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16. Abstract  <p>In September 2005, the threat of Hurricane Rita to the Houston-Galveston region resulted in the evacuation of more than one million persons from the Texas coastal and urban areas. This concentration of evacuees overloaded all routes leaving the Houston area, resulting in traffic queues on freeways as long as 36-hours. While traffic and emergency management personnel had access to real-time traffic information in the urban areas, no such information was available in rural areas where the roadways had restricted capacity. There was clearly a need to expand video and traffic monitoring capabilities beyond the urban areas to allow for better traffic management in response to evacuations as well as normal traffic operations.</p> <p>HURREVAC is a restricted-use Internet based computer program used by government emergency managers to track hurricanes and assist in evacuation-related decision making. The program includes an ETIS (Environment Transport Integrated planning System) module included which allows for inclusion and access to real-time traffic information by emergency managers. This report documents attempts to complete the integration of the module with traffic data for Texas coastal regions. It also provides for general equipment and installation guidelines for deployment of video and sensor detection stations along hurricane evacuation routes. In addition, a list of recommended additional deployments of such monitoring equipment to allow for improved monitoring and managing of traffic during evacuation events in Texas.</p>					
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# **REAL-TIME DATA FOR HURRICANE EVACUATION IN TEXAS**

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Transportation Information System in HURREVAC

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## **EXECUTIVE SUMMARY**

The objective of this project was to assess the feasibility of integrating real-time traffic data in Texas coastal regions into the ETIS model of HURREVAC. HURREVAC is a restricted-use internet based computer program used by emergency managers to track hurricanes and assist in evacuation-related decision making. The program has an Evacuation Transportation Information System (ETIS) model included which, estimates or provides available real-time traffic data on the evacuation routes for select states in the southeastern United States. There is presently no data for Texas evacuation traffic in the ETIS model within HURREVAC. The September 2005 evacuation of southeast Texas in anticipation of Hurricane Rita further identified this need for providing real-time traffic information on Texas evacuation routes.

The findings of this research did not result in satisfying the project objective of integrating Texas traffic data into HURREVAC. A factor in this was that the developers of the program could not work with the researchers without an offer of funding. The scope and budget of this project did not allow for such financial support to any private sector partners. As a result, the researchers pursued the project in terms of developing an evacuation traffic information system that, with support from other state and local agencies, can be used by traffic and emergency managers as well as the general population.





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## BACKGROUND

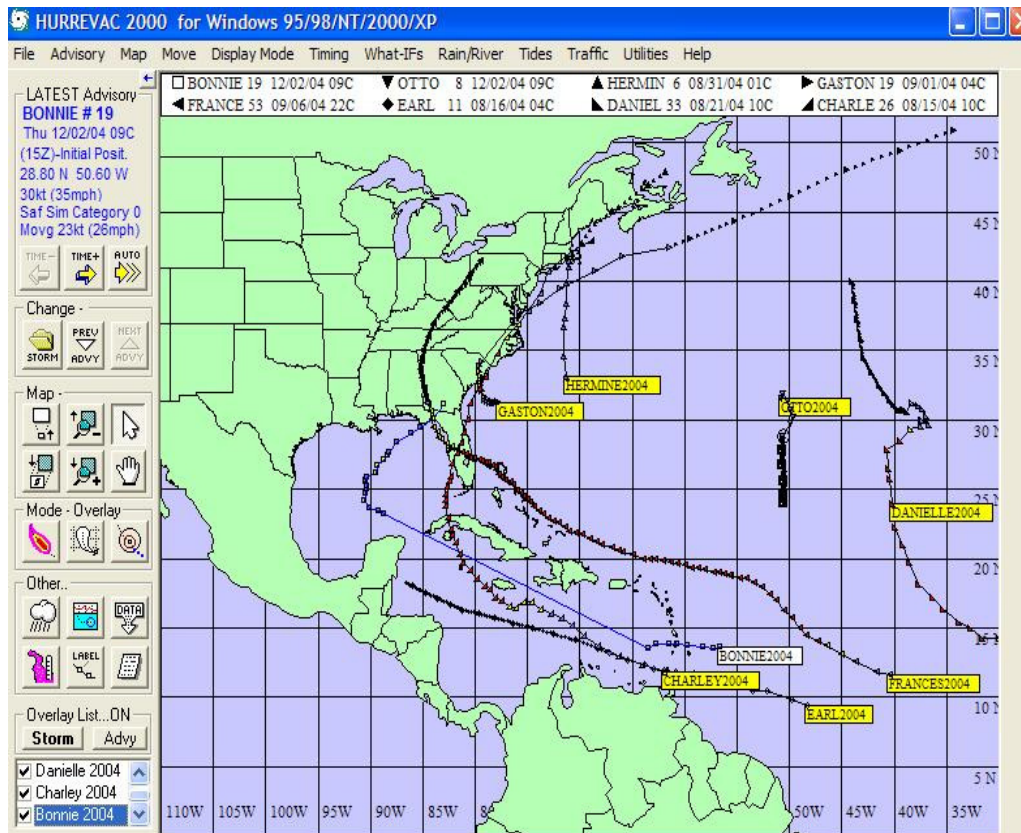
According to the National Hurricane Center (1), a total of 279 hurricanes have had a direct hit on the mainland United States coastline between 1851 and 2006. Of the 60 that struck the Texas coastline, 19 were classified as “major” hurricanes [Saffir/Simpson Category 3-5]. Texas is second only to the Florida coastline [113 hurricanes – 37 major] in direct hits during that time period. Coastal regions throughout the country are experiencing rapid growth and development; this has taxed the ability of many routes to adequately serve the increasing evacuation traffic demand. The 2005 Texas State Legislature passed H.B. 3111, which gives the county traffic judge or mayor of a municipality the authority to order an evacuation in an emergency and allows those officials to control ingress to and egress from a disaster area. It is expected that this “mandatory evacuation” will cause an additional demand increase on the designated evacuation routes as compared to previous years.

From November 2004 through January 2005, the Office of Homeland Security and the Governor’s Division of Emergency Management held a series of hurricane evacuation workshops to complete a comprehensive assessment of Texas’ current evacuation plans and capabilities. One recommendation offered is “install a system of real time traffic counters at key points along main evacuation routes to provide information on evacuation traffic flow”. (2) This recommendation further states that these counters would be linked to local emergency operations centers and to the State Operations Center; there is no mention of providing the data in the HURREVAC Model.

On September 24, 2005, Hurricane Rita made landfall just east of the Texas/Louisiana border as a Category 3 hurricane. As Rita approached the Texas coast as a then Category 5 hurricane on September 21-23, it provoked one of the largest evacuations in U.S. history. Media reports indicated that the number of evacuees in Texas could have exceeded two million. Additional evacuations involving smaller numbers took place in Louisiana. While seven fatalities have been directly attributed to the hurricane itself, at least 55 “indirect” fatalities were reported in Texas. This includes a bus fire south of Dallas during the evacuation that killed 23 elderly from a Houston area nursing home. Other persons reportedly died due to heat exhaustion during the evacuation (3). Damages have been estimated to exceed \$11.8 billion (1).

The massive evacuation from the Houston area resulted in congested roadways; a typical 4-hour drive from Houston to Dallas was reportedly taking in excess of 24-hours. Although fuel shortages, medical issues, and personal comfort needs complicated the effort, all roadways in the hurricane impact zone were cleared of motorists 12-hours before landfall. In October 2005, the Texas Governor appointed a 14-member task force to, in part; make recommendations on how to improve evacuation plans for future emergencies in Texas. The task force recommended that the Texas Department of Transportation (TxDOT) and the Texas Department of Public Safety (DPS) jointly develop contra-flow plans for major evacuation routes (4). Traffic managers and law enforcement agencies throughout the state worked together to develop the required plans including the installation of traffic monitors. However, no plans or funding were made available to integrate the data into HURREVAC.

HURREVAC is a restricted-use internet based computer program used by more than 4,450 official government emergency managers to track hurricanes and assist in evacuation-related decision making (Figure 1). It is used by emergency management officials throughout Texas coastal regions as a critical tool in determining when to make a decision to call for evacuation during hurricane events. It was first used in South Carolina and Georgia during the 1989 hurricane season, specifically with Category 4 Hurricane Hugo. Subsequently, the program was developed for 13 states, the U.S. Virgin Islands, and Puerto Rico. HURREVAC tracks hurricanes on computer plot maps using information from the National Hurricane Center, the data from federal hurricane evacuation study for the area, and provides an estimate of when various evacuation decisions should be made. The current version of the software [HURREVAC 2000] also includes National Weather Service official rainfall forecasts out to three days. Developed and maintained by Sea Island Software, Inc., the program couples FEMA and U.S. Army Corps of Engineers hurricane evacuation data and current weather forecast data from the National Weather Service.



**Figure 1. HURREVAC Storm Tracking Screenshot**

In 2007, the U.S. Army Corps of Engineers and the Federal Emergency Management Agency (FEMA) funded a complete rewrite of HURREVAC in the Microsoft.NET programming environment. The new program is expected to be operational in 2010. The upgraded program will incorporate newer web and mapping standards into the model. A survey of registered users was completed by the selected contractor in November 2007 to gather input regarding experiences using the software.

## INTEGRATION OF TEXAS TRAFFIC DATA IN HURREVAC

As the primary objective of this research was to determine the feasibility of integrating real-time traffic data from Texas coastal regions into the ETIS model of HURREVAC, the initial task within the project was to make contact with the software developers. Several conversations were made with the developers (Sea Island Software) as well as with the engineering firm (PBS&J) responsible for the “traffic end” of the software about working cooperatively with TTI to integrate Texas data within their existing systems. Neither of those private sector companies was able to work with the TTI staff unless funding could be secured to support their efforts.

Further research into the ETIS model determined that it is a product of the Southeast U.S. Hurricane Evaluation study. The systems consist of a traffic demand forecast model that accepts inputs on storm category, evacuation, compliance rate, and tourist occupancy information. Based upon this information, the model estimated the traffic on the evacuation routes (5). Although provisions were supposed to be made for real-time information which could assist in the determination of available routes and/or detours, no such data has been integrated as yet.

As was shown in dramatic fashion during the Hurricane Rita evacuation of the Houston/Galveston region in September of 2005, significant congestion on evacuation routes (Figure 2), particularly at points of restricted capacity, the lack of real-time knowledge of that congestion, hampered the orderly evacuation of the residents in affected areas.



**Figure 2. US 290 Congestion During Hurricane Rita Evacuation**

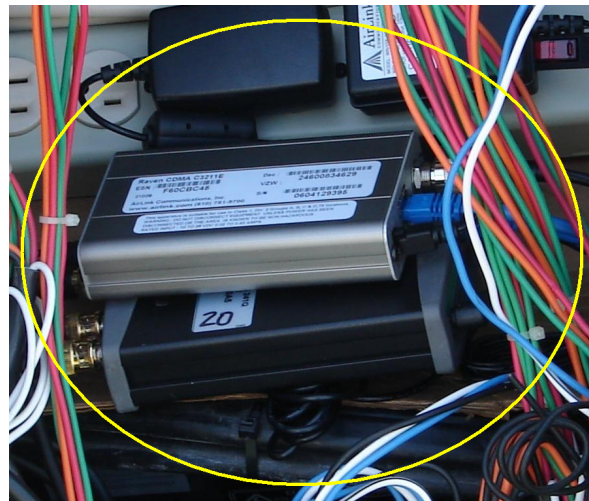
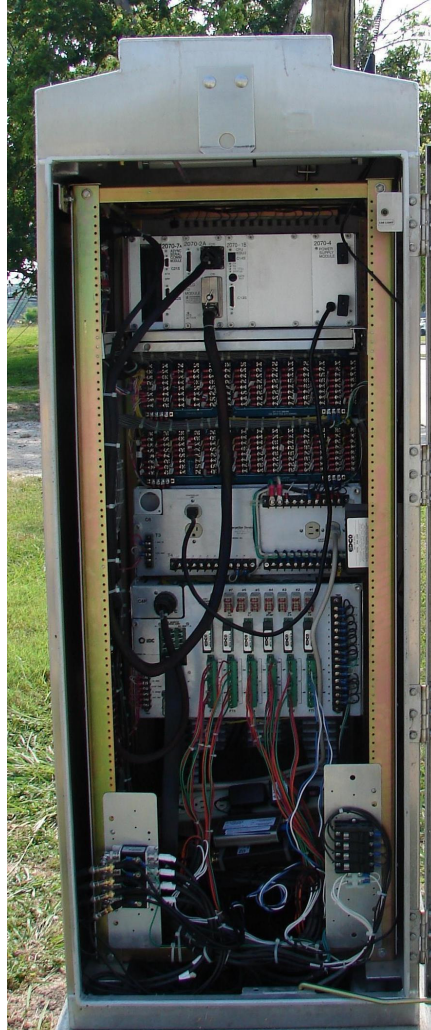


## USE OF TRAFFIC OPERATIONS DATA

HURREVAC is used as a tool by emergency management personnel as a source to obtain the necessary information to make evacuation decisions. The software combines real-time weather forecast information with hurricane evacuation study data. This allows Texas emergency managers to estimate evacuation times specific for hurricanes approaching the Texas coastal region. HURREVAC can provide information as to when decisions about evacuations should be made; providing guidance such that all necessary evacuations are expected to be completed prior to the arrival of sustained tropical storm force (39 miles per hour) winds.

Many emergency managers are expected to oversee many activities during an evacuation. As they are typically not traffic engineers by education or training, the task of traffic management is often delegated to others. Ideally, local or state traffic engineers or law enforcement are assigned traffic management duties during evacuation events. Hence, the inclusion of real-time traffic information in the ETIS model of HURREVAC may not be a high priority from an emergency management perspective. The ETIS system in the software is not a tool used by traffic managers in Texas. The evacuation in Southeast Texas in anticipation of the landfall of Hurricane Rita in September 2005 significantly changed how evacuations are handled for Texas coastal regions. Prior to this event, it was assumed that the evacuations would only occur in the coastal regions that might likely flood due to storm surge. The evacuation plans and roadway capacity for this scenario was more than sufficient to handle traffic demands as the distance traveled by evacuees was typically less than 100 miles. However, the Hurricane Rita evacuation included a significant increase in the volume of traffic departing from regions that are typically not in danger of a flooding event; many of these drove 200-300 miles to their intended destination. Therefore, emergency and traffic management personnel jointly developed revised evacuation plans for the region. TxDOT took a leading role in developing plans for contra-flow operations on major evacuation routes and began deploying monitoring cameras and traffic data collection stations at critical locations along these routes prior to the 2006 hurricane season. Given this change, the researchers determined that the development of a system independent of HURREVAC and primarily for traffic management and public information purposes is the best option to facilitate hurricane evacuations in Texas. As HURREVAC is only available to emergency managers, the development of a system which can provide real-time information to the general public is desirable.

In the Spring of 2006, TxDOT undertook a deployment of commercially available equipment to monitor selected locations that had proven to be of interest during the Hurricane Rita evacuation. Using existing video detection equipment (VIVDS) already installed at signalized intersections, relatively inexpensive and expedited installations were able to be accomplished with only the addition of cellular modems and video servers in signal cabinets. An example of the installation in a signal cabinet is shown in Figure 3. Figure 4 illustrates the visual observation that could be obtained from one of the cameras at the site. This particular example utilizes a hand held device (PDA) but similar displays were utilized on Blackberry and other such web-enabled devices by transportation officials when desired. These images are also available through the Internet to the TranStar webpage.



**Figure 3. Typical Video Server and Cellular Modem Installation in a Traffic Signal Cabinet**





**Figure 4. Handheld Display of Video Image from VIVDS camera**



## EXISTING (2007) AVAILABLE REAL-TIME TRAFFIC DATA

Prior to the 2006 hurricane season, the availability of any real-time traffic data beyond large urban areas in Texas was limited. Only the travel-time and speed information data from the Houston TranStar (Greater Houston Transportation and Emergency Management Center) was available during the 2005 Hurricane Rita evacuation. Because of the nature of the evacuation, this data was of limited use in terms real-time traffic management during the evacuation. There was no data available in rural areas along the evacuation routes; where a significant amount of congestion occurred due to lower roadway capacity. TxDOT began installing cameras and traffic data recorders at critical locations of evacuation routes in the Houston-Galveston and Beaumont-Port Arthur regions prior to the 2006 Atlantic Hurricane Season. These sensor locations were mostly located in the rural regions where congestion began to develop during the Hurricane Rita evacuation. Although the focus of the research project has moved outside of HURREVAC, the task of identifying the locations where real-time data collection/monitoring sites are presently installed and locations where information will aid emergency and traffic management personnel remains critical.

The goal for the installation of the TxDOT traffic sensing equipment was to have the capability to monitor traffic operations at critical points along critical evacuation routes in southeast Texas. In addition to the ability to receive real-time traffic information, cameras were installed at these locations to provide snap-shot images of the roadway. To allow monitoring of the traffic and images, each is accessible through the Houston TranStar website at [http://traffic.houstontranstar.org/maps/traffic\\_region\\_nav.html](http://traffic.houstontranstar.org/maps/traffic_region_nav.html) (Figure 5)

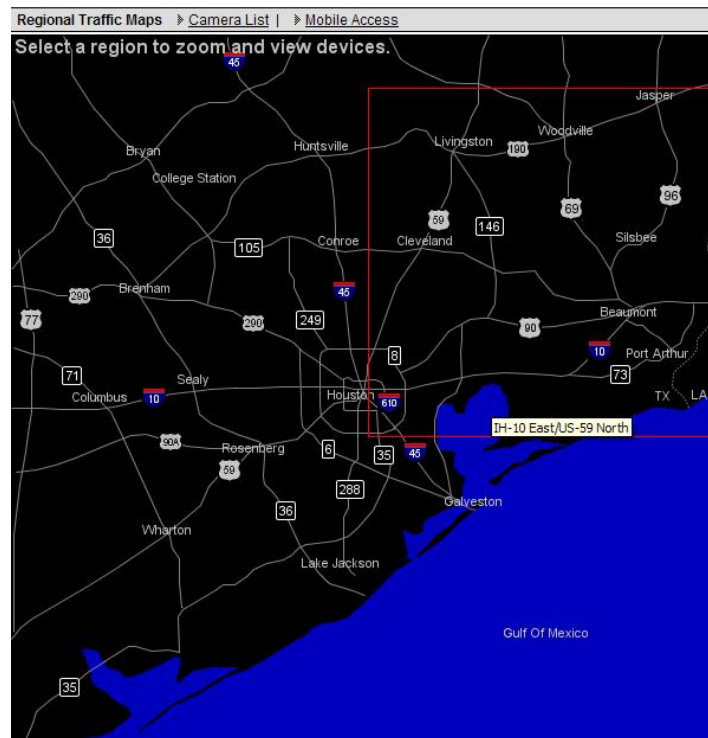
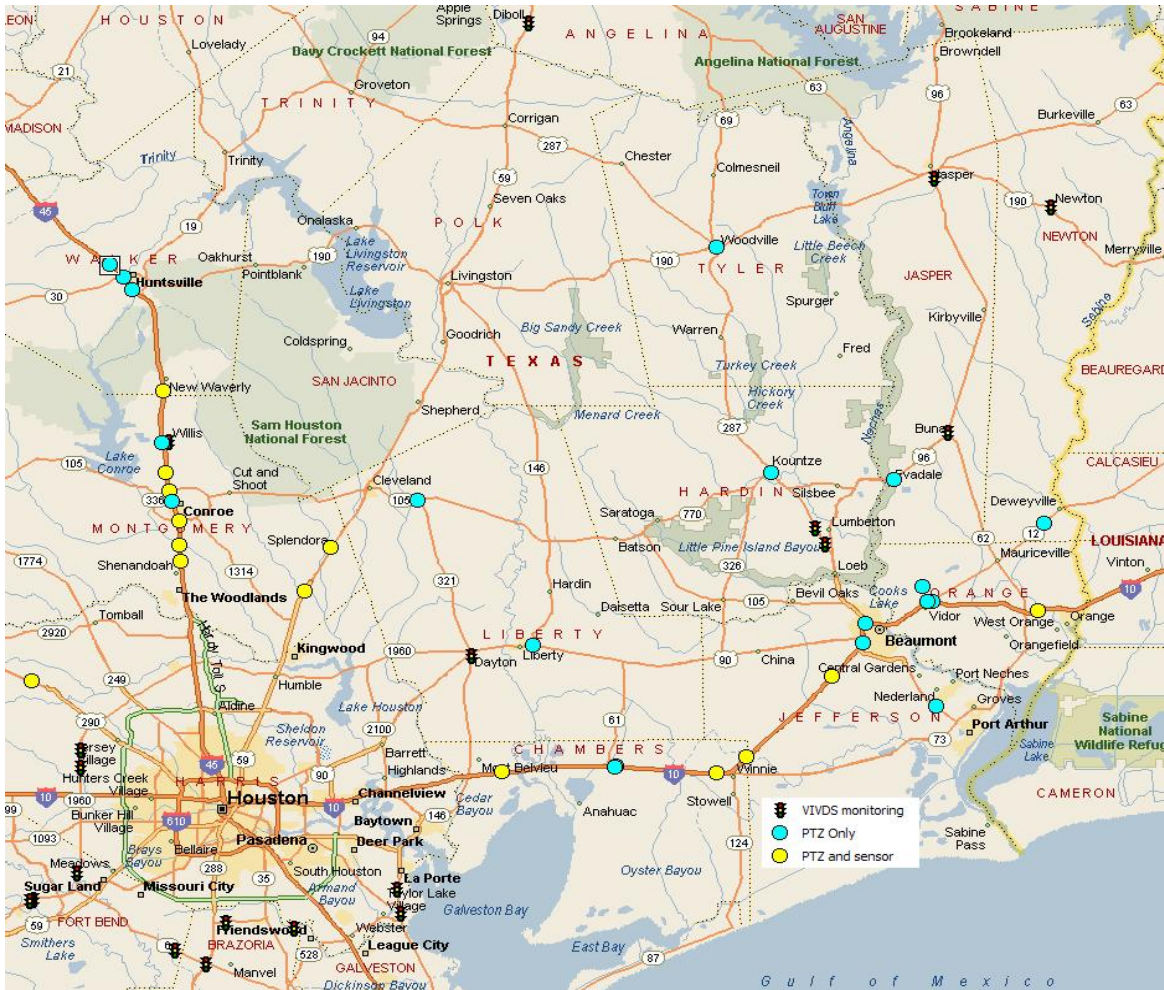


Figure 5. Screenshot of TranStar Regional Webpage

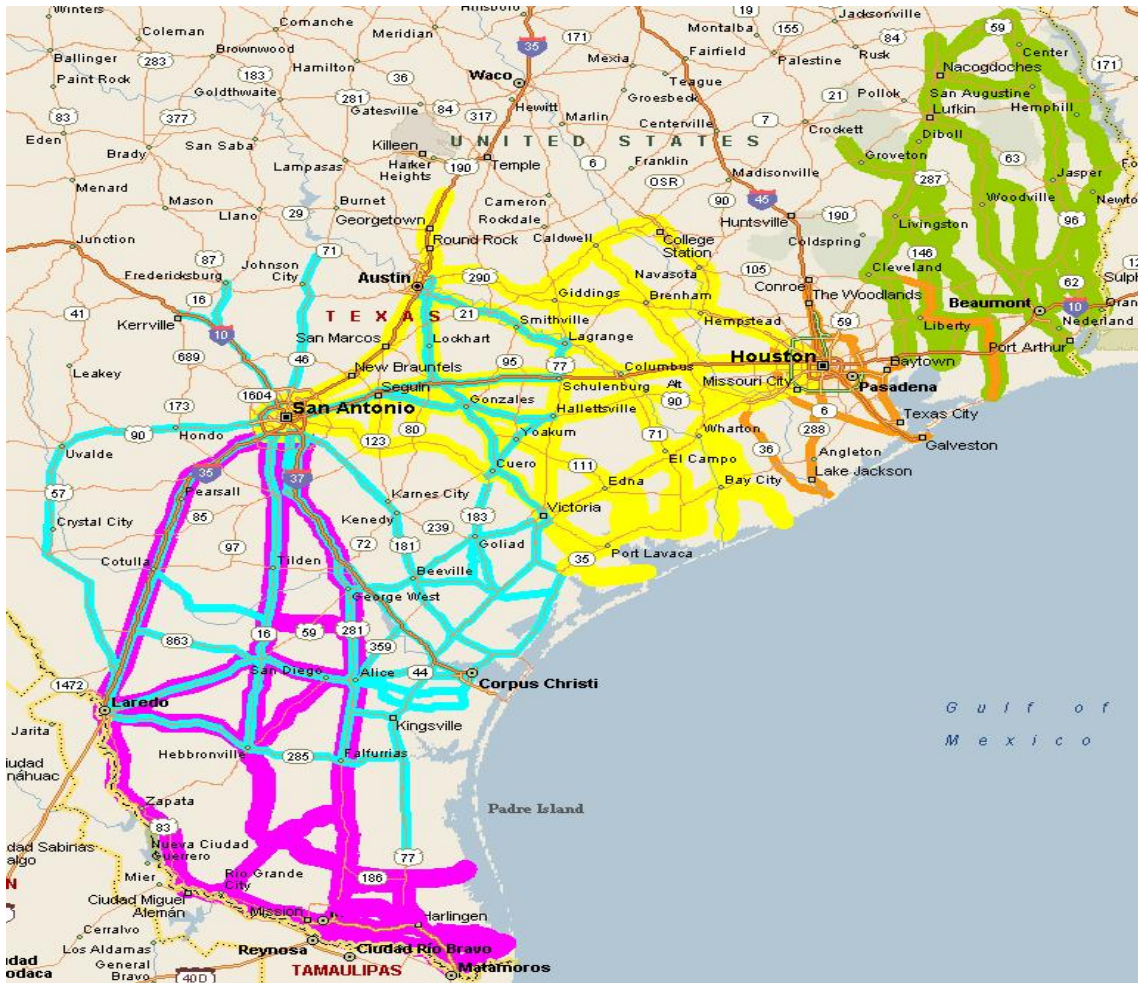
While each of the monitored locations provide images, only selected freeway sites were equipped with radar sensors to monitor and provide real-time traffic information. Location of these regional sites is presented in Figure 6. A more detailed location list is included in Appendix A. These locations are in the Houston and Beaumont regions and can be used to supplement similar information available from Houston TranStar during any evacuation scenarios as well as for routine traffic management. The regional cameras and traffic sensors are a part of the Houston TranStar network.



**Figure 6. Locations of Houston TranStar/TxDOT Evacuation Cameras and Traffic Sensors**

## FUTURE DATA NEEDS

When compared to the 2005 Hurricane Rita evacuation scenario, the only regions of Texas with sufficient coverage to more effectively manage evacuation traffic are the Houston and Beaumont regions. Video and traffic sensor capabilities are needed at additional locations throughout the State. Although the specific details concerning the ideal placements for cameras and traffic sensors are best left to local emergency and traffic management personnel, a list of recommended generalized locations are presented in Appendix B. These locations were determined by evaluation of the published evacuation routes for the various population centers along the Gulf Coast which are included in Appendix C and summarized in Figure 7.



**Figure 7. Locations of TxDOT Evacuation Routes**

These locations have also been categorized by an immediate and long-term priority. The immediate priority needs are defined as those locations located closest to the coastal regions where evacuations are most likely to occur. The long-term priority location are those that while on Texas hurricane evacuation routes, are inland such that each may not be needed for

evacuation traffic management, but will serve an important tool in determining evacuation response. The basis for the route selection is the evacuation routes as provided to the general public and are illustrated in Appendix C (6). It is also recommended that each of the locations as identified in Appendix B include both camera and traffic sensors, and that each can be viewed remotely in real-time mode. The specifics of equipment, communication, and access for the field sites are examined in the next section of this report. An overview of the current deployment of equipment overlaid on the evacuation routes in southeast Texas is shown in Figure 8 below.



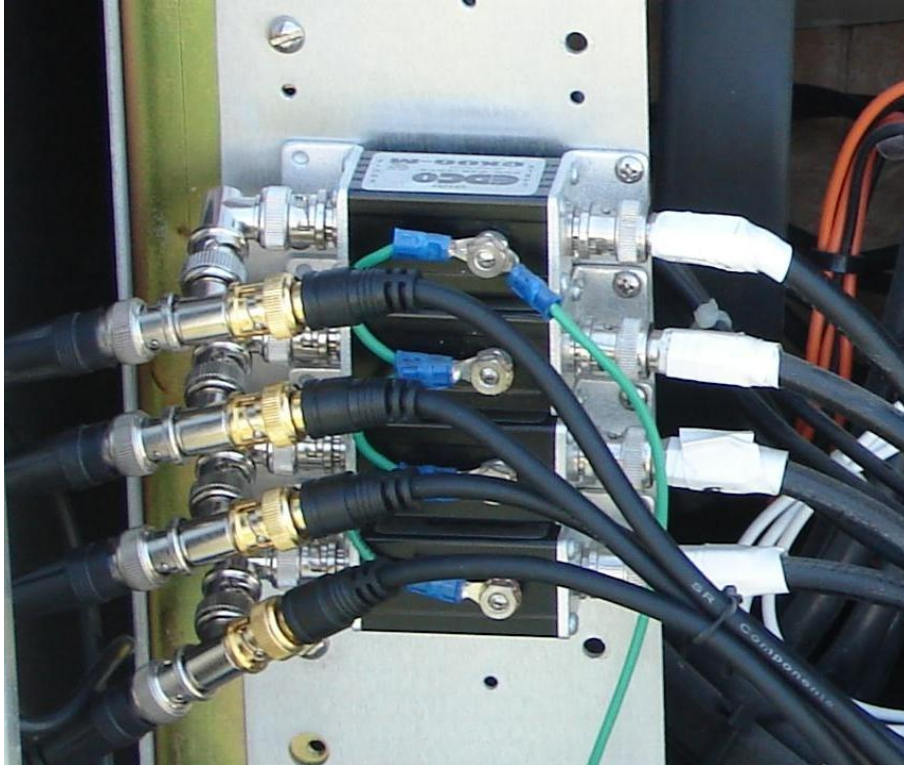
**Figure 8. Deployed equipment along TxDOT Evacuation Routes**

## **GUIDANCE FOR FIELD EQUIPMENT SELECTIONS AND COMMUNICATION**

Although there is a plan for statewide deployment of fiber optic infrastructure to enable communications from field equipment in remote locations, the completed build out of that infrastructure remains in the unforeseen future. Based on the experience of the deployments of the cameras and sensors in the Houston and Beaumont non-urban areas, it is recommended that cellular modems be utilized for data communications in those remote areas where fiber optic infrastructure has not been deployed. Although this strategy does incur an ongoing monthly cost, the cellular networks have proven to be very reliable.

While other wireless Ethernet communications approaches (WiFi and spread spectrum) may be viable alternatives in some locations, they were not pursued due to more complex design and installation requirements.

The least complex and most inexpensive deployment of monitoring equipment is the use of an Ethernet video server that can be installed in an existing traffic signal cabinet where video detection equipment is already in use. In most cases, the existing video signals are of sufficient strength to allow for the interception of the signals prior to their input at the controller using splitters. An example of that interception is shown in Figure 9. The use of the video splitters does not impact the quality of the images for the operation of the detection system, except in the case of extremely long cable runs where a signal amplifier might be required.



**Figure 9. Video splitters in traffic cabinet**

Consumer grade video servers were selected for the initial demonstrations due to their ready availability and low cost. Experience in other outdoor applications has shown them to be perfectly acceptable for use in the Houston area environment. While not “field hardened” in the normal sense of standard TxDOT specifications, these units have been shown to perform adequately for several years with minimal maintenance. When and if malfunctions occur, the low costs and ready availability of replacement prove to be a viable alternative to more ruggedized components. The same consideration has justified the use of consumer grade PTZ cameras. The video server used in the initial deployment in the Houston area was an Axis 241Q which is a four port video server with Ethernet capability. It also is easily managed over a network and is responsive to relatively simple scripting to enable incorporation into the TranStar web applications.

The cameras were also selected based on prior experience in similar applications, low cost, and availability. Color networked PTZ cameras were utilized so as to not only provide static views as with the VIVDS installations, but also to enable the change of view by TranStar staff if required. Network management of these cameras is very similar to the video servers since both are Axis products. The camera is an Axis 213, mounted in a weatherproof outdoor housing. The PTZ camera is mounted usually, where existing power can be obtained from the infrastructure at the site. Signalized intersections without VIVDS equipment utilized the existing signal support poles for mounting as shown in Figure 10.



**Figure 10. PTZ Camera on Signal Pole**



In some cases where deployments were needed at locations other than signalized intersections, power for the equipment was obtained from existing infrastructure. Some locations utilized the power at a sign bridge as shown in Figure 11. Other locations utilized the power from a light standard as shown in Figure 12.

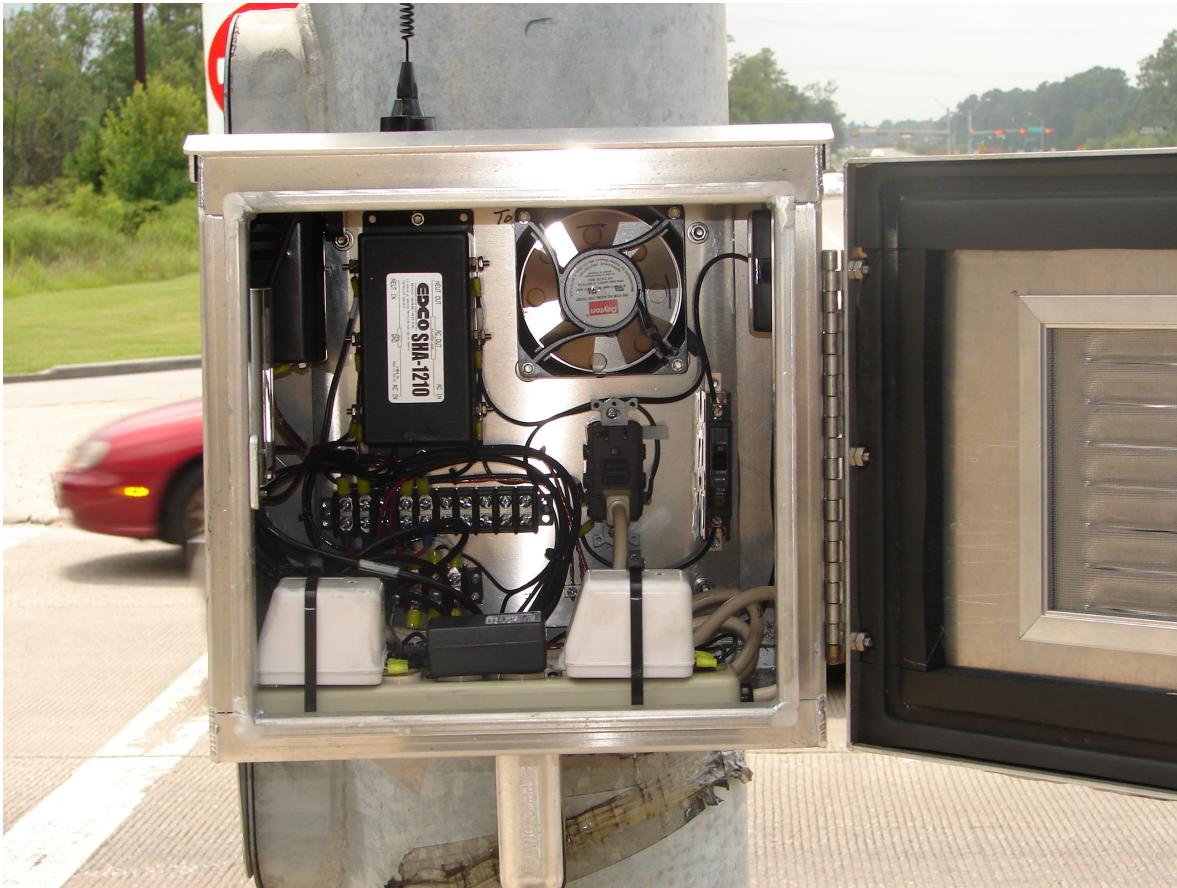


**Figure 11. PTZ Camera and Sensor on a Sign Bridge**



**Figure 12. PTZ Camera and Sensor on Light Standard**

A relatively small weatherproof cabinet was preconfigured in advance in order to provide for expedited installation in the field. This cabinet is shown in Figure 13.



**Figure 13. Weatherproof cabinet with components**

While not utilized in this deployment, a relatively simple component could be utilized on light standards with a photocell. It is inserted between the photocell and the light and 120v power can be made available for the equipment. That adapter is shown in Figure 14.



**Figure 14. Photocell Power adapter for light standard**

In all cases where fiber communications infrastructure is not available, only power is required to enable the deployment of the Hurricane Evacuation Monitoring equipment. The only impediment to statewide deployments with this equipment is the availability of cellular coverage. Prior to the deployments in the Houston and Beaumont areas, a survey of the anticipated sites was conducted to determine the availability of cellular communications at those locations. There were very few desired locations where sufficient signal strength was not available. One concern expressed was the possibility of service interruptions during periods of heavy use of the cellular network by the public during an event. Since the data traffic for these devices is separate from the voice traffic, it has not proven to be an issue.



## STEPS NEEDED FOR DEPLOYMENT

Based on the deployment in the Houston and Beaumont areas, it has proven successful to utilize the experience and local knowledge of the maintenance forces within the various TxDOT area offices to prepare and install the monitoring equipment in the field. These technicians are familiar with the territory, infrastructure, and are best equipped complete the installation and maintenance activities. Their local knowledge assures that the installations are completed with minimal interference with any existing equipment.

Using the framework of the outline of suggested deployments (Appendix B) it is recommended that the local technicians perform a survey of the areas and determine the exact placements of individual components, depending on the desired functionality and available resources. During the survey and when candidate locations have been determined, a check of cellular signal strength should be conducted to assure that communication capability exists to provide connections to the host computers. If standard 120v AC power is available, then a weatherproof cabinet can be preconfigured to accommodate the requisite components as described earlier. In the event that higher voltage power is only available, such as at a light standard without a photocell, the cabinet should also be equipped with a step down transformer to provide the appropriate power.

The list and estimated cost of equipment for the monitoring locations are presented in Figure 15. These material costs are based upon that needed to deploy monitoring equipment in 2007. No labor costs are included in the estimates as most local agencies should be able to complete the installations using in-house technicians. These also assume that electrical power is available at the installation location; additional costs would be incurred for solar powered sites. As outlined in Appendix B, it is recommended that an additional 280 monitoring locations be installed in the near term and up to 158 considered in the next several years. While additional effort would be required to determine the exact locations and specifics of each installation, total equipment costs are estimated from \$518,000 to \$3,380,440 for the immediate installations, plus an additional \$292,458 to \$1,907,534 for the longer term sites. Monthly costs for the cellular modems are estimated at \$14,000 for the immediate installations and an additional \$7,900 for the longer term sites.

<b>VIVDS monitoring at a signal cabinet</b>			Unit	Extended
Quantity	Part		Cost	Cost
4	BNC tee adapters		\$4	\$16
4	BNC right angle adapters		\$3	\$12
4	BNC video cables 36 inch length		\$5	\$20
1	Axis 241Q video server		\$750	\$750
1	AirLink Raven-E cellular modem		\$950	\$950
1	Ethernet cable 24 inch length		\$3	\$3
1	external cellular antenna 48 inch length		\$100	\$100
		<b>Total</b>		<b>\$1,851</b>
<b>Stand Alone Camera and Sensor ( maximum requirement)</b>				
Quantity	Part		Unit	Extended
			Cost	Cost
1	weather proof cabinet with fan, circuit breaker, power filter and terminal blocks		\$550	\$550
1	power strip for component power supplies		\$15	\$15
1	AirLink Raven-E cellular modem		\$950	\$950
1	Ethernet cable 50 foot length		\$10	\$10
1	2 conductor 18ga camera power cable 50 foot length		\$18	\$18
1	Axis 213 PTZ camera in weatherproof housing and gooseneck mount		\$2,700	\$2,700
1	Wavetronix Smartsensor with 50 foot cable		\$8,000	\$8,000
2	24VAC 50amp transformers for camera		\$15	\$30
1	external cellular antenna 48 inch length		\$100	\$100
		<b>Total</b>		<b>\$12,273</b>

**Figure 15. Estimated Video/Sensor Costs (per site)**

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## APPENDIX A



### TxDOT Installed Hurricane Cameras and Traffic Sensors

Roadway Limits	Approximate <sup>1</sup> Distance (miles)	Number of Devices		
		Cameras <sup>2</sup>		Sensors <sup>3</sup>
		CCTV	VIDS	
<u>Houston Region</u>				
I-10 West Luling to Katy	110	13	-	9
US-290 Northwest Giddings to Waller	70	8	4	4
SH-36/US-59 Needville to Rosenberg	19	3	16	-
SH-6 SH-6 @ FM 521 in Arcola	-	-	4	-
SH-146 SH-146 @ FM 646 in Bacliff	-	-	4	-
I-45 North Huntsville to Conroe	37	10	-	6
SH-71 SH-71 @ US-90 in Columbus	-	1	-	-
<u>Beaumont Region</u>				
US-59 Nacogdoches to Cleveland	95	3	20	-
SH-105 SH-105 @ SH-321 in Tarkington	-	1	-	-
US-90/SH-146 Dayton to Livingston	57	1	7	-
US-69 Woodville to Lumberton	44	4	12	-
FM-105 Evddak to Vidor	14	2	-	-
SH-87 Deweyville to Newton	43	1	4	-
I-10 East Orange to Baytown	82	8	-	6
Totals	-	55	71	25

<sup>1</sup>Distances not reported for locations along a roadway that are not consecutively adjacent.

<sup>2</sup>There are two types of cameras: a) CCTV- these have PTZ capabilities, b) VIDS – views from traffic signal video detection cameras.

<sup>3</sup>Sensors include data for both direction of travel.



## **APPENDIX B**



### Recommended Hurricane Camera and Traffic Sensor Locations

Roadway	Limits	Number of Locations	
		Immediate	Long-Term
US-281	Brownsville to Pharr	3	-
	Pharr to Falfurrias	7	-
	Falfurrias to Three Rivers	10	-
	Pleasanton to San Antonio	4	-
US-83	Brownsville to McAllen	6	2
	McAllen to Laredo	2	6
SH-186	Raymondville to Linn	1	1
FM 1017	Linn to Hebbronville	1	3
SH-285	Rivera to Hebbronville	3	1
SH-359	Hebbronville to Laredo	1	2
SH-41/FM 2295	Kingsville to Benavides	2	-
SH-339	Benavides to Freer	1	1
SH-16	Hebbronville to Freer	3	2
	Freer to San Antonio	1	8
US-59	Freer to Laredo	-	2
FM 665	Corpus Christi to Alice	2	2
SH-44	Corpus Christi to Alice	3	1
	Alice to Freer	1	2
	Freer to Encinal	-	1
I-35	Laredo to San Antonio	3	15
FM 624	Corpus Christi to US-16	2	4
I-37	Corpus Christi to San Antonio	12	4
SH-72	Three Rivers to Tildes	1	-
US-181	Corpus Christi to San Antonio	10	4
SH-188	Aransas Pass to Sinton	1	-
SH-35	Rockport to Tivoli		1
SH-239	Tivoli to Goliad		1
US-77/US-77A/SH-183	Corpus Christi to Cuero		2
SH-123	Karnes City to Stockdale		1
	Stockdale to Seguin		1
	Seguin to San Marcos		1

**Recommended Hurricane Camera and Traffic Sensor Locations (Cont.)**

Roadway	Limits	Number of Locations	
		Immediate	Long-Term
SH-87	Port Lavaca to Victoria	2	-
	Victoria to Cuero	2	1
	Cuero to San Antonio	6	4
US-77	Victoria to Schulenburg	6	4
	Schulenburg to LaGrange	2	2
	LaGrange to Giddings	1	1
	Giddings to Rockdale	1	2
SH-111	Midfield to Edna	2	1
	Edna to Yoakum	3	1
US-183	Cuero to Yoakum	1	1
US-183/SH-111	Yoakum to Gonzales	2	1
US-183	Gonzales to Luling	2	-
	Luling to Austin	2	2
SH-71	Midfield to El Campo	1	2
	El Campo to Columbus	2	1
	Columbus to LaGrange	1	1
	LaGrange to Austin	1	2
SH-35	Blessing to Bay City	1	-
SH-60	Bay City to Wharton	2	1
	Wharton to Wallis	2	1
SH-36	Brazoria to West Columbia	1	1
	West Columbia to Rosenberg	2	2
	Rosenberg to Sealy	2	2
I-10	Katy to Sealy	6	-
	Sealy to Columbus	5	-
	Columbus to Weimer	3	-
	Weimer to Luling	3	2
	Luling to Seguin	2	2
	Seguin to San Antonio	2	1
SH-288	Lake Jackson to Houston	4	2
SH-6	Hitchcock to Alvin	1	1
	Alvin to Arcola	1	1
	Arcola to Sugar Land	1	1
	Sugar Land to Cypress	2	2
	Hempstead to College Station	2	2
	College Station to Hearne	1	1



**Recommended Hurricane Camera and Traffic Sensor Locations (Cont.)**

Roadway	Limits	Number of Locations	
		Immediate	Long-Term
US-290	Cypress to Hempstead	1	2
	Hempstead to Brenham	2	1
	Brenham to Giddings	1	1
	Giddings to Austin	2	3
I-45	The Woodlands to Huntsville	8	2
	Huntsville to Buffalo	6	2
	Buffalo to Ennis	4	-
	Ennis to Dallas	2	1
US-59	Kingwood to Cleveland	3	1
	Cleveland to Livingston	3	1
	Livingston to Corrigan	3	1
	Corrigan to Lufkin	3	1
	Lufkin to Nacogdoches	2	2
SH-287	Corrigan to Crockett	1	2
SH-146	LaMarque to La Porte	8	4
	Baytown to Mount Belvieu	2	1
	Mount Belvieu to Dayton	1	1
	Liberty to Livingston	2	2
SH-321	Dayton to Cleveland	1	1
FM 563	Wallisville to Liberty	1	-
US-90	Dayton to Liberty	2	1
	Liberty to Beaumont	2	1
SH-105	Beaumont to Moss Hill	2	-
US-69	Beaumont to Kountze	3	1
	Kountze to Woodville	3	1
	Woodville to Lufkin	4	2
FM 92	Silsbee to Colmesneil	2	1
US-96	Nederland to Beaumont	3	1
	Beaumont to Silsbee	3	1
	Silsbee to Evadale	1	-
	Evadale to Buna	1	-
	Buna to Jasper	3	1
	Jasper to San Augustine	3	1
FM 105	Vidor to Evadale	1	1
SH-62	I-10 to Buna	2	1

**Recommended Hurricane Camera and Traffic Sensor Locations (Cont.)**

Roadway	Limits	Number of Locations	
		Immediate	Long-Term
SH-87	Bridge City to Orange	2	1
	Orange to Bleakwood	3	1
	Bleakwood to Burkeville	2	1
	Burkeville to Hemphill	2	1
	Hemphill to Center	3	1
I-10	Mount Belvieu to Wallisville	3	2
	Wallisville to Winnie	3	2
	Winnie to Beaumont	3	3
	Beaumont to Orange	8	4
Total		280	158

## **APPENDIX C**

### **Hurricane Evacuation Route Maps**



