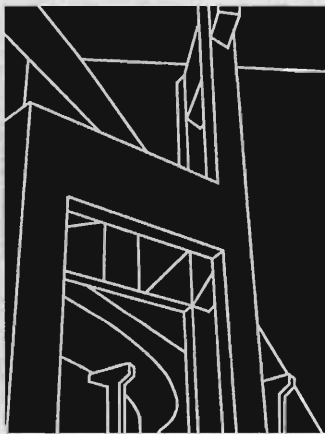


SPECIAL RESEARCH REPORT

ANALYSIS OF VEHICLES USING THE  
ENTRANCE RAMP FROM PEARL STREET  
TO SOUTHBOUND IH 45

Alexei Tsyganov, Rob Harrison, and Nabeel Khwaja



CENTER FOR TRANSPORTATION RESEARCH  
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THE UNIVERSITY OF TEXAS AT AUSTIN

SEPTEMBER 1999

**Analysis of Vehicles Using the Entrance Ramp  
From Pearl Street to Southbound IH 45**

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## INTRODUCTION

As shown in Figure 1, the investigated ramp is located at the intersection of US 75 and IH 45. The street map, aerial photograph, and panoramic photo of this intersection and ramp are shown in Appendixes 1, 2 and 3.

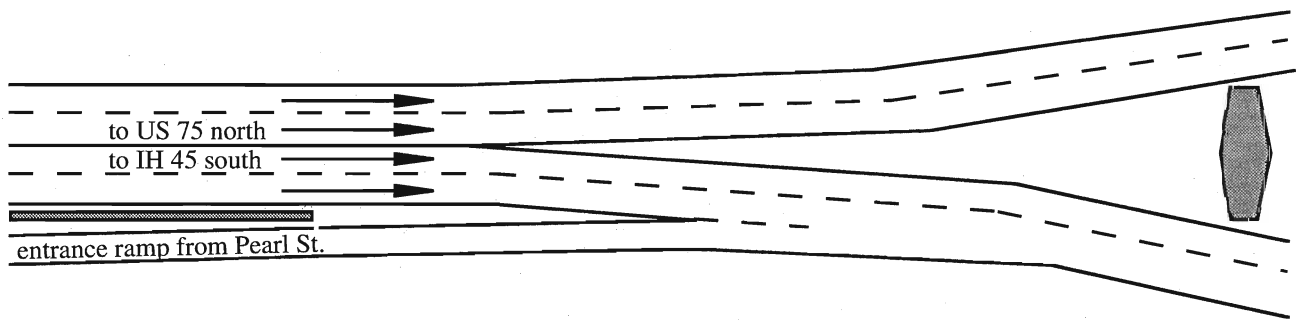


Figure 1. Basic Layout of the Investigated Highway Section (not to scale).

It is legal to use the entrance ramp from Pearl Street to enter southbound (SB) IH 45 only. However, it has been observed that some drivers do not observe traffic signs and make unsafe maneuvers to cross the white pavement lines that divide traffic on northbound (NB) US 75 and SB IH 45 to enter US 75, as shown in Figure 2 and Photo 1 in Appendix 4.

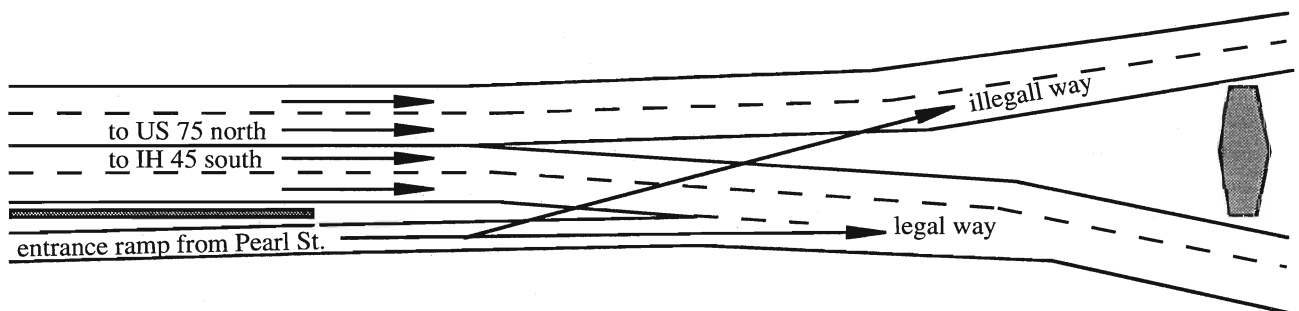


Figure 2. Basic Traffic Scheme on the Investigated Highway Section (not to scale).

The existing situation should be investigated to better understand driver needs/actions and provide the safest design possible. The following plan for investigation was formulated to study the problem.

1. Make traffic observations on the given highway section and estimate the significance of the problem,
2. Determine and analyze the reasons for unsafe driver behavior,
3. Analyze the vehicle paths of unsafe drivers, and
4. Develop recommendations to prevent unsafe vehicle driver maneuvers and ensure traffic safety.

### **TRAFFIC OBSERVATION METHODOLOGY**

Traffic observations must be made at different times to estimate the situation at different traffic volumes on both the highway and ramp. Based on demand in the Dallas area, observation times were between 7:30-9:30 a.m. (morning peak hours), 1:00-3:00 p.m. (normal business hours), and 3:30-5:30 p.m. (evening peak hours).

During observations, the following parameters were selected for measuring purposes:

1. lane by lane traffic volume on the highway,
2. traffic volume on the ramp,
3. number of unsafe vehicle maneuvers, and
4. path of those unsafe vehicle maneuvers.

Video recording was selected to collect the observation data. This permits continuous observation and analysis of individual vehicles, repeating the process over several days if necessary. The video camera was elevated and was placed as perpendicular as possible to the given highway section in order to avoid parallax error during video image analysis. The sight chosen for camera placement was the balcony of the 47<sup>th</sup> floor of the Trammell Crow Center building, as shown in the photo 2 in Appendix 4. For recording, a HI-8 mm SONY camcorder with a 400-line resolution was selected. The original tape would be re-recorded to a VHS tape with time code input, including hours, minutes, seconds, and frames.

## TRAFFIC VOLUME DATA

Traffic volume data were collected on both the ramp and the highway (lane by lane) (Tables 1, 2). Figures 3, 4, 5, and 6 are graphical representations of the collected traffic volume data. First, traffic volume data on the ramp were collected (Table 1, Fig 3), and showed that ramp volumes peak only in the evening hours. Therefore, it was decided to make detailed observations only during normal business hours and evening peak hours (Table 2, Figs 4, 5, 6). Based on the data collected and the experts' opinions, the following conclusions were made:

1. Highway peak hours are 7:00-9:30 a.m. and 4:00-6:00 p.m. On the ramp, only evening peak hours (4:00-6:00 p.m.) were observed.
2. High traffic volumes exist on both highway and ramp. During normal business hours, total highway traffic volumes are around 800 vehicles per 15 minutes. On the ramp, these values are 40 to 60 vehicles per 15 minutes. At peak hours, highway traffic volumes are around 1,100 vehicles per 15 minutes, and ramp volumes are around 350 vehicles per 15 minutes.
3. During normal business hours, traffic volumes are similar on both IH 45 and US 75 (around 400 vehicles per 15 minutes). During peak hours, a greater difference can be seen between IH 45 and US 75. It was observed that traffic volume on IH 45 during peak hours is around 650-750 vehicles per 15 minutes; on US 75, the corresponding volume was around 350-450.
4. Traffic volume on Woodall Rodgers traveling to IH 45 (lanes 1 and 2) is equal for both lanes. Traffic volume on Woodall Rodgers traveling to US 75 (lanes 3 and 4) during normal business hours is split 75 to 25. Seventy-five percent of the traffic travels the US 75 main lanes and 25 percent of the traffic stays in lane 3 leading to the NB frontage road (FR) at Hall Street. During peak traffic times, the fourth lane has stop-and-go traffic and the volume is around 23 percent.

Table 1. Traffic volume on entrance ramp from Pearl Street  
to SB IH 45

Texas Department of Transportation, Dallas District Traffic Operations

Time:		Date: 2/8/99		Date: 2/9/99		Date: 2/10/99	
		vehicles #	hourly equivalent	vehicles #	hourly equivalent	vehicles #	hourly equivalent
from	to						
0:00	0:15			13	52	13	52
0:15	0:30			16	64	15	60
0:30	0:45			6	24	7	28
0:45	1:00			14	56	3	12
1:00	1:15			10	40	11	44
1:15	1:30			6	24	5	20
1:30	1:45			4	16	7	28
1:45	2:00			7	28	8	32
2:00	2:15			6	24	4	16
2:15	2:30			8	32	5	20
2:30	2:45			8	32	3	12
2:45	3:00			4	16	4	16
3:00	3:15			2	8	4	16
3:15	3:30			3	12	5	20
3:30	3:45			3	12	4	16
3:45	4:00			3	12	0	0
4:00	4:15			2	8	5	20
4:15	4:30			4	16	3	12
4:30	4:45			5	20	7	28
4:45	5:00			7	28	5	20
5:00	5:15			4	16	5	20
5:15	5:30			8	32	12	48
5:30	5:45			6	24	8	32
5:45	6:00			6	24	7	28
6:00	6:15			8	32	13	52
6:15	6:30			13	52	11	44
6:30	6:45			17	68	31	124
6:45	7:00			24	96	27	108
7:00	7:15			47	188	42	168
7:15	7:30			16	64	24	96
7:30	7:45			36	144	33	132
7:45	8:00			52	208	37	148
8:00	8:15			49	196	53	212
8:15	8:30			53	212	48	192
8:30	8:45			38	152	45	180
8:45	9:00			60	240	37	148
9:00	9:15			51	204		
9:15	9:30			43	172		
9:30	9:45			32	128		
9:45	10:00			48	192		
10:00	10:15	32	128	44	176		
10:15	10:30	30	120	40	160		
10:30	10:45	42	168	40	160		
10:45	11:00	53	212	51	204		



Time:		Date: 2/8/99		Date: 2/9/99		Date: 2/10/99	
		vehicles #	hourly equivalent	vehicles #	hourly equivalent	vehicles #	hourly equivalent
from	to						
11:00	11:15	41	164	43	172		
11:15	11:30	46	184	49	196		
11:30	11:45	55	220	50	200		
11:45	12:00	55	220	69	276		
12:00	12:15	56	224	54	216		
12:15	12:30	63	252	53	212		
12:30	12:45	49	196	58	232		
12:45	13:00	62	248	56	224		
13:00	13:15	58	232	73	292		
13:15	13:30	60	240	64	256		
13:30	13:45	55	220	73	292		
13:45	14:00	67	268	72	288		
14:00	14:15	68	272	72	288		
14:15	14:30	83	332	81	324		
14:30	14:45	97	388	108	432		
14:45	15:00	118	472	112	448		
15:00	15:15	107	428	106	424		
15:15	15:30	151	604	125	500		
15:30	15:45	186	744	166	664		
15:45	16:00	219	876	247	988		
16:00	16:15	233	932	255	1020		
16:15	16:30	217	868	211	844		
16:30	16:45	262	1048	283	1132		
16:45	17:00	305	1220	290	1160		
17:00	17:15	319	1276	351	1404		
17:15	17:30	346	1384	319	1276		
17:30	17:45	373	1492	291	1164		
17:45	18:00	208	832	260	1040		
18:00	18:15	237	948	219	876		
18:15	18:30	199	796	172	688		
18:30	18:45	150	600	125	500		
18:45	19:00	119	476	147	588		
19:00	19:15	99	396	123	492		
19:15	19:30	86	344	100	400		
19:30	19:45	64	256	64	256		
19:45	20:00	77	308	68	272		
20:00	20:15	73	292	74	296		
20:15	20:30	63	252	52	208		
20:30	20:45	48	192	52	208		
20:45	21:00	51	204	50	200		
21:00	21:15	50	200	69	276		
21:15	21:30	49	196	37	148		
21:30	21:45	31	124	35	140		
21:45	22:00	36	144	37	148		
22:00	22:15	28	112	52	208		
22:15	22:30	19	76	40	160		
22:30	22:45	29	116	35	140		
22:45	23:00	27	108	38	152		
23:00	23:15	38	152	36	144		

Time:		Date: 2/8/99		Date: 2/9/99		Date: 2/10/99	
		vehicles #	hourly equivalent	vehicles #	hourly equivalent	vehicles #	hourly equivalent
from	to						
23:15	23:30	23	92	32	128		
23:30	23:45	25	100	28	112		
23:45	0:00	16	64	20	80		

Table 2. Traffic volumes on Woodall Rodgers Freeway and Pearl Street Entrance Ramp

University of Texas at Austin, Center for Transportation Research

Time: from to		Pearl Street Entrance Ramp		Woodall Rodgers Freeway toward:								Total on HW	
				IH 45				Hall St.		US 75			
				Lane 1 (right)		Lane 2		Lane 3		Lane 4 (left)			
				vehicles #	hourly equivalent	vehicles #	hourly equivalent	vehicles #	hourly equivalent	vehicles #	hourly equivalent		
13:15	13:30	72	288	160	640	222	888	124	496	315	1260	821	3284
13:30	13:45	72	288	182	728	214	856	119	476	320	1280	835	3340
13:45	14:00	60	240	161	644	225	900	129	516	309	1236	824	3296
14:00	14:15	97	388	161	644	218	872	126	504	307	1228	812	3248
14:15	14:30	99	396	174	696	240	960	117	468	316	1264	847	3388
14:30	14:45	82	328	167	668	213	852	129	516	329	1316	838	3352
14:45	15:00	133	532	180	720	235	940	131	524	323	1292	869	3476
15:00	15:12	109	545	199	995	282	1128	128	640	255	1275	864	4038
15:15	15:30												
15:30	15:45	180	720	303	1212	366	1464	197	788	253	1012	1119	4476
15:45	16:00	253	1012	351	1404	381	1524	275	1100	94	376	1101	4404
16:00	16:15	241	964	368	1472	365	1460	273	1092	98	392	1104	4416
16:15	16:30	237	948	302	1208	323	1292	252	1008	100	400	977	3908
16:30	16:45	224	896	306	1224	325	1300	250	1000	123	492	1004	4016
16:45	17:00	296	1184	308	1232	315	1260	246	984	151	604	1020	4080
17:00	17:15	305	1220	315	1260	303	1212	242	968	155	620	1015	4060

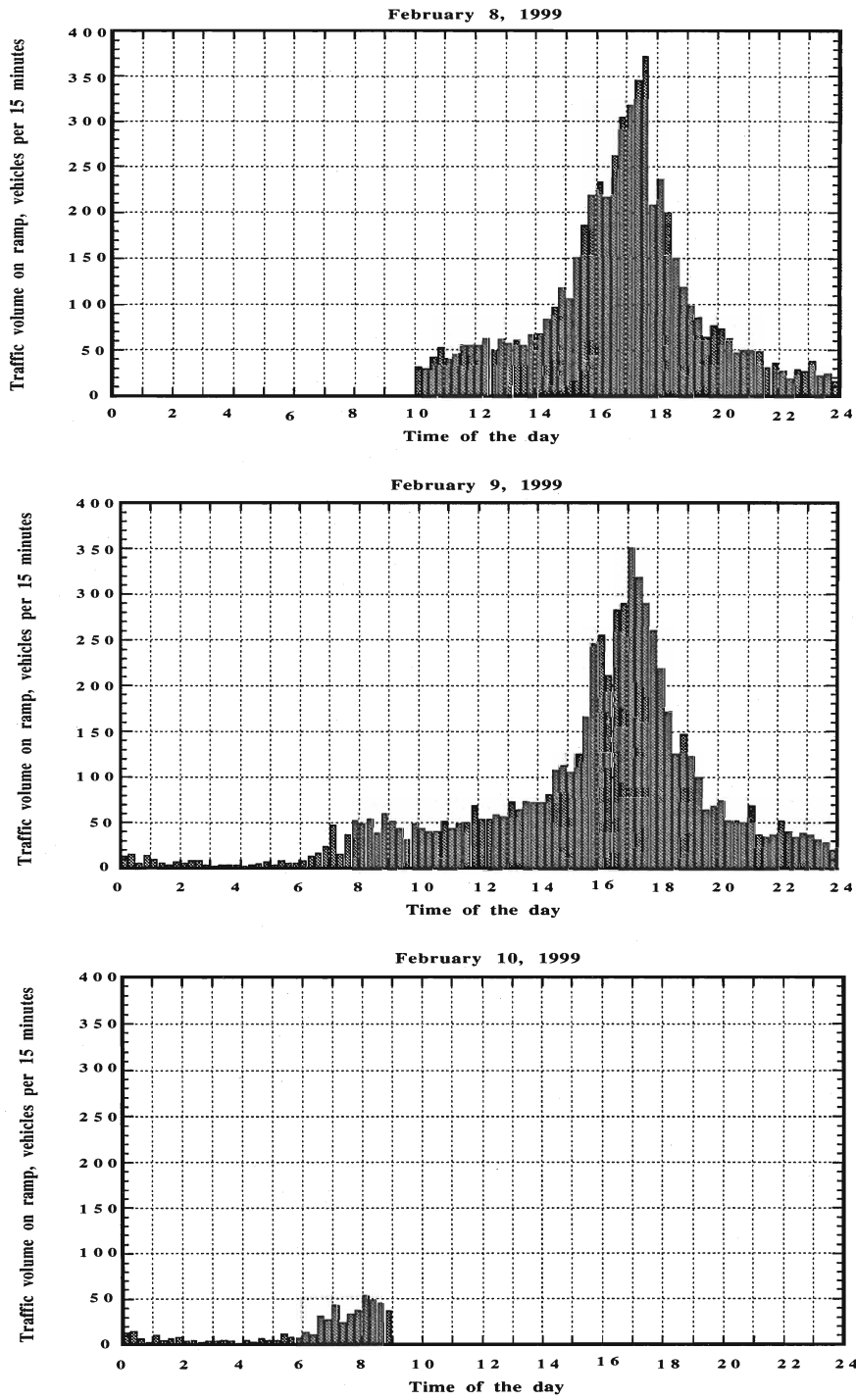


Figure 3. Traffic Volume on Pearl Street Entrance Ramp (TxDOT Data)

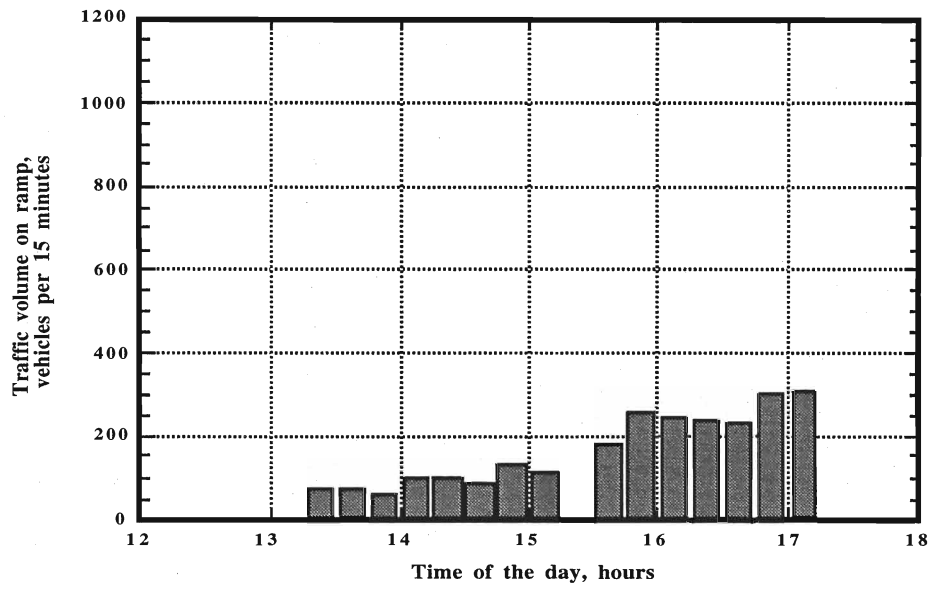
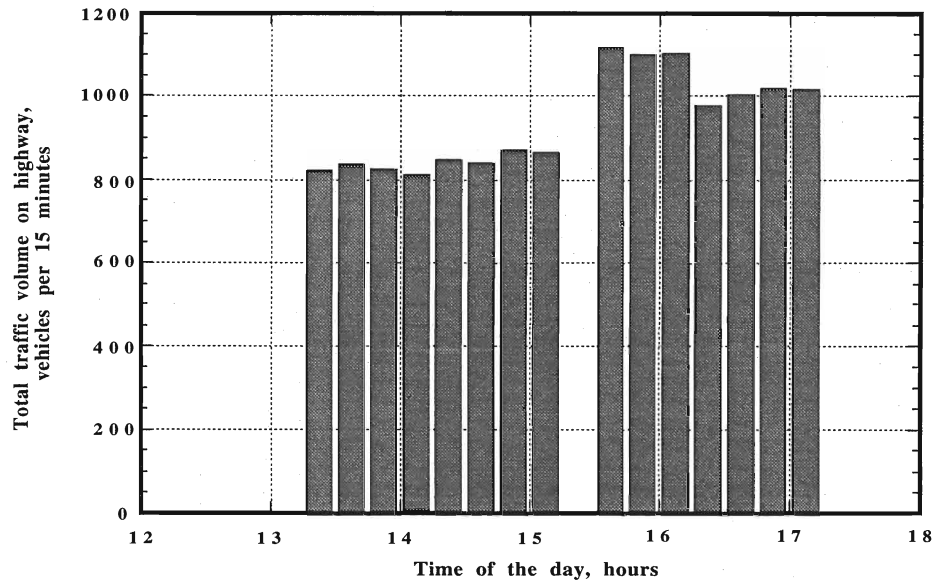


Figure 4. Traffic Volume on Woodall Rodgers Freeway and Pearl Street Entrance Ramp (CTR Data)

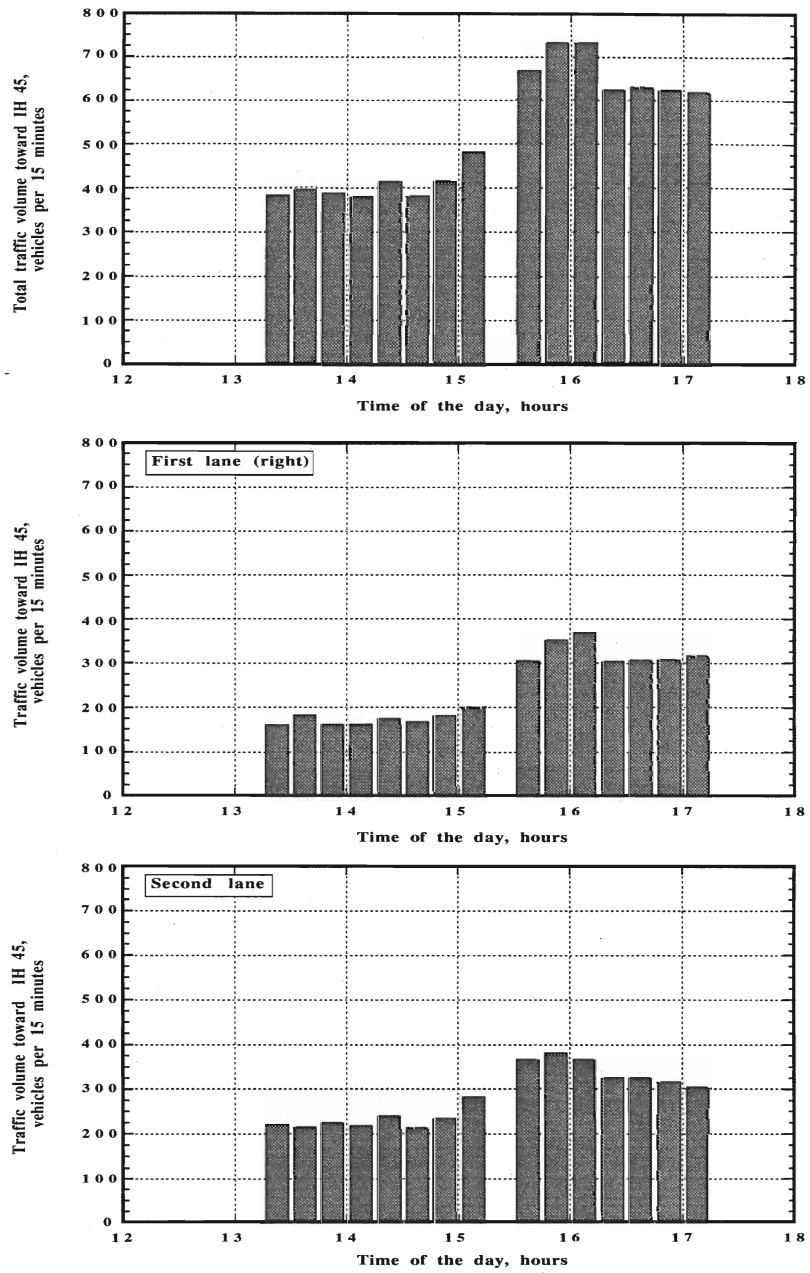


Figure 5. Traffic Volume on Woodall Rodgers Freeway toward IH 45 (CTR Data).

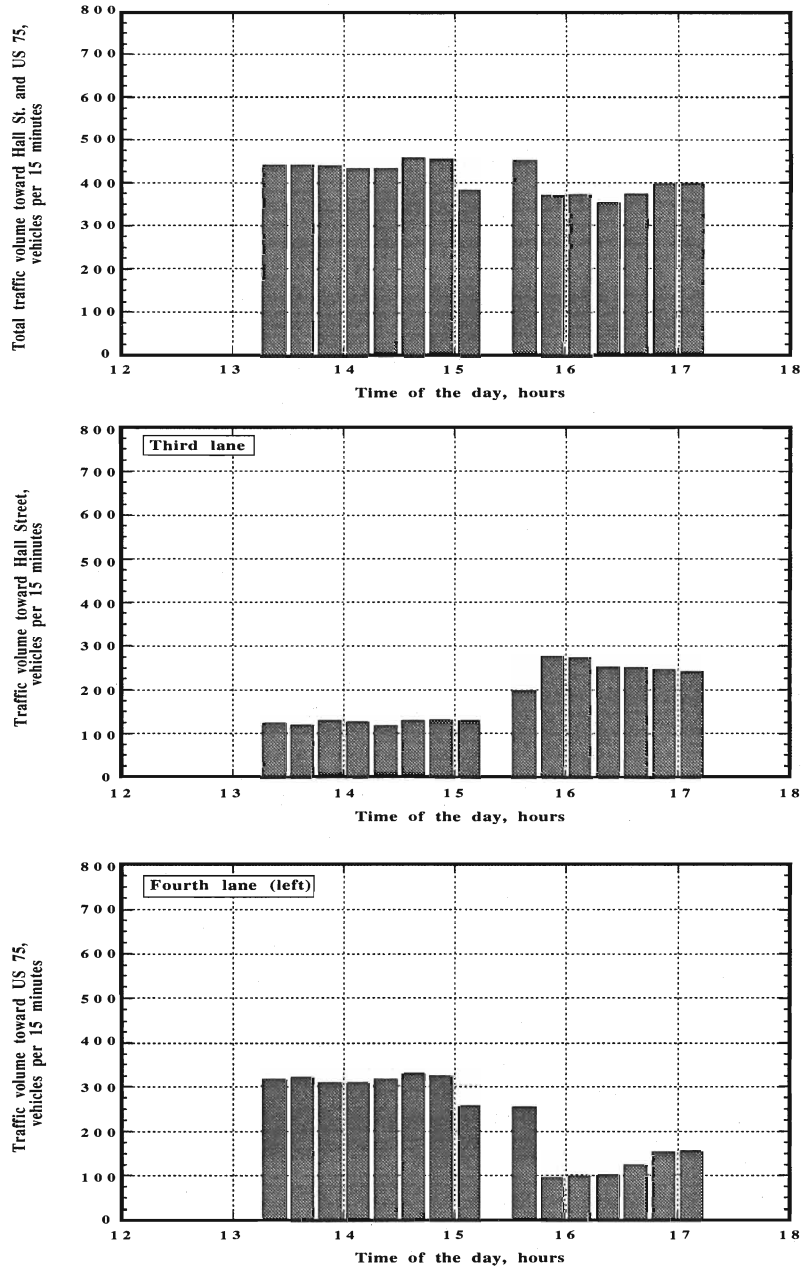


Figure 6. Traffic Volume on Woodall Rodgers Freeway toward Hall Street and US 75 (CTR Data).

## VEHICLE MANEUVER COUNTS

The duration of each observation period was approximately two hours. To obtain data for more uniform traffic conditions, a fifteen minute interval for data reduction was selected, during which the following parameters were registered: (1) number of vehicles on each highway lane and on ramp, and (2) number of illegally entering vehicles. The collected data are represented in Table 3.

Table 3. Traffic volume on ramp and number of illegally entering vehicles.

Time		Number of vehicles		
From	To	On ramp	Entering unsafely	%
<b>Set #1</b>				
13:15	13:30	72	9	12.5
13:30	13:45	72	5	6.94
13:45	14:00	60	8	13.33
14:00	14:15	97	3	3.09
14:15	14:30	99	11	11.11
14:30	14:45	82	11	13.41
14:45	15:00	133	7	5.26
15:00	15:12	109	3	2.75
<b>Set #2</b>				
15:30	15:45	180	4	2.22
15:45	16:00	253	2	0.79
16:00	16:15	241	1	0.41
16:15	16:30	237	0	0
16:30	16:45	224	0	0
16:45	17:00	296	0	0
17:00	17:15	305	0	0

Taking into consideration high traffic volumes and speeds on both the highway and ramp, each unsafe vehicle maneuver could cause or be involved in an accident at this location. Figure 7 represents the distribution of unsafe vehicle maneuvers in time, and Figure 8 represents the frequency of unsafe vehicle maneuvers versus total highway traffic volumes during normal business hours. These data allow us to conclude that the number of errant vehicles incorrectly entering US 75



is high, and could potentially cause an accident. On average, around nine percent of all vehicles on the ramp during normal business hours do not correctly observe traffic signs when entering US 75. These vehicle numbers vary from 3-11 vehicles per 15 minutes during normal business hours, and can be explained by the random character of vehicles arriving at the given ramp making the unsafe maneuver.

The data clearly show a significant reduction in the frequency of unsafe vehicle maneuvers at high levels of traffic volume. After 3:00 p.m., when total highway traffic volume exceeds 3500 vph, only occasional unsafe vehicle maneuvers were observed. At peak hours, when there is a high flow density on the highway, such maneuvers are virtually impossible, and after 4:15 p.m., no such incidents were observed.

Therefore, the following conclusions can be made:

1. Improvement can be made on this highway section to enhance safety.
2. During normal business hours, the potential for an accident increases as the frequency of unsafe driver maneuvers is highest. During this time, highway traffic volume is lower, allowing for higher speeds and greater speed differential between highway and ramp traffic.
3. When total highway traffic volume exceeds 3,500 vehicles per hour, only occasional unsafe vehicle maneuvers occurred.
4. At peak hours, the heavy highway traffic does not allow motorists to make unsafe maneuvers.

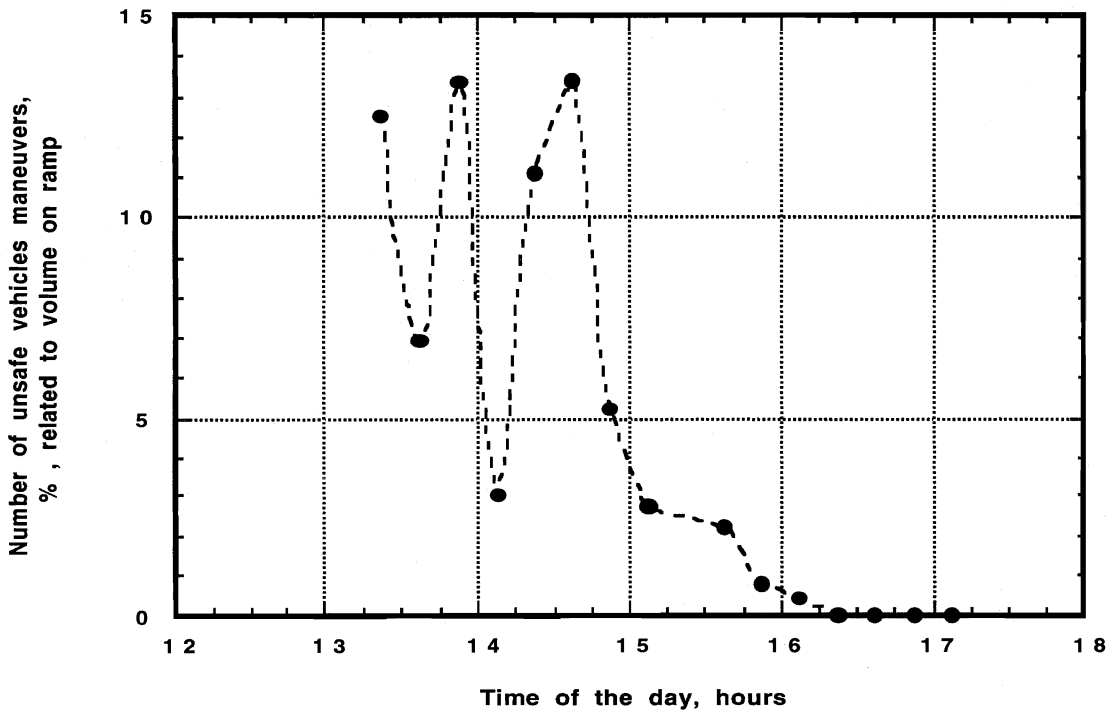
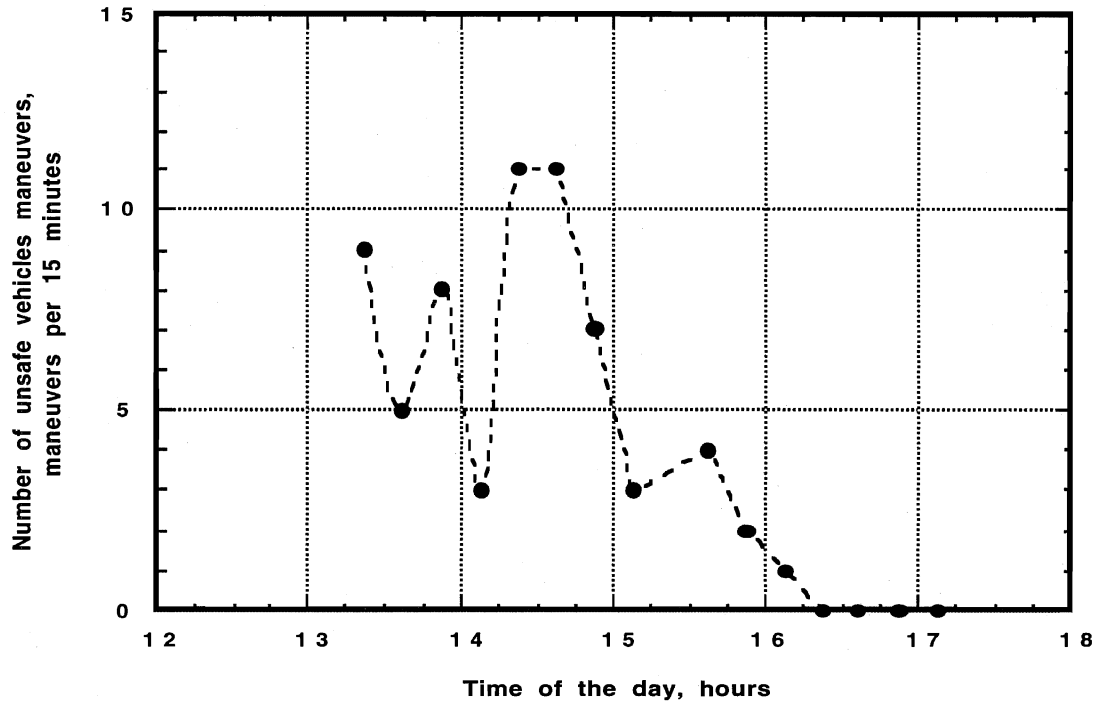


Figure 7. Distribution of Unsafe Vehicle Maneuvers

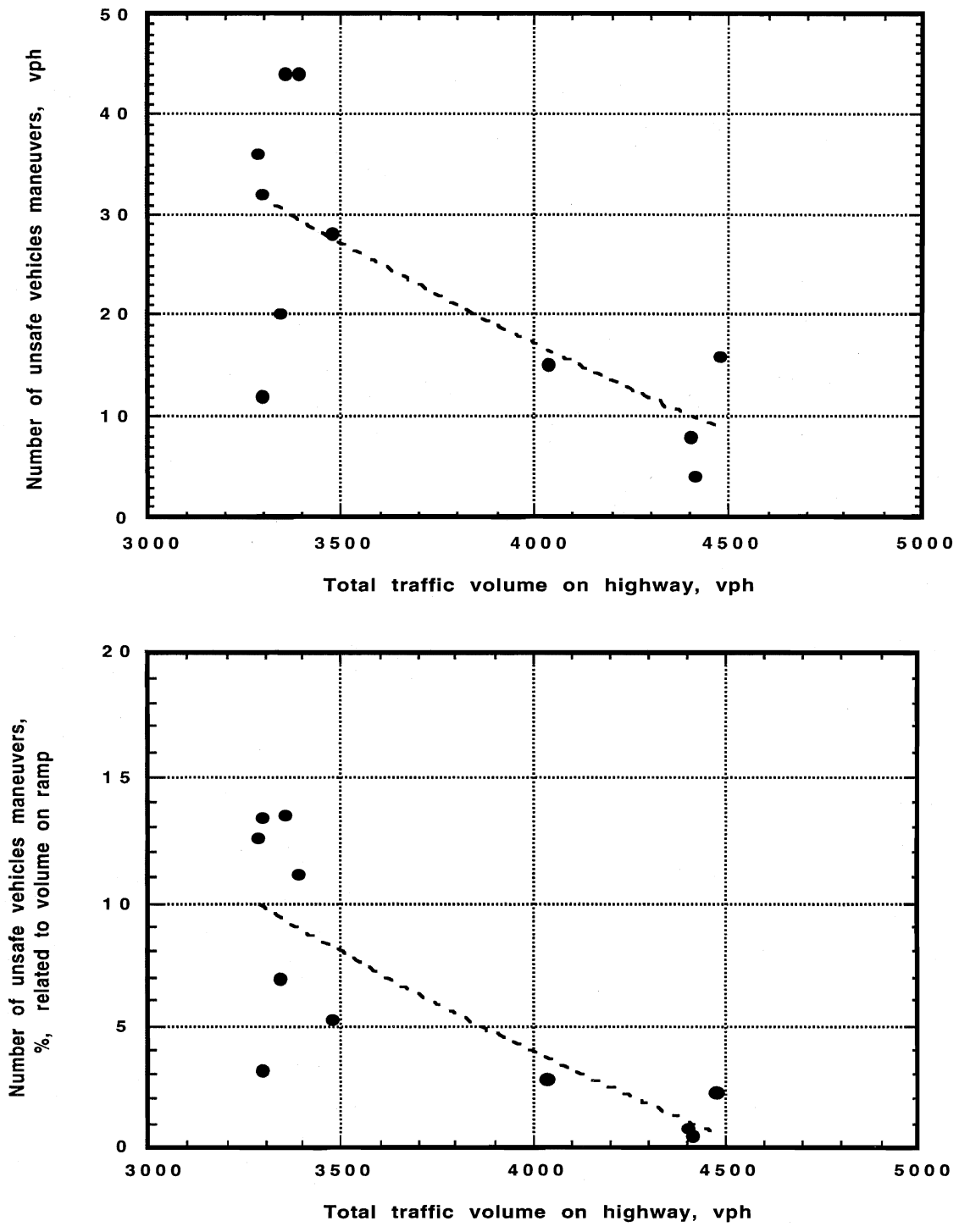


Figure 8. Number of Unsafe Vehicle Maneuvers at Different Highway Traffic Volumes (Normal Business Hours)

## PATH OF UNSAFE VEHICLE MANEUVERS

Table 4 shows the recorded times for each unsafe vehicle maneuver occurrence and the vehicle identification. Figure 9 shows the path of these vehicles.

Table 4. Unsafe Vehicle Maneuver Identification and Time

<b>Vehicle #</b>	1	2	3	4	5	6	7	8
<b>Time</b>	13:21:32	13:23:40	13:23:45	13:24:02	13:24:46	13:25:36	13:25:44	13:25:51
<b>Vehicle #</b>	9	10	11	12	13	14	15	16
<b>Time</b>	13:28:12	13:35:12	13:37:30	13:38:50	13:40:10	13:44:36	13:46:35	13:49:37
<b>Vehicle #</b>	17	18	19	20	21	22	23	24
<b>Time</b>	13:49:49	13:51:17	13:54:00	13:54:25	13:58:05	13:59:54	14:08:20	14:08:30
<b>Vehicle #</b>	25	26	27	28	29	30	31	32
<b>Time</b>	14:11:00	14:15:10	14:16:44	14:20:25	14:20:31	14:23:57	14:25:50	14:26:22
<b>Vehicle #</b>	33	34	35	36	37	38	39	40
<b>Time</b>	14:26:25	14:28:53	14:28:55	14:29:45	14:32:21	14:32:34	14:33:45	14:36:01
<b>Vehicle #</b>	41	42	43	44	45	46	47	48
<b>Time</b>	14:36:07	14:38:23	14:38:30	14:40:10	14:40:51	14:40:53	14:43:05	14:45:42
<b>Vehicle #</b>	49	50	51	52	53	54	55	56
<b>Time</b>	14:46:46	14:47:09	14:48:43	14:50:00	14:59:37	14:59:45	15:05:26	15:07:29
<b>Vehicle #</b>	57	58	59	60	61	62	63	64
<b>Time</b>	15:09:48	15:35:33	15:37:09	15:40:07	15:44:20	15:46:23	15:57:29	16:02:59

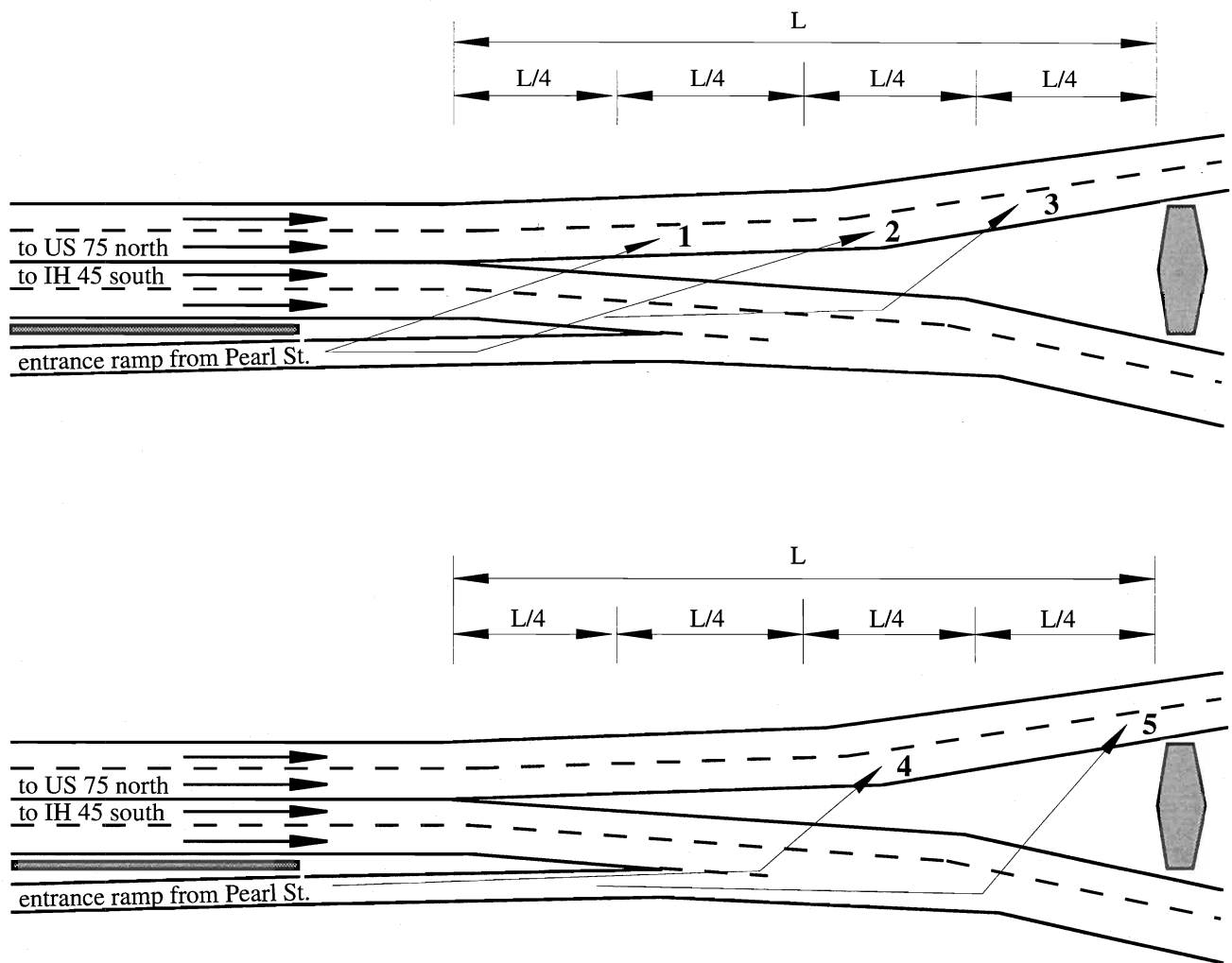


Figure 9. Path of Unsafe Vehicle Maneuver (not to scale)

Path 1 – vehicle # 4, 5, 7, 8, 11, 13, 14, 16, 18, 21, 23, 27, 28, 42, 43, 49, 55, 58

Path 2 – vehicle # 3, 6, 17, 22, 24, 26, 30, 36, 38, 44

Path 3 – vehicle # 9, 41

Path 4 – vehicle # 1, 12, 19, 20, 25, 29, 32, 33, 34, 35, 39, 40, 46, 47, 48, 53, 54, 56,  
59, 60, 62, 64

Path 5 – vehicle # 2, 10, 15, 31, 37, 45, 51, 52, 57, 61, 63

All observed unsafe vehicle maneuvers can be divided into five types:

Type 1 – vehicles cross the double white line that divides the ramp and highway at the first possibility and go straight to US 75, crossing the division between IH 45 and US 75 in the first quarter (29 percent of incidents) (Fig 9).

Type 2 – vehicles cross the double white line that divides the ramp and highway at the end and go straight to US 75, crossing the division in the middle (16 percent of incidents) (Fig 9).

Type 3 – vehicles cross the double white line that divides the ramp and highway at the end, proceed on the first and second highway lanes, and then to US 75, crossing the division in the third quarter (3 percent of incidents) (Fig 9).

Types 4 and 5 – vehicles enter IH 45 and then go to US 75, crossing the division in the middle and at the end, respectively (35 and 17 percent of incidents) (Fig 9).

Maneuver types 1, 2, and 3 were observed during relatively light highway traffic volumes. Maneuver types 4 and 5 occurred most often during heavy highway traffic flows, when it is necessary to wait for an acceptable gap in the traffic for merging. Sometimes, vehicles on the ramp come to a complete stop, waiting for an opportunity to cross IH 45 and to enter US 75.

In summary, the accident potential due to an unsafe driver maneuver is highest between 10:00 a.m. and 3:00 p.m. At other times, high traffic volumes on the highway deter motorists using the ramp from trying to enter US 75

Possible reasons for the unsafe driver behavior on the given highway section include:

1. Local users are familiar with this unsafe maneuver, while some non-local users are confused about the proper access route to NB US 75. Additional signs may improve user information.
2. Alternate routes from Pearl Street to NB US 75 require more travel time.

3. The large visible space between the entrance ramp to IH 45 and US 75 allows drivers to undertake the unsafe maneuver.

Therefore, to provide a safe and uninterrupted traffic flow at this location, it may be necessary to perform some of the following:

1. investigate the existing traffic control plan,
2. investigate the zone of influence from the observed ramp,
3. for the ramp influence zone, investigate all existing options for entering NB US 75 and select the most effective,
4. if it is necessary and appropriate, develop a more effective traffic control plan,
5. make a geometric scheme with pavement markings of the ramp and division zone of IH 45 and US 75, and
6. select the appropriate engineering solution to prevent unsafe driver behavior.

These are now discussed.

### **EXISTING TRAFFIC CONTROL PLAN**

The existing traffic control plan at the intersection of Pearl Street and Woodall Rodgers Freeway was investigated, as shown in Figure 10. The photographs of the main road signs are included in Appendix 4.

The investigation found that there is some driver confusion when traveling on Pearl Street to Woodall Rodgers Freeway (from Flora Street). A "NO ACCESS TO N.B.CENTRAL/FOLLOW DETOUR/DETOUR 75" (photo 3 in Appendix 4) traffic sign has no directional arrow, and the abbreviation "N.B.Central" is unknown to transit drivers not familiar with Dallas. From the frontage road, the sign above the highway indicating "75 NORTH/SHERMAN" (see photos 5 and 8 in Appendix 4) is clearly visible. Drivers may see this sign and the entrance ramp ahead and mistakenly

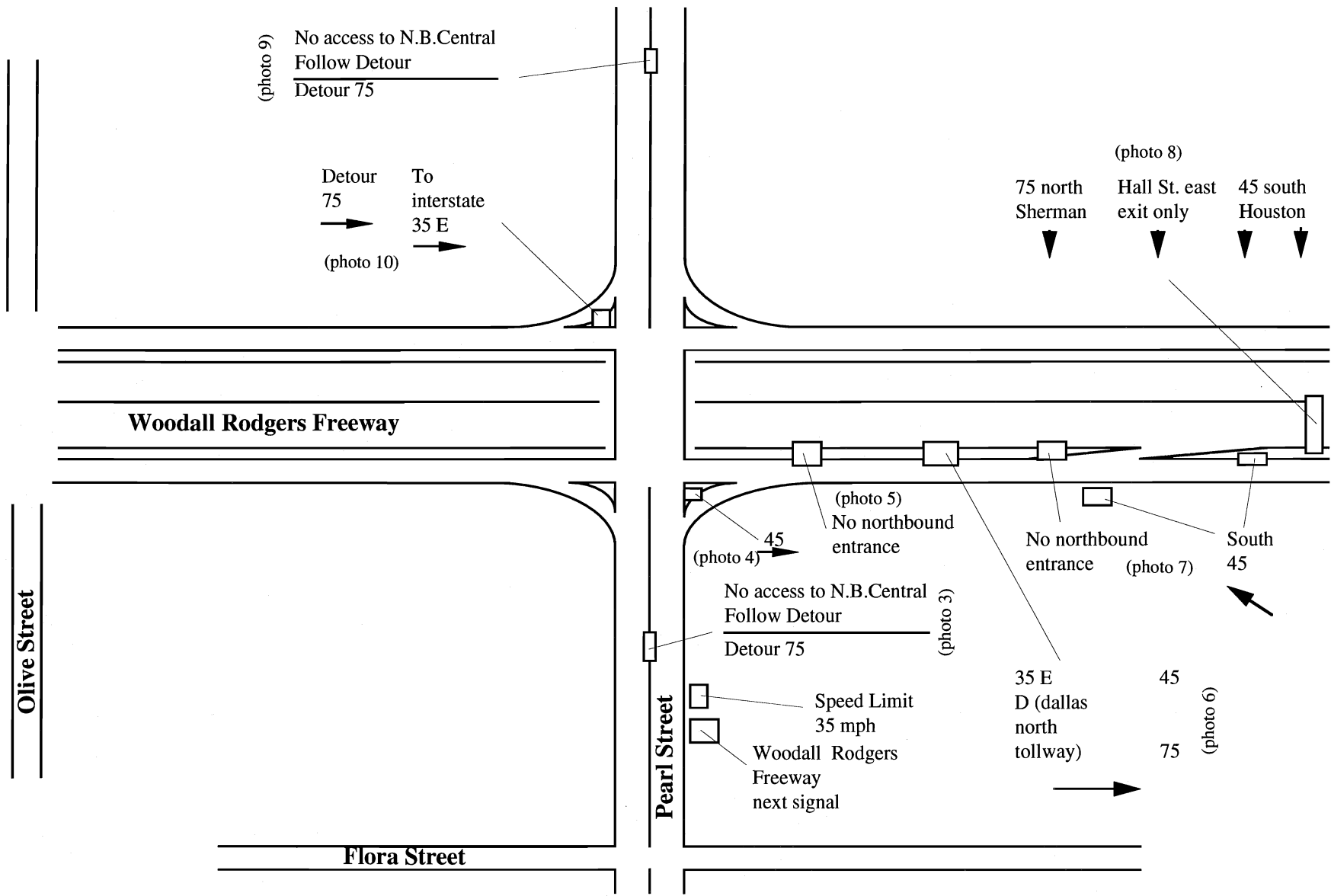


Figure 10. Existing traffic control plan at the intersection of Pearl Street and Woodall Rodgers Freeway.



think that this ramp allows entrance to NB US 75. Other traffic signs on the frontage road prior to the investigated ramp are problematic and confusing, as well (see photos 4, 5, and 6 in Appendix 4). Also, the entrance ramp provides limited visibility of the highway and drivers only see the legal directions at the last moment (see photos 7 and 8 in Appendix 4).

Taking into consideration the previously mentioned points, there seems to be a clear case that some of the unsafe driver maneuvers are in part a result of driver confusion.

## **ENTRANCE TO US 75**

Figure 11 shows the street scheme of the area surrounding the investigated ramp. Observations showed that the area bordered by Akard Street, Ross Avenue, and Crockett Street has the greatest influence on the Pearl Street entrance ramp traffic. There are two ramps (excluding Pearl Street) that can be used to enter US 75. Pearl Street was selected for test driving as a midpoint of the investigated area. All available entrances to US 75 were investigated, and are as follows:

1. Traffic moves south on Pearl Street, then west on Ross Avenue, then north on Field Street, and then uses the entrance ramp from Field Street. The total extra travel time on the highway is 3 minutes.
2. Traffic moves south on Pearl Street, then east on Bryan Street, and then uses the entrance ramp from Bryan Street. Total extra travel time is also 3 minutes.
3. Traffic moves south on Pearl Street, then east on Ross Avenue, then NB on the US 75 frontage road, and then uses the entrance ramp from Haskell Avenue. Total travel time to reach the Haskell Avenue entrance ramp from Pearl Street is 5 minutes.

By making these unsafe maneuvers, drivers either incorrectly assume that travel time will be substantially shortened or they do not pay attention to traffic signs and regulations.

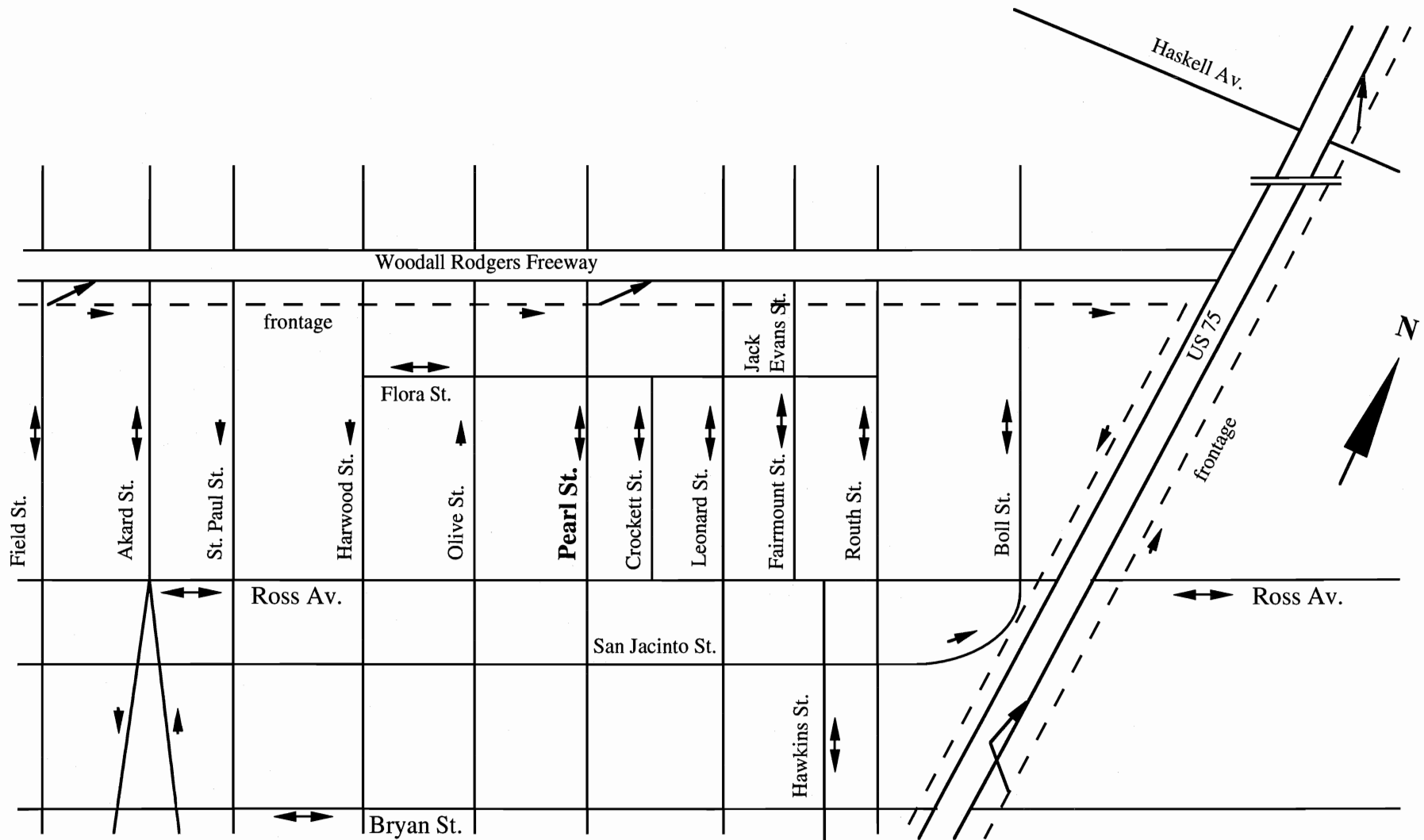


Figure 11. Pearl Street area traffic scheme (not to scale)

➔ one way street      ↔ two way street

## RECOMMENDATIONS

Our recommendations concentrate on three different areas:

1. Improve the traffic control plan of the surrounding area.
2. Educate the travelling public (especially those drivers who use this ramp on a regular basis to enter US 75).
3. Install deterrence devices in the gore area that separate the ramps from Woodall Rodgers Freeway to US 75 and IH 45.

Once construction on the new ramp to NB US 75 is complete (estimated completion date is December 1999), the traffic control plan for the surrounding area will need to be modified accordingly. Based on the "Manual on Uniform Traffic Control Devices," Figure 12 shows the proposed traffic control plan for the Pearl Street entrance ramp area. This plan provides clear information to road users about routes to NB US 75 and SB IH 45 ramps. The above mentioned traffic control plan will help drivers who are not familiar with this area, navigate through it. smoothly.

To prevent unsafe driver maneuvers in the future, it is proposed to distribute a brief, informative notice to each employee in this business area. This would be relatively easy, since the business area is not large and is concentrated in multi-story office buildings. The notice should indicate that it is unsafe to use Pearl St. ramp to enter NB US 75 and that citations will be issued in the future.

Figure 13 shows the geometric scheme of the investigated highway section and the locations of existing protective barriers and pavement markings.

As previously discussed, there are five types of unsafe vehicle maneuvers. The first three cross the pavement markings that divide the Woodall Rodgers Freeway and Pearl St. entrance ramp. The fourth and fifth comprise a legal entrance to the highway and then an illegal crossing of the gore area

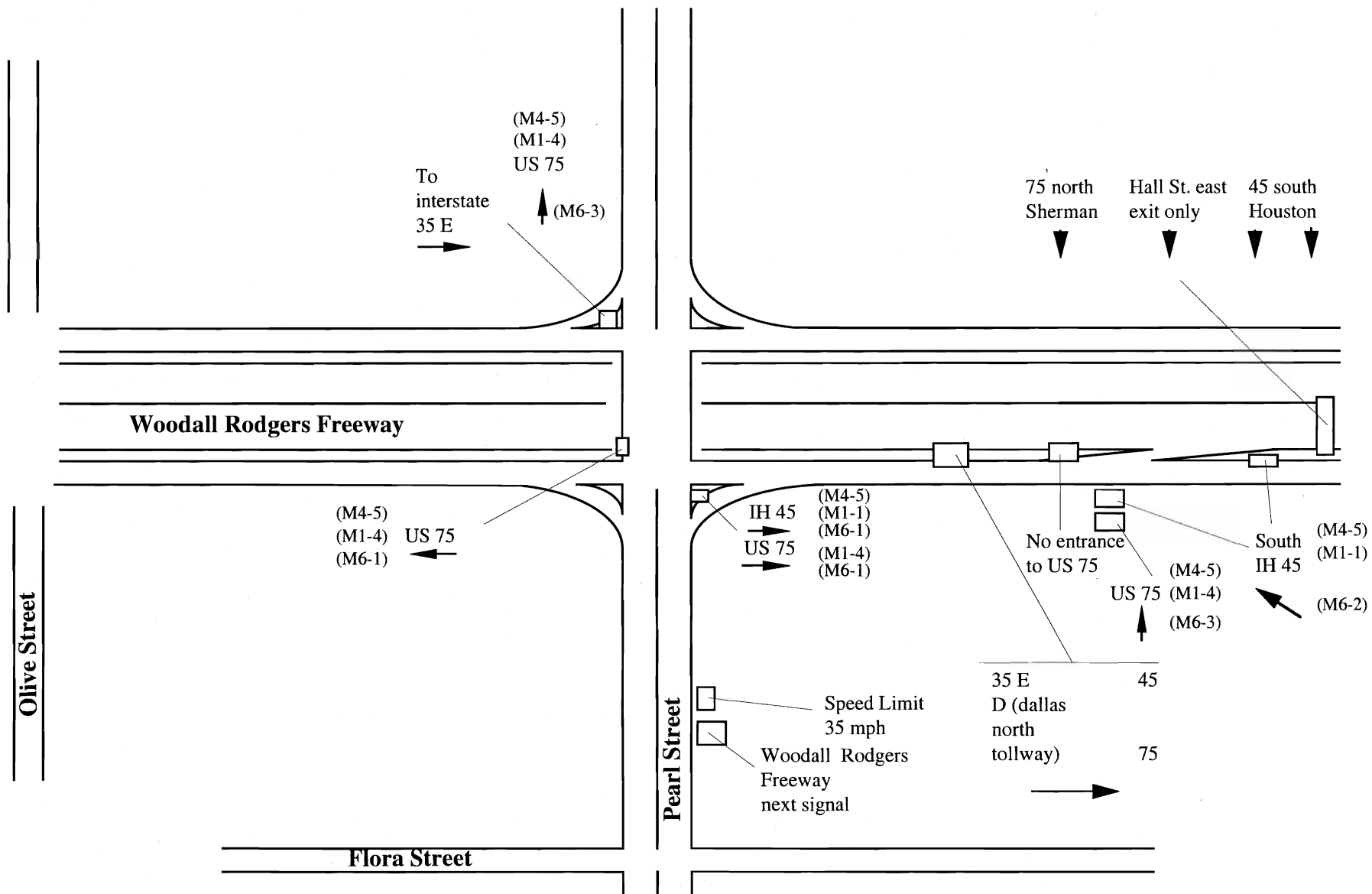
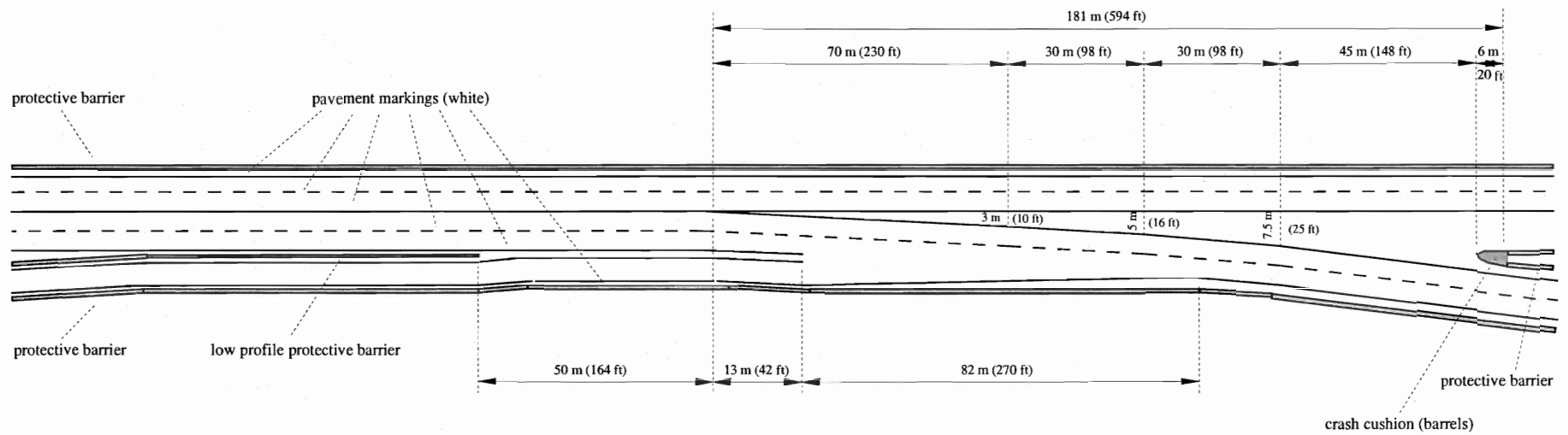


Figure 12. Proposed traffic control plan at intersection of Pearl Street and Woodall Rodgers Freeway.  
 (M4-5) - sign code corresponding to MUTCD

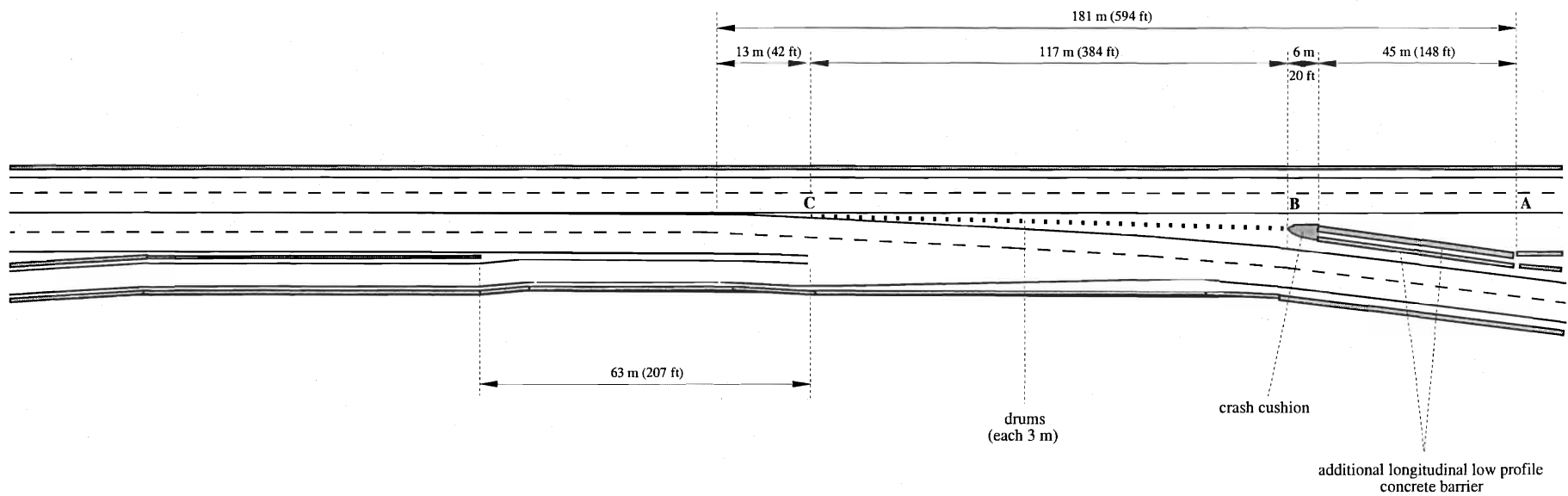


**Figure 13. Geometric scheme, protective barrier locations and pavement markings on the investigated highway section**

between the IH 45 and US 75 ramps. Analysis of the recommended protective devices and requirements for their placement show that cones, portable rigid vertical panel systems, self-righting vertical panels, drums (channelization devices), concrete barriers, and light portable plastic barriers can be used to prevent premature freeway entrance (first three types of unsafe vehicle maneuvers) (Refs 1, 2, 3, 4, 5).

Experience shows that some drivers are not concerned about hitting light devices such as cones, thus making stronger devices preferable for the given situation. Drums (channelization devices), longitudinal low profile light portable plastic barriers and concrete barriers are recommended for additional separation of freeways. These devices ensure vehicle stability on the roadway following a collision, and, at the same time, are perceived by drivers as being sturdy enough to deter hitting them deliberately. Based on the Highway Design Manual, the minimal gap acceptance lengths must be 90 meters. Pearl Street ramp was designed based on minimum requirements and therefore additional separation devices cannot be installed between the ramp and the highway. Therefore, extra separation of highways can be made only. The recommended locations of these devices are represented in Figure 14. As shown in Figure 14, an analysis of the gore area's geometric parameters show that it is possible to install additional longitudinal traffic barrier up to point B in the figure 14. This placement ensures a shoulder width of 3.0 meters on the freeway. The concrete barrier is recommended. The existing crash cushion would need to be reinstalled to include the new barriers. The narrow section of the division should be protected by lighter devices such as drums (channelization devices), portable rigid vertical panel systems, etc. installed from the crash cushion to the point C in the figure 14.

The other solution, which does not influence existing traffic through the use of physical devices, is to record license plates of the vehicles making unsafe maneuvers using photo radar. Two photo radar devices focusing on rear license plates can be installed on the sign supports under the freeway at different heights for optimum visibility. Two photo radar devices are recommended in this case because each covers a smaller zone, providing better picture resolution. Rear photo radar will prevent vehicle



**Figure 14. Recommended locations for additional traffic control devices.**

headlights from influencing the picture. Figure 15 shows the recommended locations for photo radar installation.

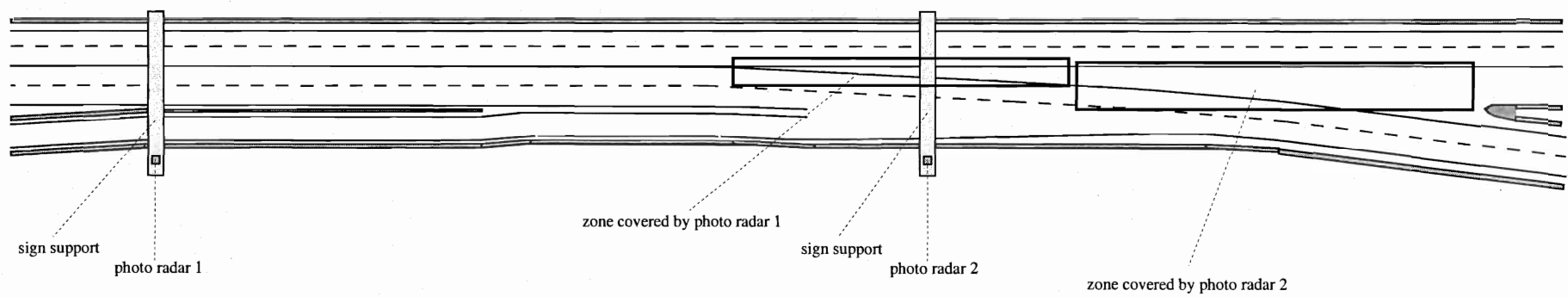
It is also recommended that traffic observations be undertaken soon following the implementation of the above mentioned recommendations in an effort to monitor their effectiveness. If observations show that they are effective, no further solutions may be needed and temporary devices may be removed.

However, if the notice is not successful, further solutions to the problem should be implemented, such as redesigning highway pavement markings in this area to extend more space for strong devices (as a concrete barrier) in the gore area.

Currently the gore area has jiggle bars (raised pavement markings) installed at 20 feet spacing. If temporary devices between the entrance ramps to US 75 and IH 45 are not used, then the spacing between the jiggle bars may be decreased to 10 feet, to clearly delineate the gore area.

It was also noted during our observations that low profile concrete traffic barriers have been used to physically separate the Pearl Street entrance ramp and the Woodall Rodgers Freeway. The low profile temporary barriers may be converted to permanent low profile concrete barrier wall to enhance the aesthetics of the surrounding area.



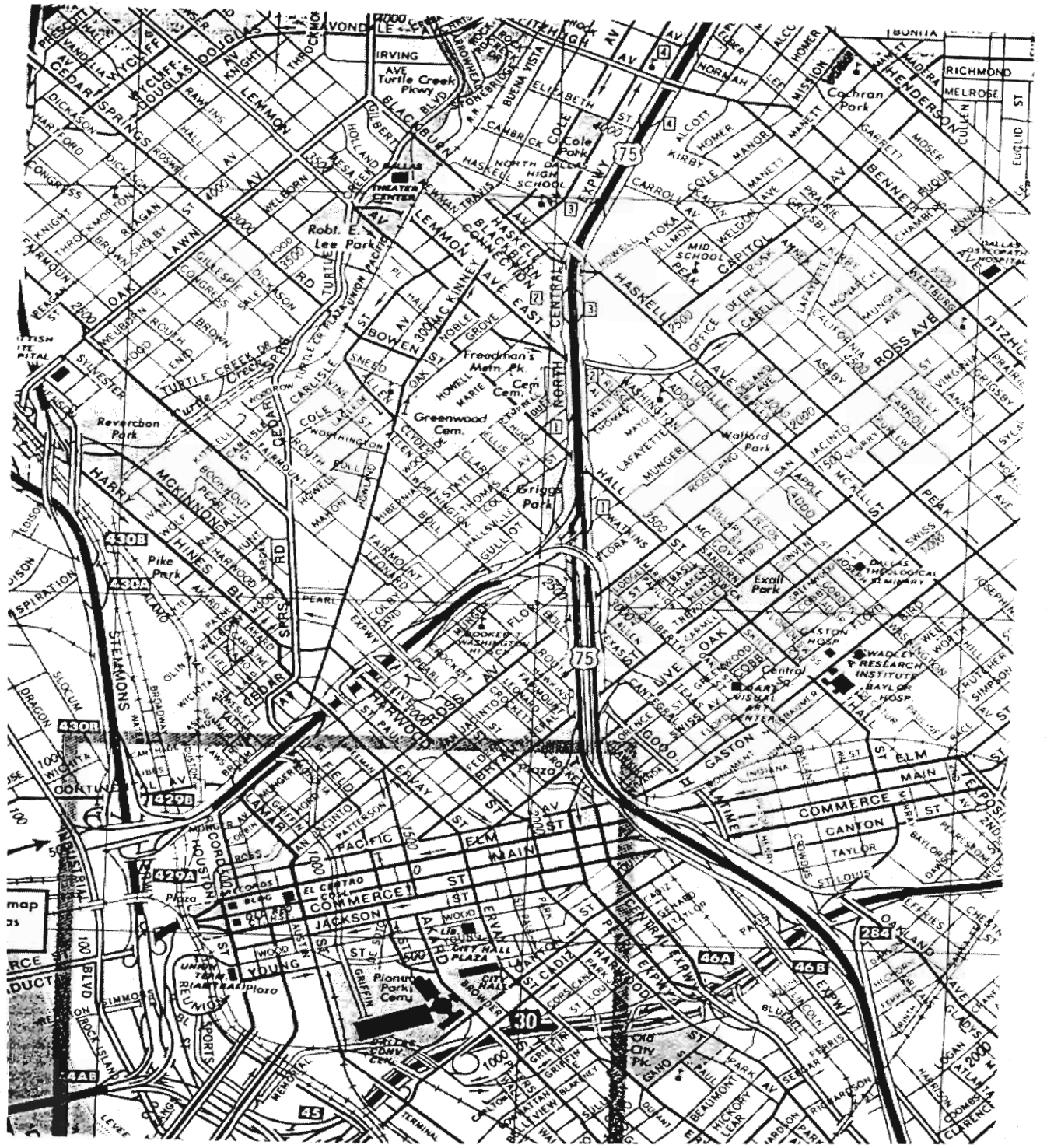


**Figure 15. The recommended scheme of photo radar installation and covered zones.**

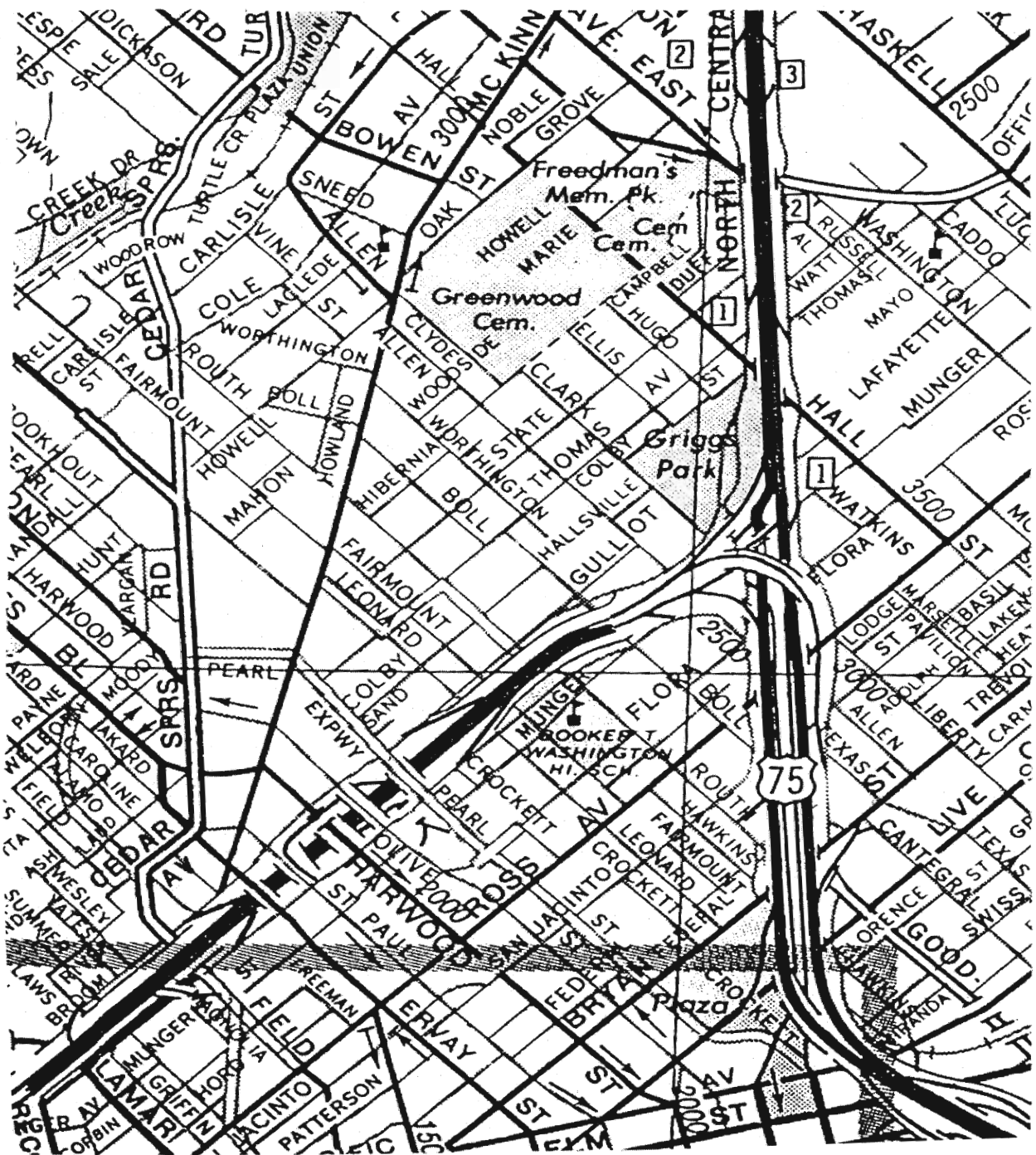
## REFERENCES

1. "Manual on Uniform Traffic Control Devices for Streets and Highways," U.S. Department of Transportation, Federal Highway Administration, 1988.
2. "Texas Manual on Uniform Traffic Control Devices for Streets and Highways," Texas Department of Transportation, 1980.
3. "A Policy on Geometric Design of Highways and Streets," American Association of State Highway and Transportation Officials, 1994.
4. "Highway Capacity Manual," Transportation Research Board, National Research Council, 1995.
5. R. Lamm, B. Psarianos, T. Mailaender, "Highway Design and Traffic Safety Engineering Handbook," 1999.

**Appendix 1. Street Map.**



Street Map



Detail Area

**Appendix 2. Aerial Photograph.**

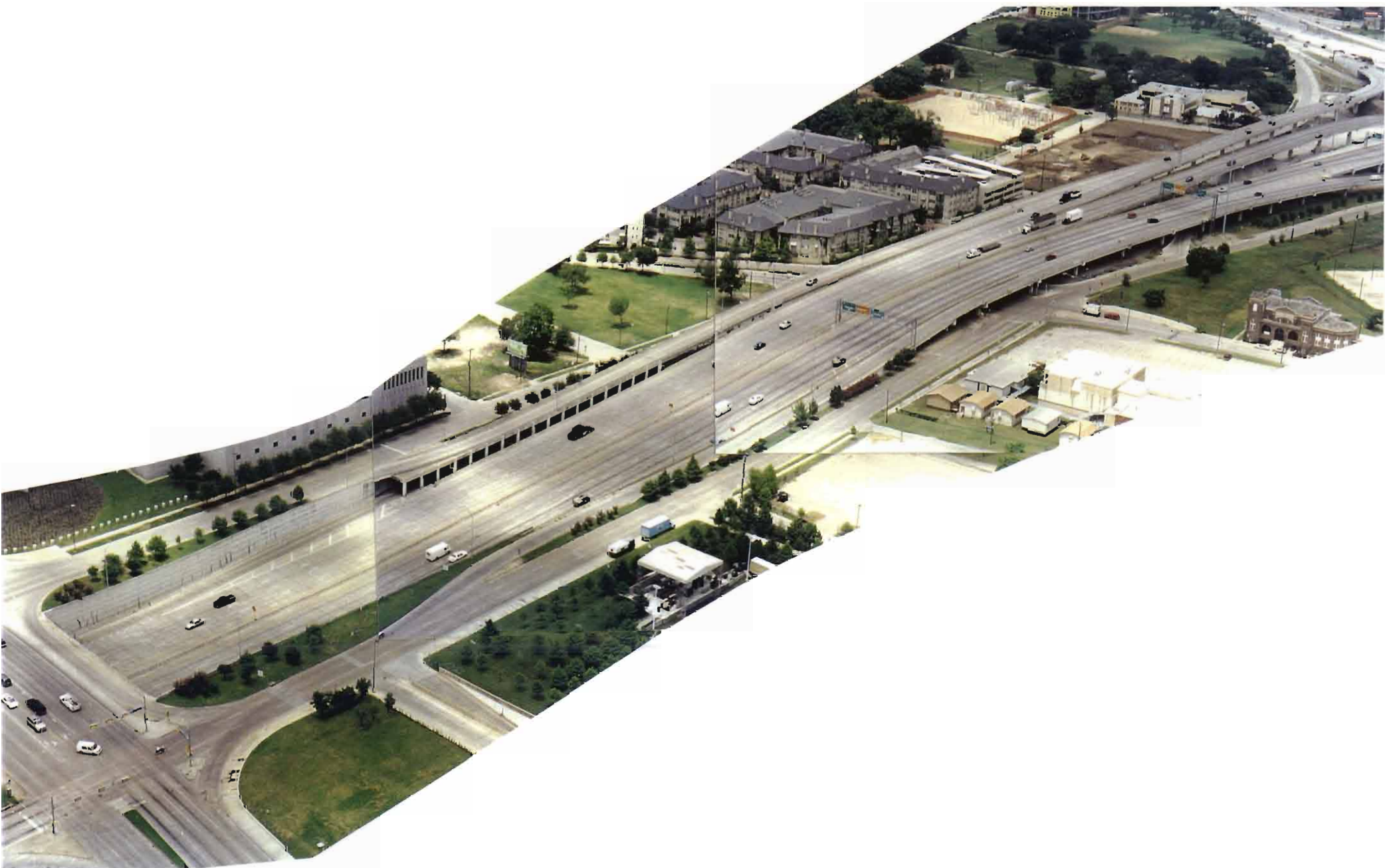
A PDF of Appendix 2: Aerial Photograph (a foldout feature of the original report) can be downloaded from:

[http://library.ctr.utexas.edu/digitized/IACreports/IAC-98-0003\\_app2.pdf](http://library.ctr.utexas.edu/digitized/IACreports/IAC-98-0003_app2.pdf)

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**Appendix 3. Panoramic View of the Investigated Highway Section.**





**Appendix 4. Photos.**



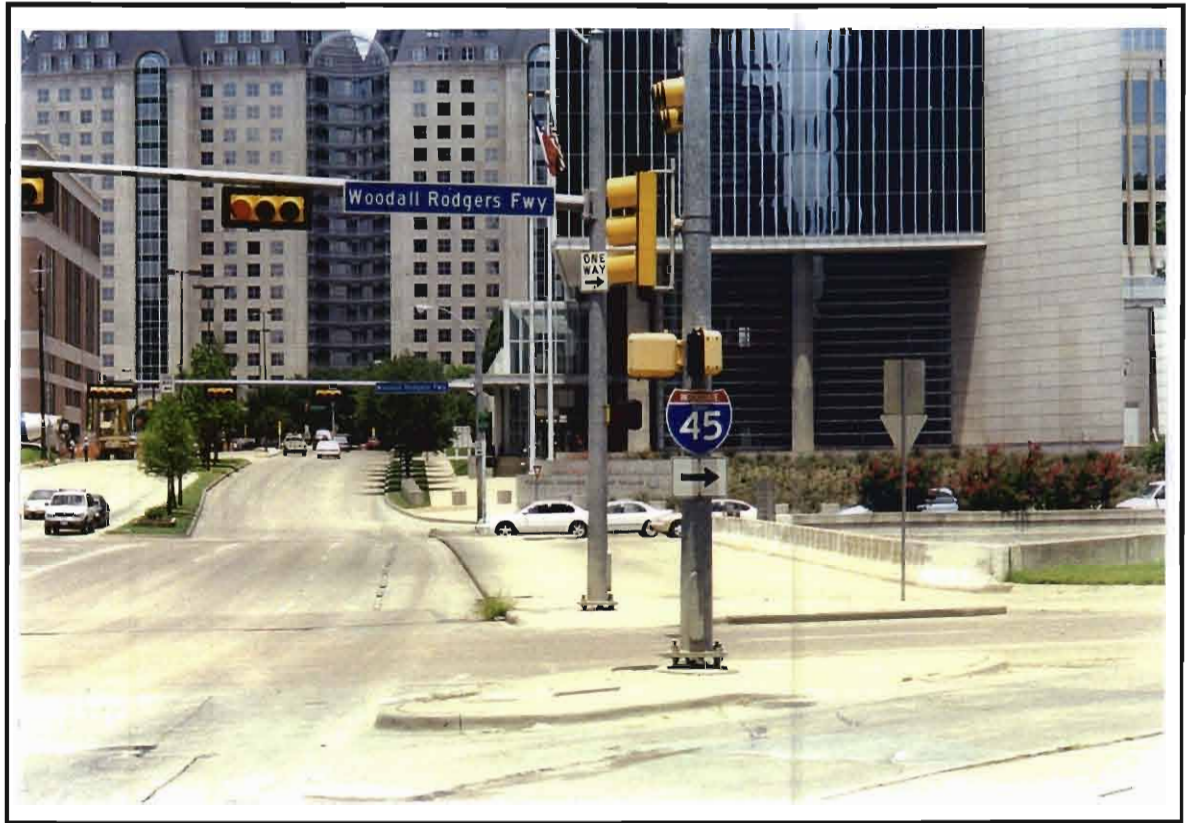
**Photo 1. Photo showing unsafe driver maneuver (note red vehicle).**



**Photo 2. Trammell Crow Center. Video camera was located on the balcony of the 47<sup>th</sup> floor.**



**Photo 3. Detour notice on Pearl Street (directed to traffic coming from Flora Street and heading towards Woodall Rodgers Freeway).**



**Photo 4. Existing road signs at the intersection of Pearl Street and frontage road of Woodall Rodgers Freeway (directed to traffic coming from Flora Street).**



**Photo 5. Existing road signs on the frontage road of Woodall Rodgers Freeway (before Pearl Street entrance ramp).**



**Photo 6. Guide sign on the frontage road of Woodall Rodgers Freeway (before Pearl Street entrance ramp).**





**Photo 7. Existing road signs in front of Pearl Street entrance ramp.**



**Photo 8. View of guide signs above Woodall Rodgers Freeway (view from Pearl Street entrance ramp).**



**Photo 9. Detour notice on Pearl Street (directed to traffic coming from Howland Street and heading towards Woodall Rodgers Freeway).**



Photo 10. Existing road signs at the intersection of Pearl Street and frontage road of Woodall Rodgers Freeway (directed to traffic coming from Howland Street).