GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

NO action 9/25 OK

Date: 9/29/77

Project Title: "Wrong-Way Traffic Movements on Freeway Ramps."

Project No: E-20-624

Project Director: Dr. P. S. Parsonson

Sponsor: Georgia Department of Transportation

Agreement Period: From 9/23/77 Until 1/22/79

Type Agreement: Contract (GDOT Research Project No. 7703)

Amount: $14,842 GDOT
6,349 GIT (E-20-349)
$21,191

Reports Required: Quarterly Progress Reports, Interim Progress Report, Final Project Report.

Sponsor Contact Person (s):

Technical Matters

Contractual Matters
(thru OCA)

Mr. Hugh L. Tyner, P. E., Chief
Research and Development Bureau
Office of Materials and Research
15 Kennedy Drive
Forest Park, GA 30050
(404) 363-7585

Defense Priority Rating: N/A

Assigned to: Civil Engineering (School/Laboratory)

COPIES TO:

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- Division Chief (EES)
- School/Laboratory Director
- Dean/Director—EES
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- Office of Computing Services
- Director, Physical Plant
- EES Information Office
- Project File (OCA)
- Project Code (GTRI)
- Other

CA—3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: October 30, 1979

Project Title: "Wrong-Way Traffic Movements on Freeway Ramps"

Project No: E-20-624

Project Director: Dr. S. P. Parsonson

Sponsor: Georgia Department of Transportation

TERMINATED

Effective Termination Date: 9/22/79

Clearance of Accounting Charges: 9/22/79

Grant/Contract Closeout Actions Remaining:

- _x_ Final Invoice and Closing Documents
- _ Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
- _ Other _____

Assigned to: Civil Engineering (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
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EES Information Office
Project File (OCA)
Project Code (GTRI)
Other _____

CA–4 (1/79)

RESEARCH QUARTERLY PROGRESS REPORT

GEORGIA DEPARTMENT OF TRANSPORTATION

Date of Report: October 11, 1977

1 Project No. State/Agency	2 Project Title	3 Quarterly Report No. 1
7703/E-20-624	Wrong-way Traffic Movements on Freeway Ramps	From Sept. 23, 1977 To Sept. 30, 1977

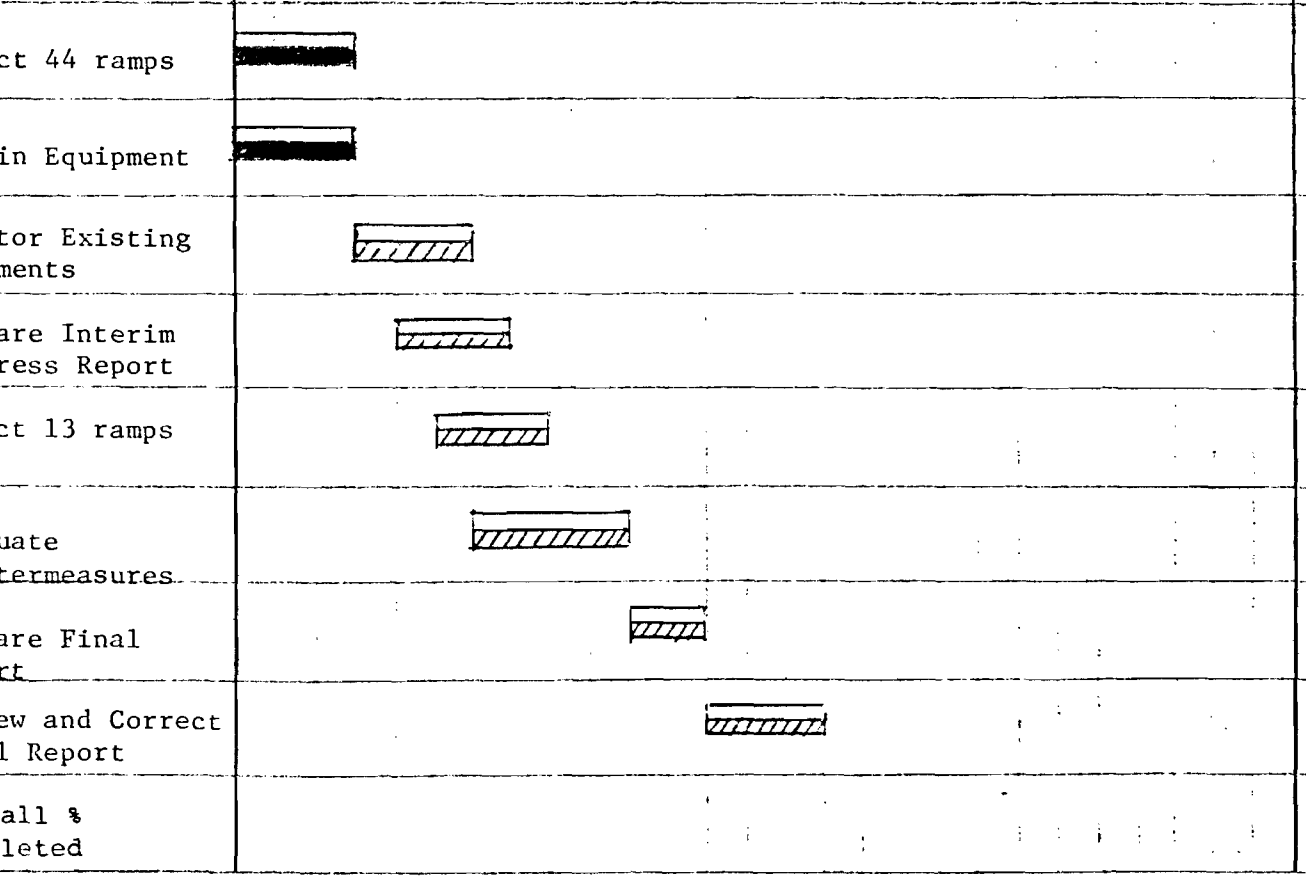
4 Research Agency	5 Project Director(s)
Georgia Institute of Technology	Dr. P.S. Parsonson Associate Professor Civil Engineering

6 Starting Date	7 Completion Date	8 % Time Expended	9 Schedule Status	10 Sufficiency of Funds
Sept. 23, 1977	January 22, 1979	1.44%	☐ Ahead ☒ Behind ☐ On	☒ Sufficient ☐ Insufficient

Funds Authorized		Funds Expended				
11 Total	12 Current Fiscal Year	13 Total to Date	%	14 Current Fiscal Year	%	15 Report Quarter
14842 GDOT 6349 GIT	14842 GDOT 6349 GIT	0.00	0	0.00	0	0.00

16 Project Schedule — Time Period: 77 (J A S O N D) 78 (J F M A M J J A S O N D)

Research Tasks	% Task Completed
Select 44 ramps	80%
Obtain Equipment	5%
Monitor Existing Movements	0
Prepare Interim Progress Report	0
Select 13 ramps	0
Evaluate Countermeasures	0
Prepare Final Report	0
Review and Correct Final Report	0
Overall % Completed	5%



17 Progress This Quarter (By Task)

Selection of ramps - Most of this work is complete. All ramps in District 7 were categoriz and several from each category were selected to make a list of 44. In conference with DOT representatives, 6 ramps of unusual configuration were selected for priority study. A decision was made to eliminate some of the 44 to make room for these. The number to be dropped from each of the 13 categories was made but the actual ramps to be dropped have not been selected.

Obtain equipment - Road tubes and wrong-way counters have been ordered from the California DOT. These units are expected to arrive by the middle of October. In the meantime, other equipment is being obtained. At the end of the report period no new equipment has been obtained. However, many of the tools are in current stock.

Monitor Existing Movements - no activity

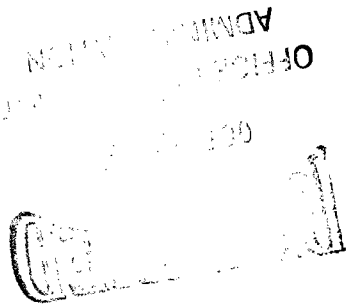
Prepare Interim Progress Report - no activity

Select 13 ramps - no activity

Evaluate countermeasures - no activity

Prepare final report - no activity

Review and correct final report - no activity



18 Work Planned for Next Quarter

The main activity for the next quarter is to finish obtaining the necessary equipment and begin monitoring of ramps. Ramp selection will not be completed before we begin monitoring. However, enough priority ramps have been selected that we can begin with these while the Department makes final recommendations on the others.

19 Significant Technical Information, Recommendations, Implementation

We have not really gotten into the project so no results are available yet. However, the pilot project has Central Ave. indicates that placement of buttons on the centerline of the road helped considerably there. Wrong-way movements have been just about cut in half.

20 Problems

We are behind the original schedule because funding was delayed until the end of September. Even though the project deadline has been extended, it is still necessary to complete the project on the original schedule so that it can be done using one graduate assistant. With intensive work on the monitoring task we should be within about a week of schedule by March.

21 Report Prepared by

Signature — PETER S. PARSONSON (Name) — ASSOC. PROF. (Title)

RESEARCH QUARTERLY PROGRESS REPORT
GEORGIA DEPARTMENT OF TRANSPORTATION

Date of Report: 1-13-78

1 Project No. State/Agency	2 Project Title	3 Quarterly Report No.
7703/E-20-624	Wrong-way Traffic Movements on Freeway Ramps	2 From Oct 1, 1977 To Dec 1, 1978

4 Research Agency	5 Project Director(s)
Georgia Institute of Technology	Dr. Peter S. Parsonson Associate Professor Civil Engineering

6 Starting Date	7 Completion Date	8 % Time Expended	9 Schedule Status	10 Sufficiency of Funds
Sep 23, 1977	Jan 22, 1979	20.4%	☐ Ahead ☒ Behind ☐ On	☒ Sufficient ☐ Insufficient

Funds Authorized		Funds Expended				
11 Total	12 Current Fiscal Year	13 Total to Date	%	14 Current Fiscal Year	%	15 Report Quarter
$14842 GDOT 6349 GIT	$14842 GDOT 6349 GIT	$5985.22	28	$5985.22	28	$5985.22

16 Project Schedule

Research Tasks	Time Period: J A S O N D J F M A M J J A S O N D	% Task Completed
Ramp Selection		100
Obtain Equipment		100
Monitor Existing Movements		18
Prepare Interim Progress Rpt		0
Select 13 Ramps		0
Evaluate Countermeasures		0
Prepare Final Report		0
Review and Correct Final Report		0
Overall % Completed		26

☐ Approved Schedule ▨ Work Completed Schedule ▨ Projected Completion

17 Progress This Quarter (By Task)

Ramp Selection - This phase was completed in cooperation with representatives of DOT early in October.

Material Acquisition - Material acquisition was begun immediately upon the approval of the research contract. All essential material was purchased before the counters arrived from California DOT. Some additional items such as additional road clamps and tape will be purchased as needed.

Monitor Existing Movements - This phase was begun as soon as the equipment was purchased and the work crew was trained. The first installation was made on October 26 and continued up to the end of the quarter (December 5). We tried to go out twice a week and do two setups each of these days. Because of rain we weren't able to do all the installations planned. However, we did go out several days while school was out in December and finished the first 16 installations. At present, monitoring activities are complete at 7 ramps and we expect to be finished at 5 more within two weeks.

Prepare Interim Progress Report - No activity.

Select 13 ramps - This is being done on a preliminary basis as data comes in. At present there are only 2 likely candidates for further study.

Evaluate countermeasures - No activity.

Prepare final report - No activity.

Review and Correct Final Report - No activity.

18 Work Planned for Next Quarter

During next quarter we should finish up all the installations for monitoring existing movements. The actual monitoring phase would extend for approximately one month after this. We are going to prepare an Interim Progress Report as soon as there is enough data to report. For installations during the bad weather months we will try to work 3 days a week if possible so as to allow some time for bad weather. We should also have all but a few of the ramps chosen for further study and be ready to start this phase.

19 Significant Technical Information, Recommendations, Implementation

So far we have found no location which has such a bad record as did I-75 and Central Ave. in the pilot study. Only 1 ramp appears at this time to have any significant movement and that is Douglas Co. #7 (I-20 at Chapel Hill Rd.). This is a half-diamond interchange with only a one-way sign at the ramp terminal. There are two WRONG WAY signs about a hundred feet down the ramp but they are hidden from view at the terminal. Despite this fact, I suspect that a good deal of this movement may be intentional as people want to go west but have no available ramp. They don't want to go a few miles out of their way so they use the exit ramp to enter the west-bound side of the freeway.

20 Problems

There have been two main sources of trouble so far: weather and hose failure. The weather was not planned for in scheduling so it makes us have to work a little harder to catch up. Our only major equipment problem is the road tube. If there is heavy traffic on the ramp, especially trucks, we often end up with the hoses either torn or crossed. Not only does that necessitate a repair, but the data is lost up to the last check of the location.

21 Report Prepared by

Signature	Name	Title

RESEARCH QUARTERLY PROGRESS REPORT

GEORGIA DEPARTMENT OF TRANSPORTATION

Date of Report: 4-13-78

1 Project No. State/Agency	2 Project Title	3 Quarterly Report
7703/E-20-624	Wrong-Way Traffic Movements on Freeway Ramps	No. 3 From Jan 1, 1978 To March 31, 1978

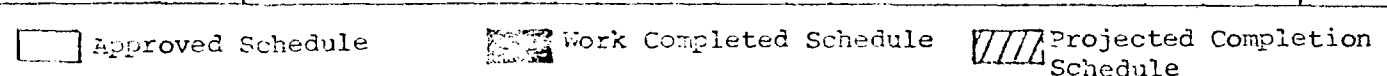
4 Research Agency	5 Project Director(s)
Georgia Institute of Technology	Dr. Peter S. Parsonson Associate Professor Civil Engineering

6 Starting Date	7 Completion Date	8 % Time Expended	9 Schedule Status	10 Sufficiency of Funds
Sep 23, 1977	Jan 22, 1979	38.9	☐ Ahead ☒ Behind ☐ On	☒ Sufficient ☐ Insufficient

Funds Authorized		Funds Expended				
11 Total	12 Current Fiscal Year	13 Total to Date	%	14 Current Fiscal Year	%	15 Report Quarter
$14842 GDOT 6349 GIT	$14842 GDOT 6349 GIT	$6777.82	32	6777.82	32	792.60

16 Project Schedule

Research Tasks	Time Period (1977: J A S O N D; 1978: J F M A M J J A S O N D)	% Task Completed
Ramp Selection		100
Obtain Equipment		100
Monitor Existing Movements		62
Prepare Interim Progress Report		5
Select 13 Ramps		30
Evaluate Countermeasures		0
Prepare Final Report		0
Review and Correct Final Report		0
Overall % Completed		37



17 Progress This Quarter (By Task)

Monitor Existing Movements--This phase was in full swing this quarter. Due to weather, we were not able to get out on all the days scheduled. However, this task is over 50% complet As of the end of this report period, we have completed study of 27 ramps and have 11 set-ups in the field. This leaves 6 locations, most of which will be deployed in the first few weeks of April. Also, several of the installations in place are just about ready to be moved.

Prepare Interim Progress Report--Some preliminary classification of data has been done by individual ramp and by ramp type. This type of data will form the backbone of the interim report.

Select 13 Ramps--We have also picked a few ramps with relatively high wrong way rates. This number may have to be cut.

Evaluate Countermeasures--Dr. Parsonson visited the offices of Applied Technical Services in Marietta and inspected the flapper devices recently purchased by the GDOT.

Prepare final report--No activity

Review and correct final report--No activity

18 Work Planned for Next Quarter

We are now moving into a critical phase of the project. The ramp monitoring should be completed by about the end of April. We will have the interim report ready before the end of May, but will recommend some ramps and countermeasures before then based on already-completed findings. We will monitor these ramps as the countermeasures are implemented. The progress of this phase will also depend on the available time which District 7 has to implement the countermeasures. We will probably not complete the evaluations next quarter.

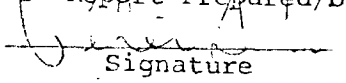
19 Significant Technical Information, Recommendations, Implementation

We have attached a summary of the data collected so far, plus sketches of the 6 ramps with a fairly high (greater than 3 per month) rate of wrong-way entry. At present we recommend that the 7 new flapper units be installed at the I-75/Central Ave. ramp. We would like to evaluate results here before trying the device elsewhere. This off-ramp will not be signalized until December, so we can evaluate it under both conditions. Further recommendations will be forthcoming.

20 Problems

In addition to weather problems and hose failure, we had a problem with the counters being hit at two locations, DeKalb 27 ((I-85 @ Northcrest) and Fulton 105 (I-285 @ Peachtree-Dunwoody). We have dropped these ramps and will add I-285 @ M.L.K. NB and I-85 @ Peachtree St. SB to make up for them.

21 Report Prepared by



Signature

Peter S. Parsonson

Name

Assoc. Professor

Title

GEORGIA DOT PROJECT 7703

WRONG WAY MOVEMENTS ON FREEWAY RAMPS

PROJECT STATUS REPORT
AS OF 3-31-78

LOCATION	DAYS	WW	RATE (PER 30-DAY MONTH)	STATUS
FULTON COUNTY				
2 - I-85 @ SR-74 SB	59	0	0.0	complete
8 - I-85 @ Central Avenue NB	9	0	---	active
9 - I-85 @ Central Avenue SB	25	3	3.6	complete
18 - I-75/85 @ University SB	0		---	active
24 - I-75/85 @ Decatur Street SB	22	+	---	active
26 - I-75/85 @ Butler Street SB	49	3	1.8	complete
27 - I-75/85 @ Peachtree Street NB	39	0(?)	0.0	complete
37 - I-85 @ Piedmont Road NB	9	+	---	active
45 - I-75 @ Moores Mill Road SB	34	0	0.0	complete
46 - I-75 @ W. Paces Ferry NB	9	0(?)	0.0	complete
59 - I-20 @ Ashby St. EB	21	0	---	active
65 - I-20 @ Hightower Rd. WB	35	2	1.7	complete
74 - SR166 @ Campbellton Rd. WB	24	0	0.0	complete
75 - SR166 @ Mt. Gilead Rd. EB	28	0	0.0	complete
79 - SR166 @ Sylvan Road EB	23	0	0.0	complete
82 - SR166 @ Lakewood Ave (Fleet St)WB	22	4	5.5	complete
83 - SR166 @ Lakewood Ave. EB	18	0	0.0	complete
90 - I-285 @ Jonesboro Road EB	19	0(?)	0.0	complete
91 - SR400 @ Holcomb Bridge Rd. NB	25	1	1.2	complete
92 - SR400 @ Holcomb Bridge Rd. SB	35	4	3.4	complete
93 - SR400 @ Haynes Bridge Rd. NB				future
94 - SR400 @ Haynes Bridge Rd. SB				future
105 - I-285 @ Peachtree-Dunwoody WB				suspended
DEKALB COUNTY				
7 - I-20 @ Wesley Chapel Rd. WB	8	+	---	active
19 - I-85 @ N. Druid Hills Rd. SB	36	1	0.8	complete
20 - I-85 @ N. Druid Hills Rd. NB	36	0	0.0	complete
27 - I-85 @ Northcrest Rd. NB	4	0	---	suspended
28 - I-85 @ Pleasantdale Rd. SB	20	0	0.0	complete
30 - I-285 @ Moreland Ave. WB	8	0	---	active
32 - I-285 @ Bouldercrest Rd. WB	0			inactive
42 - I-285 @ E. Ponce de Leon SB	34	0(?)	0.0(?)	complete
44 - I-285 @ Lawrenceville Hwy. SB	42	0	0.0	complete
CLAYTON COUNTY				
1 - I-75 @ SR54 WB	29	4	4.1	complete
2 - I-75 @ SR54 WB	29	0	0.0	complete
4 - I-285 @ Riverdale Rd. EB				future
5 - I-285 @ Clark Howell Hwy. WB	56	0(?)	0.0(?)	complete
6 - I-285 @ Clark Howell Hwy. EB				future
7 - I-285 @ US 19/41 WB	28	3(?)	3.2	complete
8 - I-285 @ US 19/41 EB	39	11	8.5	complete

COBB COUNTY				
27 - I-20 @ Six Flags Rd. WB	0			active
28 - I-20 @ Six Flags Rd. EB	0			active
DOUGLAS COUNTY				
6 - I-20 @ SR92 EB	38	0	0.0	complete
7 - I-20 @ Chapel Hill Rd. WB	33	8	6.9	complete
ROCKDALE COUNTY				
3 - I-20 @ SR70/138 WB	8	+	---	active

+ - no film processed yet

(?) - data questionable

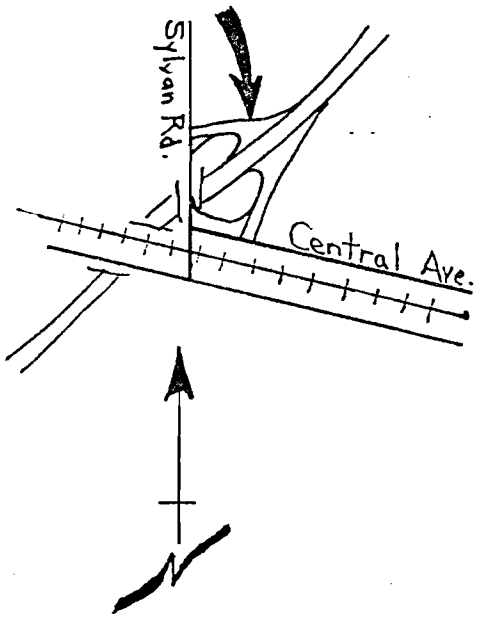
GEORGIA DOT PROJECT 7703
WRONG WAY MOVEMENTS ON FREEWAY RAMPS

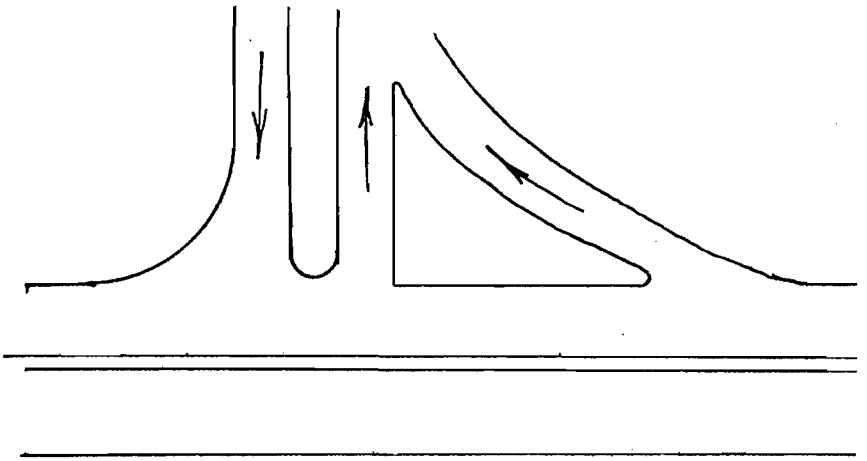
WRONG-WAY FREQUENCIES
BY RAMP TYPE
(FROM DATA AS OF 3-31-78)

TYPE	RAMPS COMPLETED	STUDY DAYS	WRONG WAY	RATE (per 30-Day Month)
I-Diamond Close Front Road	1	38	Ø	---
II-Half Diamond	2	51	8 (0+8)	4.7
III-Quarter Diamond	1	49	3	1.8
IV-Split Diamond	Ø			
V-Split Diamond With Close Frontage Road	1	20	Ø	---
VI-Partial Cloverleaf Diagonal Ramp	1	35	4	3.4
VII-Parclo Loop Ramp	1	25	1	1.2
VIII-Parclo 1-Quad Diag. Ramp With Close Frontage Road	2	78	1 (0+1)	0.4
IX-Parclo 1-Quad. Loop Ramp	1	39	Ø	---
X-Parclo 1-Quad Loop Ramp With Close Frontage Raod	1	36	Ø	Ø
XI-Parclo AB Diag. Ramp	4	116	6 (3+0+3+0)	1.6
XII-Parclo AB Loop Ramp	3	103	17 (2+11+4)	5.0
DIAMOND	1	59	Ø	Ø

FULTON CO. 9 - I-85 @ Sylvan Rd. SB

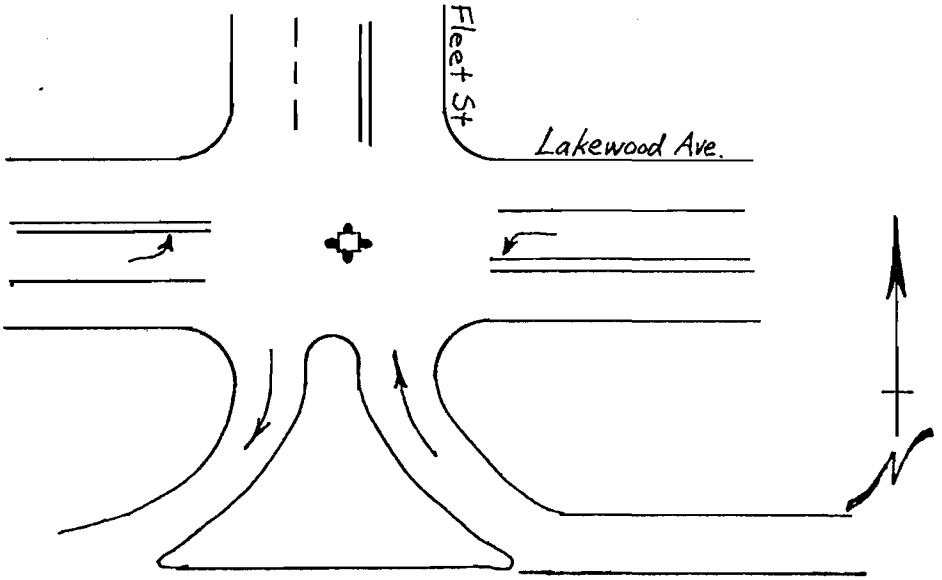
Type: Parclo AB Diagonal Ramp



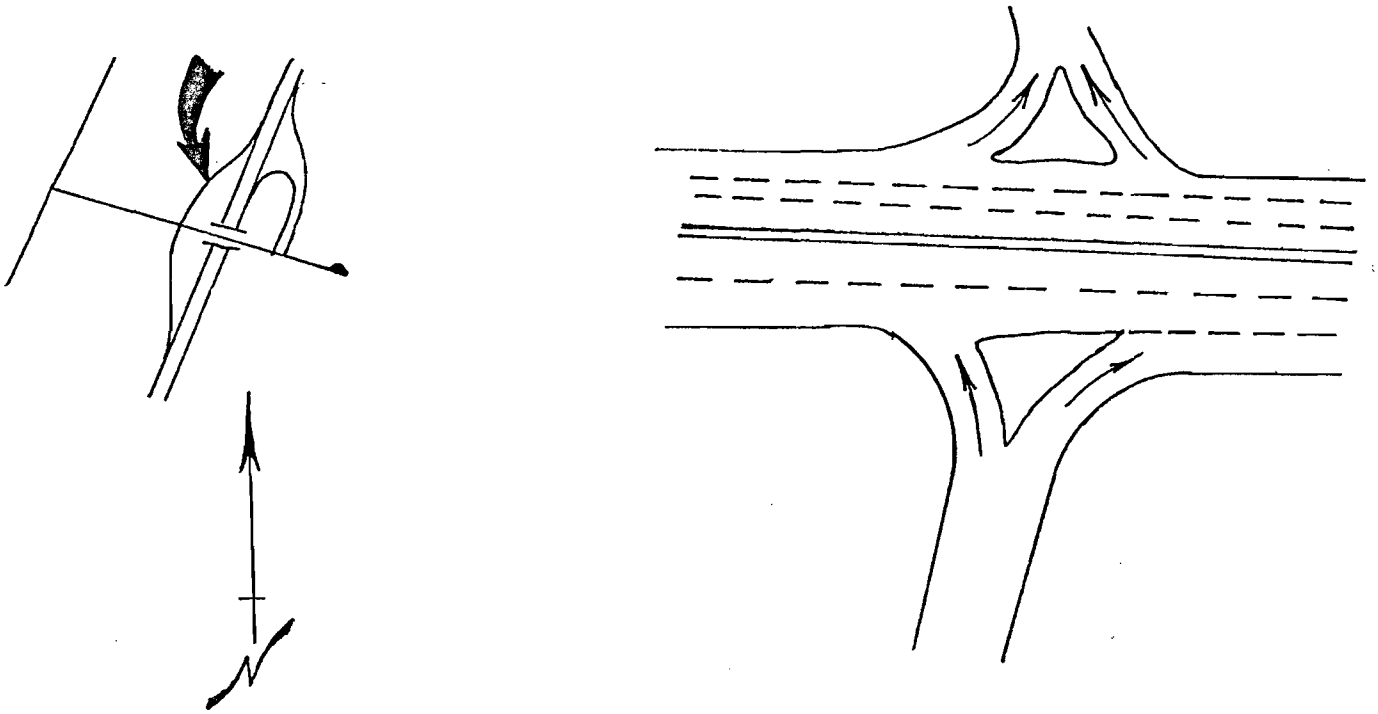


FULTON CO. 82 - SR 166 @ Lakewood Ave. WB

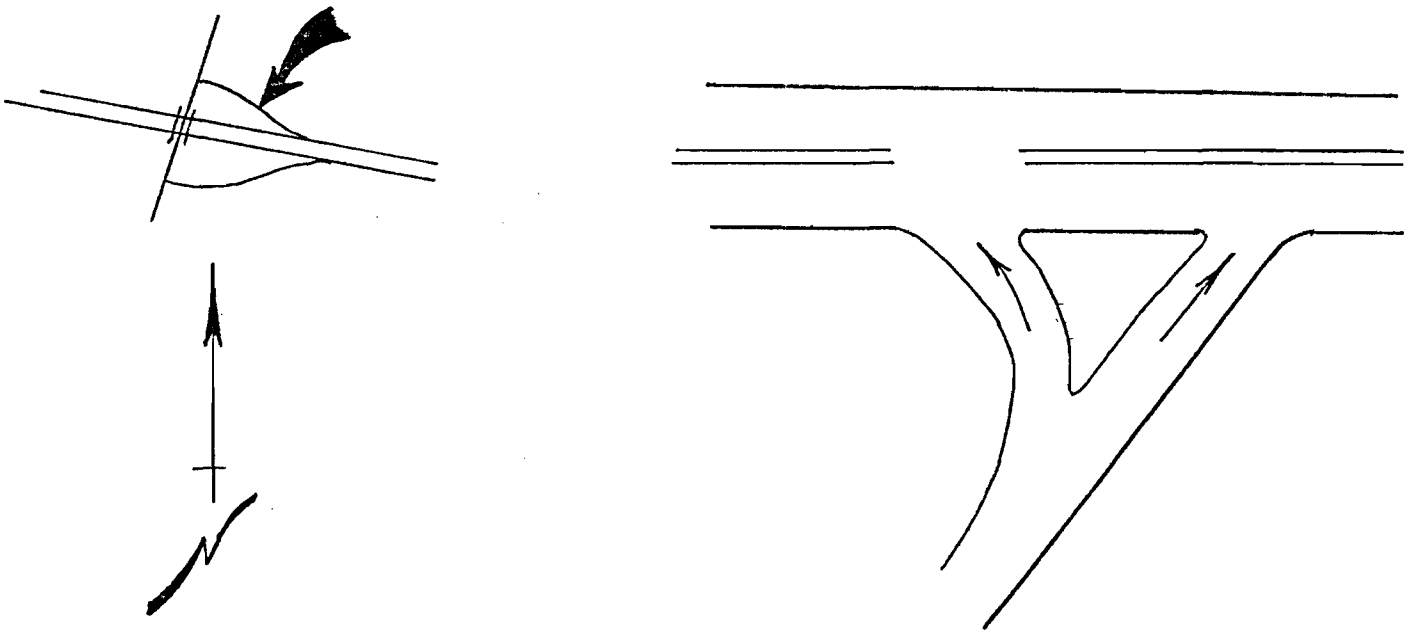
Type: Irregular



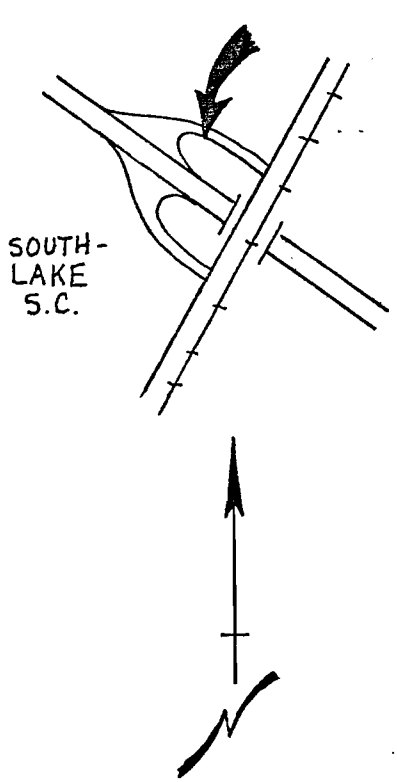
FULTON CO. 92 - SR 400 @ Holcomb Bridge Rd. SB Type: Parclo 3-quad. Diagonal

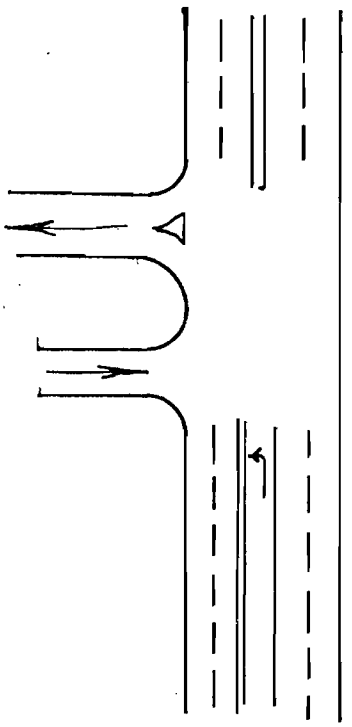


DOUGLAS CO. 7 - I-20 @ Chapel Hill Rd.
Type: Half Diamond

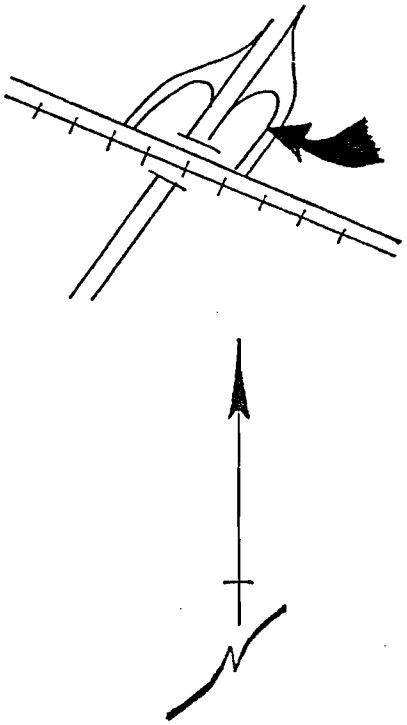


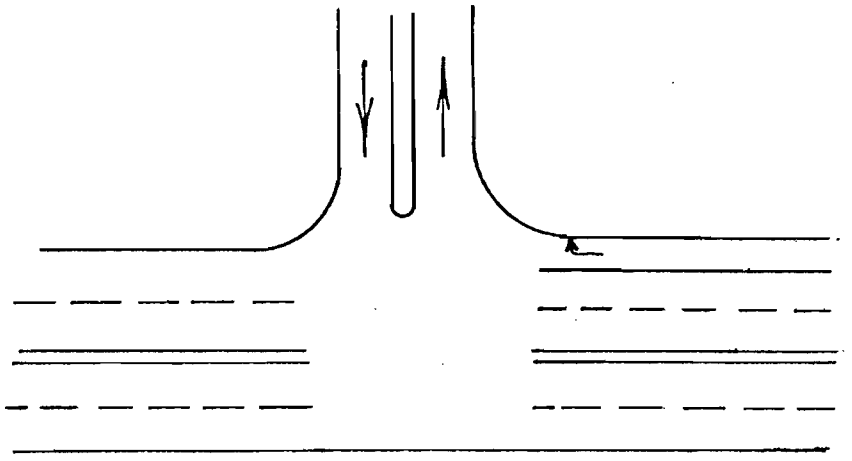
CLAYTON CO. 1 - I-75 @ SR 54 NB
Type : Parclo AB Loop Ramp





CLAYTON CO. 8 - I-285 @ US 19/41 EB
Type : Parclo AB Loop Ramp





RESEARCH QUARTERLY PROGRESS REPORT

GEORGIA DEPARTMENT OF TRANSPORTATION

Date of Report: 6-30-78

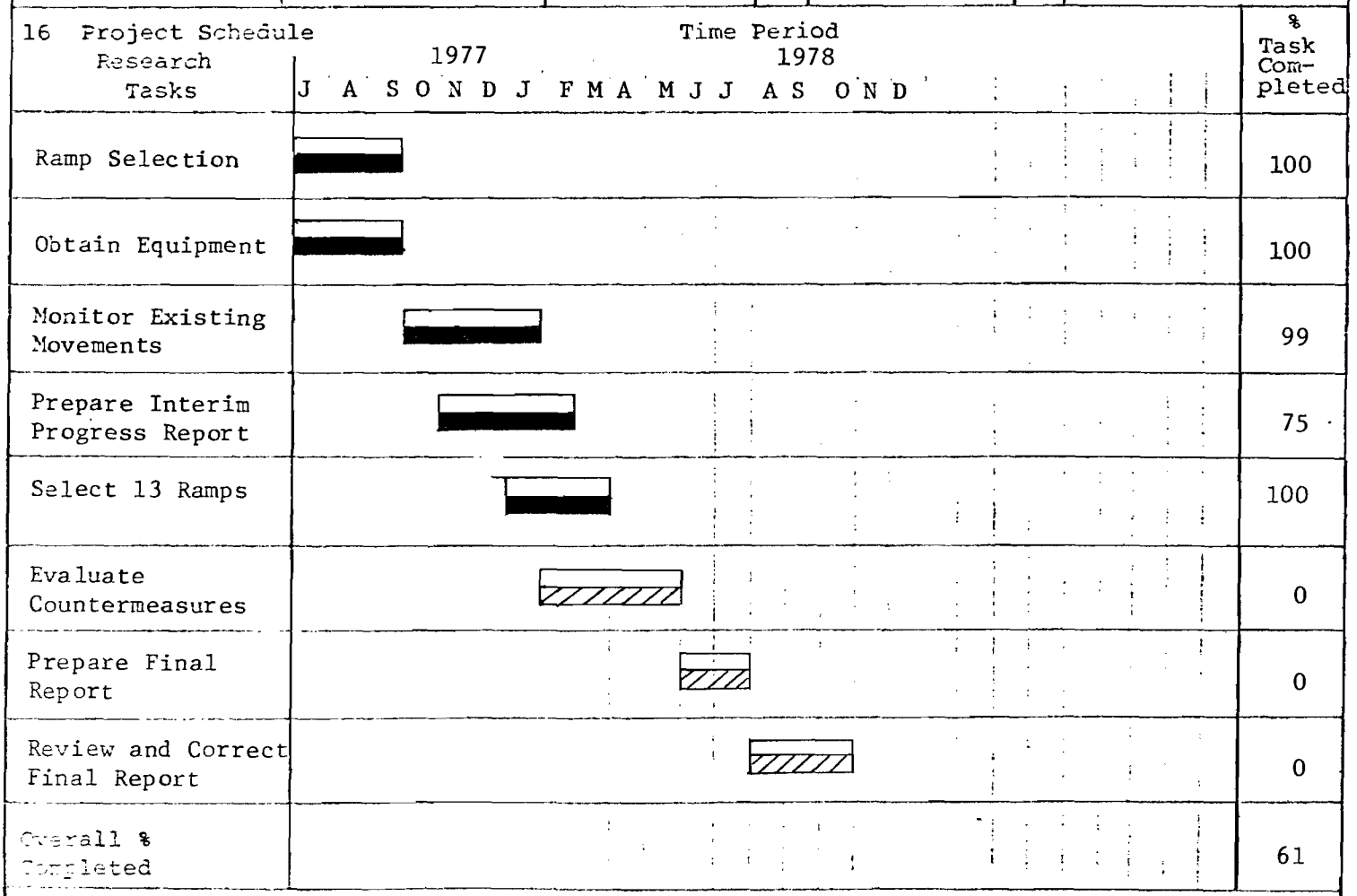
1 Project No. State/Agency	2 Project Title	3 Quarterly Report No.
7703/E-20-624	Wrong-way Traffic Movements on Freeway Ramps	4 From April 1, 1978 To June 30, 1978

4 Research Agency	5 Project Director(s)
Georgia Institute of Technology	Dr. Peter S. Parsonson Associate Professor Civil Engineering

6 Starting Date	7 Completion Date	8 % Time Expended	9 Schedule Status	10 Sufficiency of Funds
Sept 23, 1977	Jan. 22, 1979	57.6	☐ Ahead ☒ Behind ☐ On	☒ Sufficient ☐ Insufficient

Funds Authorized		Funds Expended				
11 Total	12 Current Fiscal Year	13 Total to Date	%	14 Current Fiscal Year	%	15 Report Quarter
14842 GDOT 6349 GIT	14842 GDOT 6349 GIT	$11548	54.6	$11548	54.5	$4770

16 Project Schedule



17 Progress This Quarter (By Task)

Ramp selection - COMPLETE
Obtain equipment - COMPLETE
Monitor Existing Movements - During the past quarter we have essentially completed this task. Only one ramp is still being monitored, I-20@Six Flags Rd. WB. We had trouble keeping hoses down here but have now apparently worked things out. We now ha enough data for the attached technical information on ramp frequencies.
Prepare Interim Progress Report - We have delayed the preparation of this report in order to be able to include complete data from the first phase of the study and also the countermeasures for implementation. This report should be ready to be submitted by the second week of July.
Select 13 ramps - We have completed the selection of ramps for further study. Because we had relatively few ramps with a discernible problem, we were only able to select 9 ramps. These are not one of each type but there is probably some overlap between some types.
Evaluate countermeasures - On June 7, we met with GDOT personnel and presented our counter measure recommendations for comments. Final recommendations have been submitted and we are awaiting implementation. We have reinstalled equipment at all locations and are currently collecting new control information.
Prepare Final Report - NO ACTIVITY
Review and Correct Final Report - NO ACTIVITY

18 Work Planned for Next Quarter

We plan to continue collecting control data at each ramp until countermeasures are implemented. Each location, except Ga400@Haynes Bridge Rd. which will be studied in phases will be studied for a month. After this time we hope to be able to recommend a full package of countermeasures, installing them at all locations for another month of study. Also the ATS wrong-way flapper device will be tested at Central Ave. & I-75 for its effectiveness. After the first round of data collection, work will begin on the Final Project Report.

19 Significant Technical Information, Recommendations, Implementation

See attachments for a final summary of data from the first phase of the study and drawings showing recommended countermeasures for each phase 2 ramp.

20 Problems

21 Report Prepared by

Signature

Dr. Peter S. Parsonson
Associate Professor
Civil Engineering
Name

Project Director
Title

GEORGIA DOT PROJECT 7703

WRONG-WAY MOVEMENTS ON FREEWAY RAMPS

INITIAL MONITORING FINAL REPORT

LOCATION	DAYS	WRONG WAY	WRONG WAY RATE (PER 30-DAY MO)
FULTON COUNTY			
2 - I-85 at SR-74 SB	59	0	0.0
8 - I-85 at Central Avenue NB	21	0	0.0
9 - I-85 at Central Avenue SB	25	3	3.6
18 - I-75/85 at University SB	14	1	2.1
24 - I-75/85 at Decatur Street SB	29	3	3.1
26 - I-75/85 at Butler Street SB	49	3	1.8
27 - I-75/85 at Peachtree Street NB	39	0(?)	0.0(?)
35 - I-85 at Peachtree Street SB	28	1	1.1
37 - I-85 at Piedmont Road NB	28	0	0.0
45 - I-75 at Moores Mill Road SB	34	0	0.0
46 - I-75 at W. Paces Ferry NB	9	0(?)	0.0(?)
59 - I-20 at Ashby Street EB	28	0	0.0
65 - I-20 at Hightower Road WB	35	2	1.7
74 - SR166 at Cambellton Road WB	24	0	0.0
75 - SR166 at Mt. Gilead Road EB	28	0	0.0
79 - SR166 at Sylvan Road EB	23	0	0.0
82 - SR166 at Lakewood Ave (Fleet St) WB	22	4	5.5
83 - SR166 at Lakewood Avenue EB	18	0	0.0
90 - I-285 at Jonesboro Road EB	19	0(?)	0.0(?)
91 - SR400 at Holcomb Bridge Rd. NB	25	1	1.2
92 - SR400 at Holcomb Bridge Rd. SB	35	4	3.4
93 - SR400 at Haynes Bridge Road NB	28	0	0.0
94 - SR400 at Haynes Bridge Road SB	28	9	9.4
106 - I-285 at Martin Luther King Dr. NB	29	1	1.0

DEKALB COUNTY			
7 - I-20 at Wesley Chapel Road WB	23	3	3.9
19 - I-85 at N. Druid Hills Road SB	36	1	0.8
20 - I-85 at N. Druid Hills Road NB	36	0	0.0
28 - I-85 at Pleasantdale Road SB	20	0	0.0
30 - I-285 at Moreland Avenue WB	8	0(?)	0.0(?)
32 - I-285 at Bouldercrest Road WB	30	0	0.0
42 - I-285 at E. Ponce de Leon SB	34	0(?)	0.0(?)
44 - I-285 at Lawrenceville Hwy. SB	42	0	0.0
CLAYTON COUNTY			
1 - I-75 at SR54 WB	29	4	4.1
2 - I-75 at SR54 WB	29	0	0.0
4 - I-285 at Riverdale Road EB	29	3	3.1
5 - I-285 at Clark Howell Hwy. WB	56	0(?)	0.0(?)
6 - I-285 at Clark Howell Hwy. EB	29	0	0.0
7 - I-285 at US19/41 WB	28	3	3.2
8 - I-285 at US19/41 EB	39	11	8.5
COBB COUNTY			
27 - I-20 at Six Flags Road WB	23	2	2.6
28 - I-20 at Six Flags Road EB	29	2	2.1
DOUGLAS COUNTY			
6 - I-20 at SR92 EB	38	0	0.0
7 - I-20 at Chapel Hill Road WB	33	8	7.3
ROCKDALE COUNTY			
3 - I-20 at SR70/138 WB	30	1	1.0

(?) Data questionable

E-20-624

Georgia Institute of Technology

School of Civil Engineering

INTERIM PROGRESS REPORT

Project E-20-624

Wrong-Way Traffic Movements on Freeway Ramps

Dr. P. S. Parsonson, Project Director
and
James R. Marks, Graduate Research Assistant

Georgia DOT Research Project 7703

June 30, 1978

Contract with
Department of Transportation
State of Georgia

In cooperation with
U.S. Department of Transportation
Federal Highway Administration

ABSTRACT

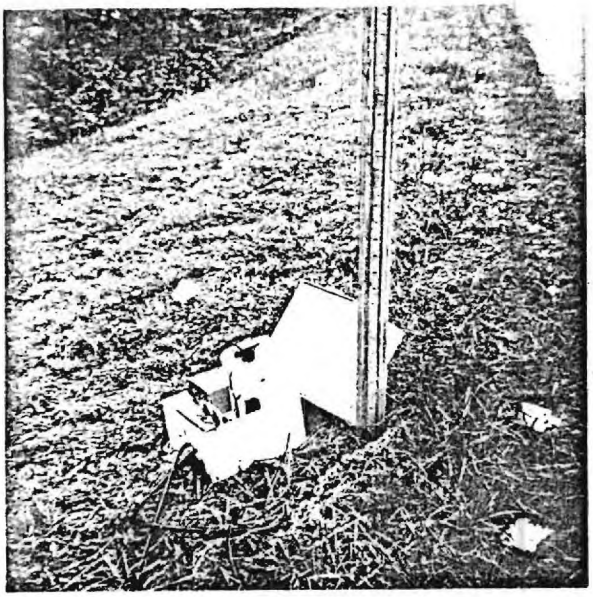
This project involves the monitoring of 44 selected freeway exit ramps in the Atlanta area using a special wrong-way counter device developed by the California DOT. These ramps were grouped into 13 types, and each ramp was studied for approximately one month. Three ramp types, Half Diamond, Partial Cloverleaf loop ramp and Parclo AB loop ramp, were found to have higher rates of wrong-way movements than other ramp types. However, a statistical analysis revealed that variations within ramp types were greater than between types. Nine ramps were chosen for further study. Signing and marking improvements have been recommended and their effectiveness will be evaluated in the next phase of the project.

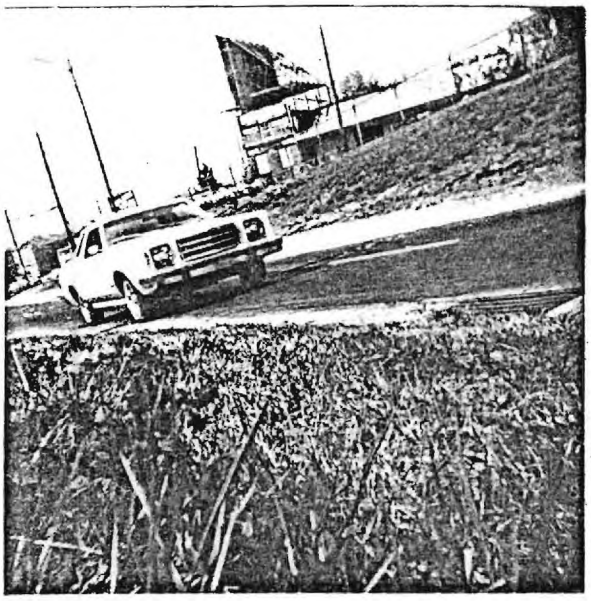
Experimental Work

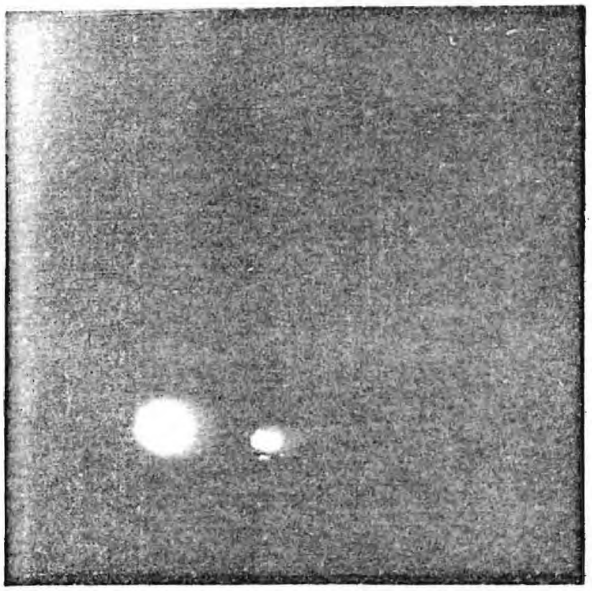
The heart of this project involves a survey of ramps for wrong-way movements using a special wrong-way directional counter developed by the San Diego office of the California Department of Transportation. (1) The installation utilizes two road tubes rather than the normal one for traffic counters with a spacing of about 3" between tubes. The circuitry of the device is such that wrong-way actuations cause the counter to advance while right-way actuations have no effect. Figure 1 shows one of these counters in place.

The wrong-way unit also incorporates a snapshot camera to take a photograph of vehicles which actuate the device. The photographs serve two purposes; they indicate whether the movement occurs at day or night, and they confirm that the actuation is due to a wrong-way vehicle. If traffic conditions are heavy, a queue may form on the ramp. Vehicles, especially those with standard transmissions, may roll back over the hoses, causing an actuation. Also emergency vehicles may occasionally have to use the ramp to get to accidents and these movements should not really be considered as wrong-way. The same goes for highway maintenance equipment. Figure 2 illustrates a rollback, while Figures 3 and 4 show actual day and night wrong-way movements. Figure 5 shows a wrong-way police car entering I-20 at Wesley Chapel Road on an emergency call.

The ramps in District 7 were classified into 13 categories (excluding simple diamond interchanges) as shown in Figure 6. These are not all ramp types but are considered all which are either susceptible to wrong-way movements or occur frequently enough to justify consideration. From these classifications we chose, in cooperation with Georgia DOT personnel, about 3 ramps from each type to study. Also 5 simple diamond ramps were chosen for a total of 44 phase I ramp studies. The plan was to monitor each of these locations for approximately one month. The ramps chosen are listed by type in Table 1.







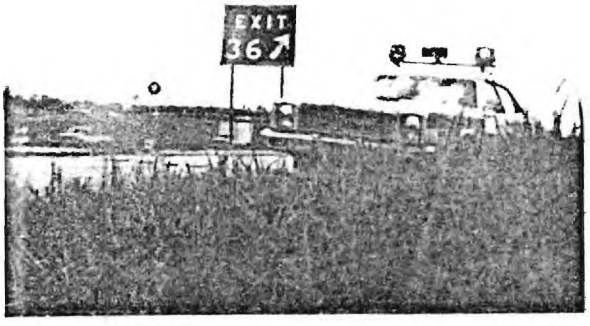
TOP LEFT: Fig. 1: Wrong-way camera unit in place.

ABOVE LEFT: Fig. 2: False actuation by vehicle rollback.

TOP RIGHT: Fig. 3: Daytime wrong-way movement.

MIDDLE RIGHT: Fig. 4: Nighttime wrong-way movement; note that vehicle has on upper headlight beams.

BOTTOM RIGHT: Fig. 5: Wrong-way movement by emergency vehicle; these were not counted in wrong-way statistics.



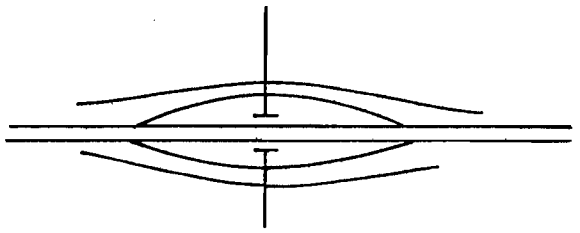
Eighteen wrong-way counters were purchased from California. After this and other equipment was acquired, we began installations on October 26, 1977. At some locations we had problems due to heavy rollback volumes or high-speed cars or trucks constantly ripping up the hoses. As a result, 2 locations (I-85 at Northcrest Road and I-285 at Peachtree-Dunwoody Road) were abandoned altogether. In their places, we added I-285 at Martin Luther King Drive (Parclo 3-quad diagonal ramp) and I-85 at Peachtree Street (Diamond with close frontage road). Some locations have questionable results and these are indicated in the data. For example, no wrong-way movements were confirmed at I-285 and E. Ponce de Leon in DeKalb County, although a previous study had indicated a definite problem there. (2) This is a high rollback location, so there are probably wrong-way movements mixed in with the rollbacks. However we do not have photos for most of the actuations.

The ramps were monitored often longer than a month in an effort to get a month 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. Phase I was completed at the end of June.

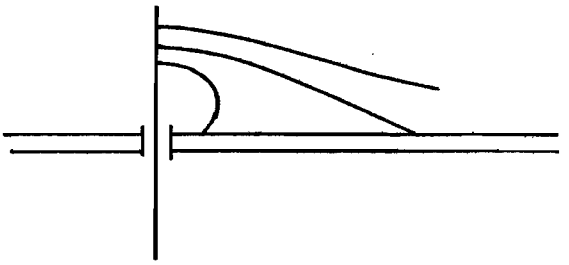
Table A-1, in Appendix A, shows the Phase I data for each ramp studied. The wrong-way rate is based on a 30-day month in order to be comparable to other data reported by California. Table A-2 shows this same data grouped by ramp type except for the unique configuration ramps.

Figure 6
RAMP TYPES

I. DIAMOND DIAGONAL RAMP
CLOSE FRONTAGE ROAD

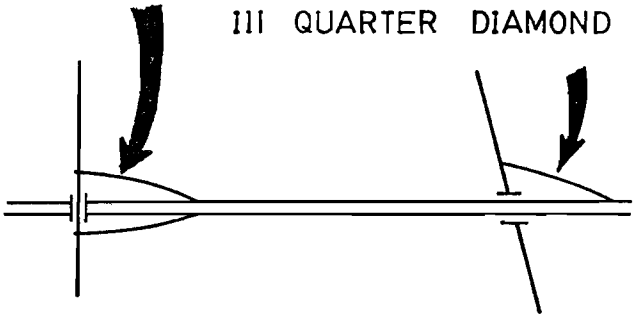


IX PARCLO ONE QUAD
DIAGONAL RAMP
CLOSE FRONTAGE ROAD

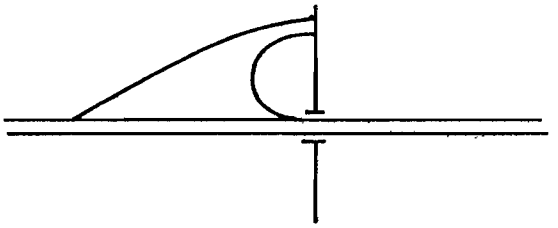


II HALF DIAMOND

III QUARTER DIAMOND



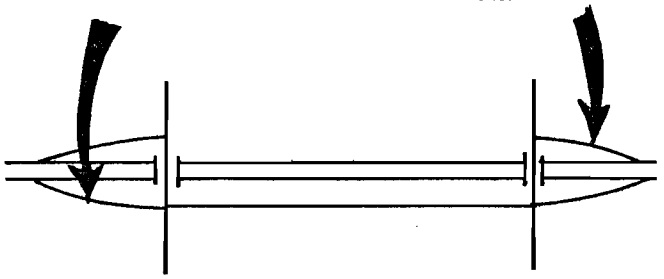
X PARCLO ONE QUAD
LOOP RAMP



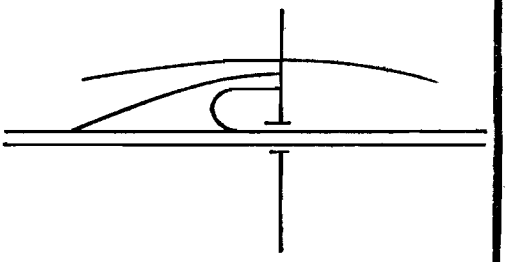
SPLIT DIAMOND

V WITH FRONT. RD.

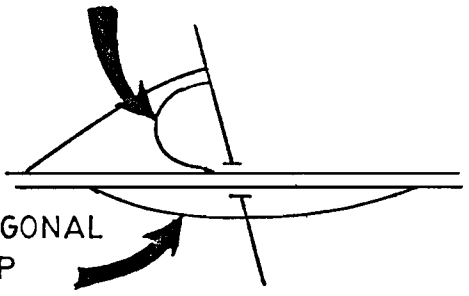
IV WITHOUT FRONT. RD.



XI PARCLO ONE QUAD
LOOP RAMP WITH CLOSE
FRONTAGE ROAD

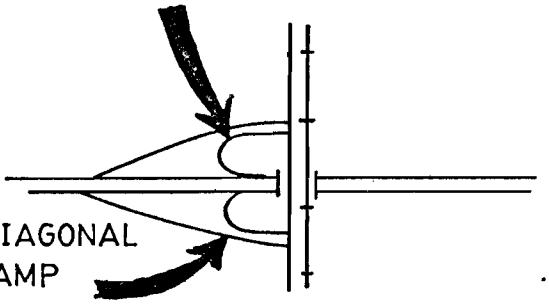


PARTIAL CLOVERLEAF (PARCLO)
VIII LOOP RAMP



VII DIAGONAL
RAMP

PARCLO AB
XIII LOOP RAMP



XII DIAGONAL
RAMP

TABLE I

RECOMMENDED RAMPS OF EACH TYPE

I. Diamond, diagonal, close frontage road.

Fulton #35 (Peachtree St. at I-85) urban
Clayton #4 (Riverdale Road at I-285) suburban
Rockdale #3 (GA20 at I-20) rural
Douglas County #6 (GA 92 at I-20) suburban
DeKalb #7 (Wesley Chapel Rd. at I-20) suburban

II. Half diamond, diagonal ramp

Douglas #7 (Chapel Hill Road at I-20) rural
Fulton #83 (Lakewood Freeway GA166 at Lakewood Avenue) urban

III. Quarter diamond, diagonal ramp (only 2)

Fulton #26 (Baker Street at I-75/85) urban
Fulton #24 (Decatur Street at I-75/85) urban

IV. Split diamond, diagonal ramp

Cobb #27 (Six Flags Road at I-20) suburban
Cobb #28 (Six Flags Road at I-20) suburban
DeKalb #42 (E. Ponce de Leon at I-285)

V. Split diamond, diagonal ramp, close frontage road

DeKalb #28 (Pleasantdale Road at I-85) suburban

VI. Unusual configuration

Fulton #46 (West Paces Ferry Rd. at I-75) suburban
Fulton #59 (Ashby Street at I-20) urban
Fulton #79 (Sylvan Rd. at GA166) suburban
Fulton #82 (Lakewood Ave. at GA166) suburban
Fulton #74 (Cambellton Rd. at GA166) suburban
Fulton #75 (Mt. Gilead Rd. at GA166) suburban

VII. Parclo diagonal ramp

Fulton #92 (Holcomb Bridge Road at GA400) rural
Fulton #93 (Haynes Bridge Road at GA400) rural
Fulton #106 (M. L. King Dr. at I-285) suburban

VIII. Parclo Loop ramp

Fulton #91 (Holcomb Bridge at GA400) rural
Fulton #94 (Haynes Bridge at GA400) rural

IX. Parclo, diagonal, one-quad, close frontage road

DeKalb #19 (N. Druid Hills at I-85) suburban
DeKalb #44 (Lawrenceville Hwy. at I-285) suburban

X. Parclo, 1 quad, loop (only 2)

Fulton #27 (Peachtree Street at I-75/85) urban
Fulton #37 (Piedmont Road at I-85) urban

XI. Parclo, 1 quad, loop w/close frontage road

DeKalb #20 (N. Druid Hills at I-85) suburban

XII. Parclo AB with diagonal ramp

Fulton #9 (Sylvan Road at I-85) suburban
Fulton #45 (Moores Mill Road at I-75) suburban
Clayton #7 (Dixie Hwy., US19/41 at I-285) suburban
Clayton #2 (Jonesboro Road, GA54 at I-75) rural
Clayton #6 (Clark Howell Hwy. at I-285) suburban

XIII. Parclo AB with loop ramp

Fulton #8 (Central Avenue at I-85) suburban
Fulton #65 (Hightower Road at I-20) urban
Clayton #5 (Clark Howell Hwy. at I-285) suburban
Clayton #8 (Dixie Hwy., US19/41 at I-285) suburban
Clayton #1 (Jonesboro Road, GA54 at I-75) rural

XIV. Diamond interchanges

University and I-75 urban
GA42 and I-285 suburban
GA54 and I-285 suburban
GA74 and I-85 rural
Bouldercrest and I-285 suburban

Discussion

Upon examining the results classified by ramp type in Table A-2, it would appear that several ramp types are particularly susceptible to wrong-way movements. These would be:

Type II: Half Diamond (4.7 per month)

Type VIII: Partial Cloverleaf Loop Ramp (5.7 per month)

Type XIII: Parclo AB Loop Ramp (4.1 per month)

This is not surprising as Type VIII and XIII reflect the same problem, entrance and exit ramps in close proximity. The half diamond is susceptible because it is an incomplete interchange and people may even make intentional wrong-way entries. We highly suspect this was the case at the Douglas Co. ramp (I-20 @ Chapel Hill Rd.). Here local residents would have to go about 2 or 3 miles out of their way to make a legal westbound entry at Georgia 92. The problem would probably be less severe in urban areas where access points are more closely spaced.

Before making any conclusions, we should also note the variation within each ramp type itself. In fact, a rough analysis (See Appendix B.) shows that the difference between ramp types are probably not statistically significant. While there may be some differences, it appears that wrong-way problems are fairly specific to individual ramps and other surrounding conditions than to ramp types. This would imply that any counter measures decided upon cannot be applied just to certain types of ramps. They should either be applied system-wide or after a series of spot checks to screen problem locations.

The problem with screening is that wrong-way movements vary with time. This study could not show a pattern of time variation, but one may exist. Also when rates are as low as is generally the case here, it may be hard to tell if there are a significant number of wrong-way movements. 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. (3) The most likely entry point was the interchange at Peachtree St. We studied this location in spring of 1978 and had a rate of 1.1 per month, not considered a bad rate (we consider 3 or greater a possible problem). However, it appears that a wrong-way entry at this ramp led to a fatality.

For studying countermeasure effectiveness it is necessary to have a discernible number of wrong-ways initially. With this in mind, we have selected nine ramps for further study. These all have initial rates of greater than 3, per 30-day month. These ramps and associated countermeasures are given in the next section.

Recommendations

We make the following recommendations to the Georgia DOT in connection with the project (See Appendix C for drawings illustrating these recommendations.):

(1) Continue study of pavement arrow at Central Avenue and I-75;

(2) Install wrong-way car stop device at Central Avenue; activate only after completing study of pavement arrow;

(3) Install the following countermeasures at eight of the nine ramps for a month of further study: (see appendix for drawings)

Ramp 1 - I-285 & Riverdale Rd.:
1. Large pavement arrows
2. 24" stop bar
3. DO NOT ENTER sign; R-5-1
4. Guide sign

Ramp 2 - I-285 & US 19/41 (Old Dixie Hwy.)
1. 24" stop bar
2. Large pavement arrow
3. Trailblazer
4. Ceramic buttons

Ramp 3 - I-20 & Chapel Hill Rd.
1. Standard MUTCD arrows (4)
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

Ramp 4 - GA 166 & Lakewood Ave.
1. Repaint median extension
2. 24" stopbar
3. DO NOT ENTER sign, R 5-1

Ramp 6 - I-85 & Sylvan Rd./Central Ave.
1. Ceramic buttons
2. KEEP RIGHT sign, R 4-7
3. 24" stopbar
4. Large pavement arrows

Ramp 7 - I-20 & Wesley Chapel Rd.
1. Large pavement arrows
2. Extend pavement edge line
3. DO NOT ENTER; R 5-1
4. KEEP LEFT; R 4-8

Ramp 8 - GA 400 & Holcomb Bridge Rd.
1. Large pavement arrows
2. 24" stopbar

Ramp 9 - I-75/85 & Decatur Street
1. Large pavement arrows
2. KEEP RIGHT; R 4-7

(4) For the ramp at GA 400 & Haynes Bridge Rd. phase in improvements at two-week intervals as follows:

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

(5) After an evaluation is made of individuals elements and a package proposed, install this package at all nine ramps and collect more data.

Future Work

Georgia Tech will continue to monitor the nine locations for further study. Several locations will use two counters because they have two roadways. These are I-20 and Wesley Chapel Rd., GA 400 and Holcomb Bridge Rd., and I-75/85 and Decatur Street. This way we can tell which roadway is the problem or if they both are. Georgia DOT will be kept informed by letter of results as they are available.

Also the parclo AB loop ramp at I-75 and Central Avenue will be studied further in connection with a wrong-way car stop device. (2) One counter is presently in place there. Another one will be placed downstream of the device and utilize Georgia Tech's movie camera to record the actions of drivers when they encounter the device. This wrong-way device is also a source of noise and a "bump" to right-way drivers. Before and after sample volume counts are being made to see if there is any diversion of traffic which can be attributed to the device.

APPENDIX A

DATA FOR PHASE ONE

TABLE A-1

GEORGIA DOT PROJECT 7703

WRONG-WAY MOVEMENTS ON FREEWAY RAMPS

INITIAL MONITORING FINAL REPORT

LOCATION	DAYS	WRONG WAY	WRONG WAY RATE (PER 30-DAY MO)
FULTON COUNTY			
2 - I-85 at SR-74 SB	59	0	0.0
8 - I-85 at Central Avenue NB	21	0	0.0
9 - I-85 at Central Avenue SB	25	3	3.6
18 - I-75/85 at University SB	14	1	2.1
24 - I-75/85 at Decatur Street SB	29	3	3.1
26 - I-75/85 at Butler Street SB	49	3	1.8
27 - I-75/85 at Peachtree Street NB	39	0(?)	0.0(?)
35 - I-85 at Peachtree Street SB	28	1	1.1
37 - I-85 at Piedmont Road NB	28	0	0.0
45 - I-75 at Moores Mill Road SB	34	0	0.0
46 - I-75 at W. Paces Ferry NB	9	0(?)	0.0(?)
59 - I-20 at Ashby Street EB	28	0	0.0
65 - I-20 at Hightower Road WB	35	2	1.7
74 - SR166 at Cambellton Road WB	24	0	0.0
75 - SR166 at Mt. Gilead Road EB	28	0	0.0
79 - SR166 at Sylvan Road EB	23	0	0.0
82 - SR166 at Lakewood Ave (Fleet St) WB	22	4	5.5
83 - SR166 at Lakewood Avenue EB	18	0	0.0
90 - I-285 at Jonesboro Road EB	19	0(?)	0.0(?)
91 - SR400 at Holcomb Bridge Rd. NB	25	1	1.2
92 - SR400 at Holcomb Bridge Rd. SB	35	4	3.4
93 - SR400 at Haynes Bridge Road NB	28	0	0.0
94 - SR400 at Haynes Bridge Road SB	28	9	9.4
106 - I-285 at Martin Luther King Dr. NB	29	1	1.0

TABLE A-1 (cont'd.)

DEKALB COUNTY			
7 - I-20 at Wesley Chapel Road WB	23	3	3.9
19 - I-85 at N. Druid Hills Road SB	36	1	0.8
20 - I-85 at N. Druid Hills Road NB	36	0	0.0
28 - I-85 at Pleasantdale Road SB	20	0	0.0
30 - I-285 at Moreland Avenue WB	8	0(?)	0.0(?)
32 - I-285 at Bouldercrest Road WB	30	0	0.0
42 - I-285 at E. Ponce de Leon SB	34	0(?)	0.0(?)
44 - I-285 at Lawrenceville Hwy. SB	42	0	0.0
CLAYTON COUNTY			
1 - I-75 at SR54 WB	29	4	4.1
2 - I-75 at SR54 WB	29	0	0.0
4 - I-285 at Riverdale Road EB	29	3	3.1
5 - I-285 at Clark Howell Hwy. WB	56	0(?)	0.0(?)
6 - I-285 at Clark Howell Hwy. EB	29	0	0.0
7 - I-285 at US19/41 WB	28	3	3.2
8 - I-285 at US19/41 EB	39	11	8.5
COBB COUNTY			
27 - I-20 at Six Flags Road WB	23	2	2.6
28 - I-20 at Six Flags Road EB	29	2	2.1
DOUGLAS COUNTY			
6 - I-20 at SR92 EB	38	0	0.0
7 - I-20 at Chapel Hill Road WB	33	8	7.3
ROCKDALE COUNTY			
3 - I-20 at SR70/138 WB	30	1	1.0

(?) Data questionable

TABLE A-2

Type	Location	Days	WW	Rate
I	I-85 @ Peachtree St. SB (U)	28	1	1.1
	I-285 @ Riverdale Rd. (S)	29	3	3.1
	I-20 @ SR 20 (R)	30	1	1.0
	I-20 @ SR 92 (R)	38	0	0.0
	I-20 @ Wesley Chapel (S)	23	3	3.9
	Overall	148	8	1.6
II	I-20 @ Chapel Hill Road (R)	33	8	1.6
	SR 166 @ Lakewood Ave. EB (U)	18	0	0.0
	Overall	51	8	4.7
III	I-75/85 @ Butler Street (U)	49	3	1.8
	I-75/85 @ Decatur Street (U)	29	3	3.1
	Overall	78	6	2.3
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	I-285 @ Martin Luther King Dr. (S)	29	1	1.0
	SR 400 @ Holcomb Br. Road SB (R)	35	4	3.4
	SR 400 @ Haynes Br. Road NB (R)	28	0	0.0
	Overall	92	5	1.6
VII	SR 400 @ Holcomb Br. Road NB (R)	25	1	1.2
	SR 400 @ Haynes Br. Road SB (R)	28	9	9.4
	Overall	53	10	5.7
VIII	I-85 @ N. Druid Hills Road SB (S)	36	1	0.8
	I-285 @ Lawrenceville Hwy. SB (S)	42	0	0.0
	Overall	78	1	0.4
IX	I-75/85 @ Peachtree (U)	*	*	*
	I-85 @ Piedmont (U)	28	0	0.0
X	I-85 @ N. Druid Hills (S)	36	0	0.0
XI	I-85 @ Sylvan Road (S)	25	3	3.6
	I-75 @ Moores Mill Road (S)	34	0	0.0
	I-285 @ US 19/41 (S)	28	3	3.2
	I-75 @ Jonesboro Road (R)	29	0	0.0
	I-285 @ Clark Howell (S)	29	0	0.0
	Overall	145	6	1.2

TABLE A-2 (cont'd.)

XII	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)	39	11	8.5
	I-75 @ SR 54 (R)	29	4	4.1
	Overall	124	17	4.1
XIII	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.

APPENDIX B

STATISTICAL EVALUATION

A rough statistical analysis was made on the Phase 1 data. Analysis of variance (ANOVA)(5) 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. More sophisticated analysis, which will be performed at a later date, may disclose significant differences.

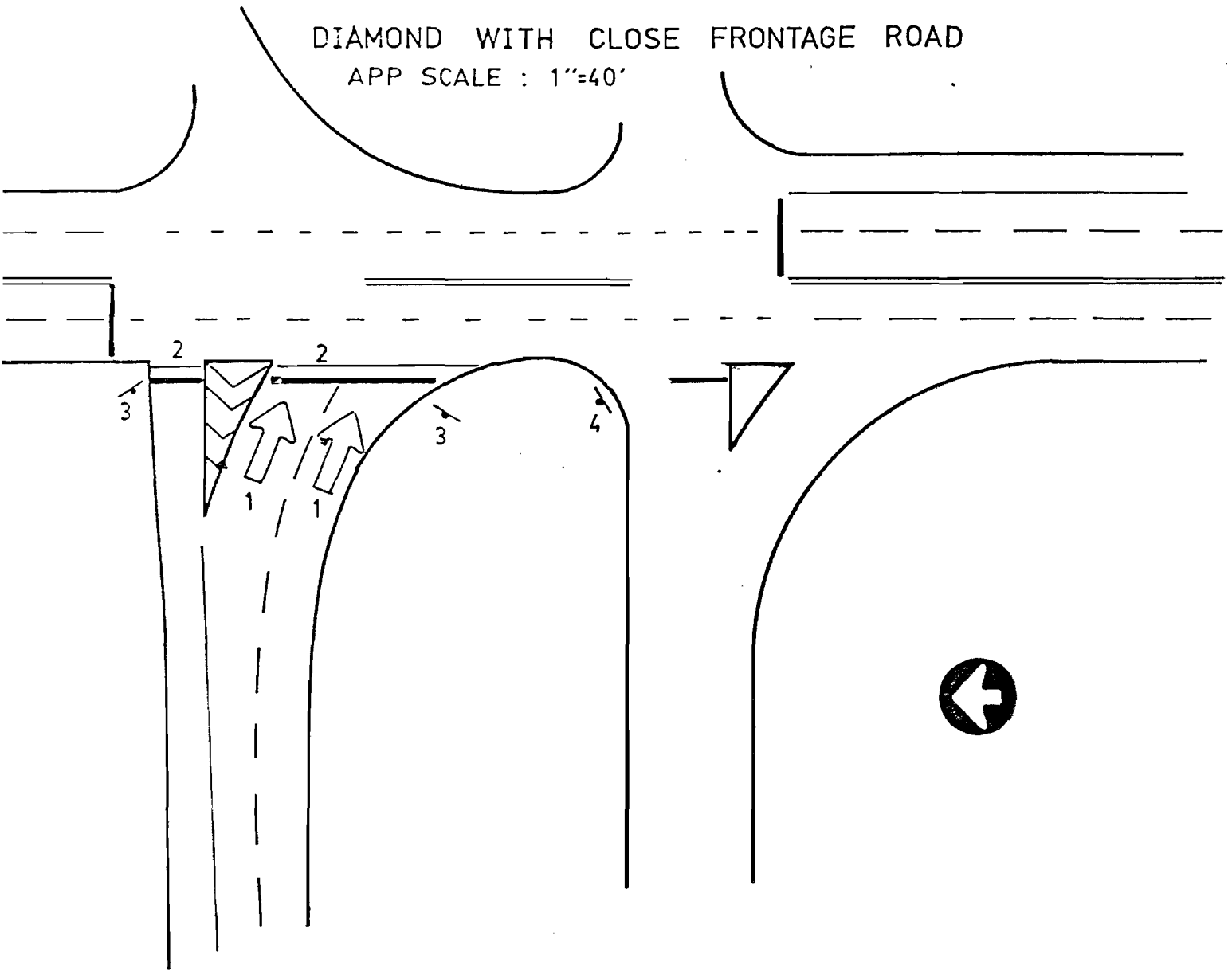
APPENDIX C

COUNTERMEASURE RECOMMENDATIONS

I - 285 & RIVERDALE RD

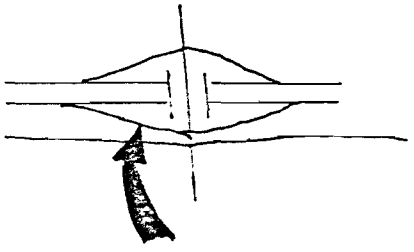
DIAMOND WITH CLOSE FRONTAGE ROAD

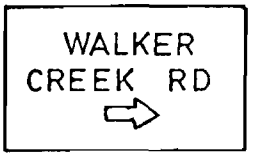
APP SCALE : 1"=40'



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

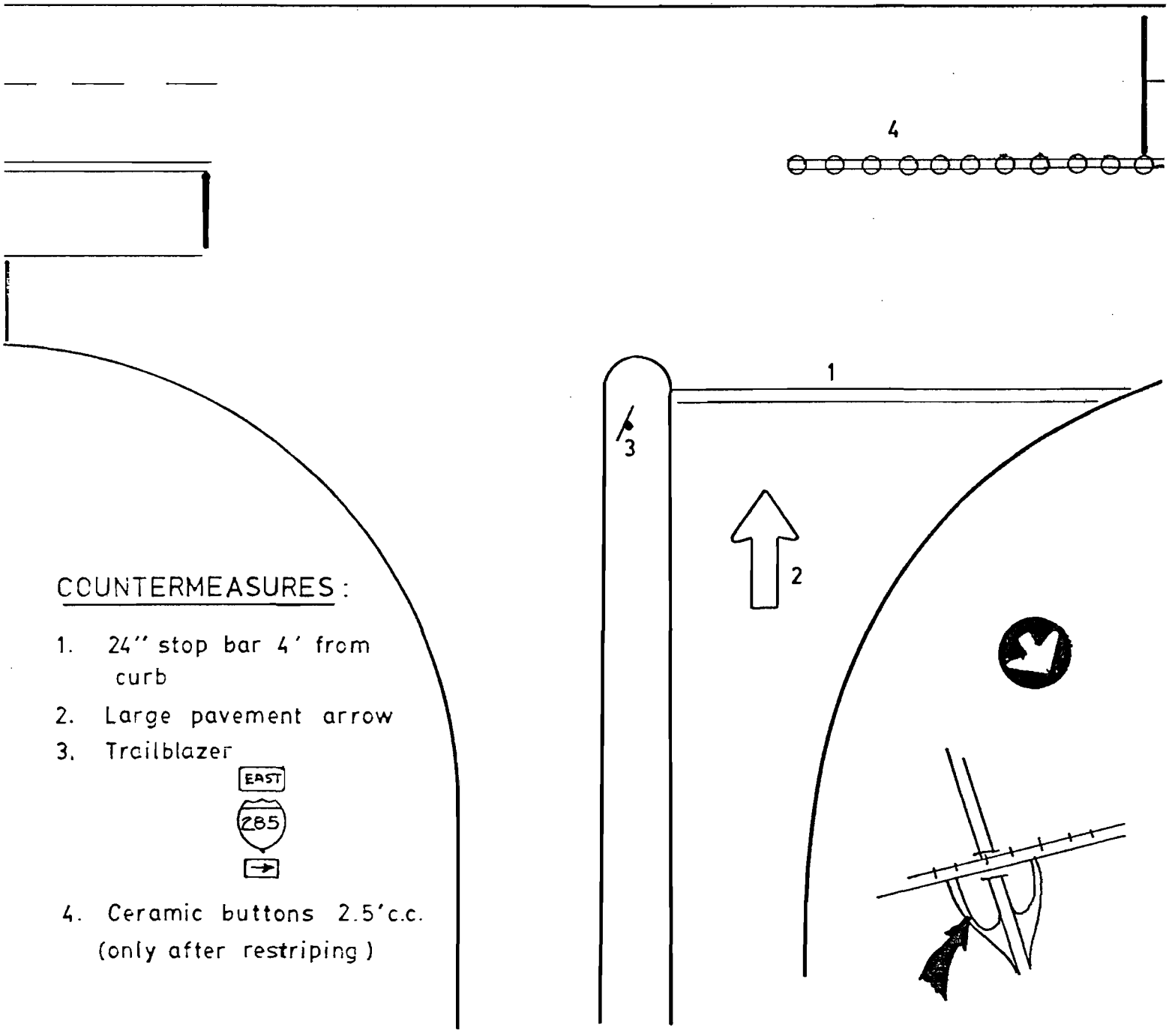




I-285 & US 19/41

PARCLO AB LOOP RAMP

APP SCALE : 1"=20'



COUNTERMEASURES :

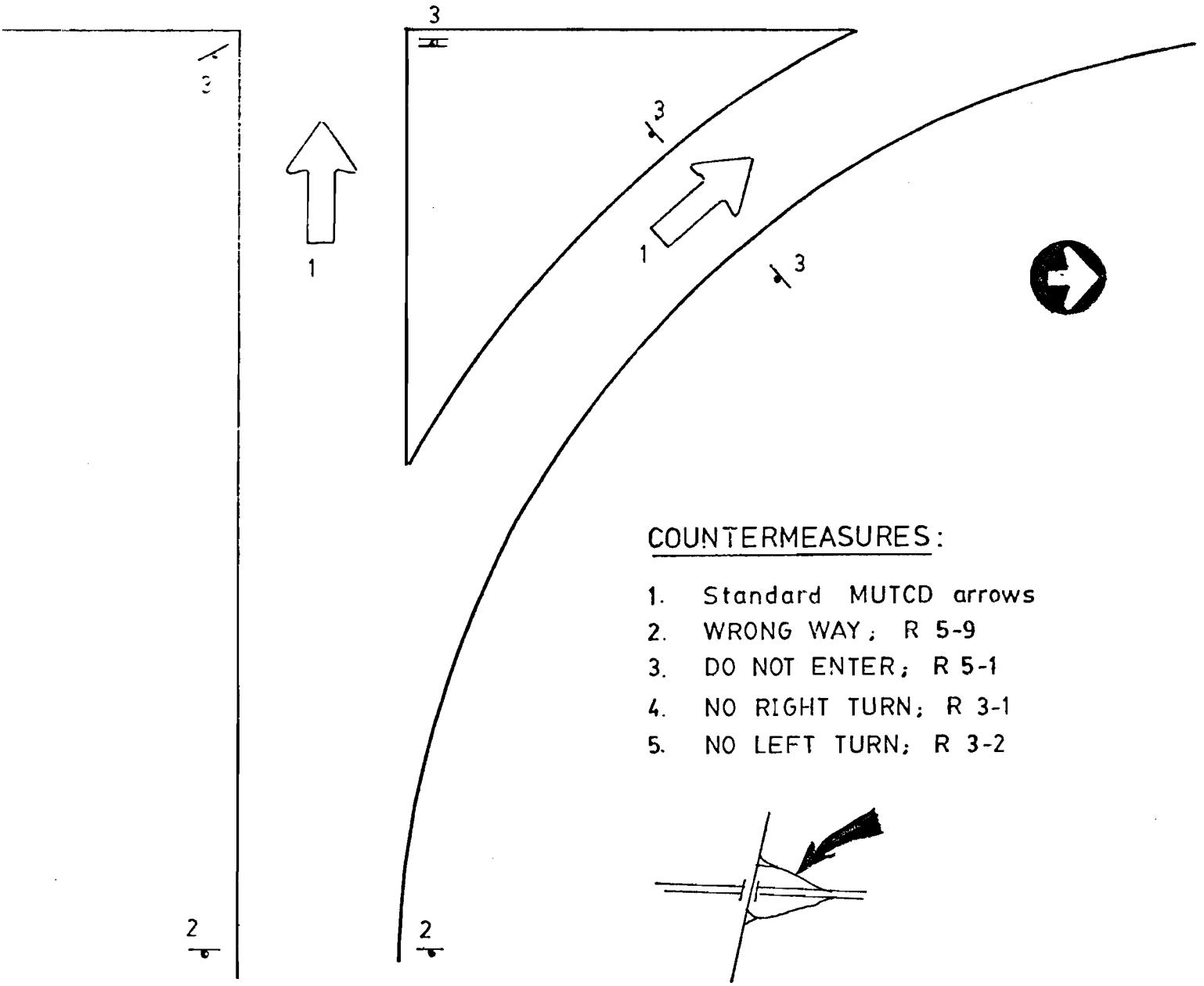
1. 24" stop bar 4' from curb
2. Large pavement arrow
3. Trailblazer

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

I-20 & CHAPEL HILL RD

HALF DIAMOND

APP. SCALE : 1" = 20'

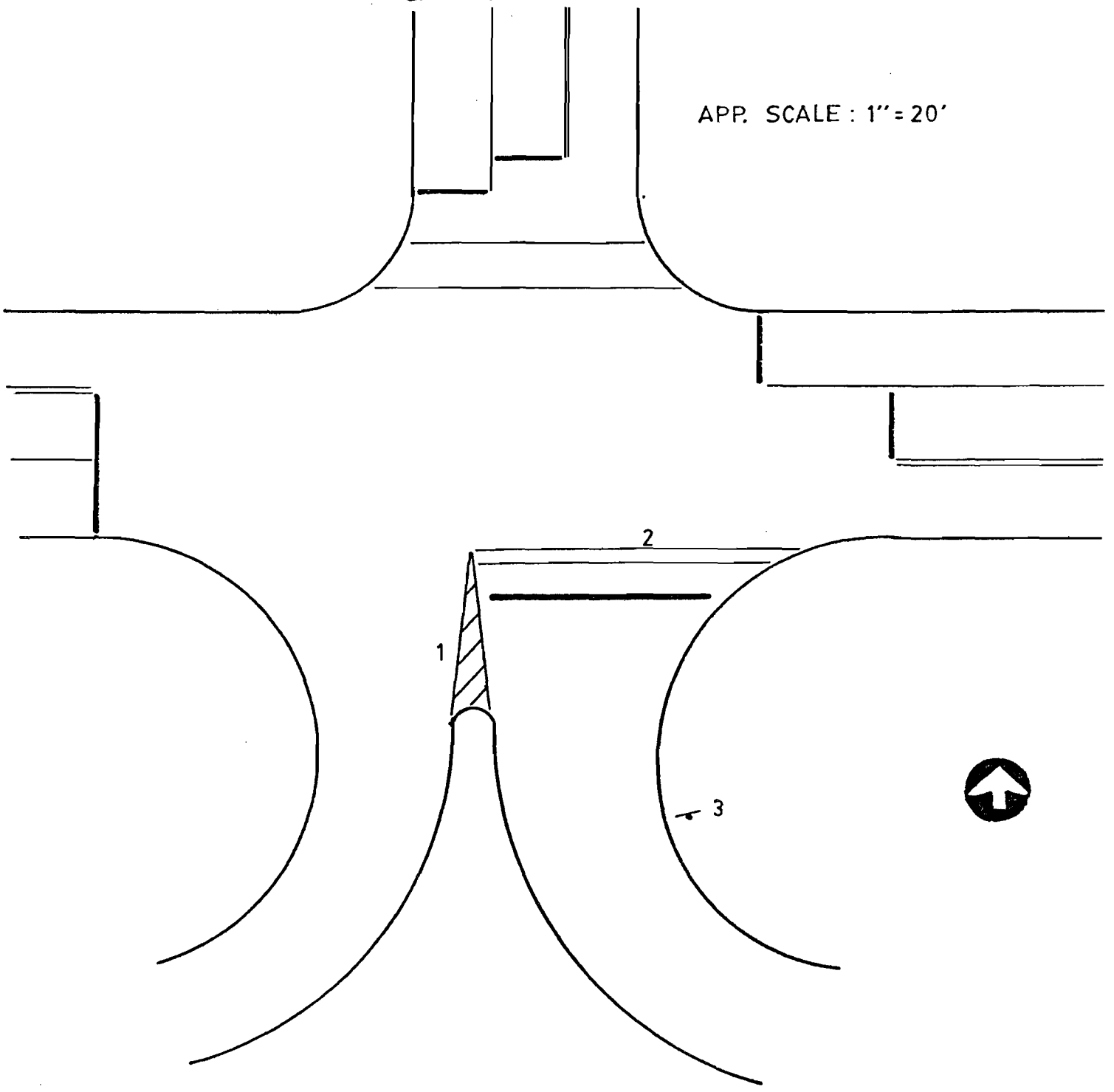


COUNTERMEASURES:

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 166 & LAKEWOOD AVE

APP. SCALE : 1" = 20'



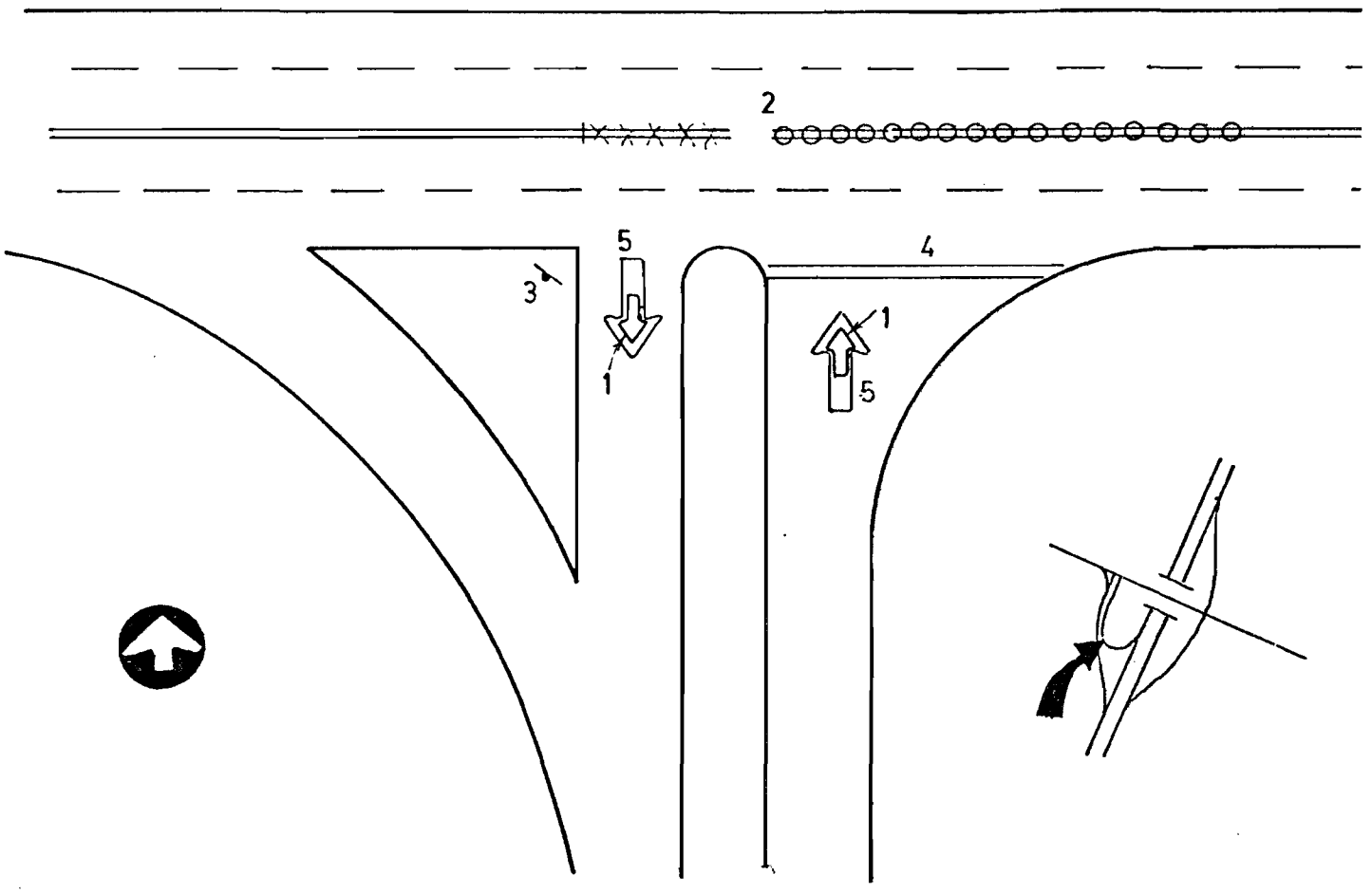
COUNTERMEASURES :

1. Repaint and reflectorize median extension
2. Install 24" stop line, 4' from curb
3. DO NOT ENTER ; R 5-1

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

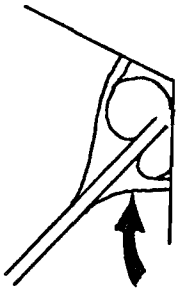
PHASE 4 (if necessary)

6 Ceramic buttons
2.5' c.c.

I-85 & SYLVAN RD/CENTRAL AVE

PARCLO AB DIAGONAL RAMP

APP. SCALE : 1"=40'



COUNTERMEASURES:

1. Ceramic buttons, 2.5' c.c., from end of flare to end of stripe
2. KEEP RIGHT sign ; R4-7
3. 24" stop bar , 4' from curb line
4. Large pavement arrows

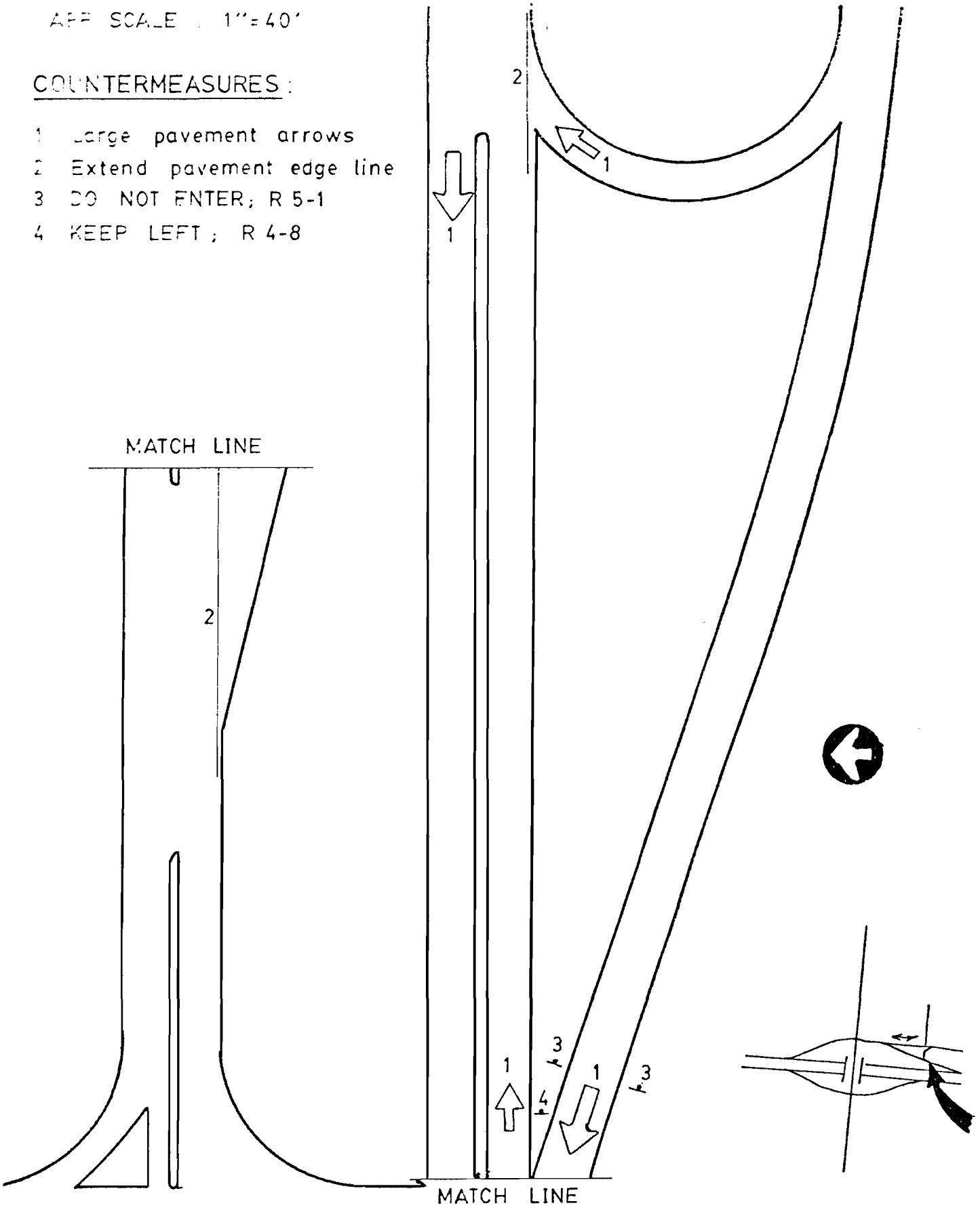
I-20 & WESLEY CHAPEL RD

DIAMOND WITH CLOSE FRONTAGE ROAD

APP SCALE 1"=40'

COUNTERMEASURES:

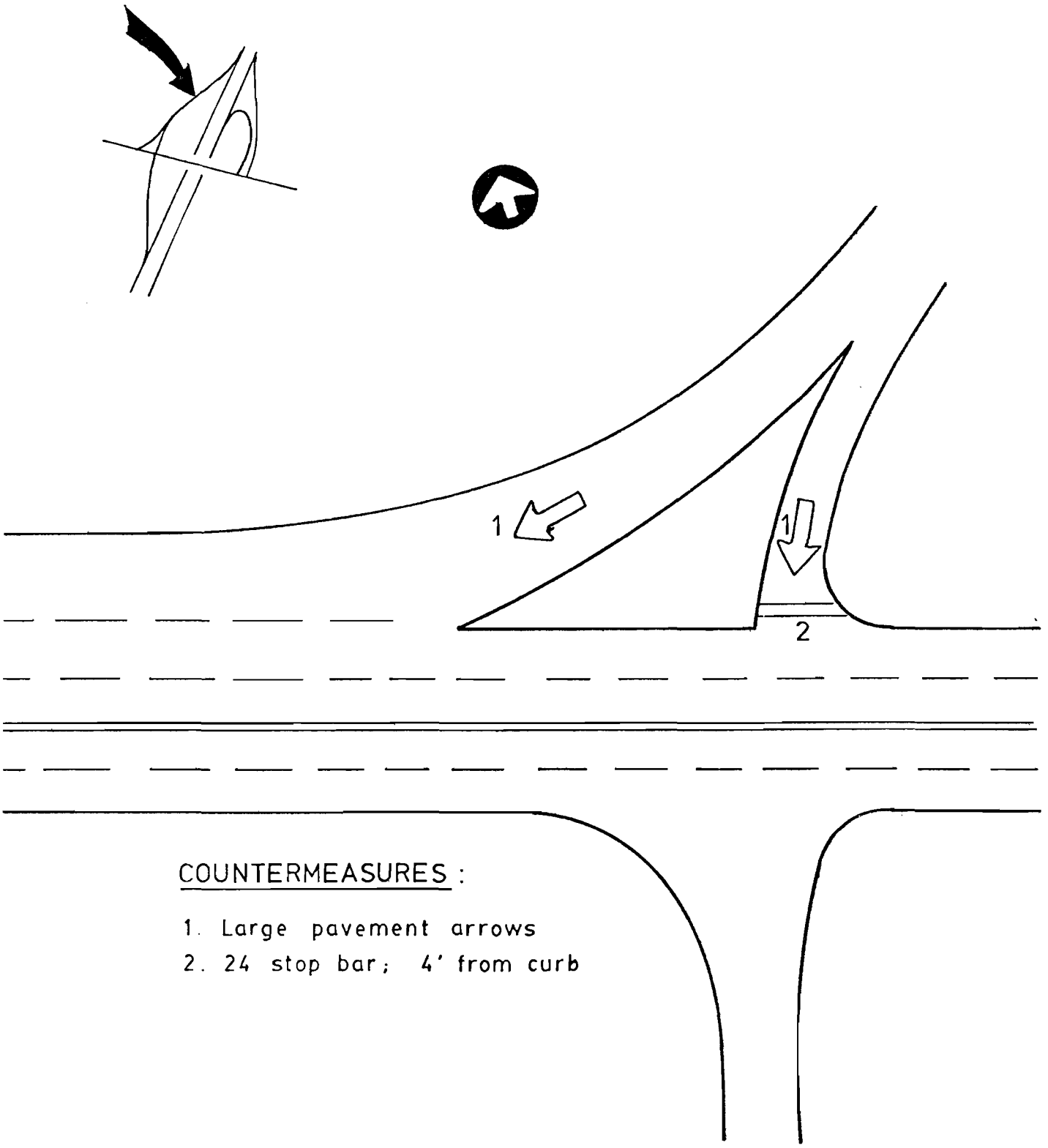
1 Large pavement arrows
2 Extend pavement edge line
3 DO NOT ENTER; R 5-1
4 KEEP LEFT; R 4-8



GA 400 & HOLCOMB BRIDGE RD

PARCLO 3-QUADRANT DIAGONAL RAMP

APP SCALE : 1"= 40'



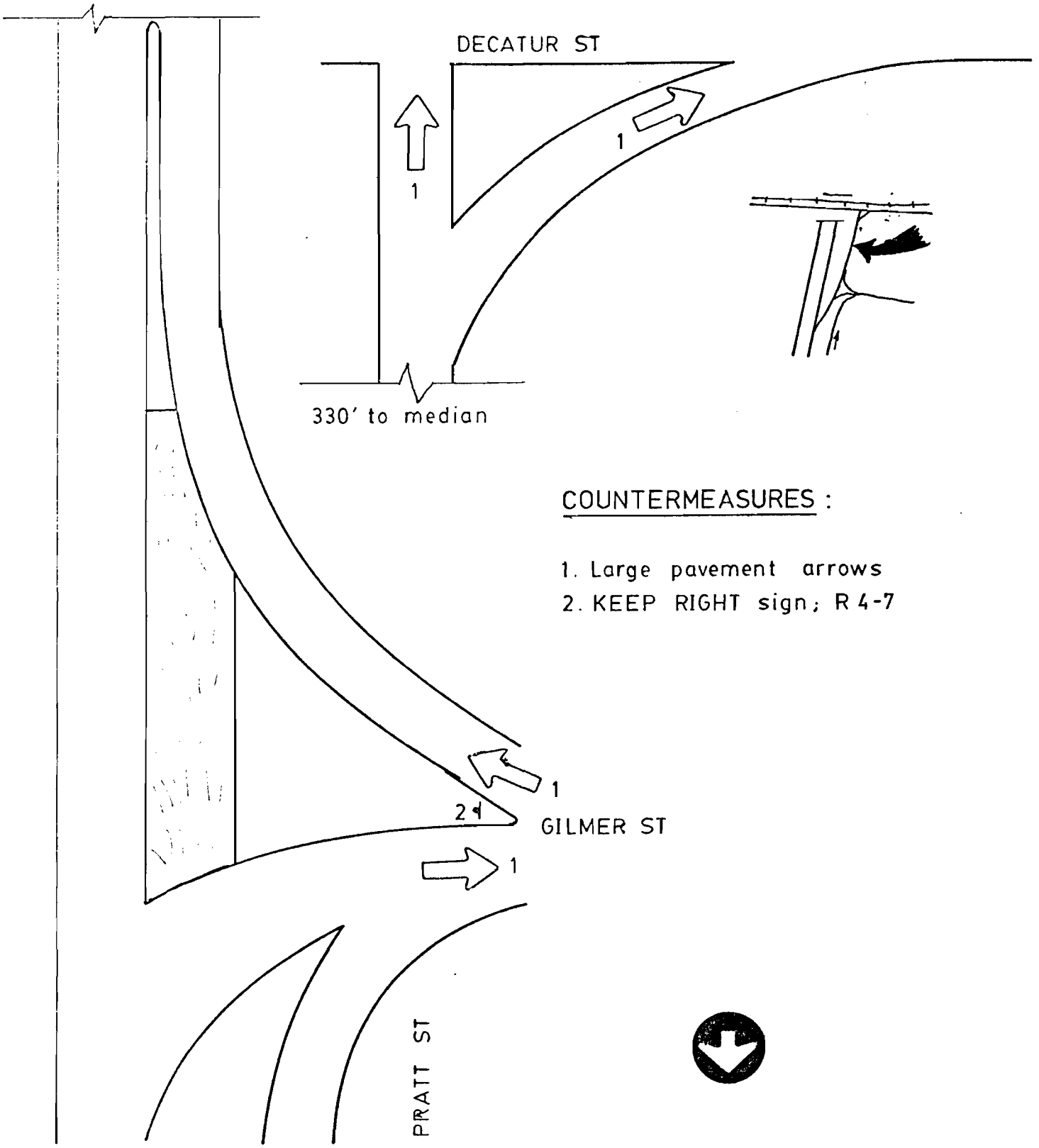
COUNTERMEASURES :

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

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(1) Richard P. Weaver, "Hidden Camera to Detect Wrong-Way Driving on Freeway Ramps", California Department of Public Works, Division of Highways, District II, San Diego, California [no date].

(2) Percy B. Middlebrooks, Jr., Freeway Wrong-Way Entry Study, GDOT Research Assistance Project No. 3-75, Office of Materials and Research, Georgia Department of Transportation, Atlanta, Georgia, December 1976.

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

(4) Official Rulings on Requests for Interpretations, Changes, and Experimentations (Manual on Uniform Traffic Control Devices), Vol. VIII, U. S. Department of Transportation, Federal Highway Administration, pp. 6 - 8, December 1977.

(5) Douglas C. Montgomery, Design and Analysis of Experiments, John Wiley & Sons, 1976.

RESEARCH QUARTERLY PROGRESS REPORT

GEORGIA DEPARTMENT OF TRANSPORTATION

Date of Report: 10-4-78

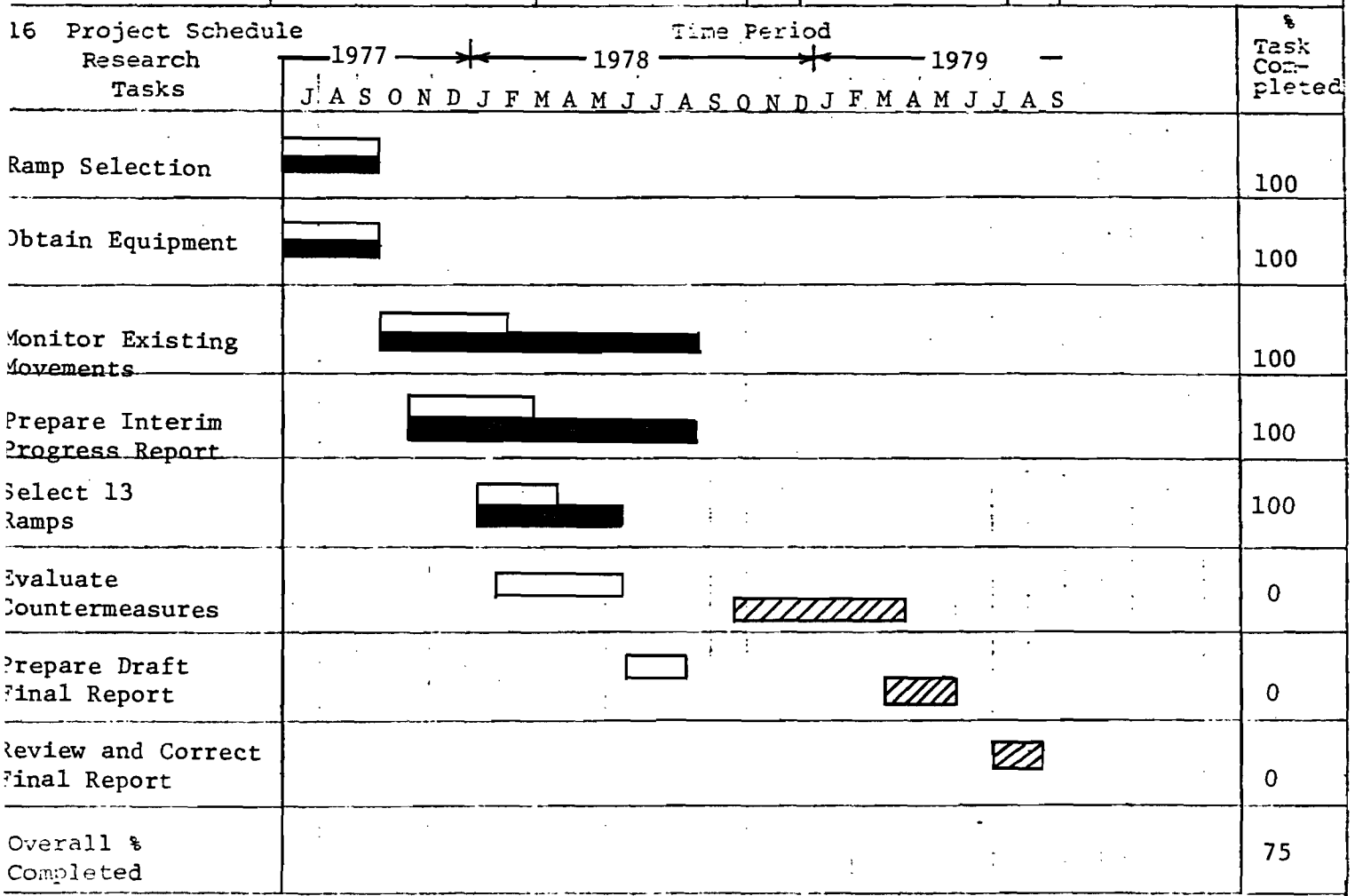
1 Project No. State/Agency	2 Project Title	3 Quarterly Report No. / From / To
7703.E20-624	Wrong-Way Traffic Movements on Freeway Ramps	No. 5 From July 1, 1978 To Sept. 30, 1978

4 Research Agency	5 Project Director(s)
Georgia Institute of Technology	Dr. Peter S. Parsonson Associate Professor School of Civil Engineering

6 Starting Date	7 Completion Date	8 % Time Expended	9 Schedule Status	10 Sufficiency of Funds
Sept. 23, 1977	Jan. 22, 1979	75%	☐ Ahead ☒ Behind ☐ On	☐ Sufficient ☒ Insufficient

Funds Authorized		Funds Expended		
11 Total	12 Current Fiscal Year	13 Total to Date	14 Current Fiscal Year	15 Report Quarter
$14,842 GDOT 6,349 GIT	$14,842 GDOT 6,349 GIT	12,469 GDOT 5,646 GIT	$3484 GDOT 3351 GIT	$3484 GDOT 3351 GIT

16 Project Schedule



17 Progress This Quarter (By Task)

Prepare Interim Progress Report - An updated Interim Progress Report was submitted on Sepetember 1. It included all of the data from the monitoring performed during the summer.

Later in September all of the equipment was brought in from the field, for repair and to await installation of countermeasures at the of selected locations.

It was agreed with Mr. Middlebrooks that in early October Georgia Tech would deploy a wrong-way camera at I-75 and Central Ave., and he would then take the readings, change the film, and perform minor maintenance (batteries, tape, etc.).

18 Work Planned for Next Quarter

It is anticipated that District 7 maintenance forces will install the countermeasures at the nine selected locations, and that Georgia Tech would immediately deploy cameras at these locations.

19 Significant Technical Information, Recommendations, Implementation

Dr. Parsonson presented a paper entitled "Wrong-Way Traffic Movements on Freeway Ramps in Atlanta" to the 48th Annual Meeting of the Institute of Transportation Engineers, August 6, 1978, Atlanta. A copy of the paper as printed in the compendium is attached.

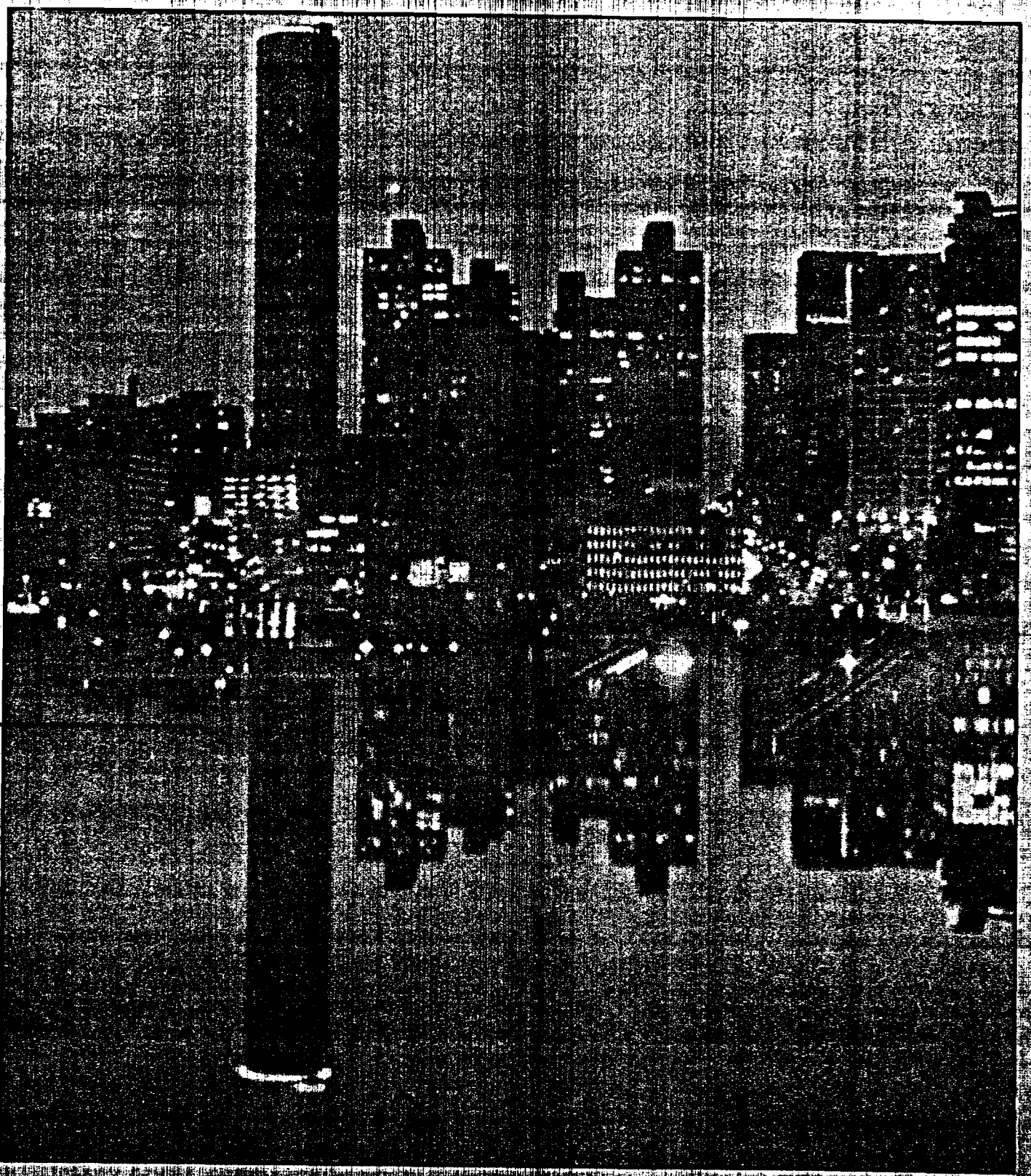
20 Problems

The project is running out of funds because it was not contemplated in the original budget that it would be necessary to hire personnel for field work after September, 1978. We are currently preparing a request for a small increase in budget and extension of time.

21 Report prepared by

Peter S. Parsonson — Name

Assoc. Professor — Title



COMPENDIUM

OF TECHNICAL PAPERS

STITUTE OF TRANSPORTATION ENGINEERS 48th ANNUAL MEETING

AUGUST 6-10, 1978

ATLANTA, GEORGIA

WRONG-WAY TRAFFIC MOVEMENTS ON FREEWAY RAMPS IN ATLANTA

[a]Peter S. Parsonson, Fellow, I.T.E.
[b]James R. Marks, Student Member, I.T.E.
[c]Andres E. Nunez, Jr., Associate Member, I.T.E.

A research project is currently underway to monitor the wrong-way traffic movements occurring at 44 representative off-ramps in the Greater Atlanta freeway system. The research uses 18 special-purpose still-camera units and one movie-camera unit purchased from the California D.O.T. Before-and-after evaluations of several countermeasures are included in the project. This paper is an interim report of the results to date. It includes the statistics of frequency of wrong-way movements at most of the sites, and detailed before-and-after research results for one parclo AB interchange that has been observed to be particularly confusing to drivers.

In the early 1970's California designed and built 150 still camera units to monitor every off-ramp in the state for 30 days. The project has been completed and the cameras now sit idle, available for purchase as surplus to the needs of the state. The authors have found their 19 units to be economical and dependable; they believe that many traffic engineering agencies may wish to consider purchasing one or more California units in order to perform monitoring programs of their own.

INTRODUCTION

Significant research on wrong-way ramp movements has been performed by a number of states since 1961. Some recent Georgia research, and certain elements of the California work, are discussed next as an introduction to 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" (1). 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 fatalities are attributable to these movements. In California 18 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 (2).

In 1967 the California DOT developed 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-spaced 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 paper 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 to 1975 used 150 of them to monitor every off-ramp in the state. California has found them to be consistent, reliable and accurate in detecting wrong-way entries (2). Although no comprehensive report of the California monitoring program has yet been released, an interim paper

[a]Associate Professor, Georgia Institute of Technology.

[b]Graduate Research Assistant, Georgia Institute of Technology.

[c]Engineer, Alan M. Voorhees & Associates, Consultants.

was published in 1974 (3).

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 (4).

California also developed a Super 8 movie camera as a companion to 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.

PILOT STUDY AT CENTRAL AVE./I-75

In early 1977 Georgia Tech purchased from California one still-camera unit and a companion movie model. They were installed in April 1977 on the northbound off-ramp from Interstate 75 to Central Avenue in the Atlanta area. This location, a type AB partial cloverleaf, is shown in Figure 1. It was recommended by the Georgia DOT because it was known to experience a relatively high incidence of wrong-way movements.

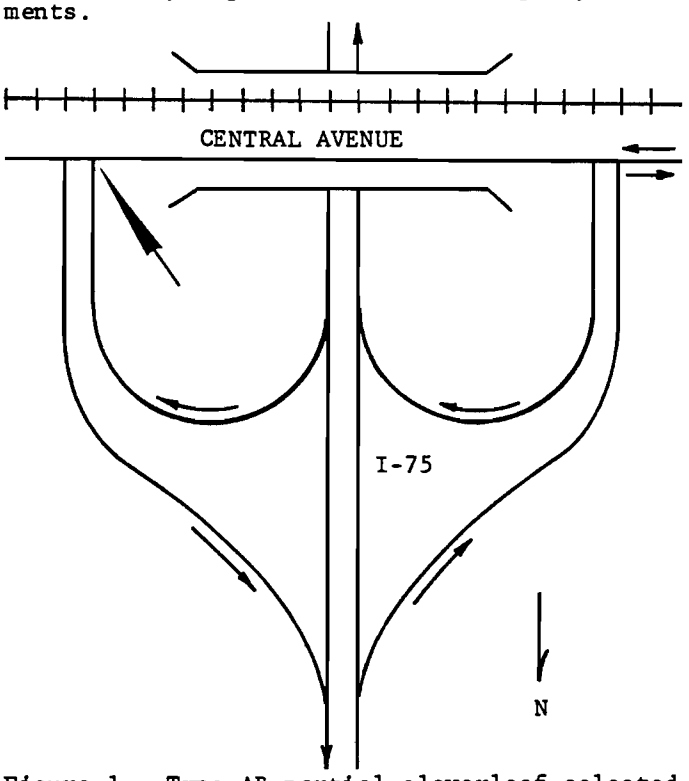


Figure 1. Type AB partial cloverleaf selected for pilot study

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.

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

The road tubes are of semi-circular cross-section, flat on the bottom, in order that they will remain 3 to 4 inches apart. Industrial tape (Nashua 200) was applied to hold the tubes in place (Figure 3).

The study site was visited twice a week to check road tubes and equipment, record the number of wrong-way actuations, 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 three 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 is very high by California standards; there, a "problem" off-ramp is characterized by a rate of three or more per month.

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 taillights, 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 a manual transmission. 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.

Figure 8 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 9 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 inside the intersection with the ramps, as shown in Figure 8.

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.

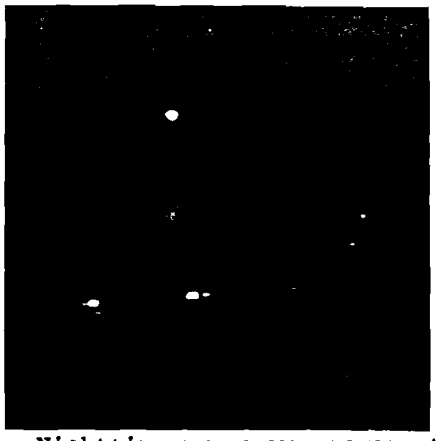


Figure 5. Nighttime wrong-way movement. Note rectangular headlights, easily distinguished from taillights.

Figure 6. Daylight wrong-way movement

Figure 7. False actuation caused by vehicle roll-back

Phase 3: Phases 1 and 2 were removed, returning the intersection to its original condition. Then an 18-inch-wide stop line was taped at the Central Avenue end of the off-ramp pavement. The purpose of the 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

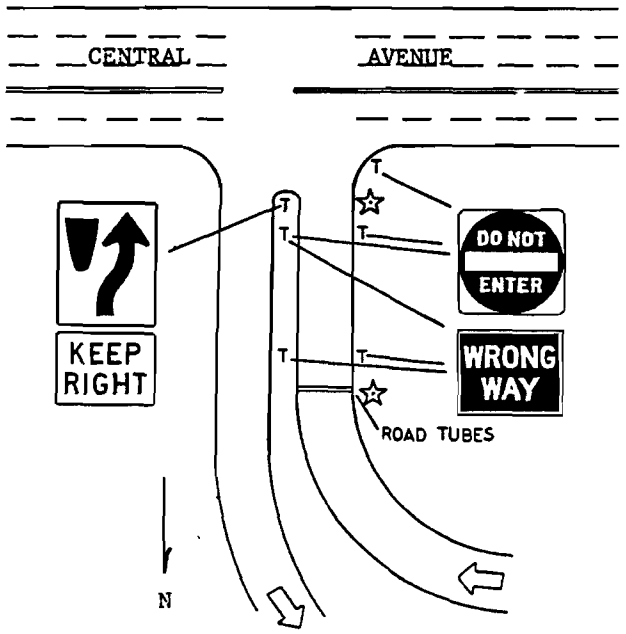


Figure 8. Initial signing plan at Central Ave./I-75

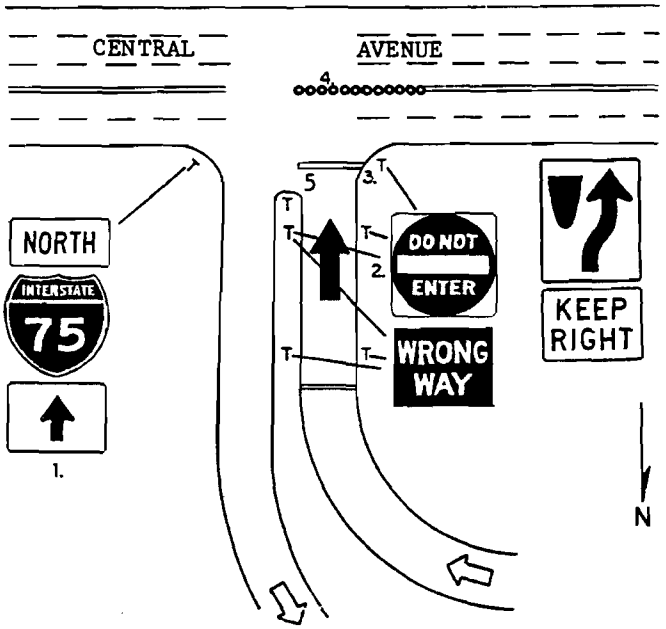


Figure 9. Phased improvements at Central Ave./I-75

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 1 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 one-third to one-half of its original rate. The ceramic buttons were about as effective as any one of the first three improvements.

Phase	Description	Length of Recording Period	Wrong-Way Entries Per Day
	Original Signing Plan*	22 days	2.9
1	Trailblazer sign	15 days	1.5
2	Lower "DO NOT ENTER" and "WRONG WAY" signs	14 days	1.1
3	18"-wide stop line	21 days	1.4
4	8"-diameter yellow ceramic buttons	30 days	1.0
5	18-foot-long painted pavement arrow	14 days	0.07

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

Table 1. Effectiveness of phased improvements at Central Ave./I-75

The finding that the buttons alone were an insufficient countermeasure came as a surprise to the senior author. He had 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. 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 was equally surprising to find that Phase 5, the painted pavement arrow plus the ceramic buttons, was extremely effective. At the time of this writing, 14 days of data had shown a wrong-way incidence of only .07 entries per day, equivalent to 0.5 per month.

The success of Phase 5 suggests that most of the wrong-way movements remaining after the installation of the ceramic buttons (in Phase 4) were attributable to right-turning vehicles.

The next step in the research at this location will be the replacement of the first three phases of improvements. It is likely that the "package" of all five phases will reduce wrong-way incidence to the vanishing point.

GREATER ATLANTA PROJECT

The results of the pilot project at Central Avenue/I-75 led to a larger program, sponsored by the Georgia DOT, in which Georgia Tech monitored the wrong-way movements at 44 freeway off-ramps in Greater Atlanta.

First, the total of 218 off-ramps in the area were classified by type, according to the

AASHTO ramp classification (5) and the scheme prepared by the geometric-design authority Jack Leisch (6). It was found that Greater Atlanta has 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 make a wrong turn.

Of the 23 ramp layouts identified, 19 are considered susceptible to wrong-way movements and four are not. Of the 19, six 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 susceptible. Therefore 13 layouts were identified as candidates for the research project. These are shown in Figure 10. It was decided to monitor two to four examples of each of these types, for a total of 39 sites. With respect to the four layouts that are not susceptible to wrong-way movements, it was decided to monitor two simple diamond ramps and one of each of the other three types, for a total of five. Therefore, 44 sites in all were identified to be monitored by still-camera units for one month each. Eighteen units were purchased from the California DOT so that this work could be completed in a few months.

As of this writing 31 ramps have been monitored with the results shown in Table 2. This table shows that there is no consistency of results among several ramps of any one type. For example, Type XIII is the loop ramp of a type AB partial cloverleaf, the same as the Central Avenue/I-75 pilot study. The results of substantial data at five such ramps show a wide variation in wrong-way rates from 0.0 to 8.5 per 30-day month. The average of 3.0 for the group barely suggests a problem with this ramp design.

The table does show that there is little difficulty with types V, IX, X, XI, and XIV. Therefore, there remain nine types of designs for which certain example ramps will require countermeasures.

CONCLUSIONS

To date the project has succeeded in identifying nine ramp types in the Greater Atlanta area that are potentially hazardous because of wrong-way traffic movements. Currently, countermeasures are being designed for one example ramp of each of the nine types. Once installed, the countermeasures will be evaluated by still-camera units to determine their effectiveness.

ACKNOWLEDGMENTS

The Greater Atlanta research on the 44 off-ramps is being carried out as Georgia DOT Research Project No. 7703.

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 contents of this paper do not necessarily reflect the official views or policies of either the Georgia DOT or the U. S. Department of Transportation.

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1. Middlebrooks, Percy B., Jr., "Freeway Wrong-Way Entry Study", Final Report of Georgia DOT Research Assistance Project No. 3-75, Office of Materials and Research, Georgia DOT, December 1976.

2. 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, pp. 39 - 44, November 1971.

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

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

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RESEARCH QUARTERLY PROGRESS REPORT

GEORGIA DEPARTMENT OF TRANSPORTATION

Date of Report: January 5, 1979

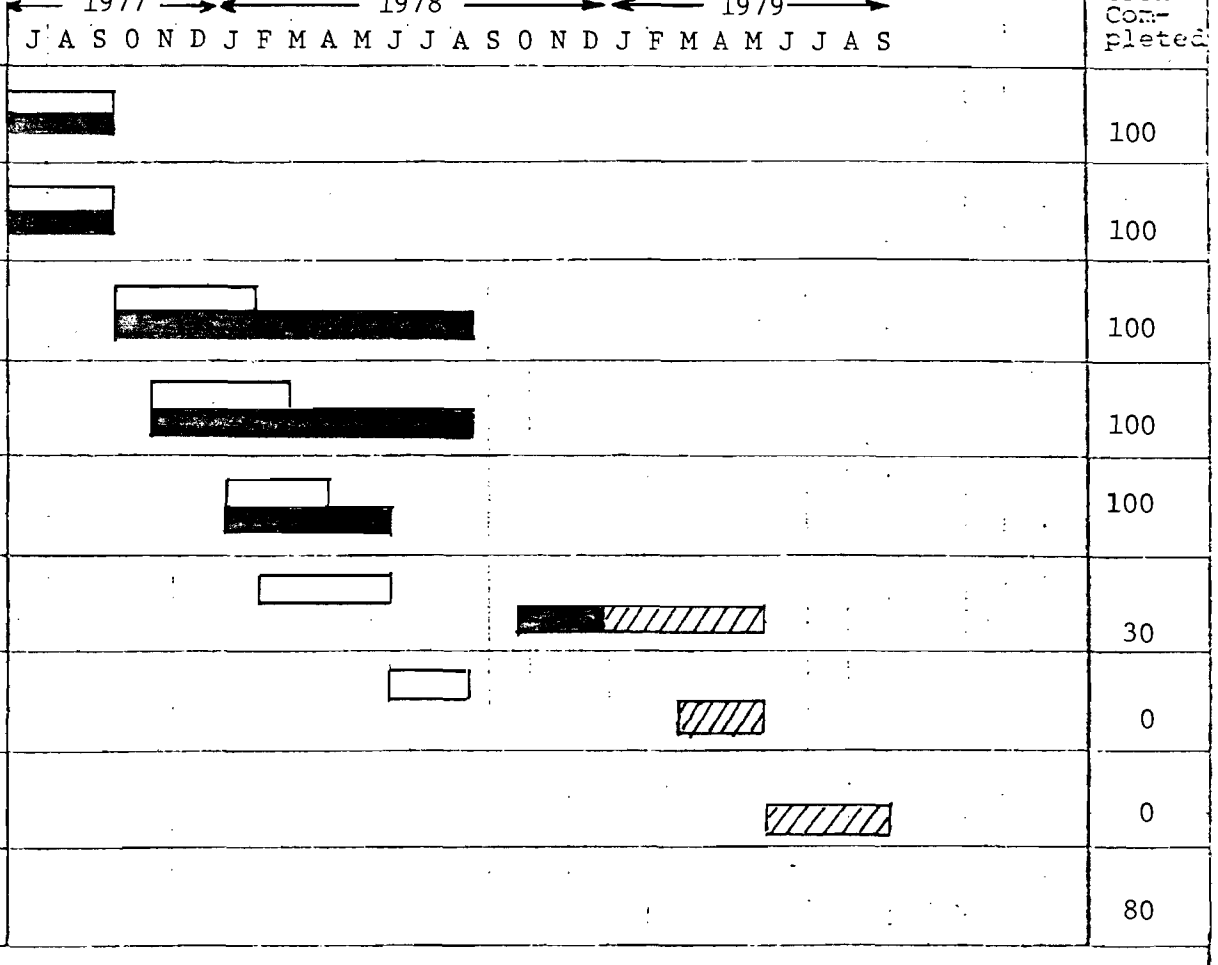
1 Project No. State/Agency	2 Project Title	3 Quarterly Report No. 6
7703. E20-624	Wrong-Way Traffic Movements on Freeway Ramps	From Oct. 1, 1978 To Dec. 31, 1978

4 Research Agency	5 Project Director(s)
Georgia Institute of Technology	Dr. Peter S. Parsonson Associate Professor School of Civil Engineering

6 Starting Date	7 Completion Date	8 % Time Expended	9 Schedule Status	10 Sufficiency of Funds
Sept. 23, 1977	Jan. 22, 1979	95%	☐ Ahead ☒ Behind ☐ On	☐ Sufficient ☒ Insufficient

Funds Authorized		Funds Expended				
11 Total	12 Current Fiscal Year	13 Total to Date	%	14 Current Fiscal Year	%	15 Report Quarter
14,842 GDOT 6,349 GIT	14,842 GDOT 6,349 GIT	14,014 GDOT 5.646 GIT		5,029 GDOT 3,351 GOT		1,545 GDOT 0 GIT

16 Project Schedule — Time Period



17 Progress This Quarter (By Task)

The GDOT installed the Phase 1 countermeasures at all of the selected locations except Ga. 54 at I-75. Georgia Tech installed wrong way cameras at these locations and recorded a substantial amount of data during the quarter. These data were transmitted informally to Mr. Middlebrooks in early January, and are appended hereto.
The locations studied were as follows:

Ga. 400 at Holcomb Bridge Rd (SB)

I-75/85 at Decatur St. (SB)

I-285 at Riverdale Rd. (EB)

I-285 at U. S. 19/41 (EB)

I-20 WB at Chapel Hill Rd. (WB)

Ga. 400 at Haynes Bridge Rd. (SB)

I-20 at Wesley Chapel Rd. (WB)

18 Work Planned for Next Quarter

We are continuing to take the required additional data on the Phase 1 countermeasures, and are waiting for the GDOT to install the Phase 2 countermeasures where needed.

19 Significant Technical Information, Recommendations, Implementation

Monitoring of Phase 1 countermeasures was completed at I-20 & Wesley Chapel, I-285 and Riverdale Rd., Ga 400 and Holcomb Bridge. We are continuing to monitor at the other four locations. The attachment gives the data supporting these decisions.

20 Problems

We continued informal assistance at I-75 and Central Ave., with two still cameras and a movie camera. The movie camera sometimes fails to operate, probably because of the cold weather that occurs from time to time.

21 Report Prepared by

Signature	Peter S, Parsonson Name	Assoc. Professor Title

RESEARCH QUARTERLY PROGRESS REPORT

GEORGIA DEPARTMENT OF TRANSPORTATION

Date of Report: April 6, 1979

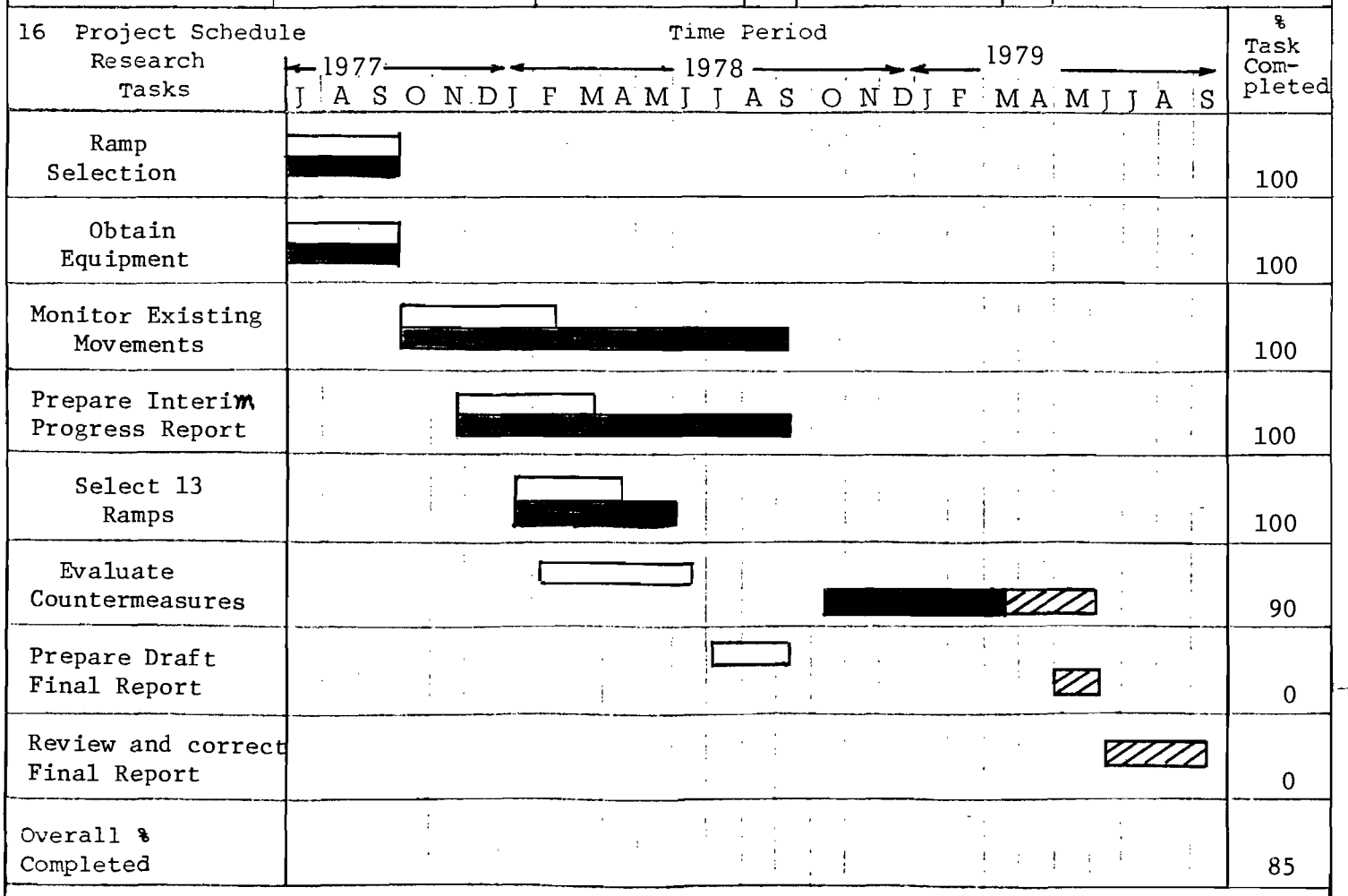
1 Project No. State/Agency	2 Project Title	3 Quarterly Report
7703. E 20-624	Wrong-Way Traffic Movements on Freeway Ramps	No. 7 From Jan. 1, 1979 To March 31, 1979

4 Research Agency	5 Project Director(s)
Georgia Institute of Technology	Dr. Peter S. Parsonson Associate Professor School of Civil Engineering

6 Starting Date	7 Completion Date	8 % Time Expended	9 Schedule Status	10 Sufficiency of Funds
Sept. 23, 1977	Sept.22, 1979	75	☐ Ahead ☐ Behind ☒ On	☒ Sufficient ☐ Insufficient

Funds Authorized		Funds Expended		
11 Total	12 Current Fiscal Year	13 Total to Date	14 Current Fiscal Year	15 Report Quarter
17,798 GDOT 6,349 GIT	17,798 GDOT 6,349 GIT	15,645 GDOT 6,349 GIT	6,660 GDOT 3,746 GIT	1,631 GDOT 395 GIT

16 Project Schedule



17 Progress This Quarter (By Task)

We continued to monitor at four locations, with the following results:

I-75/85 at Decatur St.: Data from 11/20/78 to 4/10/79 show 7 wrong-way movements in 90 days of recorder operation, or 2.3 per 30 days. This indicates that the countermeasures were successful, and monitoring can stop.

I285 at U.S. 19/41 (EB): Data from 11/3/78 to 3/27/79 show 5 wrong-way movements in 82 days of recorder operation, or 1.8 per 30 days. This is so low that we believe we should discontinue monitoring.

I-20 WB at Chapel Hill Rd (WB): Data from 11/15/78 to 3/14/79 show 10 wrong-way movements in 99 days, or 3.0 per 30 days. This is low enough to warrant discontinuing monitoring, we believe.

Ga. 400 at Haynes Bridge Road (SB): Data from 10/18/78 to 4/6/79 show 31 wrong-way movements in 78 days or 11.9 in 30 days. This is unacceptably high; we recommend the installation of the next phase of the countermeasures, which is the 24" stop bar (Ph.

I-75 at Hwy 54 (NB): Data from 2/8/79 to 4/6/79 show 3 wrong-way movements in 48 days, or 1.9 in 30 days. We recommend discontinuing monitoring.

18 Work Planned for Next Quarter

We plan to complete the monitoring of countermeasures and to write the final report.

19 Significant Technical Information, Recommendations, Implementation

A copy of a student report by Michael Melder is enclosed. It details the data taken from October, 1978, to date and includes an anotated bibliography. In addition, we have become aware of NCHRP Synthesis of Highway Practice 35, Design and Control of Freeway Off-Ramp Terminals.

20 Problems

As expected, work during January and February was hampered by wet weather, during which it is very difficult to keep the road tubes in place.

21 Report Prepared by

Signature

Peter S. Parsonson
Name

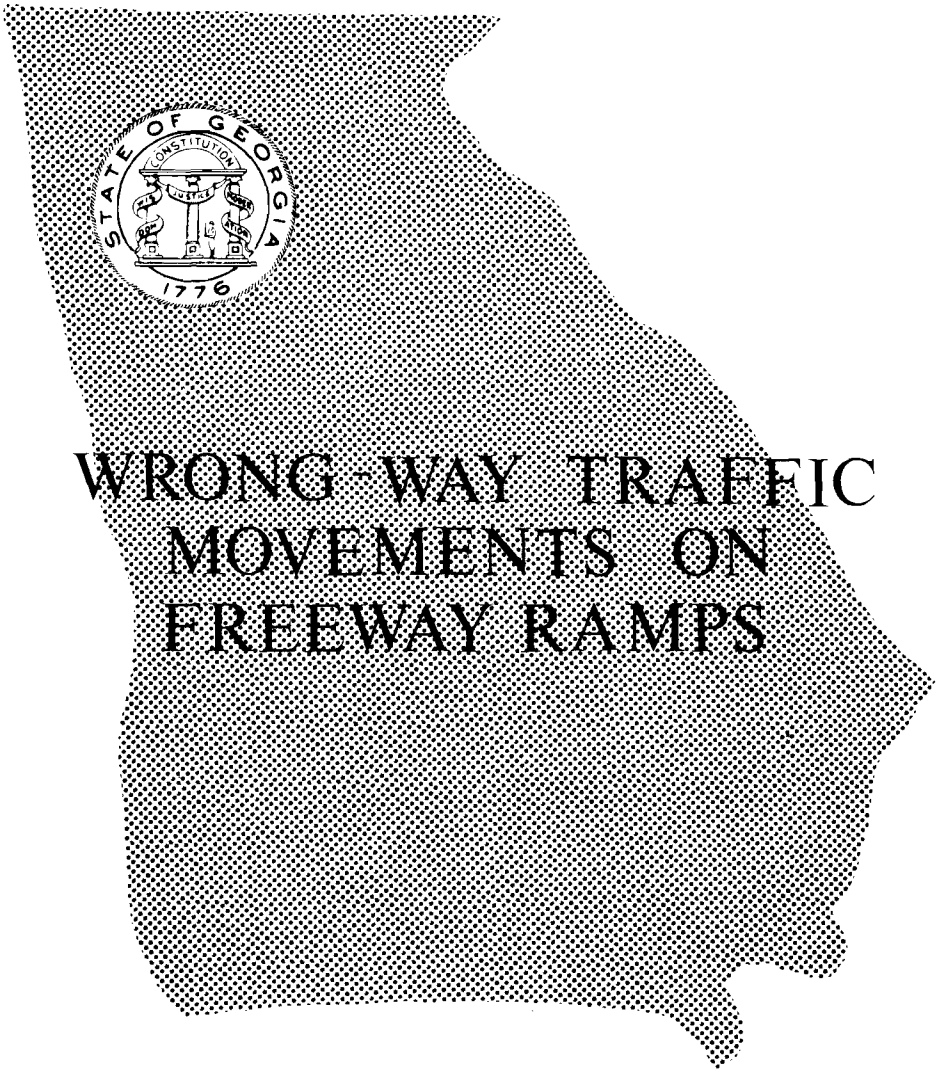
Associate Professor
Title

E-20-C24

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

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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.

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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,

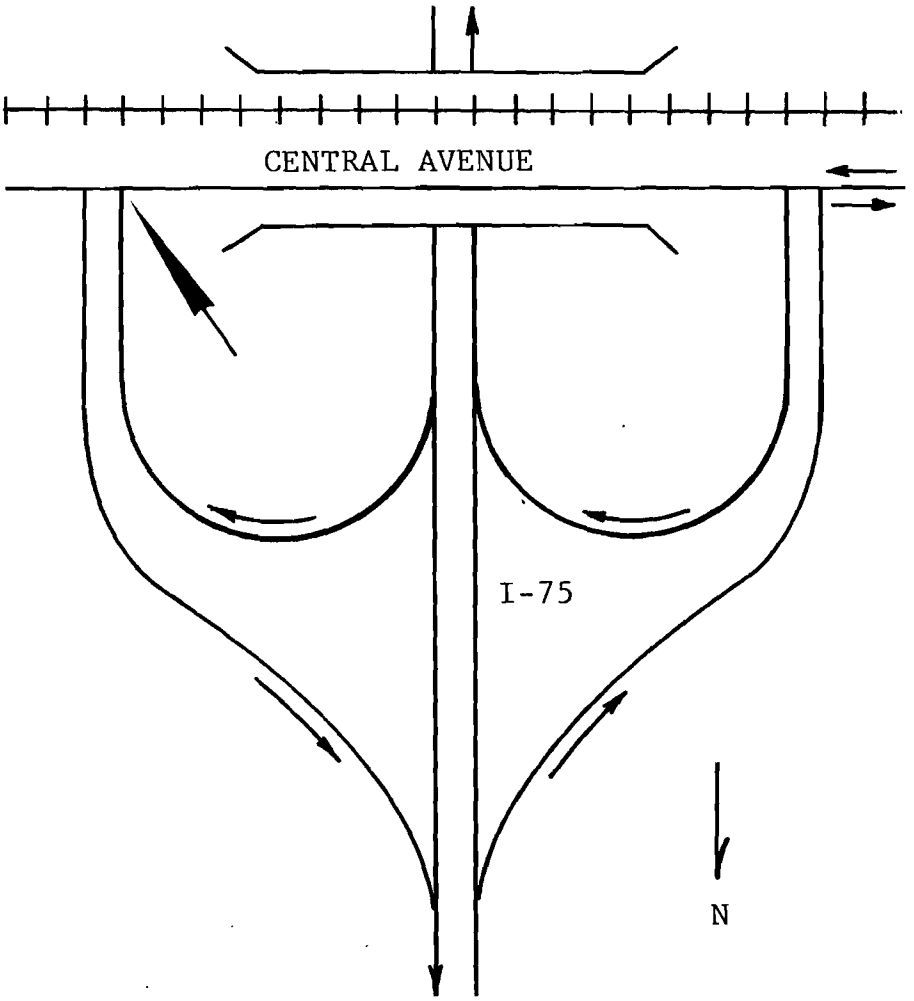


Figure 1. Type AB partial cloverleaf selected for pilot study

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

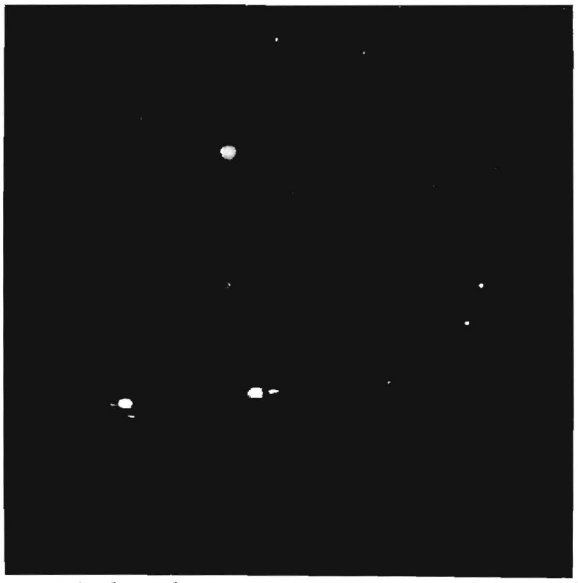


Figure 5. Nighttime wrong-way movement. Note rectangular headlights, easily distinguished from taillights.

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	COUNTY					
	Fulton	DeKalb	Cobb	Douglas	Clayton	Rockdale
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.

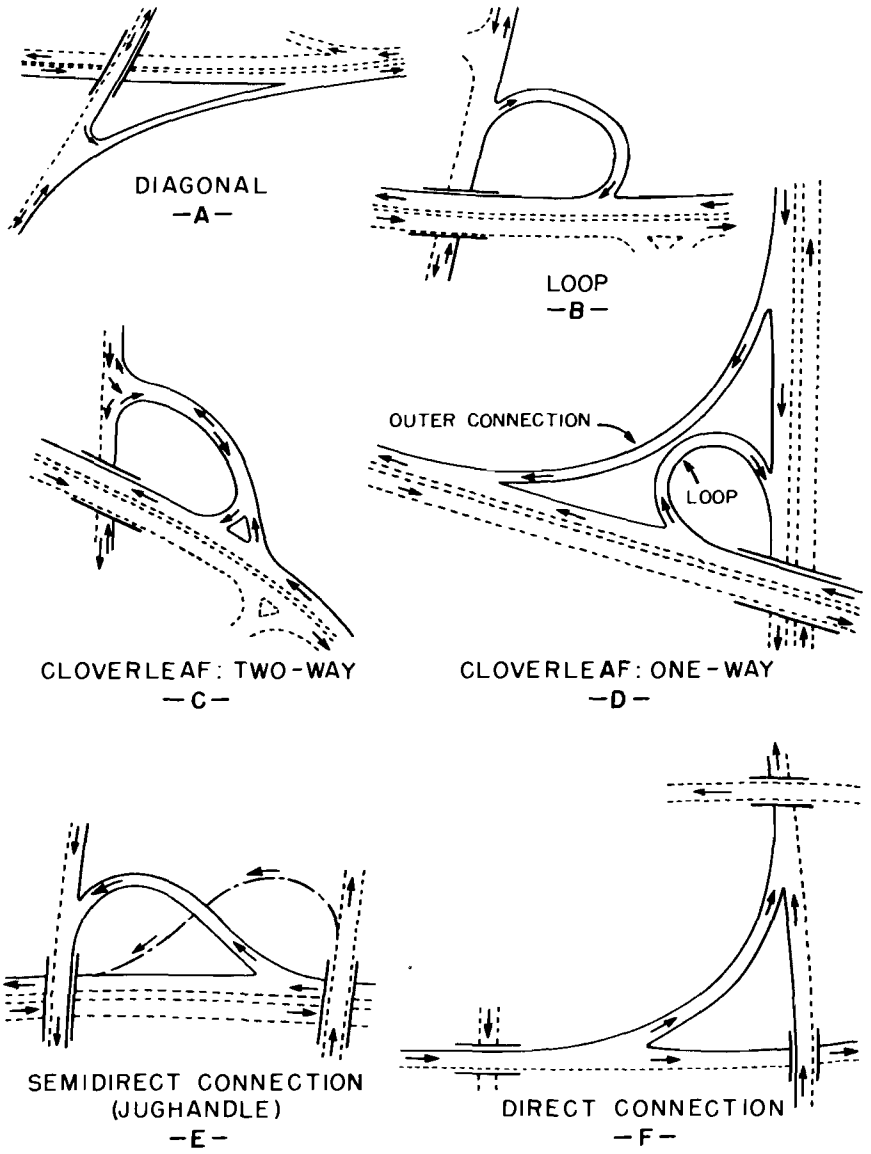


Figure 8. AASHO Classification of Ramps (from Reference 11)

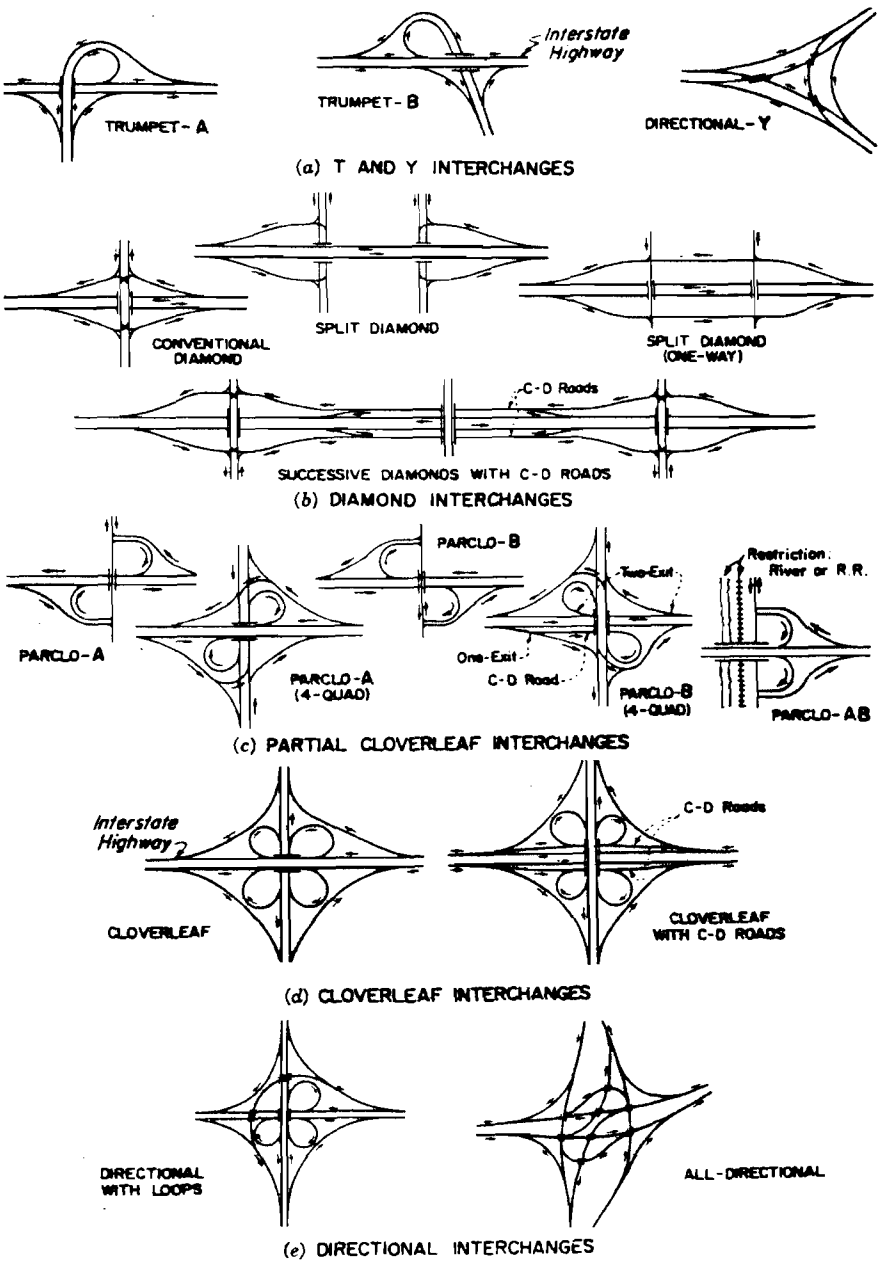


Figure 9. Leisch Classification of Interchanges (from Reference 12)

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

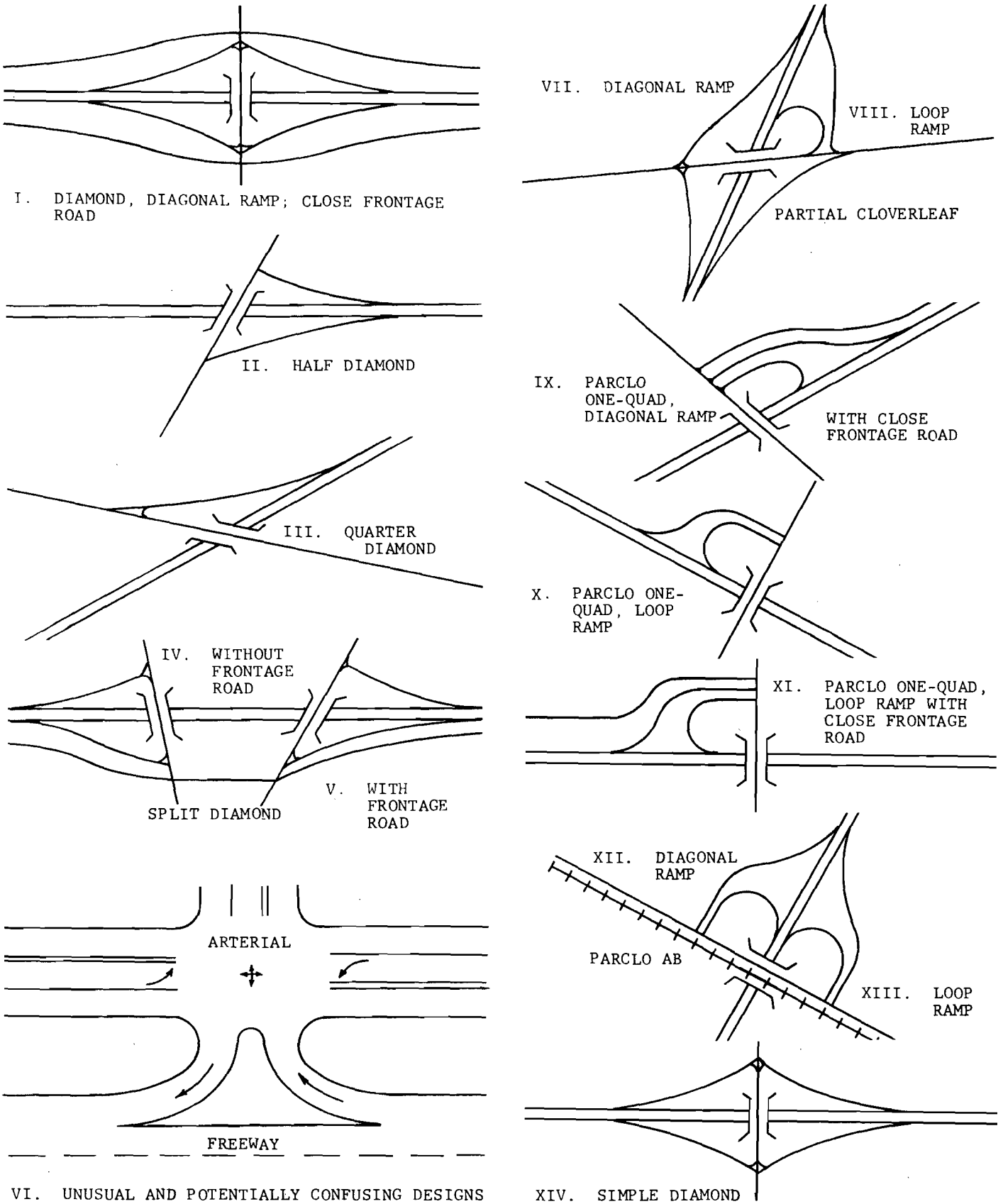


Figure 10. Ramp types studied in Greater Atlanta

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.

Central Avenue/I-75 Results

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

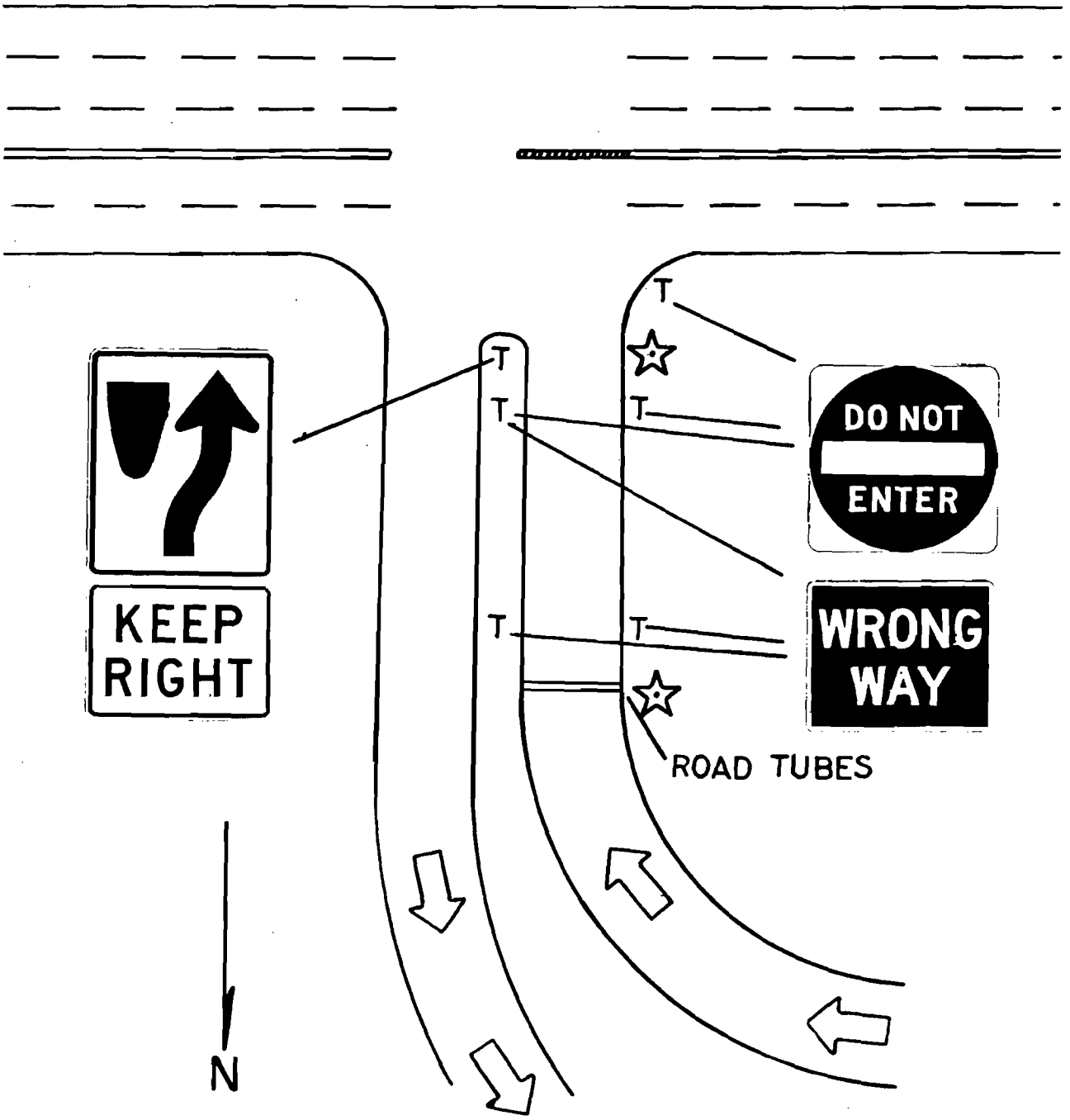


Figure 11. Initial signing plan at Central Avenue/I-75

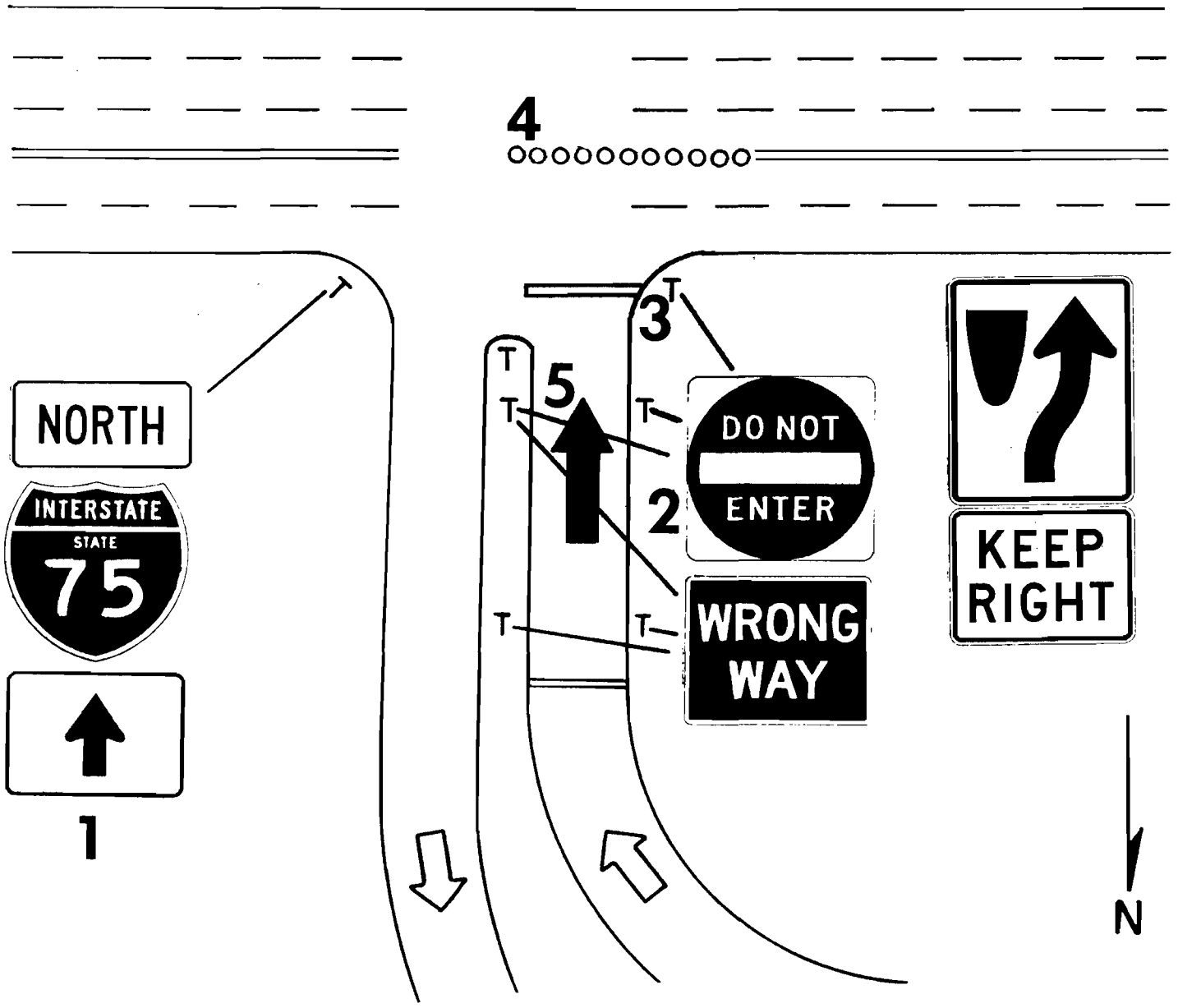


Figure 12. Phased improvements at Central Avenue/I-75

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:

o It is not unusual for the digital counter to record a value greatly in excess of the number of photograph-confirmed wrong-way movements.

o 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.

o The counter was designed to use an unusual, 7.5-volt battery that must be special-ordered. It is not a rechargeable type.

o 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:

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

- 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 Depart-

ment, 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 cross-road 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 counter-measures such as the use of a concrete median on the cross-road, better signs, and the avoidance of confusing lay-outs. 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

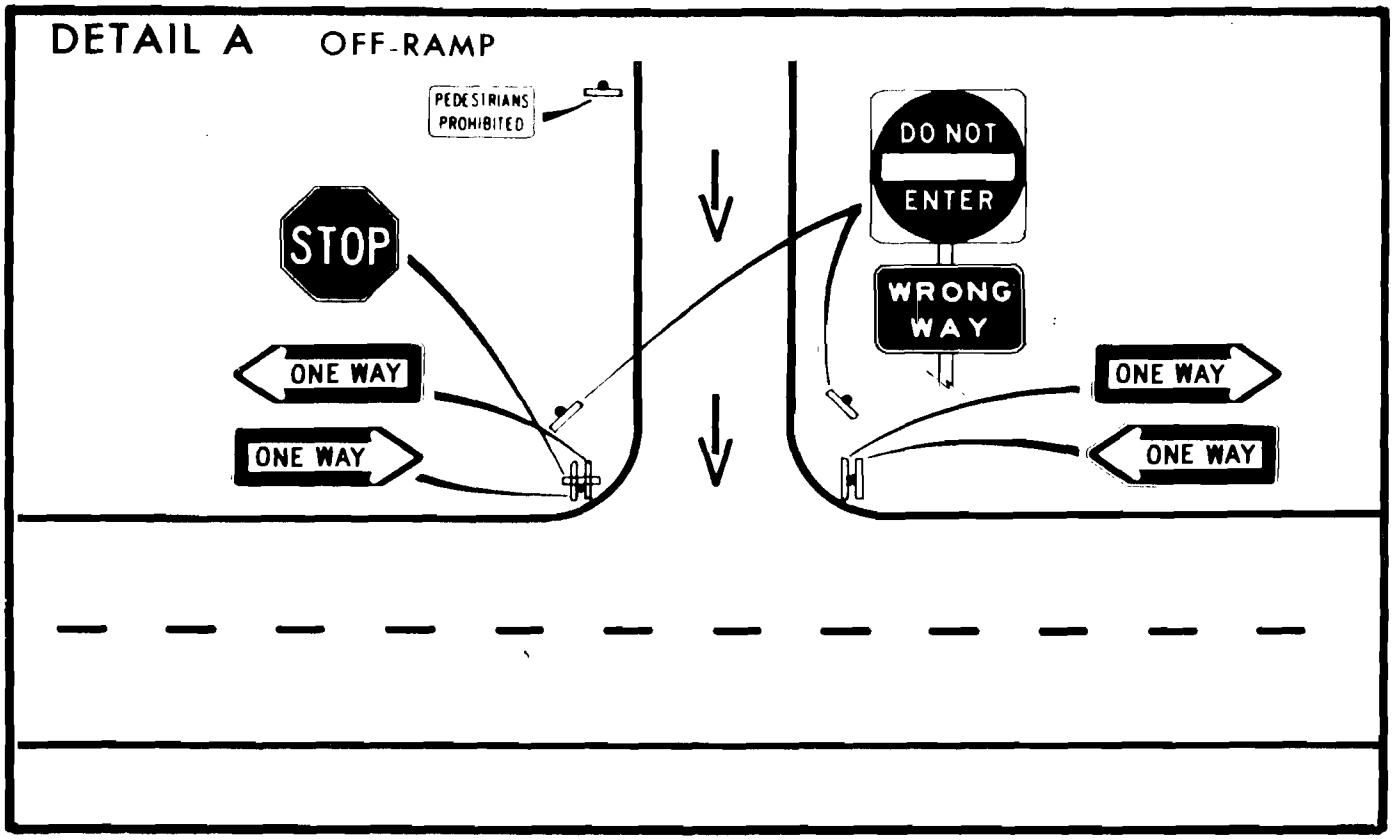
At least one DO NOT ENTER package should be placed to fall within the area covered by a car's headlights and visible to the driver from the decision point on each likely approach.

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".

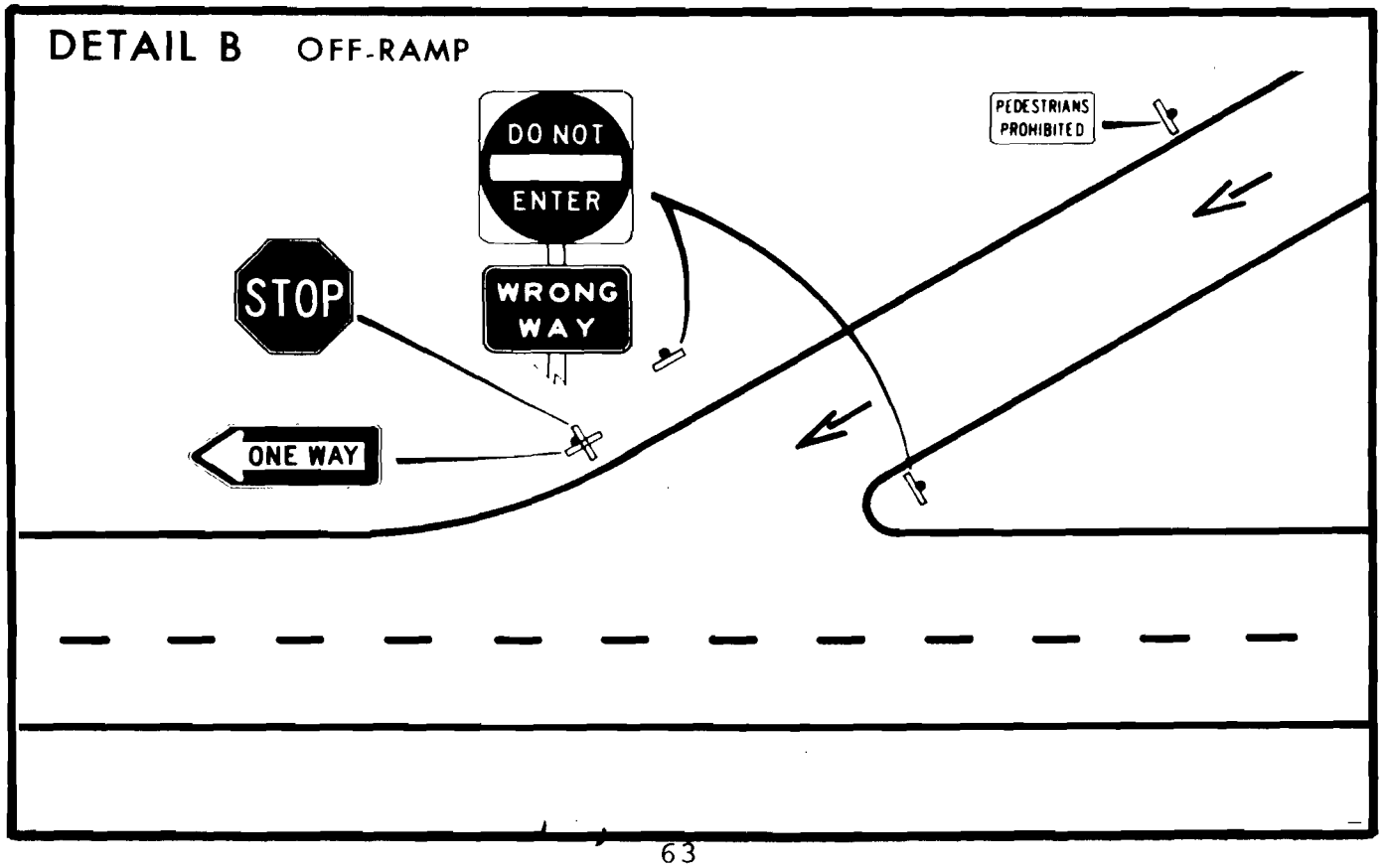
ONE-WAY arrows (R10) should be placed as close to the crossing street as possible. If there are sidewalks immediately adjacent to the cross street, these signs should be located behind the sidewalk to avoid conflicting with pedestrians. A less desirable alternate is relocating the signs above the pedestrian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

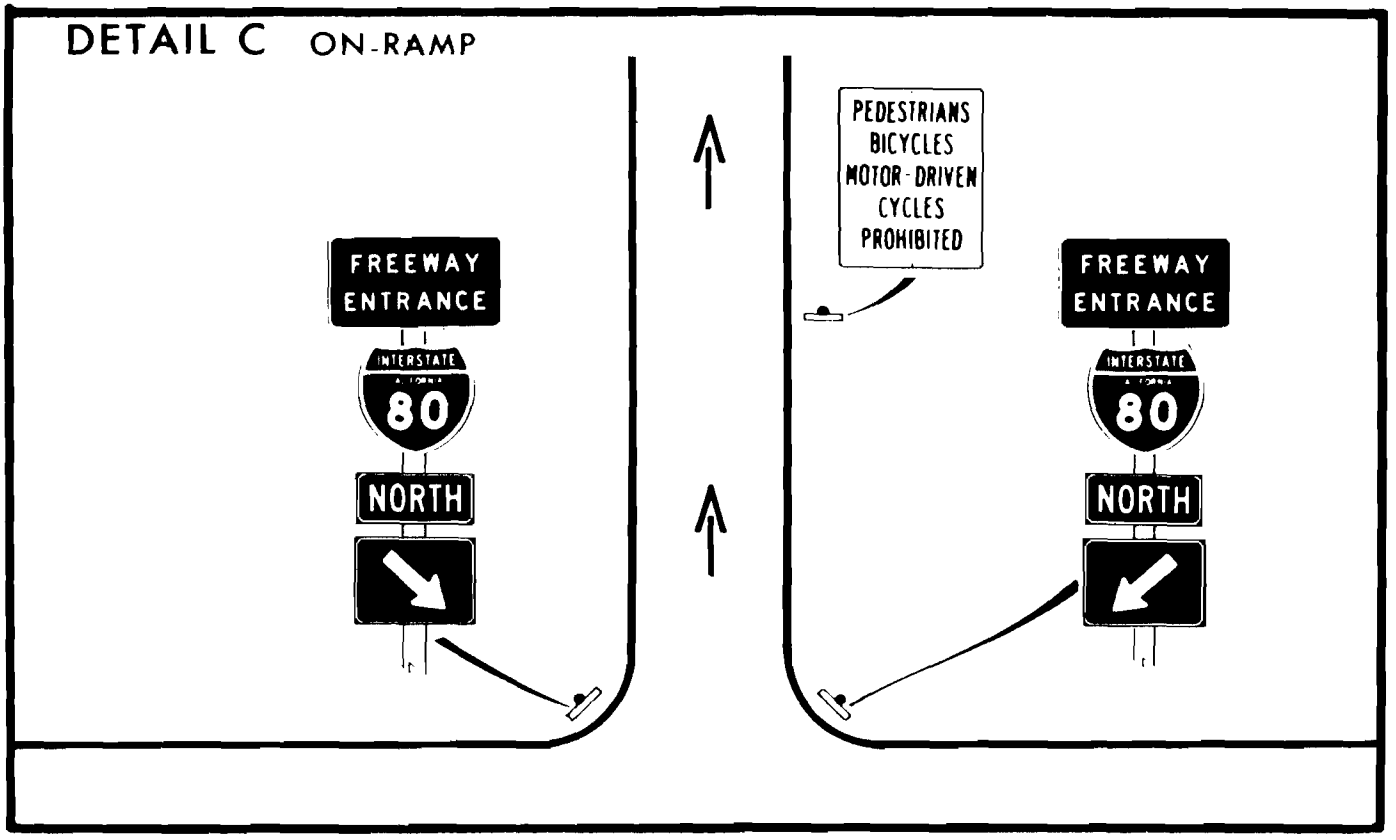
At skewed ramp intersections, where the angle approaches 90°, a second ONE-WAY arrow should be added on the obtuse side when it would be visible to approaching traffic. Refer to detail "B".

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.

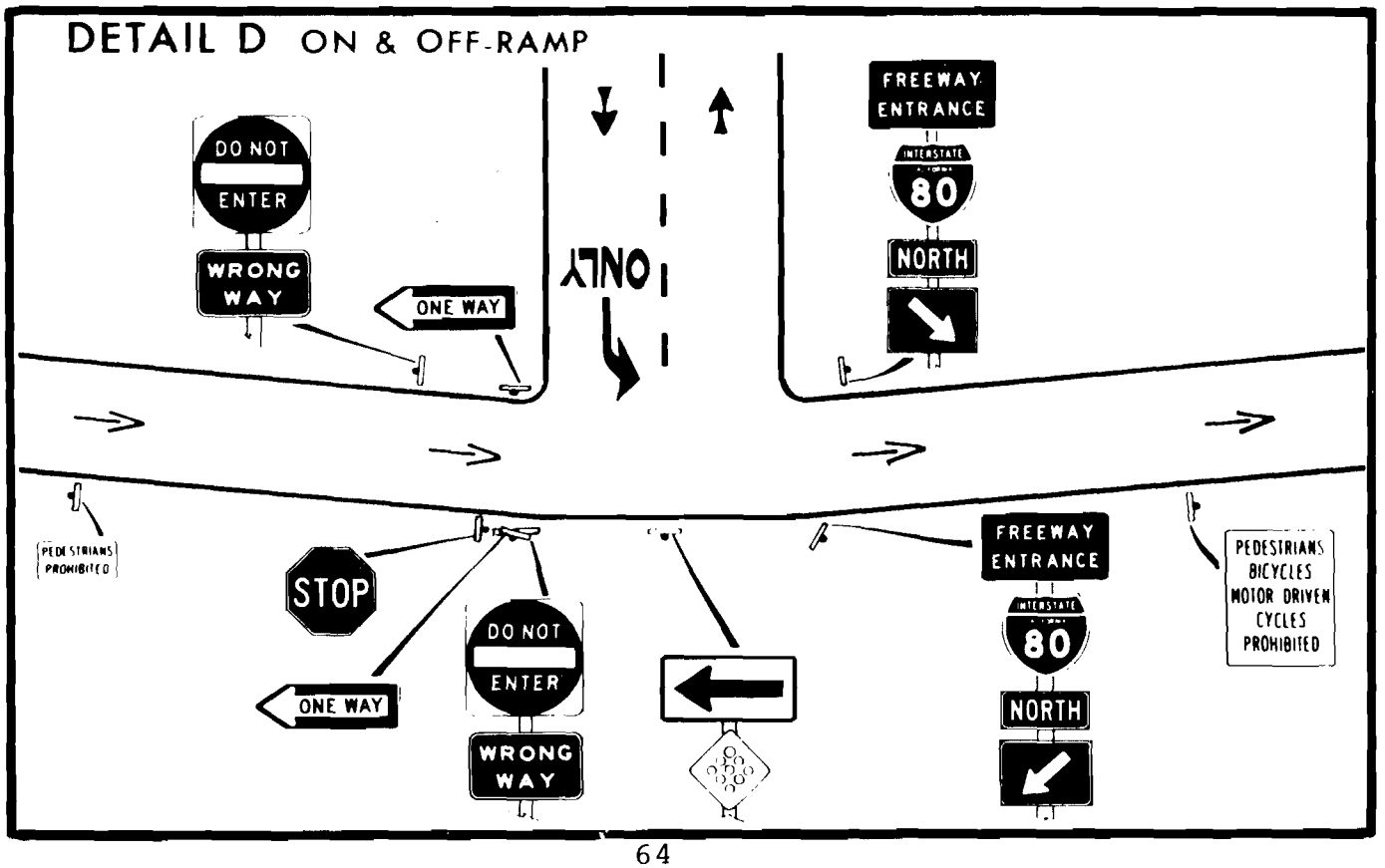

DETAIL A OFF-RAMP
PEDESTRIANS PROHIBITED
STOP
ONE WAY
ONE WAY
DO NOT
ENTER
WRONG WAY
ONE WAY
ONE WAY

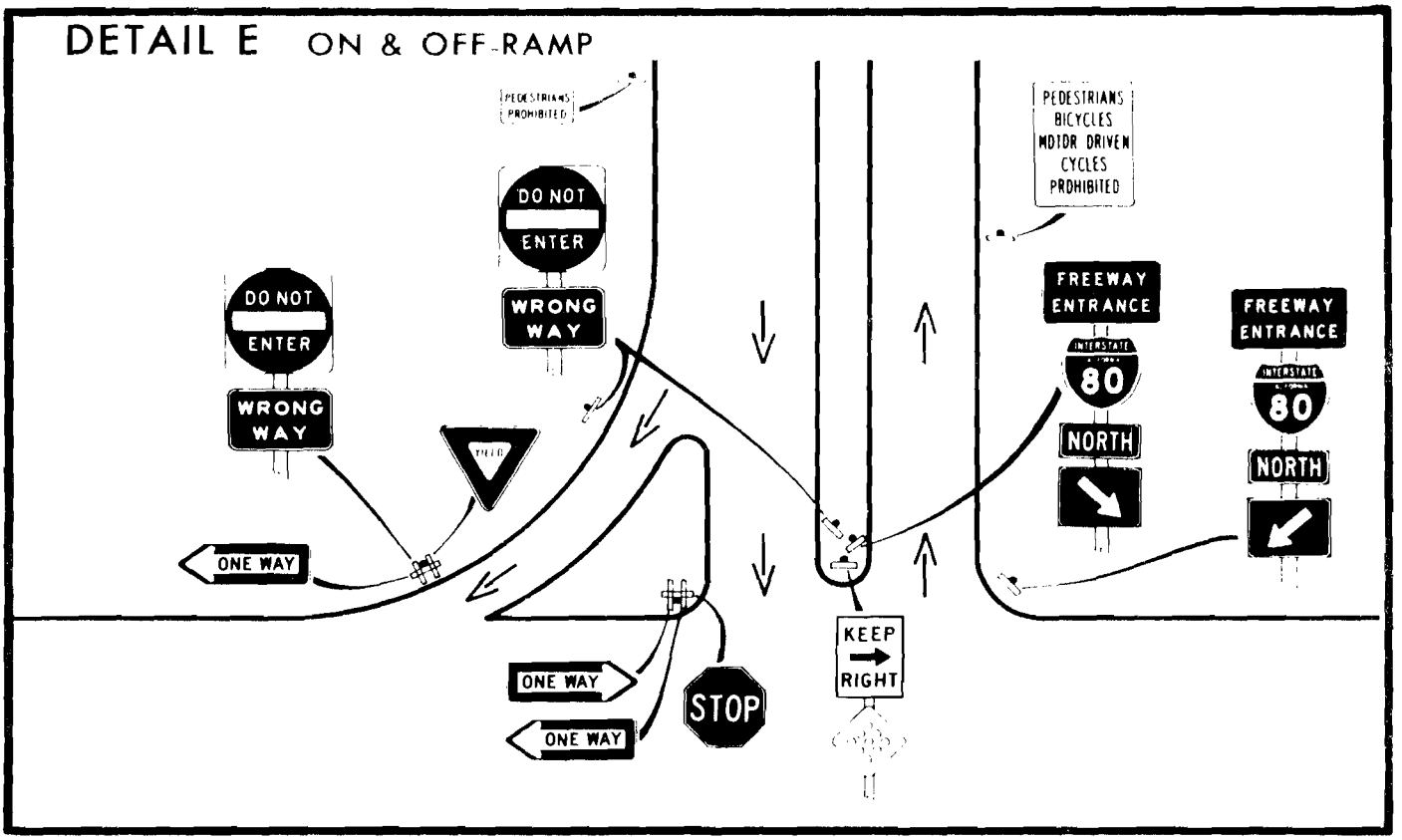
No Scale


DETAIL B OFF-RAMP
DO NOT
ENTER
WRONG WAY
PEDESTRIANS PROHIBITED
STOP
ONE WAY

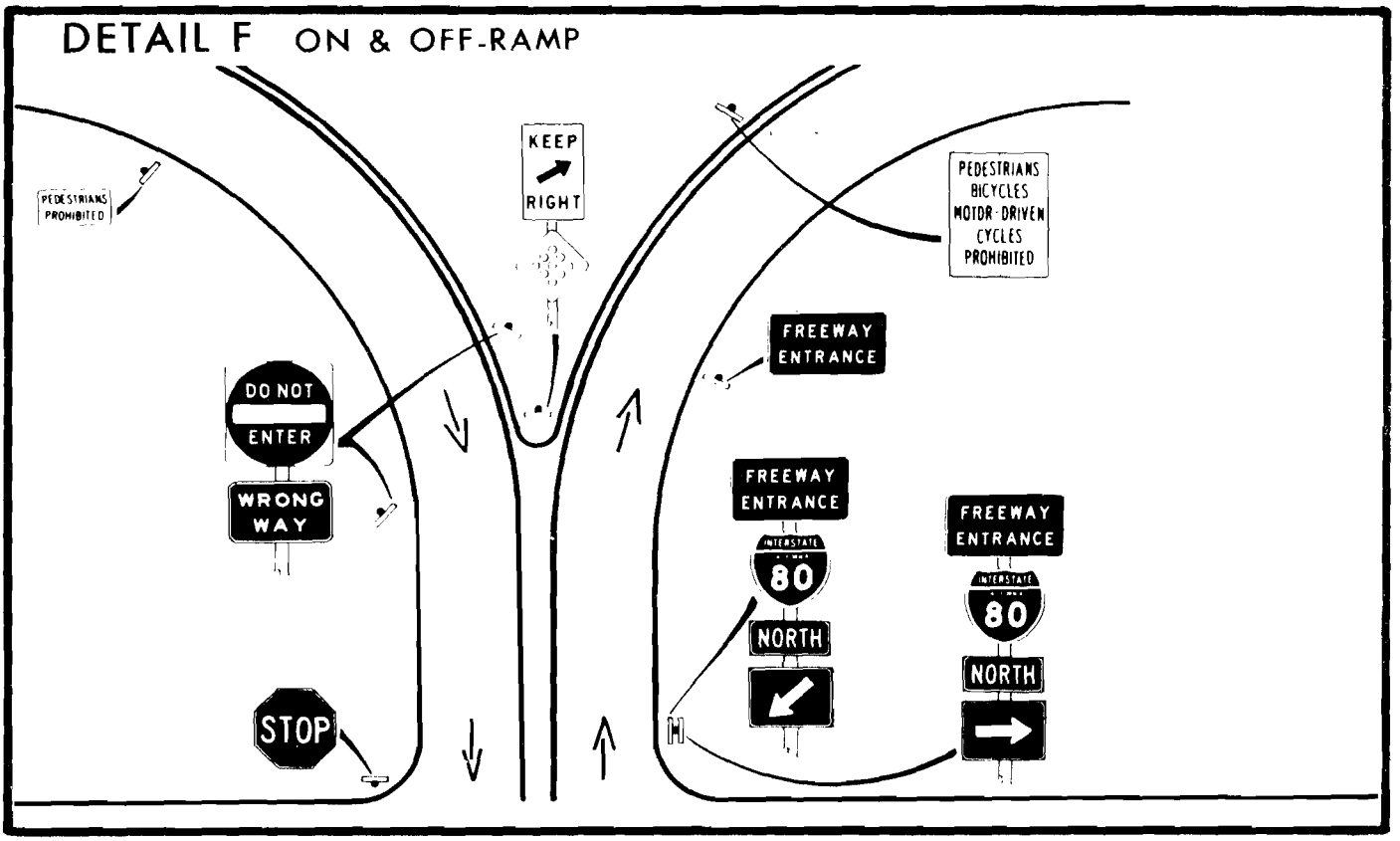

DETAIL C ON-RAMP
FREEWAY ENTRANCE
INTERSTATE
80
NORTH
PEDESTRIANS
BICYCLES
MOTOR-DRIVEN
CYCLES
PROHIBITED
FREEWAY ENTRANCE
INTERSTATE
80
NORTH

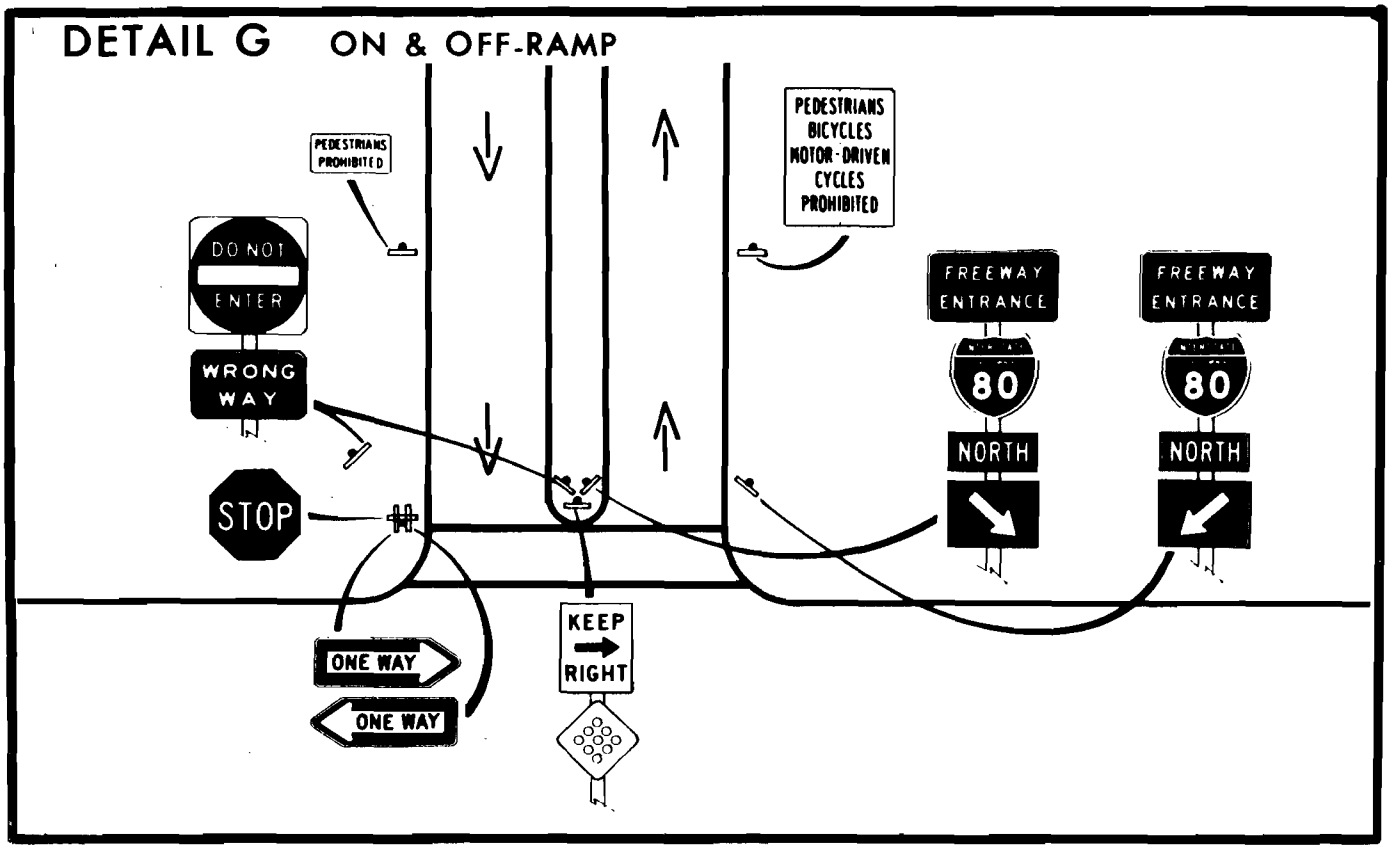
No Scale


DETAIL D ON & OFF-RAMP
DO NOT
ENTER
WRONG
WAY
ONE WAY
ONLY
FREEWAY ENTRANCE
INTERSTATE
80
NORTH
PEDESTRIANS PROHIBITED
STOP
ONE WAY
DO NOT
ENTER
WRONG
WAY
FREEWAY ENTRANCE
INTERSTATE
80
NORTH
PEDESTRIANS
BICYCLES
MOTOR DRIVEN
CYCLES
PROHIBITED

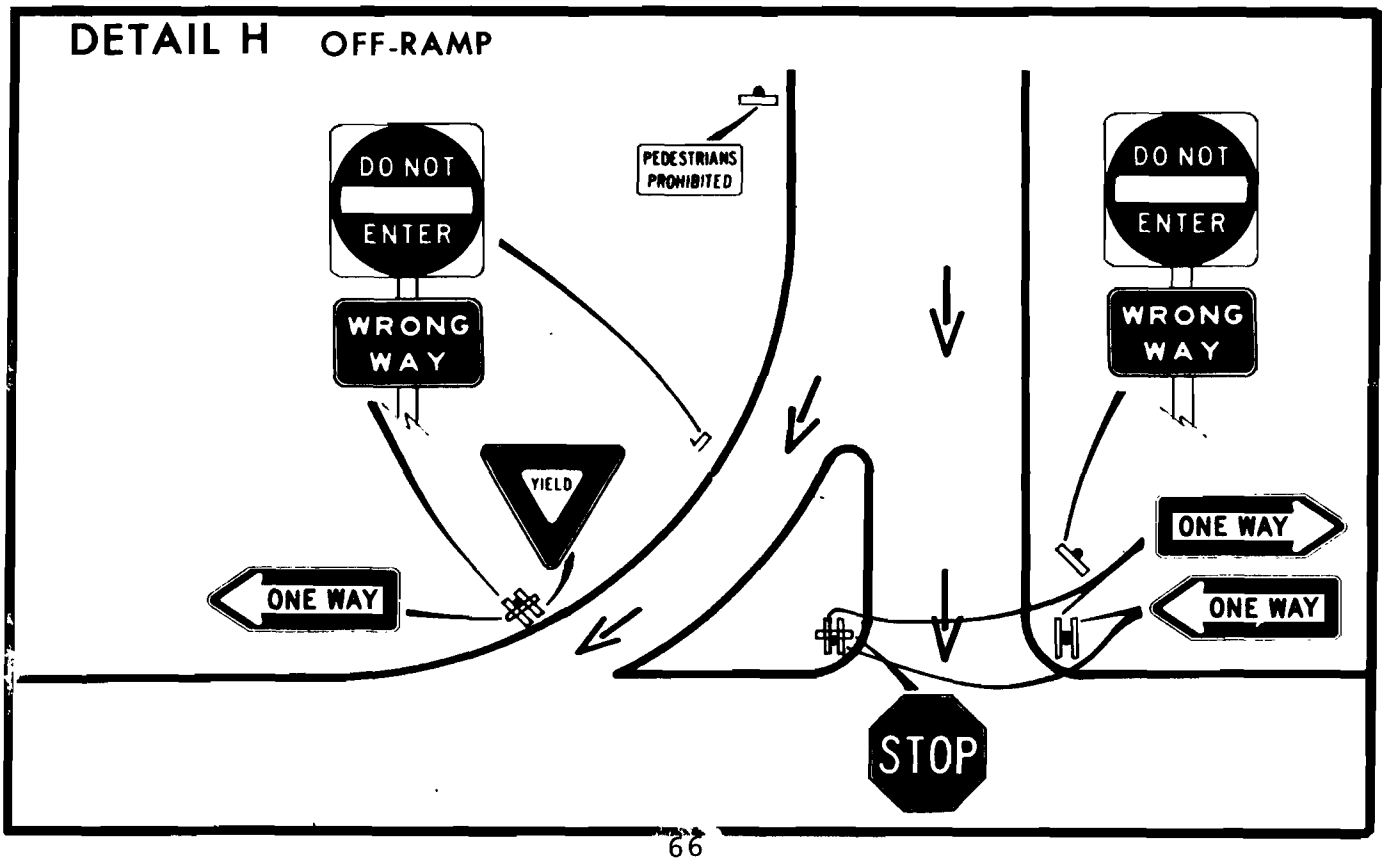

DETAIL E ON & OFF-RAMP
PEDESTRIANS PROHIBITED
DO NOT ENTER
WRONG WAY
DO NOT ENTER
WRONG WAY
YIELD
ONE WAY
ONE WAY
ONE WAY
STOP
KEEP RIGHT
PEDESTRIANS BICYCLES MOTOR DRIVEN CYCLES PROHIBITED
FREEWAY ENTRANCE
INTERSTATE 80
NORTH
FREEWAY ENTRANCE
INTERSTATE 80
NORTH

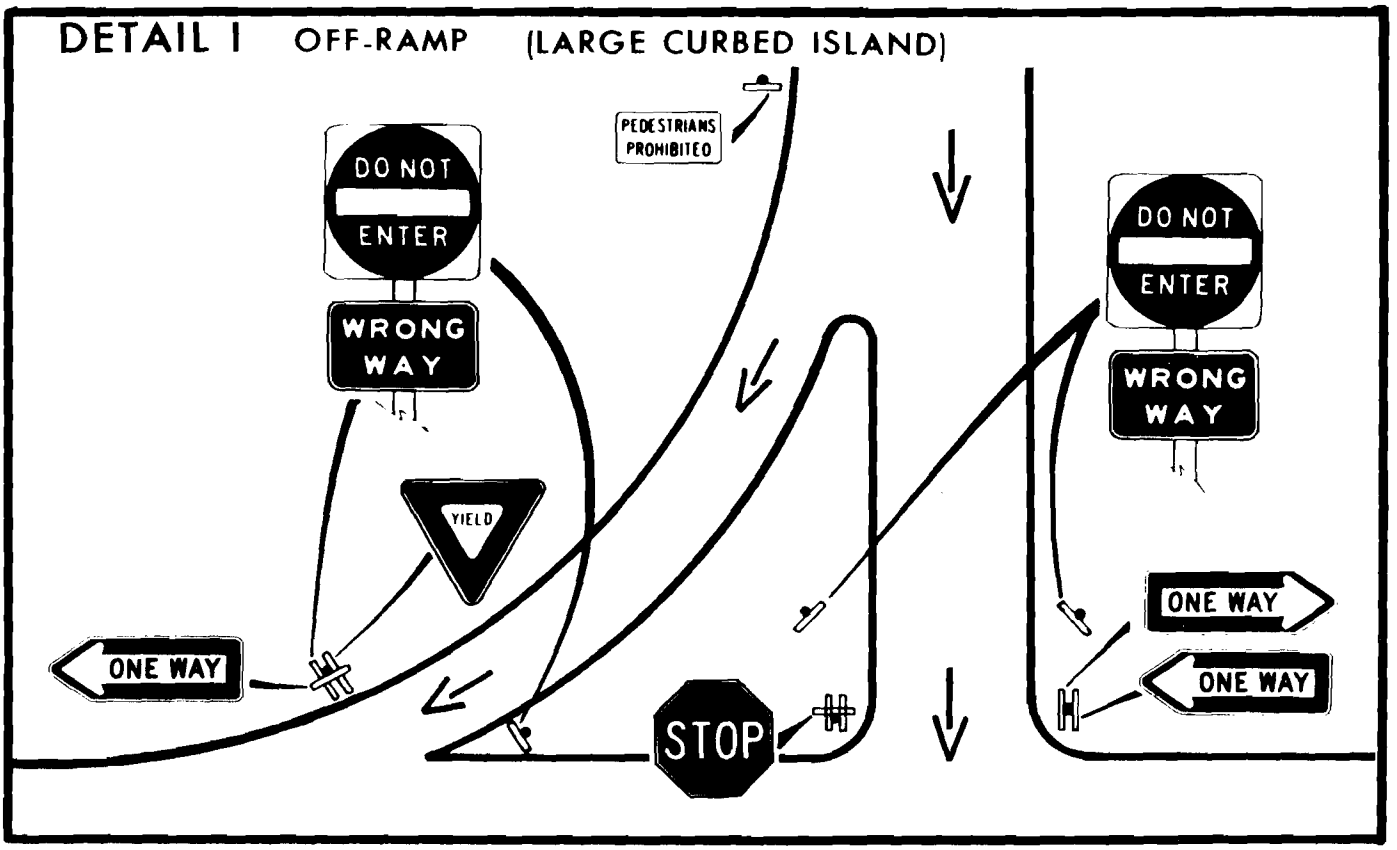
No Scale


DETAIL F ON & OFF-RAMP
PEDESTRIANS PROHIBITED
KEEP RIGHT
PEDESTRIANS BICYCLES MOTOR-DRIVEN CYCLES PROHIBITED
FREEWAY ENTRANCE
DO NOT ENTER
WRONG WAY
FREEWAY ENTRANCE
INTERSTATE 80
NORTH
FREEWAY ENTRANCE
INTERSTATE 80
NORTH
STOP

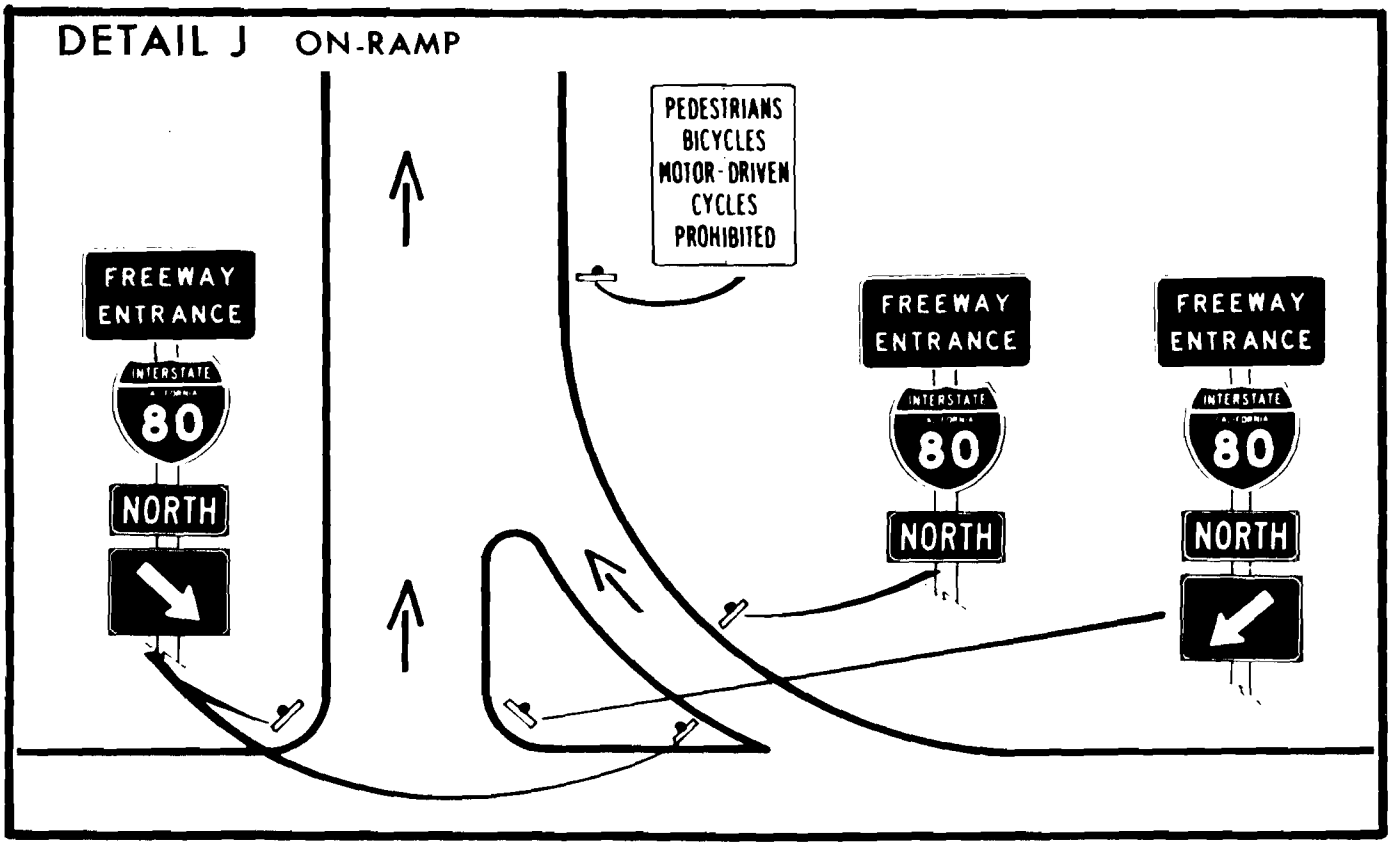

DETAIL G ON & OFF-RAMP
PEDESTRIANS PROHIBITED
PEDESTRIANS BICYCLES MOTOR-DRIVEN CYCLES PROHIBITED
DO NOT ENTER
WRONG WAY
STOP
FREEWAY ENTRANCE
80
NORTH
FREEWAY ENTRANCE
80
NORTH
ONE WAY
ONE WAY
KEEP RIGHT

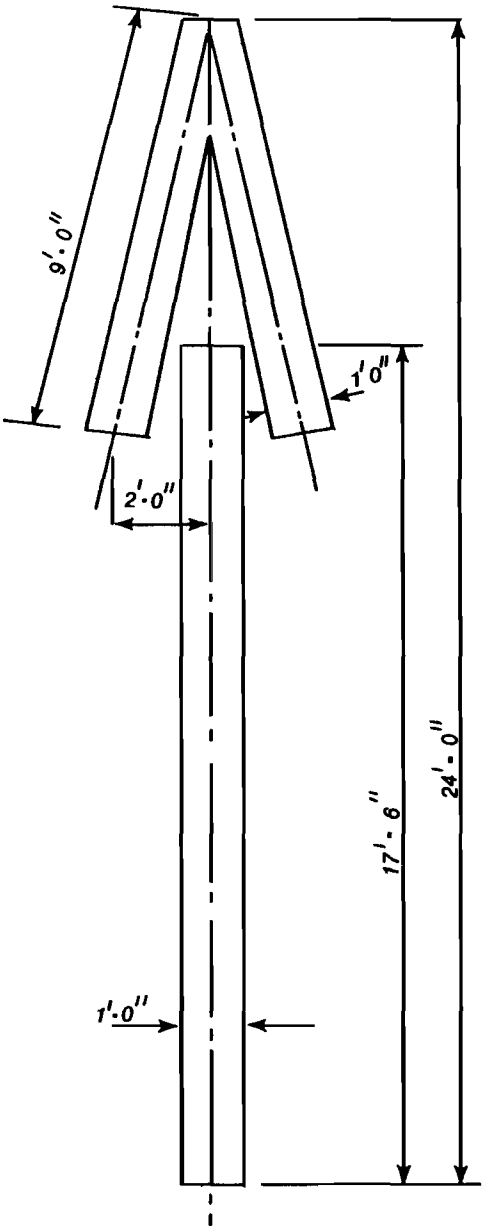
No Scale


DETAIL H OFF-RAMP
DO NOT ENTER
WRONG WAY
PEDESTRIANS PROHIBITED
YIELD
ONE WAY
DO NOT ENTER
WRONG WAY
ONE WAY
ONE WAY
STOP


DETAIL I OFF-RAMP (LARGE CURBED ISLAND)
PEDESTRIANS PROHIBITED
DO NOT ENTER
WRONG WAY
YIELD
ONE WAY
STOP
DO NOT ENTER
WRONG WAY
ONE WAY
ONE WAY

No Scale


DETAIL J ON-RAMP
PEDESTRIANS BICYCLES MOTOR-DRIVEN CYCLES PROHIBITED
FREEWAY ENTRANCE
INTERSTATE
80
NORTH
FREEWAY ENTRANCE
INTERSTATE
80
NORTH
FREEWAY ENTRANCE
INTERSTATE
80
NORTH



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			WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
		Day	Night	of (number shot)			
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			WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
		Day	Night	of (number shot)			
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			WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
		Day	Night	of (number shot)			
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.

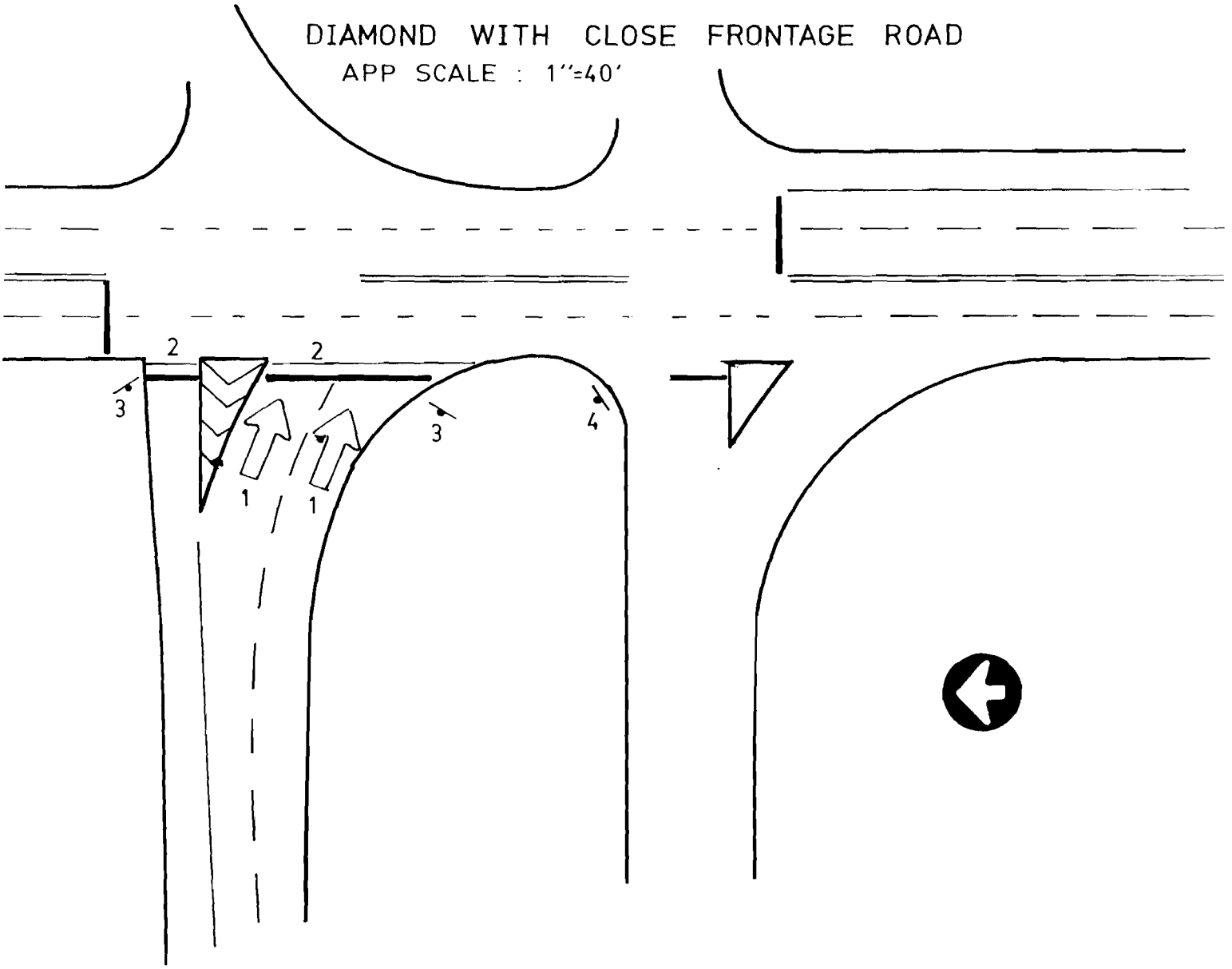
Appendix E

Countermeasures Evaluated in Greater Atlanta Study

I - 285 & RIVERDALE RD

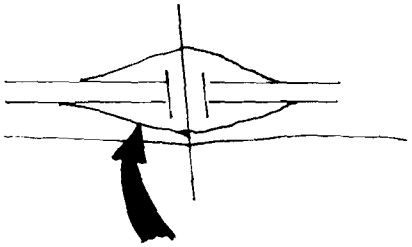
DIAMOND WITH CLOSE FRONTAGE ROAD

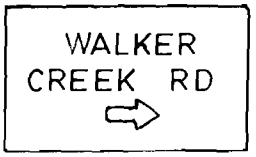
APP SCALE : 1"=40'



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

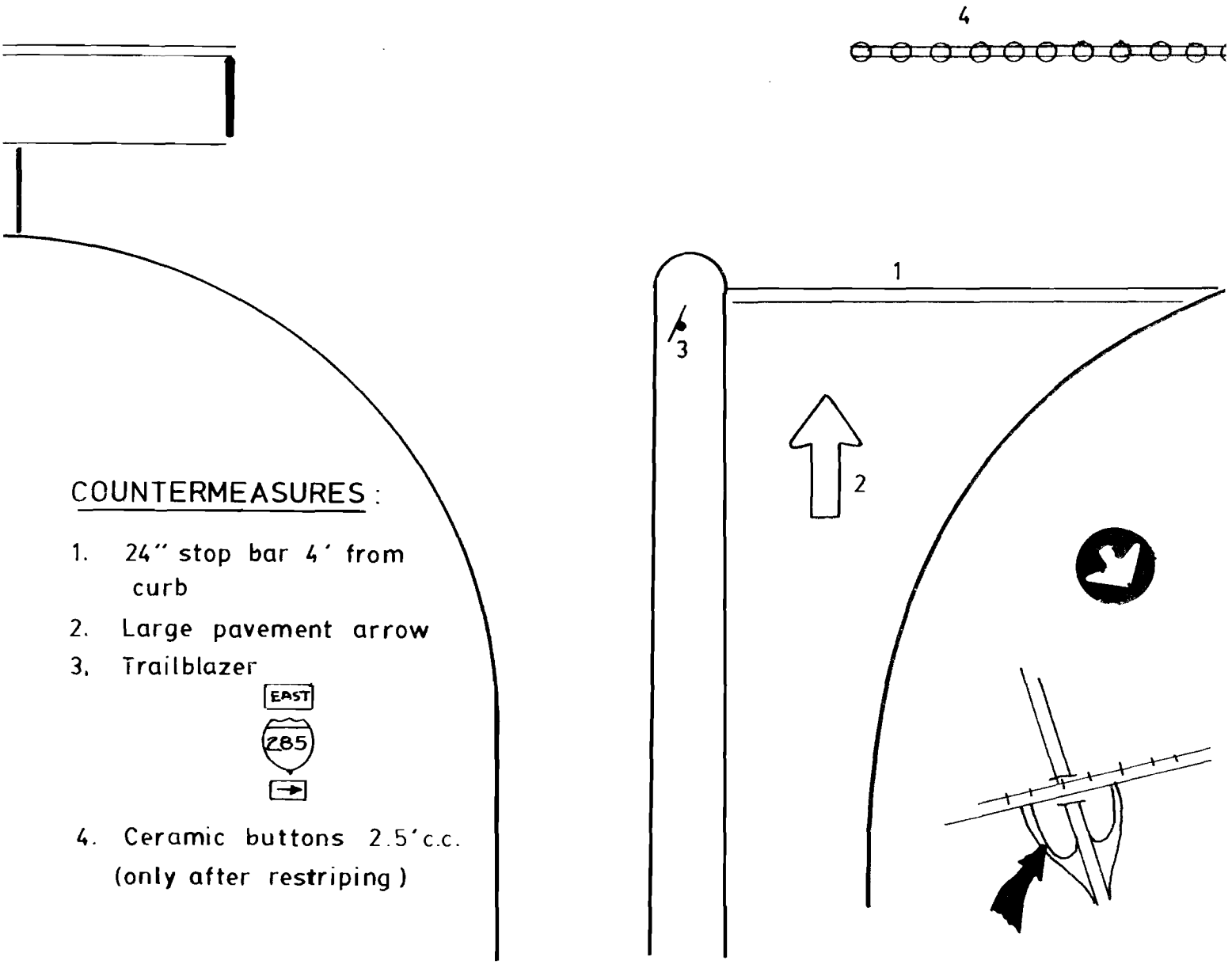




I-285 & US 19/41

PARCLO AB LOOP RAMP

APP SCALE : 1"=20'



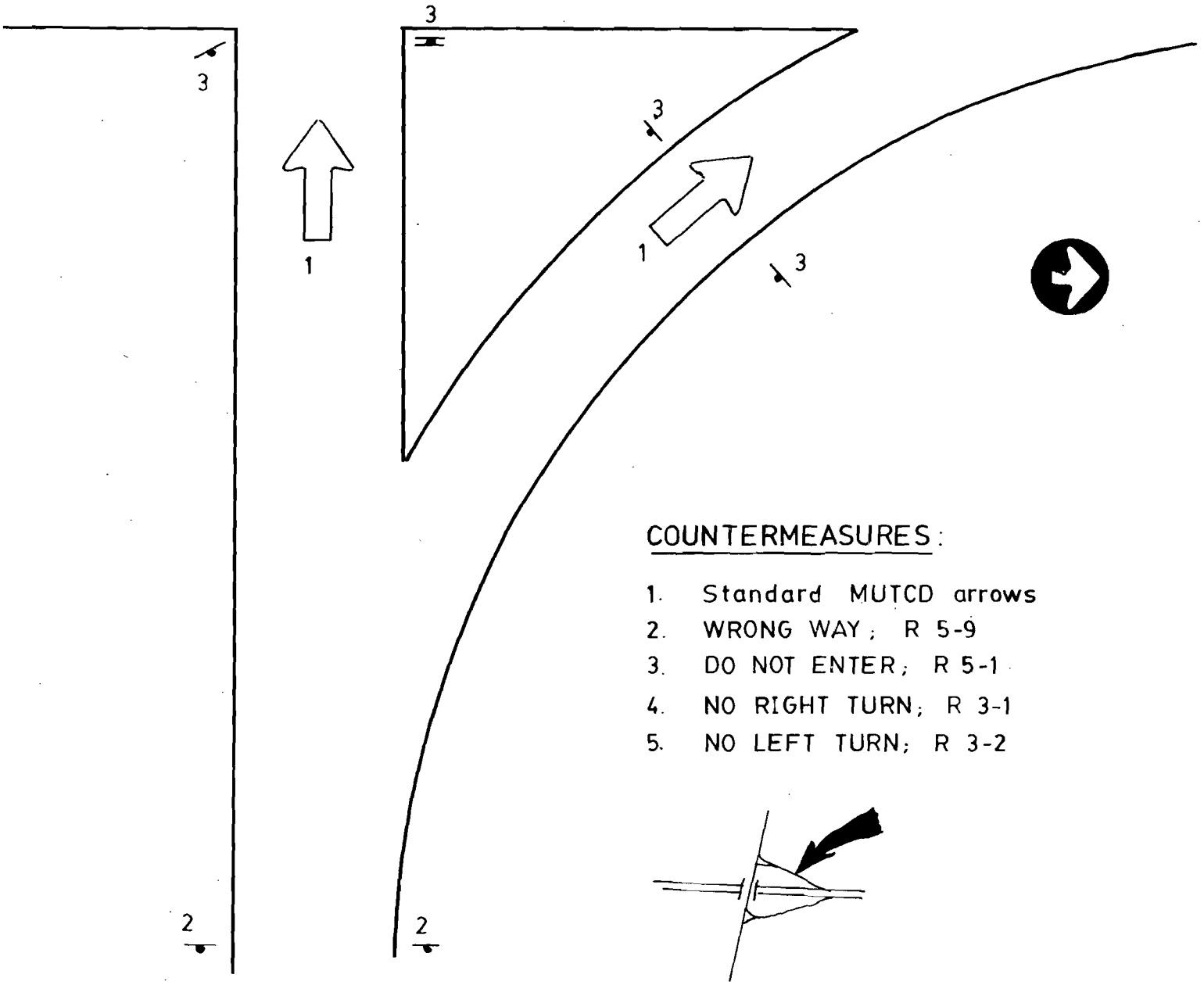
COUNTERMEASURES :

1. 24" stop bar 4' from curb
2. Large pavement arrow
3. Trailblazer
4. Ceramic buttons 2.5'c.c. (only after restriping)

I-20 & CHAPEL HILL RD

HALF DIAMOND

APP. SCALE : 1" = 20'



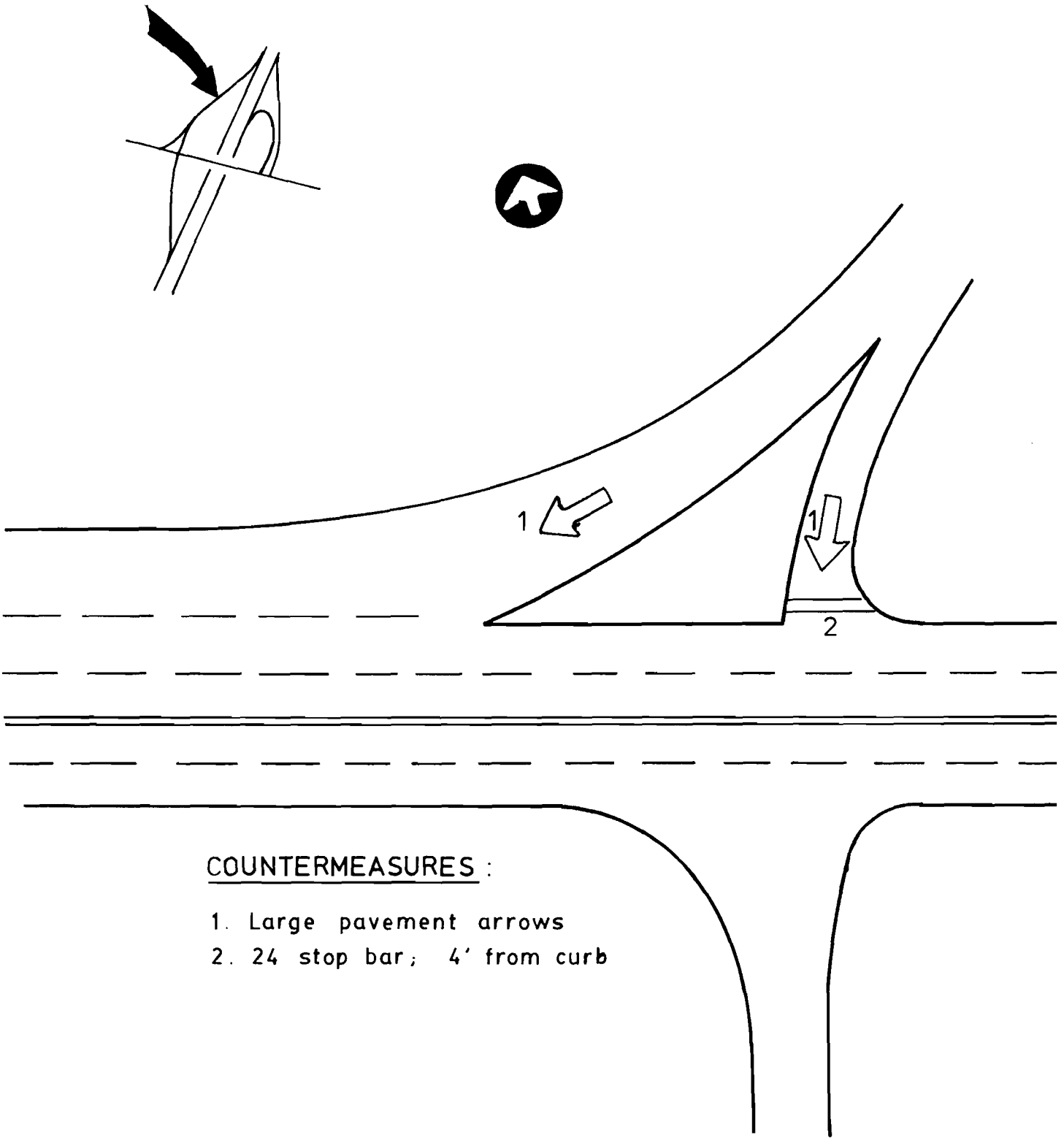
COUNTERMEASURES:

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'



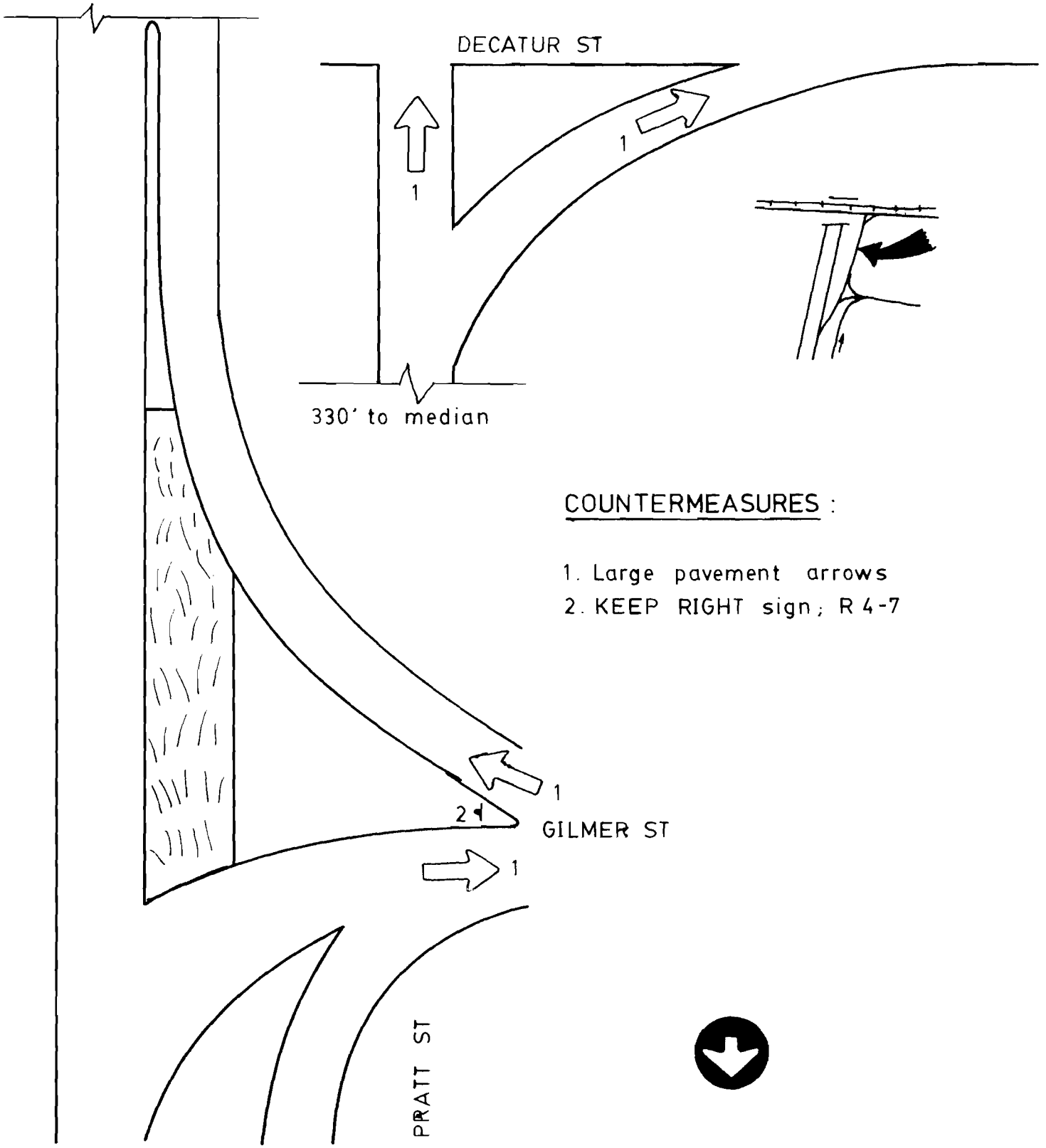
COUNTERMEASURES :

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

I-75/85 & DECATUR ST

QUARTER DIAMOND

APP SCALE : 1"=40'



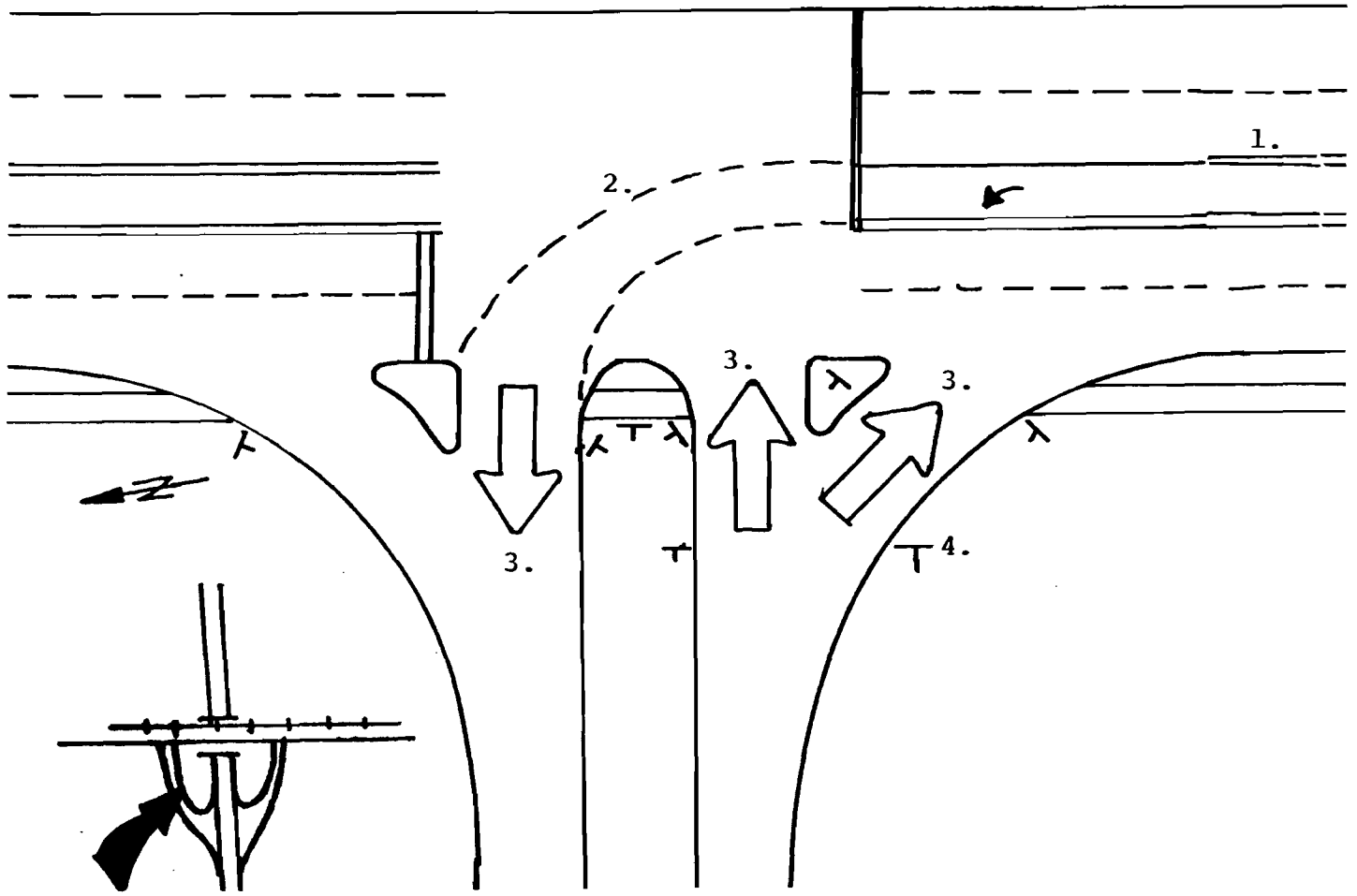
COUNTERMEASURES :

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

I-75 & JONESBORO RD

PARCLO AB LOOP RAMP

APP. SCALE: 1" = 20'



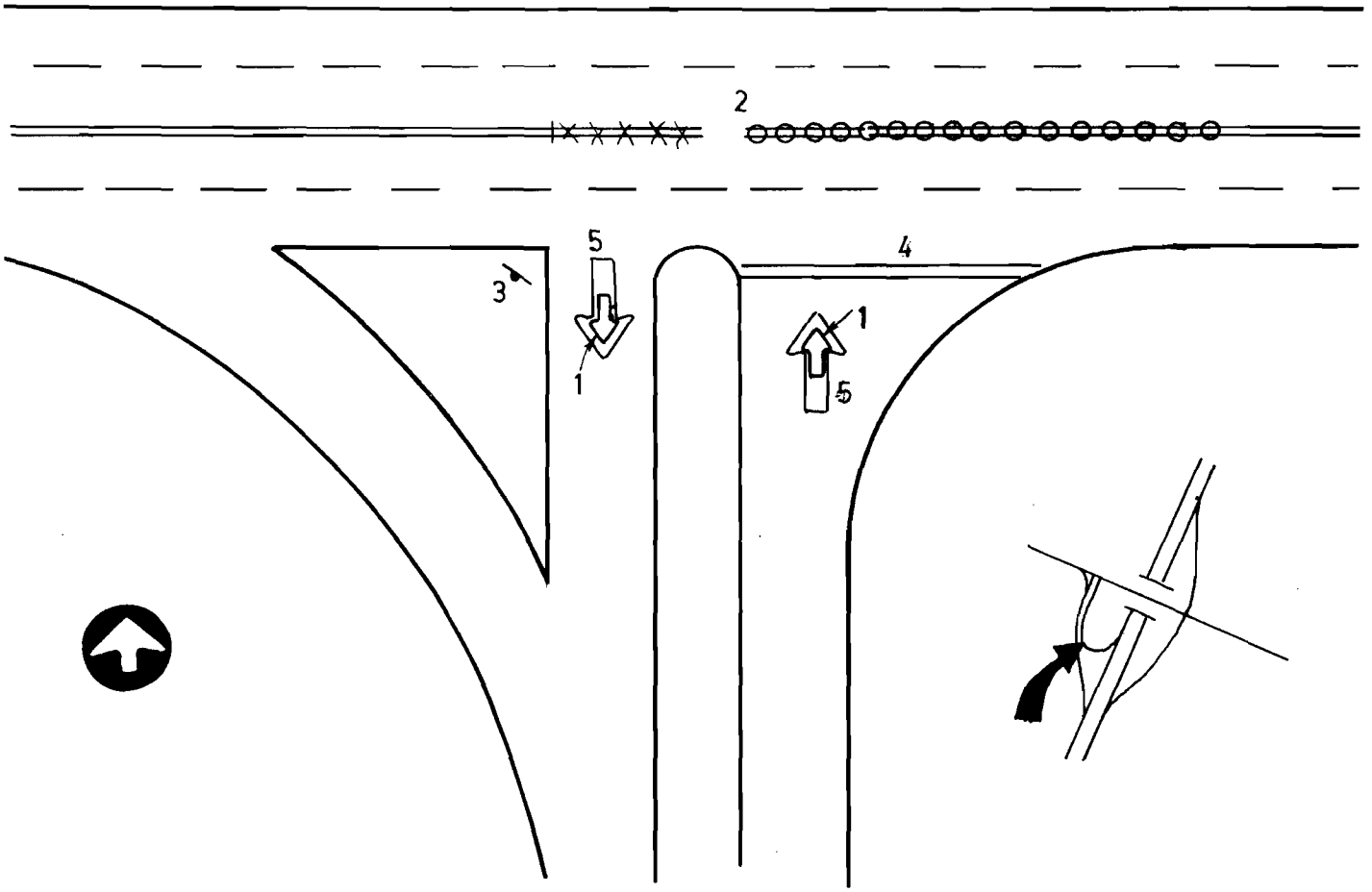
COUNTERMEASURES:

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.

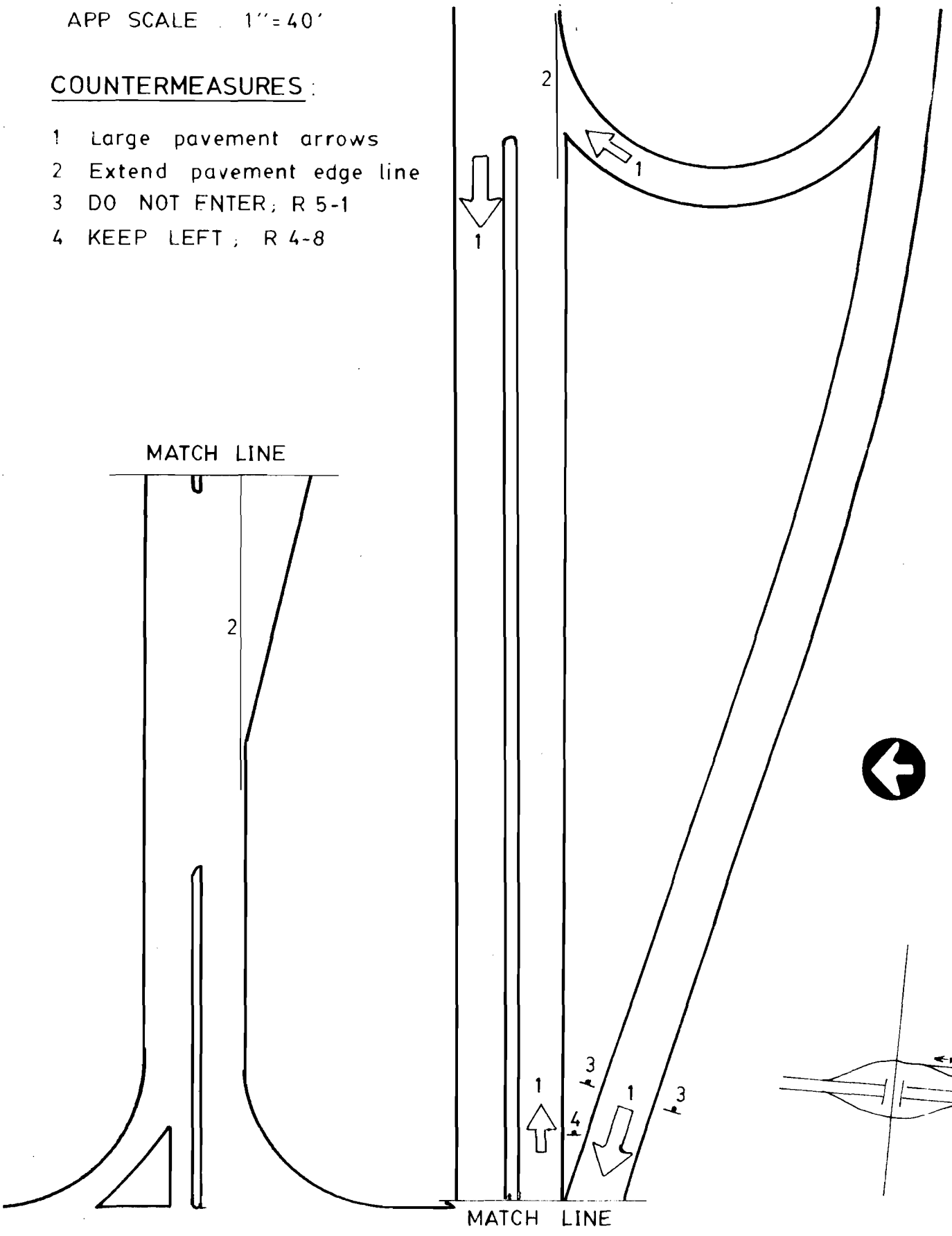
I-20 & WESLEY CHAPEL RD

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			WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
		Day	Night	of (number shot)			
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

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)			
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			WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
		Day	Night	of (number shot)			
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			WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
		Day	Night	of (number shot)			
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)

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)			
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 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)			
10/18/78	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 to 4/17/79 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.							
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			WRONG-WAY MOVEMENTS	DAYS IN PERIOD	WRONG-WAY RATE (per 30-day month)
		Day	Night	of (number shot)			
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.							