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16. Abstract

Traffic incidents on Texas' urban highways are becoming an increasing source of delay, congestion, safety problems, and poor air quality. An effective incident management program can significantly reduce the effects of incidents on freeways. Many incident management strategies are dependent upon some aspect of geometric design. For example, the travel time required for emergency vehicles to reach the site of the incident is affected by accessibility to the incident. Providing freeway features such as emergency cross-overs, median barrier gates, or refuge areas may enable emergency personnel to respond to the incident in a more safe and timely manner.

The objective of this research project was to develop geometric design guidelines to accommodate incident management strategies. The research team's approach to this project included a review of existing literature, a survey of those involved in incident management, and on-site visits to existing locations that have implemented certain incident management strategies. Results from these efforts are combined with existing geometric design principles to develop guidelines for accommodating incident management strategies.

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FACILITATING INCIDENT MANAGEMENT STRATEGIES ON FREEWAYS

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DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the opinions, findings, and conclusions presented herein. This project was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration (FHWA). The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation, and is not intended for construction, bidding, or permit purposes. The engineer in charge of this project was Mark D. Wooldridge (TX-65791).

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CHAPTER 1
INTRODUCTION

Incidents are a major cause of concern to today's transportation manager. An incident is any nonrecurrent event which causes reduction of roadway capacity or abnormal increase in demand. Predictable incidents include roadway construction, scheduled maintenance activities, and special events (concerts, sporting events, festivals, etc.). Incident management activities at predictable events mostly involve on-site traffic control and the dissemination of motorist information. Unpredictable incidents include disabled vehicles, traffic accidents, and inclement weather. In addition to on-site traffic control and dissemination of motorist information, incident management activities at unpredictable events also require detection, verification, and activation of emergency personnel to provide care to the injured and clear the roadway (*1*).

Every day, traffic incidents impede mobility on urban, suburban, and rural highways. In Texas cities during 1992 alone, incidents were the source of more than 450,000 hours of delay, costing the motoring public approximately $2.45 billion. As a result, it costs substantially more for the traveling public to use these roads. Additionally, nonrecurrent congestion due to an accident, stalled vehicle, or spilled load leads to unexpected delay and magnifies driver frustration. Incident-caused congestion may also lead to secondary accidents by causing unexpected stops or slowdowns. In Minnesota, 13 percent of all peak period accidents on one Minneapolis freeway were caused by a previous incident. Another problem generated by an incident is the danger to motorists, police officers, and other response personnel who are out of their vehicles due to the incident. Studies have shown that 20 to 30 percent of freeway pedestrian fatalities are the result of motorists wandering away from disabled vehicles to obtain mechanical assistance (*1*).

Incident management includes the spectrum of activities involved in detecting, responding to, and clearing roadway incidents. It requires the coordinated, preplanned use of human and technological resources to restore full capacity to a roadway after an incident occurs and to provide motorists with information and direction until the incident is cleared. Incident management programs vary widely in cost and sophistication, but they all share the following common elements: detection, verification, response, removal, traffic management, and information to motorists (*2*).

A number of factors determine the magnitude of incident-caused delay, which is represented by the shaded area in Figure 1-1. Only some of these factors can be influenced by freeway incident management techniques; other factors, such as the freeway's capacity and demand flow, are generally fixed by external environmental circumstances such as the number of lanes and the time of day. Two factors that *can* be influenced by incident management techniques are the reduced capacity past the incident and the incident's total duration. Effective, on-site traffic management techniques optimize the use of whatever freeway capacity remains after the incident. Another factor influencing total delay is the time from the moment the incident occurs to the time it is cleared from the roadway. This time interval is the sum of the detection, response, and clearance times, as shown in Figure 1-1. Minimizing any of these times through efficient incident management will result in less total delay. Therefore, incident management programs need to focus on the:

- time to detect incidents,
- time to identify the nature of an incident,
- time to respond with appropriate personnel and equipment to deal with any particular incident,
- time to clear the incident and restore roadway capacity, and
- traffic demands during the incident by instituting a variety of traffic management measures.

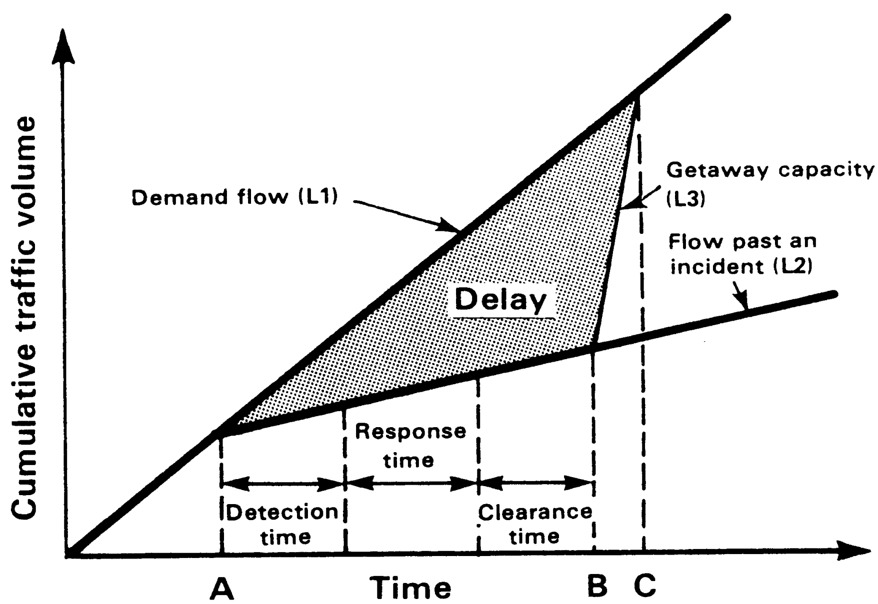

Figure 1-1. Quantifying Incident Delay (*1*).

Reducing emergency vehicle response times has a huge impact on time and cost savings. Table 1-1 illustrates the typical capacity reduction for four types of incidents. The capacity reduction may increase to 100 percent if all lanes in one direction are blocked by an incident (*2*).

Table 1-1. Typical Capacity Reduction (*2*).

Incident Type	Capacity Reduction (Percent)
Normal flow (three lanes)	—
Stall (one lane blocked)	48
Noninjury accident (one lane blocked)	50
Accident (two lanes blocked)	79
Accident on shoulder	26

The amount of roadway capacity available around the incident scene is a contributing factor to the severity of nonrecurrent congestion. As illustrated in Table 1-2, incidents reduce roadway capacity at levels far greater than the physical reduction in lane space. A traffic accident that blocks only the roadway shoulder can reduce capacity on a three-lane road roadway by nearly 20 percent, while an accident that blocks just one lane reduces capacity by almost 50 percent. The disproportionate reduction in roadway capacity is primarily caused by driver tentativeness and inquisitive behavior (rubbernecking) when traveling past the incident scene (*1*).

Table 1-2. Percentage of Freeway Capacity Available under Incident Conditions (*1*).

Number of Freeway Lanes in Each Direction	Shoulder Disablement	Shoulder Accident	Lanes Blocked		
			One	Two	Three
2	95%	81%	35%	0%	n/a
3	99%	83%	49%	17%	0%
4	99%	85%	58%	25%	13%
5	99%	87%	65%	40%	20%
6	99%	89%	71%	50%	25%
7	99%	91%	75%	57%	36%
8	99%	93%	78%	63%	41%

Incident statistics show that nearly 80 percent of all recorded incidents are attributable to disabled vehicles. Eighty percent of these disabled vehicles are on the shoulder for an average of 15 to 30 minutes where they cause 100 to 200 vehicle-hours of delay during the peak periods. The remaining 20 percent of disabled vehicles break down in the main lanes where they block traffic for an average of 15 to 30 minutes and cause 500 to 1000 vehicle-hours of delay during peak periods (*1*).

The objectives of this research were to identify geometric features which facilitate incident management and to provide guidelines for utilizing these techniques. The approach included a state-of-the-practice literature review of incident management techniques, a written survey of designers and emergency service personnel, on-site visits to agencies and locations that have implemented certain incident management strategies based upon survey results and suggestions of project panel members, and documentation of the findings. Survey design and results are discussed in Chapter 2. The six most frequently used techniques related to geometrics are discussed in Chapters 3 through 8. Chapter 9 is a summary of other incident management techniques which were investigated but were found to have limited use. Chapter 10 is a summary of the recommendations for use of incident management techniques related to geometrics. The Appendix contains copies of the survey forms for city and state agencies and for emergency response personnel.

REFERENCES

1. *Incident Management in the United States: A State-of-the-Practice Review* for Korea Road Traffic Safety Association. Final Report. Texas Transportation Institute. November 1997.
2. *Freeway Incident Management Handbook.* Report No. FHWA-SA-91-056. U.S. Department of Transportation, Federal Highway Administration. July 1991.

CHAPTER 2
SURVEYS

SURVEY SAMPLE AND ADMINISTRATION

A survey was mailed to 158 city and state transportation agencies and fire, police, and other emergency response agencies in the larger cities within the United States. The survey was used to identify incident management techniques that are being used successfully along with the corresponding geometric requirements needed for the techniques to work effectively. The survey requested information on response techniques that the agencies use, have seen in use, or believe would be effective in decreasing the response time to freeway incidents.

SURVEY FORMAT

The survey questions were designed to determine the types of incident management techniques that responding agencies use or have seen used and to determine which techniques work effectively for emergency response personnel. Additionally, respondents were asked to provide information about their system for locating incidents and the issues they believe to be important relating to incident management.

A copy of the survey is included in the Appendix, and survey responses are summarized on the following pages.

PHONE INTERVIEWS AND ON-SITE VISITS

Researchers conducted phone interviews as a follow-up to the written survey. The interviews provided additional information about specific incident management techniques identified in the written surveys. They were also used to identify locations for on-site visits. Additional phone calls were made to agencies where incident management techniques were known to be in place.

Phone interviews were informal, focusing on the experiences of the agency being contacted. The issues addressed included the location, date of installation, and the pros and cons of the techniques. Phone interviews were also used to set up meetings and to obtain contact names for other agencies that could provide information about the incident management technique being studied. Researchers attempted to include a representative of the agency responsible for the design of the incident management technique and representatives from emergency response agencies, including police and fire, in each meeting. Towing company representatives also attended some of the meetings. Researchers conducted on-site meetings and/or made on-site visits in the following locations (Figure 2-1):

Figure 2-1.   Locations of On-Site Visits.

Documentation from the surveys, phone interviews, meetings, and on-site visits is included in the report. Photographs from the on-site visits are used to enhance the descriptions and experiences related to the incident management techniques.

SURVEY RESULTS

A total of 53 responses (30 percent) were received. Twenty-eight of these responses were from Texas; the other 13 states represented in the responses were Arkansas, California, Florida, Georgia, Illinois, Maine, Maryland, New Jersey, Nevada, Ohio, Rhode Island, South Carolina, and Wisconsin. Surveys were received from 28 city or state transportation agencies and from 25 emergency response agencies.

Question 1 was different for city or state design officials or transportation management center officials than the version used for emergency service personnel. The other survey questions were the same for all agencies. The survey results are summarized on the following pages.

City or State Design Officials or Transportation Management Center Officials

Question 1: Are you aware of problems with locating incidents on ramps or roadway in interchanges? Y/N If yes, please describe.

Table 2-1. Question 1. Part A.

<table>
<tr><th colspan="2">DESCRIPTIONS OF RESPONSES</th></tr>
<tr><th>YES: 14</th><th>NO: 8</th></tr>
<tr><th colspan="2">INFORMATION</th></tr>
<tr><td>• Bad information given to 911 operators.
• Calls from the public are least reliable. Our system does not have location problems.
• The basic problem is that the reporting party does not have an accurate description of the location and details of the accident/incident.
• Yes; accidents are typically called in by motorists via cellular calls to 911 or the highway patrol. Motorists are ignorant of their roads, locations, and directions.</td><td>• No lengthy description is used.</td></tr>
<tr><th colspan="2">LOCATION</th></tr>
<tr><td>• I am sure mistakes have been made referring to these locations due to direction (N, S, etc.) configuration.
• I am aware of problems locating accidents or incidents on other facilities.
• Wrong location descriptions are often given when initial notification originates from passing motorists.
• If there is an incident at a location that is not a ramp, on or off of the freeway, but is merely an over crossing or under crossing or a bridge it is difficult to give an easily discernable location to motorists.
• Yes. Ramp and reference markers have been valuable in locating stranded motorists and those in need of emergency medical assistance. Area dispatchers would receive multiple calls about the same incident, often with conflicting data prior to the marker installation.
• Yes. On interstate freeways it is sometimes difficult to identify milepost location.
• There have been problems at US 183 and Loop 1 as well as Loop 1 and US 290. The 1st and 5th Street areas on Loop 1 may also be a problem area.</td><td>• Have not had any significant problems with locating incidents.</td></tr>
</table>

Table 2-1. Question 1. Part A (continued).

SOLUTIONS	
• The report of incident locations are entered into a computer-aided dispatch system. This system is driven by locations and provides accurate information to identify ramps and interchanges. • Yes; this issue was recently discussed with the County's 911 dispatch counter personnel regarding several complex interstate interchanges in the Fort Lauderdale area.	

Does your agency have a system for labeling or identifying specific ramps or roadways in interchanges? Y/N. If yes, please describe.

Table 2-2. Question 1. Part B.

Yes: 13	No: 11
Descriptions of Systems	
ACCIDENT SYSTEM	
• Only for accidents when they are recorded into the accident database. No labeling or identification is assigned prior to this.	
DIRECTIONAL SYSTEM	
• Our system is the only one I am aware of that labels ramps as per the direction and location of each ramp (i.e. WB IH-10 connector to SB West Loop). • Usually with multiple ramps, we label them such as IH-95 NB @ Ramp to SB MD 214, IH-95 SB @ Ramp from WB MD 214. We also include this type of logic when doing our CD roadways. • None other than (IH-20) Eastbound entrance ramp from Broad River Road, as an example. • Not numbered. We just use "Eastbound to Northbound IH-8 to 163 direct connector ramp." Of course, the public would not usually have it that precise. • We use a system of acronyms which describe the point of origin. The direction and destination of traffic on each section of roadway or ramp; we also use tenth of a mile markers.	
LETTER DESIGNATION	
• Mile markers and certain ramps in a four level interchange as ramps as A, B, etc. • TxDOT standard conventions: (1) During design–interchange label "A," " B," or "AA;" (2) signing–exit/entrance use mile marker number: Exit 28; (3) operation personnel sometimes use nicknames such as "ski jump."	

Table 2-2. Question 1. Part B (continued).

MILE POST MARKERS
• Yes. Mile post markers and signing. • The name of the street or ramp or a post mile cross reference if the ramp or roadway is identified with a post mile. • Yes. Not in interchange per se. We have used 10th of a mile markers with a letter designated direction attached to the median barrier wall around a three-mile freeway loop. • We use mile post markers.
NO SYSTEM
• No specific names/labels other than the technical, functional name. • Not ramps, but all overpasses over all the interstate roadways are labeled with their name and route numbers (when applicable).
RAMP AND REFERENCE MARKERS
• Yes; we (FDOT District 4 Operations office) have installed (blue and white) ramp identification signs at several interchanges but are uncertain as to their effectiveness in identifying incident locations. • Yes. ARTMIS has federal highway approved $ to perform operational tests of ramp and reference markers. Blue and white signs are posted along the median and on the entrance and exit ramps. The signs are positioned every 1/10 mile. • Ramp numbers are used.

Emergency Response Agencies

Question 1. What types of incidents does your agency typically respond to on freeways? Please estimate the percentage of each type of response.

Table 2-3. Question 1 of Emergency Response Agencies.

Type of Incident	# of Agencies Responding to this Type of Incident	# of Agencies NOT Responding to this Type of Incident
Debris on road	8	15
Fatal crashes	16	13
Injury crashes	16	10
Property damage only crashes	11	13
Hazardous chemical spills	14	11
High water/Snow/Ice	12	13
Stalled vehicle/Mechanical breakdown	7	17
Vehicle fires	14	11
Overturned vehicles	14	11
Other: Routine patrol/Proactive enforcement	1	-
Other: Crimes in progress	1	-

Question 2: Please give one or two locations where you have seen the following techniques on urban freeways, and comment on the effectiveness of the technique.

Table 2-4. Question 2. Part A. Accident Investigation Sites.

Accident Investigation Sites: Designated areas located adjacent to the main travel lanes that provide motorists and police with a site to relocate damaged vehicles, complete accident reports, and place necessary phone calls. **Where have you seen this used?**		
	Successful	**How could it be used more effectively?**
INTERSTATES		
• Houston Freeways • Houston, Texas major freeways • Fort Worth Freeways (IH-30, IH-35W) (4 responses)	No Yes No	• Not a good idea, cannot provide spaces for all needs. Police want easy access of freeway, and unpredictable where accidents occur. Also safety issue: light, phone not accessible.
• IH-35 from 610 N to BW8N Houston, TX	No	• Need acceptance from law enforcement public information campaign.
• IH-45 Gulf	Unsure	• Need more of them. Public education.
• IH-45 North outside of central Houston (3 responses)	No	• In undesirable, unsafe neighborhood.
• HOV lane on 635 between US 75 and IH-35 (2 responses)	No	• Remove them from Interstates.
• US 95 N in Las Vegas	Unsure	• Only one type area exists. It needs to be larger.
• Freeways by C.H.P. M.A.I.T on major events	Yes	• Education (more) to police personnel and the public of the benefits; make police agencies use these sites with greater frequency.
• IH-270 CD, Mainline Montgomery County	Yes	• Where possible, police/other vehicles turn off lights to reduce rubbernecking/slowed traffic.
• Loop 610/290	Yes	• Educate public of intended use.
• Interstates IH-75 and IH-20, IH-85 in Atlanta City Limits	No	• By educating motorist through media campaign about utilizing these areas for Atlanta investigations.
• Many locations on IH freeways initiated in 1974	Yes	• Telephone service is a must. Security a problem. Must be well located and open.
• Interstates	No	• Used on by-pass around city-lane limits areas.
• During the widening of IH-10 in El Paso District	Yes/No	• It worked very well. Avoiding stalled accident vehicles.
• Between Austin & Round Rock on IH-35	Yes	• Move vehicles quicker and at more locations.

Table 2-4. Question 2. Part A. Accident Investigation Sites (continued).

STATES AND CITIES		
• Chicago, Illinois (3 responses) • St. Louis • Fort Worth • Georgia • San Antonio • Other cities • Other states • Charlotte, North Carolina	Unsure Yes No Unsure Unsure Unsure Unsure	 • Pull off zones. • Have not seen in action. • They need to be signaled and preferably lighted, and info campaign should promote use of the AIS with law enforcement.
NOT SEEN		
• None in Houston • None in Fort Worth • Have not seen them (9 responses) • NA but planned trying ROW cost (2 responses)		 • Not cost effective to establish designated areas for this purpose. • Put out of view of mainlanes (rubbernecking); trees/berms.

Table 2-5. Question 2. Part B. Contraflow Lanes.

Contraflow Lanes: Temporary reconfiguration of the freeway corridor to allow for diversion of impacted traffic to opposing freeway lanes. **Where have you seen this used?**		
	Successful	**How could it be used more effectively?**
STATES AND CITIES		
• MD 2/4-Calvert County; MD-2, Anne Arundel County	Yes	• More police involvement; better advance signing for unique traffic problems.
• Houston Pre-HOV system	Yes	
• Dallas	Yes	
	No	• (1) By the time shoulders and room for barrier are provided, two lanes could be installed permanently in each direction. (2) Limited shoulders do not provide emergency room to pull off in case of flat or other car trouble.
• Dallas District	Yes	
• Have seen only as part of traffic control plan and not temporarily due to incidents (Houston)	Yes	
• Houston, Arlington	Yes	• Physical barrier between traffic could make drivers feel safer.
• Not applicable in the Sacramento area; temporary reconfiguration is used in other areas of the state, such as the Bay Area and San Diego Area		• Not applicable.
• Boston (unsure); Chicago (Y); Wash D.C (Y); Minn, St. Paul (Y); New York-Tappan Zee Bridge (Y); Philadelphia-Ben Franklin (Y)		• Currently underutilized.
OTHER		
• [No comment]	No	
• I have seen this used.		
• The configuration of the ramps makes this potentially dangerous. Will open HOV lanes or reverse their direction as needed for incidents.	Y, Y	• This is performed on an as needed basis with TxDOT and Metro cooperation. • This is not a good idea on a high speed route for incidents unless the incident will last more than one day. If a long duration incident has occurred, this would take a large amount of support of advance warning of the event and an undivided highway. • Much needed.

Table 2-5. Question 2. Part B. Contraflow Lanes (continued).

AREAS		
• Frequently, one lane per direction. • Long term construction projects on freeways. • During consideration; occasionally on non-divided four-lane roadway.	Yes Yes Y,Y	• I think they are as effective as needed now • Use on shorter term projects. • Use of 6" LTC Screening Barriers.
INTERSTATES		
• Near the Las Vegas Strip/construction of IH-15 N Downtown Las Vegas • IH-30, IH-20 Tarrant County • Ad hoc now crossover and cones; 95-main to HOV (same direction) • East RLT Fwy; North LBJ Fwy • Interstate IH-65 • (1) IH-45 in Houston (2) Golden Gate Bridge (PA) (3) Texas Motor Speedway near Ranger Station, Harlingen • On extremely rare occasions, we have used this on the New Jersey Turnpike to relieve traffic congestion at an accident site which took more than the usual amount of time to clear • (1) N & S IH-5 at City (2) Drive during construction	Yes Yes Yes Yes Yes Yes	• We could not see any better solutions. • Plan in design of roadway; use only in total shutdown IH-95 in LTS to slow down traffic (fire truck). • Poor design, dangerous. • This method of traffic mitigation is recommended only as a last resort.

Table 2-5. Question 2. Part B. Contraflow Lanes (continued).

NOT SEEN		
• I have not seen this used. I have seen areas set up for this use but has not been enacted.	Unsure	• Gates that are used to shift traffic have to be cleaned and maintained on a regular basis. Need to coordinate agencies.
• [No comment]	No	• Much needed.
• Not used; vehicles routed off freeway to surface streets		
• None		
• Nowhere	Unsure	• This would require great care. A detour route, if available, would be better.
• N/A		
• None in Houston		
• N/A		
• No, I have never seen it used		
• Have seen contraflow lanes, but have not seen them used for incidents	Unsure	
• Never have this reconfiguration before	Unsure	
• Never		
• N/A		
• None		
• N/A		
• Not applicable— concrete medians		
• Do not recall ever seeing this	No	
• N/A	Unsure	
• None used in this district—Ft Worth		
• Not on freeways		
• None		
• On a short term duration incident, 24 hours or less, I have not seen this technique used.		
• N/A		
• I have not seen this done in Florida	N/A	
• Have not seen this used on freeways		• We have median barriers to prevent cross-median, head-on accidents.

Table 2-6. Question 2. Part C. Emergency Crossovers.

Emergency Crossovers: Designated gaps in freeway medians, intended for use only by emergency vehicles to improve response times on freeways where the distance between interchanges is substantial. **Where have you seen this used?**		
	Successful	**How could it be used more effectively?**
STATES AND CITIES		
• Chicago • Ohio, Kentucky and many other states	Yes	• (1) Useful for emergency vehicles; must be signed as such. (2) Down side is unauthorized use by the public, causing accidents and raising liability issues.
• North Carolina on a limited basis	Yes	• Should be.
• Possibly Ga or Ohio, North Carolina	Yes Yes	• More gaps; allow public safety agencies more input on locations in Dallas area.
• St Louis, Missouri and St. Charles, Missouri	Unsure	• Needed on No. Central Expressway in our city.
• Dallas area	Unsure	• Would facilitate emergency equipment: easier/faster response to scene.
• Old Dallas/Ft. Worth toll road	Unsure	
• Houston Tollway		
EMERGENCY		
• To evacuate traffic; poor control; public uses	No	• Larger turning radii speeds fire engines; cruisers can't see over tall walls.
• We utilize emergency crossovers and official grade separated U-turns for emergency vehicles.	Yes	• Greater effectiveness could be achieved if all of the U-turns were grade separated.
AREAS		
• Mountainous and rural areas	Yes	• I think they are as effective as needed now.
• SAT district	Yes	• No change necessary.
• S. Eastex @ McGowen	Yes	
• Numerous areas	Yes	• Successful for intended means but cause danger when used illegally by non-emergency persons.
• In multiple rural areas; generally for use by emergency and law enforcement	Unsure	• Rarely used, as they must be monitored for safety.
• Several urban locations in Houston have retractable barrier gates to create emergency openings.	Unsure	
• Rural areas	Unsure	

Table 2-6. Question 2. Part C. Emergency Crossovers (continued).

NOT SEEN		
• Not used in our area • None • N/A • Have not • None in Houston • Have not seen this configuration. Not applicable in metro Atlanta because of concrete barrier walls		• Questionable about safety. • Would be effective in reducing response time to emergency situations by up to 10 minutes.

Table 2-7. Question 2. Part D. Emergency Gates.

Emergency Gates: Gates in median rail accessible only to emergency personnel to provide access during incidents. **Where have you seen this used?**		
	Successful	**How could it be used more effectively?**
STATES AND CITIES		
• Houston HOV system (2 responses) • Houston Tollway • Dallas areas (2 responses) • Chicago	Unsure Unsure Unsure Unsure	• Questionable about reliability when needed. Also, would emergency vehicles get to site on the left shoulder after cross median gap?
INTERSTATES		
• US 50/MD 2, Anne Arundel County • EBE50, Rowe Blvd and Md Rt Richie Severn Bridge (or remove barrier) • IH-45N gates for access to HOV lanes • IH-45S for crossover access on Galveston Island Causeway • IH-610EL on Ship Channel Bridge • The section of US 183 north of great hills • Toll roads IH system • Access on IH-30 w/o gate	Unsure Unsure Unsure Unsure Unsure Unsure Yes Yes	• Not used to date. Working on guidelines for usage and MOU between police/SHA for operations. • Need the ability to open and close the gates remotely with CCTV surveillance. • Reverse flow to incident by tow trucks. • Good idea. Gate has to be automatic; otherwise, it may require added time that emergency crew may not have.

Table 2-7. Question 2. Part D. Emergency Gates (continued).

MISCELLANEOUS		
• Emergency gates in HOV lenes • None on normal freeways–only in unique circumstances • Turnpike uses emergency gates to speed access for fire or first aid responders	Unsure Yes Yes	• Sometimes successful if emergency vehicle can get to gate quickly and gate operates correctly. • We use motorcycle access points and emergency vehicle access removable barrier panels on the IH-15 HOV express lanes (reversible). • Since the emergency gates can present a breach in toll security, it would be more effective if they were automatically operated by only emergency responders.
NOT SEEN (26 responses)		
	Unsure	• Sounds dangerous if responders have to stop flow of traffic; if these gates used, use a knox lock.

Table 2-8. Question 2. Part E. Emergency Pull-Off Zones.

Emergency Pull-Off Zones: Designated areas, typically provided alongside roadway sections with little or no shoulder width, that provide sites for the temporary relocation of damaged or broken-down vehicles. **Where have you seen this used?**		
	Successful	**How could it be used more effectively?**
INTERSTATES		
• Freeways w/contract tow trucks to remove from roadways	Yes	
• PA Turnpike; 168 for trucks at top mountain for trucks		
• In construction on IH-35	Yes	
• All freeways	No	• Increase width for safety of personnel and civilians occupying space.
• All interstates	Yes	• Make lanes bigger, if possible.
• IH-75, 85, 20	Yes	• Educating the motorist.
• US-290 EB at Mason Road	Unsure	• Never seen it used. Signing should be provided and lighting for safety.
STATES AND CITIES		
• Chicago, Illinois (2 responses)	Yes	• Used to drag off debris/vehicles from major lane-blocking incidents (trucks, trailers, etc.). Push spilled load to this area, and make recovery after rush hour.
• Madison, Wisconsin		
• St. Louis		
• Houston and Fort Worth	No	• Location is a problem in our area. The police should be involved in the design of those in order for them to accept them and use them.
• Los Angeles		• These are used where the shoulder has been converted to traffic lanes.
• North Carolina	Unsure	• Must sign zone and in advance of zone.
• Boston: route on Cape Cod		
• Massachusetts utilizes these “cutouts” in various locations where breakdown lanes are used as travel lanes during peak periods and where no breakdown lane exists on roadway	Yes Yes	
NOT SEEN (20 responses)		

Table 2-9. Question 2. Part F. Emergency Staging Area.

Emergency Staging Area: A specially designated area sometimes used near high-incident or other critical facilities (bridges, tunnels, etc.) for the parking of towing and recovery equipment. **Where have you seen this used?**		
	Successful	**How could it be used more effectively?**
INTERSTATES		
• IH-10 at Trinity • IH-95, 895 Tunnels, US 50 Bay Bridge	Unsure Yes	
STATES AND CITIES		
• Chicago (2 responses) • Virginia, Illinois • Houston HOV systems • Several locations in Northwest Dallas County • Throughout US	Yes, Unsure Yes Yes Yes Yes Yes	• Must be used, as they are still in existence. • TxDOT uses several locations to temporarily drum debris from accidents. This allows the roadways to be reopened faster. • I think this would be successful if TxDOT would accept and support them in the implementation of larger projects. • Provide funding to tow trucks.
SPECIAL EVENTS		
• Major special events at Texas Motor Speedway • Used during special events when large closures are required. Short duration	Yes Yes	• We need to find a way to have it available cheaper. • This is required of the event organizer.
INFORMAL		
• Nothing formal, but can overlap with accident sites • Not formal w/VDT		• Stage at ramp upstream of incident; good access and degrees.
NOT SEEN (29 responses)		
		• Good idea. Plenty of room at most interchanges.

Table 2-10. Question 2. Part G. Incident Equipment Storage Sites.

Incident Equipment Storage Sites: Designated storage sites typically located adjacent to roadway sections that experience high incident rates. They are stocked with common incident removal/clearance material and equipment. **Where have you seen this used?**		
	Successful	**How could it be used more effectively?**
INTERSTATES		
• IH-495, Prince George's County • IH-270, Montgomery County • IH-695/IH-83, Baltimore County • N. Central Expressway; E. Freeway		• On all of these examples, the sites were determined and set up at the time of the incident. We don't have pre-established sites. • Worked well.
STORAGE AREA		
• Looking into, but equipment spaced out at shops around area • TxDOT equipment is stored in the various maintenance section yards located around the district • An incident response trailer is stored at a Mass Highway Depot along Route 128. • Caltrans does not have specific roadside storage. However, the Transportation Management Teams respond to incidents and provide necessary equipment, such as cones and signing.		• Create a centrally located or several locations of designated response teams and equipment. This is cost prohibitive. • The TMT units are very useful in reducing congestion and secondary collisions.
CONSTRUCTION		
• Yes, in gore areas and near interchange at construction sites for freeway construction • Only for construction areas		
PATROL UNITS		
• On Courtesy Patrol units • Freeway service patrol on most interstates with towing capabilities		• Not sure it is a good idea to have these type of sites; they may be hit by out of control vehicles. How would this site be kept secure from vandalism? • Our freeway incident management team has looked into this — no locations have yet been identified.
NOT SEEN (27 responses)		

Table 2-11. Question 2. Part H. Incident Screens.

Incident Screens: Portable screens erected at major incidents to reduce onlooker delay. **Where have you seen this used?**		
	Successful	**How could it be used more effectively?**
INTERSTATES		
• IH-35 North - Sahara, Las Vegas	Yes	
CALTRANS		
• Caltrans uses portable message signs to advise motorists. The signs are mounted on trailers and can be rolled to an incident scene upon request. (2 responses)	Yes	• This is a very effective means of deterring subsequent accidents. It provides real-time information to the motoring public.
TRAFFIC		
• Traffic— hand held—limited use • Rubbernecking – responders can't see upcoming cars	No	• Portable, larger equipment.
OTHER		
• Only for construction • On various fatalities or major injury type of incidents where the body needs to be removed from the vehicle • On video clips for incident management	Yes Yes	• I'd like to see this more often.
NOT SEEN		
• None (31 responses)		• Stage these in storage areas similar to bike storage on college campus – lightweight and maneuverable. • Motorists would still want to slow down and see what is happening. • It requires CBT design with slots/hole on top. Good idea.

Table 2-12. Question 2. Part I. Tall Concrete Barriers or Concrete Barriers with Glare Screens.

Tall Concrete Barriers or Concrete Barriers with Glare Screens: Concrete barriers that separate directions of traffic and reduce headlight glare. The barriers may also reduce onlooker delay. **Where have you seen this used?**		
	Successful	**How could it be used more effectively?**
INTERSTATES		
• IH-695, Baltimore County • 695 Exit 3 • N. Central Expressway • All interstates • IH-10 and US 54 • IH-20, 30 and IH-35 W • IH-30 around Oakland Street • Construction on US 75 • IH-35 in Austin District • San Antonio District IH-35 • Various locations on Los Angeles freeways • Along both IH-95 and portions of IH-595 • On interstate facilities		• Need to test this operation more. • Works very well. • Somewhat helps the glare from opposing car headlights. High maintenance. Does not look pleasant. • This is a good idea; however, the cost would be twice as much to put up guard walls. If the screens were built with the guard wall, it would be very helpful. However, the maintenance would be very costly. • I believe the biggest drawback is the maintenance cost involved in maintaining the glare screen. • I would like to install milepost markers at 1/10 mile (approx) spacing panels but have not found a product/method as of yet. • The barrier can be made tall enough to serve as a barrier and glare screen.
STATES AND CITIES		
• Houston • California • Local Cincinnati area • Madison, Wisconsin • St Louis, Missouri • Northern cities • San Antonio • South and North Carolina-Charlotte • Dallas, Texas • Orange County • All states	Yes Yes Yes Yes Yes Unsure Unsure Yes Yes	• Business owners complain that a tall median barrier restricts contact to their potential customers; more to maintain. • Effective for glare control but of limited value in reducing “rubbernecking.” • Would significantly reduce on-looker delays. • Unknown. • Does reduce headlight glare from oncoming traffic. We installed several breaks in the glare screen to allow our emergency personnel to pass equipment and material across barrier wall. Proven ineffective: never used. • Repair them as needed more frequently.
NOT SEEN (11 responses)		

Table 2-13. Question 2. Part J. Temporary Ramps.

Temporary Ramps: Special roadway ramps that allow emergency vehicles to directly access the incident scene from adjacent frontage roads or cross-streets when no permanent entrance ramps exist. **Where have you seen this used?**		
	Successful	**How could it be used more effectively?**
LOCATION		
• Chicago	Yes	
• Informal; remote control gate TRC3 in state police headquarters		
• Maybe in Houston along sections of HOV lanes	Unsure	
• Used by buses for special events by Alamodome	Yes	
• “Motorist made” ramps when heavy congestion takes place, especially on rural highways	Unsure	• Under multi levels of directional interchange (mix master). There is space available for “Texas U-Turn” type.
• US 75 Forrest	Yes	• Put more in heavily congested areas.
NONE		
• Have not seen (37 responses) • Purposes currently exist. I am looking into the possibility of installing gates in limited access fencing to allow for emergency vehicles to cross.		• Would be very hard to control. • Weight and size of vehicle (fire). • Accidents are random events at ever-changing locations. We may use “wrong way” access with police escort to access the site.

Table 2-14. Question 2. Part K. Temporary Shoulder Lanes.

Temporary Shoulder Lanes: Provided that they exceed a minimum width, roadway shoulders can be used as temporary travel lanes during incidents or as an area to stage emergency vehicles in a manner that minimizes lane closures. **Where have you seen this used?**		
	Successful	**How could it be used more effectively?**
INTERSTATES		
• IH-20 and IH-30	Yes	• Start funneling traffic to the shoulder at a greater distance.
• Most freeways in Houston IH-19, Hwy 59, IH-45, Hwy 225, Hwy 288, IH-610	Yes	
• All freeways inside city limits	Yes	• More police officer participation.
• Interstate system; various places in state		• During design/planning stages of roadways and overlay projects; include upgrades of shoulder.
• Many freeways	Yes	• Very useful.
• IH-10 and US 54, SH 20, Loop 375, and FM roads, FM 3255	Yes	
STATES AND CITIES		
• Las Vegas	Yes	
• St. Louis, Missouri	Yes	
• Richardson, Texas	Yes	
• Several locations in Tarrant County	Yes	
• Various areas around Houston	Yes	
• Houston, Texas	Yes	
• In Virginia, back east		
• Charlotte, North Carolina	Yes	
• Cincinnati, Ohio	Yes	
• New Orleans	Yes	
	Yes	

Table 2-14. Question 2. Part K. Temporary Shoulder Lanes (continued).

MISCELLANEOUS		
• Signed for use in rush sometimes; CMS to allow in incidents (media) • Use of shoulder in incident—consistent between local roadways. Quickly used state turned marking on educating motorist (manuals and mailing) • All the time on roadways/wing cones at official • This is used but generally at the discretion of law enforcement and TxDOT response crews on scene. • Shoulders, where available and unobstructed, are the most useful. • Using shoulders as a temporary lane is used all the time. • As traffic volumes have continued to grow, we convert shoulders to travel lanes during certain construction activities.		• Lost for stops. • Okay, but used automatically—can't access site for emergency vehicles if someone breaks down. • The extensive use of raised pavement markers on freeway shoulders makes this a less than attractive alternative. The RPMs can cause damage or can cause motorists to lose control of vehicles. • Keep the shoulders clear of bridge rails and columns!! Keep the shoulders! • Requires a police presence to maintain order. • Because of the volume of traffic and proportion of commercial vehicles, the shoulders, which are not built to the same standards as the traveled lanes, experience some pavement unraveling or inlet grate failures.
NOT SEEN (10 responses)		
		• I would think this would work. Could be expensive ROW costs, construction costs. • Use for construction zones.

Table 2-15. Question 2. Part L. Other.

Other – Where have you seen this used?		
	Successful	**How could it be used more effectively?**
ARTMIS-Advanced Regional Traffic Interactive Management and Information System		
• Ohio, Kentucky, Indiana region, and local Cincinnati area	Yes	Although in its infancy, this system has been extremely helpful in identifying traffic congestion areas and accident locations.
Public Education		
• Don't block shoulder--blocks emergency vehicles • Move it–educate driver consistently and simple		• Ramp markings simple to understand and use
Quick access to sand and heavy equipment, like a front end loader		
N. Central	Yes	• Makes a big difference in many bad wrecks
Lane closures for long term construction projects. Remove lane delineation to encourage high speed merge		
• Southbound IH-35 at IH-20 construction project	Yes	• Use more often.
Use of Transguide lane control signals and changeable messages		
• In San Antonio and other cities ITS	Yes	
Georgia Dept. of Transportation HERO program (Highway Emergency Response)		
• Utilized in metro Atlanta for a few years. DOT HERO trucks scan police frequencies and respond to all highway incidents; carry emergency lights, barricades, equipment for clearing roadways	Yes, No	• Highly successful. Utilize more HERO trucks 24 hours per day; 7 days a week.
Cameras and Traffic Flow Monitors		
• No comment made		
Alternative Routes		
• Two people suggested; no location given		• Hard to predict incident unless a history of incidents. Alternative routes may not be needed if there is a large shoulder.

Table 2-15. Question 2. Part L. Other (continued).

Freeway Service Patrols		
• Most interstates/freeways in South Florida provide such patrols—typically from 6 AM-7PM Mon-Fri	Yes	• Use in-house personnel rather than provide towing companies, and continue to increase level of coverage to 24 hours per day, 7 days a week.
Miscellaneous		
• In North Carolina, we have a motorist assistance patrol that aids stranded motorists and usually helps get them off road in the case of emergencies. • Beyond geometric improvements, traffic engineers must focus on early incident detection and verification to improve response and reduce congestion. These techniques would include more frequent police patrols, highway operations patrols, CCTVs and automatic surveillance systems.	Yes	

Question 3. Once equipment is in the vicinity of an incident, are there roadway features or characteristics that make it particularly difficult to move emergency vehicles into position or remove other affected vehicles?

Responses included:

- An enclosed roadway (i.e., rail on each side) makes it more difficult but not impossible. If you have ROW available on one side, you have access to move incident off road.
- Use of courtesy patrol.
- No, tunnels can be.
- The traffic that is built up behind the crash scene inhibits approach from behind.
- Depending on location; some areas are very tight with no shoulders and no ramps to get quick access, but most of our freeways have good accessibility.

Question 4. If you were designing a freeway for improved incident response and faster clearing of traffic backups, which of these issues would be important to you?

Table 2-16. Question 4.

Issue	Important	Somewhat Important	Not Important
Accessibility to the scene from the opposing direction or frontage roads (barriers, grass medians, etc.)	39	9	1
Capacity of alternative routes	32	14	1
Changeable message signs and lane-control signals	36	11	0
Establishment of temporary exit ramps on freeway frontage road corridors	16	21	9
Fire hydrant/water accessibility	18	16	14
Location and frequency of access points	31	17	1
Reversal of traffic flow on entrance ramps to move blocked traffic	18	23	4
A system for labeling or identifying specific ramps or roadways in interchanges	25	10	7

Question 5. Do you have any other comments or suggestions?

Most of the respondents mentioned the following:

- Quicker accident clean up time.
- Adding surveillance cameras with a patrol to detect speeding.
- Fire hydrants present a problem if located near sound walls, vice versa.
- A comprehensive program that addresses incident management in a whole:
  - closed circuit T.V. cameras,
  - changeable message signs,
  - highway advisory radio,
  - reference and ramp markers,
  - freeway service patrol vans, and
  - telephone advisory travelers service.
- Communication with the media is important.

CHAPTER 3
EMERGENCY CROSSOVERS

DESCRIPTION AND INTRODUCTION

Emergency response time is a function of many factors, including traffic conditions along the emergency response route and emergency vehicle accessibility to the incident scene. An emergency vehicle approaching the incident scene from the opposing direction of travel on a limited-access facility has to travel beyond the incident to the next interchange, turn around, and proceed back to the incident scene, most likely through heavy traffic congestion. This situation not only lengthens the response time—it also delays the removal of the incident from the roadway, increases the potential for secondary accidents, and worsens the incident-induced traffic congestion.

Emergency or median crossovers are an incident management strategy designed to allow passage of emergency vehicles through designated breaks in the freeway median, thereby improving accessibility to an incident scene. These designated gaps in freeway medians are intended for use only by emergency vehicles to improve incident response times on rural freeways where the distance between interchanges is substantial. In addition, median crossovers can be used to accommodate "turn backs" and contraflow diversion of queued traffic upstream of the incident scene.

In the case of HOV lanes, barriers are often used to separate the HOV lane from the mainlanes. Limited access to the HOV lanes enhances smooth flow on the facility by eliminating conflicts with slower moving traffic on the adjacent mainlanes and by reducing use by unauthorized vehicles. In the event of an incident, however, limited access to the HOV facility impedes the ability of wreckers and other emergency equipment to access the site or to divert traffic to or from the lane. One solution to improve access is to provide emergency access gates at various locations on the HOV lane. Barrier gates can also be useful in concrete median barriers (CMB) for freeways without HOV lanes, allowing traffic to be re-routed in the event of a freeway-closing incident.

LITERATURE REVIEW

1994 Policy on Geometric Design of Highways and Streets

The 1994 *Policy on Geometric Design of Highways and Streets* includes criteria for the design of emergency crossovers (*1*). The policy suggests application of emergency crossovers only at locations with above-minimum stopping sight distance and separated by at least 1500 feet (457 m) from adjacent structures. The policy further suggests that emergency crossovers be depressed below shoulder level, have 10:1 or flatter side slopes, and provide sufficient width to allow for safe turning maneuvers. The policy warns against construction of emergency crossovers on restricted-width medians, particularly where the median width is insufficient to accommodate the design vehicle length.

Emergency crossovers on rural freeways are normally provided where interchange spacing exceeds 5 miles (8 km) to avoid extreme adverse travel for emergency and law enforcement vehicles. Between interchanges, emergency crossovers are spaced at 3-mile (5 km) to 4-mile (6.5 km) intervals. Maintenance crossovers may be required at one or both ends of interchange facilities, depending on interchange type, for the purpose of snow removal and at other locations to facilitate maintenance operations. Maintenance or emergency crossovers generally should not be located closer than 1500 feet (457 m) to the end of a speed change taper of a ramp or to any structure. Crossovers should be located only where above-minimum stopping sight distance is provided and preferably should not be located within curves requiring superelevation.

The width of the crossover should be sufficient to provide safe turning movements and should have a surface capable of supporting the maintenance equipment used on it. The crossover should be depressed below shoulder level to be inconspicuous to traffic and should have 10:1 or flatter side slopes to minimize its effect as an obstacle to uncontrolled vehicles. Crossovers should not be placed in restricted-width medians unless the median width is sufficient to accommodate the vehicle length, say 25 feet (8 m) or more. Where median barriers are employed, each end of the barrier at the opening may require a crashworthy termina (*2*).

1999 Highway Design Division Operations and Procedures Manual

The *1999 Highway Design Division Operations and Procedures Manual* (*3*) states that median crossings between the main lanes are sometimes necessary for proper law enforcement or for the performance of highway maintenance on rural freeways. The construction of such median crossings is not encouraged since the necessary U-turns by such vehicles should be accomplished by using ramps at interchanges to the maximum extent feasible.

Median crossings as turnarounds create safety concerns, interfere with through traffic, and should be avoided. Normally, the spacing of interchanges and layout of the highway provides for all necessary traffic movements, including those of emergency vehicles. In unusual situations, where the distance between interchanges is great, emergency crossings may be provided with administrative approval.

Due to the close spacing of interchanges on urban freeways, emergency median openings are not needed for the operation of official vehicles and, in general, they should not be provided. In rural areas where the spacing of interchanges is greater than 3 miles (4.8 km), a U-turn median opening may be considered at a favorable location about halfway between interchanges. In no case shall emergency median openings be spaced at less than 1 mile (1.6 km) intervals. All emergency median openings should be at least 0.5 miles (0.8 km) from any structure that crosses over a freeway and at least 1 mile (1.6 km) from any ramp terminal or other access connection, such as those serving as safety rest areas. Openings should be located where adequate stopping sight distance is available and where the median is sufficiently wide to permit an official vehicle to turn between the inner freeway lanes. Emergency median crossings should be as inconspicuous to the traveling public as possible.

The *Manual* states that the location and type of emergency median openings should be made a part of the Plans, Specifications, and Engineering (PS&E) as a contract item and installed as such.

Emergency Gates

Four types of emergency barrier gate designs were identified in the literature review: the TTI barrier gate, the EA BarrierGate, a removable barrier system developed by the California Department of Transportation (Caltrans) (*4*), and the REVLAC system of opening and closing reversible express lanes in Chicago. The TTI barrier gate is a manually operated gate that can swing open and closed, pivoting around one end. The EA BarrierGate (manufactured by Energy Absorption Systems, Inc.) uses a generator and motor for automated opening that allows the barrier gate to open from the middle, with both halves of the gate retracting over the CMB on either end. The barrier system developed by Caltrans consists of two 10-foot (3 m) precast concrete panels weighing approximately 2 tons (2000 kg) each which can be moved with the assistance of a large emergency vehicle. The Chicago Reversible Lane Control (REVLAC) system incorporates several types of advance signing, swing gates which rotate out of concrete barrier walls to direct traffic away from reversible lane entry ramps, and restraining barrier mechanisms which are deployed across entry ramps to safely stop errant vehicles before a wrong-way incursion into the reversible lanes.

A 1984 report by TTI (*5*) documented the development of a manual swing gate to accommodate emergency access onto the barrier-separated HOV lanes in Houston, Texas (*3*). This system consists of two 30-foot (9 m) long square mounted steel tubes placed on top of each other, separated vertically by 1.38 inches (3.5 cm), and mounted between two modified 30-foot (9 m) concrete median barrier sections. The gate is opened by removing a security pin at the downstream end and pushing the unit open with an emergency vehicle. The gate is closed through the use of a wench attached both to the gate and the emergency vehicles. Crash tests of the emergency gate system indicated that it exceeded minimum standards for redirecting errant vehicles.

A 1992 report by Caltrans also examined the use of emergency gates to accommodate crossovers on barrier-separated facilities (*4*). It consists of two 10-foot (3 m) precast concrete panels weighing approximately 2 tons (2000 kg) each. The removable section provides safety characteristics similar to a standard concrete barrier and can be moved with the assistance of a large emergency vehicle. Design policy in California recommends placement of the emergency openings based on the location of emergency response headquarters, availability of backup fire stations, availability of freeway ramps, distance to adjacent interchanges, and availability of alternate routes. The design policy also recommends no more than one median opening per mile (1.6 km) and no more than one opening between structures.

In 1994, the Texas Department of Transportation installed automated median barrier gates at five high-incident locations in the Houston/Galveston area (*5*). These gates, manufactured by Energy Absorption Systems, Inc., differ from other gate systems in several key areas. The gate is electrically driven, and responding personnel can open and close the gate by simply typing a password into the gate's keypad. The automated median barrier gate also differs from other gate systems in that it slides rather than swings open, eliminating a potential safety hazard. The gate device opens in the center, with the two halves sliding along inverted V-shaped tracks anchored to the ground. The gate meets the requirements of NCHRP 350 Test Level 3 and can be operated to create either 26 or 40 foot openings in less than 1.5 minutes.

The Chicago REVLAC system provides a new mechanized closure of entry ramps to the expressway's reversible lanes on the IH-90/94 Kennedy Expressway. The system has been in successful operation since major expressway reconstruction was completed in 1994. The system incorporates several types of advance signing, swing gates which rotate out of concrete barrier walls to redirect traffic away from reversible lane entry ramps, and restraining barrier mechanisms which are deployed across entry ramps to safety stop errant vehicles before a wrong-way maneuver into the reversible lanes *(6)*.

SITE EXPERIENCES

Maryland

Maryland State Highway Administration and emergency personnel believe that emergency crossovers would be most effective if they were located between every interchange, and that the gates should be provided "as frequently as possible." They stated that the basis for gate design should be emergency vehicles, specifically fire engines; the emergency crossovers should be designed so that the fire engine does not block other lanes when making the tight-turning maneuver. The participants also believe that public use is a problem.

Virginia

Virginia DOT representatives and emergency service personnel believe that if crossovers are intended for use by the public, large trucks should be used as the design vehicle. They also believe that if use is restricted to emergency vehicles, fire engines should be used as the design vehicle.

Las Vegas, Nevada

In Las Vegas, most medians without concrete barriers are gravel. Many of the medians are so flat with respect to cross slopes that police vehicles can turn around in most areas. Many of the emergency crossovers north of Las Vegas on IH-15 and west of Las Vegas on US-95 were made simply as a result of use; however, the Nevada DOT has been requested to grade crossovers in the past for the State Highway Patrol.

IH-95 west of IH-15 has a concrete median barrier for the first 5 miles (8 km). The following 6-mile (9.7 km) section is flat enough for emergency vehicles to cross over at any location. West of this point, cross slopes make crossing difficult. In the following 8-mile (13 km) section, there are a total of 41 gravel crossovers. Photos of typical crossovers in this section are shown in Figures 3-1 and 3-2. These crossovers occur every 0.1 miles (0.16 km) to 0.3 miles (0.5 km). US-95 has positive and negative grades; thus, the median is sectioned for drainage purposes. The location of each crossover corresponds to the downstream point where median water flow is diverted under the mainlanes via culverts. A crossover is possible at the downstream end of each drainage section where a gravel fill causes runoff diversion through the culvert. These crossovers appear to be used frequently based on tire path impressions in the gravel. None of the crossovers are signed as such, although some of the crossings had black and yellow object warning markers as seen on the right hand side of Figure 3-1.

U.S. 95 west of Las Vegas has 10 paved crossovers. These crossovers do not have any advanced signing or any signing restricting their use to emergency vehicles. Signing consists only of “ONE WAY” with “NO RIGHT TURN” assemblies along with “DO NOT ENTER” plaques. Photos of this type of crossover are shown in Figures 3-3 through 3-6. Approximately one half of these crossings—those furthest from town—coincided with speed enforcement areas, as evidenced by pavement markings associated with aircraft speed surveillance. A State Highway trooper issuing a ticket to a driver verified that these locations are used in part for enforcement purposes.

Figure 3-1. Gravel Crossover.

Figure 3-2. Gravel Crossover.

Figure 3-3. Paved Crossing.

Figure 3-4. Paved Crossing.

Figure 3-5. Paved Crossing.

Figure 3-6. Paved Crossing.

Houston: Crossovers

Design personnel and emergency responders noted the distinction between emergency crossovers and public access crossovers. There are a number of emergency crossovers on IH-10 East between Winnie and Beaumont; these crossovers were made by laying down a culvert and placing gravel on top. The crossovers are also signed with a message denoting them for use by emergency vehicles only. Emergency service personnel noted that the width of the median in this area is too small to allow large vehicles to have sufficient turning radius. There was general consensus that fire trucks would not be able to use these particular crossovers because of the inadequate turning radius and loose gravel surface.

Emergency service personnel believed that emergency crossovers for emergency vehicles only were a good idea. The crossover can be constructed at low costs with either gravel or hot mix, but public-use crossovers require a set of standards, resulting in higher costs. TxDOT representatives noted that this type of design is under-designed for large vehicles, thereby restricting its use by larger vehicles such as fire trucks, tractor trailers, etc. Furthermore, since these crossovers are not designed for public use, no advanced signing is provided. By the time a motorist sees the sign and crossover, it's probably too late to slow down and use the crossover. However, law enforcement officials and emergency responders may be familiar with the locations of these crossovers and can make use of them. TxDOT representatives believe that signing indicating the crossovers were for emergency vehicles only is a good idea, but they didn't see a need for active enforcement. They believe that this type of low cost design is needed and should not be upgraded to paved crossings.

The other type of crossover discussed was the general crossover provided for greater public access. These crossovers are present at regular intervals between Houston and College Station on State Highway 6. However, these crossovers are signed with the green guide sign "CROSSOVER" and have features such as acceleration/deceleration lanes. TxDOT personnel believe that more of this type of crossover should be provided for public use. One benefit of these public use crossovers is that they are constructed in a manner that makes them accessible to fire trucks.

Houston: TTI Emergency Access Barrier Gate

The TTI access gate was developed for implementation on Houston area HOV lanes beginning in 1984. The TTI access gate has been deployed on IH-45 North (four gates), US-59 Eastex (five gates), US-59 Southwest (11 gates), and US-290 Northwest (eight gates) freeways. An example of the TTI access gate is shown in Figures 3-7 and 3-8. The TTI access gate has not been certified as NCHRP 350 compliant. The gate consists of a double steel tube beam connected at ends by removable pins and supported during use by caster assemblies.

Figure 3-7. TTI Access Gate.

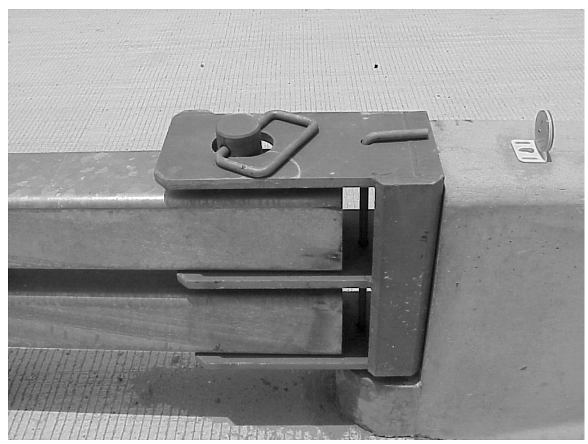

Figure 3-8. Closeup of TTI Access Gate.

By removing one of the pins, the gate can be opened by pivoting the gate around the remaining pin. The gate can be opened from either end and swung into the mainlanes or the HOV lane. When opened, the TTI access gate creates a 30-foot (9 m) opening in the concrete barrier.

TxDOT and emergency service personnel in Houston noted that the TTI access gates are not used very often. The gates are locked with large padlocks, and police department and wrecker drivers have keys to the locks. TxDOT's protocol is to have the police open the gates if they need access.

Most of the gates were installed during the initial construction of the HOV lanes; however, one gate was retrofitted under another project. TxDOT and emergency service personnel noted that the gates were somewhat difficult to open; one police officer was seen using his police cruiser to push the gate open. Also, if the gate is hit by a vehicle, there may be some binding forces at the pin connection which could either make it difficult to remove a pin or to rotate the gate around the pin.

The HOV lane has the capability of being used as a contraflow lane during a very critical incident. However, changing the direction of the HOV lane is a very time and manpower-consuming task, as noted in the following steps:

- The HOV lane has to be closed at the entrance points, including the origin as well as any slip ramps, frontage road wishbone ramps, and T-ramps.
- Police personnel have to be stationed at access points for safety.
- Motorists expecting to use the HOV lane have to be warned by radio, dynamic message signs (DMS), and police personnel at the access points that the lane is closed.
- A police wrecker driver first drives the length of the lane after closing the origin gate to ensure the lane is cleared and then closes the terminus gate.
- The wrecker driver then has to open the opposing flow entrance gate and traverse the entire length of the HOV lane again to open the corresponding gate at the exit terminus.

Because of the time required to complete the reversal process, this action is appropriate only for extremely rare incidents. Furthermore, if the incident occurred before a peak period where the direction of travel during the incident mode opposed the normal commute direction, the entire reversal process would have to be repeated again to reopen the lane for normal peak period traffic. TxDOT representatives stated that the direction of the HOV lane had been changed only three or four times in 10 years and that the reversal process would most likely not occur in the future during a peak period.

To open the gates during an incident with normal direction of HOV flow, the request would be made either by a police officer or someone at TranStar (Houston's Traffic Management Center), to which the police commander or supervisor would make the final decision. It is estimated to take approximately 20 minutes from the time the decision to open a gate is made for police personnel at the gate to open it.

In the event of a major incident, police personnel said that opening the HOV lane earlier than normal was not much of a problem. In the event of a stalled vehicle in the HOV lane, there is sufficient space (provided the driver is able to move the vehicle to one side of the lane) for traffic to continue to flow around the stalled vehicle. In the event that an accident occurred in the HOV lane and caused total closure, the gates could be used to divert the upstream HOV queue through the nearest upstream gate. For this action, an officer would block off lane one of the mainlanes with his vehicle in order to allow vehicles from the HOV lane to safely merge into lane one of the mainlanes. TxDOT personnel noted that the decision to open an HOV gate is technically a joint decision between TxDOT and Metro; however, the final decision is always deferred to the police department.

The manpower issue was brought up by both TxDOT and Metro, since an officer would have to physically remain at the site while the gate was open to divert mainlane traffic and ensure that vehicles exiting the HOV lane did so safely. The comment was made that several of the freeways with HOV lanes do not have an inside shoulder, so the placement of law enforcement personnel was critical. In the event that an HOV lane was completely closed due to an incident, traffic could also be diverted off the lane through a park and ride (PNR) T-ramp. DMS messages would be used to notify drivers that the HOV lane was closed ahead and to exit at the PNR ramp. The comment was made that gates at closer spacings would be useful, and that there needed to be better education among officers regarding their use.

TxDOT personnel stated that the HOV lane has been opened to mainlane traffic during a major mainlane accident on a number of occasions; however, only the occupancy requirement changed under these conditions—all vehicle type restrictions still applied.

Houston: Energy Absorption BarrierGate

The BarrierGate designed by Energy Absorption Systems, Inc., creates an opening (up to 42 feet [13 m]) in a concrete barrier when needed. The gate is also structurally designed to resist penetration and to prevent snagging. The BarrierGate is the only gate system that is known to be NCHRP 350 Test Level 3 compliant. The BarrierGate is shown in Figures 3-9 through 3-11. Rather than opening via a swinging movement like the TTI access gate, the BarrierGate retracts over specially designed adjacent concrete barrier segments. The gate moves over an inverted V-shaped rail, which is mounted on the ground. A debris skirt prevents debris from obstructing gate movement.

There are four BarrierGates in Houston. Two gates are located on the IH-45 North Freeway on either side of North Main near downtown, and two gates are located on either side of the IH-610 ship channel bridge. There is also one BarrierGate in Galveston on the north end of the Galveston Island Causeway.

Figure 3-9. EA BarrierGate.

Figure 3-10. EA BarrierGate Installation.

Figure 3-11. EA BarrierGate Controls.

The BarrierGates are designed to be operated electronically. A generator at the site would provide the needed 220 volt power so that an officer could drive up to the concrete barrier-mounted control box, enter a security code, and open the gate with the push of a button. The gates are very simple to operate with a generator. The gate is intended to be used with electrical power; however, it can be operated manually using a jack and hand crank. Under electronic control, two security-coded keypads located at the ends of the gate allow authorized personnel access from either direction while remaining in their vehicle. Optional accessories for the BarrierGate system allow the gate to be operated by radio remote control at a distance of up to one-half mile. The gates can also be opened with a hand crank; however, this is reported to be a rather strenuous job. Likewise, the gate can be closed the majority of the way manually. However, electrical power is required to close the gate the last 1.5 feet (0.5 m) to lock the gate segments together.

The four BarrierGates in Houston do not have electrical power, which greatly decreases the chance that they will ever be used. In fact, the gates have not been used to date. The cost of each gate is approximately $85,000, and it would cost an additional $10,000 per site to provide a permanent generator. Without an on-site generator, a portable generator on a truck must be driven to the site and plugged in, which greatly increases the response time to open the gate.

Although the BarrierGate is NCHRP 350 approved, the gate in Galveston was apparently damaged enough by a construction vehicle during construction in the vicinity on the south side of the IH-610 ship channel bridge that it had to be completely replaced. The photo in Figure 3-10 was taken during this replacement. The replacement BarrierGate does not have power. However, it is equipped with an on-site generator, and TxDOT believes that the gate has been used in the past.

TxDOT noted that the police department was interested in using the BarrierGates for the Eastex HOV lane construction; however, the costs associated with the BarrierGate were prohibitive, so TTI access gates were used instead.

Chicago: Emergency Crossovers

Emergency crossovers are provided as gaps in several concrete barriers on Chicago freeways. As shown in Figure 3-12, the crossovers are signed with the no U-turn symbol and a sign stating "EXCEPT FOR AUTHORIZED VEHICLES."

Figure 3-12. Emergency Crossovers in Chicago.

Chicago: REVLAC System

A new mechanized closure of entry ramps to the expressway's reversible lanes has been in successful operation since the major expressway reconstruction on the IH-90/94 Kennedy Expressway was completed in October 1994 (*6*). Prior to the installation of the REVLAC system along the 7-mile section, the entry ramps were manually closed using barricades. The initial system criteria included the following elements:

1st: Passive, Informational;
2nd: Active, Safely Defeatable Positive Redirection of Traffic;
3rd: Impact-Absorbing Barrier for Safe Stop of Errant Vehicle; and
4th: Positive Lane Closure to Protect Reversible Lane Traffic (*6*).

Inbound traffic uses the reversible lanes for the weekday morning peak period; the lanes are then typically closed for two hours for maintenance purposes and then reversed for the afternoon outbound peak. The expressway is typically not closed at all on Fridays due to the early occurrence of afternoon outbound traffic. Weekend operations depend upon traffic flow and on any special events occurring during the weekend.

This mechanized system is improving safety and operational effectiveness during the twice-daily (and occasionally four times) reversal of traffic flow. The system incorporates several types of advance signing, swing gates which rotate out of concrete barrier walls to direct traffic away from reversible lane entry ramps, and restraining barrier mechanisms which are deployed across entry ramps to safely stop errant vehicles before a wrong-way incursion into the reversible lanes. The changeable elements in the system (i.e., the changeable signs, swing gates, etc.) are within the view of surveillance cameras to confirm that they are appropriately configured prior to switching traffic direction.

The design was simulated to evaluate the control design system using normal drivers. A CAD representation was prepared from a driver's eye view, and a series of views approaching the ramp were prepared. This series was animated to produce a video tape of the approach to the junction point from a distance of 525 feet (160 m) upstream of the junction, traveling at a nominal speed of 47 miles per hour (75 km/hr). The simulation included all of the design elements: roadway, pavement markings, signing, and barrier gates. The video was projected on a large screen TV and presented to a group of test subjects. Results were evaluated and reviewed by a human factors expert.

The signing system has three elements: an overhead drum sign, a fiber optic sign, and chevron signs mounted above the first three swing gates which flash during the gate closure period (see Figures 3-13, 3-14, and 3-15 respectively). The overhead drum sign displays a destination message and a directional arrow pointing to the open reversible lane. When the lane is closed and just before the barrier gates begin to close, the drum sign message is "Lane Closed - Keep Right." The other two sign types are designed solely for the 30-second period when the gates are closing. The fiber optic sign flashes at the beginning of the closing operation with the flashing message "Gates Closing - Keep Right." Additionally, a 6 foot (2 m) chevron sign is mounted on top of the swing gate pivot on the first three swing gates. The chevron points right and flashes during the gate closure period.

Entry ramps to the reversible lanes are built on auxiliary pavement so that other freeway lanes are not blocked. A series of eight swing gates are used to close the entry ramps, and the minimum swing gate angle is 45 degrees (see Figures 3-16 and 3-17). The end of each aluminum gate is rubber-tipped to allow a somewhat forgiving effect for vehicles which may try to outrun the gates. There is a five-second delay before the last gate is closed. The final barrier to prevent wrong-way traffic from entering the reversible lane, a wire mesh restraining barrier, is shown in Figure 3-14 (partially raised) and in closeup in Figure 3-18.

Figure 3-13. Advance Warning Sign for Reversible Lane Ramp.

Figure 3-14. Fiber-Optic Sign on Barrier Structure (Enhanced Digitally to Show Indication).

Figure 3-15. Fiber-Optic Chevrons.

Figure 3-16. Retracted Swing Gate.

Figure 3-17. Swing Gates.

Figure 3-18. Wire Mesh Restraining Barrier.

Emergency vehicles can enter the gates to access incidents. The gates may be opened by a Minuteman with a remote control device with permission from the Communication Center, directly from the Communication Center, and they may also be operated manually.

As part of the final project work, extensive telemetry, programming, CCTV, and communications were integrated. Programming was designed to automatically detect and diagnose failures, to maintain operating integrity by working around these failures, and then to automatically return to normal operations following repairs.

Illinois Department of Transportation (IDOT) personnel noted the system has been extremely successful and well received by the public. It has greatly reduced the manpower requirements for lane reversal and increased safety for IDOT personnel.

RECOMMENDATIONS

In suburban or urban areas where distance exceeds rural guidelines, the use of emergency crossovers is recommended with the following suggestions:

- Permit crossings in suburban areas as needed when spacing exceeds the current rural standard.
- Install and sign the crossover for the use of authorized vehicles only.
- Continue the practice of using a designating sign only—do not install advance signing.
- Install an improved surface.
- Use powered gates for breaks in median barriers that are compliant with current crash-test requirements.

The use of emergency crossovers are currently governed by a section titled "Emergency Median Openings on Freeways" in TxDOT's *Design Manual* (*3*). The text from the *Manual* is provided; draft text to modify that section is underlined.

VII. H EMERGENCY MEDIAN OPENINGS ON FREEWAYS

VII.H.1 Introduction

Median crossings between the mainlanes are sometimes necessary for proper law enforcement or for performance of highway maintenance on rural freeways. The construction of such median crossings is not encouraged since the necessary U-turns by such vehicles should be accomplished by using ramps at interchanges to the maximum extent feasible.

VII.H.2 Conditions

Median crossings as turnarounds create safety concerns and interfere with through traffic and should be avoided. Normally the spacing of interchanges and layout of the highway provides for all necessary traffic movements, including those of emergency vehicles.

In unusual situations, where the distance between interchanges is great, emergency crossings may be provided with administrative approval.

VII.H.3 Spacing of Openings

Due to the close spacing of interchanges on urban freeways, emergency median openings are not <u>usually</u> needed for the operation of official vehicles and, in general, they should not be provided. In rural or suburban areas where the spacing of interchanges is greater than approximately [3 mi] 4.8 km, a U-turn median opening may be considered at a favorable location about halfway between interchanges. In no case should emergency median openings be spaced at less than [1 mi] 1.6 km intervals. All emergency median openings should be at least [0.5 mi] 0.8 km from any structure that crosses over a freeway and at least [1 mi] 1.6 km from any ramp terminal or other access connection, such as those serving safety rest areas. Openings should be located where adequate stopping sight distance is available and where the median is sufficiently wide to permit an official vehicle to turn between the inner freeway lanes. <u>If breaks in a median barrier are necessary, use powered, crash-worthy gates to bridge the opening.</u> Emergency median openings should also be as inconspicuous to the traveling public as possible.

VII.H.4 Construction

Location and type of emergency median openings should be made a part of the PS&E as a contract item and should be installed as such.

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CHAPTER 4
REFUGE AREAS

DESCRIPTION AND INTRODUCTION

Refuge areas include emergency pull-off zones and accident investigation sites. Emergency pull-off zones are designated areas that are typically provided along roadway sections with little or no shoulder width. Pull-off zones provide sites that can be used for the temporary relocation of damaged or broken-down vehicles or for law enforcement purposes. Accident investigation sites are designated and signed areas off of the freeway where damaged vehicles can be moved, motorists can exchange information, and police and motorists can complete necessary accident report forms. To reduce rubbernecking, accident investigation sites are generally located so that motorists involved in an accident, the investigating police officer, and the tow truck operators are out of view from the freeway. These sites help minimize disruption to freeway and arterial traffic flow (*1*).

LITERATURE REVIEW

The duration of lane closure time during an incident has a substantial effect on the level of traffic congestion and the amount of incident-induced traffic delay. A stall or crash blocking just one out of three lanes will reduce roadway capacity at the scene by nearly 50 percent, costing the average motorist four to five additional minutes of delay for each minute required to clear the roadway (*2*). Removal of wreckage and debris completely out of the main travel lanes to the shoulder area does not completely eliminate this problem. Driver tentativeness and inquisitive behavior (rubbernecking) will still impair traffic flow, reducing the roadway capacity at the incident scene by about 25 percent on a three-lane highway (*3*).

A 1988 report by TTI provides guidance on the location, design, and operation of accident investigation sites (*4*). The typical layout recommended by the report for an accident investigation site is illustrated in Figure 4-1. In general, the site is a paved parking area with space to accommodate a minimum of five vehicles; is easily accessible; is well marked; has sufficient lighting; and is not located in a high crime area. The construction or layout of the site should also take into account the traffic stream of the roadway, such as the amount of truck or commercial vehicle traffic.

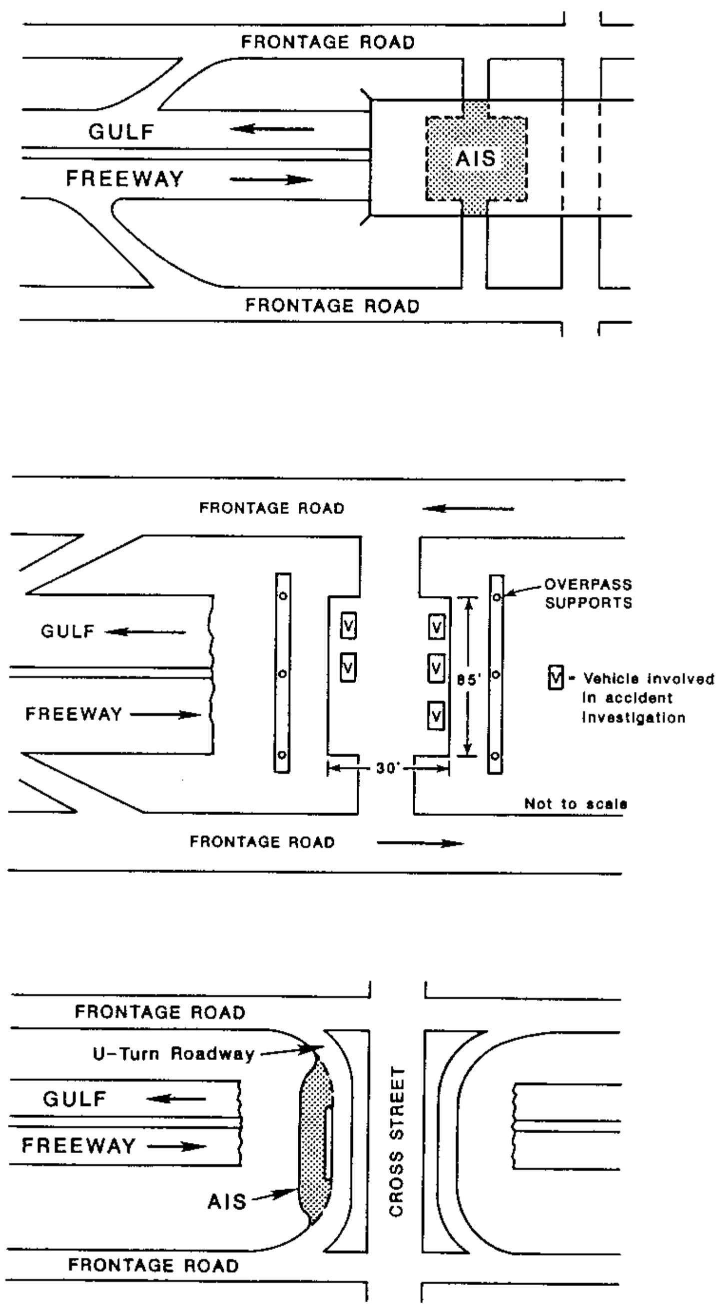

Figure 4-1. Typical Layouts for Accident Investigation Sites (*4*).

Typical locations of accident investigation sites include under a freeway overpass, on a side street or parallel frontage road, or in a shopping center parking lot out of view of the freeway (*4*). An accident investigation site should have space for parking a minimum of five vehicles (approximately 1,000 $feet^2$ [93 m^2]). If the accident investigation site uses curb parking, a minimum of 85 feet (26 m) in length is needed to permit pulling into and out of the curb parking area.

Unfortunately, one of the fundamental weaknesses of accident investigation sites is that they are often difficult to implement in the areas where they are most needed. These areas, which are distinguished by congestion and high incident rates, often have limited space and poor geometrics. These characteristics limit the implementation of accident investigation sites as an effective incident management strategy (*5*).

Public awareness of accident investigation sites is crucial for an incident management program, including accident investigation sites, to be successful. The public must not only be educated on the availability, purpose, and location of accident investigations sites, but they must also be informed about legal implications and procedures for moving vehicles to the sites (*6*).

The construction of accident investigation sites in Houston, Texas, has produced benefits that outweigh costs at a ratio of 28 to 1 (*4*). Maximum benefits were found at sites with the following characteristics:

- easy access to and from the freeway;
- concealment from other freeway motorists;
- well-marked and delineated parking area;
- location near a high accident area;
- provision of at least 985 feet (300 m) of parking space;
- sufficient overhead lighting and other features to ensure personal safety; and
- telephone accessibility, such as a pay phone or call box.

SITE EXPERIENCES

Houston

There are currently 17 accident investigation sites in Houston, all located on IH-45 North Freeway. Three types of locations have been used for these sites: U-turn (one site), frontage road (six sites), and side street (10 sites). Most sites are not visible from the freeway. Examples of each are shown in Figures 4-2 through 4-4.

Figure 4-2. AIS U-turn Design.

Figure 4-3. AIS Side Street Design.

Figure 4-4. AIS Frontage Road Design.

Each accident investigation site is well signed, and motorists are initially made aware of the site by a freeway guide sign located upstream of the appropriate exit, as shown in Figure 4-5. Motorists are then directed to the site by one or more trailblazer signs, as shown in Figure 4-6. The site itself is identified by two "Accident Investigation Site" signs, located towards the edges of the site, with arrows on the sign pointing towards the center of the site (see Figure 4-7). The site is also marked in the center of the site with "Emergency Parking Only" sign and "No Parking/Tow Away Zone" signs, as shown in Figure 4-8.

Figure 4-5. AIS Freeway Signing.

Figure 4-6. AIS Frontage Road Signing.

Figure 4-7. AIS Site Signing.

Figure 4-8. AIS On-site Signing.

One disadvantage of the AISs is that drivers may feel uncomfortable following someone they don't know off of the freeway to an obscure location. It may be an area that they are unfamiliar with, and it may not be the best area in town. Although motorists are most likely placing themselves in greater danger by remaining in the mainlanes following a collision or even standing around their vehicles on the shoulder, they may perceive remaining in an open visible area to be safer than driving to an unfamiliar, low-visibility area with a stranger. The general consensus is that AISs are seldomly used by individuals; the majority of the time, the sites are used when a police officer instructs the drivers to move their vehicles there. Drivers are likely to have a higher comfort level going to these sites when in the presence of a police officer.

Sixteen AISs were built on the IH-45 Gulf Freeway during the early 1970s. The total construction cost for these 16 sites was reported to be $34,500 (*4*). None of these sites officially remain today; some were lost during reconstruction projects, while others physically remain but are not signed as AISs. The construction cost to build the 17 investigation sites on IH-45 North

Freeway in 1995 totaled between $350,000 and $400,000, with the majority of the costs occurring due to signing and pavement widening.

Another issue is the reluctance of drivers to move their vehicles to the shoulder of the road, even after the most minor of incidents; many drivers are not aware that the law requires drivers involved in minor accidents to move their vehicles out of the freeway mainlanes.

Comments from law enforcement personnel indicated that the police officers working incidents on IH-45 did not use the accident investigation site facilities with any great frequency. TxDOT representatives stated that they probably would not have built the IH-45 sites if they knew what they know now.

Chicago

The first and largest accident investigation site in Chicago was installed during the construction of a three-mile (4.8 km) section of the Dan Ryan Expressway. The AIS was so effective that it was left as a permanent site. The AIS is located in the median of the Dan Ryan Expressway at Polk Street. The site is approximately 600 feet (183 m) long; it is 52 feet (16 m) wide on one end and 130 feet (40 m) wide at the other end (as shown in Figure 4-9). Advance signing for the site is shown in Figure 4-10. Nine other accident investigation sites were installed during a three-year construction project on the Kennedy Expressway. Some of these sites and related signage are illustrated in Figures 4-11 through 4-15. They vary in size and are located adjacent to the mainlanes, under the freeway, and adjacent to the freeway lanes but separated by a grassy area (*7*).

Figure 4-9. Accident Investigation Site.

Figure 4-10. AIS Advance Freeway Signing.

Figure 4-11. AIS Site and Signing.

Figure 4-12. AIS Signing.

Figure 4-13. AIS On-Site Signing.

Figure 4-14. AIS Site Adjacent to Freeway.

Figure 4-15. AIS Separated by Grassy Area.

Construction is now in progress on the IH-55 Stevenson Expressway, and several AISs have been installed on this freeway largely due to a lack of shoulder. These AISs are illustrated in Figures 4-16 and 4-17.

Figure 4-16. AIS Adjacent Construction Site.

Figure 4-17. AIS in Construction Area.

The Chicago AISs include advance signing, on-site signing identifying the location (typically a cross street), a telephone, a trash can, and water. Portable toilets were originally included at some of the sites but were later removed due to vandalism. Additionally, a police trailer was formerly installed at the large site at the Dan Ryan Expressway at Polk Street. State troopers used the site as an office; it was later removed due to problems with rodents.

Chicago's emergency response vehicles, the "Minutemen," move stalled or damaged vehicles out of the freeway mainlanes to the shoulder, accident investigation site, or to the closest exit ramp. The Minuteman then wait for the police to call a towing company (*7*).

Chicago law enforcement officers had requested the installation of pull-out zones, complaining that the AISs were not visible. Law enforcement officials did not like the first pull-out zones that were constructed because they felt that they weren't safe enough. They wanted the pull-out zones to extend further away from the roadway, with a median area within the pull-out zone. However, this was difficult to accomplish within the right-of-way. Six emergency pull-off zones were constructed for use by officers issuing citations. The sites are not being used because officers feel that they are unsafe due to the small size and lack of separation from the mainlanes (*7*).

Virginia

Designers and emergency response personnel in Virginia believe that refuge areas could double as equipment staging areas. They noted that the sites should be somewhat separated from the freeway, but crime problems can result if they are too remote. They also believe the sites should be lighted and have call boxes.

RECOMMENDATIONS

The use of refuge areas/accident investigation sites is recommended with the following suggestions:

- Use where the right shoulder does not allow refuge.
- Locate adjacent to or near the freeway lanes.
- Include a median to provide a separation distance equal to the required horizontal clearance (clear zone).
- Provide telephone access.
- Provide for acceleration or deceleration if no shoulder is present.
- Include advance signing.
- Design to allow for easy movement of tow vehicles, police, and fire. A recommended nominal size is 45 feet (14 m) by 150 feet (46 m).
- Provide separate entrances and exits to limit the possibility of wrong-way movements.

Suggested modifications to TxDOT's *Design Manual* (*8*) include:

Freeways, Mainlanes, Shoulders

"Continuous surfaced shoulders are provided on each side of the mainlane roadways, both rural and urban, as shown in Figure E-4. The minimum widths should be [12 ft] 3.0 m on the outside and [3.7 ft] 1.2 m on the median side of the pavement for four-lane freeways. On freeways of six lanes or more, [12 ft] 3.0 m inside shoulders for emergency parking should be provided where flush medians are used. A [12 ft] 3.0 m outside shoulder should be maintained along all speed change lanes with a [5.5 ft] 1.8 m shoulder considered in those instances where light weaving movements take place. See Table E-3 and Figure E-4 for further information."

Consideration should be given to providing accident investigation sites if outside shoulders are not provided in a freeway section. The sites should be nominally sized at 45 feet (14 m) wide by 150 feet (46 m) long, separated from the mainlanes by a median to provide the recommended horizontal clearance for the freeway, and constructed with a separate upstream entrance and a downstream exit with suitable deceleration and acceleration lengths, respectively.

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CHAPTER 5
TEMPORARY SHOULDER LANES

DESCRIPTION AND INTRODUCTION

Diversion of traffic is necessary to maintain traffic flow when an incident blocks multiple lanes. Alternative routes may include the use of paved shoulders as temporary traffic lanes.

LITERATURE REVIEW

The function and use of paved roadway shoulders has broadened considerably in recent years. The original purpose of a roadway shoulder was to accommodate vehicles that stopped for emergency purposes and to laterally support the base and surface courses of the roadway. In recent years, functions have been broadened to accommodate increasing encroachment of traffic; expedite water runoff from travel lanes; provide added space for construction and maintenance activities; reduce edge stresses and pavement drop offs; and accommodate alternative uses such as bicycle paths, slow moving vehicle lanes, equipment lanes, and emergency vehicle lanes (*1*).

Interstate roadways are required to have paved shoulders. As congestion on urban freeways grow, the feasibility of using shoulders as traffic lanes is being investigated by traffic managers. A study by Curren reports that although using the shoulder as an additional travel lane is feasible, transportation managers should consider narrowing travel lanes or reducing the interior shoulder before reducing the right shoulder. The researchers found that both emergency and enforcement personnel preferred that the right shoulder be reserved as a refuge area and for emergency response (*2*).

SITE EXPERIENCES

Houston

Temporary shoulder lanes can be used to direct traffic around a major incident blocking multiple lanes. TxDOT and emergency response personnel believe that traffic diversion at the location of the incident is acceptable. However, they expressed concerns about a separate queue forming on the shoulder; drivers at the back of the mainlane queues may realize that the shoulder is being used and race up the shoulder to the end of the shoulder queue. They believe that this poses a safety problem and could set driver expectancy to drive on the shoulder during incidents.

TxDOT and emergency service personnel noted that leaving the shoulder open for emergency vehicle access is very important, because this provides the only access for emergency vehicles in some cases. It was suggested that positioning a patrol car on the shoulder slightly upstream of the diversion point is the best tactic to control shoulder use and keep it limited to the area adjacent to the incidents; this blocks any queue jumpers. A patrol vehicle is believed to be the only adequate barrier; police personnel commented that cones and flares were effective, although people were more reluctant to drive over flares than cones because of the potential of getting a flat. Officers had observed people driving over a flare, getting a flat, then requesting help with changing the tire.

Houston police officers have the authority to direct motorists onto the shoulder during an incident. However, they believe that motorists will move over and form a shoulder queue if a police vehicle is not used to block the shoulder upstream of the diversion.

The use of shoulders other than to get around an incident at slow speed was seen as infeasible on many Houston freeways due to the presence of jiggle bars. TxDOT personnel commented that they are trying to omit the installation of jiggle bars from future urban freeway construction contracts. They believe that other techniques, such as pavement grooving, could be used to reduce runoffs due to drowsy drivers.

TxDOT personnel also commented that shoulders would not be used as a part-time lane due to safety and driver expectancy issues. A recent project on the IH-10 Katy Freeway and Beltway 8 used the outside shoulder as a permanent lane over a relatively short section. TxDOT personnel believe that although this removes the shoulder in the immediate area, the overall section is safer due to reduced queues.

Law enforcement representatives noted that for minor incidents, the focus should be more on getting the accident vehicles and emergency vehicles out of the mainlanes and onto the shoulder as quickly as possible rather than making the shoulder available as a lane. They also believe that the use of DMS messages is effective in getting motorists to divert to alternate routes.

TxDOT and emergency service personnel also commented that motorists will often naturally divert around an incident, using the shoulder if necessary, before police authorities arrive at a scene and take control. They noted that drivers sometimes divert from the freeway to the frontage road in locations without ramps. While this is technically illegal, the group believed that most drivers doing this would not be ticketed.

Las Vegas

Law enforcement officials commented that the temporary use of shoulder lanes is acceptable and occurs during major incidents. Although an officer of the State Highway Patrol—who work most freeway incidents—may decide to direct traffic onto the shoulder in a major incident, officials noted that motorists usually divert to the shoulder around an incident on their own, even before emergency response vehicles arrive. They also noted that many sections of IH-15 and US 95 do not have shoulders. Much of the IH-15 corridor is under construction; although both left and right shoulders exist in some areas, they are used to store construction barrels. The barrels are spaced far enough apart to permit storage of disabled vehicles; however, diversion of traffic onto the shoulder would require the relocation of several barrels.

A 14.3-mile (23 km) segment of US 95—from IH-15 to Henderson—was recently reconstructed. This section is amenable to shoulder use because it has both full left and right shoulders. Another section of US 95, headed westbound from IH-15, lacks shoulders during the first five miles (8 km); Nevada DOT personnel commented that shoulders have been turned into full-time lanes due to the high ADTs in this area. West of this section, US 95 has full right shoulders but only partial left shoulders. Although the left shoulders are typically inadequate for use by vehicles because of the narrowness, there is a 20-foot (6 m) or larger gravel median with negligible cross slopes that would allow vehicles to get around an incident with left side wheels on the gravel and right side wheels on the left shoulder.

None of the shoulders observed in urban or rural areas had any type of rumble strip or pavement buttons. Grooved pavement on rural shoulders (visible in Figure 5-1) is used to help prevent runoffs due to drivers falling asleep at the wheel.

Figure 5-1. Shoulders with Rumble Strips.

Virginia

Maryland State Highway Administration (SHA) officials noted that shoulders on IH-66 between Washington, D.C., and Fairfax, Virginia, are signed for use as a travel lane during rush hour; changeable message signs are used to indicate when their use is permitted (see Figure 5-2). This shoulder use results in no accommodation of break-downs. Because the shoulders are not always available as a refuge area for vehicles' use in incidents, emergency pull offs are provided periodically along the freeway. Officials also noted that shoulders must be relatively clean if

Figure 5-2. Explanatory Sign Used for Shoulder/Lane.

they are to be used as travel lanes.

The shoulders are available for use as travel lanes during morning and evening rush hours into and out of the Washington, D.C. metropolitan area. Signs and lane use indications are shown in Figure 5-3; the sign indicates that when the shoulder's usage indication has a green arrow, it is available for use as a travel lane; if marked by a red "X," it is available for emergency stopping only. Figure 5-3 shows one of the use indicators and an explanatory sign. The sign provides the hours when the shoulder is typically open as a travel lane (in this case, 3 to 7 PM Monday through Friday). Figure 5-3 also shows a smaller sign indicating the upcoming emergency pull off. A limited number of incidents have been recorded where vehicles were stopped on the shoulder when it was opened for use as a lane. Emergency responders have also reported problems when motorists use the shoulder to bypass freeway backups due to incidents, blocking access by emergency vehicles seeking to use the shoulder to access the site of the incident.

Figure 5-3. Allowable Use Sign, Lane Use Indicator, and Emergency Pull-Off Sign.

Atlanta

Emergency lanes and shoulders are utilized in metro Atlanta to allow access to incidents when traffic is stopped.

RECOMMENDATIONS

The use of shoulder lanes for a short period is appropriate when directed by officers on the scene (using police flaggers); however, the use of shoulder lanes on a permanent or frequent basis is *not* recommended because:

- usage impacts safety, particularly with regard to the right shoulder;
- usage impacts enforcement activities, particularly with regard to the right shoulder;
- usage impacts incident response time due to shoulder blockage; and
- usage may become habitual, which could potentially cause problems.

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CHAPTER 6
INCIDENT EQUIPMENT STORAGE SITES

DESCRIPTION AND INTRODUCTION

Incident equipment storage sites are specially designated areas for the parking of towing and recovery equipment sometimes used near high-incident or other critical facilities, such as bridges and tunnels. The sites may also include emergency-type supplies to speed and increase the efficiency of clearing an incident. Storage sites are used because state patrol cars and police cars, which are often the first responders, often do not have the supplies needed to control and return traffic to normal conditions. An incident response storage site, which is normally located near a high incident site, provides the initial responder with access to commonly needed supplies and equipment.

LITERATURE REVIEW

Quick response and mitigation of incidents are primary factors for successful incident management. Equipment staging areas and equipment storage sites are two examples of low cost incident management options. In three reports written during the late 1970s, Urbanik and his co-authors (*1*, *2*, *3*) outline experiences of pre-positioning and stationary tow truck surveillance of a bridge in Tampa, Florida. A demonstration project was conducted and showed that this low cost incident management technique could improve traffic operations on the heavily traveled bridge. The project indicated that response times to incidents could be reduced by one half.

In 1992, Middleton et al. (*4*) noted that the courtesy patrol for the Howard Frankland Bridge in Tampa, Florida, had been implemented in 1989. Two heavy duty wreckers were stationed at either end of the 3.1 mile (5 km) bridge during peak hours—Monday through Friday from 6:00 A.M. to 10:00 A.M. and 3:00 P.M. to 7:00 P.M. Every 15 minutes, the wreckers moved to the other end of the bridge looking for incidents and any other hazards, such as debris in the road. A regression analysis by the Florida Department of Transportation of accident data indicated that the rate of increase in accidents was less during the time the patrol was active as compared to the non-patrol periods (*4*).

Middleton et al. also noted that a similar incident management option was used by the Pennsylvania Department of Transportation (PennDOT) in the Pittsburgh area. Heavy-duty tow trucks are stationed at major tunnels in the area. The tow trucks, owned by PennDOT, are only used to render aid and remove vehicles within the tunnel. Because the tow trucks are stationed at the entrance to the tunnel at all times, response time for incidents within the tunnel is almost immediate, and PennDOT drivers are efficient because they are familiar with the tunnel (*4*).

Jones and Mannering (*5*) observed that equipment for handling major incidents must be readily available for use by responders. They recommended that larger items, such as barriers, cones, and cleanup materials, be stored at sites near high accident prone areas. Mannering, Jones, and Sebranke (*6*) described an equipment storage site developed at the Washington State Department of Transportation (WSDOT) Traffic Systems Management Center (TSMC) in Seattle. An evaluation of this pilot site revealed that there are three aspects necessary to ensure that the equipment storage option is successful as an incident management tool. First, DOT and other users must be continually aware of the existence of the sites and develop the habit of using them. Second the location of the site is very important; it must be in a strategic location that is easily accessible and near high accident locations. Responders should not have to "go out of their way" to access the storage site. Finally, multiple sites are necessary for the program to be effective (*6*).

SITE EXPERIENCES

Houston

The TxDOT Houston District currently has 11 maintenance sections, and each section has its own equipment yard. TxDOT personnel believe that the spread of incidents in Houston is so broad and random that it would not be effective to establish key scattered locations. In the event that equipment is needed for a major incident (a sand truck, arrow board truck, etc.), law enforcement personnel call TranStar personnel (Houston's Traffic Management Center), who in turn contact the nearest TxDOT maintenance section. Each maintenance yard has trucks loaded and ready to respond. The Houston Police Department also has a pickup truck loaded with smaller items, such as cones, an arrow board, etc., that is available for call out.

Houston TxDOT personnel commented that no equipment would be stored outside of TxDOT yards, since it might either pose a hazard or be stolen. However, they noted that most interchanges around IH-610 loop have piles of sand and gravel under them. At one time, TxDOT had some construction equipment staged under IH-610 and IH-10. However, FHWA requested that TxDOT remove the equipment because it was an eyesore.

Houston police personnel also believe the sites are not necessary since most fire trucks, police units, and the Motorist Assistance Patrol (MAP), etc., have cones/flares. The police department also has a bus loaded with equipment that can serve as a command station for very major incidents. Police personnel commented that cones and flares were not very effective; people drive over both. Driving over flares will usually extinguish the flare, but it may also burn a hole in a tire, causing a blowout. The cones are often run over and may be broken or destroyed. Emergency personnel mentioned two incidents which involved flooding on Beltway 8 frontage roads under IH-10 and on the IH-10 mainlanes under Washington. Both locations were flooded with over five feet (1.5 m) of water. Even with cones, barricades, and a police vehicle, several motorists still drove around the cones and into the water. Emergency personnel believe that cones/flares/barricades are not effective unless an officer is present.

TxDOT and emergency service personnel stated that manpower, not equipment, is the critical link in responding to incidents.

Dallas

TTI recently completed a video incident study along IH-635 (LBJ Freeway) in which incidents were detected from the video cameras placed along LBJ Freeway. The cameras monitored seven separate views which were recorded on two separate VCRs. TTI personnel viewed a total of 159 hours of usable tape looking for incident data. A total of 158 incidents were recorded, ranging from mechanical problems to crashes to unknowns. The breakdown of the 158 incidents indicates that 68 percent of the incidents did not need a wrecker; 11 percent of the incidents could possibly use a wrecker; 12 percent could use a wrecker; and 9 percent of the incidents were unknown (not enough video to determine an action). TTI calculated that the possible delay reduction associated with these 158 incidents (based on 15 minute reduction for mechanical breakdown and 20 minute reduction for crashes) was approximately $860,000 ($554,000 for crashes and $309,000 for mechanical breakdowns). Based on the 159 hours of videotape collected, this amounts to approximately $5400 per hour in possible reduced delay. A "staged" tow truck stationed along the LBJ Freeway corridor is expected to cost about $60 per hour; staging on a tow truck along the LBJ corridor would produce a 90:1 benefit-cost ratio based on the number of $5400 per hour in possible reduced delay. An "after or during" data collection effort is also planned as part of this evaluation study.

Chicago

The Illinois Department of Transportation serving the Chicago area stores maintenance equipment at a central equipment yard south of downtown. However, a heavy wrecker and sand truck are also stored in at least one location within major freeway construction projects in order to provide quicker and more efficient incident clearance. Additionally, some accident investigation sites were used as temporary storage for arrow boards and other equipment (see Figures 6-1 and 6-2).

Figure 6-1. Equipment in AIS.

Figure 6-2. Equipment Stored in AIS.

Las Vegas

Nevada DOT personnel in Las Vegas did not feel there was a need for incident equipment storage sites. In Las Vegas, the Nevada DOT district office is positioned in a central area with good accessibility near the US 95 and IH-15 interchange. This location is also home to the DOT maintenance section. Thus, any equipment needed during a major incident (i.e., sand truck, portable DMS, arrow boards, etc.) can be dispatched from the maintenance yard to the incident site. Night shift personnel are available at the maintenance shop in an emergency response scenario; Nevada Highway Patrol notifies them of any equipment needed.

Virginia

Virginia DOT personnel were concerned about the accountability for the equipment at incident equipment storage sites and believed that this could be a problem. They expressed concern about who ensures that the equipment is ready and who restocks the equipment. The DOT also believed that providing sufficient ROW can be a problem.

Seattle

In 1988, the Washington State DOT initiated a pilot program to create storage sites for prepositioned equipment and supplies needed for managing incidents. The first site was established at the WSDOT Traffic Systems Management Center, which is located near the intersection of IH-5 and State Route 520. A storage closet with outside access was stocked with commonly used supplies and equipment, including shovels, brooms, flares, sandbags, signs, plastic bags, traffic cones, and fuel absorption pads (*6*).

Emergency Response Patrols

Chicago

The Chicago Minutemen are one of the oldest emergency response patrols in the country. The Minutemen roam the freeways and respond to freeway emergencies. The medium-duty patrol trucks typically carry: two gallons of gasoline, water, jumper cables, air, and fire extinguishers. The IDOT Emergency Traffic Patrol Minutemen continue to provide about 100,000 expressway motorist assists each year. Approximately 22 percent are lane-blocking incidents, and about 7000 of the assists involve trucks. The Minutemen tow vehicles to accident investigation sites when they are available. Clearance times average 12 minutes for incidents blocking one lane and 22 minutes for vehicles blocking two lanes. The equipment fleet includes 35 medium-duty patrol trucks, 11 light 4 x 4s, and numerous specialty and heavy-duty units. The fleet of 35 patrol trucks has now been completely upgraded with advanced technology, hand-free vehicle relocation units. Operator safety has been greatly improved, and incident clearance duration has been reduced (*7*).

Atlanta

Atlanta's **H**ighway **E**mergency **R**esponse **O**perators are a component of NAVIGATOR, *Georgia's Smart Way to Travel*. The goal of the HERO program is to minimize the disruption of the normal flow of traffic at an incident site. The HERO patrols are assigned routes during designated hours, and they initiate measures to reduce traffic congestion from accidents or incidents. When HEROs are not responding to accidents, they attend to stalled vehicles or stranded motorists by providing minor mechanical repairs and assistance such as changing flat tires, reviving dead batteries, supplying fuel and/or coolant, providing road and travel information, providing courtesy use of a cellular telephone, and providing transportation to the safest area away from the freeway.

There are currently 28 HEROs. They work Monday through Friday in two shifts of 5:30 A.M. to 1:00 P.M. and from 1:30 P.M. to 9:00 P.M. The HEROs serve approximately 175 miles (282 km) of metro-Atlanta highway during peak hours and approximately 247 miles (398 km) during non-peak areas. These areas include IH-75 from Eagles Landing/Hudson Bridge Road to Chastain Road; IH-85 from Riverdale Road to SR-120; I-20 from Thornton Road to Evans Mill Road; GA-400 from Sidney Marcus Boulevard to Mansell Road; and IH-285.

The HEROs' vehicles are specially equipped one-ton (1000 kg) trucks which are painted Occupational Safety and Health Administration (OSHA) green. The trucks' basic equipment includes a push bumper (to move vehicles out of travel lanes), retractable lighted arrow board, public address system, jump-starting system, portable 3500-watt power generator, halogen floodlights, traffic control devices (cones, flares, etc.), absorbent materials (for hazardous substances), auxiliary pump and tank (to off-load leaking fuel tanks, etc.), low-band and 800 MHz radios, cellular telephone, first aid kits, shovels and brooms, air compressor, jack and lug wrenches, gasoline, diesel fuel, and coolant.

HEROs' training includes basic automobile mechanics, personal awareness (street wise), work zone traffic control, defensive driving, push bumper training, hazardous materials (first responder), First Responder/First Aid, auto vehicle extrication, radio communications, legal liability issues, interagency coordination, agencies' standard operating procedures (Georgia Department of Transportation and others), and wreckmaster recovery training (shift supervisors only). A summary of HERO assists is included in Table 6-1.

Table 6-1. History of HERO Assists (*3*).

	1996 Totals	1997 Totals	1998 Totals
ASSISTS	15,630	15,158	28,708
ACCIDENTS	2,084	2,748	5,029
TOTAL	17,714	17,906	33,737
Average Response Time	------------	12 minutes	10 minutes

Los Angeles

Caltrans' vehicles tow stalled or damaged vehicles to safe locations just off the freeway. The Freeway Service Patrols (FSP) use 160 tow trucks to tow vehicles to a safe site and to respond to other minor incidents or emergencies.

RECOMMENDATIONS

The use of incident equipment storage sites is recommended for typical conditions. Their use is largely supplanted by the use of courtesy trucks for lighter materials and by the practice of loading maintenance trucks or trailers with heavy materials. Concerns with using equipment storage sites include control, access, ROW for site, replenishment, and aesthetics.

New equipment storage sites may be useful in at least one location during a major roadway construction project; the number of sites recommended depends upon the length and duration of the project.

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CHAPTER 7
INCIDENT LOCATION

DESCRIPTION AND INTRODUCTION

Reporting incidents and determining the location of incidents, especially in rural or suburban areas, have always challenged incident managers. Emergency mile post markers and call box phones are just two of the devices that are used extensively to identify incident locations.

Emergency mile post markers assist drivers and emergency response personnel in determining and detecting the exact location of incidents on roadways. The markers are usually incremented in one-tenth mile spacings. Some mile post markers give precise location information, i.e., the actual mile identification to the tenth mile, while other posts merely indicate the direction of the nearest emergency assistance location. If the mile post markers are used in conjunction with emergency call boxes, a directional arrow is often used to indicate the direction to the nearest call box.

Emergency call boxes are communication devices that are located at regular intervals along the roadway. The call boxes are linked through some form of telecommunications —telephone line, cellular, or radio frequency signal—to a location that can provide assistance.

LITERATURE REVIEW

California has an extensive network of call boxes. The call boxes, which are located approximately one-half mile apart in urban areas, are operated by either a local or county level call box organization. These distances are slightly longer for rural areas. The San Bernadino County organization reports that approximately 9769 motorists per month receive assistance through the program (*1*). The California call boxes consist of a battery-powered, solar-charged cellular telephone which automatically connects to the local California Highway Patrol Dispatch Center when activated by a push button. San Bernadino County is also the site of one of the 16 federally sponsored field tests for the Smart Call Box. These call boxes combine the traditional call box function with the ability to transmit traffic monitoring and weather data over the cellular radio installed in the call box (*1*).

The Caldecott Tunnel between Oakland and Orinda is also the site of a new type of call box system. Forty-eight call boxes located in the tunnel area are electrically operated, battery backup sites that are equipped with cellular telephones. The telephones activate warning signs at tunnel entrances in addition to connecting the caller with Caltrans. The warning signs alert entering motorists of possible trouble or incidents in the tunnel (*2*).

Emergency road markers and call box systems are also used extensively in Europe. Roadside reflective markers, which are placed every 328 feet (100 m) on the Autobahns and at regular intervals on other federal roads, have a small arrow that indicates to the motorist the direction of the nearest emergency call box. Italy's Autostrade motorways are equipped with emergency call boxes every 1.2 miles (2 km). The call boxes have emergency buttons for breakdown services and medical assistance, and they transmit the exact position of the request for help to the proper agency (*3*).

SITE EXPERIENCES

Ft. Worth

TxDOT has been installing location or reference signs on overhead bridge structures. These location signs are intended to help motorists accurately identify their location on the freeway. The signs indicate the cross-street and the freeway block number, as shown in Figure 7-1.

Figure 7-1. Street Name Sign on Overpass.

Maryland

The use of 0.1 mile (0.16 km) marker spacings has helped to identify the exact location and roadway of incidents, particularly on tangent sections of roadway (See Figure 7-2). Another tool that has helped is a landmark reference book; Maryland incident management center operators have written descriptions of landmarks along primary freeway corridors. If a caller is uncertain of his exact location, the operator can ask him/her to describe any visible landmarks. By matching the reported landmarks with the book descriptions, locations can be estimated with more accuracy.

Figure 7-2. Mile Marker at 0.1 Mile Spacing.

Kentucky

The Kentucky Transportation Cabinet is currently installing a system of standard reference markers for freeways and freeway ramps. The markers are a component of TRIMARC—Traffic Response and Incident Management Assisting the River Cities, a freeway incident management system for Louisville and the southern Indiana urbanized area. Louisville has over 100 miles (161 km) of interstate, including IH-64, IH-65, IH-71, IH-264, and IH-265.

Louisville is using markers with a blue background spaced at 0.2-mile (0.32 km) intervals, in addition to the ramp marker as shown in Figures 7-3 and 7-4. Lexington is using markers with a green background also installed at 0.2-mile (0.32 km) intervals. The neighboring city of Cinncinatti, Ohio, is using a marker with a blue background at a 0.1-mile (0.16 km) interval, while Indianapolis, Indiana, is using a marker with a green background at a 0.1-mile (0.16 km) interval. Tennessee is using blue markers at 0.1 mile (0.16 km) spacings and on ramps but has just begun their installation (See Figure 7-5). A similar system in Fayette County, Kentucky, is being installed utilizing markers at 0.2-mile (0.32 km) intervals (*4*). These markers are part of a test being sponsored by the Federal Highway Administration, and the University of Kentucky is evaluating the marker system.

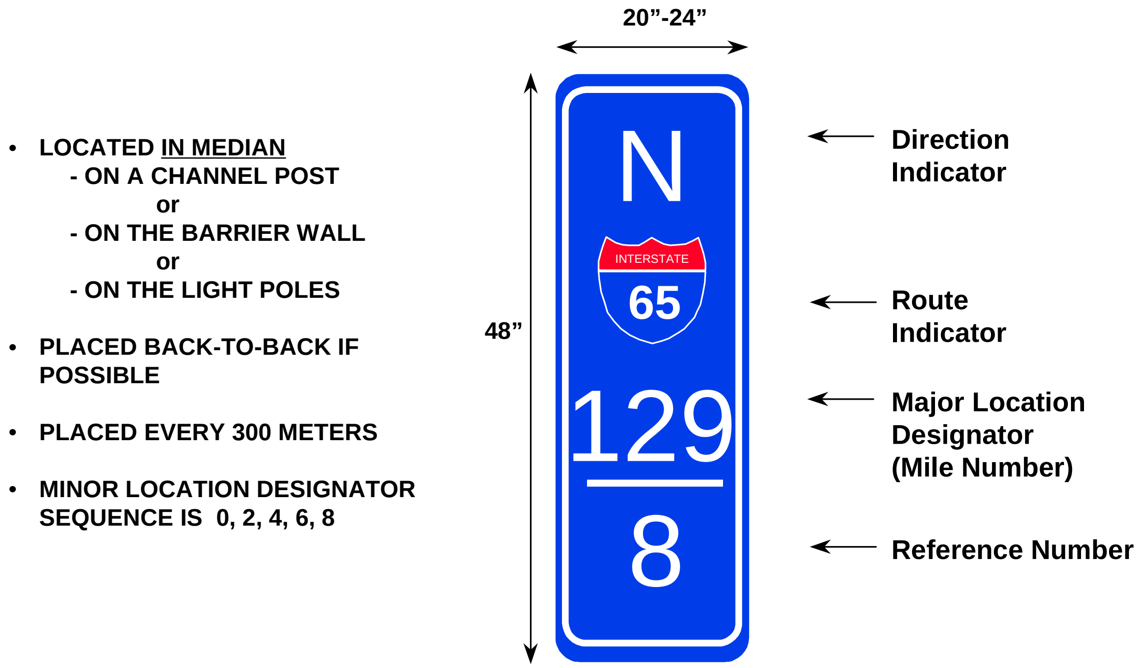

Figure 7-3. Reference Marker System Design.

Figure 7-4. Ramp Marker Design.

Figure 7-5. Ramp Marker Sign in Tennessee.

Virginia

Virginia DOT and emergency service personnel noted that markings to help locate incidents should be simple to understand, easy to use, and closely spaced (0.1 mile [0.16 km] intervals). They also noted that drivers should be educated regarding their presence and use.

UPDATED 911 SYSTEM

Today the wireless 911 calls of one-third of Texas's population do not electronically provide the location or call-back number of the caller. Often callers do not know their exact location, or they are injured and find it difficult to explain their location. The technology is available, and the Texas Legislature has made a $2.3 million commitment to improve the service available. By August 2000 the Commission on State Emergency Communications, state 911, will provide the technology for 75 percent of the state system's population. This service will provide the number the person is calling from and a general location of the caller. The Legislature did not provide the funding for a service that would pinpoint the caller within a few yards. It will also be part of the state 911's duty to negotiate the price and approve the services wireless carriers provide customers as well as ensure that 911 answering centers have compatible technology.

The state 911 system does not include all of Texas. In fact, Austin is the largest town located in the system. Houston, Dallas, and most large cities have their own districts. These districts will begin using the technology on their own schedules, but many feel the state system will lead the way encouraging other areas to use similar implementation programs.

RECOMMENDATIONS

Incident location is critical for effective incident response. Mile markers at a 0.1-mile (0.16 km) spacing (approximately) are recommended. As a supplement, ramp markings should be provided that identify ramps for the public and enforcement personnel. Ramps should be defined as roadways in the state roadway database, facilitating accurate accident reporting. These improvements would enhance incident responses and provide the means to perform more accurate accident studies and to more effectively evaluate safety projects. The 911 location system currently under development should be monitored for future developments.

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CHAPTER 8
TALL CONCRETE BARRIERS AND CONCRETE BARRIERS WITH GLARE SCREENS

DESCRIPTION AND INTRODUCTION

Concrete barriers are used to separate directions of traffic and to reduce headlight glare; these barriers may also reduce onlooker delay. Tall concrete barriers separate traffic and reduce glare with their height, while shorter concrete barriers may have paddles or other devices attached in order to reduce glare. Vegetation may also be planted so that it forms a screen and reduces headlight glare from oncoming lanes.

LITERATURE REVIEW

Tall concrete barriers and barriers with glare screens may be used for multiple applications, including median separation, glare reduction, reduction of gawking at accidents, and prevention of slush and other objects being thrown into opposing lanes. Very little literature was found regarding the application and results of these measures. The first form of glare-screening was median plantings. In addition to beautifying the roadway, the plants screened glare of oncoming traffic and acted as a noise barrier. The types of plants used varied by region, climate, and rainfall conditions. There are no national standards for using plants as glare screens or barriers (*1*).

The type and size of concrete barriers have varied through the years. Although the barrier was originally used for median and traffic separation, the taller barriers can be used for glare control. The standard high concrete barrier is 32 inches (81 cm) in height. The concrete barrier used by New Jersey on the Garden State Parkway has a height of 42 inches (107 cm), and Michigan uses a barrier of 51 inches (130 cm) (*2*).

SITE EXPERIENCES

Las Vegas

Glare screens were identified in two freeway corridors: US-95 west of IH-15, and IH-15 in the vicinity of the US-95 interchange. The Nevada DOT installs glare screens such as these where roadway elevation differentials make them beneficial.

An image of the glare screens used on a 5.4-mile (8.7 km) section of US-95 west of the IH-15 interchange is shown in Figure 8-1. These glare screens are a permanent installation.

Figure 8-1. Glare Screen on Concrete Barrier.

Several types of glare screens are in place over a two-mile (3.2 km) segment of IH-15 in the vicinity of the US-95 interchange, which is currently undergoing major reconstruction A 0.8-mile (1.3 km) section just north of US-95 has a chain link fence glare screen installation, as shown in Figure 8-2. A 0.7-mile (1.1 km) section follows with a vegetation glare screen, as shown in Figure 8-3. Directly at the interchange with US 95, a 0.2-mile (0.32 km) section has a temporary glare screen constructed of vertical wood supports and sections of pressed wood board, as shown in Figure 8-4.

The type of glare screen shown in Figure 8-1 is used in several mountainous locations around Carson City and will most likely be used in any future installations.

Figure 8-2. Chain Link Glare Screen.

Figure 8-3. Vegetation Glare Screen.

Figure 8-4. Temporary Glare Screen.

Maryland

Maryland SHA representatives reported that glare screens are maintenance intensive; they use tall concrete barriers primarily for accommodating grade differences between directions of travel.

Virginia

Virginia DOT representatives and emergency service personnel noted that tall barriers can prevent emergency responders from finding and viewing accident sites when they are responding from the opposite direction of travel. They also noted potential problems with passing fire hoses or patients on stretchers from one side of the freeway to the other.

Los Angeles

Caltrans representatives noted that glare screens are not widely used. They were tried in a few locations and were not liked by the maintenance section. As Figure 8-5 shows, maintenance can be a problem with a number of missing paddles. Plywood screens are frequently used above New Jersey barriers at construction sites. An example is shown in Figure 8-6.

Figure 8-5. Glare Screens in Las Vegas.

Figure 8-6. Temporary Plywood Screen at Construction Site.

Charlotte, NC

Median walls on a section of IH-77 are constructed with openings so that a person can climb over the wall or pass emergency supplies through the opening (Figure 8-7).

Figure 8-7. Concrete Barrier Opening in Charlotte, NC.

RECOMMENDATIONS

Screening and tall barriers reduce headlight glare and the negative impact of incidents on freeway capacity for traffic traveling in the opposing direction. Local experience is the best indicator of areas where screening can be effective. Tall concrete barriers appear to be the best alternative from a maintenance standpoint. No changes are recommended to current TxDOT practice.

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CHAPTER 9
OTHER INCIDENT MANAGEMENT STRATEGIES

EMERGENCY RAMPS AND RAMP REVERSAL

Dallas

TxDOT is constructing an emergency exit ramp along westbound IH-30 in the "Canyon," south of downtown Dallas. This emergency exit ramp will be constructed across an existing entrance ramp (see Figure 9-1). The entrance ramp is from a collector-distributor road that is underutilized during the morning peak period. The primary function of the collector-distributor road is to unload the central business district (CBD) area during the evenings. Just downstream of this location is the "mixmaster," which is the junction of several freeways in downtown Dallas. The mixmaster is the location of numerous crashes, some involving heavy trucks. These crashes tend to shut down the entire freeway for several hours. When a crash occurs, TxDOT will be able to open the emergency exit ramp, allowing motorists to access the collector-distributor road, thus bypassing the crash location.

Figure 9-1. Eastbound IH-30 at the Harwood Exit Ramp (Location of Ramp Reversal).

TxDOT is providing improvements to the eastbound direction of IH-30 in the “Canyon,” a closely confined section of the freeway. This improvement will reverse an existing exit ramp to an entrance ramp. During the evening peak periods, an overcapacity weave in the mixmaster results in heavy congestion on southbound IH-35E. The weave is a result of the heavy demand to eastbound IH-30. By reversing a downstream exit ramp from IH-30 to an entrance ramp, the demand on the weave will be reduced, thus reducing the congestion. This ramp reversal will also be beneficial if and when crashes occur in this overloaded weaving section. (See Figure 9-2.)

Figure 9-2. Westbound IH-30 at the Emergency Ramp Location (across the Harwood Entrance Ramp).

CONTRAFLOW LANES

Contraflow lanes are a temporary reconfiguration of the freeway corridor to allow for diversion of impacted traffic to opposing freeway lanes. Very few studies have been done regarding contraflow lanes. In 1986, Holder et al. investigated the use of contraflow lanes for use by trucks in Houston to increase safety and relieve congestion in certain situations. The study found that although the lanes are more than adequate for truck usage, very few trucks would choose to utilize the contraflow lanes (*1*).

Virginia

Virginia DOT representatives and emergency service personnel believed that contraflow lanes should be used only in cases of total shutdown of the freeway direction. They also noted that their use must be accommodated in the design of the roadway to permit entering and leaving the lanes normally serving opposing traffic.

FIRE HYDRANTS

Virginia

Virginia DOT representatives indicated that fire hydrant/water accessibility can be critical in the case of flyover bridges; providing standpipes is desirable in those cases. High temperature and long duration fires were noted as a potential cause of structural failure. Fire hydrants are sometimes provided along freeways in urban areas; Figure 9-3 shows a hydrant location in a sound wall along a freeway in the Washington, D.C. area. Figure 9-4 shows a mile marker using red lettering to indicate the presence of a fire hydrant along a freeway in the same area.

Figure 9-3. Fire Hydrant in Sound Reduction Wall.

Figure 9-4. Red-Lettered Mile Marker Near Fire Hydrant.

Winston-Salem, NC

Noise walls constructed in Winston-Salem were designed and built with circular openings for fire hoses so that the hoses could go through the wall rather than having to go over or around the wall (Figures 9-5 and 9-6.). Advance signing is used to post the distance to the next opening (Figure 9-7); a sign is also placed at the opening in the noise wall to indicate the distance to the fire hydrant.

Figure 9-5. Fire Hose Opening and Sign.

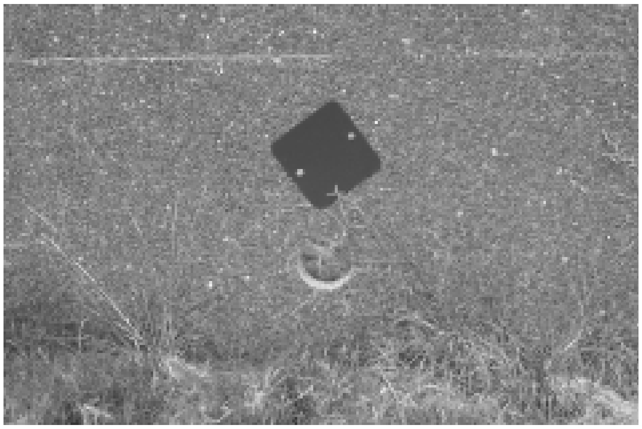

Figure 9-6. Closeup of Opening for Fire Hose.

Figure 9-7. Distance Sign for Hydrant.

TRUCK BYPASS LANES

Truck bypass lanes are lanes that allow trucks to bypass a difficult geometric or operational feature of a roadway. Two of the most prominent examples of this are the bypass of the Tigard Street and IH-5 interchange in Portland, Oregon, and the bypass lanes for a series of interchanges in Los Angeles, California. Both of these facilities allow through trucks to bypass the interchange and avoid weaving maneuvers on roadways that either cause difficulties due to grade or congestion.

Interstate 5 north of Los Angeles is a corridor with a very heavy volume of truck traffic. In the 1970s, Caltrans built truck bypass lanes on IH-5 near three high volume interchanges. The lanes were built to physically separate trucks from other traffic and to facilitate weaving maneuvers in the interchange proper. The first truck facility encompasses the section of IH-5 which includes the Route 14 and Route 210 interchanges. The other truck facilities are at Route 99 near Grapevine and at the interchange of Route 110 and IH-405. Although these facilities were built for truck bypass of the interchanges, automobiles and other vehicles use the lanes. Trucks are restricted to the right lane in California (*2*).

The reason cited by Caltrans engineers for building the truck lanes was to reduce weaving problems. The truck bypass lanes are typically two lanes and have received mixed reviews. Passenger car drivers often prefer to use them instead of going through the interchange in order to avoid weaving. Truck drivers would like to limit the bypass lanes to trucks only due to differences in vehicle operating characteristics between the two vehicle classes and because of an apparent lack of understanding by auto drivers of truck operating characteristics (*2*).

On the section of IH-5 near Portland, a truck bypass at the Tigard Street interchange, which is similar to some of the California facilities, has been implemented. The bypass lane allows trucks to stay in the right lane, exit onto a truck roadway, and re-enter the traffic downstream of the interchange. Passenger cars are also allowed to use the bypass facilities (*2*).

The main lanes are built on a significant grade. Without the truck roadway, larger vehicles are forced to climb a grade, then weave across faster moving traffic to enter the main lanes. The resulting speed differentials caused by trucks performing these maneuvers created operational as well as safety problems prior to the implementation of the bypass lane. Observations of trucks traveling northbound indicated that nearly every truck uses the truck bypass. There are no before-and-after accident data for the truck bypass lane. However, Oregon DOT officials indicated that the removal of the slow-moving trucks from the complex-weaving section has substantially eliminated the operational problems at this site. Truck speeds are now typically 50 miles per hour (80.5 km/hr) in the merge area; prior to implementation of the bypass lane, truck speeds were 20 (32 km/hr) to 25 miles per hour (40 km/hr). There was no specific cost data available for construction of the bypass lane (*2*).

Los Angeles

Truck bypass lanes have been constructed on several L.A. freeways in areas where it was judged especially difficult or hazardous for trucks to use the existing freeway lanes. The lanes are constructed in specifically defined areas where grades are 3.5 percent or more for a substantial distance. The lanes are separated from through freeway lanes, typically taking a slightly longer path in order to reduce steep grades or sharp curvatures. The lanes average three to four miles (6.4 km) in length. Where truck bypass lanes are available, all trucks are required to use the lanes (see Figure 9-8); other vehicles may also use the lanes, although the section is signed as a "truck route" (see Figure 9-9).

Figure 9-8. Exit Sign for Truck Lane.

Figure 9-9. Entrance to Truck Lanes.

RECOMMENDATIONS

Because of the nature of the features in this chapter (i.e., emergency ramps, ramp reversal, contraflow lanes, fire hydrants, and truck lanes), specific recommendations regarding their use were not prepared. Although the benefits of these features can be considerable if located appropriately, their characteristics dictate that they be selected for use after study of area-specific needs and requirements.

REFERENCES

1. R. W. Holder, D. L. Christiansen, C. A. Fuhs, and G. B. Dresser, *Truck Utilization of the IH-45N Contraflow Lane in Houston—A Feasibility Study*, Research Report 205-6, Texas Transportation Institute, Texas A&M University System, College Station, Texas, 1986.

2. D. Middleton, K. Fitzpatrick, D. Jasek, and D. Woods, *Truck Accident Countermeasures on Urban Freeways*, Final Report, Texas Transportation Institute, Texas A&M University System, College Station, Texas, 1992.

CHAPTER 10
SUMMARY OF RECOMMENDATIONS

Researchers identified incident management techniques currently in use through a state-of-the-practice literature review, a written survey of designers and emergency service personnel, and on-site visits to agencies and locations based upon survey results and on the suggestions of project panel members.

The most frequently used incident management techniques related to roadway geometrics include emergency crossovers, refuge areas, shoulder lanes, equipment storage sites, incident location techniques, and tall concrete barriers and barriers with glare screens. The recommendations for these techniques are summarized in Table 10-1.

Other techniques that were investigated include emergency ramps and ramp reversal, contraflow lanes, fire hydrant techniques, and truck bypass lanes. Use of these techniques was very limited; therefore, these topics are included for information, but recommendations for these techniques are not provided.

Table 10-1. Summary of Recommendations of Geometric Design Guidelines to Accommodate Incident Management Strategies.

Technique	Recommendation
Emergency Crossovers 	In suburban or urban areas where distances exceed rural guidelines, the use of emergency crossovers is recommended with the following suggestions: • Permit crossings in suburban/urban areas as needed when spacing exceeds the current rural standard. • Install and sign the crossover for the use of authorized vehicles only. • Use a designating sign only—do not install advance signing. • Install an improved surface. • Use powered gates for breaks in median barriers that are compliant with current crash-test requirements.
Refuge Areas 	The use of refuge areas/accident investigation sites is recommended with the following suggestions: • Use where the right shoulder does not allow refuge. • Locate adjacent to or near the freeway lanes. • Include a median to provide a separation distance equal to the required horizontal clearance (clear zone). • Provide telephone access. • Provide for acceleration or deceleration if no shoulder is present. • Include advance signing. • Make the area large enough to allow easy movement of tow, police, and fire vehicles. A nominal size is 45 feet (14 m) by 150 feet (46 m). • Provide separate entrances and exits to limit the possibility of wrong-way movements.

Table 10-1. Summary of Recommendations of Geometric Design Guidelines to Accommodate Incident Management Strategies (continued).

Technique	Recommendation
Temporary Shoulder Lanes 	The use of shoulder lanes for a short period is appropriate when directed by officers on the scene (using police flaggers); however, the use of shoulder lanes on a permanent or frequent basis is *not* recommended because: • usage impacts safety, particularly with regard to the right shoulder; • usage impacts enforcement activities, particularly with regard to the right shoulder; • usage impacts incident response time due to shoulder blockage; and • usage may become habitual, which could potentially cause problems.
Equipment Storage Sites 	The use of equipment storage sites is not recommended for typical conditions. Their use is largely supplanted by the use of courtesy trucks for lighter materials and by the practice of loading maintenance trucks or trailers with heavy materials. Concerns with using equipment storage sites include control, access, ROW for the site, replenishment, and aesthetics. Equipment storage sites may be useful in at least one location during a major roadway construction project; the number of sites recommended depends upon the length and duration of the project.

Table 10-1. Summary of Recommendations of Geometric Design Guidelines to Accommodate Incident Management Strategies (continued).

Technique	Recommendation
Incident Location 	Incident location is critical for effective incident response. Mile markers at a 0.1-mile (0.16 km) spacing (approximately) are recommended. As a supplement, ramp markings should be provided to identify ramps for the public and for enforcement personnel. These improvements would enhance incident response and provide the means to perform more accurate accident studies and more effectively evaluate safety projects. The 911 location system currently under development should be monitored for future developments.
Tall Concrete Barriers and Concrete Barriers with Glare Screens 	Screening and tall barriers reduce headlight glare and the negative impact of incidents on freeway capacity for traffic traveling in the opposing direction. Local experience is the best indicator of areas where screening can be effective. Tall concrete barriers appear to be the best alternative, from a maintenance standpoint.

APPENDIX

This Appendix contains copies of the survey instruments administered to city and state transportation agencies and to emergency service agencies, respectively. A total of 158 surveys were mailed. The survey was used to identify incident management techniques that are being used successfully along with corresponding geometric requirements needed for the techniques to work effectively.

The survey form for city and state transportation agencies is included on pages 105 through 109. The survey form for emergency response personnel is included on pages 111 through 115.

SURVEY OF INCIDENT MANAGEMENT TECHNIQUES
for Texas Department of Transportation (TxDOT) Project 1848

City and State Transportation Agencies

Freeway incidents are a major cause of congestion. Incidents can range from disabled vehicles on the shoulder to major incidents blocking several freeway lanes. The effect of an incident on surrounding traffic depends heavily on the time required to detect, respond to, and clear the incident. An effective incident management program can significantly reduce the effects of incidents on freeways. **We need your help in identifying incident management techniques that are being used successfully and the corresponding geometric requirements that need to be in place so that the techniques work effectively.**

This information will assist us in developing geometric design techniques that can facilitate a quick response by emergency vehicles in reaching incident sites or in clearing traffic backups more quickly and easily.

THANK YOU FOR YOUR INPUT. All respondents will receive a synopsis of the research findings at the conclusion of the project.

If you are interested in obtaining further information about this project or survey, please call Mark Wooldridge at (409) 845-7321.

---

1. **Are you aware of problems with locating reported incidents on ramps or roadway in interchanges? Y / N**
   If yes, please describe. ____

   ____

   ____

   ____

   Does you agency have a system for labeling or identifying specific ramps or roadways in interchanges? Y / N
   If yes, please describe. ____

   ____

   ____

   ____

2. Please give one or two locations where you have seen the following techniques on urban freeways and comment on the effectiveness of the technique.

Accident Investigation Sites: Designated areas located adjacent to the main travel lanes that provide motorists and police with a site to relocate damaged vehicles, complete accident reports, and place necessary phone calls.

Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
•	• Y / N / Unsure	•
•	• Y / N / Unsure	•

Contraflow Lanes: Temporary reconfiguration of the freeway corridor to allow for diversion of impacted traffic to opposing freeway lanes.

Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
•	• Y / N / Unsure	•
•	• Y / N / Unsure	•

Emergency Crossovers: Designated gaps in freeway medians, intended for use only by emergency vehicles to improve response times on freeways where the distance between interchanges is substantial.

Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
•	• Y / N / Unsure	•
•	• Y / N / Unsure	•

Emergency Gates: Gates in median rail accessible only to emergency personnel to provide access during incidents.

Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
•	• Y / N / Unsure	•
•	• Y / N / Unsure	•

Emergency Pull-off Zones: Designated areas, typically provided alongside roadway sections with little or no shoulder width, that provide sites for the temporary relocation of damaged or broken-down vehicles.

Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
•	• Y / N / Unsure	•
•	• Y / N / Unsure	•

Equipment Staging Area: A specially designated area sometimes used near high-incident or other critical facilities bridges, tunnels, etc.) for the parking of towing and recovery equipment.

Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
•	• Y / N / Unsure	•
•	• Y / N / Unsure	•

Incident Equipment Storage Sites: Designated storage sites typically located adjacent to roadway sections that experience high incident rates. They are stocked with common incident removal/clearance material and equipment.

Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
•	• Y / N / Unsure	•
•	• Y / N / Unsure	•

Incident Screens: Portable screens erected at major incidents to reduce onlooker delay.

Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
•	• Y / N / Unsure	•
•	• Y / N / Unsure	•

Tall Concrete Barriers or Concrete Barriers with Glare Screens: Concrete barriers that separate directions of traffic and reduce headlight glare. The barriers may also reduce onlooker delay.

Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
•	• Y / N / Unsure	•
•	• Y / N / Unsure	•

Temporary Ramps: Special roadway ramps that allow emergency vehicles to directly access the incident scene from adjacent frontage roads or cross-streets when no permanent entrance ramps exist.

Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
•	• Y / N / Unsure	•
•	• Y / N / Unsure	•

Temporary Shoulder Lanes: Provided that they exceed a minimum width, roadway shoulders can be used as temporary travel lanes during incidents or as an area to stage emergency vehicles in a manner that minimizes lane closures.

Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
•	• Y / N / Unsure	•
•	• Y / N / Unsure	•

Other:

Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
•	• Y / N / Unsure	•
•	• Y / N / Unsure	•

3. **Once equipment is in the vicinity of an incident, are there roadway features or characteristics that make it particularly difficult to move emergency vehicles into position or remove other affected vehicles?** ________

____

____

____

____

4. If you were designing a freeway for improved incident response and faster clearing of traffic backups, which of these issues would be important to you?

Issue	Important	Somewhat Important	Not Important
Accessibility to the scene from the opposing direction or frontage roads (barriers, grass medians, etc.)			
Capacity of alternative routes			
Changeable message signs and lane-control signals			
Establishment of temporary exit ramps on freeway-frontage road corridors			
Fire hydrant/water accessibility			
Location and frequency of access points			
Reversal of traffic flow on entrance ramps to move blocked traffic			
A system for labeling or identifying specific ramps or roadways in interchanges			
Other:			

5. **Do you have any other comments or suggestions?** ______________________

____

____

____

Name ______________________________

Address ______________________________

____

Phone/Fax ______________________________

E-Mail ______________________________

Agency ______________________________

Please mail or fax survey to:

Mark Wooldridge, P.E.
Texas Transportation Institute
College Station, TX 77843-3135

Fax: (409) 845-6481

E-mail: mwooldridge@tamu.edu

SURVEY OF INCIDENT MANAGEMENT TECHNIQUES
for Texas Department of Transportation (TxDOT) Project 1848

Emergency Response Agencies

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---

1. What types of incidents does your agency typically respond to on freeways? Please estimate the percentage of each type of response.

✔	Type of Incident	Estimated Percentage
_____	Debris on Road	_____
_____	Fatal Crashes	_____
_____	Injury Crashes	_____
_____	Property Damage Only Crashes	_____
_____	Hazardous Chemical Spills	_____
_____	High water / Snow / Ice	_____
_____	Stalled Vehicle / Mechanical Breakdown	_____
_____	Vehicle Fires	_____
_____	Overturned Vehicles	_____
_____	Other: ____________________________	_____
_____	Other: ____________________________	_____
	TOTAL	100%

2. Please give one or two locations where you have seen the following techniques on urban freeways and comment on the effectiveness of the technique.		
Accident Investigation Sites: Designated areas located adjacent to the main travel lanes that provide motorists and police with a site to relocate damaged vehicles, complete accident reports, and place necessary phone calls.		
Where have you seen this used? • •	*Successful?* •Y / N / Unsure •Y / N / Unsure	*How could it be used more effectively?* • •
Contraflow Lanes: Temporary reconfiguration of the freeway corridor to allow for diversion of impacted traffic to opposing freeway lanes.		
Where have you seen this used? • •	*Successful?* •Y / N / Unsure •Y / N / Unsure	*How could it be used more effectively?* • •
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Where have you seen this used? • •	*Successful?* •Y / N / Unsure •Y / N / Unsure	*How could it be used more effectively?* • •
Emergency Gates: Gates in median rail accessible only to emergency personnel to provide access during incidents.		
Where have you seen this used? • •	*Successful?* •Y / N / Unsure •Y / N / Unsure	*How could it be used more effectively?* • •

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•	•Y / N / Unsure	•

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Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
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•	•Y / N / Unsure	•

Temporary Shoulder Lanes: Provided that they exceed a minimum width, roadway shoulders can be used as temporary travel lanes during incidents or as an area to stage emergency vehicles in a manner that minimizes lane closures.

Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
•	•Y / N / Unsure	•
•	•Y / N / Unsure	•

Other:

Where have you seen this used?	*Successful?*	*How could it be used more effectively?*
•	•Y / N / Unsure	•
•	•Y / N / Unsure	•

3. **Once equipment is in the vicinity of an incident, are there roadway features or characteristics that make it particularly difficult to move emergency vehicles into position or remove other affected vehicles?** ________

____

____

____

____

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Accessibility to the scene from the opposing direction or frontage roads (barriers, grass medians, etc.)			
Capacity of alternative routes			
Changeable message signs and lane-control signals			
Establishment of temporary exit ramps on freeway-frontage road corridors			
Fire hydrant/water accessibility			
Location and frequency of access points			
Reversal of traffic flow on entrance ramps to move blocked traffic			
A system for labeling or identifying specific ramps or roadways in interchanges			
Other:			

5. **Do you have any other comments or suggestions?** ______________________________

____

____

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Name ______________________________

Address ______________________________

____

Phone/Fax ______________________________

E-Mail ______________________________

Agency ______________________________

Please mail or fax survey to:

Mark Wooldridge, P.E.
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