

Hurricane Georges Post Storm Assessment

Executive Summary

On September 20, 1998, Hurricane Georges passed near the U.S. Virgin Islands making landfall over Puerto Rico. Georges made its way into the Florida Straits early on the 25th after making landfall over Hispaniola and Cuba. Georges made its next landfall near Key West before moving towards the Gulf Coast. On September 28th, Georges made landfall again near Biloxi, Mississippi. Georges caused 602 direct deaths and over 5 billion dollars of estimated damage. Hurricane Georges provided an opportunity to answer several key questions regarding these major FEMA/Corps planning efforts:

- Did local and state officials use the products produced in these major studies?
- Were study data regarding storm hazards, behavioral characteristics of the threatened population, shelter information, evacuation times, and decision-making accurate and reliable?
- Which study products were most useful and which least useful - what improvements could be made to current methodologies and products?

To answer these questions, study teams comprised of representatives from FEMA, the U.S. Army Corps of Engineers, and Post, Buckley, Schuh & Jernigan, Inc. visited with local and state officials throughout the directly impacted areas of South and Northwest Florida, Alabama, Louisiana, Mississippi, Puerto Rico, and the U.S. Virgin Islands.

Interviews and analysis conducted during the post-Georges effort revealed modest evacuation participation rates on the part of permanent population and tourists throughout the study areas.

Major recommendations from this post-Georges effort include:

1. Complete new SLOSH modeling and associated mapping for the Florida Keys, Alabama, Mississippi, and Louisiana.
2. Produce a comprehensive atlas showing storm surge areas and 100 year floodplain for the entire island of Puerto Rico.
3. Address the unique rainfall vulnerability and mudslide potential for hurricane events in the Caribbean through activities of the FEMA/Corps/NWS Island Task Force.
4. Educate the emergency management community about the three fold effect of wave run up, wave set up and wind driven wave run up on SLOSH predicted values and measuring high water marks.
5. Provide Puerto Rico and the U.S. Virgin Islands with public shelter evaluation resources and monies for emergency power supplies/generators.
6. Address the unique wind vulnerability of island shelters due to mountain terrains/downslope accelerations.

7. On the Gulf Coast, make sure public shelter staff keep evacuees out of gymnasiums during the brunt of storms due to potential roof problems.
8. Build on the success of Escambia County, Florida, in working with the military to successfully staff public shelters.
9. Update Alabama, Mississippi, Louisiana and lower southeast Florida hurricane evacuation studies.
10. Run scenarios for St. Thomas under lower assumed participation rates.
11. Develop maintenance of traffic plans for Louisiana parishes that have road construction projects on major evacuation routes (specifically for the hurricane season).
12. Conduct a Louisiana-Mississippi regional hurricane evacuation analysis to better anticipate traffic flows into Mississippi and associated shelter demand.
13. Provide Gulf states and counties with an abbreviated version of the transportation model so that roadway construction impacts to clearance time can be calculated in real time.
14. Implement permanent traffic count stations along the Gulf Coast states so that evacuation traffic can be monitored and documented.

15. Update clearance time data and incorporate into the new HURREVAC model.
16. Conduct extensive training sessions with local EM's regarding the new HURREVAC model.
17. Deliver new SLOSH storm tide atlases to Mississippi Counties as soon as possible.
18. Provide detailed river and mudslide area maps such as USGS maps for Puerto Rico and the U.S. Virgin Islands.
19. Provide rain and wind gauges for the U.S. Virgin Islands.
20. Study update in Alabama including clearer/more definable evacuation zones.
21. Update Louisiana study including SLOSH forecasts.
22. Assist Puerto Rico municipios in obtaining necessary data during a storm.

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Chapter 1

Introduction

As reported from the National Hurricane Center, Georges developed from a tropical wave in the far eastern Atlantic on September 15, 1998 and became a tropical storm a day later. Georges moved west to west-northwest for the next several days intensifying to a Category 4 hurricane. Georges' first landfall was over Antigua in the Leeward Islands late on the 20th. After moving near the U.S. Virgin Islands, Georges made landfall in Puerto Rico the evening of the September 21st with estimated maximum winds of 115 mph. Georges weakened very little while over Puerto Rico and was even stronger when it made landfall in the Dominican Republic on the afternoon of the 22nd. After crossing the mountainous terrain of Hispaniola, Georges made landfall over eastern Cuba on the afternoon of the 23rd. Georges continued along the northern coast of Cuba for the next day and moved into the Florida Straits early on the 25th. It then intensified, making landfall near Key West, Florida. Georges turned northwest and moved toward the Gulf Coast while it gradually slowed down. Georges made its final landfall near Biloxi, Mississippi early on September 28 with 105 mph winds. Georges weakened to a tropical storm later that day and was downgraded to a tropical depression by midmorning on the 29th.

Prior to Hurricane Georges, comprehensive hurricane evacuation studies (HES) had been conducted for many of the impacted areas. These studies and their associated work products are jointly funded by the Federal Emergency Management Agency (FEMA), the U.S. Army Corps of Engineers (USACOE) and the National Weather Service (NWS). The Jacksonville District of the U.S. Army Corps of Engineers had completed studies for St. Thomas and St. Croix in the early and mid 1990's and had developed HES products for portions of Puerto Rico. The district also had developed a study for lower southeast Florida (including the Florida Keys) which was about ten years old. The Mobile District had recently completed a restudy of the northwest Florida area and had initiated a restudy for Alabama and Mississippi. A ten year old study was also available for the southeast Louisiana area which had been developed by the New Orleans District of the Corps. It should also be noted that the Southwest Florida Regional Planning Council had recently produced a study update for southwest Florida which included several interviewed counties.

With these studies in hand and with some draft restudy products on the table, Georges provided an opportunity to answer several key questions regarding these major FEMA/Corps planning efforts:

- Did local and state officials use the products produced in these major studies?
- Were study data regarding storm hazards, behavioral characteristics of the threatened population, shelter information, evacuation times, and decision-making accurate and reliable?
- Which study products were most useful and which least useful - what improvements could be made to current methodologies and products.

To answer these questions, study teams comprised of representatives from FEMA; the Corps of Engineers; and Post, Buckley, Schuh & Jernigan, Inc. visited with local and state officials throughout the directly responding or impacted areas of Northwest and South Florida, Alabama, Louisiana, Mississippi, Puerto Rico and the U.S. Virgin Islands. Post, Buckley, Schuh & Jernigan, Inc. was retained to accompany the study team and document all relevant findings. Many local and state officials provided their observations. Local emergency management directors, law enforcement officers, and shelter personnel were involved in meetings held in each area that responded to Hurricane Georges. Separate meetings were held to discuss study product usage with local media representatives. Appendix A lists those individuals who either attended meetings or provided input through telephone conversations.

Discussion with local emergency management officials focused on study products and their use relative to the evacuation decision process, evacuation and clearance time, sheltering, and public information. Discussions with state officials centered on the role the state played in the evacuation process, including the use of study products in communicating with local officials. Media representatives were asked to focus on study related materials that they possessed and that were broadcast to the general public. They also addressed the types of materials and public information they could have used that had not been developed or delivered to them to date.

In addition to the meetings held with state and local officials, Hazards Management Group conducted and analyzed a residential behavioral sample survey for selected communities in Northwest and South Florida, Alabama, Louisiana, and Mississippi. Telephone interviews were conducted to ascertain actual evacuation response in Georges and to predict evacuation response parameters for future comprehensive hurricane evacuation restudies. The behavioral analysis focused on the actual percent of the affected population that evacuated during Georges, when the evacuees left their residence, what sort of

evacuation refuge was used, where the refuge was located, and the number of vehicles used by evacuating households.

This report documents the findings of the study team and is organized by general category of hurricane evacuation study product. Those general categories that are addressed include:

Hazards/Vulnerability Data

Behavioral Characteristics of Evacuees

Shelter Issues

Transportation/Clearance Time Data

Evacuation Decision-Making

Public Information

Each of the following chapters describes typical study components and products produced in comprehensive hurricane evacuation studies. The chapter then summarizes actual data related to Georges, and where relevant, compares it with study produced data for a relevant storm scenario. Recommendations are then given for future study efforts concerning that study topic.

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Chapter 2

Hazards/Vulnerability Data

In FEMA/Corps comprehensive hurricane evacuation studies, the primary objective of the hazards analysis is to determine the probable worst-case storm surge effects for the various intensities of hurricanes that could strike an area. Specifically, a hazards analysis quantifies the expected hurricane-caused inundation that would require emergency evacuation of the population. Historically, the hazards analysis also has assumed that mobile homes outside the surge inundation area must be evacuated due to their vulnerability to winds. The National Weather Services' SLOSH (Sea, Lake, and Overland Surge from Hurricanes) numerical storm surge prediction model was used as the basis of the hazards analysis for studies that have been completed or studies that are ongoing in Florida, Alabama, Louisiana, Mississippi, Puerto Rico, and the U.S. Virgin Islands.

The vulnerability analysis uses the hazards analysis to identify the population potentially at risk to coastal flooding caused by the hurricane storm surge. Storm tide atlases are produced showing the inland extent of surge inundation for various hurricane intensities.

Hazards and vulnerability issues related to Georges that were discussed with local and state officials included the following:

What technical data/mapping were used to choose the areas to evacuate?

Did the technical data provide a good depiction of the hazards area?

The National Hurricane Center was able to compare SLOSH model predictions with actual high water marks for the Florida Keys and the Gulf Coast. High water mark data collected by the Mobile District of the U.S. Army Corps of Engineers for the Gulf Coast, and collected by the Jacksonville District for

the Keys were transmitted to the National Hurricane Center for comparison with the SLOSH model. Figures 2-1, 2-2, 2-3 and 2-4 show these interesting comparisons. The radius of maximum winds is indicated on Figure 2-4 for the Gulf Coast landfall but not for the Florida Keys graphics. This is because Georges took a left-hand (westerly) turn as it made landfall at Key West which swept the radius of maximum winds across Marathon and the lower Keys. In addition, the storm had a broad area of maximum winds extending out some 60-70 miles from the center. A more typical storm would have maximum winds extending only 40 miles from the center.

[Figure 2-1](#) High water marks along the Florida Keys

[Figure 2-2](#) Storm Tide plus wave effects along the Keys

[Figure 2-3](#) SLOSH storm tide & Observed storm tide along the Keys

[Figure 2-4](#) High water marks along the Gulf Coast

The results of the SLOSH comparison are similar to previous hurricane storm surge comparisons and generally show that the SLOSH model calculates the storm surge within plus or minus 20 percent of the observed values. At first glance, differences in the Key's values appeared higher than 20 percent different, however when wave run up, wave set up and wind driven wave run up are factored out, the comparison is quite favorable. In the Gulf Coast area the comparison is also favorable except in the Gulf Shores, Alabama area where the water is quite deep immediately off shore (30 feet plus), causing a significant breaking wave effect during Georges. When this is factored out, the SLOSH comparison is within acceptable and anticipated margins of difference.

In addition to the SLOSH model comparison, the National Hurricane Center provided their preliminary forecast and warning critique for Hurricane Georges. Appendix B includes the "Best Track" positions for Hurricane Georges, including positions, barometric pressure, wind speed, and storm classification by date. The appendix also includes a table reporting selected surface observations at various localities throughout the impacted areas and a tropical cyclone watch and warning summary for Georges. An important rainfall graphic for Puerto Rico is also included.

Excerpts from the NHC report regarding forecast error are provided as follows:

Overall, the track forecasts for Georges were generally good. The low average errors of CLIPER show that the hurricane followed a climatologically-favored path. The average official forecast errors are well below the most recent 10-year average. These values represent a 47% to 60% improvement over the 10-year official averages: 60% at 12 hours, 56% at 24 hours, 56% at 36 hours, 53% at 48 hours, and 47% at 72 hours. It should be noted that the slow motion of Georges over the north central Gulf of Mexico contributed to the low errors.

Examination of the intensity forecast history of Georges shows several interesting trends. The first five official forecasts after the system attained tropical storm strength under-forecast the intensity an average of 18 knots between 12 to 48 hours and 44 knots at 72 hours. While SHIPS' intensity errors were comparable to the official forecast, the GFDL fared worse with 29 knots between 12 and 48 hours and 55 knots at 72 hours. These forecasts represent the period when Georges went through its rapid intensification phase.

The intensity forecasts from 1800 UTC 19 September to 0600 UTC on 20th show a significant positive bias. This is when Georges went through a marked weakening trend. During this period, both the official NHC forecast and SHIPS over-forecast the intensity an average of about 21 knots between 12 and 48 hours; at 72 hours the errors were 43 knots and 36 knots, respectively. The GFDL showed lower errors for this period with a mostly negative bias. Several of the 12 hour forecasts under-forecast the intensity by 50 knots. These data highlight our limited skill level in forecasting rapid, abrupt changes in intensity.

Recommendations:

- 1 Complete new SLOSH modeling and associated mapping for the Florida Keys, Alabama, Mississippi, and Louisiana.

- 2 Produce a comprehensive atlas showing storm surge areas and 100 year floodplain for the entire island of Puerto Rico.

- 3 Address the unique rainfall vulnerability and mudslide potential for hurricane events in the Caribbean through activities of the FEMA/Corps/NWS Island Task Force.

- 4 Educate the emergency management community about the three fold effect of wave run up, wave set up and wind driven wave run up on SLOSH predicted values and measuring high water marks.

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Chapter 3

Behavioral Analysis - Public Response in Georges

The narrative below is provided by Hazards Management Group (HMG) for the post Georges evacuation assessment and focuses on describing the evacuation behavior of permanent residents in Northwest and South Florida, Alabama, Mississippi, and Louisiana during the Georges event.

Method/Sample

Telephone interviews were conducted with approximately 800 residents ranging from Louisiana through the Florida Keys. The sample locations and sample sizes are given below.

Sample Sizes, by state

| Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-----------|-------------|---------|------------|------------|
| 206 | 193 | 99 | 106 | 208 |

In Louisiana, interviews were conducted in Orleans and Jefferson Parishes. Residents were advised to evacuate from both parishes by local officials. In Mississippi, the interviews were distributed among Hancock, Harrison, and Jackson Counties, with half coming from Harrison. Households were selected from locations advised to evacuate by local officials. In Alabama, the respondents were equally divided among Mobile and Baldwin Counties, and in Northwest Florida they came from Escambia through Bay Counties. In both Alabama and Northwest Florida, most of the interviews were conducted in Category 1 storm surge areas, with the remainder selected from Category 2 and 3 surge zones. All were either advised or ordered to evacuate in Georges. In the Florida Keys, all interviews were conducted in the “Lower Keys” south of Big Pine Key. This area was smaller than the “Lower Keys” as defined in the Monroe County Evacuation Plan, which extends northward to Seven-Mile Bridge. Half the interviews were conducted in Key West. It is important to recognize that there can be different response patterns within these survey locations, from county to county.

Statistical Reliability

Figures reported in surveys cited in this report are based upon samples taken from larger populations. The sample values provide estimates of the values of the larger populations from which they were selected, but are usually not precisely the same as the true population values. In general, the larger the number of people in the sample, the closer the sample value will be to the true population value. A sample of 200 will provide estimates which one can be 90% “confident” are within 4 to 6 percentage points of the true population values. With a sample of 100, one can be 90% “confident of being within 5 to 8 percentage points of the actual population value. A sample of 50 is “accurate” only within 7 to 11 percentage points, and a sample of 25 is 90% “accurate” only within 10 to 17 percentage points. The sample size was too small in most cases to report separate findings for each risk zone by county, for example.

This is particularly noteworthy in drawing conclusions about whether two survey results are “different” from one another. Differences of a few percentage points in sample results of 100 or less do not necessarily mean the populations from which the samples were drawn are different. When the aggregate samples are broken down into subgroups, the reliability of estimates for the subgroups suffers.

Evacuation Participation

In all the survey locations, except Northwest Florida, more than half those interviewed said they left their homes to go someplace safer. However, the participation rates were only slightly more than 50%, ranging from 54% in Louisiana to 67% in Alabama. In Northwest Florida, only 22% evacuated their homes. These are not substantial participation rates, considering that all the interviewees lived in locations from which evacuation was at least recommended by authorities. The Louisiana figure is not significantly different in a statistical sense from the 48% found by Howell (1998). The Keys figure is higher than the 54% found in a survey by the Monroe County School Board (Lannon, 1998), among other things, the difference could stem from the school board questionnaire asking whether the household evacuated, rather than asking whether residents left their home to go someplace safer. To some people evacuation implies leaving the local area. The results are shown below.

Percent evacuating in Georges, by state

| Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-----------|-------------|---------|------------|------------|
| 54% | 60% | 67% | 22% | 62% |

Those who did not evacuate were asked whether they would have eventually left if they had been convinced that Georges was going to strike their location more directly. Roughly half said they would have left in that case. More than half (59% in Louisiana to 75% in Northwest Florida) said they had made the necessary preparations to leave in case the situation worsened. The results are shown below.

Percent of stayers in Georges saying they would have left if storm had hit directly

| Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-----------|-------------|---------|------------|------------|
| 55 | 48 | 39 | 59 | 48 |

Percent of stayers in Georges saying they were prepared to leave

| Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-----------|-------------|---------|------------|------------|
| 59 | 61 | 61 | 75 | 65 |

When asked what convinced them to go someplace safer, the two most common groups of responses centered on the severity of the storm and advice or notices from others. Using the breakdowns in table below, concern about the severity of the storm was the most frequently mentioned factor in each location, with a high of 52% giving that response in Alabama. The percentage would be even higher if other response categories dealing with concern about flooding and wind were included. Advice or appeals from others were mentioned often in every survey location, but in some places (Northwest Florida, Mississippi, and the Keys) notices from officials were most prominent. In other places (Alabama and Louisiana) appeals from friends and relatives were cited more often. Finally, some people focused on being convinced that the storm would hit their location. A variety of other reasons were also given, reflected collectively under "other."

Reasons given for evacuating in Georges

| | LA | MS | AL | NW FL | Keys |
|-------------------------|----|----|----|-------|------|
| Officials said evacuate | 3 | 20 | 15 | 35 | 22 |
| NWS said evacuate | 10 | 1 | 14 | 30 | 19 |

| | | | | | |
|------------------------------------|----|----|----|----|----|
| Police/Fire said evacuate | 4 | 7 | 11 | 4 | 5 |
| Media said evacuate | 11 | 5 | 6 | 17 | 8 |
| Friend/Relative said evacuate | 14 | 12 | 23 | 9 | 19 |
| Concern about severity of storm | 33 | 35 | 52 | 44 | 44 |
| Concern about increase in severity | 12 | 8 | 11 | 9 | 9 |
| Concern about flooding | 23 | 18 | 14 | 22 | 6 |
| Concern about wind | 6 | 17 | 14 | 4 | 20 |
| Concern about road flooding | 4 | 10 | 8 | 0 | 4 |
| Concern storm would strike | 12 | 8 | 6 | 4 | 12 |
| High strike probabilities | 1 | 3 | 2 | 4 | 3 |
| Other | 24 | 16 | 8 | 22 | 25 |

As shown in the following table, most of those who did not evacuate said they did not think the storm was strong enough to pose a threat to their safety, given their home's construction and location. Those giving that sort of response ranged from 56% in the Florida Keys to 76% in Mississippi. No other response category was cited nearly so often. Most notably, fewer than 10% in every location mentioned a lack of transportation or a place to go as reasons for not evacuating, and the figure was below 5% every place except Louisiana, where it was 7% . No one in Alabama or Northwest Florida gave those reasons. Concerns about being able to prevent looting and damage from the storm were over 10% only in Alabama and the Keys. Traffic, in one form or another (traffic bad, tried and gave up, waited too long, too dangerous), was a fairly frequently mentioned factor except in Mississippi. Fewer than 10% mentioned jobs or lack of facilities for pets in public shelters.

Reasons given for not evacuating in Georges

| | LA | MS | AL | NW FL | Keys |
|-----------------------------------|----|----|----|-------|------|
| Storm not severe/house safe | 50 | 76 | 67 | 68 | 56 |
| Officials said stay | 2 | 0 | 0 | 5 | 3 |
| Media said stay | 2 | 1 | 0 | 2 | 1 |
| Friends/relatives said stay | 5 | 12 | 6 | 0 | 3 |
| Officials did not say to evacuate | 0 | 1 | 6 | 2 | 4 |
| Low probability of hit | 9 | 5 | 9 | 11 | 13 |
| Would miss | 1 | 3 | 3 | 4 | 4 |
| No transportation | 7 | 3 | 0 | 0 | 4 |
| No place to go | 7 | 4 | 0 | 0 | 3 |
| Protect against looters | 1 | 3 | 12 | 1 | 8 |
| Prevent damage | 7 | 3 | 12 | 1 | 9 |
| False alarms | 1 | 4 | 6 | 6 | 10 |
| Job | 4 | 5 | 0 | 3 | 10 |
| Waited too long | 7 | 1 | 0 | 1 | 9 |
| Traffic bad | 11 | 1 | 9 | 12 | 17 |
| Tried, gave up | 0 | 0 | 0 | 3 | 8 |
| Too Dangerous | 4 | 4 | 0 | 4 | 8 |
| No pets allowed in shelters | 0 | 7 | 6 | 0 | 6 |
| Other | 28 | 20 | 9 | 5 | 9 |

Everyone in the survey was asked whether they heard, either directly or indirectly, from anyone in an official position that they should evacuate. Those who answered affirmatively were asked whether officials recommended that they evacuate or whether they said evacuation was mandatory. The results appear in the table below. Few people said they heard mandatory evacuation orders, the highest being 37% in the Florida Keys. In Northwest Florida only 6% gave that response. Slight majorities said they heard some sort of official notice in Louisiana and the Florida Keys. In the other three survey locations, most people (77% in Alabama) said they heard no evacuation notice from officials.

Type of evacuation notice heard in Georges, by state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-----------------|-----------|-------------|---------|------------|------------|
| Mandatory Order | 12 | 21 | 29 | 6 | 37 |
| Recommendation | 42 | 20 | 19 | 17 | 24 |
| None | 46 | 60 | 52 | 77 | 39 |

Hearing notices from officials made a major difference in response in Georges in every survey location except the Keys. As shown in the table below, Louisiana, Mississippi, Alabama, and Northwest Florida, 79% (Louisiana) to 88% (Mississippi) residents left if they thought they heard mandatory evacuation orders, which were much higher rates than those for people who said they did not hear official notices at all. In Mississippi and Alabama, recommendations were more effective than in other locations. In Florida's Lower Keys, however, the response was essentially the same, regardless whether respondents heard orders, recommendations, or neither.

Percent evacuating in Georges, by type of official evacuation notice heard, by state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|--------------------------|-----------|-------------|---------|------------|------------|
| If Heard Mandatory Order | 79 | 88 | 86 | 83 | 61 |
| If Heard Recommendation | 49 | 70 | 71 | 44 | 61 |
| If Hear None | 49 | 47 | 56 | 9 | 67 |

Respondents were told that at one point Georges's winds were nearly 125 MPH. They were then asked whether Georges would have caused dangerous flooding of their home if Georges had struck near their location with winds that strong. The sample was designed to include households located in areas which would be inundated by at least some hurricanes of that strength, depending upon other characteristics of the storm such as its forward speed and angle of approach to the coast. Only in Louisiana did a clear majority (65%) say a 125 MPH Georges would have caused dangerous flooding of their home. In Mississippi and the Keys approximately half expected dangerous flooding, but in Alabama and Northwest Florida less than 40% gave that response. The table below describes the results.

Belief that home would experience dangerous flooding in 125 MPH hurricane, by state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-----------------|-----------|-------------|---------|------------|------------|
| Would Flood | 65 | 50 | 33 | 39 | 53 |
| Would Not Flood | 27 | 40 | 61 | 44 | 42 |
| Don't Know | 8 | 10 | 7 | 17 | 4 |

People who believed their homes would be vulnerable to flooding in 125 MPH hurricane were more likely than others to evacuate in Georges. The table below shows that in every location, except Northwest Florida, a clear majority evacuated in Georges if they thought their homes were susceptible to dangerous flooding.

Percent evacuating in Georges, by belief home would flood in 125 MPH hurricane, by risk state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-------------------------|-----------|-------------|---------|------------|------------|
| Said would Flood | 63 | 74 | 75 | 27 | 69 |
| If said would not Flood | 38 | 44 | 60 | 16 | 53 |

Respondents were also asked whether they thought their homes would be safe, considering both wind and water, in a 125 MPH hurricane. Only in Alabama did as many as half (53%) say their homes would be safe. However, the highest percentage saying their homes would definitely not be safe was 65% (in Louisiana and Northwest Florida). In Alabama, only 41% said their homes would be unsafe in a 125 MPH hurricane. The results are shown below.

Belief that home would be safe in 125 MPH hurricane, by state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-------------------|-----------|-------------|---------|------------|------------|
| Would Be Safe | 26 | 43 | 53 | 26 | 37 |
| Would Not Be Safe | 65 | 52 | 41 | 65 | 57 |
| Don't Know | 10 | 5 | 6 | 9 | 7 |

Those believing their homes would be unsafe in a 125 MPH hurricane were much more likely to evacuate in Georges than those who said their homes would be safe. The table below shows that of those believing their homes would be unsafe, at least two-thirds evacuated in Georges in every location except Northwest Florida. In the Keys (76%), Mississippi (79%), and Alabama (80%) even

more left. Only in Northwest Florida did a majority not evacuate. But even in Northwest Florida those believing their homes would be unsafe in a 125 MPH hurricane were more than twice as likely as other to evacuate in Georges.

Percent evacuating in Georges, by belief home would be safe in 125 MPH hurricane, by state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|--|-----------|-------------|---------|------------|------------|
| | | | | | |

| | | | | | |
|---------------------------|----|----|----|----|----|
| If Said Would Be Safe | 35 | 39 | 57 | 13 | 40 |
| If Said Would Not Be Safe | 66 | 79 | 80 | 33 | 76 |

Those who did not evacuate in Georges were asked whether they had any concerns about trying to evacuate and having the storm arrive while they were caught on the road because of heavy traffic. This has often been mentioned as a concern in the Keys and the New Orleans area, and in Opal traffic congestion was a major problem in Alabama and Northwest Florida. Roughly half the stayers expressed concern about being caught trying to evacuate in every survey location except Mississippi, where only 24% expressed that worry. The results are shown below.

Percent of stayers in Georges saying they were concerned about being trapped on road in heavy traffic

| Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-----------|-------------|---------|------------|------------|
| 53 | 24 | 42 | 57 | 47 |

Those who indicated they were concerned about the possibility of being caught on the road in heavy evacuation traffic were given another scenario. They were asked whether they would be more likely to evacuate if emergency management officials were able to monitor traffic on the roads so that they could reassure residents that if they left at a certain time they would still have enough time to reach their destination before the storm arrived. In every survey location except Alabama (44%), a strong majority (78% in Northwest Florida) said they would be more likely to evacuate in that case. It is notable that Monroe County already has such a monitoring and notification scheme in place. The results are shown below.

Percent concerned (Table 13) saying they would be more likely to leave if officials could ensure safe passage

| Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-----------|-------------|---------|------------|------------|
| 73 | 60 | 44 | 78 | 65 |

The tables below show that between 13% (Alabama) and 27% (Keys) said someone in their household had to work

while the Georges evacuation was in effect. Most said the circumstance had no effect on their decision whether to evacuate in George, however, there was considerable variation among survey sites. In the Keys, 25% of those in households in which someone had to work during the evacuation said they delayed their departure, and 13% said they did not evacuate at all because of that.

Percent of households with someone required to work in during Georges, by state

| Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-----------|-------------|---------|------------|------------|
| 21 | 20 | 13 | 18 | 27 |

How work affected evacuation in Georges, by state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|------------------|-----------|-------------|---------|------------|------------|
| No Effect | 67 | 69 | 77 | 79 | 54 |
| Made All Stay | 7 | 5 | 0 | 0 | 13 |
| Made Some Stay | 2 | 0 | 0 | 5 | 0 |
| Delayed Some/All | 14 | 21 | 8 | 11 | 25 |
| Other | 5 | 0 | 8 | 5 | 7 |
| Don't Know | 5 | 5 | 8 | 0 | 2 |

Some emergency management officials have expressed concerns that when businesses stay open in areas under evacuation notices, residents are deterred from leaving. In Georges, between 22% (Mississippi) and 40% (Louisiana) said businesses remained open in their neighborhoods during the Georges evacuation. In Louisiana, Alabama, and the Keys, most respondents said the businesses were located in areas being evacuated. The results are shown in the following two tables.

Percent saying businesses stayed open in neighborhood in Georges, by state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|------------|-----------|-------------|---------|------------|------------|
| Yes | 40 | 22 | 28 | 26 | 37 |
| No | 43 | 53 | 39 | 44 | 46 |
| Don't Know | 17 | 24 | 32 | 29 | 17 |

Percent saying open businesses were in evacuation zone in Georges, by state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|------------|-----------|-------------|---------|------------|------------|
| Yes | 59 | 30 | 61 | 36 | 83 |
| No | 28 | 47 | 29 | 57 | 12 |
| Don't Know | 13 | 23 | 11 | 7 | 5 |

As shown in the table below, very few said the open businesses affected their response in Georges. Only in Louisiana did as many as 13% say they stayed because the businesses were open. In other locations, fewer than 10% gave that response.

Percent saying open businesses affected response in Georges, by state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|------------|-----------|-------------|---------|------------|------------|
| Stayed | 13 | 0 | 4 | 7 | 4 |
| No Effect | 81 | 95 | 89 | 93 | 93 |
| Other | 4 | 2 | 0 | 0 | 0 |
| Don't Know | 2 | 3 | 7 | 0 | 3 |

Finally, all respondents were asked whether they would do anything differently, given the same situation in the future. In the Keys, 43% of those who did not evacuate in Georges said they would do so if faced with the same situation again. Twenty-three percent gave that response in Mississippi, but in Louisiana and Northwest Florida fewer said they would leave in the future. The Lower Keys and Mississippi were hit by Georges. The results are shown below.

Percent saying they would respond differently in future

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|------------------|-----------|-------------|---------|------------|------------|
| Stayers Who Say | | | | | |
| They Would Leave | 14 | 23 | 12 | 5 | 43 |
| Leavers Who Say | | | | | |
| They Would Stay | 10 | 6 | 8 | 9 | 5 |

Sources of Information in Georges People in the survey were given a list of sources of information and asked how much they relied on each for information about Georges. For each source they were asked whether they relied on that source none at all, a little, a fair amount, or a great deal. The table below indicates the percentage of respondents who said they relied a great deal on the various sources. Local television was indicated by a clear majority every place except in the Florida Keys, where 49% said local TV. In Louisiana and Northwest Florida, 80% and 82% respectively, said local TV. In most locations, The Weather Channel on cable and local radio were in virtual dead heats for second place. In the Keys, local radio was relied upon more than other sources. CNN on cable was a distant fourth, and other sources such as other cable stations, and the Internet got relatively little attention. Word of mouth

was relied upon a great deal by up to 19% (in the Keys), but word of mouth was also said to be the most unreliable source of information.

Percent of respondents saying they relied a fair amount or a great deal on sources of information about Georges, by state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-------------|-----------|-------------|---------|------------|------------|
| Local Radio | 35 | 47 | 49 | 38 | 57 |
| Local TV | 80 | 71 | 66 | 82 | 49 |
| CNN | 20 | 15 | 17 | 18 | 18 |

| | | | | | |
|------------------|----|----|----|----|----|
| Weather Channel | 38 | 45 | 46 | 56 | 50 |
| Other Cable | 5 | 3 | 5 | 5 | 6 |
| Internet | 3 | 8 | 6 | 1 | 9 |
| On-line Services | 2 | 4 | 4 | 1 | 4 |
| Word of Mouth | 15 | 11 | 7 | 4 | 19 |

Evacuation Timing

For the Florida Keys, a hurricane watch was issued for Georges at 5 AM on Wednesday, September 23, followed by a warning at 5 AM on Thursday the 24th. For the middle Gulf Coast, a watch was issued at 11 AM on Friday, September 25, followed by a warning at 10 AM on Saturday the 26th. Beyond the Keys, early forecasts pointed toward Northwest Florida. Later forecasts shifted Georges farther west, eventually to New Orleans, and then back east again to Mississippi. The times when evacuees left were generally consistent with those events. More evacuees than usual indicated that they left prior to the time warnings were issued. Timing of evacuation notices may have been earlier in some locations. Note too, that a substantial percentage of the population did not evacuate at all. If they had eventually decided to leave, they would have been late evacuees, reducing the percentage of total evacuees who left early. The results are shown below.

Date evacuated in Georges, by state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-----------|-----------|-------------|---------|------------|------------|
| Tuesday | 0 | 0 | 0 | 0 | 17 |
| Wednesday | 4 | 4 | 5 | 19 | 44 |
| Thursday | 8 | 4 | 8 | 6 | 30 |
| Friday | 24 | 18 | 22 | 38 | 6 |
| Saturday | 51 | 49 | 47 | 38 | 1 |
| Sunday | 12 | 26 | 17 | 12 | 0 |

Type of Refuge

As described in the table below, very few residents who evacuated (as a percentage of all evacuees) went to public shelters. The highest stated usage rate was 5% in Louisiana. A plurality in every survey location, and a majority in all but Louisiana went to the homes of friends and relatives. Between 16% (Mississippi) and 35% (Northwest Florida) went to hotels and motels. Others went to churches, workplaces, second homes, and a sundry of other places. Such low public shelter use is lower than usual but generally consistent with a trend observed in hurricane evacuations within the past decade. Low reliance upon public shelters is especially common when a substantial percentage of evacuees leave their local area and go significant distances inland.

Type of refuge in Georges, by state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-----------------|-----------|-------------|---------|------------|------------|
| Public Shelter | 5 | 3 | 2 | 0 | 1 |
| Friend/Relative | 45 | 68 | 65 | 65 | 57 |
| Hotel/Motel | 30 | 16 | 24 | 35 | 29 |
| Other | 20 | 13 | 9 | 0 | 13 |

Evacuation Destinations

Few evacuees sought refuge in their own neighborhoods. In most locations only 12% to 18% did so, and in Northwest Florida only 4% did so. In Louisiana, 23% said they went someplace in their own neighborhood. However, a substantial number of respondents in Louisiana indicated they did not know whether their refuge was in their neighborhood or not, and in subsequent questions regarding whether the place they went was in their own parish or state, others said they did not know. The “don’t know” responses were excluded from calculations. If the “don’t know’s” were included, 18% in Louisiana said they left their home but stayed in their neighborhood. The results are shown below.

Evacuation destinations in Georges, by state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|------------------|-----------|-------------|---------|------------|------------|
| Own Neighborhood | 23 | 18 | 12 | 4 | 13 |

| | | | | | |
|--------------------|----|----|----|----|----|
| Own County/Parish | 16 | 27 | 31 | 38 | 12 |
| Louisiana | 24 | 8 | 2 | 0 | 0 |
| Mississippi | 9 | 36 | 2 | 0 | 0 |
| Alabama | 1 | 5 | 49 | 4 | 0 |
| Florida | 1 | 1 | 2 | 38 | 73 |
| Georgia | 4 | 1 | 2 | 4 | 1 |
| Texas | 13 | 2 | 0 | 0 | 0 |
| Arkansas/Tennessee | 6 | 2 | 2 | 4 | 0 |
| Other | 3 | 0 | 0 | 8 | 2 |

There was more variation among the sites with respect to whether evacuees who went out of their neighborhood stayed within their own county or parish. In Northwest Florida and Alabama, approximately a third of all evacuees said they stayed in-county (or in-parish). In Louisiana and the Florida Keys, however, fewer than 15% gave that response. The low figures for Louisiana and the Keys could result from the lack of availability of shelters within the south Louisiana parishes and Monroe County. Nevertheless, in both Louisiana and the Florida Keys, numerous “evacuees” stayed in county, either in their own neighborhoods or elsewhere in their parish or county. In Louisiana, 37% of the evacuees said they went out-of-state, with most of those going to Mississippi and Texas. Although the survey did not address reasons for going to the destinations they identified, other information suggests that many did so because of a shortage of accommodations closer by. Howell (1998) reported that more than half the evacuees from Orleans and Jefferson Parishes went out-of-state.

Transportation

It was indicated earlier that few respondents overall indicated they did not evacuate because of a lack of transportation (although that constraint almost certainly affected the destination to which some people evacuated). The table below shows that when evacuating households were asked whether they or anyone else in their household required assistance evacuating, the percent replying affirmatively ranged from zero in Northwest Florida (based on a small number of

evacuees in the sample) to 6% in Louisiana. About half those requiring assistance need just transportation, with the remainder also needing special care due to a medical or physical condition. In almost all instances, the assistance was provided either from within the household itself or by friends or relatives. Non-evacuating households were asked whether anyone would require assistance in evacuating, and the results were comparable to those from evacuating households except in Northwest Florida. Four percent of the non-evacuating households there said someone in the residence would require assistance.

Percent of evacuating households in Georges with someone requiring assistance, by state

| Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|-----------|-------------|---------|------------|------------|
| 6 | 3 | 3 | 0 | 5 |

Not all vehicles available to households are used in evacuations, as reflected in the table below. In Georges, the percentage of vehicles actually used in evacuating ranged from 68% in Alabama to 79% in Louisiana. The figures are consistent with those observed in other evacuations. The number of vehicles used per evacuating household varied from a low of 1.21 in the Florida Keys to 1.54 in Mississippi. Finally, evacuees were asked if they pull a trailer, camper, boat, or took a motorhome. In most locations, fewer than 10% of the evacuating households said they did so, with a slightly higher figure in Alabama.

Vehicle use in Georges, by state

| | Louisiana | Mississippi | Alabama | NW Florida | Lower Keys |
|--|-----------|-------------|---------|------------|------------|
| % of Available Vehicles Used | 79 | 77 | 68 | 77 | 71 |
| Vehicles per Household | 1.28 | 1.54 | 1.31 | 1.25 | 1.21 |
| % Who Pulled Trailer or Took Motorhome | 5 | 6 | 14 | 8 | 7 |

References

Howell, S. E. (1998) "Evacuation Behavior in Orleans and Jefferson Parishes," University of New Orleans Survey Research Center, New Orleans, Louisiana.

Lannon, M. J. (1998) November 29, 1998 Correspondence to Billy Wagner, from Monroe County School Board, Key West, Florida.

Note:

In addition to the two Georges surveys cited above, at least two others were performed. One was conducted by Hazards Management Group, Inc. for the Tampa Bay Regional Planning Council. The other was done in Dade and Monroe counties by Florida International University.

Hurricane Georges Post Storm Assessment

Chapter 4

Shelter Issues

The primary objectives of shelter analyses prepared for FEMA/Corps of Engineers comprehensive hurricane evacuation studies are to list public shelter locations, assess their vulnerability relative to storm surge flooding, and to estimate the number of people who would seek local public shelter for a particular hurricane intensity or threat. Shelter location/capacity data are obtained from state and local emergency management staff working in conjunction with the American Red Cross, school board or other local agencies. Comparisons are then made with SLOSH data to assess flooding potential. Public shelter capacity is usually compared to public shelter demand figures generated in the transportation analysis to determine potential deficits or surpluses in sheltering. The behavioral analysis is important to this process as assumptions for the transportation analysis (regarding the percent of evacuees going to public shelter) come from the behavioral analysis or behavioral parameters recommended by the local directors.

Shelter issues related to Georges were discussed with local and state officials. Discussions focused on the following topics:

- When were shelters opened and when did evacuees arrive/stop arriving?
- How many shelters were opened and how many people were sheltered?
- Were any flooding, wind, or loss of power problems encountered with shelters during the storm?

Table 4-1 summarizes the responses to each of these topics gathered for the areas interviewed in Florida, Alabama, Louisiana, Mississippi, Puerto Rico and the U.S. Virgin Island.

Northwest Florida Counties experienced low numbers of public shelter evacuees except Escambia County where a large number of military trainees were housed. The military provided tremendous help in staffing the local shelters. Low public shelter demand resulted from very low evacuation participation rates even in the Category 1 evacuation areas. Okaloosa County is concerned about staffing in the special needs shelters. Walton County identified the need

for emergency generators at the shelters.

Table 4-1

Public Shelter Data Summary

Hurricane Georges Evacuation Assessment

| Location | Number of Shelters Opened | Number of People Sheltered | Technical Data Report Shelters/Expected Shelter Demand | Time Opened/Duration | Problems Encountered |
|--------------------------|----------------------------------|---|---|-----------------------------|---|
| Northwest Florida | | | | | |
| Escambia County | 23 | 5200 of which 200 were from Santa Rosa County, 3250 from military, 61 special needs | Applicable due to low evacuation participation levels | 9/25/98 6 PM | No problems; military students staffed shelters and did excellent job |
| Santa Rosa County | 5 | 1,000 | Applicable due to low evacuation participation levels | 9/25/98 5 PM | None reported |
| Okaloosa County | 2 | 325 | Applicable due to low evacuation participation levels | 9/25/98 6 PM | Staffing for special needs |

| | | | | | |
|---------------|----------------------------------|------|---|----------------|---------------------------------------|
| Walton County | 2 (1 of which was special needs) | Few | Applicable due to low evacuation participation levels | 9/26/98 | Need emergency generators at shelters |
| Bay County | 2 shelters on standby | None | Applicable due to low evacuation participation levels | Not applicable | None reported |

Table 4-1 (Continued)

Public Shelter Data Summary

Hurricane Georges Evacuation Assessment

| Location | Number of Shelters Opened | Number of People Sheltered | Technical Data Report Shelters/Expected Shelter Demand | Time Opened/Duration | Problems Encountered |
|----------------------|---------------------------|--------------------------------------|--|--|----------------------|
| South Florida | | | | | |
| Lee County | 11 | 3650 of which 150 were special needs | (No Corps/FEMA study) | 9/23/98 Shelter open for special needs 9/24/98 1 PM other shelters opened | None reported |

| | | | | | |
|----------------|--|--|--|-------------------------------|---|
| Collier County | 12 | 3415 of which 281 were special needs and 250 homeless evacuees | (No Corps/FEMA study) | 9/24/98 2 PM 2 Days | Dilemma with ARC 4496 rule |
| Broward County | 12 | 4450 of which 450 were special needs | No scenarios run with this level of evacuation | 9/23/98 Noon One day | One shelter lost power |
| Dade County | 16 plus 15 Medical Management Facilities plus FIU for Monroe Co. | 10,701 of which 1050 were special needs | No scenarios run with this level of evacuation | 9/23/98 Variable durations | Shelter staffing at special needs shelters |
| Monroe County | FIU in Dade County | 150 | No scenarios run with this level of evacuation | 9/23/98 8 AM | Difficulty in getting FIU's activated fully for Monroe Co. due to normal business |

Table 4-1 (Continued)

Public Shelter Data Summary

Hurricane Georges Evacuation Assessment

| Location | Number of Shelters Opened | Number of People Sheltered | Technical Data Report Shelters/Expected Shelter Demand | Time Opened/Duration | Problems Encountered |
|----------------|---------------------------|----------------------------|--|----------------------|----------------------|
| Alabama | | | | | |

| | | | | | |
|-------------------|---------------|----------------|---|--|---|
| Washington County | None | Not applicable | N/A Study 17 years old | Not reported | None reported |
| Mobile County | 9 | 4,189 | N/A Study 17 years old | Opened upon voluntary evacuation order; 4 days | Minimal power loss |
| Baldwin County | 8 | 788 | N/A Study 17 years old | 8/26/98 8 AM | None reported |
| Louisiana | | | | | |
| Lafourche | 6 | 1,200 | 3,600 people | 9/26/98 9:00 AM | Shelters have no food or beds |
| Terrebonne | 5 | 1,800 | No study | Already open due to prior storms | None reported |
| Orleans | 6 | 20,900 | Local public shelters not recognized for this category of storm | 9/26/98 9:00 AM | News media needs briefing; need inland shelters |
| St. James | Not available | Not available | 850 people | 9/26/98 8:00 AM | Red Cross policy should be re-evaluated |
| St. Charles | Not available | Not available | 3,400 people | Not reported | No shelters in Parish for a category 3 storm |
| Jefferson | 9 | Not available | 5,000 people | 9/26/98 5:00 PM | None reported |

Table 4-1 (Continued)

Public Shelter Data Summary

Hurricane Georges Evacuation Assessment

| Location | Number of Shelters Opened | Number of People Sheltered | Technical Data Report Shelters/Expected Shelter Demand | Time Opened/Duration | Problems Encountered |
|--------------------|---------------------------|----------------------------|--|----------------------|--|
| Mississippi | | | | | |
| Harrison County | 27 | 3,800 | N/A Study 17 years old | 9/26/98 4:00 PM | Need emergency power; need more shelters |
| Hancock County | 5 | 1,000 | N/A Study 17 years old | 9/26/98 4:00 PM | Need emergency power; communication difficulties; security problems; language barriers with foreigners |
| Forrest County | 10 + Camp Shelby | Not calculated | N/A Study 17 years old | Not reported | People sheltered were eventually moved to Camp Shelby |
| Jackson County | 8 | 2,000 | N/A Study 17 years old | 9/26/98 | Roof damage at 2 schools; shelters are announced but not published |

Table 4-1 (Continued)

Public Shelter Data Summary

Hurricane Georges Evacuation Assessment

| Location | Number of Shelters Opened | Number of People Sheltered | Technical Data Report Shelters/Expected Shelter Demand | Time Opened/Duration | Problems Encountered |
|---------------------------------|---------------------------|----------------------------|--|----------------------|------------------------------|
| Puerto Rico - Ponce Zone | | | | | |
| Ponce | Not available | Not available | Study not available | 9/20/98 6:00 PM | Loss of power |
| Juana Díaz | 8 | 2,000 | Study not available | 9/21/98 8:00 AM | Loss of power; lack of water |
| Guayanilla | 4 | 1,100 | Study not available | 9/20/98 10:00 AM | Flooding; loss of power |
| Guánica/Yauco | 11 | 591 | Study not available | 9/20/98 6:00 AM | Lack of water; loss of power |

Table 4-1 (Continued)**Public Shelter Data Summary****Hurricane Georges Evacuation Assessment**

| Location | Number of Shelter Opened | Number of People Sheltered | Technical data Report Shelters/Expected Shelter Demand | Time Opened/Duration | Problems Encountered |
|-----------------|---------------------------------|-----------------------------------|---|-----------------------------|-----------------------------|
|-----------------|---------------------------------|-----------------------------------|---|-----------------------------|-----------------------------|

| Puerto Rico - Arecibo Zone | | | | | |
|---|---|-----------|---------------------|-----------------|---|
| Vega Baja | 5 | 300 - 400 | Study not available | 9/21/98 9:00 AM | Lack of water; loss of power |
| Hatillo | 5 | 113 | Study not available | Not recorded | |
| Manatí | 9 | 240 | Study not available | 9/21/98 1:00 PM | Broken windows due to wind; lack of water, flooding |
| Puerto Rico - Carolinás Zone | | | | | |
| Loíza | 3 | 3,000 | Study not available | 9/20/98 1:00 PM | Loss of power; lack of water |
| Río Grande | 6 | 175 | Study not available | 9/20/98 6:00 PM | Shattered windows during storm |
| Carolina | 8 | 218 | Study not available | 9/21/98 8:00 AM | Flooding; shattered windows |

Table 4-1 (Continued)

Public Shelter Data Summary

Hurricane Georges Evacuation Assessment

| Location | Number of Shelters Opened | Number of People Sheltered | Technical Data Report Shelters/Expected Shelter Demand | Time Opened/Duration | Problems Encountered |
|---|----------------------------------|-----------------------------------|---|-----------------------------|--|
| Puerto Rico - Aguadilla Zone | | | | | |
| Añasco | 1 | 118 | Study not available | 9/21/98 10:00 AM | Not enough bathrooms |
| Aguadilla | 3 | 121 | Study not available | 9/21/98 4:00 PM | None reported |
| Quebradillas | Not available | Not available | Study not available | N/A | N/A |
| Isabela | 1 | 89 | Study not available | 9/20/98 5:00 PM | Loss of power |
| Aguada | 2 | 139 | Study not available | 9/20/98 6:00 PM | Loss of power; lack of water; not enough bathrooms (including showers) |
| Rincón | 4 | 225 | Study not available | 9/20/98 8:00 AM | None reported |

Table 4-1 (Continued)

Public Shelter Data Summary

Hurricane Georges Evacuation Assessment

| Location | Number of Shelters Opened | Number of People Sheltered | Technical Data Report Shelters/Expected Shelter Demand | Time Opened/Duration | Problems Encountered |
|----------------------|----------------------------------|-----------------------------------|---|-----------------------------|----------------------------------|
| Puerto Rico - | | | | | |
| Mayagüez Zone | | | | | |
| Lajas | 7 | 785 | Study not available | 9/21/98 3:30 PM | Loss of power |
| Cabo Rojo | 4 | 400-600 | Study not available | 9/21/98 2:00 PM | None reported |
| Mayagüez | 3 | 1,500 | Study not available | 9/20/98 4:30 PM | Not enough of cots/sleeping bags |

| Puerto Rico - San Juan Zone | | | | | |
|--|---|-------|---------------------|-----------------|--|
| Toa Baja | 5 | 962 | Study not available | 9/20/98 9:00 AM | Loss of power; lack of water; need generators; need showers in bathrooms |
| Dorado | 6 | 2,000 | Study not available | 3:00 PM | Need more bathrooms |

Table 4-1 (Continued)

Public Shelter Data Summary

Hurricane Georges Evacuation Assessment

| Location | Number of Shelters Opened | Number of People Sheltered | Technical Data Report Shelters/Expected Shelter Demand | Time Opened/Duration | Problems Encountered |
|---------------------------------------|--|---------------------------------------|---|-----------------------------|-----------------------------|
| Puerto Rico - Fajardo Zone | | | | | |

| | | | | | |
|---------------------|----|---------------|---------------------|------------------|---|
| Fajardo | 3 | 205 | Study not available | 9/20/98 6:00 PM | Loss of power; lack of water |
| Ceiba | 1 | 175 | Study not available | 9/19/98 5:00 PM | Loss of power; lack of water |
| Vieques | 1 | 80 | Study not available | 9/21/98 8:00 AM | Lack of communication with state |
| Puerto Rico | | | | | |
| Guayama Zone | | | | | |
| Guayama | 7 | 1,500 | Study not available | 4:00 PM | Loss of power; need generators |
| Arroyo | 3 | 230 | Study not available | 9/19/98 6:00 PM | Structural problems; loss of power; lack of water |
| Salinas | 11 | 1,606 | Study not available | 9/21/98 2:00 PM | Loss of power; lack of water |
| Coamo | 5 | 1,500 - 2,000 | Study not available | 9/21/98 8:00 AM | Loss of power; lack of water |
| Santa Isabel | 3 | 1,800 | Study not available | 9/20/98 9:00 AM | Flooding & structural damage in some shelters |
| Patillas | 4 | 500 | Study not available | 9/20/98 12:00 PM | Lack of food; loss of power; lack of water |

Table 4-1 (Continued)

Public Shelter Data Summary

Hurricane Georges Evacuation Assessment

| Location | Number of Shelters Opened | Number of People Sheltered | Technical Data Report Shelters/Expected Shelter Demand | Time Opened/Duration | Problems Encountered |
|---------------------------------------|---|--|---|-----------------------------|--|
| Puerto Rico - Humacao Zone | | | | | |
| Humacao | Not available | Not available | Study not available | Not recorded | None reported |
| Yabucoa | 2 | 85 | Study not available | 9/20/98 5:00 PM | Lack of water; loss of power |
| Maunabo | 4 | 90 | Study not available | 9/21/98 | Loss of power; lack of water |
| US Virgin Islands | | | | | |
| St. Thomas/ St. Croix/ St. John | St. Thomas 6 St. Croix 3 St. John 3 | St. Thomas 476 St. Croix 802 St. John 92 | St. Thomas - 2,845 people | 3 PM/2 days | Roofing problems; leakage; loss of power; wind problems due to weak structures |

South Florida Counties had several sheltering issues. Collier County is wrestling with the American Red Cross 4496 Rule in regards to shelter selection. Broward County had loss of power at one shelter, and Dade County commented on the need for staffing at the special need shelters. Considering the modest levels of evacuation that took place in Dade and Broward Counties, public shelter demand was actually quite substantial. Monroe County experienced difficulty getting Florida International University fully activated for sheltering due to their normal academic business.

On the Gulf Coast, Washington and Baldwin Counties in Alabama reported no problems encountered while Mobile County reported minimal loss of power at shelters. Parishes in Louisiana encountered several problems with shelters including lack of food and beds. Red Cross shelters are north of I-10, requiring drive times of 4-6 hours for evacuees. St. Charles Parish does not have adequate facilities for a Category 3 storm. Counties in Mississippi experienced lack of power at shelters. Local officials in Mississippi experienced difficulties with evacuees not going to their designated shelters. Residents travel to Camp Shelby even if it is not their designated shelter causing traffic and shelter capacity problems. Significant roof damage occurred at two schools in Jackson County that were used as shelters. However, they were not in the primary impact area of Georges.

Puerto Rico and the U.S. Virgin Islands had similar difficulties in shelters including loss of power, lack of water, lack of bathrooms and beds, staffing needs, loss of communication, and structural damage. Currently, there are "refugees" in several municipios in Puerto Rico. Once the official shelters close, evacuees are moved to abandoned buildings that can serve as shelters managed under the Puerto Rico Department of Housing. Local officials commented on the need for permanent shelters throughout the Island to combat many of the problems that are encountered during a storm. Some of the shelters in Puerto Rico experienced flooding problems. It is understood that this was from freshwater flooding from rainfall.

Recommendations:

- 1 Provide Puerto Rico and the U.S. Virgin Islands with public shelter evaluation resources and monies for emergency power supplies/generators.
- 2 Address the unique wind vulnerability of island shelters due to mountain terrains/downslope accelerations.

3 On the Gulf Coast, make sure public shelter staff keep evacuees out of gymnasiums during the brunt of storms due to potential roof problems.

4 Build on the success of Escambia County, Florida in working with the military to successfully staff public shelters. This should be explored in communities with a high concentration of military.

Hurricane Georges Post Storm Assessment

Chapter 5

Transportation/Clearance Time Data

In FEMA/Corps of Engineers comprehensive hurricane evacuation studies, the primary objective of the transportation analysis is to determine the clearance times needed to conduct a safe and timely evacuation for a range of hurricane threats. Information from the vulnerability, shelter, and behavioral analyses are directly input as well as various sources of permanent and seasonal population data.

Except for Northwest Florida and Southwest Florida, clearance times available from existing FEMA/Corps of Engineers hurricane evacuation studies were either outdated or non-existent. Most of Puerto Rico has not been studied for evacuation clearance time issues. Times developed for Alabama and Mississippi are over 15 years old. Times for Louisiana were calculated almost ten years ago.

Transportation and clearance time issues related to Georges and discussed by the study teams with local and state officials included the following:

- Was the evacuation roadway network accurate - did evacuees use projected routes?
- Were any traffic control actions taken to speed up flow?
- When was the evacuation essentially completed - how long did the evacuation take?
- Were any major problems encountered in this evacuation?

Table 5-1 provides a summary of the interview responses regarding transportation and clearance time data. Northwest and South Florida traffic moved smoothly during the evacuation process indicating that local and state officials started the evacuations in a timely manner, that traffic control was appropriate and effective, and that evacuation participation rates were modest out of those areas that potentially could have been impacted. Figures 5-1 and 5-2 show the evacuation traffic versus normal daily traffic for US 1 south of CR 905 in Monroe County, Florida. The graphs depict traffic moving northbound and southbound two days prior to the Georges landfall and two days after. The northbound traffic substantially increased on Wednesday September 23, peaking during the early afternoon with about 1,500 vehicles per hour moving through US 1. The only traffic problems reported were for vehicles re-entering the Keys after the Georges event. No traffic problems were reported for Northwest Florida which is a great improvement over the Opal experience.

Table 5-1
Transportation/Clearance Time Data Summary

Hurricane Georges Evacuation Assessment

| Location | Evacuation Roadway Network Accurate | Traffic Control Actions | Clearance Time Experienced | Study Calculated Time | Problems Encountered |
|--------------------------|-------------------------------------|--|---|--|---|
| Northwest Florida | | | | | |
| Escambia County | Yes | Minimal | Not discernible due to lack of evacuation response | No scenario with low participation rates | I-10 closed due to flooding after the storm |
| Santa Rosa County | Yes | Minimal | Not discernible | No scenario with low participation rates | None; traffic was not heavy |
| Okaloosa County | Yes | Assets prepositioned but not necessary | Not discernible due to low compliance with evacuation order | No scenario with low participation rates | None reported |
| Walton County | Yes | Minimal | Minimal | No scenario with low participation rates | None reported |
| Bay County | Not applicable | None reported | Not discernible | No scenario with low participation rates | None reported |

Table 5-1 (Continued)
Transportation/Clearance Time Data Summary
Hurricane Georges Evacuation Assessment

| Location | Evacuation Roadway Network Accurate | Traffic Control Actions | Clearance Time Experienced | Study Calculated Time | Problems Encountered |
|----------------------|-------------------------------------|---|----------------------------|-----------------------|--|
| South Florida | | | | | |
| Lee County | Yes | Law enforcement monitored evacuation; people told to evacuate to local destinations | Not discernible | (No Corps/FEMA study) | Traffic was very light; SR 74 blocked in Glades County |

| | | | | | |
|----------------|-----|---|---|---|--|
| Collier County | Yes | None reported | 5½ hours; evacuation was complete by 8 PM | (No Corps/FEMA study) | None reported |
| Broward County | Yes | None reported | Mass transit completed by 6 PM; other traffic not discernible | No scenario run with this level of evacuation | None, no roads were blocked with evacuating traffic |
| Dade County | Yes | None reported | Not discernible | No scenario run with this level of evacuation | None reported; bridges locked down at 5 PM; mass transit played key role |
| Monroe County | Yes | 9/22/98 7 PM Bridges locked down, tolls lifted 9/23/98 all southbound traffic stopped 9/24/98 5 PM all northbound traffic stopped in Middle Keys | Traffic spread out over several days; FDOT counts showed modest levels of evacuation taking place | No scenario run with this level of evacuation | None reported |

Table 5-1 (Continued)
Transportation/Clearance Time Data Summary
Hurricane Georges Evacuation Assessment

| Location | Evacuation Roadway Network Accurate | Traffic Control Actions | Clearance Time Experienced | Study Calculated Time | Problems Encountered |
|-------------------|-------------------------------------|---------------------------------------|--|------------------------------|---|
| Alabama | | | | | |
| Washington County | Yes (Hwy 43 & 45) | None reported | Not Reported | Not included in old HES | Would like Hwy 45 4- laned to Mississippi; heavy traffic moved fine |
| Mobile County | Yes | Manned congestion points; worked well | People evacuated over a 24 hour period | Study data over 17 years old | Construction affected routes; complacency of people who were asked to leave |
| Baldwin County | Yes | Highway 59 three- laned northbound | Not discernable | Study data over 17 years old | None - people left early and orderly |
| Louisiana | | | | | |

| | | | | | |
|------------|----------------|---------------|--------------|----------------|--|
| Lafourche | Yes | None reported | 12 hours | 11½ hours | Highway 90 East flooded from previous storms; I-10 backed up; need better coordination between parishes; signed evacuation routes did not work |
| Terrebonne | No | None reported | 15 hours | Not calculated | US 90 flooded; previous storm flooding; EAS not working |
| Orleans | Not applicable | None reported | Not reported | 15¼ hours | US 90 floods; I-10 construction slowed evacuation; do not have sufficient traffic capacity for evacuation |

Table 5-1 (Continued)
Transportation/Clearance Time Data Summary
Hurricane Georges Evacuation Assessment

| Location | Evacuation Roadway Network Accurate | Traffic Conditions Actions | Clearance Time Experienced | Study Calculated Time | Problems Encountered |
|--------------------|--|-----------------------------------|-----------------------------------|------------------------------|---|
| St. James | Yes | None reported | 13 hours | 12 hours | Not enough roadway capacity for evacuation; evacuation routes are closed off too early due to flooding; coastal erosion |
| St. Charles | Yes | None reported | 10 hours | 12 hours | No Hurricane protection levees; need more highway maintenance |
| Jefferson | Yes | None reported | Not reported | 15¼ hours | Traffic congestion on I-10; traffic/information signs in plan not in place |
| Mississippi | | | | | |
| Harrison County | Yes | None reported | Not reported | Study out of date | Evacuation roadway network not adequate |
| Hancock County | Yes | None reported | Not reported | Study out of date | No comments provided |

| | | | | | |
|----------------|-----|---------------|--------------|-------------------|---|
| Forrest County | Yes | None reported | Not reported | Study out of date | Heavy congestion on Hwy 49; many vehicles parked on side of highway; flash flood problems of US 49; fallen trees along major roadways |
| Jackson County | Yes | None reported | Not reported | 24 hours | None reported |

Table 5-1 (Continued)
Transportation/Clearance Time Data Summary
Hurricane Georges Evacuation Assessment

| Location | Evacuation Roadway Network Accurate | Traffic Control Action | Clearance Time Experienced | Study Calculated Time | Problems Encountered |
|-----------------------------------|--|-------------------------------|-----------------------------------|------------------------------|--|
| Puerto Rico - Ponce Zone | | | | | |
| Ponce | Yes | None reported | 7-8 hours | 8 hours | Some flooding but alternate routes taken |
| Juana Díaz | Yes | None reported | 6-8 hours | Not calculated | None reported |
| Guayanilla | Yes | None reported | 4-5 hours | Not calculated | None reported |
| Guánica/Yauco | Yes | None reported | 2 hours | Not calculated | None reported |
| Puerto Rico - Arecibo Zone | | | | | |
| Vega Baja | Yes | None reported | 2-3 hours | Not calculated | None reported |
| Hatillo | Partial | None reported | 2-3 hours | Not calculated | None reported |
| Manatí | Yes | None reported | 2-3 hours | Not calculated | None reported |

Table 5-1 (Continued)
Transportation/Clearance Time Data Summary
Hurricane Georges Evacuation Assessment

| Location | Evacuation Roadway Network Accurate | Traffic Control Actions | Clearance Time Experienced | Study Calculated Time | Problems Encountered |
|---|--|------------------------------------|---------------------------------------|----------------------------------|------------------------------------|
| Puerto Rico - Carolinas Zone | | | | | |
| Loíza | Yes | None reported | 6 hours | 8 hours | None reported |
| Río Grande | Yes | None reported | 6-8 hours | Not calculated | None reported |
| Carolina | Yes | None reported | Not reported | 8 hours | Not reported |
| Puerto Rico - Aguadilla Zone | | | | | |
| Añasco | Yes | None reported | 10 hours | Not calculated | Fallen tree limbs |
| Aguadilla | Yes | None reported | 3-4 hours | Not calculated | None reported |
| Quebradillas | Yes | None reported | Not reported | Not calculated | None reported |
| Isabela | Yes | None reported | 2-3 hours | Not calculated | None reported |
| Aguada | Yes | None reported | 4 hours | Not calculated | Last minute evacuations; timing |
| Rincón | Yes | None reported | 4-5 hours | Not calculated | None reported |

Table 5-1 (Continued)
Transportation/Clearance Time Data Summary
Hurricane Georges Evacuation Assessment

| Location | Evacuation Roadway Network Accurate | Traffic Control Actions | Clearance Time Experienced | Study Calculated Time | Problems Encountered |
|-----------------|--|------------------------------------|---------------------------------------|----------------------------------|---------------------------------|
|-----------------|--|------------------------------------|---------------------------------------|----------------------------------|---------------------------------|

| Puerto Rico - Mayagüez Zone | | | | | |
|--|-----|---------------|---------------|----------------|---------------|
| Lajas | Yes | None reported | 3-4 hours | Not calculated | None reported |
| Cabo Rojo | Yes | None reported | 5 hours | Not calculated | None reported |
| Mayagüez | Yes | None reported | 3 hours | Not calculated | None reported |
| Puerto Rico - San Juan Zone | | | | | |
| Toa Baja | Yes | None reported | 12-16 hours | Not calculated | None reported |
| Dorado | Yes | None reported | None recorded | Not calculated | None reported |

**Table 5-1 (Continued)
Transportation/Clearance Time Data Summary
Hurricane Georges Evacuation Assessment**

| Location | Evacuation Roadway Network Accurate | Traffic Control Actions | Clearance Time Experienced | Study Calculated Time | Problems Encountered |
|---------------------------------------|--|------------------------------------|---------------------------------------|----------------------------------|---------------------------------|
| Puerto Rico - Fajardo Zone | | | | | |
| Fajardo | Yes | None reported | 6 hours | Not calculated | None reported |
| Ceiba | Yes | None reported | 6 hours | Not calculated | None reported |
| Vieques | Yes | None reported | None recorded | Not calculated | No comment provided |
| Puerto Rico - Guayama Zone | | | | | |
| Guayama | Yes | None reported | Not available | Not calculated | None reported |
| Arroyo | Yes | None reported | Not available | Not calculated | None reported |

| | | | | | |
|--------------|-----|---------------|---------------|----------------|---------------------|
| Salinas | Yes | None reported | 5 hours | Not calculated | None reported |
| Coamo | Yes | None reported | 6 - 8 hours | Not calculated | None reported |
| Santa Isabel | Yes | None reported | 12 - 15 hours | Not calculated | None reported |
| Patillas | Yes | None reported | 6 hours | Not calculated | No comment provided |

Table 5-1 (Continued)
Transportation/Clearance Time Data Summary
Hurricane Georges Evacuation Assessment

| Location | Evacuation Roadway Network Accurate | Traffic Control Actions | Clearance Time Experienced | Study Calculated Time | Problems Encountered |
|---------------------------------------|--|--------------------------------|-----------------------------------|------------------------------|---|
| Puerto Rico - Humacao Zone | | | | | |
| Humacao | Not available | None reported | Not available | Not calculated | No comment provided |
| Yabucoa | Yes | None reported | 4-5 hours | Not calculated | Flooding on some roadways |
| Maunabo | Yes | None reported | 3 hours | Not calculated | Improve computer system |
| US Virgin Islands | | | | | |
| St. Thomas/ St. Croix/ St. John | Yes | None reported | Not discernable | 3-8 hours | No traffic problems during evacuation; difficult to tell tourists what to do; air lines stop service at least 12 hours before event |

Figure 5-1

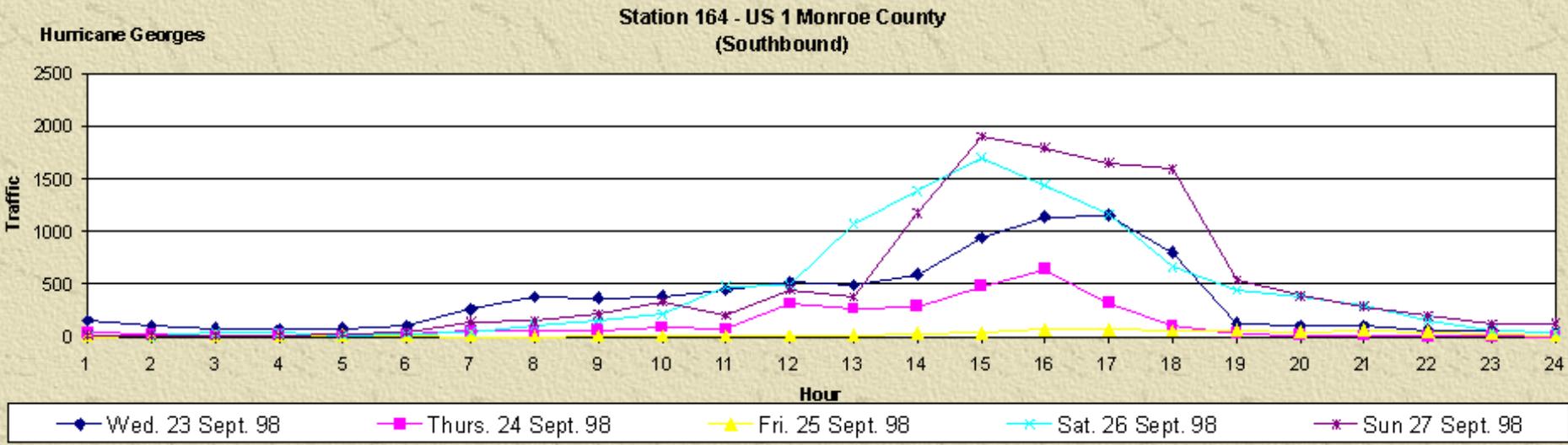
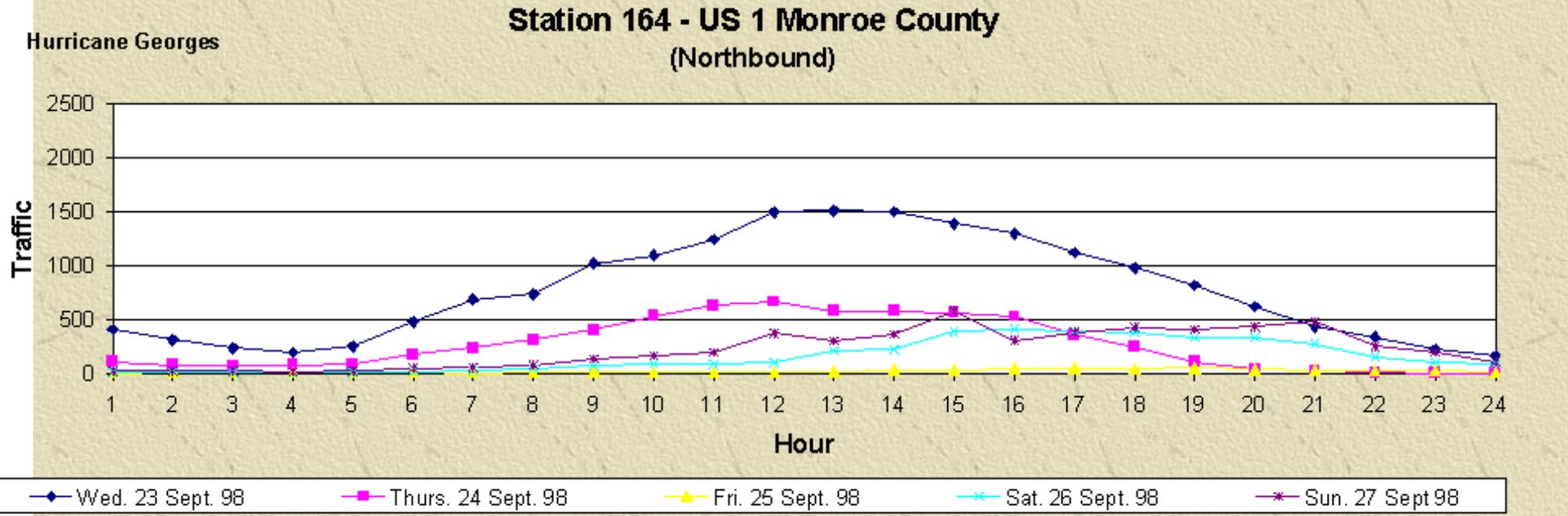


Figure 5-2

Alabama, Louisiana, and Mississippi experienced similar issues with construction along evacuation routes causing delays. Washington County, Alabama, and several parishes in Louisiana commented on the lack of capacity along evacuation routes. The most significant traffic congestion appeared on I-10 westbound out of New Orleans where one westbound lane was closed due to construction. This congestion was alleviated by the State by clearing construction and opening both westbound lanes. Parishes in Louisiana also had flooded roadways due to the heavy rains of previous storms. Lafourche Parish mentioned the need for better traffic coordination between parishes. St. Charles Parish also noted the need for hurricane protection levees and associated highway maintenance. Harrison County, Mississippi commented on the need to reevaluate the roadway network for evacuation routing. Forrest County, Mississippi had heavy traffic congestion and flash flooding on a major evacuation route, US Hwy 49.

Four municipios in Puerto Rico encountered traffic problems due to flooding, fallen tree limbs and last minute evacuation by residents. The remaining municipios experienced little traffic problems during evacuation. The close proximity to shelters for residents and early evacuation due to local experience made the process smoother. The U.S. Virgin Islands also had no significant traffic problems. The only difficulty experienced was directing tourists during evacuation. Actual clearance times of three to ten hours matched up well with the few areas where hurricane clearance time analysis had been conducted.

Recommendations:

- 1 Update Alabama, Mississippi, Louisiana and lower southeast Florida hurricane evacuation studies.
- 2 Run scenarios for St. Thomas with lower participation rates assumed.
- 3 Develop maintenance of traffic plans for Louisiana parishes that have road
- 4 construction projects on major evacuation routes (specifically for the hurricane season).
- 5 Conduct a Louisiana-Mississippi regional hurricane evacuation analysis to better anticipate traffic flows into Mississippi and associated shelter demand.
- 6 Provide Gulf states and counties with an abbreviated version of the transportation model so that roadway construction impacts to clearance time can be calculated in real time.
- 7 Implement permanent traffic count stations along the Gulf Coast states so that evacuation traffic can be monitored and documented.

Hurricane Georges Post Storm Assessment

Chapter 6

Decision Making

Some of the most important products developed as part of the FEMA/Corp of Engineers hurricane evacuation studies and delivered to local and state officials have been evacuation decision making tools. These tools are decision arc maps and tables as well as computer software such as HURREVAC. These products graphically tie real-time storm characteristics with HES produced hazards, shelter and clearance time data. Their purpose is to give emergency management directors a means of retrieving Technical Data Report information without having to dig through a report during an emergency. Evacuation decision tools provide guidance and assistance to decision makers as to when an evacuation should begin relative to a specific hurricane, its associated wind field, forward speed, probabilities, forecast track, and intensity.

Discussions initiated by the FEMA/Corps study teams with local and state officials regarding the evacuation decision process focused on the following questions:

- When was the Emergency Operating Center fully activated and what prompted this decision?
- What study products/decision aides were used to decide when to evacuate and who should evacuate? Was the new HURREVAC product used?
- When was the evacuation order or request made?

Table 6-1 provides a summary of the responses and information gathered from each county. Most areas interviewed used similar products: HURREVAC, decision arcs, zone maps and surge maps. Those that did not have HURREVAC used HURRTRAC or other commercial products. Northwest Florida counties agreed that the study products worked well. Several areas commented that a FEMA/Corps of Engineers study was not available for Lee and Collier Counties in South Florida. Those areas without studies used decision arcs, and/or HURREVAC. Several areas also mentioned the need for HURREVAC training. Mobile County, Alabama and St. Charles Parish, Louisiana requested a study update. Counties in Mississippi commented that a new SLOSH model is needed.

The municipios without a study rely on local operational plans and surge maps produced by the Corps of Engineers. Many municipios were unaware of HURREVAC, and also lacked the computer hardware to use it. These areas relied on decision arcs, weather bulletins, and local experience. Also, many areas commented on the need for measuring river flooding and mapping areas prone to mud slides, the cause of most deaths and property destruction.

Local officials in the U.S. Virgin Islands use HURREVAC and decision arcs. Comments made included getting the upgraded HURREVAC, and automated rain and wind gauges.

Recommendations:

1. Update clearance time data and incorporate into the new HURREVAC model.
2. Conduct extensive training sessions with local EM's regarding the new HURREVAC model.
3. Deliver new SLOSH storm tide atlases to Mississippi Counties as soon as possible.
4. Provide detailed river and mudslide area maps such as USGS maps for Puerto Rico and the U.S.

Virgin Islands.

5. Provide rain and wind gauges for the U.S. Virgin Islands.
6. Study update in Alabama including clearer/more definable evacuation zones.
7. Update Louisiana study including SLOSH forecasts.
8. Assist Puerto Rico municipios in obtaining necessary data during a storm.

Table 6-1

Evacuation Decision Process Summary
Hurricane Georges Evacuation Assessment

| Location | Time EOC Was Activated | What Prompted Decision to Activate | What Study Products/ Decision Aids Were Used in Decision Making | Time of Evacuation Order/ Number Evacuated | How Well Study Products Worked |
|--------------------------|--|---|---|---|---|
| Northwest Florida | | | | | |
| Escambia County | 9/25/98 10 AM | HURREVAC, NHC information | HURREVAC, decision arcs | 9/25/98 5 PM Reissued 9/26/98 6 PM | New study products worked great; used HES zones |
| Santa Rosa County | 9/25/98 1 PM | HURREVAC <u>not</u> up and running at new EOC | Zone and route mapping; storm surge maps | 9/25/98 1 PM 10,000 is population of evacuation area | New study is great; promoted zone map heavily |
| Okaloosa County | 9/25/98 | HURRTRAC | Zone maps, surge maps | 9/25/98 11 AM 26,000 in area | HURREVAC won't work because of county's internet server "firewall"; other study products were excellent; flood forecasts were low |
| Walton County | 9/25/98 10:30 AM | NHC information/clearance time requirements | HURREVAC (beta version), clearance times | 9/25/98 | New study products worked well |
| Bay County | 9/23/98 Level 2 9/25/98 11 AM full activation | NHC HURREVAC decision arcs; HURRTRAC | HURREVAC (new) | No major areas of evacuation recommended or ordered | Worked well |

Table 6-1 (Continued)

Evacuation Decision Process Summary

Hurricane Georges Evacuation Assessment

| Location | Time EOC Was Activated | What Prompted Decision to Activate | What Study Products/ Decision Aids Were Used in Decision Making | Time of Evacuation Order/ Number Evacuated | How Well Study Products Worked |
|----------------------|--|---|---|---|--------------------------------|
| South Florida | | | | | |
| Lee County | 9/22/98 | GDS, TDS, NHC information | (No Corps/FEMA study) | 9/24/98 1 PM Voluntary 11 PM mandatory with warning issued | (No Corps/FEMA study) |
| Collier County | 9/23/98 5 AM | GDS, Decision ARCs | (No Corps/FEMA study) | 9/24/98 2:30 PM Marco Island - 8,000 left 25,000 left county wide | (No Corps/FEMA study) |
| Broward County | 9/23/98 5 AM | Anticipation of hurricane watch issuance by the NHC | HURREVAC, decision arcs, GDS, HURRTRAC | 9/23/98 mobile home/low lying area evacuation | Well |
| Dade County | 9/21/98 initial 9/23/98 level II activation 9/24/98 level III activation | SALT, GDS, NWS forecast information; state conference calls | GDS | 9/24/98 11:30 AM mobile home and electric dependent residents encouraged to evacuate | Need training on HURREVAC |

| | | | | | |
|---------------|--|-----------------|----------------------|---|----------------------|
| Monroe County | 9/21/98 8 AM partial 9/23/98 7 AM full 2 operation centers primary - Marathon secondary - Key West | NHC information | No comments provided | 9/22/98 7 AM tourists 4 PM mobile homes mandatory 9/23/98 7 AM mandatory evacuation ordered for 7 Mile Bridge South 11 AM mandatory for Middle Key 4 PM mandatory for Upper Keys | No comments provided |
|---------------|--|-----------------|----------------------|---|----------------------|

Table 6-1 (Continued)

Evacuation Decision Process Summary

Hurricane Georges Evacuation Assessment

| Location | Time EOC was Activated | What Prompted Decision to Activate | What Study Products/ Decision Aids Were Used in Decision Making | Time of Evacuation Order/ Number Evacuated | How Well Study Products Worked |
|-------------------|--|--|---|--|--|
| Alabama | | | | | |
| Washington County | 9/25/98 Alert 9/26/98 Full activation | Information from state emergency management; DTN information | No comments reported | 9/26/98 100 ± homes in low lying areas | Don't have enough staff and computers to run Inland Winds programs |

| | | | | | |
|------------------|--|---|--|---|--|
| Mobile County | Partial activation during watch; full activation during warning 9/26/98 6 AM | Weather/rainfall/wind predictions; NHC forecast; continuous calls; HURRTRAC | HURREVAC, SLOSH Model | 9/26/98 Asked people to evacuate locally and not to leave county | Need study updated; zones too hard to describe to public |
| Baldwin County | 9/26/98 6 AM | NHC information, HURRTRAC | HURREVAC, beta version | 9/26/98 6 PM Pleasure Island, Ono Island and mobile homes under mandatory order; 20,000 ± | Evacuation zone too difficult to classify to the public; need update of study |
| Louisiana | | | | | |
| Lafourche | 9/25/98 Morning | Impending threat of hurricane | HURREVAC, decision arcs's, National Weather Service | 9/26/98 8:00 AM 30,000 ± | Would like exact elevation maps; information on structural integrity of shelters |
| Terrebonne | 9/26/98 | Not provided | National Weather Service (Slidell), DTN, Weather Channel, HURRWIN 95, surge maps, decision arcs's | 9/26/98 102,000 | Extremely well |

Table 6-1 (Continued)

Evacuation Decision Process Summary

Hurricane Georges Evacuation Assessment

| Location | Time EOC Was Activated | What Prompted Decision to Activate | What Study Products/ Decision Aides Were Used | Time of Evacuation Order/Number Evacuated | How Well Study Products Worked |
|-----------------|-------------------------------|---|--|--|---|
| Orleans | 9/25/98 | Expected hurricane land-fall | HURREVAC, National Weather Service, State | 9/26/98 2:00 PM | Need more HURREVAC training; SLOSH maps over predicts flooding; Roadway elevations/levees may have changed since study |
| St. James | 9/25/98 5:00 AM | Storm intensity, location and forecast National Hurricane Center information | Contracted meteorologist, HURREVAC, National Weather Service | 9/26/98 6:00 AM 4,000 | Believe SLOSH maps over predict water levels; Need better tools to predict hazards such as including rainfall in model |
| St. Charles | Not reported | Not provided | Hurricane Evacuation Study, HURREVAC | 9/26/98 6:00 AM 38,000 - 40,000 | Study is outstanding; Need to update study; SLOSH model worked well |
| Jefferson | 9/26/98 8:00 AM | Not provided | No comments reported | Not recorded | SLOSH model predicts realistic results; Clearance times are realistic; Need to update study (levee heights); erosion needs to be included in next study |

Table 6-1 (Continued)

Evacuation Decision Process Summary
Hurricane Georges Evacuation Assessment

| Location | Time EOC Was Activated | What Prompted Decision to Activate | What Study Products/ Decision Aides Were Used | Time of Evacuation Order/ Number Evacuated | How Well Study Products Worked |
|--------------------|-------------------------------|---|--|---|---|
| Mississippi | | | | | |
| Harrison County | Not reported | Not provided | Decision arc, HURREVAC | 9/26/98 9:00 AM 10,000 | Need an updated SLOSH model |
| Hancock County | 9/26/98 | Not provided | HURREVAC | 9/26/98 7:00 PM 4,500 | Need study to be updated |
| Forrest County | Not reported | Not provided | Hurricane Center bulletins off Internet | Not recorded | Forecast of hurricane landfall too far off |
| Biloxi County | 8/26/98 | Not provided | HURREVAC, old SLOSH software | Not recorded | Need SLOSH model for Mississippi; need new SLOSH maps; include traffic count data in next study |

| | | | | | |
|----------------|-----------------|--------------|---|--------------------------|---|
| Jackson County | 9/25/98 1:00 PM | Not provided | HURREVAC, National Hurricane Center information | 9/26/98 2,500 - 3,000 | Need new SLOSH model for Mississippi Would like better communications with Hurricane Center; more accurate elevation data needed |
|----------------|-----------------|--------------|---|--------------------------|---|

Table 6-1 (Continued)

Evacuation Decision Process Summary

Hurricane Georges Evacuation Assessment

| Location | Time EOC Was Activated | What Prompted Decision to Activate | What Study Products/ Decision Aides Were Used | Time of Evacuation Order/Number Evacuated | How Well Study Products Worked |
|-----------------|-----------------------------------|---|--|--|---|
|-----------------|-----------------------------------|---|--|--|---|

| Puerto Rico - Ponce Zone | | | | | |
|-------------------------------------|-------------------|---|--|------------------------------------|--|
| Ponce | 9/19/98 | None recorded | Maps in the operational plan, Weather bulletins | 9/20/98 2,000 | Not aware of HURREVAC |
| Juana Díaz | 9/19/98 | Experience | Local operational plan | 9/20/98 Afternoon 1,500 - 1,800 | Have computer but need HURREVAC |
| Guayanilla | 9/19/98 Afternoon | NOAA information; State Civil Defence information | Surge Maps | 9/20/98 Morning 6,000 - 7,000 | Have Internet access; not aware of HURREVAC |
| Guánica/Yauco | 9/19/98 8:30 AM | Weather Service information; Internet | Experience, Surge Maps, Local operational plan | 9/20/98 1:00 PM 1,200 | Not aware of HURREVAC; have computers |

Table 6-1 (Continued)

Evacuation Decision Process Summary

Hurricane Georges Evacuation Assessment

| Location | Time EOC Was Activated | What Prompted Decision to Activate | What Study Products/ Decision Aides Were Used | Time of Evacuation Order/Number Evacuated | How Well Study Products Worked |
|-------------------------------------|--|---|--|---|--|
| Puerto Rico - Arecibo Zone | | | | | |
| Vega Baja | 9/19/98 | Experience | Surge Maps, Communications with Manati & zone | 300 - 400 | Maps need to be improved; Not aware of HURREVAC |
| Hatillo | 9/19/98 | Advisories/warnings | Maps; news (media), Zone, Program - "storm" | 125 | No study available; need HURREVAC; have computer |
| Manatí | No comment provided | Hurricane trajectory | No comment provided | 1:00 PM 240+ | No comment provided |
| Puerto Rico - Carolinas Zone | | | | | |
| Loíza | 9/19/98 Alert 9/20/98 Full activation | Weather service; experience; history of municipio during disaster; operational plan | Municipio operational plan | 9/20/98 Approximately 3,500 | Plan worked well. Primary source of information was experience |
| Río Grande | 9/20/98 | Weather information | Maps, weather channel bulletins | 9/20/98 Approximately 175 | No study available |
| Carolina | 9/19/98 Morning | Public need to begin evacuation | Maps, Decision arcs | 9/21/98 3::00 6,316 | No comment provided |

Table 6-1 (Continued)

Evacuation Decision Process Summary
Hurricane Georges Evacuation Assessment

| Location | Time EOC Was Activated | What Prompted Decision to Activate | What Study Products/ Decision Aids Were Used in Decision Making | Time of Evacuation Order/Number Evacuated | How Well Study Products Worked |
|-------------------------------------|-------------------------------|---|--|--|---------------------------------------|
| Puerto Rico - Aguadilla Zone | | | | | |
| Añasco | 9/19/98 | Experience; size of hurricane | Decision arcs and maps | ± 600 | Not aware of HURREVAC |
| Aguadilla | 9/19/98 | Trajectory of hurricane | Computer program developed by municipio | 9/21/98 Morning 120-130 | Not aware of HURREVAC |
| Quebradillas | 9/20/98 Morning | Hurricane Track, expected landfall | Surge Maps, experience | 9/20/98 Morning | No comment provided |
| Isabela | 9/20/98 | Experience; good communications with zone | Used draft surge map | 9/20/98 Approximately 225 | No study available |

| | | | | | |
|--------|---------------------|-----------------------|---|----------------|-----------------------|
| Aguada | 9/19/98 1:00 PM | Information from NOAA | Maps, program developed (tracking) by municipio | 139 | Not aware of HURREVAC |
| Rincón | No comment provided | Hurricane trajectory | Surge Maps, data from Corps of Engineers | 9/20/98 225 | No comment provided |

Table 6-1 (Continued)

Evacuation Decision Process Summary

Hurricane Georges Evacuation Assessment

| Location | Time EOC Was Activated | What Prompted Decision to Activate | What Study Products/ Decision Aides Were Used | Time of Evacuation Order/Number Evacuated | How Well Study Products Worked |
|------------------------------------|-------------------------------|---|--|--|---------------------------------------|
| Puerto Rico - Mayagüez Zone | | | | | |
| Lajas | 9/20/98 | Internet information on Hurricane | Municipal operational plan | No comment provided | No comment provided |

| | | | | | |
|-----------|-----------------|---------------------------------|--|------------------------|---|
| Cabo Rojo | 9/20/98 9:00 AM | No comment provided | Operational plan, HURREVAC, Local maps | 9/21/98 2:00 PM 400 | Would like additional information on HURREVAC; information on HURREVAC from zone; no computer available |
| Mayagüez | 9/20/98 8:00 AM | Experience with past hurricanes | Municipio operational plan, experience | 10,000 -12,000 | No comment provided |

Table 6-1 (Continued)

Evacuation Decision Process Summary

Hurricane Georges Evacuation Assessment

| Location | Time EOC Was Activated | What Prompted Decision to Activate | What Study Products/Decision Aides Were Used | Time of Evacuation Order/Number Evacuated | How Well Study Products Worked |
|-----------------------------------|---|---|---|--|---------------------------------------|
| Puerto Rico | | | | | |
| San Juan Zone | | | | | |
| Toa Baja | No comment provided | Hurricane trajectory | Decision Arcs, National Weather Service, EIS System, new forecast office in San Juan, data obtained from University of Hawaii | 3,000 | No comment provided |
| Dorado | Once information was given from the State Civil Defense | Safety of local population | Maps | 2% of population | No comment provided |
| Puerto Rico - Fajardo Zone | | | | | |
| Fajardo | 9/18/98 | Hurricane trajectory | Internet, maps, weather channel | 205 | No comment provided |
| Ceiba | 9/19/98 10:00 AM | State Civil Defense; Internet; hurricane trajectory | Maps, information from State Civil Defense, risk analysis, Surge maps | 9/19/98 175+ | No comment provided |
| Vieques | 9/19/98 | Maps; information from National Meteorology Center | No comment provided | 9/20/98 | No comment provided |

Table 6-1 (Continued)

Evacuation Decision Process Summary
Hurricane Georges Evacuation Assessment

| Location | Time EOC Was Activated | What Prompted Decision to Activate | What Study Products/Decision Aids Were Used | Time of Evacuation Order/Number Evacuated | How Well Study Products Worked |
|-----------------------------------|-------------------------------|---|--|--|--|
| Puerto Rico - Guayama Zone | | | | | |
| Guayama | 9/20/98 | Experience | HURRTRAC, Surge maps and hurricane study | 1,500 | Data needs to portray number of evacuees better; not much data available |
| Arroyo | 9/18/98 | Hurricane trajectory | Maps | 9/20/98 4% of population | No comments provided |
| Salinas | 9/20/98 | Hurricane trajectory | No comment provided | 9/21/98 1,606 | No comment provided |
| Caomo | 9/21/98 | Hurricane trajectory | Maps, hurricane updates | 2,000 | No comment provided |
| Santa Isabel | 9/19/98 | Hurricane trajectory | Information from State CD, National Meteorology Service, National Hurricane Center Updates | 2,500 | Worked very well |

| | | | | | |
|----------|------------------|------------|--------------------------------------|---------|---------------------|
| Patillas | 9/19/98 10:30 AM | Experience | Information from State Civil Defense | 9/20/98 | No comment provided |
|----------|------------------|------------|--------------------------------------|---------|---------------------|

Table 6-1 (Continued)

Evacuation Decision Process Summary

Hurricane Georges Evacuation Assessment

| Location | Time EOC Was Activated | What Prompted Decision to Activate | What Study Products/ Decision Aids Were Used | Time of Evacuation Order/ Number Evacuated | How Well Study Products Worked |
|-----------------------------------|------------------------|---|--|--|--------------------------------|
| Puerto Rico - Humacao Zone | | | | | |
| Humacao | 9/19/98 | Proximity of hurricane to the municipio | Operational plan | 9/20/98 | No comment provided |
| Yabucoa | No comment provided | Threat of hurricane to Puerto Rico | Maps, information from State Civil Defense, operational plan | 175 | No comment provided |
| Maunabo | No comment provided | Hurricane trajectory | Hurricane trajectory map | Not reported | No comment provided |
| US Virgin Islands | | | | | |

| | | | | | |
|---------------------------------------|---------------|--|--------------------------------------|-----------------|--|
| St. Thomas/ St. Croix/ St. John | 9/20/98 11 AM | NHC information, NWS, Governor's actions | Old HURREVAC model, Decision Arcs | 9/20/98 3 PM | HURREVAC was good; would like scenarios incorporated with less public shelter use assumed; need new HURREVAC and automated rain and wind gauges; mapping to be more detailed and show potential mudslide areas |
|---------------------------------------|---------------|--|--------------------------------------|-----------------|--|

Hurricane Georges Post Storm Assessment

Chapter 7

Public Information

Although not a major part of previous FEMA/Corps of Engineers hurricane evacuation study efforts, public information is recognized as an important final element that must be addressed. Study products and data must ultimately be tailored to a format that the media and general public can understand so that correct evacuation decisions and preparations can be made at the household level. Georges provided a glimpse of the current means of getting hurricane evacuation information into the hands of the general public. Georges also provided local and state officials with an opportunity to assess additional needs regarding public information.

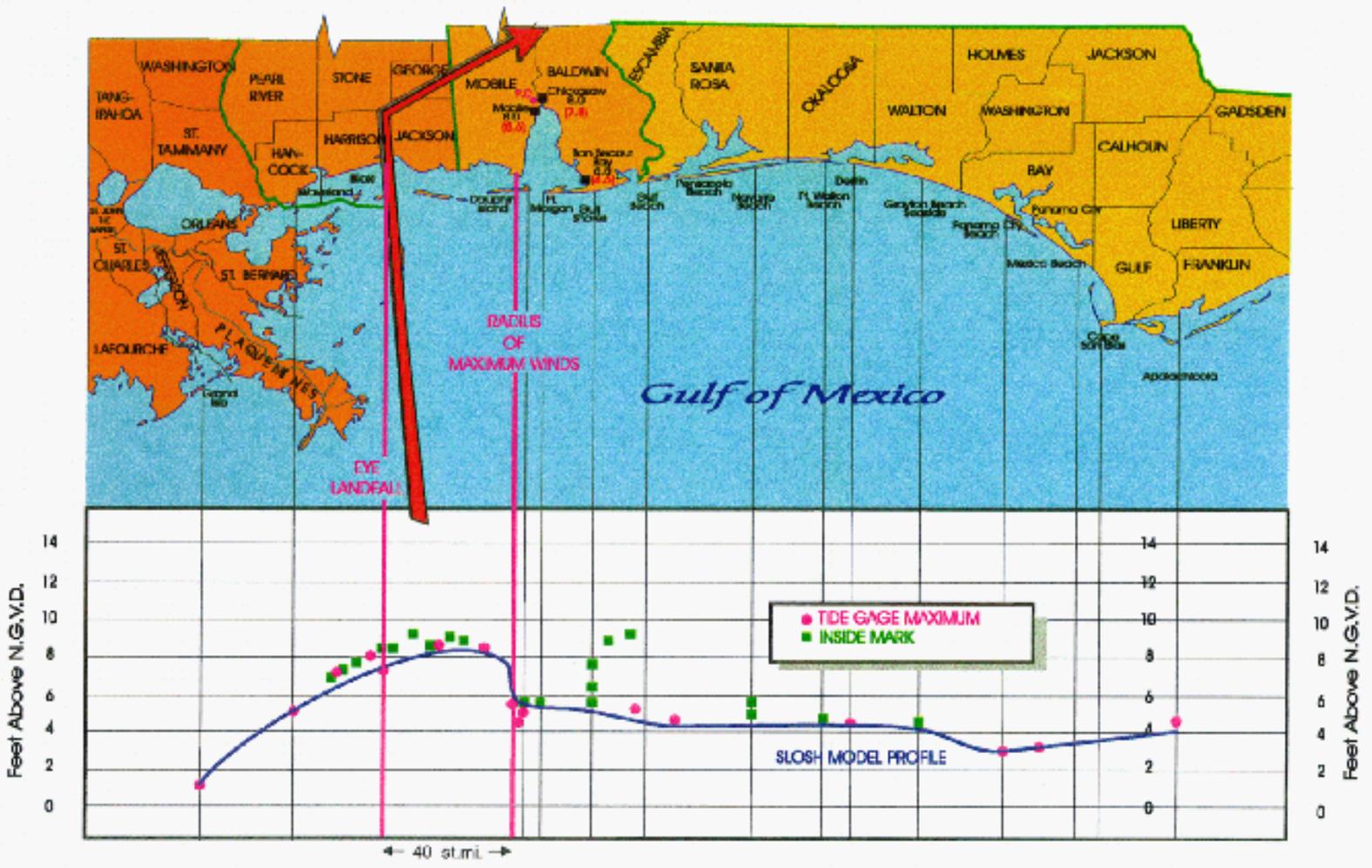
Methods used and suggestions offered in the study areas to inform the public in Georges and future events included the following:

- Public information brochures were developed and widely distributed early in the season showing vulnerable areas, evacuation levels, and tips on hurricane preparedness.
- Press briefing with national and local media to insure that they (radio, TV, newspapers) disseminate consistent information to the public - Media were given packets of hurricane materials early in the season by some emergency officials.
- Law enforcement officials drove through neighborhoods with sirens and P.A. systems to encourage people to evacuate - this technique was used in Puerto Rico extensively some officials went door-to-door.
- Some communities were able to provide evacuation information to the public through printed information in the local phone book.
- An important means was through radio and television - some communities used cable TV overrides to alert the public of evacuation advisories and provide PSAs.
- The Weather Channel was used extensively by local emergency management staff and citizens for public education and information.
- Some emergency management officials faxed advisory and teleconference information to media every six hours.
- Some counties used their web sites to display storm information and advisories.
- Decision arc systems are good for public and school education as they are easy to understand.
- County public information officers are important resources during the event to interface with the media and public.
- There is a mixture of ideas from the media regarding "canned" HES media products. Many would rather develop their own graphics.
- Some selected areas would like hurricane information in Spanish.

- There is a need for better coordination between the media and EOC during a storm.
- Improve evacuation zone maps distributed to the public by better delineating zones.

[Go back](#) Figure 2-4 High water marks along the Gulf Coast

OBSERVED HIGH WATER MARKS VERSUS SLOSH MODEL CALCULATED STORM SURGE PROFILE FOR HURRICANE GEORGES (1998)



Hurricane Georges High Water Marks are available on a separate Corps of Engineers site which uses ArcIMS to display results. If you would like to view the site click the continue button below. The site will open in a separate window, select the Map Room Button and the select Hurricane Georges from the drop down list.



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