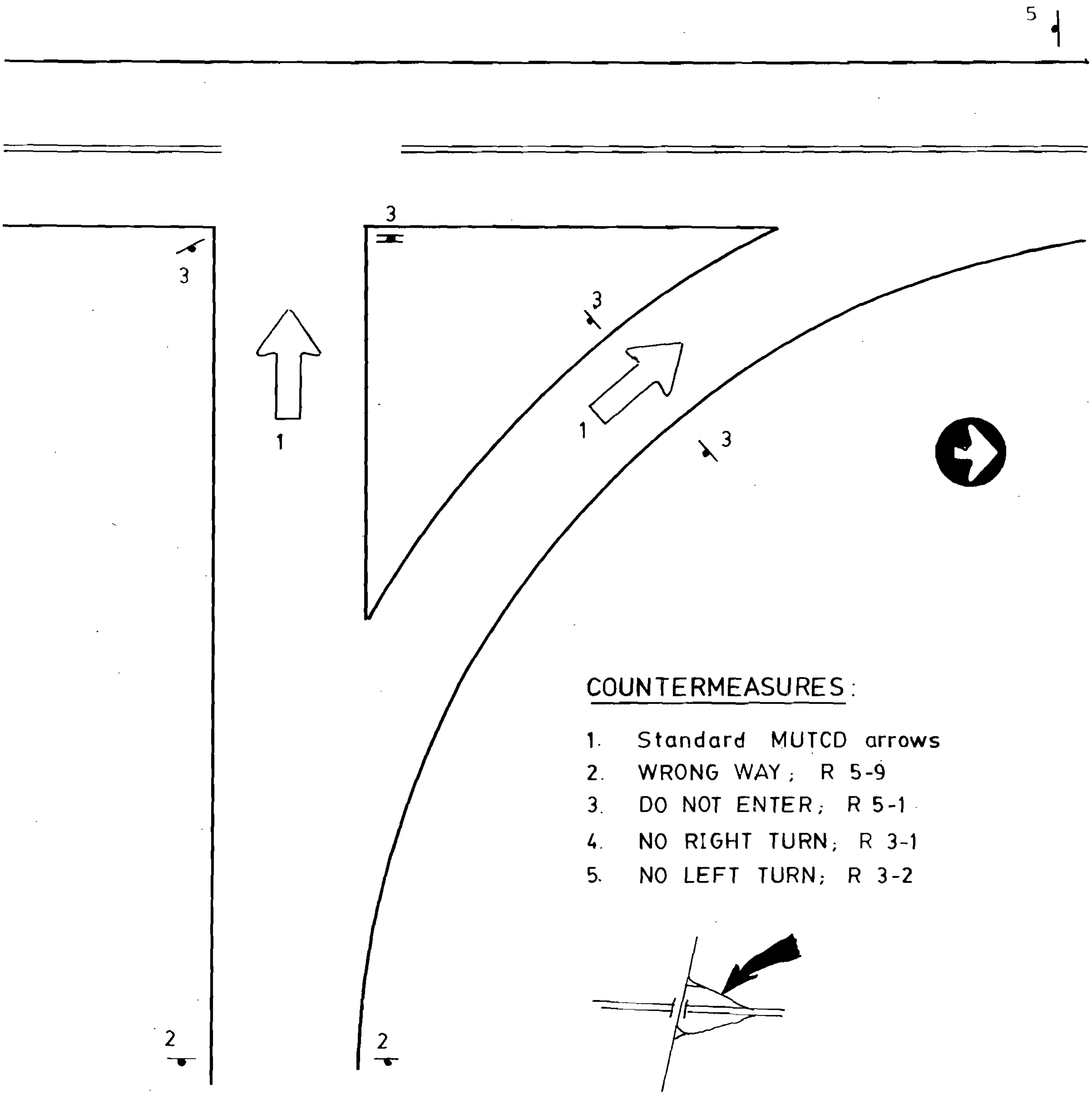
   285

4. Ceramic buttons 2.5'c.c. (only after restriping)

I-20 & CHAPEL HILL RD

HALF DIAMOND

APP. SCALE : 1" = 20'



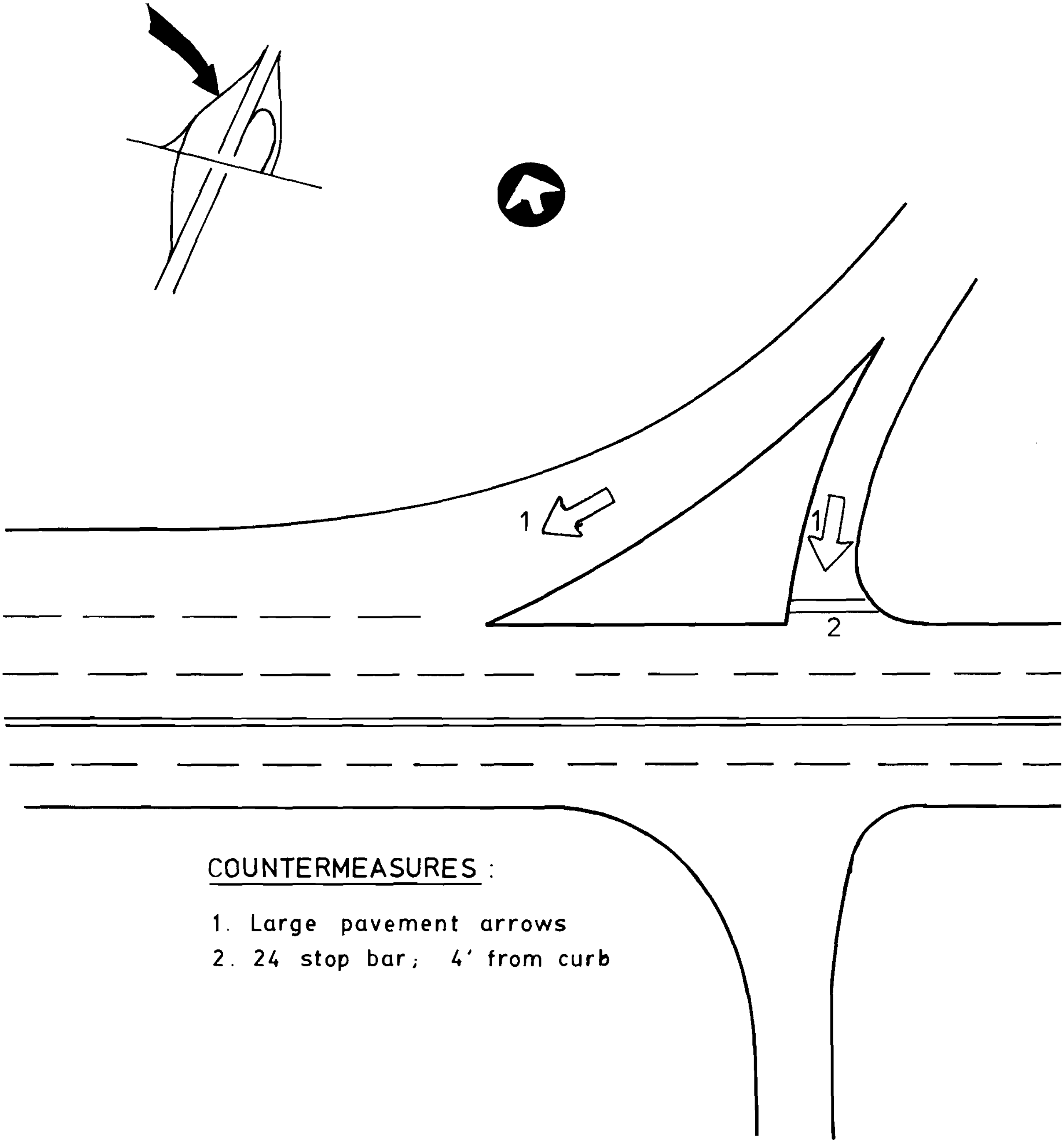
COUNTERMEASURES:

1. Standard MUTCD arrows
2. WRONG WAY ; R 5-9
3. DO NOT ENTER ; R 5-1
4. NO RIGHT TURN ; R 3-1
5. NO LEFT TURN ; R 3-2

GA 400 & HOLCOMB BRIDGE RD

PARCLO 3-QUADRANT DIAGONAL RAMP

APP SCALE : 1" = 40'



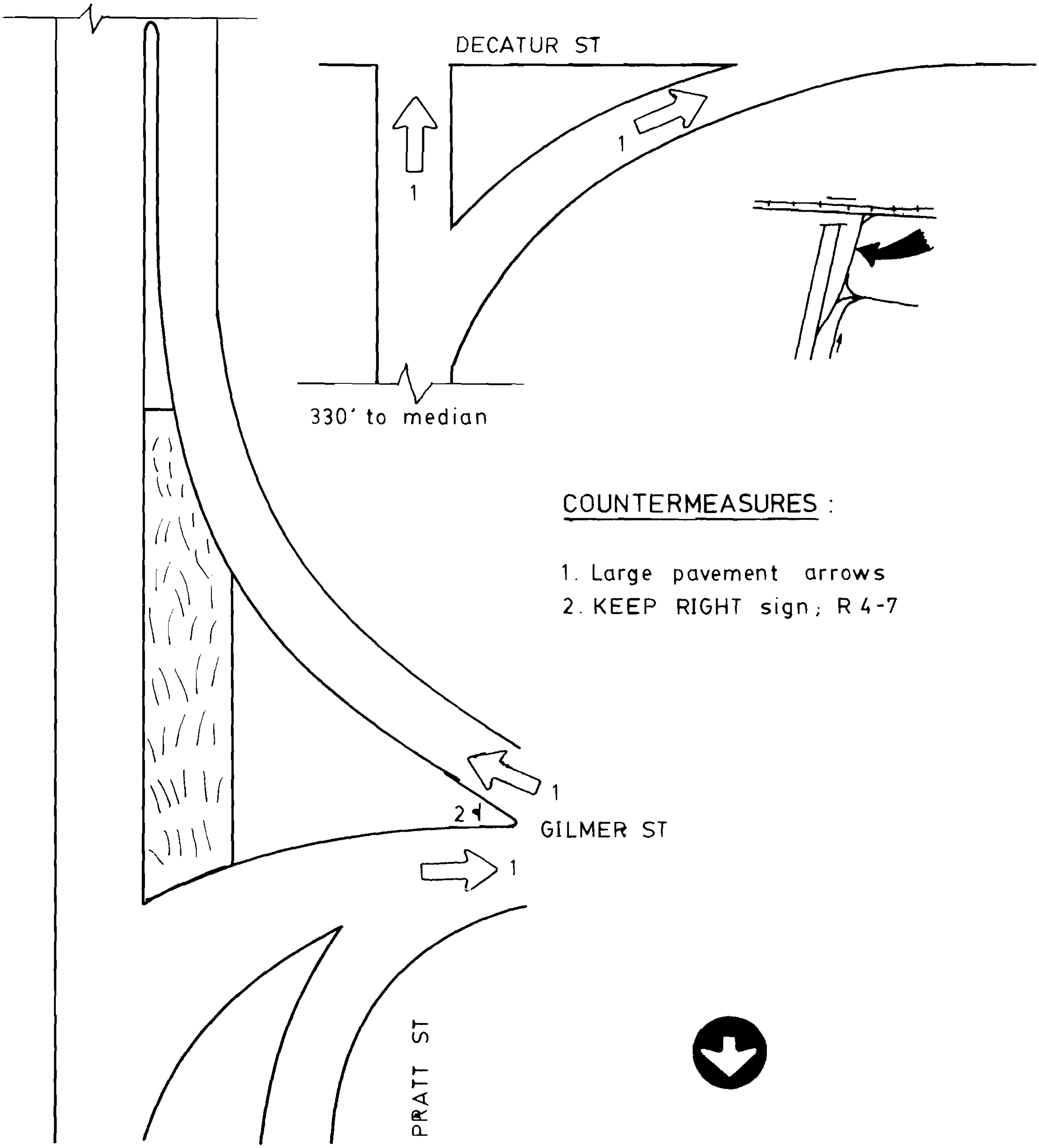
COUNTERMEASURES :

1. Large pavement arrows
2. 24 stop bar ; 4' from curb

I-75/85 & DECATUR ST

QUARTER DIAMOND

APP SCALE : 1"=40'



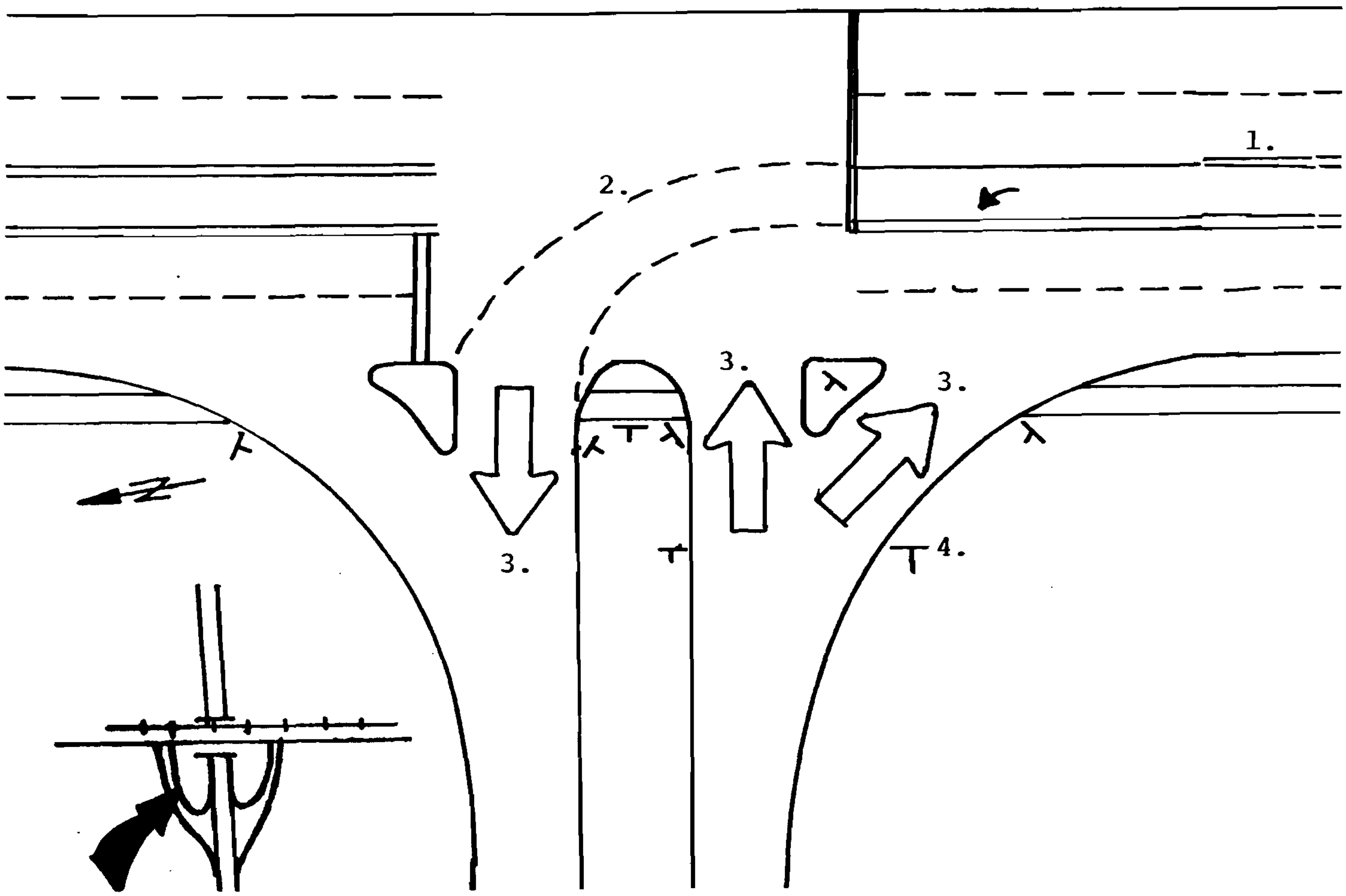
COUNTERMEASURES :

1. Large pavement arrows
2. KEEP RIGHT sign ; R 4-7

I-75 & JONESBORO RD

PARCLO AB LOOP RAMP

APP. SCALE: 1" = 20'



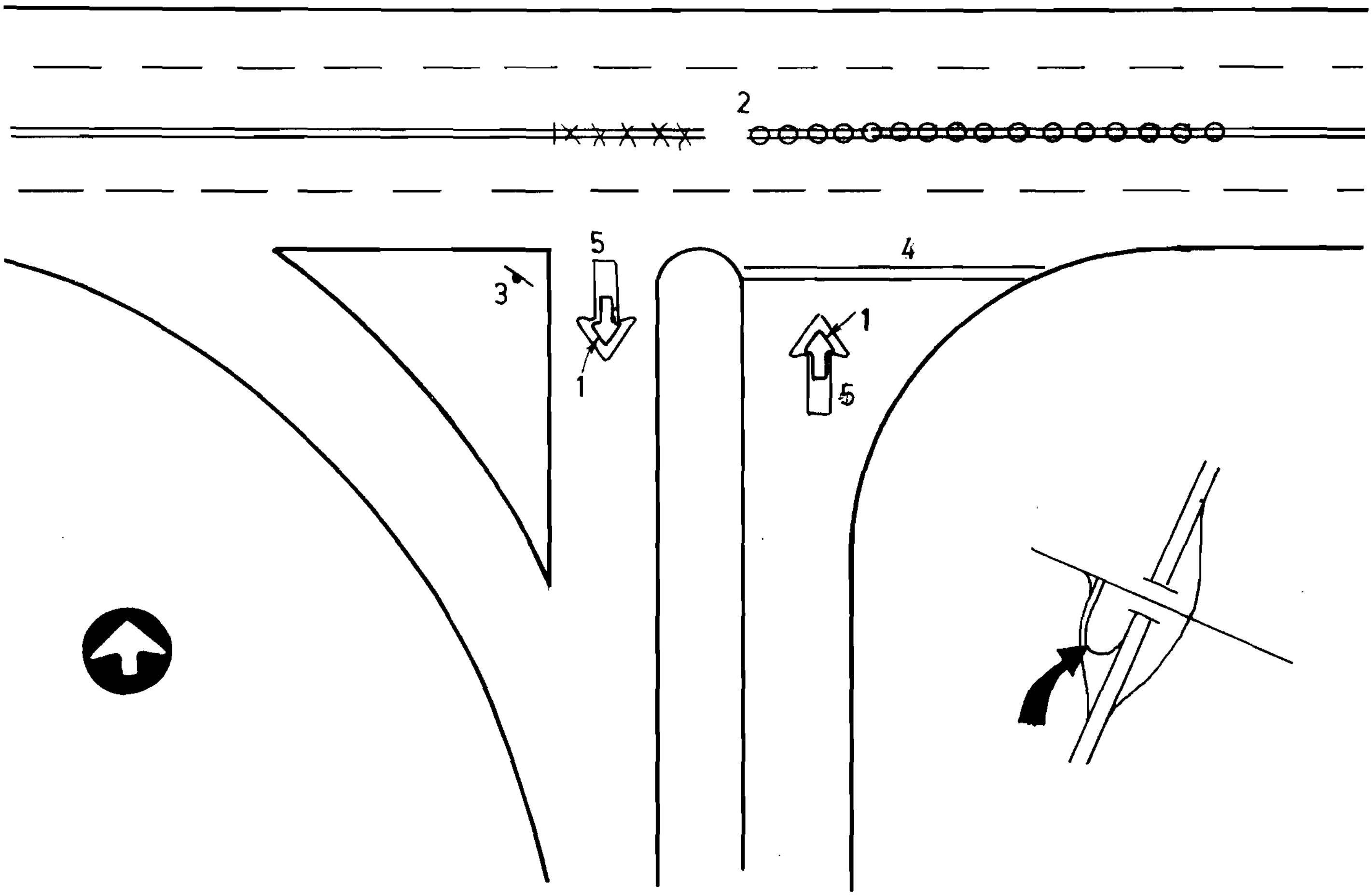
COUNTERMEASURES:

1. STRIPE GAP AT PATCH ON JONESBORO RD.
2. ADD "ELEPHANT TRACKS" TO GUIDE LEFT-TURNING TRAFFIC
3. ADD LARGE PAVEMENT ARROWS
4. REPLACE MISSING "DO NOT ENTER" SIGN (POST IS STILL IN PLACE)

GA 400 & HAYNES BRIDGE RD

PARCLO 3-QUADRANT LOOP RAMP

APP SCALE : 1" = 40'



PHASED COUNTERMEASURES:

PHASE 1

1. Standard pavement arrows
2. Adjust centerline opening
3. Trailblazer

PHASE 2

4. 24" stop bar

PHASE 3

5. Enlarge arrows

PHASE 4 (if necessary)

6 Ceramic buttons

2.5' c.c.

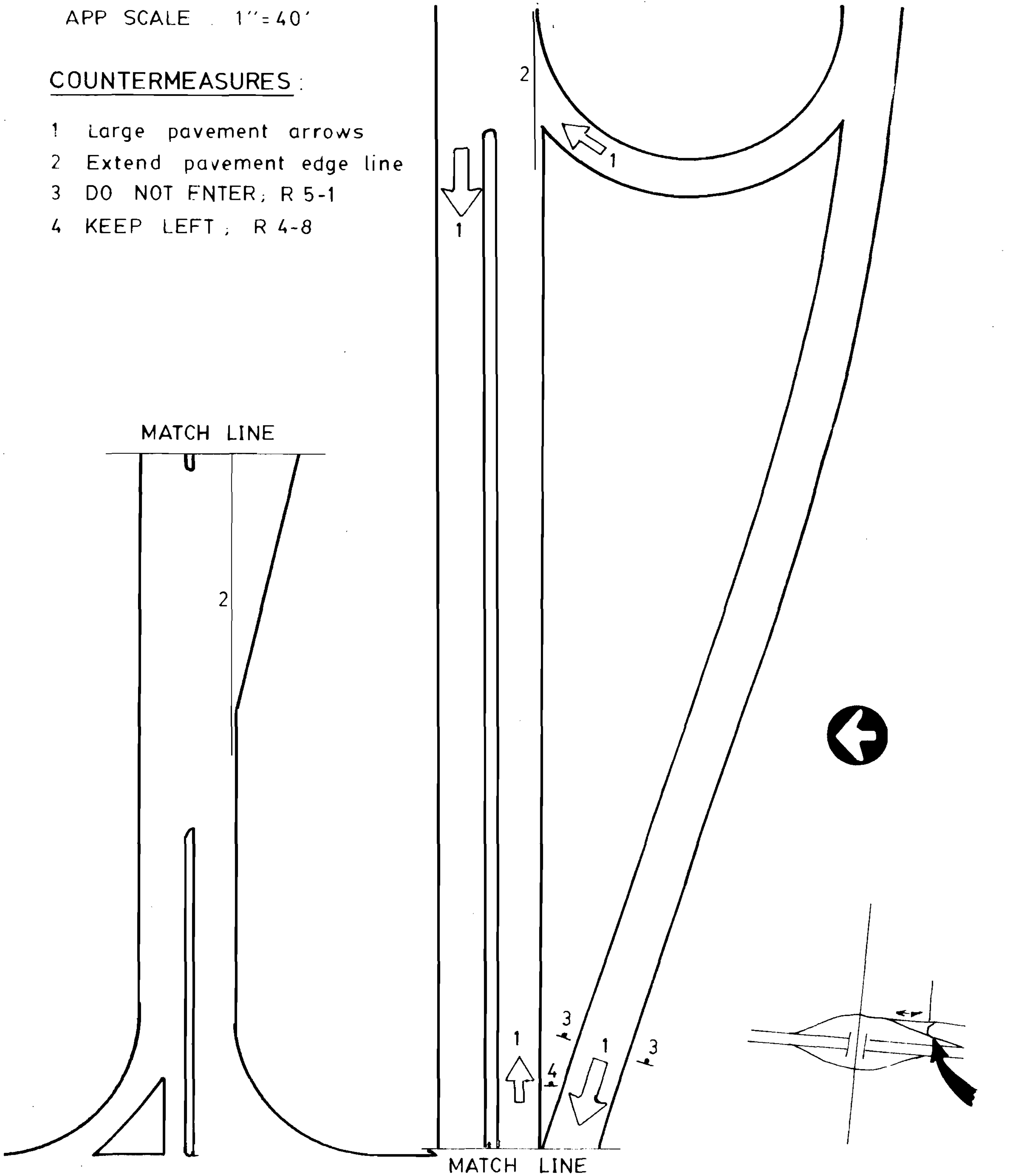
I-20 & WESLEY CHAPEL RD

DIAMOND WITH CLOSE FRONTAGE ROAD

APP SCALE . 1"=40'

COUNTERMEASURES :

1 Large pavement arrows
2 Extend pavement edge line
3 DO NOT ENTER; R 5-1
4 KEEP LEFT ; R 4-8



Appendix F

"After" Data from Greater Atlanta Study

Counter installed 10/9/78

WRONG-WAY MONITORING RECORD

Location I-285 @ Riverdale Rd. EB

Sketch (show interchange and indicate ramp studied)

DATES	ACTUATIONS	WRONG-WAY PHOTOS			WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
		Day	Night	of (number shot)			
10/13/78	14	0	0	11	0	4	0
10/20/78	0	0	0	0	0	7	0
10/23/78	1	0	1	1	1	3	10
10/27/78	1	0	0	1	0	4	0
11/3/78	1	0	0	1	0	7	0
11/10/78	1	0	1	1	1	7	4.3
11/17/78	0	0	0	0	0	7	0

There were 2 wrong-way movements in 39 days of good data, or a rate of 1.5 per month.

Counter installed 10/30/78

WRONG-WAY MONITORING
RECORD

Location I-285 @ Ga. 19 & 41 EB

Sketch(show interchange and indicate ramp studied)

DATES	ACTUATIONS	WRONG-WAY PHOTOS Day	Night	of (number shot)	WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
11/3/78	2	0	0	2	0	4	0
11/10/78	2	0	2	3	2	7	8.6
11/24/78	0	0	0	0	0	7	0
12/15/78	4	1	1	3	2	14	4
2/ 8/79	4	0	1	4	1	5	
2/15/79	1	0	0	1	0	7	
3/1/79	2	0	0	2	0	5	
3/8/79	20	0	0	12	0	7	
3/14/79	5	0	0	5	0	6	
3/27/79	5	0	0	1	0	13	
4/6/79	1	0	0	0	0	10	
4/10/79	9	0	0	9	0	4	
4/20/79	14	0	0	12	0	10	
4/29/79	6	0	0	0	0	4	

Data From 11/3/78 to 4/24/79 show 5 wrong-way movements in 110 days, or 1.4 in 30 days.

Counter installed 11/8/78

WRONG-WAY MONITORING
RECORD

Location I-20@ Chapel Hill WB

DATES	ACTUATIONS	WRONG-WAY PHOTOS Day	Night	of (number shot)	WRONG-WAY MOVEMENTS	DAYS IN PERIOD	Sketch (show interchange and indicate ramp studied) WRONG-WAY RATE (per 30-day month)
1/25/79	14	0	2	5	2	30	
2/8/79	3	0	0	0	0	5	
2/15/79	3	0	1	3	1	7	
2/20/79	6	0	3	6	3	5	
3/14/79	13	0	0	0	0	4	
4/6/79	1	0	0	1	0	10	
4/10/79	29	0	0	11	0	4	
4/24/79	49	0	0	24	0	14	

Data taken from 11/15/78 to 4/24/79 show 10 wrong-way movements in 127 days, or 2.4 per 30 days.

Counter installed 10/11/78

WRONG-WAY MONITORING RECORD

Location Ga. 400 @ Holcomb Bridge SB

Sketch (show interchange and indicate ramp studied)

DATES	ACTUATIONS	WRONG-WAY PHOTOS Day	Night	of (number shot)	WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
10/18/78	0	0	0	0	0	7	0
10/23/78	0	0	0	0	0	5	0
10/27/78	0	0	0	0	0	4	0
11/3/78	0	0	0	0	0	7	0
11/10/78	0	0	0	0	0	7	0
11/17/78	0	0	0	0	0	7	0
11/24/78	0	0	0	0	0	7	0

There were no wrong-way movements in 45 days of good data.

Counter installed 11/8/78

WRONG-WAY MONITORING RECORD

Location I-75,85 @ Decatur St. SB

Sketch (show interchange and indicate ramp studied)

DATES	ACTUATIONS	WRONG-WAY PHOTOS Day	Night	of (number shot)	WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
11/20/78	3	0	2	3	2	7	8.6
11/24/78	1	0	0	1	0	4	0
12/18/78	7	0	2	7	2	24	2.5
12/20/78	0	0	0	0	0	2	0
12/26/78	3	0	1	3	1	6	5
1/6/79	7	0	1	7	1	11	2.7
3/8/79	4	0	0	4	0	3	
3/14/79	3	0	1	3	1	6	
3/27/79	0	0	0	0	0	13	
4/6/79	2	0	0	0	0	10	
4/10/79	2	0	0	0	0	4	
4/17/79	21	0	0	12		7	
4/24/79	14	0	0	12		7	

Data from 11/20/78 to 4/24/79 show 7 wrong-way movements in 104 days, or 2.0 in 30 days.

Counter installed 2/3/79

WRONG-WAY MONITORING
RECORD

Location I-75 @ Hwy 54 (NB)

DATES	ACTUATIONS	WRONG-WAY PHOTOS Day	Night	of (number shot)	WRONG-WAY MOVEMENTS	DAYS IN PERIOD	Sketch (show interchange and indicate ramp studied) WRONG-WAY RATE (per 30-day month)
2/8/79	4	0	0	4	0	5	
2/15/79	1	0	0	1	0	7	
3/8/79	5	0	0	5	0	7	
3/14/79	19	0	0	0	0	6	
3/27/79	0	0	0	0	0	13	
4/6/79	23	0	3	12	3	10	
4/10/79	22	0	1	12	1	4	
4/20/79	3	0	2	3	2	10	
Data	from 2/8/79	to 4/20/79		show 6	wrong-way	movements	
in 62 days	or 2.9 in	30 days.					

WRONG-WAY MONITORING
RECORD

Location Ga. 400 @ Haynes Bridge SB

Sketch(show inter-change and indicate ramp studied)

DATES	ACTUATIONS	WRONG-WAY PHOTOS Day	WRONG-WAY PHOTOS Night	of (number shot)	WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
10/18/78	9	2	0	9	2	7	8.6
10/23/78	6	1	1	6	2	5	12
10/27/78	3	1	2	3	3	4	22.5
11/10/78	1	0	1	2	1	7	4.3
11/17/78	4	0	4	4	4	7	17.2
11/24/78	3	1	2	3	3	7	12.9
2/8/79	10	2	4	10	6	5	36
3/8/79	22	2	5	12	7	7	
3/14/79	18	0	0	12	0	6	
3/27/79	36	1	1	12	1	13	
4/6/79	187	1	2	12	2	10	
4/10/79	28	1	1	12	3	4	
4/17/79	27	1	3	12	4	7	

Data from 10/18/78 to4/17/79 show 38 wrong-way movements in 89 days, or 12.8 in 30 days. This is a high rate and we recommend the installation of the next countermeasure, which is the 24" stop bar.

The 24" stop bar was installed on 6/21/79, but the camera malfunctioned until 8/2/79. From that date to 9/6/79 it functioned well.

DATES	ACTUATIONS	WRONG-WAY PHOTOS Day	WRONG-WAY PHOTOS Night	of (number shot)	WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
8/9/79	9	2	7	9	9	7	
8/22/79	9	4	5	9	9	13	
9/6/79	8	5	3	8	8	15	

Data from 8/2/79 to 9/6/79 show 26 wrong-way movements in 35 days, or 223 in 30 days.

Counter installed 10/4/78

WRONG-WAY MONITORING RECORD

Location I-20 @ Wesley Chapel WB

Sketch (show interchange and indicate ramp studied)

DATES	ACTUATIONS	WRONG-WAY PHOTOS Day	Night	of (number shot)	WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
10/23/78	2	0	0	2	0	3	0
11/3/78	0	0	0	0	0	7	0
11/10/78	1	0	0	1	0	7	0
11/17/78	3	0	0	3	0	7	0
11/24/78	2	0	0	2	0	7	0
12/15/78	6	1	0	5	1	14	2.1

Data from 10/4/78 to 12/15/78 indicate 1 wrong-way movement in 45 days of good data, for a rate of 0.67 in 30 days.