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EXECUTIVE SUMMARY

The coastal communities of the Northern Gulf of Mexico (NGM), which stretches from Florida to Louisiana, are predominantly rural and are under the constant threat of hurricanes each fall. In the last five years, deadly hurricanes such as Katrina, Rita, Ivan, and others have required mass evacuations and other major emergency transportation services to be deployed. The rural transportation network is a major component of a larger, multimodal system that is critical for mobility of people, goods and services. Rural roads have a larger role in evacuation than is currently recognized. The purpose of this research project is to evaluate the use of rural transportation infrastructure in evacuation operations through the investigation of current evacuation practices in the NGM, in which the communities are predominantly rural. A survey of emergency management agencies (EMAs) and district departments of transportation (DOTs) was conducted to gather information about evacuations in this region. The findings of this research project are thought to be useful in improving rural evacuations.

The findings, conclusions, and recommendations of this study are summarized below:

1) A variety of communication tools can be used for the dissemination of evacuation information. In the NGM, television and newspapers are the most widely used media to convey evacuation information. Also, television was found to be the most efficient means of communication, which could be due to the fact that television is popular in rural areas and it is capable of disseminating a variety of information.

2) Among different types of traffic control devices, dynamic message signs (DMS) were found to be the most efficient devices in evacuations, although they have not been widely used in the coastal communities. In the future, EMAs may consider using more (portable) DMS in evacuations if such resources are available. These devices could be available in many agencies, especially transpiration agencies. However, it is important to first identify existing resources available and how to use them for emergency management.

3) The majority of designated and undesignated evacuation routes in the NGM had high or oversaturated traffic flow in recent evacuation events. High traffic volume on these routes will cause excessive delay during evacuations. Historical traffic information could be very useful for better planning of evacuation routes. However, gathering historical traffic information in rural communities is difficult as a significant portion of evacuation routes are state or county roads on which no vehicle detectors are available to record traffic flow during evacuations. In such situations, it is important to have good estimates of traffic demand that may leave, travel through, or come to the rural communities. Good coordination efforts between EMAs and transportation agencies are key to planning an effective evacuation route.

4) This study identified several major issues in rural evacuations. The most commonly reported issue is the lack of workforce to handle evacuations. To address this issue, EMAs may establish or improve mutual aid agreements with related agencies regarding the allocation of manpower in evacuations. Increasing the role of other agencies (e.g., transportation agencies) in evacuation will help improve the use and efficiency of

existing resources (facilities and workforce). Moreover, EMAs may consider recruiting volunteers to assist in evacuations through education, training and, if possible, incentives. School bus systems are well-equipped resources in rural areas with large vehicle fleets and an available workforce that can be utilized in the evacuation of transit-dependent people.

5) Coordination between agencies is challenging in rural evacuations. The characteristics of hurricanes and other emergency events, the population surge into rural areas, limited rural infrastructure, and other issues make it difficult for EMAs to gather real-time information during evacuations. The interface between EMAs and other lead or support agencies such as DOTs and law enforcement agencies needs to be improved so that information about evacuation progress can be reported and shared in real time among these agencies. Improving coordination with surrounding communities in the NGM is also important due to the large scale of areas affected by hurricanes and floods. As found by this study, significant portions of evacuees will travel through rural communities and this will put pressure on multiple jurisdictions. The evacuation flow needs to be handled by communities working together.

6) Communication between agencies is also a big issue. Emergency phone lines may be set up for communication among agencies during evacuations. Information on the progress of the evacuation can be reported and exchanged by phone. However, it could be a problem to communicate with field personnel in evacuations since communication services may be limited in rural areas. In such cases, more advanced communication options such as satellite phone services can be very useful and should be investigated further.

7) Finally, lack of operating budget was the most frequently reported barrier to emergency management activities. Funding restrictions or inadequate funding could hamper all phases of emergency evacuations. This is perhaps the most poorly addressed topic in transportation and emergency management activities. In the reauthorization of a new transportation bill, Congress should recognize this issue and authorize the Federal Highway Administration (FHWA) to reimburse evacuation operation expenses and to purchase communication and intelligent transportation system (ITS) equipment to enhance the efficiency of rural evacuation operations. Evacuation operations should be included in the Federal Emergency Management Agency's Catastrophic Planning Initiative and the National Response Framework so the operation can have the same privileges to leverage expenses as is available for debris removal.

CHAPTER 1. INTRODUCTION

The coastal communities in the Northern Gulf Region (NGM) are under constant threat of hurricanes each fall, witnessing deadly hurricanes Katrina, Rita, Ivan, and others in the last five years that required mass evacuations and other major emergency transportation services. Residents of these communities experienced fuel shortages, traffic congestion, significant delays receiving civil supplies, frustration, and risk during evacuations in the wake of hurricanes Katrina and Rita. These events led all systems including emergency management, law enforcement, and transportation to fail, particularly affecting the young, elderly, poor, and disabled. Seniors living independently but unable to drive, were victims of the flooding to a disproportionate degree.

When evacuations take place, planning and coordination among emergency management, law enforcement and transportation agencies can lead to an effective system allowing anyone with a car to evacuate from urban areas. But rural coastal communities remain at high risk and are difficult to evacuate in a timely manner due to larger geographical areas, low population density, and limited resources. To date, emergency planning efforts have focused primarily on addressing urban needs at the expense of rural areas. Furthermore, urban evacuees' travel behavior may impact rural areas. In a common evacuation scenario, urban evacuees travel to rural communities in close proximity to urban areas. A lone rural evacuation study, "Urban to Rural Evacuation: Planning for Rural Population Surge" by the Rural Health Research and Policy Centers, finds the following:

- Significant population surges are likely to occur in rural communities following an urban disaster.
- Fifty-five percent of evacuees would likely travel to nearby rural communities.
- There is lack of coordination between urban and rural evacuation planning efforts.
- Rural communities do not consider an urban-to-rural population surge in emergency planning efforts.
- Urban and rural evacuees are likely to drive on rural roads.
- Traffic jams and blockages are likely to happen on rural roads due to unexpected and spontaneous evacuation on two-lane rural roads.
- Evacuees may consume fuel, food, water, and sanitation resources while traveling through rural areas.
- Limited health care and public health infrastructure are critical weaknesses in rural communities.

As described above, the resources of the receiving rural communities adjacent to urban areas can be overwhelmed by the population increase. In smaller rural communities even small numbers of evacuees can represent sizeable increases in population, and can jeopardize the integrity of resources and disproportionately impact rural law enforcement agencies, health care facilities, and transportation agencies, which often have limited fiscal resources. But behind all issues and

concerns, the transportation network is the key component as all amenities and resources are placed along the transportation network. An efficient and effective evacuation and emergency management plan relies on the performance of the transportation network. Thus, it is necessary to understand the dynamics of rural transportation networks to understand rural evacuation issues. Important features of this network include the following (FHWA, 2001):

- Rural roads comprise 80 percent of national road miles (3.1 million rural road miles).
- Rural areas are facing a phenomenal period of growth and development, accompanied by large increases in travel within and through these areas. For example, after the 2005 hurricanes, rural communities within 100 miles of the coastline of the North Gulf Coastal Region experienced rapid growth that impacted already limited infrastructures. In this time period, almost 5,000 new dwelling units have been built in rural areas bordering the coastal counties in Mississippi.
- Nearly 40 percent of the country's transit-dependent population, primarily senior citizens, persons with disabilities, and low-income individuals, live in rural areas.
- Due to a lack of travel services, rural populations are more automobile dependent than their urban counterparts. Rural households travel 38 percent more miles than urban households, even though they make 5 percent fewer trips.
- Ninety percent of rural roads are two-lane.

The rural transportation network is a major component of a larger, multimodal system that is critical for moving people, goods and services. When evacuations occur, the recommended safe distance is 150 miles from the immediate coastline. Evacuees may drive 150 miles or more, largely through rural areas, giving rural roads a larger role in evacuations than may be currently recognized. Further, rural roads may substitute for interstates and other major highways in the event they become functionally impaired (e.g., congested or damaged).

With an increased focus nationally on safe evacuation and dealing with natural disasters, the rural transportation network across and throughout every region of the country must be effective and efficient during emergencies. Therefore, national evacuation policy must address evacuation and transportation as whole—not just isolated urban hotspots where the evacuation process is highly visible—but also focus on the large rural areas that hold the country together. It is critical to begin identifying and addressing the gaps in evacuation planning and operations relative to critical rural transportation issues.

The purpose of this research project is to evaluate the use of rural transportation infrastructure in evacuation operations through the investigation of current evacuation practices in the NGM, in which the communities are predominantly rural. The selected geographical area of the study covers 24 counties and four parishes along the Interstate 10 corridor from Florida to Louisiana, as shown in Figure 1-1. In the 28-county study area, 75 percent of all citizens live in rural or suburban settings, and 12.7 percent of citizens are age 65 or older (EDIS, 2009) (Appendix B). The Gulf Coast transportation infrastructure is essential for the mobility of people and commodities on a domestic and international scale. Some of the most vital sea ports in the United States, including Houston–Galveston, South Louisiana, and New Orleans, are located in this region. In addition, approximately two-thirds of all U.S. oil imports are conveyed through

the area. This region has important air, rail, highway, and transit networks (Burkett et. al., 2008). The evaluation focuses on the use and performance of rural transportation infrastructure to handle emergency events. The remainder of this article includes a literature review (CHAPTER 2), which covers the areas of evacuation flow, the role of transportation in evacuation, contraflow/reverse lane operations, and traveler information. This is followed by an analysis of survey results to identify similarities, differences, and issues of evacuation practices in rural areas (CHAPTER 3 and CHAPTER 4). Lastly, the findings of this study are summarized and conclusions drawn (CHAPTER 5).

Figure 1-1: Study Area: Northern Gulf of Mexico.

CHAPTER 2. LITERATURE REVIEW

This chapter reviews and summarizes the state of the art and practice pertinent to emergency evacuations, with a focus on rural areas. Specially, information related to the following topics was reviewed:

- Classification of evacuation community versus evacuee-receiving community with respect to community resources, and historical and infrastructure context;
- Stakeholders involved in evacuation events;
- Use of rural transportation infrastructure;
- Tools for the dissemination of traveler information; and
- Lessons learned from previous evacuation events.

2.1 Classification of Evacuation Communities

When evacuations take place, people move or are moved from dangerous or potentially dangerous areas (classified as evacuee communities) to safe areas (classified as impacted communities). A community where evacuees would like to move to or is designated as a safe area that provides resources such as personal services, shelters, health care, law and order, education, animal care and so on is called an evacuee-receiving community or destination community. Both the communities' resources are impacted by evacuation operations. For example, during the 2005 hurricane season, around 300,000 evacuees from New Orleans passed through or were sheltered in the city of Fort Worth, Texas, and other surrounding areas, and 900 families were provided long-term shelter (Williams, 2006).

Based on urban and rural area classifications, evacuations can be divided into four categories:

1) Urban-to-urban evacuation;
2) Urban-to-rural evacuation;
3) Rural-to-urban evacuation; and
4) Rural-to-rural evacuation.

Evacuees traveling to urban areas might not have the same impact they would have when moving to rural areas because of the ample infrastructure available in urban settings. Based on an analysis of interviews with 17 preparedness experts and planners at the national and local levels, the Walsh Center for Rural Health Analysis found that urban evacuees are likely to travel to and through rural areas (Meit et al., 2008). Traffic flow into rural areas may exceed existing roadway capacity and result in unexpected traffic jams and blockages. People evacuated to rural areas would consume fuel and food and use roadside amenities. Researchers recommend two important areas to be studied: 1) estimates and information about urban-to-rural evacuees, and 2)

identification of sites in rural areas where evacuees can be sheltered and provided resources (Meit et al., 2008).

2.2 Evacuation Stakeholders

The objective of evacuations is to move people out of affected areas to safe places as quickly as possible. Needless to say, evacuees are the most important stakeholders in evacuations. In addition, a variety of agencies are involved during the evacuation process. An emergency evacuation should be carried out through interagency coordination due to its extensive impact on people and property in affected areas. Among the partners, governors and/or mayors are the decision makers that usually have the ultimate authority to order evacuations. A survey of 18 states revealed that governors and mayors from 17 states had the authority to order evacuations (Wolshon et al., 2005a). In addition, the decision makers are responsible for requesting assistance from neighboring state and federal governments through mutual aid agreements or other prescribed methods (Houston, 2006).

Emergency evacuations are usually coordinated through state emergency management agencies (EMAs) or local (e.g., county or city) emergency operations centers (EOCs). In most states, emergency evacuation preparedness, response, recovery, and mitigation are developed and coordinated at local EOCs. The EOC is staffed with employees from different partners. For example, the EOC in St. John the Baptist Parish, Louisiana, is staffed with employees from the parish's Department of Public Safety (DPS), Civil Defense, Office of Fire and Rescue Service, and the E-9-1-1 communications center (http://www.sjbparish.com/eoc.asp). In some other states, such as Florida, the state EMA takes a greater managerial role than local emergency management offices because the entire state is exposed to hurricanes (Wolshon et al., 2005b). During evacuation operations, emergency managers from state EMAs or local EOCs are responsible for gathering key players in the evacuation, collecting and analyzing information, recommending actions, and ordering and providing resources for emergency operations (Houston, 2006).

Over the past decade, transportation has been playing a more and more active role in emergency evacuations. Many transportation agencies such as state and local departments of transportation (DOTs), transit agencies, public works agencies, highway contractors, and the towing industry are involved before, during, and after evacuations to maintain transportation systems. The potential roles of transportation in emergency evacuation are summarized in Table 2-1 (Houston, 2006; Wolshon, 2009a). One of the important roles of transportation during evacuations is the direction and control of highway networks. Transportation agencies have developed tools and strategies to convey information to travelers and help control and guide traffic during evacuations. The most common tools and strategies are signs, pavement markings, traffic signals, and contraflow plans (Wolshon et al., 2009a). It should be noted that while transportation plays active roles in evacuations, transportation personnel do not get involved in the declaration and timing of evacuation. The study (Wolshon et al., 2009a) also found that barriers or obstacles to coordination in command and operations exist between transportation and other government agencies (e.g., law enforcement or emergency management agencies).

Table 2-1: Transportation's Role in Evacuation

Phase of Evacuation	Transportation's Role
Before (Readiness and Activation)	1) Provide road inspections/assessments 2) Develop management and control strategies 3) Provide evacuation routes
During (Operations)	1) Order and provide traffic operations resources 2) Direct and control highway networks 3) Collect, analyze, and report traffic information 4) Conduct traffic incident management with first responders and local law enforcement 5) Provide information to EOC 6) Provide information to FHWA (Federal Highway Administration) and other impacted state DOTs as necessary
After (Reentry)	1) Remove debris 2) Restore traffic

First responders and volunteers also play an important role during evacuation operations as they provide on-scene services to evacuees. First responders consist of people from different departments such as police, fire, and emergency medical services (Houston, 2006). They can provide needed resources and equipment to facilitate safe evacuation, especially for those with special needs. Volunteers from various organizations provide support to relieve evacuees along highways, open and staff shelters, coordinate with first responders and transportation personnel, etc.

Coordination between partners involved in evacuations is necessary and important. Before evacuation, emergency managers and transportation personnel should work together to determine evacuation routes, as transportation personnel have specialized transportation knowledge and possess assets that are useful for evacuations. Highway contractors, law enforcement, public works officials, and other stakeholders need to be involved to make sure that those routes are clear before evacuation. Interagency coordination is also needed between jurisdictions since in many cases evacuees need to cross jurisdictional and state boundaries. Some examples of coordinated efforts are presented by Plowman (2001):

- Florida has developed formal procedures to coordinate multi-county evacuations. These procedures include the designation of inland "host counties" that will open shelters for evacuees from coastal counties.
- Delaware, Maryland, and Virginia have formed the Delmarva Emergency Task Force to improve evacuation traffic flow between the states on that vulnerable peninsula.

- The Georgia Emergency Management Agency has created an interstate coordinator position to facilitate communications with neighboring states.

2.3 Rural Transportation Infrastructure

The most important rural transportation infrastructure is the existing road system, especially those routes planned for use in evacuations. The rural road system is largely managed and maintained by local governments. In Kansas, the maintenance of rural transportation infrastructure is mainly the responsibility of local governments. Ninety percent of roads and 80 percent of bridges are their direct responsibility (Hossain et al., 2003). In addition, local government agencies (e.g., EOCs, EMAs) are responsible for evacuation planning. Evacuation route maps, evacuation guidance, emergency contacts, and other information are usually available on local agencies' web sites. In Louisiana, the parish emergency management web site (http://www.ohsep.louisiana.gov/linkpages/parishpa.htm) provides links to each parish's Office of Homeland Security and Emergency Preparedness, from which evacuation routes and other emergency evacuation information can be easily accessed. Such information is also available in other Northern Gulf Coast states (Mississippi, Alabama, and Florida). The vast majority of evacuation routes in rural areas are interstate highways, U.S. highways, and state highways; lower-level roads are usually not used for evacuation due to their limited capacities and other restrictions.

The use of contraflow or reverse lanes was given little attention until after Hurricane Floyd in 1999 (Tibbetts, 2002). Since then, contraflow has been one of the most important traffic management strategies for evacuation operations. Transportation officials are responsible for contraflow operations as they have the best knowledge about existing road systems and traffic operations. Contraflow is effective as it increases the directional capacity of an evacuation route without further highway design or construction efforts. Nevertheless, setting up contraflow operations requires a certain amount of time: South Carolina requires two hours to place barricades and two hours to flush traffic (Harrelson, 2004); Alabama DOT requires approximately one hour to implement reverse-laning operations (Conner, 2006); and the state of North Carolina requires three to four hours (PBS&J, 2000). As of 2003, approximately 10 states have implemented contraflow or reverse-laning operations, with a focus on interstate highways (Urbina and Wolshon, 2009). The length of contraflow or reverse-laning operations varied from a few miles to nearly 200 miles.

Successes have been achieved through the implementation of contraflow or reverse lanes. Data from the Interstate 55 (I-55) contraflow segment showed a 40 percent increase in the 48-hour outbound volume between hurricanes Ivan (without contraflow operations) and Katrina (with contraflow operations) (Wolshon and McArdle, 2009). However, data from an I-10 contraflow segment in Louisiana showed that the maximum recorded traffic flows were somewhat lower than what would have been assumed (Wolshon and McArdle, 2009). In addition, without proper implementation of contraflow, the strategy will not have a positive impact on evacuations. The state of Louisiana used contraflow operations during Hurricane Ivan on a 12-mile segment of I-10 (Laska, 2004). The distance of the segment was limited due to state police concerns about the need for staff to close the exits. As a result, evacuees felt that "the short distance merely shifted

the location of the major jams" and "it took residents up to 11 hours to go the distance usually traveled in less than 1.5."

Highway construction work zones may affect emergency evacuations by reducing traffic capacities. Highway work zones are an often-overlooked issue in evacuation planning and preparedness (Urbina and Wolshon, 2001). It was reported that during the evacuation for Hurricane Georges in 1998, the states of Alabama, Mississippi, and Louisiana all had construction work zones on evacuation routes. Only one lane was open to the evacuation traffic on westbound I-10 out of New Orleans. Fortunately, state DOT requested the construction contractor to clear equipment and open both of the partially constructed lanes to outbound traffic and the contractor acted quickly to minimize traffic delay. To reduce the impact of work zones on evacuation operations, it has been suggested that DOTs could have procedures in place to inform EMAs of construction plans and schedules (Wolshon, 2009). Based on the experience gained from Hurricane Floyd, some DOTs have been adding special provisions in construction contracts to accommodate evacuation traffic through work zones; clauses have been added to require a contractor to stop construction activities, clear equipment, and open all lanes once an evacuation is declared (Urbina and Wolshon, 2001).

Public transportation is potentially another useful element in rural transportation infrastructure for evacuations. Rural transit systems have facilities, personnel, and equipment to evacuate people with special needs. Transit agencies have the potential to play a role in each phase of emergency planning, including mitigation, preparedness, response, and recovery. The role of transit in an emergency evacuation is affected by many factors, including the characteristics of an emergency incident, the predisposition of the public, available resources, the characteristics of the transit system itself, etc. (TRB, 2008).

The Texas Disaster Act of 1975 and the Texas Emergency Management Plan include public transit systems that can be called into service during disasters. However, many local jurisdictions do not have a detailed plan for transit's role in emergency evacuations (Higgins et al., 2000). A study by the Federal Transit Administration (FTA) provided recommendations to assist in transit and emergency response organization personnel to evaluate their emergency response plans (Hathaway and Markos, 1991). The study also provided recommendations for the use of urban, rural, and specialized transit systems by the general public, elderly disabled persons, clients of human service agencies and so on.

In addition to the above infrastructure, implementation of regional evacuations requires a lot of other resources, both in rural and urban areas. In a Florida study, a variety of resources are listed to support evacuations (State of Florida, 2002):

- programmable electronic public information signs/displays;
- local/small-area radio broadcast stations;
- wreckers, tow trucks, and other heavy equipment for clearing roadways;
- gasoline tankers for replenishing fuel supplies at gas stations on regional routes; and
- shelters and supplies.

2.4 Traveler Information

Dissemination of evacuation-related information to the public is key to an effective evacuation. Emergency evacuations are unplanned events so evacuation-related information should be provided to the public as timely and accurately as possible. Before an evacuation, the public needs to be notified and potential evacuees need to prepare for the event; during an evacuation, the evacuees need information about transportation, shelter, lodging, etc.; after an evacuation, evacuees need to know when safe reentry is possible (Wolshon, 2009).

Traveler information is important for providing guidance to evacuees. There are numerous tools that can be used to facilitate communication and information exchange. Table 2-2 shows tools that can be used for evacuations and they are divided into three categories: communication, traffic control, and weather and condition assessment tools. Different tools can be used depending upon the characteristics of the evacuation itself. Some of the tools are discussed in this subsection.

Table 2-2: Evacuation Information Exchange Tools

Communication	Traffic Control	Weather and Condition Assessment
Dial 511 Dial (reverse) 911 Loudspeakers Siren System Highway Advisory Radio Roadside Information Locations Dynamic Message Signs Newspapers Flyers Television Public Address Mailing List and Emails Cell phones	Portable Traffic Signal Ramp Meters Ramp Gates Traffic Signs Channelization Devices Temporary Pavement Markings Dynamic Message Signs Traffic Management Centers	National Weather Service *Clarus* Initiative (Established by the FHWA Road Weather Management Program) Evacuation Traffic Information System (Developed by FHWA) Evacuation Travel Demand Forecasting System Hazard U.S.-Multihazard (HAZUS-MH MR2) (Developed by FEMA)

During evacuations, Intelligent Transportation Systems (ITS) have been widely deployed to monitor roadways and disseminate real-time traveler information. The most commonly used systems include Dynamic Message Sign (DMS), Highway Advisory Radio (HAR), traffic sensors (to detect traffic volume and speed), traffic surveillance cameras, and traffic signal systems. Due to lack of utilities (or other supporting infrastructure) in rural areas, portable (or temporary) systems equipped with solar panels are usually utilized and placed at designated locations (Ishak et al., 2008). Although ITS systems could help make evacuations safer and more

efficient, their usage is limited by expense (Wolshen, 2009). Studies have been conducted to develop low-cost ITS systems for evacuations. For example, a FHWA study was done to develop a low-cost surveillance system model that can be used to monitor rural evacuation routes, on which surveillance systems are not typically available due to low traffic volumes (Maxon Hill, 2005). Transportation system managers can better manage the road network and provide evacuees with better real-time information with such a low-cost system in place.

A variety of evacuation-related information can be obtained through the Internet. Evacuees may use the Internet to find information about evacuation routes, weather, lodging, etc. As noted by Wolshen (2009), nearly all DOTs and EMAs maintain web sites to keep people informed of evacuation routes, road conditions, shelter availability, and weather information; some emergency management web sites also provide links to hotels within and outside of their state to facilitate lodging reservations.

The 511 (America's traveler information number) service can provide information to the traveling public during emergency evacuations (Wilson-Goure, Houston and Easton, 2006). 511 is the single FCC (Federal Communications Commission) designated telephone number for use by states and local jurisdictions. This traveler information system has been widely used across the nation. As of July 2009, more than 30 states have deployed 511 and more than 10 other states have received federal assistance funding under the 511 Planning Assistance Program (http://www.fhwa.dot.gov/trafficinfo/511.htm). The 511 service provides weather information that ranges from a regional alert (e.g., hurricane) to a route-specific observation or alert (e.g., pavement conditions, low visibility). During emergency evacuation, 511 can be used together with other traveler information systems (e.g., DMS) to increase its usage (call volumes) (Wilson-Goure, Houston and Easton, 2006).

In practice, different traveler information system technologies are used together to facilitate evacuations. The state of Alabama uses a combination of technologies including reversed direction signage, DMS, HAR, and the Alabama DOT web site for hurricane evacuations (Conner, 2006). The combination of technologies provides different ways of information dissemination to the public and facilitates evacuation operations in a safer and more efficient way.

2.5 Lessons Learned

Various lessons have been learned from previous evacuation events (e.g., wildfires, hurricanes, blackouts, terrorist attacks, and floods). Based on the project scope, this part of the review mainly included those lessons that are more related to the rural environment and evacuation events (e.g., hurricanes, floods) and that are more of concern in the North Gulf Coastal Region. Those lessons are summarized in Table 2-3. The lessons learned from previous evacuation events could be useful for better planning for and responding to future events.

Table 2-3: Lessons Learned

Discussed Topics	Lessons (Reference)
Evacuation Planning	1) Coordinate evacuation plans that cross state lines (SAIC, 2003); 2) Use historical evacuation data for developing future evacuation plans (PBS&J, 2000); 3) Plan for the evacuation of those with special needs (Sill, 2003); and 4) Consider the emergency needs (e.g., drinking water, food, and gas) of both people and equipment (DeBlasio et al., 2004).
Training and Education	1) Conduct exercises and test evacuation plans (MIPT, 2002; Hulett, 1999); 2) Include public transit in the training exercises (MTI, 2002); 3) Educate the public on evacuation routes (Moller, 2004); 4) Provide better education to the public regarding their vulnerability (Dumont, 2000).
Coordination and Cooperation	1) Coordinate evacuation routes across jurisdictional boundaries (Sill, 2003; SAIC, 2003); 2) Develop better coordination between various agencies (PBS&J, 2000); 3) Develop mutual-aid agreements (Hulett, 1999); and 4) Develop strong interpersonal relationships with other agencies/entities (Buck et al., 2004).
Shelters	1) Locate shelter hubs appropriately (Carpender et al., 2006); and 2) Consider strategies to reduce demand for shelters near evacuation origins (Sill, 2003).
Work Zones	1) Coordinate current work zone activities (Sill, 2003); and 2) Plan for how to deal with construction along evacuation routes (Hulett, 1999).
Transit	1) Plan for the use of public transit to support evacuations (Jenkins, 2003); 2) Use public transit equipment for the response (Jenkins, 2003); and 3) Consider use of a bus system to provide transportation for special needs members of the community (Hulett, 1999).

Discussed Topics	Lessons (Reference)
Evacuation Management	1) Improve the efficiency of detecting, responding to, and clearing incidents on evacuation routes (Sill, 2003); 2) Develop the capacity of evacuation routes (PBS&J, 2000); 3) Efficiently utilize the available capacity to reduce the potential for operational failures during evacuation (Sill, 2003); 4) Improve management of the local streets that provide access to and from evacuation routes (Sill, 2003); 5) Identify conflicting needs and impediments (SAIC, 2003); 6) Modify evacuation routes as necessary (Sill, 2003); 7) Consider tow truck usage at key bottleneck locations along evacuation routes (Hulett, 1999); 8) Station tow trucks at strategic points so that accidents and broken-down vehicles can be quickly cleared (Moller, 2004); and 9) Ensure the efficient, safe, and secure reentry of the evacuees to their counties (Sill, 2003).
ITS Technologies	1) Consider ITS functionality that could be particularly useful during an emergency (DeBlasio, 2004); and 2) Use ITS technologies to provide information and assist in decision making (DeBlasio, 2004).
Communication	1) Develop convenient communication tools (PBS&J, 2000); 2) Ensure the ability to communicate (Carpender, 2006; Buck et al., 2004); 3) Ensure clear and accurate communication (Brown, 2004); 4) Provide lodging information (Morrow, 2002); and 5) Use multiple communications technologies and types (DeBlasio, 2004).
Public Health	(UMN, 2004): 1) Identify state and local public health (PH) capacities in rural areas; 2) Identify the expanded rural PH system for PH response; 3) Identify necessary competencies in rural PH response; 4) Model practices in rural PH response; and 5) Increase human and financial resources to build necessary infrastructure.

CHAPTER 3. ASSESSMENT OF RURAL TRANSPORTATION INFRASTRUCTURE

Rural transportation infrastructure predominantly consists of two-lane roads that are lower in capacity and in most instances have fewer amenities compared with urban and other major interstate highways. In the case of emergency evacuations, when massive numbers of vehicles need to use the road network during a short period, the ability of rural roads to accommodate the unexpected and unusual traffic is questionable at best. In this chapter, the performance and capabilities of rural transportation infrastructure to handle emergencies will be assessed.

A survey method is used in this research to assess the use of rural transportation infrastructure in evacuation operations for the NGM. The survey of rural evacuation operations was distributed to 33 agencies within the NGM, including state and county (or parish) EMAs as well as district DOTs. A total number of 18 surveys were returned with a response rate of 55 percent. Among the responses, 14 were returned by county (or parish) EMAs: three from Alabama, four from Mississippi, three from Louisiana, and four from Florida. The other four responses were from DOT districts, with one from each state in the NGM region. The survey questionnaire is divided into several topic categories as shown below. The questions and survey results (raw data) are presented in Appendix C. The analysis of the survey results is described in this chapter and the next. It is noted that the analysis does not follow the sequence of questions (or topic categories).

- Communication systems used in emergency situations (CHAPTER 4),
- Evacuee estimation (CHAPTER 3),
- Issues specific to an emergency event (CHAPTER 3),
- Employee issues (CHAPTER 3),
- Evacuation preparation (CHAPTER 3),
- Emergency event financial responsibility (CHAPTER 3), and
- Assessment of needs/coordination/planning (CHAPTER 3 and CHAPTER 4).

3.1 Evacuation Routes and Evacuee Flow

This study investigated evacuee flow in rural communities and traffic flow levels on evacuation routes during evacuations. Information related to evacuation routes and evacuee flow is useful for developing more efficient evacuation route planning, especially for better understanding of route choices and traffic demand estimation.

Respondents were asked to provide a listing of all major rural evacuation routes used in the most recent evacuation, along with a description of the degree of usage for each. Usage degrees (in terms of traffic volume levels) were defined as low, medium, high, or exceeded capacity. A total of 110 designated and undesignated evacuation route segments were reported by 16 agencies. The distribution of degrees of use is shown in Figure 3-1. It was found that 83 evacuation route

segments (75 percent) experienced high or oversaturated traffic flow in recent evacuation events. Among the 10 route segments with exceeded capacity, six of them were Interstate routes and four were U.S. highways.

Eleven (11) of the 110 route segments were undesignated evacuation routes. Although these routes were not included in evacuation plans, eight routes (73 percent) experienced high usage or exceeded capacity traffic flow during recent evacuations. A potential reason is that local evacuees (or seasoned evacuees) had identified their own evacuation routes over the years. They might have preferred the undesignated routes during evacuations instead of designated routes because they were more familiar. It is recommended that evacuation routes be updated to include those undesignated routes that had high or oversaturated traffic in past evacuation events.

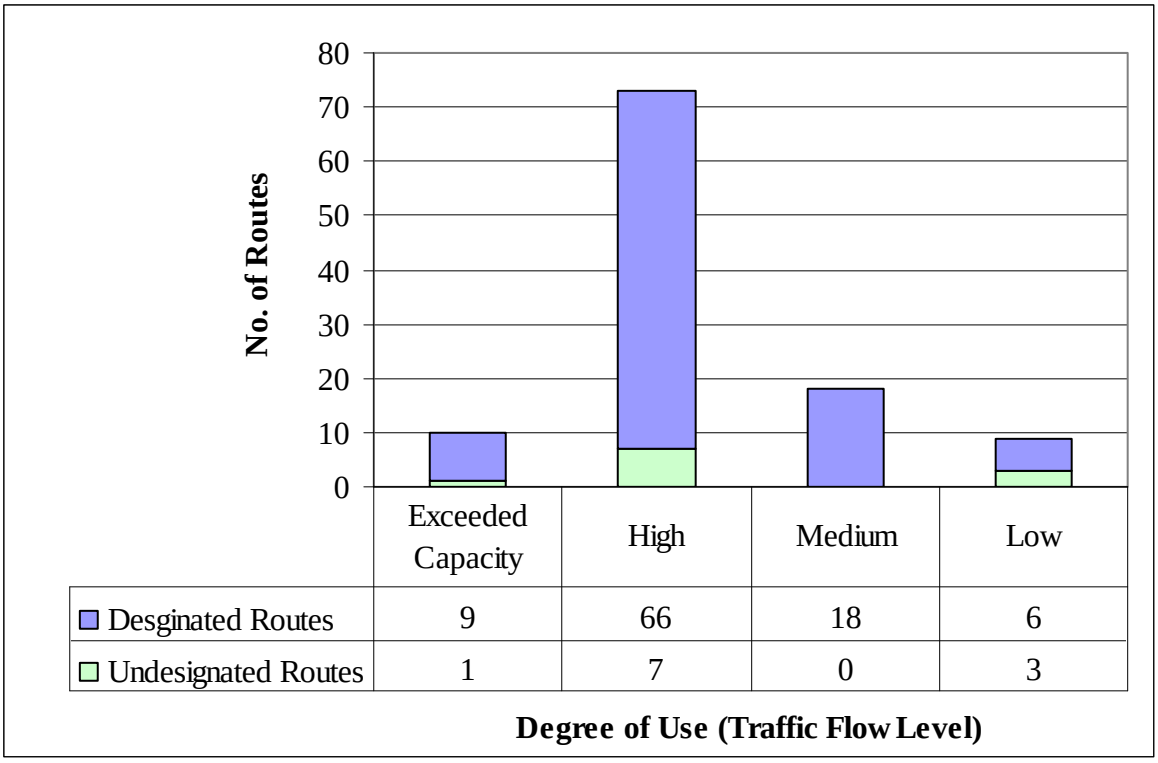
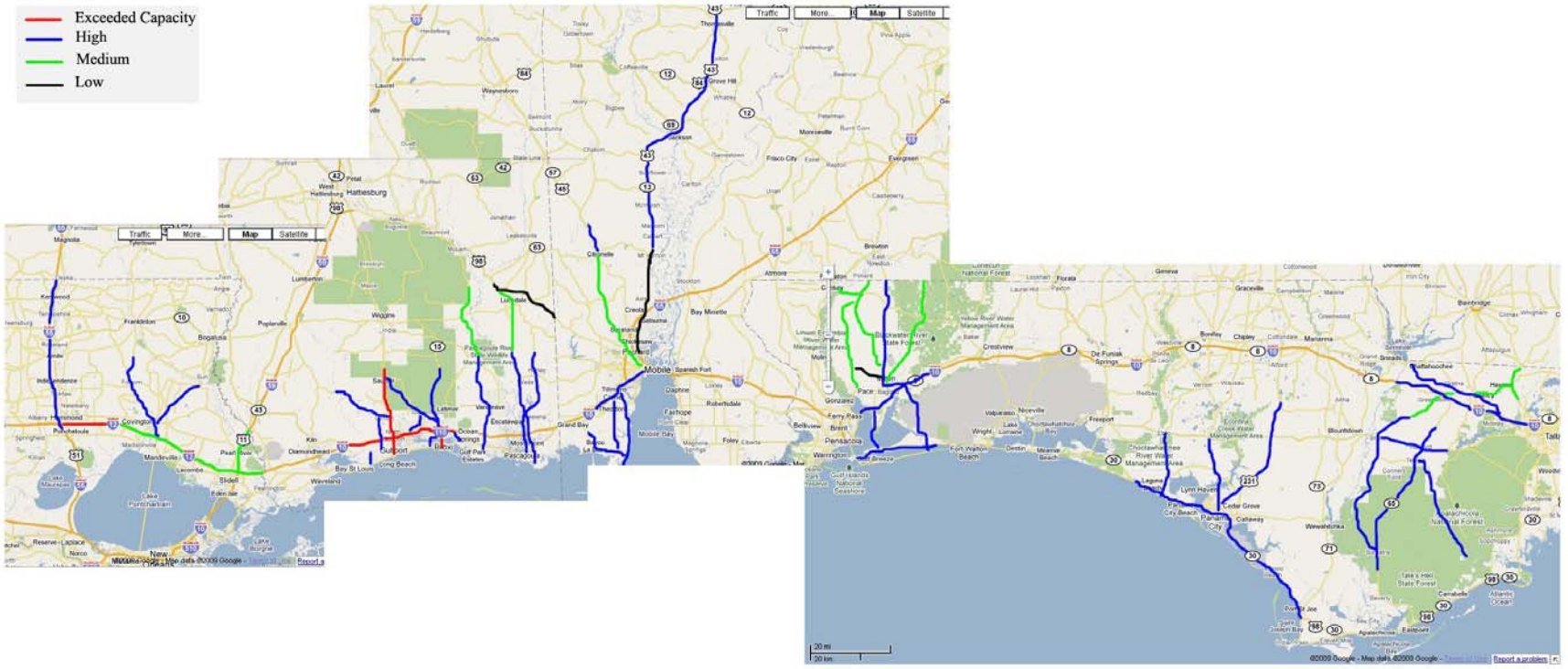


Figure 3-1: Degree of Use for Designated and Undesignated Evacuation Route Segments.

Figure 3-2 and Figure 3-3 display the location and traffic flow levels of designated and undesignated route segments in past evacuation events. Evacuation route segments from DOTs were not plotted because of the difficulty of locating starting and ending points. The figures clearly show that most evacuation routes located south of I-10 experienced high traffic flow during past evacuations.



(Map source: Google)

Figure 3-2: Traffic Flow Levels on Designated Evacuation Route Segments.

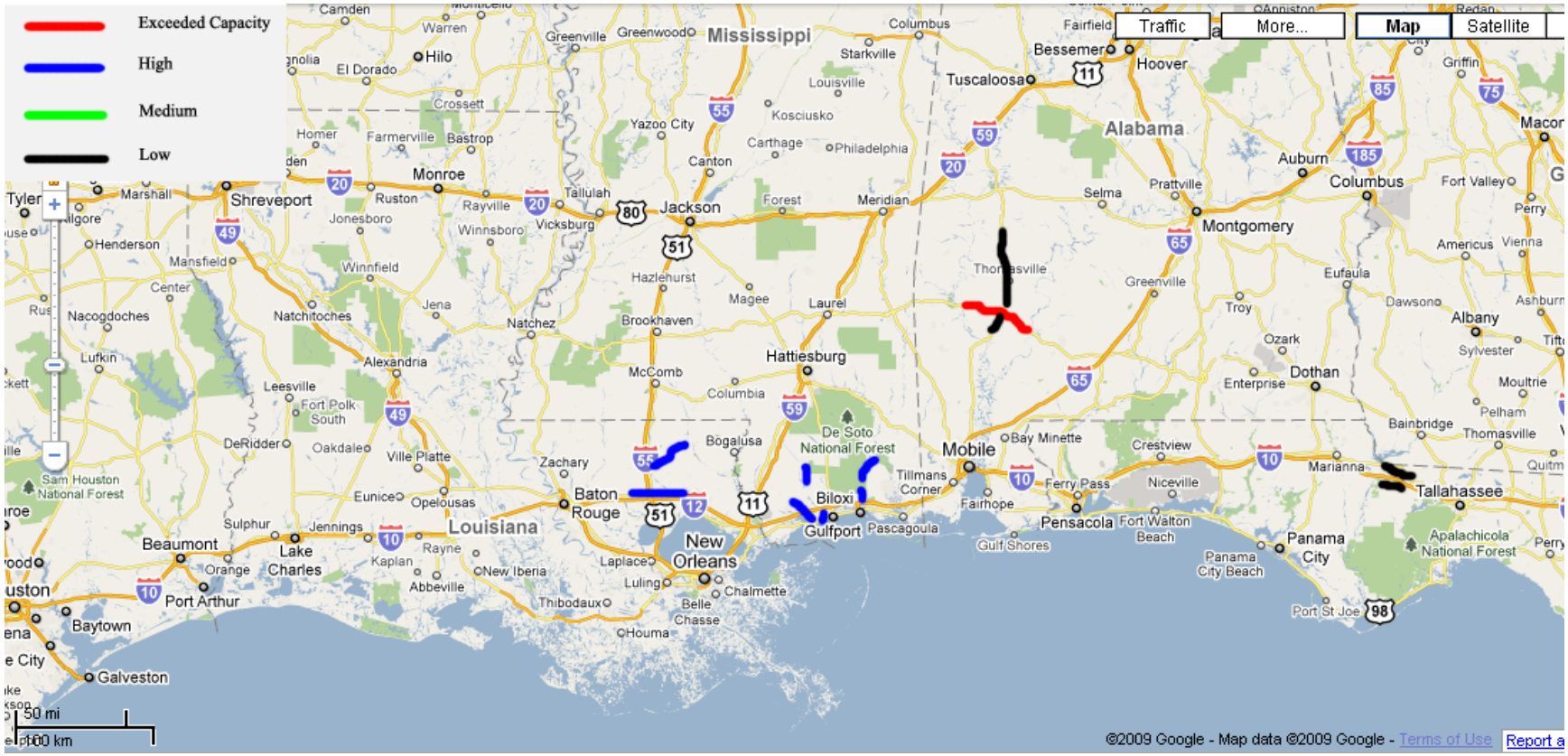


Figure 3-3: Traffic Flow Levels on Undesignated Evacuation Route Segments.

(Map source: Google)

A survey question was posed to estimate the percentage of population that would use rural evacuation routes. As shown in Figure 3-4, about one-third (6) of the respondents indicated that 31–50 percent of the population will use rural routes. Also, more than half of population in six jurisdictions [4 (51%–75%) + 2 (76%–100%)] would use rural evacuation routes.

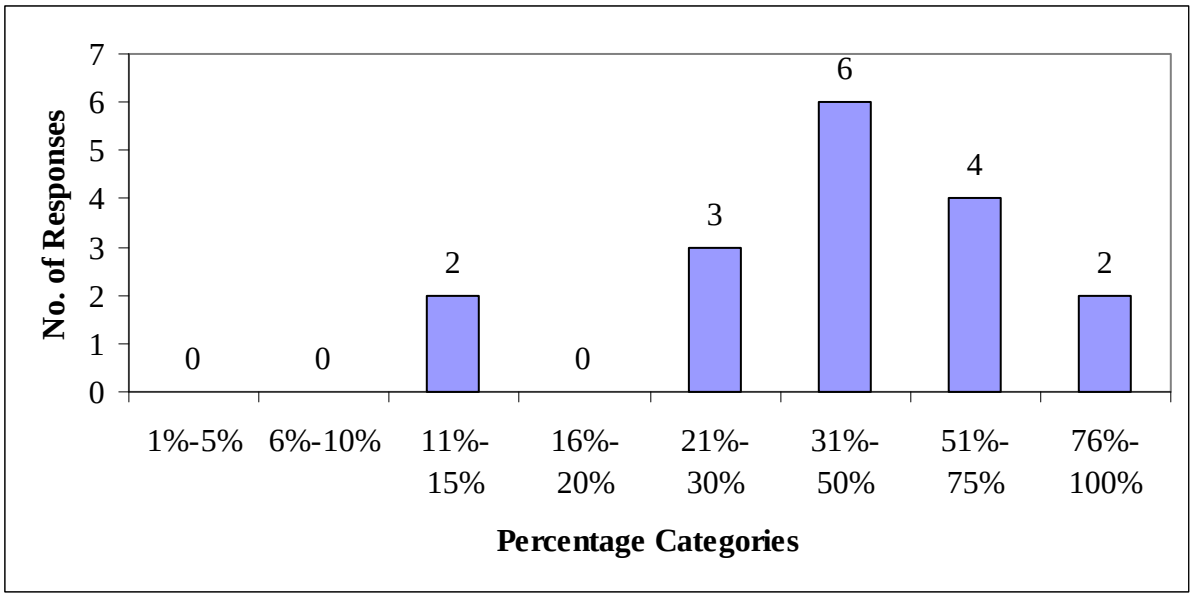


Figure 3-4: Percentage of Population That Would Use Rural Evacuation Routes.

Survey participants were also asked to estimate the percentage of evacuation flow in their jurisdictions that fell into the following types of evacuations: urban to urban, urban to rural, rural to rural, and rural to urban. The results from 14 responses showed that 20 percent of evacuees moved from urban areas to other urban areas, 12 percent went to urban areas from rural areas, 38 percent left urban areas to rural areas, 28 left rural to other rural areas, and the remaining 2 percent went to "other destinations" (e.g., moving to shelters) (Figure 3-5). Thus, around 66 percent (38 percent + 28 percent) of evacuees were moving to rural communities during evacuations in the NGM; only 32 percent (20 percent + 12 percent) of evacuees were moving to urban areas. The results clearly show that evacuations in the NGM predominantly affect rural areas.

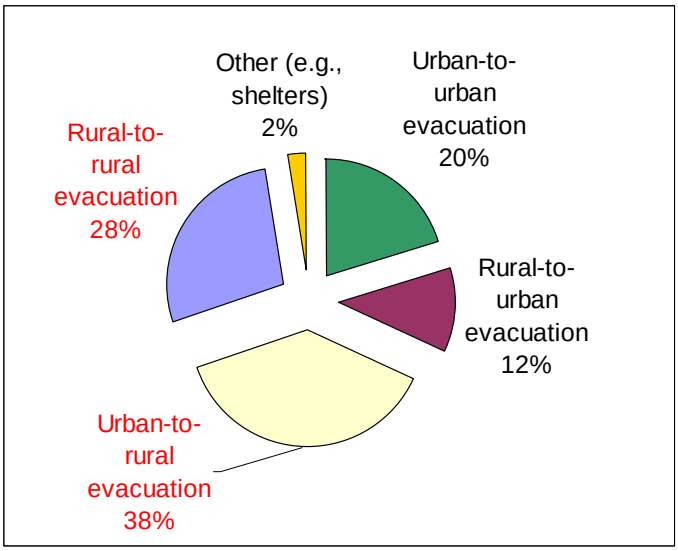


Figure 3-5: Distribution of Evacuee Flow.

Respondents were further asked to estimate the percentage of evacuees coming to their areas, passing through their areas, staying in their areas due to altered weather conditions, and local evacuees leaving their areas (Figure 3-6). Based on the results from 13 responses, it was found that, on average, 53 percent of evacuee traffic passed through their jurisdictions, 23 percent came and stayed in their jurisdictions (for shelter or due to altered weather conditions), and 24 percent were local evacuees leaving their areas. Thus, more than half of evacuees will pass through rural communities during evacuation events.

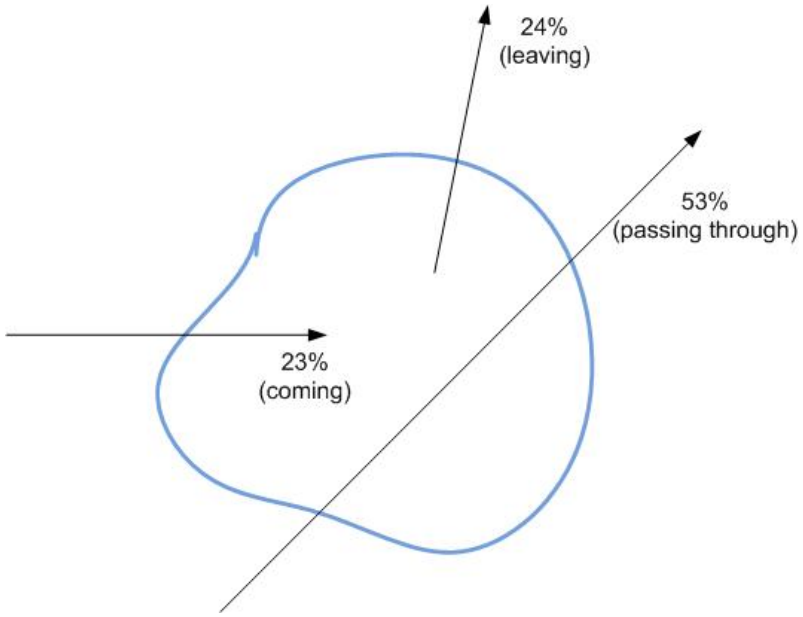


Figure 3-6: Percentage of Traffic Coming, Leaving, and Passing Through Jurisdictions.

3.2 Evacuation Preparation

EMAs and other stakeholders activate evacuation mechanisms only after evacuation orders are issued. The time required to evacuate includes clearance times (to configure traffic control elements, initiate the evacuation, and clear the routes of vehicles once deteriorating conditions warrant its end) and pre-landfall hazard time (the time during which hazardous conditions exist prior to actual hurricane landfall) (Florida Division of Emergency Management, 2000). A survey of eight states found that the evacuation order advanced notification time varied widely by location, and typically ranged from 12 to 72 hours (Wolshon, 2005b).

This study investigated the preparation time required to implement pre-evacuation plans to evacuate people in rural areas. As shown in Figure 3-7, the preparation times varied wildly across the agencies. One agency indicated that 72 hours of preparation time was required to implement a pre-evacuation plan. A further investigation into the individual inputs of EMAs and DOTs showed that the preparation times were similar regardless of the organization's identity.

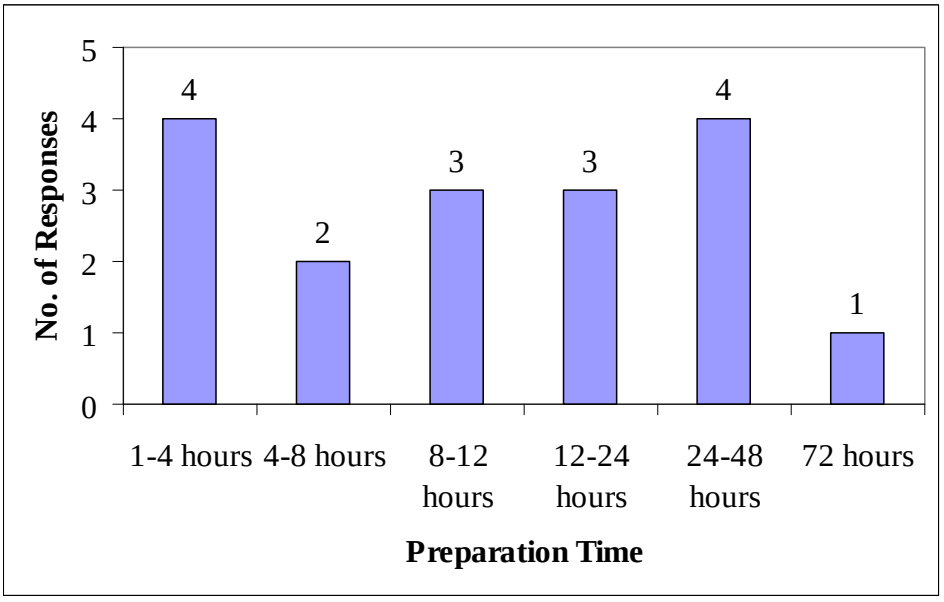


Figure 3-7: Required Preparation Time to Implement Pre-evacuation Plans.

Roadside amenities (food, lodging, healthcare, shelters, etc.) are important during evacuations and their availability along the rural evacuation routes was explored. The results are shown in Figure 3-8, in which three levels of availability were measured: not available, some available, and adequately available. The survey results were similar across the nine roadside amenities. The majority of agencies reported that some roadside amenities were availability in evacuation routes under their jurisdiction but only a few had adequate amenities available. Around one-third of the agencies indicated that there was no food, lodging, or parking available along the rural evacuation routes in their jurisdictions. One respondent commented that vehicles running out of gas and/or breaking down were an issue during evacuations. Another agency reported difficulties in getting food and drinks to the employees staged along the contraflow route. Lack of roadside

assistance could affect the evacuation process or even cause disruption of traffic on the evacuation routes.

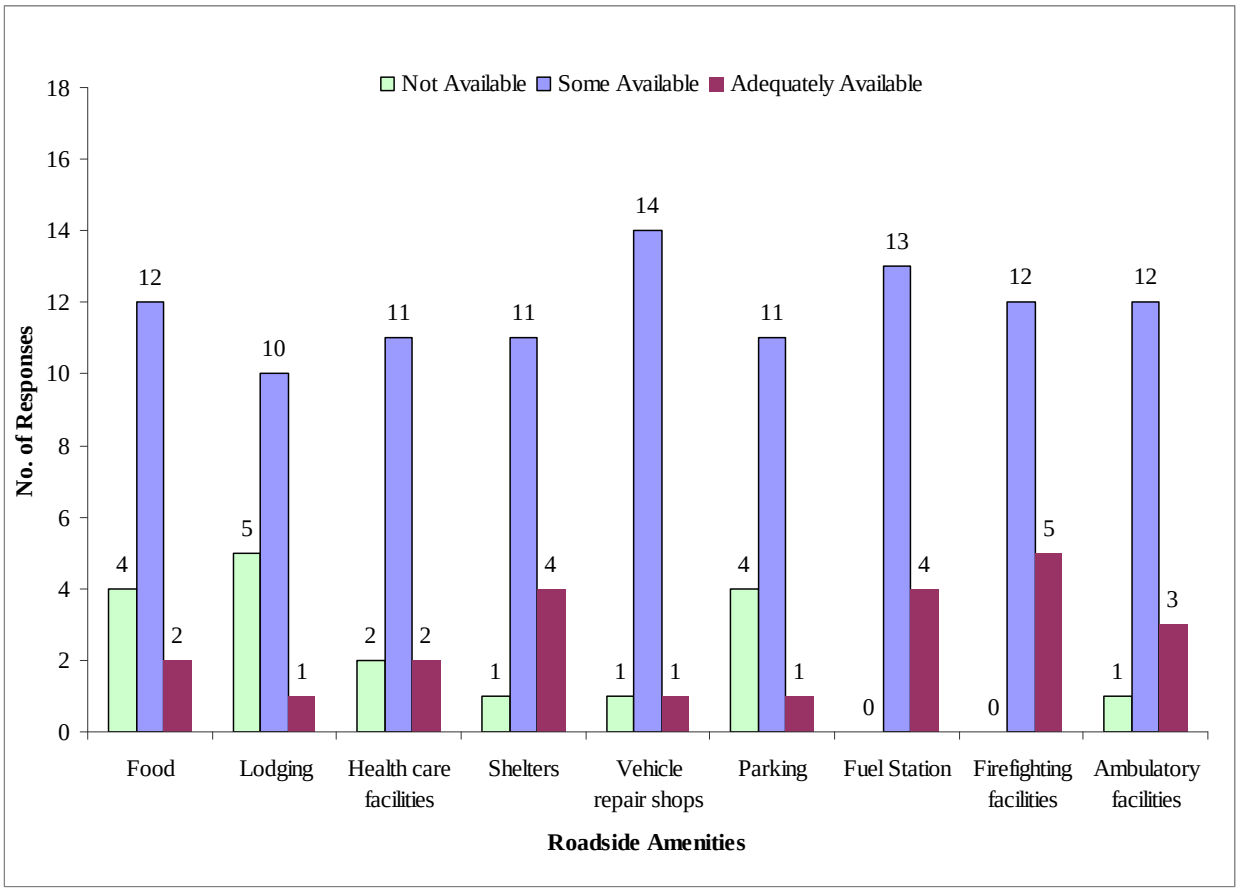


Figure 3-8: Availability of Roadside Amenities Along Rural Evacuation Routes.

Several questions were also posed to learn about mutual-aid agreements between agencies, publication of evacuation information, evacuation preparedness exercises, and involvement of agencies in reentry preparations. The results from these questions are summarized here:

- All respondents answered that they had mutual-aid agreements with law enforcement agencies and county/state emergency management centers; also, the majority of them had mutual-aid agreements with DOTs, FEMA, medical centers, and shelter facilities.
- Of the 18 responses, 16 agencies indicated that they publicized route map and shelter facilities information. In addition, 10 of them publicized information pick-up points/bus stops and reentry.
- Most agencies participated in reentry preparations such as debris removal, restoration of road infrastructure, traffic management, and restoration of traffic control.
- Of the 17 responses, 13 agencies indicated that they participated in mock training drills (or evacuation preparedness exercises). A couple of agencies commented that they participated in

drills (or evacuation exercises) annually. The drills/exercises were conducted between May and October of the year.

Finally, some questions related to employees of the responding agencies. The respondents were first asked if their employees were trained to assist special needs populations. Approximately half of the agencies answered that their employees were trained to assist the elderly, people with disabilities and other medical conditions, careless residents (residents who do not give attention or thought to avoiding harm), people with limited English proficiency, and people with hearing and visual impairments. Moreover, employees in one-third of the responding agencies were trained to assist people with service animals or pets. Secondly, when asked if the 18 agencies provided training to their employees, 17 of them indicated that they provided employees with incident command system/management training, 16 with emergency management and 15 with emergency communication training; half of them also provided primary medical services (first aid) training. Finally, a question was asked to know whether the agencies provided assistance to employees' families during evacuation, and 13 out of the 18 agencies answered "Yes."

3.3 Associated Evacuation Issues and Barriers

Unlike urban areas, rural communities have limited resources to assist in evacuations. Rural agencies also have smaller and less diverse workforces (Office of Rural Health Policy, 2002). These situations negatively affect the management of emergency activities in rural areas. For this reason, questions were developed in the survey intended to identify existing evacuation-related issues and barriers in rural communities.

The first question sought to learn about the barriers (or obstacles) to emergency management activities in the respondents' service areas. As shown in Table 3-1, the most frequently identified barrier was the lack of operating budget. Half or more of the respondents indicated that it was an obstacle for each phase of emergency management, especially the mitigation phase. In addition, funding restrictions to provide service and lack of workforce were also reported by around one-third of the agencies responding. Six agencies, all of which are EMAs, indicated a lack of workforce during the response phase. One agency commented that the law enforcement agencies in its district were stretched thin under normal conditions, and more help was required during evacuation events. Finally, five agencies reported not having enough vehicles to access flood-affected areas during the response phase of emergency management.

Table 3-1: Barriers (or Obstacles) to Emergency Management Activities

Barriers/Obstacles	Emergency Management Activity			
	Mitigation	Preparedness	Response	Recovery
Lack of operating budget	12	9	8	8
Funding restrictions to provide service	6	4	4	4
Lack of workforce	5	5	6	5
Having to plan ahead	1	1	0	0
Lack of roadside assistance	1	2	3	0
Lack of roadside amenities	1	2	2	0
Odd weather conditions	2	1	2	1
Service boundaries/jurisdiction	1	0	1	0
Lack of medical facilities	1	2	3	1
Lack of communication facilities	1	2	3	1
Lack of traffic control services	2	1	1	1
Lack of vehicles to access flood-affected area	1	0	5	2

This study also investigated issues in coordination efforts encountered during evacuation events. The most significant issue was the need for more law enforcement to assist in evacuations (e.g., to direct traffic), which was reported by six agencies. Communications is another important issue in evacuation. One agency reported that they had limited cell phone and radio services for law enforcement and fire departments. Another agency indicated a lack of communication between agencies for forwarding and sharing information. A third agency commented that there was an issue with redundant paperwork and a lack of information technology systems for better communication between agencies.

Finally, policy issues were reported by some agencies. One agency noted that their biggest challenge has been the estimation of the population that will require evacuation assistance. This information is important for evacuation planning and resource allocation to adequately support evacuations. However, policy issues can impede evacuation planning, especially in the course of deciding what constitutes a state or local responsibility. For example, is it a state or local responsibility to provide the transportation resources needed to evacuate residents from one county to another?

CHAPTER 4. ASSESSMENT OF EVACUATION TOOLS

Motorists and evacuation facilitators are the end-users of any evacuation operation system. They should be equipped with information, and facilities should be in-placed before, during, and after the evacuation. Information exchange between the evacuation operation center, motorists, and evacuation facilitators is key to an efficient and safe evacuation operation. There are numerous tools that can be used to facilitate information exchange between the various parties involved. The tools fall into three broad categories: communications, traffic control, and evacuation weather and condition assessment.

For the first two categories, questions were developed to investigate the use and efficiency of communication and traffic control devices. Under each question, the degrees of use or efficiency include four levels: not used, low, medium, and high. To campare the use of tools under each category, a matrix scorecard was created to provide values of 0 for "not used," 1 for "low," 2 for "medium," and 3 for "high." For the comparison of efficiency, inputs with "not used" were not taken into account. Two measures of effectiveness (MOEs) were developed for evaluation—the total score (TS_{use}) for use and the average score ($AS_{efficiency}$) for efficiency—as shown in the following equations. Higher scores represent more frequent use or higher efficiency, and the range of $AS_{efficiency}$ falls between 1 and 3.

$$TS_{use} = \sum_{i=1}^{n} S_{1i} \tag{4-1}$$

$$AS_{efficiency} = \frac{1}{n}\sum_{i=1}^{n} S_{2i} \tag{4-2}$$

Where,

n = the number of responses,

S_{1i} = the score of use for the ith response,

TS_{use} = total score of use,

S_{2i} = the score of efficiency for the ith response, and

$AS_{efficiency}$ = the average score of efficiency.

The use and efficiency (competency in performance) of communication devices are summarized in Table 4-1. Television (*TS=50*) was the most widely used tool for communications during evacuation events in the NGM coastal communities, followed by newspapers with a total score of 40. The finding that television had the highest usage is consistent with that of a national survey of state and local agencies conducted by the Gulf Coast Research Center for Evacuation and Transportation Resiliency between 2007 and 2008 (Wolshon, 2009b). Public address and emails, HAR, (reverse) 911, and emergency alert systems had a similar level of usage. Loudspeakers, 511, and siren systems had very low usage reported, with total scores of under 10.

In terms of efficiency, television again had the highest score at 2.73. A further investigation into individual inputs found that of those 15 responses, 12 of them indicated "high" efficiency. (Reverse) 911 did not show high usage, while it ranked second in efficiency. Also, although siren systems had very low usage, it had medium efficiency. Loudspeakers not only showed the lowest use but also the lowest efficiency ratings in evacuations.

Table 4-1: Use and Efficiency of Communication Devices/Systems

Communication Devices / Systems	Use		Efficiency	
	Number of Responses	Total Score	Number of Responses	Average Score
Dial (Reverse) 911	16	20	14	2.38
Dial 511	15	7	12	1.50
Loudspeakers	15	4	12	1.00
Siren System	15	5	13	2.00
Highway Advisory Radio (HAR)	16	24	13	1.88
Roadside Information Locations	16	14	12	1.83
Newspapers	18	40	15	1.93
Flyers	16	14	11	1.57
Television	17	50	15	2.73
Public Address and Emails	14	26	12	1.80
Cell Phones	15	21	12	1.90
Emergency Alert Systems	16	20	13	2.00

Table 4-2 shows the use and efficiency of traffic control devices for evacuations. It was found that traffic signs, channelization devices, and human directives had the highest use, while temporary pavement markings and ramp meters were used the least.

As compared to the average efficiency scores in Table 4-1, the values in Table 4-2 show a smaller variance: all average scores of efficiency for the traffic control tools fall between 2.0 (medium efficiency) and 3.0 (high efficiency). All of them can be very useful for evacuation operations. While DMS were not widely used, they were found to be the most efficient traffic control devices. Channelization devices and traffic signs were ranked second and third, respectively.

Table 4-2: Use and Efficiency of Traffic Control Devices/Systems

Traffic Control Devices/Systems	Use		Efficiency	
	Number of Responses	Total Score	Number of Responses	Average Score
Portable Traffic Signal	15	10	12	2.20
Ramp Meters	16	7	13	2.33
Traffic Signs	17	40	16	2.57
Channelization Devices (cones and barricades, concrete barricades)	16	32	16	2.75
Temporary Pavement Markings	16	6	13	2.33
Dynamic Message Signs (DMS)	17	24	15	2.78
Traffic Management Centers	17	13	15	2.50
Human Directives (Police, Army, and Volunteers)	18	35	17	2.47

Some concerns arose when respondents were asked to discuss any operating issues they faced using a traffic management center during evacuation events. One agency noted that communication with field personnel was challenging at times. Another described communication problems between the community's EOC and the traffic management center. The EOC was not able to receive real-time traffic flow information from the traffic management center, which was required to determine the progress of evacuations and support decision-making.

Finally, a question was posed regarding usage of weather condition assessment and planning tools (Table 4-3). All 18 agencies reported high usage of the National Weather Service (NWS). However, the remaining tools, including the Clarus Initiative, FHWA Road Weather Management Program, Evacuation Traffic Information System (ETIS), Evacuation Travel Demand Forecasting System, and Hazards U.S. Multi-Hazard (HAZUS-MH), were only used by a few agencies. One possible explanation is that the NWS system is easy to access (e.g., via televisions, newspapers, online access) and does not require specific skills to obtain its weather information, while the other systems may require expertise to obtain weather information or may be relatively new technology to employees in the responding agencies.

Table 4-3: Use of Weather and Condition Assessment Tools for Evacuations

Weather and Condition Assessment Tools	Use			
	Not Used	Low	Medium	High
National Weather Service	0	0	0	18
Clarus Initiative (Established by the FHWA Road Weather Management Program)	11	2	1	0
FHWA Road Weather Management Program	11	2	1	0
Evacuation Traffic Information System (ETIS)	8	1	4	1
Evacuation Travel Demand Forecasting System	9	1	2	2
Hazards U.S. Multi-Hazard (HAZUS-MH MR2- Developed by FEMA)	6	4	3	1

CHAPTER 5. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This study investigated the use of rural transportation infrastructure in the NGM coastal communities. A survey of current practices was conducted to gather information about evacuations in these areas. The survey results provided a good resource to explore the similarities, differences, and issues (or obstacles) in rural evacuations. Also, lessons were learned from past evacuation events.

A variety of communication tools can be used for the dissemination of evacuation information. In the NGM, television and newspapers are the most widely used media to convey evacuation information. Also, television was found to be the most efficient means of communication, which could have been due to the fact that television is popular in rural areas and has the ability to disseminate a variety of information.

Among different types of traffic control devices, DMS were found to be the most efficient devices in evacuations, although they have not been widely used in the coastal communities. In the future, EMAs may consider using more (portable) DMS in evacuations if such resources are available. These devices could be available in many government agencies and private entities, especially transportation agencies and construction companies. A national survey found that DMS were the most common transportation resource (Wolshon, 2009b). However, it is important to first identify existing resources available and how to use them for emergency management. Further research may be carried out to investigate how to use avaiable resources (e.g., traffic control devices) in a more efficient way within a community as well as between communities.

The majority of designated and undesignated evacuation routes in the NGM had high or oversaturated traffic flow in recent evacuation events. High traffic volume on these routes will cause excessive delay during evacuations. Historical traffic information could be very useful for better planning of evacuation routes. However, the gathering of historical traffic information in rural communities is difficult as a significant portion of evacuation routes are state or county roads on which no vehicle detectors are available to record traffic flow during evacuations. In such situations, it is important to have estimates of traffic demand that may leave, travel through, or come to the rural communities. Better coordination efforts between EMAs and transportation agencies are key to planning an effective evacuation route. Future research is needed to develop a methodology for the accuracy of forecasting/estimating evacuation flow on evacuation routes. This is a complicated task because the progress of evacuee flow is affected by many on-going factors such as weather, traffic situations, locations of shelters, and traffic accidents/incidents.

This study identified several major issues in rural evacuations. The most commonly reported issue is the lack of workforce to handle evacuations. To address this issue, EMAs may establish or improve mutual aid agreements with related agencies regarding the allocation of manpower in evacuations. Increasing the role of other agencies (e.g., transportation agencies) in evacuation will help improve the use and efficiency of existing resources (facilities and workforce). Moreover, EMAs may consider recruiting volunteers to assist in evacuations through education,

training, and providing incentives to them if possible. The study conducted by NORC (National Opinion Research Center) (2005) provided some useful information for pre-event recruitment of volunteers, including: 1) assuring volunteers in advance that they will receive protection; 2) being sure volunteers are qualified; 3) knowing state's rules about volunteer liability; and 4) paying particular attention to recruiting volunteers with multi-lingual capabilities if possible. School bus systems are well equipped resources with large vehicle fleets and an available workforce in rural areas that can be utilized in the evacuation of transit-dependent people. A survey conducted by WTI indicates that school system employees, including drivers, mechanics, bus coordinators, and dispatchers, are well trained in handling emergency events. This workforce may be utilized in traffic management activities with additional training during evacuation if they are not engaged in the evacuation of transit-dependent people (Chaudhari et al., 2009). Further research can be done to analyze the feasibility of including school system employees as a part of evacuation workforce.

Coordination between agencies is challenging in rural evacuations. The characteristics of hurricanes and other emergency events, the population surge into rural areas, limited rural infrastructure, and other issues make it difficult for EMAs to gather real-time information during evacuations. The interface between EMAs and other lead or support agencies such as DOTs and law enforcement agencies needs to be improved so that information about evacuation progress can be reported and shared in real time among these agencies. Improving coordination with surrounding communities in the NGM is also important due to the large scale of areas affected by hurricanes and floods. As found by this study, significant portions of evacuees will travel through rural communities and this will put pressure on multiple jurisdictions. The evacuation flow needs to be handled by communities working together.

Communication between agencies is also a big issue. Emergency phone lines may be set up for communication among agencies during evacuations. Information on the progress of the evacuation can be reported and exchanged by phone. However, it could be a problem to communicate with field personnel in evacuations since communication services may be limited in rural areas. In such cases, more advanced communication services such as satellite phone services and mobile communication briefcase (a standalone communication system developed by the Western Transportation Institute) can be very useful and need to be investigated further along the cost-benefit analysis

Finally, lack of operating budget was the most frequently reported barrier to emergency management activities. Funding restrictions or inadequate funding could hamper all phases of emergency evacuations. This is perhaps the most poorly addressed topic in transportation and emergency management activities. In the reauthorization of a new transportation bill, Congress should recognize this issue and authorize the FHWA to reimburse evacuation operation expenses and to purchase communication and ITS equipment to enhance the efficiency of rural evacuation operations. Evacuation operations may be included in the Federal Emergency Management Agency's Catastrophic Planning Initiative and the National Response Framework so the operation can have the same privileges to leverage expenses as is available for debris removal.

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APPENDIX A: GLOSSARY OF ACRONYMS

DMS	Dynamic Message Sign
DOT	Departments of Transportation
DPS	Department of Public Safety
EMA	Emergency Management Agency
ETIS	Evacuation Traffic Information System
EOC	Emergency Operations Center
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HAR	Highway Advisory Radio
HAZUS-MH MR2	Hazard U.S.-Multihazard
ITS	Intelligent Transportation System
MOE	Measure of Effectiveness
NGM	Northern Gulf of Mexico
NWS	National Weather Service
WTI	Western Transportation Institute

APPENDIX B: STUDY AREA

The study area of this research project included 24 counties of Mississippi, Alabama, Florida and four parishes of Louisiana listed in Table B-1, with estimated urban and rural populations of the year 2009.

Table B-1: Study Area Counties and Parishes with Population—2009

Counties	Urban Population	Rural Population
LOUISIANA PARISHES		
Tangipahoa Parish	46%	54%
Washington Parish	38%	62%
St. John the Baptist Parish	86%	15%
St. Tammany Parish	75%	25%
MISSISSIPPI COUNTIES		
George County	0%	100%
Stone County	21%	79%
Pearl River County	30%	70%
Hancock County	62%	39%
Harrison County	78%	22%
Jackson County	68%	32%
ALABAMA COUNTIES		
Washington County	0%	100%
Clarke County	26%	74%
Monroe County	22%	79%
Escambia County	39%	61%

Mobile County*	79%	21%
Baldwin County*	45%	55%
FLORIDA COUNTIES		
Holmes County	21%	79%
Jackson County	17%	83%
Washington County	17%	83%
Calhoun County	35%	66%
Liberty County	0%	100%
Gadsden County	34%	66%
Gulf County*	33%	67%
Bay County*	89%	11%
Walton County*	21%	80%
Santa Rosa County*	71%	29%
Okaloosa County*	90%	11%
Escambia County*	89%	11%

*: Counties outside the CURIS study area.

Source: (EDIS, 2009)

APPENDIX C: SURVEY QUESTIONNAIRE AND RESULTS

Rural Area Evacuation Operations Survey

The Western Transportation Institute (WTI) at Montana State University (MSU), in cooperation with the Center for Urban Rural Interface Studies at Mississippi State University, is conducting this survey to assess the use of rural transportation infrastructure in Evacuation Operations for the North Gulf Coastal Region. When evacuation occurs, planning and coordination among emergency management, law enforcement, and transportation agencies lead to an effective contraflow system allowing anyone with a car to evacuate from urban areas. But rural coastal communities remain at high risk and are difficult to evacuate in a timely manner due to larger geographical areas, low density, and limited resources. To date, emergency planning efforts focus on addressing urban needs to a larger extent and do not significantly account for rural areas. One travel scenario may be that the urban evacuees travel to rural communities in close proximity to urban areas. To some extent, evacuees' travel behavior, their final destination, travel patterns, and other travel related subjects in relation to rural areas are unknown and yet to be documented.

We invite your agency to participate in this survey and your agency input is very valuable and will help identify and prioritize rural transportation evacuation preparedness and needs. We hope that the survey will be completed by a person(s) with knowledge of your agency's activities related to emergency evacuations.

Participation is voluntary. A respondent may skip any question that he or she would rather not answer. All of the respondent's answers are completely confidential. The respondent does not have to provide your agency's name and survey results will contain only summaries of responses with no identifiable individual information.

Survey results will be made available to interested participants. If you or respondent have any questions or comments about the survey or to obtain the results, contact:

Mr. Jaydeep Chaudhari, Western Transportation Institute- Montana State University, 2327 University Way, Bozeman, MT-59717-4250. Phone: (406) 994 2322; Email: jaydeep.chaudhari@coe.montana.edu

This survey is approved by the Institutional Review Board, Montana State University—Bozeman. The survey approval number is…… If you have any questions about the participant's rights as human subjects, contact:

Dr. Mark Quinn, Chair Veterinary Molecular Biology, Montana State University 960 Technology Blvd., Room 127, Bozeman, MT 59717-3610. Phone: (406) 994-4707 Email: mquinn@montana.edu

Thank you for agreeing to participate in this survey!

I. AGENCY CHARACTERISTICS AND SERVICE JURIDICTION

1. **Agency Name: _____**

2. **Respondent's Email:_____**

3. **What is the geographic service area for your agency?**

☐ Countywide including urban, suburban, and rural areas (Specify County or Counties):
_____

☐ Citywide only (Specify):
_____

☐ Statewide only (Specify):
_____

☐ Other (Specify):
_____

4. **Please list all major rural evacuation routes used for the most recent evacuation event(s) along with their use.**

Roads	Use			
	Low (L)	**Medium (M)**	**High (H)**	**Exceeded capacity (E)**
Louisiana				
Designated evacuation routes				
1. I-55 North			☒	
2. I-12 East				☒
3. I-10			☒	
4. I-12			☒	
5. I-55			☒	
6. I-59			☒	
7. US 190			☒	
8. Pontchartrain Causeway			☒	

9. I-12 West		☒		
10. I-12 East			☒	
11. I-55 North		☒		
12. I-59 North		☒		
13. SR 25 North			☒	
14. SR 21 North			☒	
15. US 90 North			☒	
16. SR 21			☒	
17. SR 10			☒	
18. SR 16		☒		
19. SR 25			☒	
20. SR 38		☒		
Undesignated evacuation routes				
1.Hwy 190			☒	
2.Hwy 16			☒	
Mississippi				
Designated evacuation routes				
1. I-59				☒
2. US 49			☒	
3. US 45			☒	
4. I-10			☒	
5. Hwy 63			☒	
6. US 98			☒	
7. Hwy 43			☒	
8. I-20				☒
9. I-55			☒	
10. Hwy 15			☒	
11. Hwy 43			☒	
12. US 11				☒
13. SR 63			☒	
14. SR 613			☒	
15. SR 57			☒	
16. SR 609			☒	
17. HWY 63		☒		

18. HWY 98	☒			
19. HWY 57		☒		
20. US 49				☒
21. US 67			☒	
22. US 15			☒	
23. US 53			☒	
24. I-10				☒
25. US 90				☒
26. I-110				☒
27. Popps Ferry Road			☒	
28. Cowan Lorraine Road			☒	
29. Canal Road			☒	
30. Beatline/County Farm			☒	
31. Menege Ave			☒	
Undesignated evacuation routes				
1. Red Creek Road			☒	
2. Kiln Delisle Road			☒	
3. Old Highway 49			☒	
4. Old Biloxi Road			☒	
5. Tucker Road			☒	
Alabama				
Designated evacuation routes				
1. US 43			☒	
2. US 45			☒	
3. US 43			☒	
4. AL 17	☒			
5. AL 59			☒	
6. US 98			☒	
7. AL 193			☒	
8. US 43			☒	
9. I-65			☒	
10. I-10			☒	
11. AL 181			☒	
12. AL 113			☒	

13. AL 21			☒	
14. AL 41			☒	
15. US 45		☒		
16. AL 225		☒		
17. CR 59			☒	
18. SR 188			☒	
19. SR 193			☒	
20. US 43	☒			
21. US 45		☒		
22. US 90		☒		
23. US 98	☒			
24. I-10			☒	
25. I-65				☒
Undesignated evacuation routes				
1. US 84				☒
2. US 69	☒			
Florida				
Designated evacuation routes				
1. SR 65			☒	
2. SR 20			☒	
3. SR 12			☒	
4. CR 12		☒		
5. SR 67			☒	
6. Hwy 98			☒	
7. Hwy 87			☒	
8. Hwy 281 (Avalon Blvd)			☒	
9. Hwy 191 (Munson Hwy)		☒		
10. Hwy 89		☒		
11. Hwy 197 (Chumuckla Hwy)		☒		
12. Willard Norris Rd.	☒			
13. I-10			☒	
14. Hwy 4		☒		
15. US 77			☒	

16. US 79			☒	
17. US 231			☒	
18. US 98			☒	
19. I-10			☒	
20. US 90			☒	
21. CR 12		☒		
22. US 27		☒		
23. US 20	☒			
Undesignated evacuation routes				
1. Hardaway Rd	☒			
2. Sycamore Rd.	☒			

Note: Since a highway may pass through different counties or even states, there are duplicate route names in the "Roads" column and their use may differ based on the local traffic conditions.

II. COMMUNICATION

5. What type of information communication device/system is used along with its associated efficiency in an emergency/evacuation event(s)? (Please rate all applicable)

Information Communication	Use				Efficiency			
	Not Used	**Low**	**Medium**	**High**	**Not Used**	**Low**	**Medium**	**High**
Dial (Reverse) 911	8	0	4	4	6	1	3	3
Dial 511	11	2	1	1	10	1	1	0
Loud Speakers	12	2	1	0	9	3	0	0
Siren System	12	2	0	1	10	1	1	1
Highway Advisory Radio	6	1	4	5	5	3	3	2
Roadside Information Locations	9	3	1	3	6	2	3	1
Newspapers	1	3	5	9	0	5	6	4

Flyers	8	4	2	2	4	4	2	1
Television	0	0	1	16	0	1	2	12
Public Address and Emails	3	2	3	6	2	4	4	2
Cell phones	4	5	2	4	2	4	3	3
Emergency Alert System	7	2	3	4	4	2	5	2

6. What type of traffic control device/system is used along with its associated efficiency in an emergency/evacuation event(s)? (Please rate all applicable)

Traffic Control Device/System	Use					Efficiency		
	Not Used	**Low**	**Medium**	**High**	**Not Used**	**Low**	**Medium**	**High**
Portable Traffic Signal	9	3	2	1	7	0	4	12
Ramp Meters	12	1	3	0	10	1	0	2
Traffic Signs	2	1	3	11	2	2	2	10
Channelization Devices (cones and barricades, concrete barricades)	4	0	4	8	4	0	3	9
Temporary Pavement Marking	12	2	2	0	10	0	2	1
Dynamic Message Signs	6	3	3	5	6	1	0	8
Traffic Management Centers	11	2	1	3	11	0	2	2
Human Directive (Police, Army, and Volunteers)	2	5	3	8	2	2	4	9

7. If an emergency/traffic management center is used in evacuation events, please discuss any operating challenges in the space provided below.

1. N/A

2. N/A

3. Communication with field personnel can be challenging at times.

4. We just installed a new traffic management center with the DOT but haven't used it in an evacuation event yet so unsure of how it will be used.

5. The interface between the community's emergency operation center (EOC) and a traffic management center is the primary challenge. The EOC needs real time traffic flow information to determine progress of evacuations and for decision support. Currently, in our jurisdiction the EOC does not receive this level of data from traffic management.

6. At the county level we utilize the Florida DOT for management and direction of traffic. Their headquarters is located within our county.

III. EVACUEE ESTIMATION

8. What percentage of your jurisdiction population would you estimate to use rural evacuation routes?

0: 1%-5%

0: 6%-10%

2: 11%-15%

0: 16%-20%

3: 21%-30%

6: 31%-50%

4: 51%-75%

2: 76%-100%

0: None

9. Please estimate evacuation flow for the population in your jurisdiction. (Check all that apply.)

Evacuation Types	Percentage
☐ Urban-to-urban evacuation	
☐ Urban-to-rural evacuation	
☐ Rural-to-rural evacuation	
☐ Rural-to-urban evacuation	
☐ Other:_____	

Results:

Response ID	Urban-to-urban evacuation (%)	Urban-to-rural evacuation (%)	Rural-to-urban evacuation (%)	Rural-to-rural evacuation (%)	Other (e.g., shelter) (%)
1					
2	50	20	5	5	20
3				90	
4				80	
5	40	25	5	5	
6	5	60		10	
7	10	100	25	75	
8		100			
9		75		25	
10			15	15	
11	75	5	15	5	
12	35	45	3	17	10
13	45	20	70	20	
14		50	25	25	
15		5	11		

10. Please estimate the percentage of traffic in your jurisdiction based on the following categories. (Check all that apply.)

Types of Evacuees	**Percentage of Total Traffic**
☐ Evacuees coming to your area for shelter	
☐ Evacuees passing through your area	
☐ Evacuees stay in your area due to altered weather condition	
☐ Local evacuees leaving your area	
☐ Other:_____	

Results:

Response ID	Evacuees coming to your area for shelter (%)	Evacuees passing through your area (%)	Evacuees stay in your area due to altered weather condition (%)	Local evacuees leaving your area (%)
1	30	50	15	5
2	10	80	5	5
3	25	85	20	10
4	10	90	0	0
5	25	70	0	5
6	0	25	0	75
7	5	80	25	60
8	10	90	10	35
9	0	100	0	50
10	10	10	50	30
11	10	20	5	25
12	10	15	30	45
13	10	35	10	45
14	25	20	20	10
15	1	79	10	10
16	2	85	2	11

11. If your agency has used contraflow or reverse lane operations in recent evacuation event(s), please provide the following information.

Name of Route(s)	Evacuation Event	Location		Approximate Length (mile)	Challenges or Issues of Operation
		From	To		
I-55	Hurricane Katrina, and Hurricane Gustav	Extreme southern portion of Parish	Mississippi State Line	60	Cars running out of Gas and/or breaking down
I-12	Hurricanes Katrina and Gustav	West Border	East Border	25	Cars running out of Gas and/or breaking down

Hwy 190	Hurricanes Katrina and Gustav	West Border	East Border	25	Out of Parish evacuees circumventing Interstate evacuation routes and taking rural Hwys
Hwy 16	Hurricanes Katrina and Gustav	West Border	East Border	25	Out of Parish evacuees circumventing Interstate evacuation routes and taking rural Hwys
Interstate 59	Gustav	Louisiana	Poplarville, MS	21	
Interstate 55	Gustav		McComb, MS	30	
I-65	July 9, 2005	Mobile	Montgomery	130	news media coverage
I-12 West to I-55 North	Hurricane Ivan	New Orleans Metro Area	through St. Tammany	20 miles	coordination with other parishes
I-10 East to I-59 North	Hurricane Ivan	New Orleans Metro Area	through St. Tammany	20 miles	coordination with other parishes
I-12 West to I-55 North	Hurrricane Katrina	New Orleans Metro Area	through St. Tammany	20 miles	coordination with other parishes

I-1- East to I-59 North	Hurricane Katrina	New Orleans Metro Area	through St. Tammany	20 miles	coordination with other parishes
I-65	Hurrican Ivan Hurricane Dennis Hurricane Katrina	Mobile, AL	Montgomery, AL	135	Decision Timing
NA					
I 59	Gustav	Louisian State Line	Mile marker 21	21 miles	Lack of Law enforcement

IV. EMERGENCY EVENT SPECIFIC ISSUES

12. Is your agency a part of the County's/State's Emergency Operation Center in case of emergency evacuation?

18: Yes 0: No

13. Does your agency have mutual aid agreement(s) with other agencies in your area for coordination during an emergency evacuation event(s)? (Check all that apply.)

Agencies	**Yes**	**No**
Law Enforcement Agency	16	0
Department of Transportation	10	2
County/State Emergency Management Center	15	0
Shelter Facilities	13	1

Federal Emergency Management Agency	11	2
Medical Center/Health Facilities	11	1
Local Traffic Management Agency	9	3
Other:_____	☐	☐

Other:
1). Local and state law enforcement assistance, but no formal Memorandum of Understanding.
2). Florida National Guard LNO (team) and resources.

14. Does your agency publicize information about the following? (Check all that apply.)

16 Route Map
10 Pick up points/Bus Stops
6 Roadside Assistance
16 Shelter Facilities
10 Reentry
1 Other: _____

Other:
1). American Red Cross has provided shelter and stranded motorist on major arterials.

15. Does your agency participate in any of the following reentry preparations? (Check all that apply.)

14 Communication Infrastructure /Assessments prior to Reentry
17 Debris Removal
16 Restoration of Road Infrastructure
15 Traffic Management
14 Restoration of Traffic Control
2 Other:_____

Other:
1).none directly - coordinated through the Emergency Operations Center (EOC)

16. Has your agency ever participated in Mock Training Drills/Evacuation Preparedness Exercises?

13 Yes 4 No

If yes, what is the date of the most recent drill/exercise? _____

1). We participate and host drills annually but not evacuation drills
2). Point of Distribution Drill in Aug.
3). Yearly, before each hurricane season.
4). May 20, 2009

5). Oct 13, 2009

6). the real thing

7). Don't know specific date

8). 05/20/09

9). State Hurricane Exercise 2009

10). 15 OCT 09

11). July 02, 2009

V. EMPLOYEE ISSUES

17. Are your employees trained to assist the following special needs population? (Check all that apply.)

9 The elderly

8 People with disabilities and other medical conditions

7 Careless residents (residents who do not give attention or thought to avoiding harm)

7 People with limited English proficiency

8 People with hearing and visual impairments

6 People with service animals or pets

2 Other: _____

1). The American Red Cross handles this for us as well as local Military agencies
2). We are addressing pet friendly shelters within the county. This is an ongoing process.

18. Does your agency provide training to your employees on the following topics? (Check all that apply).

7 Assistance to special needs population	2 Reverse lane driving
9 Primary medical services (First Aid)	17 Incident Command System/Management
16 Emergency management	15 Emergency communication
0 Driving in hurricane traffic zone	0 Other:_____

19. Please list any employee-related issues associated with past emergency/evacuation event(s)?

1). Not enough staff, heavily dependent on volunteers

2). Getting food and drinks to the employees staged along the contraflow route.

3). None

4). None

5). Need to have a place for family members of First Responders to be safe.

20. Does your agency provide assistance to employees' families during evacuation?

13 Yes 5 No

VI. EVACAUATION PREPARATION

21. How much preparation time is required to implement your agency's pre-evacuation plan to evacuate people in rural areas?

4: 1-4 hours 2: 4-8 hours 3: 8-12 hours 3: 12-24 hours 4: 24-48 hours Other___

Other:

1). 72 hours

22. Does your agency have a security plan to protect your operation evacuation facilities/resources?

16: Yes 2: No

23. Are the following roadside amenities (or special services) available along the rural evacuation routes of your jurisdiction?

Amenities / Special Needs	**Not available**	**Some available**	**Adequately available**
Food	4	12	2
Lodging	5	10	1

Health care facilities	2	11	2
Shelters	1	11	4
Vehicle repair shops	1	14	1
Parking	4	11	1
Fuel Station (Gas Station)	0	13	4
Fire Fighting facilities	0	12	5
Ambulatory facilities	1	12	3

VII. EMERGENCY EVENT FINANCIAL RESPONSIBILITY

24. Does your agency have contracts for the following items for emergency event(s)?

Type of Contract	**Yes**	**No**
Debris removal	14	4
Portable traffic control equipments	8	10
Dynamic message signs	7	11
Portable restrooms	7	11
Vehicle towing	10	8
Road repair	10	8
Portable Fuel Station (Gas Station)	4	14
Ambulatory service	7	11
Other:_____	0	4

Please give further detail on any items checked above, or if your answer is "No."

). Funding for equipment is limited, but we do have mutual aid with DOT if needed.

2). We do not have pre-event contracts but make arrangements for portable restrooms, debris removal, and as soon as we see it is needed. We do contact these companies prior to storm arrival and have them on ready.

3). The items checked "NO" are handled by other agencies.

4) State Highway Department provides message signs. Road repairs are limited. No portable fuel or restrooms available

5) Messaging signs, we have several in the county owned by county agencies. Our public works dept has vehicles with portable gas tanks but not for public use.

6) COUNTY ROAD CREWS HANDLE DEBRIS REMOVAL.

7) Our Agency is a resource coordination entity and does not provide direct services.

25. If your agency has any kind of contracts noted in the above two questions (question 23 and 24), which agency is responsible for handling the contract and financial matters for emergency event(s)?

7	Emergency Management Agency	12	County/City Governments
7	Department of Transportation	3	Law Enforcement Agency
3	Medical Facility	0	Other:_____

VIII. ASSESSMENT OF NEEDS/COORDINATION/PLANNING

26. What type of weather, condition assessment and planning device/system/tool is used in an emergency/evacuation event(s)? (Please rate all applicable)

Weather, Condition Assessment and Planning	Use			
	Not Used	**Low**	**Medium**	**High**
National Weather Service	0	0	0	18
Clarus Initiative (Established by the FHWA Road Weather Management Program)	11	2	1	0
FHWA Road Weather Management Program	11	2	1	0
Evacuation Traffic Information System (Developed by FHWA)	8	1	4	1
Evacuation Travel Demand Forecasting System	9	1	2	2

Hazard U.S.-Multihazard (HAZUS-MH MR2-Developed by FEMA)	6	4	3	1

27. What issues, if any, have your coordination efforts encountered in evacuation event(s)? (Check all that apply.)

2 Billing and payment

2 Mutual Aid Agreements between agencies

3 Liability

2 Employee qualifications

3 Policies

6 Law enforcement

4 Other: Communications; politics; communications; none

Please give further detail on any items checked above.

1). Communication is a big issue with our County. We are very rural and have limited Cell service, radio service (UHF) for Law and Fire, and no cable service in these areas that are within the evacuation routes.

2). Law enforcement changing plans that had been agreed upon prior to the event.

3). The evacuation plan changes from event to event because the orders are given by politicians who cave into media driven pressure.

4). Lack of agencies communicating with each other (pssing on information).

5). the need for more law enforcement to assist in directing traffic

6). NOT HAVING ENOUGH PERSONNEL

7). We need more Law enforcement.

28. What do you see as barriers/obstacles to emergency management activities in your service area? (Check all that apply).

Barriers/ Obstacles	Emergency Management Activity			
	Mitigation	Preparedness	Response	Recovery
Having to plan ahead	1	1	0	0
Lack of roadside assistance	1	2	3	0
Lack of roadside amenities	1	2	2	0
Lack of operating budget	12	9	8	8

Odd weather conditions	2	1	2	1
Service boundaries/jurisdiction	1	0	1	0
Lack of medical facilities	1	2	3	1
Funding restrictions to provide service	6	4	4	4
Lack of communication facilities	1	2	3	1
Lack of traffic control services	2	1	1	1
Lack of workforce	5	5	6	5
Lack of vehicles to access flood affected area	1	0	5	2
Other (please specify below)	0	0	0	0

Other:

1). Requirements to submit updates/accomplishments seem excessive.

2). Lack of an emergency notification system and lack of emergency management software

29. Please provide any other comments you have about transportation issues and/or operations during emergency/evacuation event(s) in your area.

1). Being and inland county mandatory evacuation orders are not issued. Locals that evacuate the area do so by private vehicles.

2). The biggest challenge for us has been and continues to be estimating the population that will require evacuation assistance. This information is critical to do the planning and resource allocation needed to adequately support evacuations. Policy issues are also an impediment to planning. For example whose responsibility is it to provide the transportation resources needed to evacuate residents from one county to another? Is this a State or local responsibility? This has not been totally resolved in our jurisdiction and consequently there are shortfalls in current evacuation plans that have not been addressed.

3). We have a mutual aid agreement with the County School System to provide special needs clients transport to designated special needs shelters. The system has worked in past and they are onboard with planning and preparation.

4). Our Law enforcement is stretched thin under normal conditions. During events we obviously need more help.