HURRICANES BERTHA AND FRAN ASSESSMENT
Review of the Use and Value of Hurricane Evacuation Studies in the Hurricane Bertha Evacuation, July 9 - 12, 1996 and in the Hurricane Fran Evacuation, September 3 - 6, 1996 Georgia, South Carolina, North Carolina and Virginia

Prepared for Federal Emergency Management Agency Region IV Prepared by U. S. Army Corps of Engineers Charleston District

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PERSONS PROVIDING INFORMATION FOR ASSESSMENT AND ASSESSMENT TEAM MEMBERS

The following representatives of public agencies provided information for this assessment in meetings, personal interviews or telephone interviews.

Georgia

Chuck Gregg	Georgia Emergency Management Agency
Chuck Ray	Georgia Emergency Management Agency
Jack Hutto	Georgia Emergency Management Agency
Dr. Robert Smith	Chatham County, GA Emergency Management
Steve Rich	National Weather Service, Charleston, SC
Jerry Harrison	National Weather Service, Charleston, SC
David George,	National Weather Service, Charleston, SC
Don Bryant	Laurens County, GA Emergency Management Agency
Major Carson Knight	Laurens County, GA Sheriff Department
Don Lindsey	Laurens County, GA EMS
Rodney Manley	Courier Herald Newspaper, Dublin, GA
Col. Johnny Wingers	Bibb County, GA Emergency Management Agency
Betty Landon	Bibb County, GA Emergency Management Agency
Eugene Field	Bibb County, GA Emergency Management Agency
Rick Toller	WMAZ-TV 13, Macon, GA
Patricia Tiedeman	Columbia County, GA Emergency Management Agency
Pamela Tucker	Augusta-Richmond County, GA Emerg. Mgmt Agency
Robert Mumsford	Camden County, GA Emergency Management
Phillip Jones	Bryan County Government
Herbert Schwabe	Bryan County Emergency Management Agency
Tom Burris	Liberty County Emergency Management Agency
Ray Parker	McIntosh County Emergency Management Agency
Ed Abel	Glynn County Emergency Management Agency
Hank Rowland	The Brunswick News, Brunswick, GA
Jeremy Cooper	WJCL-TV, Savannah, GA
Scott Pierce	WJCL-TV, Savannah, GA
Audrey Puente	WJCL-TV, Savannah, GA
Beth Eckard	WJCL-TV, Savannah, GA
Donald Jones	WTOC-TV, Savannah, GA
Jim Carswell	WSAV-TV, Savannah, GA
Jeff Griffith	GA Department of Transportation, Jesup District

South Carolina

Stan McKinney	South Carolina Emergency Preparedness Division
Paul Whitten	South Carolina Emergency Preparedness Division

Ron Osborne	South Carolina Emergency Preparedness Division
Joe Farmer	South Carolina Emergency Preparedness Division
William Winn	Beaufort County, SC Emergency Preparedness
Jill Foster	Beaufort County, SC Emergency Preparedness
Louis Dugan	Georgetown County, SC Emergency Preparedness
Dora White	Days Inn, Georgetown, SC
Andrew Deckard	Days Inn, Georgetown, SC
Dennis Clark	Charleston County, SC Emergency Preparedness
Suzanne Gant	Colleton County, SC Emergency Preparedness
Jim Houser	Colleton County, SC - Zoning & Bldg Code Enforcement
Brenda Hester	Colleton County, SC - Dockside Lounge/Marina
George Fontaine	Colleton County, SC - Dockside Restaurant
Lt. Skipper Weston	Sullivan's Island, SC Fire and Rescue
Capt. Steve Yannuzzi	Isle of Palm, SC Fire Department
John H. Smith	Orangeburg County, SC Emergency Services
Todd Williams	Orangeburg County, SC Emergency Services
Charlotte Gramling	Orangeburg County, SC Department of Social Services
Danny Snead	Florence County, SC Emergency Preparedness
Crae Arnett	Florence County, SC American Red Cross
Victor Rowell	Williamsburg County SC Disaster Preparedness
Boykin Parson	Williamsburg County, SC School Board
Larry Odom	Williamsburg County, SC DSS/National Guard Liaison
Linda Grice	Marion County, SC Disaster Preparedness
Pete Rogers	Marion County, SC Disaster Preparedness
James Blake	Marion County, SC American Red Cross
Paul McKenzie	Dillon County, SC Disaster Preparedness
Preston Beach	Dillon County, SC American Red Cross
Betty Polk	Hampton County, SC Disaster Preparedness
Ted Druhot	Palmetto Chapter, SC American Red Cross
Shirley Druhot	Palmetto Chapter, SC American Red Cross
Laura McKenzie	Palmetto Chapter, SC American Red Cross
Jackie Davidson	Palmetto Chapter, SC American Red Cross
Carol Siddall	Palmetto Chapter, SC American Red Cross
Winnie Altman	Hampton County, SC Disaster Preparedness
Sidney DuPree	Hampton County, SC Sheriff Office
Bernie Zurenda	Hampton County, SC DSS
Rudy Smith	Jasper County, SC Disaster Preparedness
Tommy Harrison	Horry County, SC Emergency Preparedness
David Beaty	Horry County, SC Sheriff Office
Phillip Thompson	Horry County, SC Police Department
David Roper	SC Law Enforcement Division
V. J. Arnette	SC Law Enforcement Division
R. E. Gosnell	SC Highway Patrol
Rick McDow	Horry County, SC American Red Cross
Tom Matheson	National Weather Service, Wilmington, NC

North Carolina

Billy Ray Cameron	NC Division of Emergency Management
Buddy Jackson	NC Division of Emergency Management
Will Brothers	NC Division of Emergency Management
Doug Hoell	NC Division of Emergency Management
Tom Collins	NC Division of Emergency Management
Chris Coudriet	NC Division of Emergency Management
George Sullivan	NC Division of Emergency Management
Michelle Sparrow	NC Division of Emergency Management
Bill Gentry	NC Division of Emergency Management
Daden Wolf	Beaufort County, NC Emergency Management
Bobby Joyner	Pitt County, NC Emergency Management
Doug Belch	Chowan County, NC Emergency Management
Patty Madry	Chowan County, NC Emergency Management
Dale Lilley	Martin County, NC Emergency Management
Billy Smithwick	Bertie County, NC Emergency Management
Charles Jones	Hertford County, NC Emergency Management
Christy Saunders	Pasquotank/Camden County, NC Emergency Management
Ann Keyes	Washington County, NC Emergency Management
Donnie Beachum	Currituck County, NC Emergency Management
Sandy Sanderson	Dare County, NC Emergency Management
Cheryl Booth	Dare County, NC Emergency Management
Mitchell Newman	Hyde County, NC Emergency Management
Billy Pritchard	Elizabeth City, NC Fire Department
Tony Siebers	National Weather Service, Wilmington, NC
Dan Bartholf	National Weather Service, Newport, VA
Cecil Logan	Brunswick County, NC Emergency Management
Dan Summers	New Hanover County, NC Emergency Management
Brenda Coffey	New Hanover County, NC Emergency Management
Richard Tyndall	Jones County, NC Emergency Management
Melvin Hill	Greene County, NC Emergency Management
Cheryl Grabowski	Cumberland County, NC Emergency Management
Ann Guyton	Columbus County, NC Emergency Management
Joe Gurley	Wayne County, NC Emergency Management
Stanley Kite	Craven County, NC Emergency Management
James Smith, Jr.	Lenior County, NC Emergency Management
Carson Smith	Pender County, NC Emergency Management
Don Herman	Onslow County, NC Emergency Management
Karen Wagley	Onslow County, NC Emergency Management
Dorothy Cavenaugh	Duplin County, NC Emergency Management
Al Hadley	Carteret County, NC Emergency Management
Mike Lowder	Bladen County, NC Emergency Management
Chief Peter Stone	US Coast Guard, Ocracoke Island, NC

Drew Wilson	Virginian Pilot Newspaper, Nags Head, NC
Pete Montague	American Red Cross
J. I. Leggett	NC Department of Transportation

Virginia

Mary Camp	Virginia Division of Emergency Services
Wallace Twigg	Virginia Division of Emergency Services
Tricia Chappell	Chesapeake, VA Emergency Services
Dave Reckelhoff	Virginia State Police
Richard Denny	Virginia State Police
Craig Garriss	NC Highway Patrol
Paul Moye	US Army Corps of Engineers, Norfolk District
Bob Shapiro	FEMA, Region III

Assessment Team Members

The following individuals were members of the team that conducted the post storm assessment for Hurricanes Bertha and Fran.

Bill Massey	FEMA, Region IV
Dr. Robert Smith	FEMA Reservist - Chatham County, GA Emerg. Mgmt
Billy Wagner	FEMA Reservist - Monroe County, FL Emerg. Mgmt
William Winn	FEMA Reservist - Beaufort County, SC Emerg. Mgmt
Sandy Sanderson	FEMA Reservist - Dare County, NC Emerg. Mgmt
Jennifer Watson	US Army Corps of Engineers, Charleston, SC
Royce Tipton	US Army Corps of Engineers, Jacksonville, FL
Allan McDuffie	US Army Corps of Engineers, Wilmington, NC
Al Bjorkquist	US Army Corps of Engineers, Wilmington, NC
Don Lewis	Post, Buckley, Schuh & Jernigan, Inc.
Robert Hertz	Post, Buckley, Schuh & Jernigan, Inc.

SUMMARY AND RECOMMENDATIONS

The purpose of this post-storm assessment is to evaluate the effectiveness and usefulness of hurricane evacuation study (HES) data and products which were used during Hurricanes Bertha and Fran evacuations in Georgia, South Carolina, North Carolina and Virginia. The development of recommendations for improvements to hurricane evacuation studies, and restudies, is a key component of this process. Presented below is a summary of the events and the general, program level, observations and recommendations which resulted from this analysis. Detailed recommendations for each state are provided at the end of each chapter.

A. Summary.

Hurricanes Bertha and Fran prompted multi-state evacuations along the U. S. Atlantic coast during the busy 1996 hurricane season. An estimated 750,000 people evacuated for Hurricane Bertha, and nearly a half-million tourists and residents were ordered to evacuate the coast in North and South Carolina alone during Fran. In spite of the large number of evacuees fleeing hurricane vulnerable areas, officials successfully carried out the evacuations with minimal difficulty, using an arsenal of tools and information sources to aid in decision making. A well choreographed multi-agency response ensued when Hurricane Bertha threatened in mid-July, because officials were well trained and well prepared. When Hurricane Fran made landfall, just two months later, lessons learned during Bertha were already incorporated into local evacuation plans. Public behavior mirrored the proactive response of officials - in spite of two ordered evacuations in virtually the same areas of the coast, in as many months.

B. General Observations.

- 1. Hurricane Evacuation Study products are still useful to state and local officials, however, officials have little to no confidence in data contained in outdated studies. Each state included in this analysis has an ongoing restudy, or is scheduled for a restudy, but each had to endure the active 1996 hurricane season using old data. Guidelines and responsibilities for performing maintenance, update and restudies should be published and provided to local and state officials. Federal contributions to the updating efforts should be programmed well in advance of the need.
- 2. For the most part, state and local officials are using HES products appropriately. There were no cases examined where there were inappropriate uses of the products, however, some local officials did not use some of the products provided with their studies. This case mostly applied to computer models and was mainly due to inadequate or infrequent training. Hurricane Evacuation Studies should provide periodic training on the use of products and provisions should be made to include periodic training in areas where studies have been completed.
- 3. Inland counties were generally unfamiliar with HES products and concepts, yet inland counties play a major role in the success of an evacuation. They shelter evacuees and manage evacuating traffic to provide thoroughfares to safety. In future studies,; coordination during the HES process should be expanded into inland counties to ensure that statewide evacuation planning needs are addressed.

C. Hazards, Vulnerability and Decision Making Tools Recommendations.

- 1. All officials indicated that evacuation zones, as presented in their HES, were too complicated to communicate to the public. Where evacuation orders were issued, general descriptions were used to identify areas that needed to evacuate such as "low lying areas, beachfronts, barrier islands, mobile homes, waterfronts, areas east of Highway 17, areas near water courses, flood prone areas, etc." Evacuation zoning methodologies should be re-evaluated in future evacuation studies.
- 2. In all cases, officials indicated that HURREVAC is in need of upgrading. Better graphics, adaptation to a "Windows" environment, easier access to input information during an emergency, increased user friendliness and inclusion of more information such as rainfall data, tide data, etc. were some recommendations provide by officials to improve HURREVAC.

D. Public Response and Mitigation Recommendations. In general, the behavior of tourists during hurricane threats is not well documented. This is mostly because of the inherent difficulty in collecting the data during an emergency or in a post-storm setting. In spite of the difficulties, state and local officials continue to need, and request, behavioral information for tourists populations, especially in those areas where vulnerable populations can double (or even triple) during peak tourist season. The HES program should evaluate the need for new strides in this area of the program.

E. Public Shelter Recommendations. Future hurricane evacuation studies should include non-detailed shelter analyses. This is mainly because shelter openings and assignments are made, for the most part, on a storm-by-storm basis, and because shelter inventories may require regular updating.

F. Transportation/Clearance Times Recommendations.

- 1. There is a significant need to re-educate (and educate) officials on the concept of clearance time. Serious concerns were raised about the different interpretations that are used and the impacts of those differences.
- 2. The State of South Carolina was able to capture extensive traffic count data along key evacuation routes during Bertha and Fran. As a result, Federal, state and local officials are able to review and understand the traffic movements during the evacuations. The information will help to facilitate smoother evacuations in the future and will provide key input to future transportation analyses and clearance times development for the-state. Other hurricane prone states should be encouraged to incorporate provisions to collect this type data into hurricane preparedness plans.
- 3. Many officials did not use evacuation zones, as presented in their studies, to evacuate for Hurricanes Bertha and Fran. In spite of this fact, actual evacuation times did not exceed estimated HES clearance times, even in areas with "outdated" transportation analyses. This is an indication of healthy conservatism which is inherent in the HES transportation analysis. Future transportation analyses should employ similar approaches to ensure clearance time estimates remain conservative.

G. Public Information Recommendations.

CHAPTER 1 - INTRODUCTION

Overview

The year 1996 was a busy year for hurricanes in the Atlantic basin. Following the near-record breaking 1995 season, the 1996 hurricane season featured above normal hurricane activity and a much above normal number of intense hurricanes. There were 13 tropical storms of which nine became hurricanes. Six of the hurricanes reached Category 3 or higher intensity on the Saffir/Simpson Hurricane Scale. Two hurricanes - Bertha and Fran - made landfall in the southeastern United States, both along North Carolina's south coast. Their threats prompted multi-state evacuations from hurricane vulnerable coastlines.

Hurricane Bertha was an early season Cape Verde Hurricane that moved across the islands of the northeastern Caribbean Sea as a category 1 hurricane on the Saffir/Simpson scale and made landfall on the North Carolina coast near Wilmington as a category 2 hurricane. The primary effects of Hurricane Bertha in the continental U. S. were to coastal counties in North Carolina. Damages included storm surge flooding and beach erosion, roof damage, piers washed away, falled trees and damage to crops. A survey indicated over 5000 homes were damaged, mostly from storm surge. Total U. S. damages from Bertha are estimated at $250 million. Eight deaths were reported as related to Bertha, with none caused by storm surge flooding. An estimated 750,000 people evacuated for Hurricane Bertha.

Hurricane Fran was also a Cape Verde hurricane which moved across the Atlantic during the peak of the 1996 hurricane season. It made landfall on the North Carolina coast as a category 3 hurricane on the Saffir/Simpson scale, resulting in significant storm surge flooding on the North Carolina coast, widespread wind damage over North Carolina and Virginia, and extensive flooding from the Carolinas to Pennsylvania. U. S. damages from the storm are estimated at $3.2 billion. Storm surge on the North Carolina coast destroyed or seriously damaged numerous beachfront houses. Widespread wind damage to trees and roofs, as well as downed power lines, occurred as Fran moved inland over North Carolina and Virginia. Extensive flooding was responsible for additional damage in the Carolinas, Virginia, West Virginia, Maryland, Ohio and Pennsylvania. Thirty-four deaths, with twenty-one in North Carolina alone, are attributed to Hurricane Fran's fury. Nearly a half-million tourists and residents were ordered to evacuate the coast in North and South Carolina.

When a hurricane makes landfall in the U. S., it presents a unique opportunity to learn from the experiences of those who were involved in the emergency, and to assess the usefulness and accuracy of the tools which were used to aid in evacuation decision making.

Purpose and Scope

This post-storm analysis was requested by the Federal Emergency Management Agency (FEMA), and conducted by the U. S. Army Corps of Engineers, to assess the effectiveness and usefulness of hurricane evacuation study (HES) data and products which were used during Hurricanes Bertha and Fran evacuation activities in Georgia, South Carolina, North Carolina and Virginia. Development of

recommendations for improvements to hurricane evacuation studies and restudies is also included in the scope of this assessment.

Teams composed of representatives from the Corps of Engineers, FEMA, state and local emergency management officials, and the firm of Post, Buckley, Schuh & Jernigan visited and discussed evacuation experiences with state and local emergency managers and media representatives in the impact and near-impact areas. More than 50 separate governmental entities were interviewed in Georgia, South Carolina, North Carolina and Virginia. Table 1-1 below provides the distribution areas included in this assessment.

Discussions with state and local emergency managers were centered on if, and how, products produced by hurricane evacuation studies were used. Information on whether study data was accurate and in useable formats was also requested. Suggestions for improvements to the products or to the way they were used were solicited. Specifically, the answers to several key questions were sought:

- * Were local and state officials using the products provided by the hurricane evacuation studies?
- * Was the data in the studies related to storm hazards, behavioral characteristics of the evacuees, shelter information, evacuation times, and decision-making accurate and reliable?
- * Which study products were most useful and least useful?
- * What improvements should be made to current methodologies, technologies and products?

Prior Hurricane Evacuation Studies

Prior to the onset of Hurricanes Bertha and Fran, comprehensive hurricane evacuation studies had been completed for Georgia (in 1989), South Carolina (in 1986), North Carolina (in 1987), and Virginia (in 1992). Restudies of the South Carolina and North Carolina coastlines were underway when the storms made landfall, and the need for a restudy or update of the Georgia and Virginia coastlines was under investigation.

Report Format

This report is organized differently from past post-storm assessments. Past reports organized information similarly to a hurricane evacuation study Technical Data Report. Separate chapters addressed hazards, vulnerability, shelter, behavioral and transportation analyses and findings. This report, however, presents general information on the storms, then it presents specific information on four states and their respective experiences during the evacuation activities. This approach is used in an effort to help FEMA, the Corps of Engineers, and state and local emergency managers isolate problems or successes which were specific to Georgia, South Carolina, North Carolina and Virginia.

Because the decision making processes and evacuation plans vary from state to state, an overview of each state's hurricane evacuation decision making structure is presented so that the reader may better relate to the different strategies used by each state during these evacuations. This presentation is not intended to recommend one state's methodology over another, but rather to indicate how different strategies are employed to accomplish the same objective.

CHAPTER 2 - STORM INFORMATION AND EVACUATION CHRONOLOGY

History of Hurricane Bertha

Bertha originated from a tropical wave which moved from Africa to the Atlantic on July 1. A weak circulation was first detected on satellite imagery on July 3, centered about 500 nautical miles south of the Cape Verde Islands in the far eastern Atlantic Ocean. The track of the circulation center began on July 5 when the circulation became a tropical depression in the central tropical Atlantic. For three days, the storm followed a fairly smooth curved path and moved toward the west-northwest at the fast forward speed of 20 to 25 knots, strengthening to a hurricane with one-minute maximum sustained winds of 75 knots on July 8 as the center moved across the Leeward and Virgin Islands of the northeastern Caribbean. The track gradually turned northwestward on July 9th. By July 1O and 11, Bertha's center moved parallel to the coast of Florida and Georgia at a distance of 150 to 175 nautical miles offshore. During this time, the forward speed slowed to about 8 knots. Moving northward and re-accelerating to a forward speed of 15 knots, Bertha made landfall on July 12 on the coast of North Carolina, with the center crossing the coast midway between Wrightsville and Topsail Beaches. Figure 2-1 shows the storm track of Bertha.

Bertha had been gradually weakening since its top speed of 100 knots on the 9th to 70 knots on the 11th. Then, in 12 hours just before landfall, the winds increased to 90 knots, which is the estimated maximum one-minute wind speed at landfall. Bertha quickly dropped below hurricane strength when it moved inland over eastern North Carolina. It then moved northeastward along the U. S. east coast, producing 40 to 50 knot sustained winds over land from northern North Carolina to New England, and 60 knot winds over nearby Atlantic waters. Bertha was declared extratropical on July 14 when the center moved from the Maine coast to New Brunswick, Canada. The extratropical storm brought 40 to 50 knot winds to the Canadian Maritime Provinces and was tracked to just south of Greenland on July 17. Figure 2-2 shows Radar Imagery of Bertha.

Storm total rainfall amounts ranged from 5 to 8 inches along a coastal strip from South Carolina to Maine. Coastal storm surge flood heights, from Florida through New England, ranged from 1 to 4 feet, but values to 5 feet were estimated on the North Carolina coast from Cape Fear to Cape Lookout. A storm surge of 6 feet or a little higher is indicated near Swansboro, where 5 to 6 feet of water was "inside of businesses on the waterfront" (from Newport, North Carolina National Weather Service Forecast Office Preliminary Storm Report.)

Hurricane warnings were issued from Sebastian Inlet, Florida to Chincoteague, Virginia as well as for the Bahamas and for the islands of the northeastern Caribbean Sea from Antigua through Puerto Rico. Tropical storm warnings were issued from Sebastian Inlet to north of Deerfield Beach, Florida and from north of Chincoteague to Watch Hill, Rhode Island. Almost all of the U. S. east coast was involved with some watch or warning and this is the result of the storm track's expected close passage to the southeast U. S. coast. The hurricane watch for the North Carolina landfall area was issued 65 hours before landfall and the hurricane warning was issued 47 hours before landfall. This is far more than the 36- and 24-hour lead times that the National Hurricane Center strives for and is the result of the forward motion decreasing at a faster rate than expected.

Hurricane Bertha Evacuation Chronology

An overview of the chronology of evacuation events in a hurricane threatened area is useful to understanding the complex nature of evacuation decision making, and the contribution of the decisions to a successful, or unsuccessful, evacuation effort. Such a chronology may serve to illustrate how, or if, decision makers responded to different stimuli, and it may also disclose the interrelationship of the actions of the responders. Stimuli such as hurricane warnings and watches, information provided by decision making tools and decisions of neighboring jurisdictions, for example, often provide the impetus for key decisions. Understanding the relationships is important to improving future efforts.

To state and local officials, an evacuation chronology may be useful, not only in demonstrating how their actions fit into the overall scheme of the evacuation, but also in demonstrating how their actions impacted or influenced the actions of others in the area. To Federal officials, an evacuation chronology may be useful in determining how the development or enhancement of information sources and decision making tools might better serve decision makers.

This evacuation chronology was compiled using hurricane evacuation study related information that was obtained during interviews with officials in the impacted area. No attempt is made to capture information on political, readiness or other factors which also play a major role in evacuation decision making. A general description of the chronology of evacuation activities which occurred in Georgia, South Carolina, North Carolina and Virginia is presented below.

During Bertha, most evacuation actions appear to have been made in response to hurricane watch and warning postings by the National Hurricane Center. Early actions to the threat included the activations of Emergency Operations Centers (EOC's) in the threatened area, although, the Georgia Emergency Management Agency (GEMA) and some counties in Georgia were already poised when Bertha approached, having activated for the Olympics on July 2nd. When asked what prompted the decision to activate, many emergency managers indicated their decisions were based on "the probability of the storm hitting," "24, 36, 48 or 72 hours before possible landfall," "when there was a direct threat," and "according to the state's plan and Operating Conditions - OPCON - status."

A hurricane watch was issued for areas north of Brunswick, GA to the NC/VA border at 11:00 p.m. on Tuesday, July 9th. Early the next morning, EOC's were activated in SC, and a voluntary evacuation order was issued for Beaufort County, SC. At midday, on July 10th, a hurricane warning was issued for Sebastian Inlet, FL to Cape Romain, SC. In response, the Governor of GA declared a state of emergency for Bryan, Camden, Chatham, Glynn, Liberty and McIntosh Counties. Voluntary evacuation orders were subsequently issued for most of these counties. (Because the first South Carolina evacuation order - a voluntary order issued by Beaufort County, SC - was issued a full 6 to 8 hours before Georgia's first order, Georgia's evacuating public met South Carolina's evacuees who crowded Georgia escape routes and nearly filled hotels and motels in inland Georgian counties.) In South Carolina, the hurricane warning prompted shelter openings and a mandatory evacuation order in Beaufort County. In North Carolina, Onslow County requested a voluntary evacuation of tourist in response to the warning.

At 5:00 p.m. on July 10th, the hurricane warning was extended from Cape Romain, SC to the NC/VA border. At 7:00 p.m., the Governor of South Carolina made a media appearance and encouraged voluntary relocation for citizens along the entire South Carolina coastline. North Carolina's response to the warning began early the next morning with evacuation requests and recommendations in Dare, Onslow and Beaufort Counties, and mandatory orders in New Hanover and Pender Counties. In South Carolina, activities were increased at mid-day on the eleventh with a State of Emergency declaration by the Governor, and issuance of a mandatory evacuation order for Horry and Georgetown Counties. No significant evacuations were noted in Virginia during Bertha's approach.

Table 2-1 provides an overview of the timing of state and county preparations and evacuation orders. This information is shown in relation to significant changes in the behavior of Hurricane Bertha and watch and warning postings provided by the National Hurricane Center. Most evacuation activities noted in the assessment area appear to have been successfully completed well before the arrival of Bertha's hazards. Bertha made landfall at 4:00 p.m. on July 12th between Wrightsville and Topsail Beaches, NC.

History of Hurricane Fran

Hurricane Fran formed from a tropical wave that emerged from the west coast of Africa on August 22. The system became a tropical depression just southeast of the Cape Verde Islands on August 23. The tropical depression moved westward near 15 knots for the next few days without significant development. This lack of development may be attributed, in part, to disrupted low-level inflow due to the large and powerful Hurricane Edouard which was centered about 750 nautical miles to the west-northwest. Satellite intensity estimates suggest that the depression became Tropical Storm Fran on August 27 while located about 900 nautical miles east of the Lesser Antilles. Fran began to track toward the west-northwest in the wake of Hurricane Edouard. The storm reached hurricane status on August 28 while centered about 400 nautical miles east of the Leeward Islands. The center of Fran was about 150 nautical miles to the northeast of the Leeward Islands on August 30. The tropical cyclone weakened to just below hurricane strength later on the 30th, possibly due to the low-level inflow being disrupted again by Edouard. About this time, changing steering currents caused Fran to turn toward the northwest and slow to about 5 knots. By August 31, as Edouard moved farther away, Fran had regained hurricane strength. Figure 2-3 shows the storm track of Fran.

Fran strengthened to a category 3 hurricane by the time it was northeast of the central Bahamas on September 4, and reached maximum intensity on September 5 when it was centered about 250 nautical miles east of the Florida east coast. Fran was moving northward near 15 knots when it made landfall on the North Carolina coast. The center moved over the Cape Fear area on September 5, but the circulation and radius of maximum winds were large and hurricane force winds likely extended over much of the North Carolina coastal area of Brunswick, New Hanover, Pender, Onslow and Carteret Counties. At landfall, the minimum central pressure was estimated at 954 Mb and the maximum sustained surface winds were estimated at 100 knots. Fran weakened to a tropical storm while centered over central North Carolina and subsequently to a tropical depression while moving through Virginia. The tropical cyclone gradually lost its warm core as it moved over the eastern Great Lakes and became extratropical on September 8 while centered over southern Ontario. The remnants of Fran were absorbed into a frontal system on September 10.

Initial survey results show an extensive storm surge along the North Carolina coast primarily southwest of Cape Lookout. Still water mark elevations on the inside of buildings, indicative of the storm surge, range from 8 to 12 feet. Outside water marks on buildings or debris lines are higher due to the effect of breaking waves. Rainfall totals exceeding six inches were common near the path of Fran. Precipitation estimates were as high as 12 inches over portions of Brunswick and Pender Counties in North Carolina. Figure 2-4 shows Radar Imagery of Fran.

Extensive flooding spread well inland from the Carolinas into Virginia, West Virginia and Pennsylvania. Some of this flooding was considered the most severe in years. Near Washington, D. C., for example, the Old Town district of historic Alexandria was partially evacuated as the Potomac River rose, flooding streets with more than three feet of water. Hurricane warnings were posted for the hardest hit portions of the North Carolina coast about 27 hours prior to landfall.

Hurricane Fran Evacuation Chronology

As with Hurricane Bertha, during Hurricane Fran, most evacuation actions appear to have been made in response to hurricane watch and warning postings by the National Hurricane Center. State and local agencies responded, generally, to hurricane watches by activating EOC's and by issuing voluntary evacuation orders. Hurricane warnings prompted mandatory evacuation orders and shelter openings. In general, coastal response preceded inland actions.

A hurricane watch was issued on September 3rd at 11:00 p.m. (EDT) for areas north of Sebastian Inlet, Florida to Little River Inlet, South Carolina. Actions in response to the watch began at 6:00 a.m. the following day, on September 4th, with activations of EOC's in Georgia and South Carolina, and a voluntary relocation request for the coast of South Carolina by its governor. At 2:00 p.m; that same day, National Weather Service Public Advisory #44A indicated that "a hurricane warning is likely to be issued this evening or tonight for a portion of the watch area." Both states took aggressive actions to protect the public by issuing orders before the actual hurricane warning was posted at 5:00 p.m. on September 4th. Within a couple of hours of the advisory, mandatory evacuation orders were issued for Chatham County, Georgia, and for South Carolina's coastline. Evacuation response continued over into the night with some evacuations, Horry and Beaufort Counties in South Carolina, for example, completing shortly after midnight.

Unlike during Hurricane Bertha, Georgia and South Carolina initial responses were nearly simultaneous. Both states began preparations when a hurricane watch was posted for an area that covered both states, i.e. "north of Sebastian Inlet, FL to Little River Inlet, SC. The first hurricane watch for North Carolina followed that for Georgia and South Carolina by 12 hours (issued on September 4th at 11:00 am.)

When a hurricane watch was issued for areas north of Cape Lookout, North Carolina to Currituck Beach Light, North Carolina on September 4th at 5:00 pm, New Hanover County and Onslow County quickly responded by requesting voluntary evacuation of vulnerable areas. When the warning area was extended to areas north of Cape Lookout, North Carolina to the North Carolina/Virginia border including the Pamlico and Albemarle Sounds at 11:00 p.m. on September 4th, major North Carolina responses began on the following morning with EOC activations, shelter openings and evacuation

orders issued in New Hanover, Brunswick, Onslow and Pender Counties.

Interview information suggests that some evacuations were not completed in the impact area before the arrival of gale force winds. For example, some shelter openings in North Carolina followed NWS Public Advisory #49 (issued at 5:00 p.m. on September 5th) which indicated that "hurricane force winds are beginning to spread across the coast in hurricane warning areas." Also, in the shelter analysis evaluation section of this report for North Carolina, indications are that evacuees were arriving at shelters in New Hanover County, NC "all the way up to landfall. " One North Carolina American Red Cross official offered the following explanation: "Many times people opt not to evacuate although strongly advised to do so by the local authorities. Upon landfall, they realize how dangerous the situation has become and then decide to go into a shelter. Once a shelter reaches at least half of its capacity, additional shelters are opened. Should a shelter approach full capacity before a hurricane makes landfall, another shelter is then opened. Therefore, it is possible that evacuees could arrive up to the time of landfall."

Table 2-2 provides an overview of the timing of state and county preparations and evacuation orders. This information is shown in relation to significant changes in the behavior of Hurricane Fran and watch and warning postings provided by the National Hurricane Center.

CHAPTER 3 - STATE OF GEORGIA

Evacuation Decision Making Structure

In accordance with state laws, the Georgia Emergency Management Agency has adopted a decentralized approach for evacuation decision making. Local authorities are empowered to make evacuation decisions for their jurisdictions. All efforts at the state level are focused on providing information and recommendations to local authorities to assist in this task.

a. Role of the Governor. According to the Georgia Emergency Management Act, the Governor can "direct and compel the evacuation of all or part of the population from any stricken or threatened area within the state if he deems this action necessary for preservation of life or other disaster mitigation, response or recovery ... (and) prescribe routes, modes of transportation, and destinations in connection with evacuation." This action results only in emergencies which are beyond local control. During Hurricanes Bertha and Fran, the Governor declared a state of emergency before landfalls, but did not take particular actions in regards to evacuation decision making.

b. Role of the Georgia Emergency Management Agency (GEMA). GEMA's role in evacuation decision making is to assist and advise the local officials in their decision making efforts and to coordinate local, state and federal efforts. Under the state hurricane plan, GEMA "may recommend evacuation to save lives and property in anticipation of direct effects of a hurricane." It would only assume direction and control "in the event evacuation requirements are beyond the capabilities of the local governments(s) affected." Evacuation requirements during Hurricanes Bertha and Fran did not exceed local capabilities, therefore, GEMA did not exercise this specific authority.

c. Role of Local Elected Officials. The Georgia Emergency Management Act provides the authority to the County Commission or elected authority to order evacuation when deemed necessary to protect lives. In most cases, the Chief Executive Officer of the County, usually the County Commissioner, has the responsibility of issuing evacuation orders for their local areas. In all cases examined for Hurricanes Bertha and Fran, when evacuation orders were issued, local officials exercised the authority to do so.

d. Role of Local Emergency Managers. Local Emergency Managers have the primary role of coordinating the activities of support agencies including those of local support agencies as well as those of the National Weather Service and the National Hurricane Center. They track storm movement and employ the use of decision making tools to provide expert knowledge for evacuation decision making to the elected officials. During Hurricanes Bertha and Fran, local emergency managers carried out these responsibilities, using an array of tools to assist in their evacuation recommendations.

e. Role of Support Agencies. Support agencies such as law enforcement, transportation, human resources, Department of Defense, Red Cross, school board, etc. can provide key input for evacuation decision making. They can provide knowledge on the probable success of an evacuation and also can provide recommendations on increasing the success rates of evacuations. Their input is crucial to elected officials in deciding if, or when, an evacuation order must be issued.

Hurricane Evacuation Studies

A Hurricane Evacuation Study for the State of Georgia was conducted in the late 1980's. Storm surge maps were completed in 1987, the behavioral analysis was completed in 1987 and the Technical Data Report was published in 1989. The evacuation study included the following counties: Chatham, Glynn, McIntosh, Camden, Liberty and Bryan.

When questioned about the continued usefulness and value of the overall hurricane evacuation study, state and local officials cited many instances where the data provided in the 1989 study is outdated and is increasingly less useful for evacuation planning in areas of the state which did not have recent updates. Population data no longer provides a true representation of potential evacuees, especially in the rapidly growing coastal areas. Shelter data is out of date and no longer resembles the existing shelter situation in the state. Clearance times are questionable given the changes in the population and roadway networks. For these reasons, the State has made recent efforts to update the data contained in the original hurricane evacuation study.

The behavioral analysis for Chatham, Bryan, Liberty, McIntosh, Glynn and Camden Counties was updated in 1995 by Armstrong State College. The transportation analysis for Chatham, Glynn and Camden Counties was updated by the Architect- Engineer firm Post, Buckley, Schuh, and Jernigan Inc. in 1995. The updated transportation analysis considered increased population in the areas but resulted in decreased clearance times. These seemingly conflicting results are believed to be attributable to insufficient data which as available during the original study.

A restudy for the State of Georgia was initiated in 1997. The restudy will focus on: updating hurricane surge atlases utilizing new National Weather Service SLOSH ("Sea, Lake, Overland Surges from Hurricanes") model hurricane surge predictions; updating population data; reassessing human behavior in response to hurricane threats; revising the state-wide shelter plan; and recalculating clearance times for the area.

In an attempt to improve the data produced during the Georgia hurricane evacuation restudy, an analysis of the events surrounding the responses to Hurricanes Bertha and Fran is provided in the remainder of this chapter. A team composed of representatives from the Corps of Engineers, FEMA, and the firm Post, Buckley, Schuh & Jernigan visited and discussed pre-landfall events with state and county emergency managers, support agencies and media representatives in the following Georgia counties:

Table 3-1
Participating Georgia Counties

Coastal Counties	Inland Counties
Chatham	Laurens
Bryan	Bibb
Liberty	Columbia
McIntosh	Richmond
Glynn	
Camden	

The remainder of this chapter will address the hazards, vulnerability, shelter and transportation issues which surrounded the evacuations for Hurricanes Bertha and Fran in the State of Georgia. No public response analysis is made because no significant levels of evacuation were carried out in the state.

Georgia Hazards and Vulnerability Data

The main objective of a Hurricane Evacuation Study hazards analysis is to predict the effects of storm tide flooding from hurricanes of varying intensities. The hazards analysis quantifies the expected hurricane generated storm tide flooding that would inundate an area, and it generally references possible riverine flooding caused by rainfall associated with a hurricane. In recent studies and updates, the effects of hurricane winds have been included by introduction of an inland wind model. This model, which was available to the State of Georgia during Hurricanes Bertha and Fran, provides information that will help inland communities prepare for threatening high wind conditions.

The vulnerability analysis uses the results of the hazards analysis to identify the population which will be vulnerable to the effects of a hurricane. Using storm surge maps, census data and inland wind models, the surge vulnerable population and those structures which are vulnerable to high winds (such as mobile homes) are mapped according to evacuation zones. These zones are designed to be operational tools; to be used in communicating to the public the areas that should evacuate under various hurricane threats.

In this analysis, the accuracy and usefulness of the hazards and vulnerability data provided by the Georgia Hurricane Evacuation Study were examined. In particular, this assessment sought to evaluate the following areas:

- * Was the data accurate in depicting potential and actual hazards?
- * Did the data adequately estimate the population vulnerable to the hazards?
- * Was the data useful as an evacuation planning resource?
- * Was the data appropriately used for the evacuations?

Because Hurricanes Bertha and Fran did not make landfall near the Georgia coast, the state did not experience hurricane storm surge. For this reason, an evaluation of how well the SLOSH model performed in predicting storm surge in Georgia was not made. Also, for this same reason, the extent of riverine flooding and inland wind intensity were not evaluated. The hazards and vulnerability evaluation in Georgia focused on the amount of confidence decision makers had in the data's depiction of the potential hazards as they were tracking the storms' approaches. It also focused on if, and how, the data was used by state and local officials to assist in decision making.

a. Hazards Identification and Decision Making.

Generally, decision makers felt that storm surge maps adequately presented the potential surge which could be generated by Hurricanes Bertha and Fran, but believe that the surge maps are outdated, and in some cases overestimate potential surge heights. Although they believe that the Technical Data Report data is in need of updating, they believe that the data was useful as an evacuation planning resource and expressed confidence in it. They believe that the inland winds model is adequate, but most felt that they did not have enough training to use the tool effectively. There was a general consensus that a variety of sources were required to obtain all the hazards information needed. The Weather Channel and Data Transmission Network (DTN) were the most frequently cited sources for hazards identification. GEMA and the National Weather Service were also cited, but in most cases, it was reported that information from these two sources was not provided to the extent needed. HURREVAC was used but GEMA experienced technical breakdowns as a server in downloading the input information.

For the most part, evacuation decision makers relied on local knowledge and experience for identifying areas which needed to evacuate. GEMA, the National Weather Service, and to a lesser extent, HES tools were used to determine when evacuation orders should be given. In retrospect, most official believe that the areas evacuated were appropriate, and the issuance of evacuation orders (with the exception of Chatham County) were believed to be timely.

b. Vulnerability.

HES identification of vulnerable populations and structures were believed by Georgia officials to be adequate. Evacuation zoning of the vulnerability population, however, was not. Evacuation zones, as delineated in the HES were not used. Most emergency officials felt that the zones were too cumbersome and that they would be too confusing to communicate to the public. Evacuation zones were simplified and incorporated into local evacuation plans well-in advance of the storms. In the majority of the cases where evacuation orders were issued, no reference to zone numbers or names were used in public information. Officials used general descriptions to identify areas which needed to evacuate such as "low lying areas, waterfronts, mobile homes, islands, etc." Evacuation routes were used as outlined in the Technical Data Report.

Overall, officials used the HES hazards and vulnerability data appropriately and thought the data was useful, if current, as an evacuation planning resource. Because outdated data and inadequate training were the most often cited areas which need improvement, in future hurricane evacuation studies in Georgia, hazards and vulnerability products should be structured (to the extent possible) so that

frequent updating of information such as surge areas and population data can be easily accomplished at the state or local levels. Future studies should also include provisions which will insure that periodic training on HES products and tools is available to state and local officials. Refresher courses on the use of HES data and products would help in reducing unfamiliarity with the products on the part of new emergency officials or of those who, fortunately, did not have the opportunity to use the products in some period of time. This especially applies in cases where studies are complete or are otherwise inactive. Other decision making officials would also benefit from periodic training on hazard and vulnerability identification and evacuation decision making in Georgia.

Table 3-2 provides a summary of the hazards, decision making and vulnerability issues associated with Hurricanes Bertha and Fran.

Georgia Public Shelter Issues

The public shelter analysis of the Hurricane Evacuation Study lists public shelter locations, assess their vulnerability to flooding and estimates the number of evacuees who would seek public shelter for various types of hurricane scenarios. Shelter location and capacity data are obtained from local emergency management officials and from shelter management agencies such as the American Red Cross. Public shelter capacity is compared to public shelter demand figures generated from the vulnerability and behavioral analyses to determine potential capacity deficits or surpluses. The following type of information relating to public sheltering was sought during this assessment:

- * How many shelters were opened and how many people were sheltered?
- * What was the timing of shelter openings?
- * When did evacuee arrive at shelters?
- * What was the duration of sheltering?
- * What problems were encountered?

The State of Georgia has established a "Risk/Host" system for executing hurricane evacuations. Risk counties are those that are in the storm's direct path. Eleven counties on or near the coast have been designated as risk counties. Host counties are those that are expected to experience reduced, or no, impacts of the storm. Thirty-eight counties have been designated as host counties in Georgia. Generally, host counties provide shelter for evacuees fleeing the direct path of the storm.

Based on the latest guidelines, most American Red Cross hurricane shelters are located in host counties, and not in risk counties. In addition to Red Cross shelters, the Georgia state hurricane plan states: "County hurricane response plans will designate local shelters and refuge sites which could be used in an emergency when inland evacuation is impossible or too dangerous to attempt. Such shelters should also be used for minimal hurricanes or tropical storms when only barrier islands or low-lying areas are evacuated and inland shelters may not be required." During Hurricanes Bertha and Fran, only Red Cross shelters were utilized. Hurricane Bertha was a category 2 (not a major hurricane) during the evacuation decision making period and may have fallen into the category for non-Red Cross sheltering, however, this option was not exercised. Hurricane Fran was a category 3 hurricane during the evacuation decision making period and did not fall into the special sheltering category.

Because only partial evacuation activities were implemented in Georgia during Hurricanes Bertha and Fran, counties did not open many public shelters and there were few evacuees in opened shelters. Hotels and motels appear to have been the most sought after shelter accommodations during both storms. Most hotels and motels were full an entire day before landfalls. Several host counties activated their shelter systems and had facilities and shelter teams on standby, but did not have to utilize them. Some counties unnecessarily opened more than one shelter.

Overall, there were few sheltering problems encountered in Georgia during Hurricanes Bertha and Fran. Although some host county officials were unsure of the timing of and instructions contained in evacuation orders, they were well prepared for the few evacuees who sought shelter in their jurisdictions. Shelters were opened well before evacuees arrived and remained open until evacuees could safely return to their homes.

Most host county officials interviewed expressed a need for more coordination with risk counties and with neighboring states. Some officials were unaware of the timing of evacuation orders from the coast, or the number of potential shelterees which could be expected to seek shelter in their counties. Also, some stated that they were unaware that evacuees were instructed to "evacuate west and southwest from South Carolina."

Many evacuees fled to hotels and motels. Several emergency managers noted that the vast majority of cars in the parking lots of hotels and motels in Georgia host counties were from South Carolina. Many of the South Carolina evacuees arrived well before evacuation orders were given in Georgia counties.

Sheltering of pets was a minor issue which seem to have been easily overcome by some Georgia counties. For example, Bibb County was faced with a sheltering need for some 50 animals. The animals were sheltered in the city park.

Some inland counties were also faced with the issue of directing evacuees (who were, generally, unfamiliar with the area) toward public shelters. Directional signs, such as electronic message boards or permanent signs, would have been useful, but were not available during the evacuation. Table 3-3 provides a summary of shelter issues in Georgia during Hurricanes Bertha and Fran,

Several important factors which will affect shelter capacity and demand should be considered during future shelter analyses in Georgia. These include:

- * the inclusion of inland wind threats into the study;
- * changes which may occur in new SLOSH models which might alter vulnerabilities; and
- * the evacuation order statements from neighboring states.

In addition to the factors indicated, the Red Cross has re-assessed coastal county shelters in Georgia in accordance with their guidelines. The re-assessments may reduce the number of shelters available in the immediate threat area. The state does not suffer from a shelter deficit but has a need to design a new shelter strategy based on realistic numbers and destinations of evacuees. The state will be in a better position to support the counties during preparedness and response if a selected number of approved facilities along major evacuation routes were designated as the primary shelters.

Also during future shelter analyses, GEMA may want to incorporate measures into the statewide plan which will aid in reserving scarce shelter resources when they are not needed. Phased openings of shelters which correspond to the level of evacuation implemented may work in Georgia to accomplish this goal. This strategy has been successfully used in other states and works well to safeguard against unnecessary openings of unneeded shelters.

Georgia Transportation/Clearance Times Data

The primary objective of an HES transportation analysis is a determination of the clearance time needed to conduct a safe and timely evacuation for a range of hurricane threats. Clearance time estimates are built on information from the vulnerability, shelter and behavioral analyses and an analysis of the available evacuation highway network. Attention is focused on intersections and road segments that produce traffic bottlenecks - and thus lengthy clearance times - and recommendations are made for traffic control measures that will reduce clearance times.

Traditional post storm analyses of transportation and clearance time issues focused on answering the following questions:

- * Was the evacuation network accurate - did evacuees use the routes projected by the HES?
- * Were any traffic control actions taken to speed up flow?
- * When was the evacuation essentially completed - how long did the evacuation take - what were the actual clearance times?
- * What problems were encountered in the evacuation?

However, this type evaluation of transportation and clearance time issues is not appropriate given the extremely limited evacuations that took place along the Georgia coast. This study of the transportation issues in Georgia during Hurricanes Bertha and Fran focused on determining the level of evacuation that took place in Georgia. Traffic count information was obtained from the Georgia Department of Transportation, Jesup District, to aid in the analysis.

During Hurricane Fran, Georgia DOT officials collected evacuating traffic data at the I-16 and 1-95 interchange through manned monitoring. See Table 3-4. The data gives a glimpse of traffic movements that took place during the heart of the evacuation. Traffic was counted for six minutes of each hour beginning at 11 a.m. on September 4, 1996. The data was then factored up to an hourly flow figure by multiplying by a factor of 10. Traffic flow can vary considerably within an hour's time at a given location, but the data gives a rough idea of what was occurring. When coupled with traffic counts from the South Carolina I- 95 southbound (Jasper County Welcome Center) data, an idea of the level of out of county evacuation that took place from Chatham County can be obtained. It is assumed that most of the hour by hour South Carolina evacuation traffic coming south on I-95 went westbound on I-16. Consider the following data from the counts:

Normal daily directional traffic at this location is 8,390 vehicles. Subtracting that figure from the 11,020 vehicles attributable to Georgia gives us a rough figure of 2,630 evacuating vehicles associated with the Georgia (Chatham County primarily) evacuation at this location. This number is a small fraction of

what would be expected for a Category 2 or 3 level of evacuation based on the Georgia HES transportation analysis.

This data, coupled with the almost non-existent public shelter demand, would suggest a fairly low level of evacuation participation, particularly in Chatham County.

Table 3-5 below provides traffic/clearance time data that was gathered during the interview process. Evacuation durations were provided by state and county officials and were not derived from traffic count data. These durations most likely represent the duration/length of behavioral response, i.e., the duration over which people entered the road network or the timeframe over which evacuees were able to respond. (Primarily, behavioral response and evacuation network loading rates are influenced by the actions of public officials, which in turn is tied to urgency and aggressiveness.) Evacuation durations provided below do not indicate the time it took to clear the evacuation network, i.e., the clearance time. Clearance time analyses are appropriate only when full scale evacuations are carried out in an area. Only voluntary evacuation orders were issued in Georgia. This implies less than full evacuation participation.

Georgia Public Information

Although not a major part of the original hurricane evacuation study effort in Georgia, public information is now recognized as an integral element for successful evacuation planning and execution. 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. Hurricanes Bertha and Fran provided a glimpse of the current means used in Georgia to communicate hurricane evacuation information to the general public. These storms also provided local and state officials with an opportunity to evaluate the experiences with media coverage of the evacuation events.

Methods used in Georgia to inform the public in Bertha and Fran included print as well as broadcast media. Information was distributed by telephone, fax, press briefings, live interviews, etc. to the media for public dissemination. Information was also distributed at welcome and visitors centers.

In many cases in Georgia, television reporters were present in risk county EOC's or had direct access to emergency officials during evacuation activities. In Chatham County, for example, major television stations were present at the county EOC on a 24 hour basis. In interviews with media representatives during this assessment in Chatham County, quicker and more access to information was the primary area expressed which needs improvement. Media representatives indicated that they had to wait too long for information. They believed that information should be available to the public when compiled, and not only during scheduled briefings or established news hours. In this sense, some representatives stated that, in the public interest, the media should have access to the decision making process.

Some media representatives in Chatham County indicated that consensus (official) information was sometimes difficult to obtain, therefore, the information provided was confusing to the public. Television stations indicated that they had to field questions from the public on what actions should be taken. For

example, when evacuation orders were issued, some media representatives indicated that the public was confused about the difference between a "mandatory" and a "voluntary" order. Some sectors of the public believed that "voluntary" gave the impression that it was safe to remain in place. Others believed that any evacuation order implied that conditions were unsafe, regardless of whether or not the order was mandatory. In essence, a large segment of the population did not know if they should or should not evacuate, nor did they know whether or not officials were indicating that they were at risk of experiencing hurricane hazards.

Chatham County media representatives also indicated that they received many comments from the public indicating that the media "overreacted" during the storms. When asked how they would handle future hurricane threats, representatives indicate that they would "overreact" again, but would also provide historical hurricane information in addition to current information. (Media interview sources in Chatham County included WJCL-TV, WSAV-TV and WTOC-TV.)

In Laurens County, Georgia, a local newspaper (the Courier Herald) indicated that the paper has a good working relationship with the local emergency management agency, and depends on them for local interpretation of Associated Press news wire information.

In Bibb County, a local television station (WMAZ TV 13) indicated that they work very closely (at least monthly contact) with the Bibb County EOC. The station has recently worked with Bibb County on news stories about decision making computer models.

In Brunswick, Georgia, a local newspaper (the Brunswick News) stated that they coordinate information very closely with the Glynn County Emergency Management Agency and usually gets information in a timely manner from the agency. They also indicated that they are usually very conservative in reporting news about an approaching hurricane because they do not want to cause the public to panic.

Overall, relationships are well developed between local media and emergency agencies in Georgia. State and local officials benefit from active and interested media that are anxious to disseminate information to the public about hurricane threats. In general, however, all media representatives interviewed indicated that there is a substantial need for more graphics which can be used to help the public in understanding what threats a hurricane might pose. Most media representatives were unfamiliar with the Georgia Hurricane Evacuation Study, but some were familiar with the state hurricane plan.

Georgia Observations/Recommendations

The purpose of this post storm assessment is to improve the quality and usefulness of HES products in future studies, restudies and updates. The following recommendations are intended to accomplish this purpose and are grouped and presented by specific areas of hurricane evacuation planning.

a. Hazards and Vulnerability.

- 1) Conduct more training and awareness projects for decision makers and vulnerable

populations to ensure that they understand HES concepts and are in sync with the emergency community on evacuation decision making.

- 2) Provide more frequent training on HURREVAC and the Inland Winds model to ensure that officials understand how to manipulate the tools during a real event. This training should include local emergency managers, as well as other local officials and decision makers (as deemed appropriate.)
- 3) Update HURREVAC; consider adapting it for use in a windows environment; improve its graphics; simplify its information loading pathways; and make it more -user friendly. Also, consider adding more information such as rainfall data, fresh water flooding and tide data, etc.
- 4) Local officials should identify how evacuation zoning will be accomplished for incorporation into future vulnerability analyses.
- 5) Future studies should consider incorporating rainfall data and floodplain information into the SLOSH atlases.

b. Public Shelter Issues. In future shelter analyses, reassess shelter capacity and demand in the state based on changes in Red Cross guidelines, changes in vulnerabilities and the potential for evacuees in neighboring states seeking shelter in Georgia.

c. Transportation/Clearance Time Data.

- 1) In future analyses, increase the component of influxing traffic from neighboring states to determine the impact on Georgia's evacuation network.
- 2) In future studies, develop and disseminate the type of information that inland counties need on the timing of evacuation orders and on the number of potential evacuees who will travel to or through their counties.

d. Public Information.

- 1) There is a significant need for future evacuation studies to provide camera ready graphics such as maps of surge areas, evacuation routes, shelter location, etc. for local media.
- 2) Photographic, slide or video presentations should be prepared (at either the local, regional or national level) to help educate the public, including local officials, on the hurricane evacuation study and its concepts. Particular attention should be given to the notion of clearance times and the importance of evacuation completion before the arrival of gale force winds.
- 3) Hurricane related public information brochures could be expanded to include what hurricane hazards can be expected in inland counties, and how inland counties should prepare for the hazards.
- 4) Newspaper supplements could be prepared in advance of storms to be inserted a day before projected hurricane landfall.

CHAPTER 4

STATE OF SOUTH CAROLINA

Evacuation Decision Making Structure

In the State of South Carolina, the Governor is the only entity with statutory authority to issue an evacuation order. The South Carolina Emergency Preparedness Division (SCEPD) coordinates with local officials and emergency agencies, the National Weather Service, the National Hurricane Center and other support organizations on evacuation decision making, and participates in decision making recommendations to the Governor.

Hurricane Evacuation Studies

A Hurricane Evacuation Study for the coast of South Carolina was conducted in the mid-1980's. Hurricane surge atlases, a behavioral analysis, a transportation analysis, and the Technical Data Report were completed in 1986. The study area included Horry, Georgetown, Charleston, Berkeley, Dorchester, Colleton, Beaufort, Hampton and Jasper Counties.

In 1994, a re-study of the South Carolina coast was initiated. Justification for the re-study was based on changes in the study area, such as population increases and significant changes in roadway networks. Technological changes, such as improvements in the SLOSH model and the resulting changes in predicted surge heights, provided an additional need for updated HES data. At the time of Hurricane Bertha's landfall, updated surge maps (1996 version) for Horry County were available for use. At the time of Hurricane Fran's landfall, updated surge maps for Georgetown (1996 version) County were also available for use.

Prior to the landfalls of Bertha and Fran, South Carolina officials were concerned with the accuracy of all areas of the 1986 HES. The results of an updated (1992) SLOSH model run indicated that potential surge heights could be up to eight feet more than indicated in the original HES, in some areas of the coast. Wind hazards and the associated vulnerable population were not addressed in the original study, discluding virtually all inland counties from the study area. Population increases, up to 22% in some areas of the coast, rendered the vulnerability analysis "questionable ", at best. Changes in public response estimates (from the behavioral analysis) were unknown, especially when Hurricane Hugo experiences were taken into account. New Red Cross guidelines mandated important changes in the shelter plans for the state, making the HES shelter analysis significantly dissimilar to existing plans. (Some coastal areas lost up to 72% of shelter spaces in their counties with implementation of new Red Cross guidelines.) Most importantly, calculated clearance times for every coastal county were in need of a reanalysis because they could not be relied upon for crucial evacuation decision making.

South Carolina state and local officials were involved in an ongoing attempt to update the HES information prior to the 1996 hurricane season. Vulnerable populations were recalculated using current census data. Shelter demand figures were reassessed using percentages of evacuating populations,

as experienced in recent evacuations along the east coast of the US. Shelter capacity information was re-evaluated after incorporation of the new Red Cross guidelines. Clearance times, perhaps the most critical area of the HES, however, were virtually unknown for changed conditions in the state. Officials used the limited updated information and personal judgment, experience and knowledge to time evacuation orders - a timing which was only loosely related to HES calculated clearance times.

In an attempt to improve the data produced during the SC hurricane evacuation restudy, an analysis of the events surrounding the responses to Hurricanes Bertha and Fran is provided in the remainder of this chapter. A team composed of representatives from the Corps of Engineers, FEMA, and the firm of Post, Buckley, Schuh & Jernigan visited and discussed pre-landfall events with state and county emergency managers, support agencies and media representatives in the following South Carolina counties:

Table 4-1
Participating South Carolina Counties

Coastal Counties	Inland Counties
Georgetown	Orangeburg
Horry	Florence
Charleston	Williamsburg
Colleton	Marion
Beaufort	Dillon
Hampton	

The remainder of this chapter will address the hazards, vulnerability, shelter and transportation issues which surrounded the evacuation for Hurricanes Bertha and Fran in South Carolina. The public response analysis is included in the next chapter. It incorporates the response of evacuees in Georgetown and Horry Counties.

South Carolina Hazards and Vulnerability Data

The main objective of a Hurricane Evacuation Study hazards analysis is to predict the effects of storm tide flooding from hurricanes of varying intensities. The hazards analysis quantifies the expected hurricane generated storm tide flooding that would inundate an area, and it generally references possible riverine flooding caused by rainfall associated with a hurricane. In recent studies and updates, the effects of hurricane winds have been included by introduction of an inland winds model. This model, which was available to the State of South Carolina during Hurricanes Bertha and Fran, provides information that will help inland communities prepare for threatening high wind conditions.

The vulnerability analysis uses the results of the hazards analysis to identify the population which will be vulnerable to the effects of a hurricane. Using storm surge maps, census data and inland wind models, the surge vulnerable population and those structures which are vulnerable to high winds (such

as mobile homes) are mapped according to evacuation zones. These zones are designed to be operational tools; to be used in communicating to the public the areas that should evacuate under various hurricane threats.

In this analysis, the accuracy and usefulness of the hazards and vulnerability data provided by the South Carolina Hurricane Evacuation Study were examined. In particular, this assessment sought to evaluate the following areas:

- * Was the data accurate in depicting potential and actual hazards?
- * Did the data adequately estimate the population vulnerable to the hazards?
- * Was the data useful as an evacuation planning resource?
- * Was the data appropriately used for the evacuations?

Because Hurricanes Bertha and Fran did not make landfall along the South Carolina coast, the state did not experience major hurricane storm surge. For this reason, an evaluation of how well the SLOSH model performed in predicting storm surge in South Carolina was not made. Also, for this same reason, the extent of riverine flooding and inland wind intensity in South Carolina were not evaluated. The hazards and vulnerability evaluation in South Carolina focused on the amount of confidence decision makers had in the data's depiction of the potential hazards as they were tracking the storms' approaches. It also focused on if, and how, the data was used by state and local officials to assist in decision making.

a. Hazards Identification and Decision Making.

A number of sources were used by South Carolina officials to identify hazards associated with Hurricanes Bertha and Fran. These included the NWS, the Weather Channel, DTN, Contel weather wire, HURREVAC, Decision Arcs, state conference calls and faxes, South Carolina Law Enforcement Division (SCLED) teletype, and the Inland Winds model. Decision makers generally felt that the HES products were adequate in presenting potential hazards, but felt that HES data is outdated and in need of updating. HURREVAC was useful, but most officials believe that the software needs updating to provide better graphics and to make downloading of information quicker and easier. HURREVAC data is also outdated for South Carolina's coastal area. For example, seasonal population has increased so much that officials must use high tourist occupancy settings in every storm scenario -- even to approximate actual levels of tourist occupancy which are moderate. A number of officials also stated that HURREVAC needs to be more user friendly.

For the most part, inland counties had little knowledge of HES products. Although numerous inland winds model classes had been conducted during 1995 and 1996, most inland counties expressed a need for additional training. Also, many inland emergency managers did not have estimates of the number of evacuees who might pass through their counties.

b. Vulnerability.

HES identification of vulnerable populations and structures were believed by South Carolina officials to be adequate, but in need of incorporation of the latest census data. Evacuation zoning of the

vulnerability population, however, was not believed to be adequate. Most emergency officials felt that the zones were too complicated and that they would be too confusing to communicate to the public. In all cases where evacuation orders were issued, no reference to zone numbers or names were used in public information. Officials used general descriptions to identify areas which needed to evacuate such as "barrier islands, beach front property, low-lying areas, areas near water courses, areas east of Highway 17, areas east of the Intracoastal Waterway, mobile homes, etc." Evacuation routes were used as outlined in the 1986 Technical Data Report.

In retrospect, most official believe that the areas evacuated were appropriate, and the issuance of evacuation orders were believed to be timely. Overall, officials used the HES data appropriately and thought the data was useful as an evacuation planning resource.

Because outdated data and inadequate training were the most often cited areas which need improvement, future HES hazards and vulnerability identification products should be structured (to the extent possible) so that frequent updating of information such as surge areas and population data can be easily accomplished at the state or local levels. Future studies should also include provisions which will insure that periodic training on HES products and tools is available to state and local officials. Refresher courses on the use of HES data and products would help in reducing unfamiliarity with the products on the part of new emergency officials or of those who, fortunately, did not have the opportunity to use the products in some period of time. This is especially applicable when studies are complete or are otherwise inactive.

The upgrading of HURREVAC is essential. In all cases, emergency officials stated that problems with the timely access of input data for HURREVAC must be resolved. Also, officials stated that converting HURREVAC to a windows format, and making it more user friendly, would greatly improve the product. Table 4-2 provides a summary of the hazards, decision making and vulnerability issues in South Carolina associated with Hurricanes Bertha and Fran.

South Carolina Public Response and Mitigation Efforts

Public Response and Mitigation Efforts information for South Carolina is included in Chapter 5, State of North Carolina Response, "North Carolina Public Response and Mitigation Efforts" section.

South Carolina Public Shelter Issues

The public shelter analysis of the Hurricane Evacuation Study lists public shelter locations, assess their vulnerability to flooding and estimates the number of evacuees who would seek public shelter for various types of hurricane scenarios. Shelter location and capacity data are obtained from local emergency management officials and from shelter management agencies such as the American Red Cross. Public shelter capacity is compared to public shelter demand figures generated from the vulnerability and behavioral analyses to determine potential capacity deficits or surpluses.

The following type of information relating to public sheltering was sought during this assessment:

- * How many shelters were opened and how many people were sheltered?

- * What was the timing of shelter openings?
- * When did evacuee arrive at shelters?
- * What was the duration of sheltering?
- * What problems were encountered?

The State of South Carolina has devised a regional sheltering plan for executing hurricane evacuations. During Hurricanes Bertha and Fran, there were few sheltering problems encountered in South Carolina. Shelters opened when evacuation orders were issued, well before evacuees sought shelter. They remained open 24 to 48 hours until it was safe for evacuees to return home. Shelter capacity exceeded the demand for shelter space and no shelters were unsafe or vulnerable to storm hazards. Some county officials stated that they will increase coordination with the South Carolina Emergency Preparedness Division on the timing of shelter openings in future events. Some people did not want to evacuate because pets were not allowed in public shelters.

Important factors which effect shelter capacity and demand were incorporated in shelter plans in South Carolina before the 1996 hurricane season. Changes to shelter capacity in the state, because of the implementation of new Red Cross guidelines, and changes in shelter demand, because of the inclusion of inland wind threats into the study, for example, were incorporated into the statewide sheltering plan well before arrival of these two storms.

Table 4-3 provides a summary of shelter issues in South Carolina during Hurricanes Bertha and Fran.

South Carolina Transportation/Clearance Times Data The primary objective of an HES transportation analysis is a determination of the clearance times needed to conduct a safe and timely evacuation for a range of hurricane threats. Clearance time estimates are built on information from the vulnerability, shelter and behavioral analyses and an analysis of the available evacuation highway network. Attention is focused on intersections and road segments that produce traffic bottlenecks - and thus lengthy clearance times - and recommendations are made for traffic control measures that will reduce clearance times.

Transportation and clearance time issues related to the Bertha and Fran evacuations which were discussed with local and state officials included the following:

- * Was the evacuation network accurate - did evacuees use the routes projected by the hurricane evacuation study?
- * Were any traffic control actions taken to speed up flow?
- * When were the evacuation essentially completed - how long did the evacuations take - what were the actual clearance times?
- * What problems were encountered in the evacuations?

a. Evacuation Roadway Issues.

Most counties reported that the evacuation networks outlined in their hurricane evacuation studies were accurate and most evacuees used the indicated routes. However, in Charleston County, a major segment of the evacuation network (the Mark Clark Expressway) was constructed after the original

transportation analysis and the effects of the segment on clearance times was unknown before the 1996 hurricane season.

Traffic was very heavy on major evacuation routes traveling away from the coast. In Horry County during Bertha, roads were "backed up with outgoing traffic. " During Fran, roads were not as backed up and traffic moved evenly through Horry County.

In Georgetown County during Fran, traffic was bumper-to-bumper from Pawleys Island through the Town of Georgetown. Highway 521 had bottleneck traffic and some of it was diverted up Highway 51 to Florence. Also, road construction made a detour in Andrews necessary.

In Marion County, all three main evacuation routes, Highways 501, 9 and 378, were used. Highway 76 into Marion had bottleneck traffic and some was rerouted to alternate routes.

In Beaufort County, there was a very large tourist population during Bertha, especially on Hilton Head Island. During the evacuation, the mainland roadway network proved to be inadequate to accommodate Hilton Head's evacuating traffic volume as there was gridlock traffic on the mainland. It took many hours for evacuees to reach their planned destinations. In some cases, evacuees returned home when they encountered the gridlock traffic. It is believed by officials that too many people left at the same time.

b. Clearance Time Analysis.

Ascertaining the clearance times which were realized during the South Carolina evacuations was a challenge. To accurately determine the clearance times experienced during a particular evacuation, it is necessary to first ascertain when evacuees started traveling in response to the evacuation order, and when evacuating vehicles cleared the evacuation highway network. This can be accomplished by examining the information provided by the behavioral response survey in conjunction with traffic count data from the SC Department of Transportation (SCDOT). Information from local officials, law enforcement, traffic control personnel, etc. is also valuable for a clearance times analysis.

The original transportation analysis was completed for South Carolina in 1986. Since completion of the study, many important changes have occurred in the study area including changes in the vulnerable population, changes in the roadway network and changes in the state's evacuation strategy. The latest strategy includes the use of voluntary relocation requests to draw down the vulnerable population before a mandatory evacuation order is required. The idea is to phase evacuations to reduce overloading of the roadway network, and to reduce lengthy clearance times if a mandatory order is ultimately required. The strategy worked well during Bertha and Fran. However, under such a scenario, clearance times observations may be distorted because the voluntary relocation may overlap the mandatory evacuation. Observed traffic volumes, then, may served to document the time period over which evacuees were allowed to evacuate voluntarily, plus the time it took to clear the roadway network after the mandatory evacuation order was issued. This fact is reinforced by the behavioral response survey (see Chapter 5 for the full behavioral response analysis.) Consider Figure 4-1. In the post-storm behavioral survey, permanent resident evacuees in Horry and Georgetown Counties were asked what day and time they left their homes to go someplace safer during Hurricane Fran. The

results are depicted in the graph which shows cumulative evacuation over time - that is, of all evacuees, the percentage who had left by various times. The box below the graph summarizes the times at which events occurred which might have affected evacuation behavior.

There was little direct response to the hurricane watch which was posted through South Carolina on the evening of September 3rd. The early evacuation began midmorning of the following day, probably due to the Governor's request to relocate. The change of the evacuation notice from voluntary relocation to mandatory evacuation appears to have reinforced the behavior already underway but did not clearly prompt additional response at that time. The evacuation paused on the evening of September 4th and, by nightfall, slightly more than 40% of the eventual evacuees had left. On the morning of September 5th, the evacuation resumed.

(This analysis reinforces the notion that the observed durations of evacuation may include voluntary relocations and may likely represent the "duration of substantial evacuating traffic" rather than the clearance times. Care should be taken not to confuse the two.)

To determine the clearance times experienced in South Carolina, traffic count data which was provided by the SCDOT was examined. Traffic counts during the relevant time period (the time during which the mandatory evacuation orders were effective) were compared to normal daily counts to estimate when the evacuations actually began, and when they were completed. The resulting duration is presented as the clearance time.

The beginning of evacuation was established at the point when the evacuation traffic curve rose above the normal daily traffic curve. The completion of evacuation was established at the point when the evacuation traffic curve tapered off to almost zero. This is because there is no "normal" traffic after an evacuation since all activities in the area are presumed interrupted. The evacuation start and finish times were established at each traffic counter location to document clearance times for each coastal county. The results are presented in Table 4-4 on the next page. An example traffic count curve is presented in Figure 4-2 .

Information on evacuation durations was requested of officials during the interview process. It is also presented in Table 4-4 along with other traffic/clearance time data. The durations provided by officials did not compare well with the estimated clearance times provided in the 1986 transportation analysis. This is expected and is due to the reasons stated earlier: first, many changes have occurred in the study area since the original study effort; second, officials wisely requested voluntary relocations in the state well before the requisite "final hour;" and third, the durations provided by officials probably include both the voluntary relocation and the mandatory evacuation sequences. The durations did, however, compare extremely well with clearance times calculated from traffic count data. It is apparent that local officials had a good handle on what was going on with evacuation activities.

c. Traffic Count Data.

The extent of traffic count data which was collected by the South Carolina: Department of Transportation during both evacuations is summarized below.

1) Hurricane Bertha - Coastal Areas:

Charleston 1-26 westbound - most evacuation at this location appears to have taken place on Wednesday, July 10th, afternoon and evening with a big dropoff after midnight; a more modest level of evacuation occurred on Thursday, the 11 th. A peak flow of 2,000 vehicles per hour occurred; a duration of 24 hours of some evacuation occurring is evident.

Myrtle Beach US 501 northbound - significant evacuation occurred on Thursday, July 11th, from 4 a.m. to 6 p.m.; a maximum flow of 2,500 vph observed at 10 a.m.; significant traffic queuing may have occurred between 1O a.m. and noon indicated by dip in count curve.

SC 9 northbound - significant evacuation flow out of the area from 5 a.m. to 7 a.m.; a maximum of almost 2,500 vph is shown at about 6 p.m. which is a tremendous flow rate for this location.

Georgetown US 17 southbound - significant evacuation flow out of area from 7 a.m. to 6 p.m.; a maximum of about 1,900 vph is shown moving in the early afternoon of Thursday the 1 1th; some traffic queuing appears from 1 p.m. to 3 p.m.

Hilton Head US 278 westbound - evacuation flow heavy on Wednesday the 1Oth; evacuation appears from noon to midnight with little flow after midnight; low levels of evacuation may have occurred after about 4 a.m. on Thursday the 11 th; a maximum flow of about 2,500 vph occurred on Wednesday about 4 p.m.

2) Hurricane Bertha - Inland Areas:

1-26 westbound (west of 1-95 near Bowman) - significant evacuation occurred on Wednesday, July 10th from noon until 3 a.m.; modest levels of evacuation occurred on the 1 Ith from 6 a.m. to 4 p.m.; maximum flow was 2,000 vph late in the day on Wednesday which indicates the roadway section was rarely at maximum possible flow.

1-20 westbound (west of Florence near Lamar) - significant evacuation traffic from 9 a.m. on July 10th to 10 p.m. on the 11th with a big drop off between 3 a.m. and 6 a.m. on the 11 th; a maximum flow rate of 1,650 vph occurred at 4 p.m. on the 11 th; this location may have included some NC evacuees.

3) Hurricane Fran - Coastal Areas:

Charleston Cooper River Bridge - traffic not much different than normal perhaps because of impact of I-526 connector/loop or not a lot of evacuation participation.

1-26 westbound - clearly shows some out of county evacuation taking place; a maximum of 4800 vph is shown moving which is an impressive evacuation flow rate; six hours of significant evacuation flow are shown.

Myrtle US 501 northbound - significant evacuation flow out of Myrtle Beach area from 8 a.m. to 10 p.

m.; a maximum of almost 2,400 vph is shown moving which is quite good (a testimony to state highway patrol efforts); looks like traffic queuing occurred from about 4 p.m. to 6 p.m. which is to be expected.

SC 9 northbound - significant evacuation flow out of area from 10 a.m. to 11 p.m.; a maximum of almost 1,850 vph is shown moving at the peak of the evacuation which is very good for this roadway.

Georgetown US 17 southbound - significant evacuation flow out of area from 2 p.m. to 11 p.m.; a maximum of 1,600 vph is shown moving which is almost what we would expect during an evacuation in this location. Hilton Head US 278 westbound - significant evacuation flow out of area from 9 a.m. to 5 p. m.; a maximum of almost 2,600 vph is shown moving which is extremely good for an evacuation in this location; some traffic queuing indicated by dips in curves; Hilton Head moved well ahead of Governor's mandatory order.

4) Hurricane Fran - Inland Areas:

US 17 southbound at Jacksonboro - evacuation movements look like they are taking place from 10 a. m. to 11 p.m., but traffic flow is far from maximum flow most of the day; a maximum of 750 vph is shown moving at the peak of the evacuation which is about what we would expect for this roadway.

I-95 southbound, Jasper County - some significant evacuation traffic flowing into Georgia from SC throughout most of the day, but not at maximum flow rates for that section of highway; max. achieved flow of about 2,100 vph happened at about 7 p.m.

I-95 northbound, Jasper County - virtually little to no evacuation traffic coming into SC from Georgia which indicates little out of county evacuation taking place from Chatham County for the event.

US 17 Alt northbound, Yamassee - evacuation traffic indicated from 11 a.m. to 11 p.m. but at modest flows; maximum flow of 1 15 vph indicated at 4 p.m.

I-26 westbound West of 1-95 near Bowman - significant evacuation traffic from 11 a.m. to well after midnight; maximum flow rate of 3,200 vph achieved at around 8 p.m. which is right at what we would expect as a flow rate for evacuation at this location; shows importance of I- 26 inland as an attractor even with a modest Charleston evacuation.

I-20 westbound West of I-95 Florence near Lamar -significant evacuation traffic flow from 10 a.m. to well after midnight, but flow not at maximum like I-26 inland; maximum of 1,100 vph flow rate achieved at 7 p.m.; may have included some NC evacuees.

I-95 northbound, Dillon County - some SC to NC movements from 1 p.m. to well after midnight, but at modest flow rates; maximum of 1,200 vph at 6 p.m.; opposite southbound count shows little NC to SC evacuation traffic.

The transportation analysis for South Carolina is in crucial need of updating. Current and future dwelling units as well as roadway improvements, such as the Mark Clark Expressway in Charleston,

are examples of data which need to be reflected in the new analysis. Also, the state has revised its Hurricane Plan, using a regional (or conglomerate) concept for evacuation planning. Future transportation analyses for the state should be conducted in concert with the revised hurricane plan. In areas where severe traffic problems were encountered, (e.g., in Beaufort County during Bertha) future transportation analyses should identify special traffic control options, for facilitating smoother evacuations.

South Carolina Public Information

Although not a major part of the original hurricane evacuation study effort in South Carolina, public information is now recognized as an integral element for successful evacuation planning and execution. 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. Hurricanes Bertha and Fran provided a glimpse of the current means used in South Carolina to communicate hurricane evacuation information to the general public. These storms also provided local and state officials with an opportunity to evaluate the experiences with media coverage of the evacuation events.

South Carolina uses all forms of media to publicize hurricane evacuation information including local and national, print and broadcast media. Following are media related comments that were provided during interviews:

SCEPD Public Information Office: The principal source of information from the state EOC is provided through the Associated Press and the South Carolina media network. Media requests for local information received at the state EOC were referred to local EOC's and local public information offices. This approach worked well. There is a noted lack of information regarding guidance on response to inland flooding from rainfall during a hurricane event. Also, vulnerable population figures and numbers of people included in specific evacuation areas were generally unavailable. Recommends including a "Press" component to hurricane evacuation studies. Need more and better graphics for public information. Evacuation information primarily given to broadcast media. The media requested and needed printed maps of risk areas before the events. South Carolina is in need of a general public information data package for distribution.

Horry County: Faxed evacuation routes to press, local television and radio stations. Published telephone numbers for public to call for information.

Charleston County: No longer has evacuation information in telephone books. Need to improve public information materials and distribution. Need to better display information for news media - important but difficult - need assistance. Colored evacuation zone maps and surge maps were given to the Post & Courier Newspaper. The press was constantly fed information at the county EOC.

Colleton County: NWS information was sent to the press. Local radio and newspaper were used to distribute information.

Georgetown County: Radio and television were used for informing the public. Also, deputies with public

address systems were used to help announce evacuation orders. The press was present at the EOC during the events. Noted that the Weather Channel did not target their area in either event.

Beaufort County: Used television news conferences and radio and newspaper to get information to public.

Hampton County: Published newspaper articles a day before the events and used Red Cross publications to inform the public.

Orangeburg County: Shelter information was provided to the media by phone and fax. Also used radio and television. Charleston and Beaufort evacuees were unaware that shelters were open in Orangeburg County. Would like to see more media and public information for inland counties provided.

Florence County: Basic advisory information was faxed to the media. Public Information Officer made some announcements to the media on basic family preparedness. Used television, radio and newspaper (newspaper personnel were in EOC.) Had provided shelter information to media prior to events. Some slides of past and possible storm damage would be helpful for public education.

Williamsburg County: General status and shelter information was provided to the media through phone calls and fax as needed. Primarily used radio and television during events. Basic family preparedness and shelter locations were provided to newspapers at beginning of hurricane season in pre-hurricane season briefing with media.

Marion County: Most public information issued involved sheltering. Used cable television, and one local radio station. Faxed information to media, police and fire department. Provided response plan to media prior to the events. Also gave pre-storm family preparedness information to media.

Dillon County: No local contact made with media. Media coverage was provided at the state level by radio and television.

In the behavioral response survey, many people in Georgetown and Horry Counties said they never heard from officials that they were supposed to evacuate and fewer than a third thought they were required by officials to leave. People who heard evacuation notices, however, were more likely to evacuate than others, and those who believed they were ordered to evacuate were most likely of all to leave. Respondents indicated that they relied a great deal upon local television and radio for information, but the Weather Channel was relied on the most for storm and evacuation information. Some respondents indicated that they heard information from both state and local officials and the great majority of those hearing the information said that the information was accurate and useful. People who said they received information from government officials in Hurricane Fran about the storm's danger and how to protect property were more likely than others to have adopted mitigation efforts.

The local media in South Carolina is interested and active, and is anxious to distribute and disseminate information from emergency officials. The Weather Channel is widely used by South Carolinians for storm and evacuation information and ranked ahead of local television and radio in the post-storm

behavioral survey. Emergency officials are proactive in educating and informing the public about hurricane hazards. Although media coverage appeared adequate in inland counties, there is a severe lack of information on inland preparedness and inland hazards information to provide to the media. Provisions for more visual aids was a common theme for recommended improvements in this area of the hurricane evacuation study.

South Carolina Observations/Recommendations

The purpose of this post storm assessment is to improve the quality and usefulness of HES products in future studies, restudies and updates. The following recommendations are intended to accomplish this purpose and are grouped and presented by specific areas of hurricane evacuation planning.

a. Hazards and Vulnerability.

1) Continued emphasis should be placed on completing the restudy to update study data.

2) HURREVAC should be improved to include better graphics and better information loading capabilities.

3) More graphics should be included in HES products to aid in public education.

4) Future evacuation study vulnerability analyses should simplify evacuation zones as appropriate.

5) Federal officials should consider establishing a password accessible dedicated bulletin board to simplify information gathering for state and local officials.

b. Public Shelter Issues.

No recommendations are provided for public shelter issues in South Carolina.

c. Transportation/Clearance Times Data

- 1) Clearance time data needs to be updated throughout the state to reflect current and future levels of dwelling units as well as roadway improvements such as the Mark Clark Expressway in Charleston.
- 2) The SCEPD conglomerate concept needs to be a focal point for future transportation analyses - this will encourage regional decision making and problem solving and will include critical inland bottlenecks in the analysis.
- 3) Special traffic control options for facilitating future evacuations of Hilton Head need to be identified and evaluated, especially for circumstances where the road network is loaded quickly.
- 4) Interstate evacuation traffic between Georgia and South Carolina should be carefully quantified and factored into each state's analysis in a more definitive manner.

d. Public Information

1) A "Press" component should be added to the hurricane evacuation restudy in South Carolina. The component should include presentation materials, camera ready graphics, photograph or slides of previous and potential hurricane damage, and other materials which will aid in educating the public.

2) There is a severe deficiency in the availability of public information tools and materials for inland county use in educating the public on inland preparedness and inland hazards associated with hurricanes. The hurricane evacuation restudy should provide assistance and materials to inland areas to aid in the education of this target audience.

CHAPTER 5

STATE OF NORTH CAROLINA

Evacuation Decision Making Structure

The State of North Carolina has adopted a decentralized approach for evacuation decision making. Local authorities are empowered to make evacuation decisions for their jurisdictions. All efforts at the state and regional levels are focused on providing information, assistance and recommendations to local authorities to assist in this task.

Hurricane Evacuation Studies

A Hurricane Evacuation Study for the state of North Carolina was conducted in the late 1980's. Storm surge maps were completed in 1987, the behavioral and transportation analyses were completed in 1986, and the Technical Data Report was published in 1987. The evacuation study included an area of approximately 3000 miles of open coastline and 1700 miles of sound/estuary shoreline. There were 18 counties included in the study area: Beaufort, Bertie, Brunswick, Camden, Carteret, Chowan, Craven, Currituck, Dare, Hyde, New Hanover, Onslow, Pamlico, Pasquotank, Pender, Perquimans, Tyrrell, and Washington.

In January 1994, the North Carolina Division of Emergency Management requested a restudy of eastern North Carolina. The request was based on a "Report of Recommendation" (prepared by the Wilmington District Corps of Engineers) which indicated that data provided by the (1992) Myrtle Beach/ Wilmington SLOSH basin model reflected significantly higher storm surge values for the four southeastern coastal counties than those contained in the original study. The report also indicated that, during Hurricane Emily, actual storm surge in the Buxton area on the sound side of Hatteras Island was almost double what the SLOSH model for the basin indicated. Other justifications for a restudy included a significant increase in the tourist population on the barrier islands in the past 10 to 20 years; changes in shelter inventories; and increased evacuation times in certain areas by possibly 2 to 4 hours (as evidenced during Hurricane Emily) because of changes in the highway networks. For these reasons, NC officials indicated that the technical data compiled during the 1987 HES was "questionable " for accurate evacuation planning.

In late 1994, a re-study of the North Carolina coast was initiated. At the time of landfalls of Hurricanes Bertha and Fran, updated digital surge maps (spring 1996 version) for the four southeastern counties, Brunswick, New Hanover, Pender and Onslow, were available for use in the state. Also available for the 1996 hurricane season in North Carolina, was an updated behavioral analysis. A behavioral analysis was completed in February 1996 for the southeastern part of the state. For the northeastern part of the state, a behavioral analysis was conducted as a part of the post-storm assessment for Hurricane Felix. An updated transportation analysis for Brunswick, New Hanover, Pender and Onslow Counties was completed in late 1996 - it was not available prior to the onset of the 1996 hurricane season.

In an attempt to improve the data produced during the ongoing restudy, an analysis of the events surrounding the responses to Hurricanes Bertha and Fran in North Carolina is provided in the remainder of this chapter. A team composed of representatives from the Corps of Engineers, FEMA, and the firm of Post, Buckley, Schuh & Jernigan visited and discussed pre-landfall events with state and county emergency managers, support agencies and media representatives in the following North Carolina counties:

Table 5-1
Participating North Carolina Counties

Storm Surge Counties	Inland Counties
Beaufort	Bladen
Bertie	Columbus
Brunswick	Cumberland
Camden	Duplin
Carteret	Greene
Chowan	Hertford
Craven	Hoke
Currituck	Jones
Dare	Lenoir
New Hanover	Martin
Onslow	Pitt
Pamlico	Wayne
Pasquotank	
Pender	
Washington	

The remainder of this chapter will address the hazards, vulnerability, public response, shelter and transportation issues which surrounded the evacuation for Hurricanes Bertha and Fran in North Carolina. Input on evacuation decision making and public information is also included.

North Carolina Hazards and Vulnerability Data

The main objective of a Hurricane Evacuation Study hazards analysis is to predict the effects of storm tide flooding from hurricanes of varying intensities that have some probability of striking the study area. The hazards analysis quantifies the expected hurricane generated storm tide flooding that would inundate an area. The National Weather Service's SLOSH numerical storm surge prediction model was used as the basis for the storm surge analysis performed for the North Carolina HES. Updated SLOSH modeling was performed in 1992 for the Wilmington/Myrtle Beach basin. The remaining areas of the coast were modeled in early 1996. (Limited data from these model results were available for the 1996 hurricane season.)

In a hazards analysis, a general reference is usually made to possible riverine flooding caused by rainfall associated with a hurricane. However, because a great variability in both the amount of precipitation caused by hurricanes and in the antecedent conditions that may contribute to or mitigate the flooding effects of rainfall, no distinct attempt is made to quantify possible riverine flooding. National Flood Insurance Studies and Flood Insurance Rate maps and/or areas that have historically flooded are usually referenced as a reasonable starting point for evacuation planning efforts for nontidal flood areas.

Historically, hurricane evacuation studies have addressed the wind effects of hurricanes (other than the generation of tidal surge) in a very general manner. The Saffir- Simpson Scale, which classifies the intensity of hurricanes, is included in each HES Technical Data Report. Reference to the Saffir-Simpson scale provides jurisdictions with some idea of the maximum wind velocities that a threatening hurricane may produce. A recently developed tool (called the "Inland Winds Model ") that is currently being tested in several study areas, including North Carolina, is a wind decay model developed by the Hurricane Research Division/Atlantic Oceanographic and Meteorological Laboratory (AOML). This model provides information that can be included in the Tropical Cyclone forecast and Hurricane Local Statements that will help inland communities prepare for threatening high wind conditions. FEMA has developed software that enables state and local emergency managers to display anticipated wind intensities in the path of a hurricane. The operational portion of the program is designed to be used only in the last hours before storm landfall, when the NHC wind field forecast errors are relatively low. The planning portion can be used in the development of standard operating procedures for inland communities. The model was available in North Carolina during both Hurricane Bertha and Hurricane Fran.

The next step in the hurricane evacuation study is the development of the vulnerability data. Using the results of the hazards analysis, storm tide maps are produced showing the inland extent of surge inundation for various hurricane intensities. Analyzing these maps together with census maps, the population vulnerable to surge inundation is identified. Also identified are the locations and numbers of people living in mobile homes or other structures at increased risk of high winds. At-risk areas are mapped and included in "evacuation zones" which are used in traffic modeling. These zones are operational tools, used in communicating to the public what areas should evacuate under various hurricane threats.

This section of this post-storm assessment addresses the accuracy and usefulness of the hazards and vulnerability data provided by the North Carolina HES. The following subjects are addressed in the following paragraphs:

- * Were the technical data and storm tide maps provided accurate in depicting potential and actual hazards?
- * Did the data adequately estimate the population vulnerable to the hazards?
- * Was the data useful as an evacuation planning resource?
- * Was the data appropriately used for the evacuations?

a. Hazards Identification and Decision Making.

Generally, NC officials felt that HES products were useful in identifying the hazards from Hurricanes Bertha and Fran. Most counties relied more on NWS offices for information than on any other source. Area conference calls proved to be extremely successful in disseminating information. The Internet was widely used as an information source mainly because it was a very accessible source.

Some counties favored HURRTRAK over HURREVAC for hurricane tracking because of the better graphics available with HURRTRAK. There is a wide consensus in the area that HURREVAC needs upgrading to improve the graphics and to make it more user friendly. Also, there were numerous complaints about the difficulty in downloading information into the model. Some counties expressed a desire to see SLOSH data merged with floodplain data to give them better evacuation decision making capabilities.

b. Vulnerability.

For identifying vulnerable populations, most counties relied on local knowledge and experience, however, HES identification of vulnerable populations and structures were believed by North Carolina officials to be adequate, but in need of incorporation of the latest census data. Evacuation zoning of the vulnerability population was not believed to be adequate. Most emergency officials felt that the zones were too complicated and that they would be too confusing to communicate to the public. In all cases where evacuation orders were issued, no reference to zone numbers or names were used in public information. Officials used general descriptions to identify areas which needed to evacuate such "islands, riverfronts, low lying areas, mobile homes and flood proned areas." Evacuation routes were used as outlined in the transportation analysis.

In retrospect, most official believe that the areas evacuated were appropriate. Tables 5-2 and Table 5-3 provide a summary of the hazards, decision making and vulnerability issues associated with Hurricanes Bertha and Fran.

c. SLOSH Model Performance.

Usually, the peak surge from a hurricane occurs to the right of the storm path and within a few miles of where the radius of maximum winds is found. This is largely due to the counterclockwise rotation of the windfield surrounding the eye of the hurricane (in the northern hemisphere.) To the right of the landfall point, the winds blow toward the shoreline; to the left of the landfall point, the winds blow away from the shoreline. It is important to note, however, that the least accurately predictable parameter of a hurricane is the point of landfall. The average error in the National Hurricane Center landfall forecast at 24-hour is approximately 100 nautical miles; the average error in the 12-hour landfall forecast is about 50 nautical miles.

Because of the inability to predict exactly where a hurricane will make landfall, and because it may be necessary to begin evacuations of areas susceptible to hurricane surges as much as 24 hours before landfall, it is necessary to predict potential surge elevations for a given hurricane over a range of potential landfall points. To meet this need, the SLOSH model is used to develop a map termed a "MEOW", which is the Maximum Envelope Of Water from a number of individual hurricane simulations that differ only in point of landfall of the storm center. In this manner, the maximum water surface

elevations for a segment of coastline are calculated for different hurricanes, defined by direction, forward speed, and intensity, independent of where the storm actually crosses the coastline. This data is then compressed into a MOM (Maximum Of Maximum) which shows the maximum expected level of surge inundation irrespective of direction and forward speed, with category of hurricane being the only defining factor. This MOM data is incorporated into the Storm Tide Atlases upon which the vulnerability analysis is based.

The preceding information on how the SLOSH Model is used in hurricane evacuation studies is necessary for an understanding of how the model is evaluated for its performance for a given storm. The model can only be evaluated on how its storm surge calculations compared to the surge produced by a particular storm having its own unique track, forward speed and intensity at or near landfall. The calculated surge heights that are compared with actual surge heights are those that the SLOSH Model produces for the storm parameters in evidence at landfall, not on the parameters that may have been predicted 6, 12, or 24 hours before landfall.

As it has throughout its history, the SLOSH Model performed well for both Hurricane Bertha and Hurricane Fran. Figures 5-1 and Figure 5-2 provide a comparison of the maximum surge heights experienced at a number of locations during Bertha and Fran with the surge heights calculated by the SLOSH Model for a hurricane with Bertha's and Fran's tracks, intensities and forward speeds. Observed surge heights are based mainly on maximum tide gage readings and on high water marks taken from inside buildings where the effects of waves can be eliminated.

In summary, some officials in North Carolina did, and some officials did not rely heavily on HES hazards and vulnerability data and products to identify hurricane hazards and vulnerabilities during Bertha and Fran. State and coastal area officials were very familiar with the products and believed that they would be fairly useful as an evacuation planning resource if they were current, more user friendly and if the data for input to computer models were more accessible. Inland counties were less familiar, in general, with HES products.

North Carolina Public Response and Mitigation Efforts

The Hurricane Evacuation Studies Behavioral Analysis establishes assumptions regarding how the public in the study area will respond to a variety of hurricane threats and evacuation orders. These assumptions are used in the HES transportation analysis and for guidance in emergency decision-making and public awareness efforts. The specific objectives of the behavioral analysis are to develop reliable estimates of the following:

- * The percentages of people in various risk areas that will evacuate.
- * When the evacuating population will leave.
- * Numbers of vehicles used by evacuating households; numbers of other vehicles utilized or towed such as boats and trailers.
- * Probable destinations of evacuating households (e.g., public shelter, home of friend or relative, hotel/motel, in-county/out-of-county, etc.)
- * Evacuation responses of tourists.
- * Differences in response behavior based on forecasts of hurricane intensity and probability.

Data sources for behavioral analyses typically include sample surveys regarding response to any hurricanes that may have impacted the study area in recent years and intended responses in hypothetical evacuations. Survey responses are compared to a "general response model, " i.e. patterns observed in many of the evacuations documented over several decades in a variety of locations. Data collected in the aftermath of a hurricane contributes to the continued development of the general response model. As part of this post storm assessment, a public response survey was conducted. The survey was conducted by Dr. Jay Baker of the Florida State University, Department of Geography. Large excerpts from Dr. Baker's report, "Hurricanes Bertha and Fran in North and South Carolina: Evacuation Behavior and Attitudes Toward Mitigation," are presented in this section of this post-storm analysis. It provides important information for emergency officials in attempting to guide the public in future evacuations.

a. Survey Method.

In the Myrtle Beach area of South Carolina and in southeastern North Carolina, 815 residents were interviewed by telephone in January of 1997. Respondents were asked how they responded in Hurricanes Bertha and Fran and were asked a number of questions concerning practices designed to reduce damage from hurricanes. In North Carolina, residents lived in Brunswick, New Hanover, Pender, and Onslow Counties. In South Carolina, most of the interviews were conducted in Horry County, but some came from the northern part of Georgetown County.

One of the most important variables affecting how people respond (and should respond) to hurricanes is the vulnerability of their location to storm surge. Therefore, the sample was stratified to ensure adequate representation from certain predetermined risk zones. In North Carolina there were three zones: barrier islands (beaches), mainland surge areas susceptible to flooding in hurricanes, and areas of coastal counties inland of the surge zones (referred to in the report as non-surge areas.) The Myrtle Beach area does not lend itself to that same sort of differentiation, so the boundaries were tied more explicitly to highways and the Intracoastal Waterway (ICW in some tables in the report), as these were the referents used to delineate evacuation zones in Hurricanes Bertha and Fran. Because the interviews were conducted in January, very few seasonal residents were included in the sample. In particular, this caused the people in high-rise structures near the beach to be under-represented.

Because the sample was stratified by risk area, reverse telephone directories were used for sampling. That is, locations were selected for interviewing, streets were selected from those locations, and directories listing phone numbers on those streets were used for selecting phone numbers to call. At least three callbacks were used for each phone number before discarding it.

b. Evacuation Rates (The percentages of people that evacuated.)

In Hurricane Bertha, 34% of the respondents in South Carolina and 44% of those interviewed in North Carolina said that they left their homes to go someplace safer (i.e., evacuated.) These numbers are global, however, and more meaningful data can be obtained when individual risk areas are considered. Response in South Carolina was lower than in North Carolina, and even east of Business Highway 17 only slightly more than half said they evacuated. In North Carolina, response was higher. More than 70% said they evacuated the beach areas. Also, significantly, evacuation from the mainland surge

area was no greater than that from areas farther inland in coastal counties.

Many people in both states said they never heard from officials that they were supposed to evacuate, and fewer than a third in either state thought they were required by officials to leave. People who heard evacuation notices from officials were more likely to evacuate than others, and those who believed they were ordered to evacuate were most likely of all to leave. In North Carolina, 81% of those who said they were ordered to leave said they did so, followed by 58% of those who said officials only recommended they evacuate. The effect was not as great in South Carolina, but differences were still substantial. Of those hearing officials say they must leave, 56% said they evacuated, compared to 38% who said they heard a recommendation, and 18% who said they heard no evacuation notices at all.

Another influence on evacuation rates is the perceived level of safety. Not surprisingly, people who believe their homes would be unsafe were about twice as likely as others to evacuate in Hurricane Bertha. In South Carolina, both east of Business Highway 17 and between the Intracoastal Waterway and Business Highway 17, most people regard their homes as unsafe (in a 125 MPH hurricane.) West of the ICW, however, most believe their homes would be safe. In North Carolina, most beach residents believe their homes would be unsafe, but in mainland surge areas and in nonsurge areas, a minority have that opinion. In the North Carolina beach areas, 80% (61% in South Carolina east of Business Highway 17) evacuated if they believed their homes were unsafe, and this does not take into account whether they heard evacuation notices.

Other predictors of evacuation in Bertha include: type of residence, years lived in region, children in the home, pet ownership, race, and income. Table 5-4 indicates the breakdown of evacuation rates by risk area in each state.

Table 5-4
Percent Evacuating by Risk Area

	South Carolina		North Carolina	
	Bertha	Fran	Bertha	Fran
East of Business Hwy 17	53	66		
Intracoastal Waterway to Business Hwy 17	34	48		
West of Intracoastal Waterway	14	38		
Beaches			71	87
Mainland Surge			18	27
Non-surge			24	29

In Hurricane Fran, 49% of the respondents in South Carolina and 57% in North Carolina said that they left their homes to go someplace safer. Evacuation rates were higher than those in Bertha in all risk areas. The evacuation rate from beaches in North Carolina was particularly good, 87%. Advice or orders from elected officials was the most frequently mentioned reason in South Carolina for why people chose to evacuate. In North Carolina, general concern about the storm's severity was the most often giveni reason for why people chose to evacuate. Respondents hearing official evacuation notices were much more likely to evacuate than others. In North Carolina, 90% hearing they must leave said they did so, as did 70% in South Carolina.

People who evacuated in Hurricane Bertha also tended to evacuate in Hurricane Fran. Local television and radio were relied upon a great deal by respondents in both states for sources of information about Hurricane Fran. Local television was the most common source used, but the Weather Channel was also important. In North Carolina, 49 % said they depended upon the Weather Channel a great deal, and in South Carolina 61 % gave that response, placing the Weather Channel ahead of local radio in South Carolina. Respondents were asked whether they received any information from local and state government officials about whether Fran was going to be a danger to their safety or how to protect their property. In South Carolina, roughly half the sample said they received information from both local and state governments. In North Carolina, respondents said they heard information from both local and state (to a lesser extent) governments. (It should be noted that evacuation decisions are made at the local level in North Carolina, and at the state level in South Carolina.) In each state, the great majority of respondents said the information from both local and state officials was generally accurate and useful. Local sources received slightly better appraisals than state, and North Carolina officials scored a little better than those in South Carolina.

The participation rates shown in the Bertha/Fran survey vary slightly from the assumptions established by the original South Carolina and North Carolina Hurricane Evacuation Studies. In hypothetical response surveys conducted for the original South Carolina HES, the behavioral analysis indicated that, without disseminating evacuation orders door-to-door, 20% in moderate-risk areas in Myrtle Beach could be expected to refuse to evacuate even if ordered. In moderate-risk areas (from the ICW to Business Hwy 17) this analysis indicates that 70% in Bertha and 50% in Fran did not evacuate when ordered. In high-risk islands and beachfronts areas, the hypothetical response surveys indicated that 10% could be expected to refuse to evacuate even if ordered. In areas east of Business Hwy 17, high-risk areas, this analysis indicates that 50% (in Bertha) and 30% (in Fran) did not evacuate when ordered.

In North Carolina, evacuation rate planning assumptions presented in the February 1996 behavior analysis for southeastern North Carolina range from 65% from beaches to 50% from mainland surge areas. These figures apply for weak storms. During Bertha (considered a weak storm) actual evacuation rates were 70% in beach areas and 20% in mainland surge areas. In a severe storm, the analysis indicated evacuation levels could range from 85% in beaches to 75% in mainland surge areas. For Fran, 90% in beach areas and 30% in mainland surge areas evacuated.

c. Type of Refuge Used by Evacuees.

In Hurricane Bertha, very few evacuees went to public shelter: 3% in South Carolina and 8% in North Carolina. In both states more than half of the evacuees went to the homes of friends and relatives

(59% and 57%.) Slightly more people went to hotels and motels in South Carolina (24%) than North Carolina (15%). The remaining evacuees went to places such as churches, workplaces, and second homes. See Table 5-5 below.

Table 5-5
Percent of Evacuees Using Various Types of Refuges

	South Carolina		North Carolina	
	Bertha	Fran	Bertha	Fran
Public Shelter	3	7	8	4
Friend/Relative	59	53	57	54
Hotel/Motel	24	30	15	22
Other	14	10	20	20

In Hurricane Fran, as in Hurricane Bertha, fewer than 10% of evacuees went to public shelters. Whereas in Bertha more evacuees in North Carolina used public shelters than in South Carolina, in Fran the trend reversed: 7% in South Carolina and 4% in North Carolina. The homes of friends and relatives still received a majority of evacuees, but the totals were down slightly from Bertha, while the percentage going to hotels and motels increased.

Public shelter use was strongly related to the destination of the evacuee. Almost 90% of those going to public shelter went to someplace in their own neighborhoods. Of those who went to someplace in their own neighborhood, 20% went to public shelters, compared to only 10% of those going outside their neighborhoods. In North Carolina, public shelter use was lowest for evacuees from beach areas and greatest for people in non-surge areas.

The percentages of public shelter use were lower than the overall average presented in the original South Carolina study. In hypothetical response surveys, 35% in the Myrtle Beach area said they would go to public shelters if they evacuated. Shelter use assumptions in the South Carolina behavioral analysis labeled "cautious" (i.e., attempting not to underestimate demand in normal circumstances) was 20% for moderate-risk areas of Myrtle Beach, and 5% to 10% for high-risk barrier islands and beaches. The original behavioral analysis, however, cautioned that planners should tailor these figures to their own locales while taking income and risk-area differences into account.

In North Carolina, public shelter use rates for evacuation planning presented in the February 1996 behavior analysis ranged from 5% among medium and high income people living in beach areas to 20% among low income people living in mainland surge areas.

d. Evacuee Response Rates (When the evacuating population left.)

Evacuees were asked what day and time they left their homes to go someplace safer in Hurricane Fran. The results are depicted in Figure 5-3 below. The graph shows cumulative evacuation over time - that is, of all evacuees, the percentage who had left by various times. The box below the graph summarizes the times at which events occurred which might have affected evacuation behavior.

There was little direct response in either state to the hurricane watch which was posted through South Carolina on the evening of September 3. The early evacuation began mid-morning of the following day, probably due to the South Carolina Governor's recommendation to evacuate and to the hurricane watch being extended farther north to include southeastern North Carolina (which was a result of a northward shift of forecast tracks.) Although evacuation commenced in both states on the morning of the fourth, it was steeper in South Carolina and persisted longer during the day. The change of the evacuation notice from voluntary to mandatory in South Carolina appears to have reinforced the behavior already underway but did not clearly prompt additional response at that time. The posting of the hurricane warning for both states at 5 p.m. did little to change the way things were going. In both states the evacuation paused on the evening of the fourth, although it persisted longer into the evening in South Carolina. By nightfall on the fourth, slightly more than 40% of the eventual evacuees in South Carolina had left, compared to approximately 25% in North Carolina. On the morning of the fifth, the evacuation notices in North Carolina, and the forecast tract of the storm drifted farther east. Landfall occurred between 8 p.m. and 9 p.m. on the evening of the fifth.

Interpretation of evacuation rates and timing must account for the behavior of the storm itself, which directly or indirectly drove the behavior of forecasters, officials, and the public. Had the forecast and actual track of the storm stayed farther west and landfall occurred in South Carolina, for example, evacuation rates would have been higher in South Carolina and lower in North Carolina than those documented in this survey. Consequently, because the lines in Figure 5-3 represent percentages of eventual evacuees, the slopes of the cumulative response curves also would have changed as the number of eventual evacuees would have changed.

Although casual analysis of evacuation timing patterns is difficult because so many things are changing at the same time, the curves in Figure 5-3 are consistent with patterns generally observed in other evacuation. It is unusual for more than about 15% of the eventual evacuees to leave before someone tells them, so the response in North Carolina on the fourth might be considered slightly early. Much of that response was probably a consequence of what was happening next door in South Carolina.

e. Destinations of Evacuating Households.

In both states, slightly fewer than half of the evacuees stayed close to home (see Table 5-6 below.) During Bertha in South Carolina, 22% went to destinations in their own neighborhood, as did 28% in North Carolina. Another 20% and 21% went outside their neighborhood but stayed within their own county. Forty-three percent in South Carolina and 38% in North Carolina went elsewhere in their home state. The remainder indicated that they went out-of-state.

Table 5-6
Percent of Evacuees Going to Various Destinations

Destination	South Carolina		North Carolina	
	Bertha	Fran	Bertha	Fran
Own Neighborhood	22	19	28	16
Other Own County	20	12	21	24
Other Own State	43	41	38	53
Out of State	15	28	13	7

Evacuees in Hurricane Fran tended to go farther than those in Hurricane Bertha. Only 19% in South Carolina and 16% in North Carolina in Hurricane Fran went to places in their own neighborhoods. In South Carolina 69% and in North Carolina 60% went out of their own counties.

Behavioral assumptions for the destinations of evacuees presented in the original South Carolina study were very close to that experienced in the Myrtle Beach area. The behavioral analysis suggested that 60% to 70% in Myrtle Beach (the latter for a severe storm with a timely evacuation) would leave the local area. In North Carolina, planning assumptions for out-of-county locations of refuges ranged from 55% from beach areas to 45% in mainland surge areas for Category 1-3 storms. For Category 4-5 storms, 65% in beach areas to 55% in mainland surge areas were indicated for out-of-county destinations.

f. Mitigation Efforts.

In the Public Response Survey, respondents were asked to list actions they took to protect their property before Hurricane Fran's arrival. Securing loose objects in the yard was the most common action given, followed by applying window protection. (In this case window protection could refer to anything from putting tape on windows to covering them with shutters or plywood.) Among the reasons for not having window protection, most said that they did not believe such protection was needed, and a fewer number said such devices would not be effective. Other responses included "too expensive, too difficult to apply, and too time consuming."

When asked whether window protection would mainly just prevent the windows from breaking and reduce the danger of flying glass, or whether the window protection would also significantly reduce the total damage the house would suffer in other ways, most people said the window protection would reduce damage to the entire house.

People who said they received information from government officials in Hurricane Fran about the dangers from Fran, or how to protect property, were less likely than others to say they did not know

whether window protection would reduce overall damages.

Respondents were asked what permanent improvements, other than window protection, they had made to their homes to reduce damage to their property in a hurricane. Very few people reported doing anything of significance. The only measure indicated by more than 5% of respondents was strengthening roofs (such as bracing of trusses.) See Table 5-7 below.

People who said they received information from government officials in Hurricane Fran about the storm's danger and how to protect property were more likely than others to have adopted mitigation efforts.

Table 5-7
Percent Employing Mitigation Measures
Other Than Window Protection

	South Carolina	North Carolina
Roof/Truss Strengthening	6	10
Door/Garage Door Bracing	1	3
Flood Proofing	2	2
Anchors	3	3
Tree Trimming	3	5
Hurricane Clips	0	2

When asked how much money they planned to spend this year on changes to make their homes stronger, as a result of Hurricanes Bertha and Fran, most people said they did not plan to spend anything. Another 12% to 16% said they did not know how much they would spend. More people in North Carolina said they planned to make mitigation expenditures than in South Carolina. People who experienced more property damage in Hurricane Fran said they planned to spend much more than others on making their homes stronger. People in high risk areas planned to spend more than others.

Respondents had a very positive response to the notion of considering mitigation options in exchange for reduced insurance premiums. Almost half said they would consider the proposal, and another 15% to 21% said they might, depending upon the incentive. Fewer than 20% said they would not consider it.

This post-storm public response analysis concludes that, in most cases examined, people responded positively to the information and instructions provided by officials. During Hurricane Bertha, people who heard evacuation notices from officials were more likely to evacuate than others, and those who believed they were ordered to evacuate were the most likely of all to leave. In Hurricane Fran, advice or orders from elected officials was, again, the most frequently mentioned reason for why people chose to evacuate. On the timing of evacuation response, there was little direct response to hurricane watch and warning postings by the Hurricane Center. Most evacuation response was prompted by the advice

and orders of local and state officials. Also, people who said they received information from government officials in Hurricane Fran about the storm's danger and how to protect property were more likely than others to have adopted mitigation measures.

Officials are effectively using various media to inform the public about when and where to evacuate. Using media pathways to encourage mitigative measures, however, seems to be under utilized. Officials should explore opportunities to increase use of the media to emphasize mitigation.

It should be reiterated that the information collected during these behavioral surveys was collected in January 1997. This caused seasonal residents to be underrepresented in the sample. Also, phone numbers were taken from public telephone directories, therefore, tourist populations were not represented. In general, the behavior of tourists during hurricane threats is not well documented. This is mostly because of the inherent difficulty in collecting the data during an emergency, or in a post-storm setting. In spite of the difficulties, emergency preparedness officials continue to need, and request, behavioral information for tourists populations, especially in those areas where vulnerable populations can double (or even triple) during peak tourist season.

The most likely approaches to documenting the behavior of tourists during an emergency would be to conduct surveys as tourist are evacuating, or to collect personal information for later contact. The challenge of such approaches is in the immediate assemblage of an infrastructure to collect the information without the benefit of much advance notice. The reasonableness (or probable success) of such an immense effort on a storm-by-storm basis is questionable because the administrative requirements are mostly prohibitive. For these reasons, hurricane evacuation study program level decision makers should evaluate the need for new strides in this area of the program. State and local emergency officials continue to stress the importance of understanding the behavior of tourist during storm evacuations and the lack of much information in this field of study.)

North Carolina Public Shelter Issues

The public shelter analysis of the Hurricane Evacuation Study lists public shelter locations, assess their vulnerability to flooding and estimates the number of evacuees who would seek public shelter for various types of hurricane scenarios. Shelter location and capacity data are obtained from local emergency management officials and from shelter management agencies such as the American Red Cross. Public shelter capacity is compared to public shelter demand figures generated from the vulnerability and behavioral analyses to determine potential capacity deficits or surpluses.

The following type of information relating to public sheltering was sought during this assessment:

- How many shelters were opened and how many people were sheltered?
- What was the timing of shelter openings?
- When did evacuees arrive at shelters?
- What was the duration of sheltering?
- What problems were encountered?

Table 5-8 and Table 5-9 provide summaries of shelter issues in North Carolina during Hurricanes

Bertha and Fran.

North Carolina Transportation/Clearance Times Data

The primary objective of an HES transportation analysis is a determination of the clearance times needed to conduct a safe and timely evacuation for a range of hurricane threats. Clearance time estimates are built on information from the vulnerability, shelter and behavioral analyses and an analysis of the available evacuation highway network. Attention is focused on intersections and road segments that produce traffic bottlenecks - and thus lengthy clearance times - and recommendations are made for traffic control measures that will reduce clearance times.

Transportation and clearance time issues related to the Bertha and Fran evacuations which were discussed with local and state officials included the following:

- * Was the evacuation network accurate - did evacuees use the routes projected by the hurricane evacuation study?
- * Were any traffic control actions taken to speed up flow?
- * When were the evacuations essentially completed - how long did the evacuations take - what were the actual clearance times?
- * What problems were encountered in the evacuations?

Most counties reported that the evacuation networks outlined in their hurricane evacuation studies were accurate and most evacuees used the indicated routes. Although traffic was very heavy on major evacuation routes, traffic control appeared to be very well coordinated within the state. The only major traffic problem which surfaced during the interviews occurred in Dare County, when Route 168 was closed during the evacuation at the state line. (More insight into this incident is provided in the next chapter.)

Clearance time data was difficult to evaluate for North Carolina. To accurately determine the clearance times experienced during a particular evacuation, it is necessary to first ascertain when the evacuation began and when the evacuating vehicles cleared the evacuation highway network. This can be accomplished by examining the information provided by the behavioral response survey (previously presented in this chapter for Hurricane Fran), in conjunction with traffic count data from the North Carolina Department of Transportation. Other resources include local officials, law enforcement, traffic control personnel, etc.

The North Carolina Department of Transportation collected and summarized 24 hour traffic count data for the Outer Banks for the time periods surrounding the Bertha and Fran events. Unfortunately, the counters did not work for the Hurricane Fran event. For the Bertha evacuation, only the count reported at US 158 at Kitty Hawk School seems to show a significant difference between typical daily traffic and evacuation traffic for Thursday the 11th of July. However, 24 hour counts are very limited in their benefits for analyzing evacuation traffic. They do not show evacuation duration or peak traffic flow which are the main points of interest for evacuation analysis.

In this analysis then, because behavioral response data is provided only for Hurricane Fran, and

limited traffic count data is only available for Hurricane Bertha, information provided by local officials is the only means for comparing HES calculated clearance times with actual evacuation durations. Table 5-10 and Table 5-11 provide evacuation durations (as reported by local officials) along with other non-quantitative information regarding traffic and clearance times issues in North Carolina. New Hanover County reported a 7 hour evacuation time for Bertha and a 9 hour evacuation time for Fran. The 7 hour figure for Bertha compares well with the 7 hour clearance time calculated recently for New Hanover County (in the NC HES Restudy) for a Category 1-3 hurricane with a high tourist occupancy and a rapid response.

New Hanover County reported that there was not a lot of time available for response between when the evacuation order was issued and expected arrival of storm conditions - thus a rapid response seems justified. In Fran, the 9 hour actual time compares well with the 9'/2 hour long response calculated time. With Fran, the order was given much earlier relative to the arrival of the storm allowing evacuees a longer response time.

For Dare County, local- officials reported a 12¼ hour evacuation time experienced for Bertha. This would seem to compare favorably to the 11 to 12¼ hour time calculated in the old 1986 HES for Dare County. However, there was much less than 100% participation off the Outer Banks, and a lot of growth in seasonal units has taken place over the past 10 to 15 years. Current times are estimated to be much higher than 12 hours for a full scale evacuation where most permanent residents and tourists participate.

Brunswick County reported a five hour evacuation time for moving evacuees from the beach areas to the mainland. It is not clear what the overall clearance time is for the county as Bald Head Island actually started their evacuation the day before. A large part of Brunswick County's evacuating population should be coming from mobile homes on the mainland, yet behavioral survey data indicates that there was not a lot of mainland participation in the evacuation. The HES study calculated time of 14¼ hours does not compare well with this event. It appears that a partial barrier island only evacuation occurred, which is quite different than the HES study scenarios which include significant mainland evacuation.

It is recommended that the NCDOT work out some strategically located permanent counters that would provide traffic count data for evacuations. This would enhance traffic management and post storm analyses.

North Carolina Public Information

Although not a major part of the original hurricane evacuation study effort in North Carolina, public information is now recognized as an integral element for successful evacuation planning and execution. 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.

North Carolina uses all forms of media to publicize hurricane evacuation information including print as well as broadcast media. Following are media related comments that were provided during interviews:

Pender County: Information provided to media by fax and telephone. Television coverage hard to get in county.

Onslow County: SLOSH model data, evacuation routes and response plan were provided to the media. All media sources were used to disseminate information.

Duplin County: All weather related and NCDEM information is compiled and provided to local media by emergency officials. Information was provided throughout the emergency. Greenville, Wilmington and Washington local television (channels 7, 9, 12 and 6) and radio stations were used to get information out. Gave oral reports to media and some stations called or visited the EOC. Also used hurricane brochures to educate the public before the storms. Would like to use the Inland Winds program in media presentations in the future.

New Hanover County: Public information and media participation were excellent especially from the Wilmington media market. Myrtle Beach media also played an active part in the response. Media packets were developed by county emergency management officials and given to television and radio stations. Issued over 300 news releases during Fran. Faxed news releases/informational bulletins to local hospitals, facilities, and major industries.

Jones County: Used Channel 12 in New Bern and EBS radio channel to get information out.

Greene County: Had excellent local media coverage from TV Channel 9 in Greenville.

Brunswick County: Received 100% support from the media in Wilmington, Myrtle Beach and Raleigh. Installed a satellite system to maintain reception of the Weather Channel but did not send Brunswick County evacuation information to them. To educate and inform the public, gave hurricane talks to churches and civic groups, county public information office called every radio and television station during events, police used loud speakers on beaches, some door-to-door evacuation notifications were given by police and fire/rescue staff late in the evacuation, and brochures were given to beaches and town halls.

Cumberland County: Education of the public was reflected in their response. The media has made a lot of public service announcements on hurricanes. During both events, the media got involved 48 hours before landfall. Television Channel 40 in Fayetteville covered county.

Columbus County: Used local radio and newspaper to get information out. Also, had door-to-door evacuation notification by fire department in flood area.

Okracoke Island (US Coast Guard Station): Good media coverage by local radio stations on Manteo. Faxed evacuation order to the Weather Channel during both storms. This was instrumental in helping get a good response.

Carteret County: Used television, radio and newspaper to distribute information. Provided copies of response plan to media prior to the events.

Bladen County: The media publicizes special problems with mobile homes and, as a result, most evacuate.

Dare County: Used radio, local television, the Weather Channel, and NOAA weather radio for public information. Emergency control groups must be able to convey and demonstrate to the public, what tools and information were used to arrive at the evacuation decision. Better graphics would help the process. Used animated tracking graphics with wind field (HURRTRAK) which was very helpful in public information.

Hertford County: Need better traffic signs for evacuation. Recommends using message boards to assist in traffic control at key locations. Had some problems with local radio stations disseminating emergency information. Need hurricane shelter signs.

Washington County: Recommend using hurricane shelter signs and message boards to aid evacuation process.

Beaufort County: Used radio, television, print media and cable television to disseminate information.

Wayne County: Has a good relationship with the press and used news conferences to keep people informed.

The following information was provided by a reporter with the Virginian Pilot Newspaper in Nags Head, NC. Overall, the newspaper was pleased with their relationship with the local emergency management agency. Information is received in a timely manner (mostly by fax) by the paper. The reporter had been exposed to SLOSH atlases and was vaguely familiar with the county's hurricane response plan. He was familiar with the county EOC and had participated in a preparedness exercise. Local dissemination of information about local actions (versus receiving information from national mediums) was the preferred route for information exchange. The reporterexpressed a need for updated floodplain information and stressed the importance of informative graphics.

In the behavioral response survey, many people in North Carolina said they never heard from officials that they were supposed to evacuate and fewer than a third thought they were required by officials to leave. People who heard evacuation notices, however, were more likely to evacuate than others, and those who believed they were ordered to evacuate were most likely of all to leave. Respondents indicated that they relied a great deal upon local television and radio for information. Local television was the most common source used, but the Weather Channel was also important. Some respondents indicated that they heard information from both state and local officials and said that the information was accurate and useful. People who said they received information from government officials in Hurricane Fran about the storm's danger and how to protect property were more likely than others to have adopted mitigation efforts.

For directing evacuees to evacuation routes, some counties use (in addition to other methods) permanent signs, but some officials indicated that all sign postings were not complete when the storms arrived. Some officials felt that evacuation signs should be extended all the way to the interstate. The

lack of adequate evacuation route signage is believed to have caused some traffic problems. For example, in Martin County, evacuation route signs are posted up to the county line. As a result, officials state that many evacuees assume that they are safe when they see no more signs, and many stop in Martin County. This creates a severe bottleneck and requires extensive efforts by local officials to convince evacuees that they are not yet out of harms way and need to continue further inland. Also, some local officials felt that shelter signs would be useful to the public.

Like in other states, the local media in North Carolina is interested and active, and is anxious to distribute and disseminate information from emergency officials. Emergency officials are proactive in educating and informing the public about hurricane hazards. Provisions for more visual aids was a common theme for recommended improvements in this area of the hurricane evacuation study.

North Carolina Observations/Recommendations

The purpose of this post storm assessment is to improve the quality and usefulness of HES products in future studies, restudies and updates. The following recommendations are intended to accomplish this purpose and are grouped and presented by specific areas of hurricane evacuation planning.

a. Hazards and Vulnerability.

- 1) HURREVAC should be improved to provide better graphics and to simplify input loading. It should also be made more user friendly.
- 2) Future evacuation study vulnerability analyses should simplify evacuation zones, as appropriate.
- 3) Future hazard analyses should consider incorporating floodplain data with surge data.
- 4) State and local officials should coordinate evacuation activities with neighboring states, especially Virginia, to facilitate smoother evacuations.
- 5) Future post-storm assessments should include specific areas to address inland wind concerns.

b. Public Response and Mitigation Efforts.

Efforts should be launched to document the actual responses of tourists from hurricane threatened areas. This effort would most likely require program level planning for nationwide scoping.

c. Public Shelter Issues.

- 1) Future shelter analyses will be required to assess current shelter capacity and demand in the state. Shelter vulnerabilities should also be closely assessed.
- 2) New shelter locations should be incorporated into future transportation studies.

d. Transportation/Clearance Times Data

North Carolina officials should work out some strategically located permanent counters that would provide traffic count data for evacuations. This would enhance traffic management and the post storm analysis process.

e. Public Information

- 1) Hurricane evacuation studies should provide more camera ready graphics for use by the media.
- 2) NC officials should take full advantage of the media to stress and inform the public of the importance of mitigation efforts.

CHAPTER 6

STATE OF VIRGINIA

No mandatory evacuations were carried out in the State of Virginia during Hurricanes Bertha and Fran, however, the Virginia State Police and the North Carolina Highway Patrol implemented an action that effected the ongoing evacuations in North Carolina during Hurricane Bertha. A meeting was held in Chesapeake, Virginia on November 14, 1996, to discuss the action. Representatives of the North Carolina Division of Emergency Management; the Virginia Division of Emergency Services; Chesapeake, VA Emergency Services; Currituck, NC Emergency Services; the Virginia State Police; the NC State Highway Patrol; FEMA; the Corps of Engineers; and the firm Post, Buckley, Schuh & Jernigan were in attendance.

At 3:35 p.m. on July 11th, Virginia State Police requested the North Carolina Highway Patrol to implement the "Barco Diversion Plan" (see Figures 6-1 and 6-2.) The request was made because North Carolina evacuation traffic was backing up at the state line.

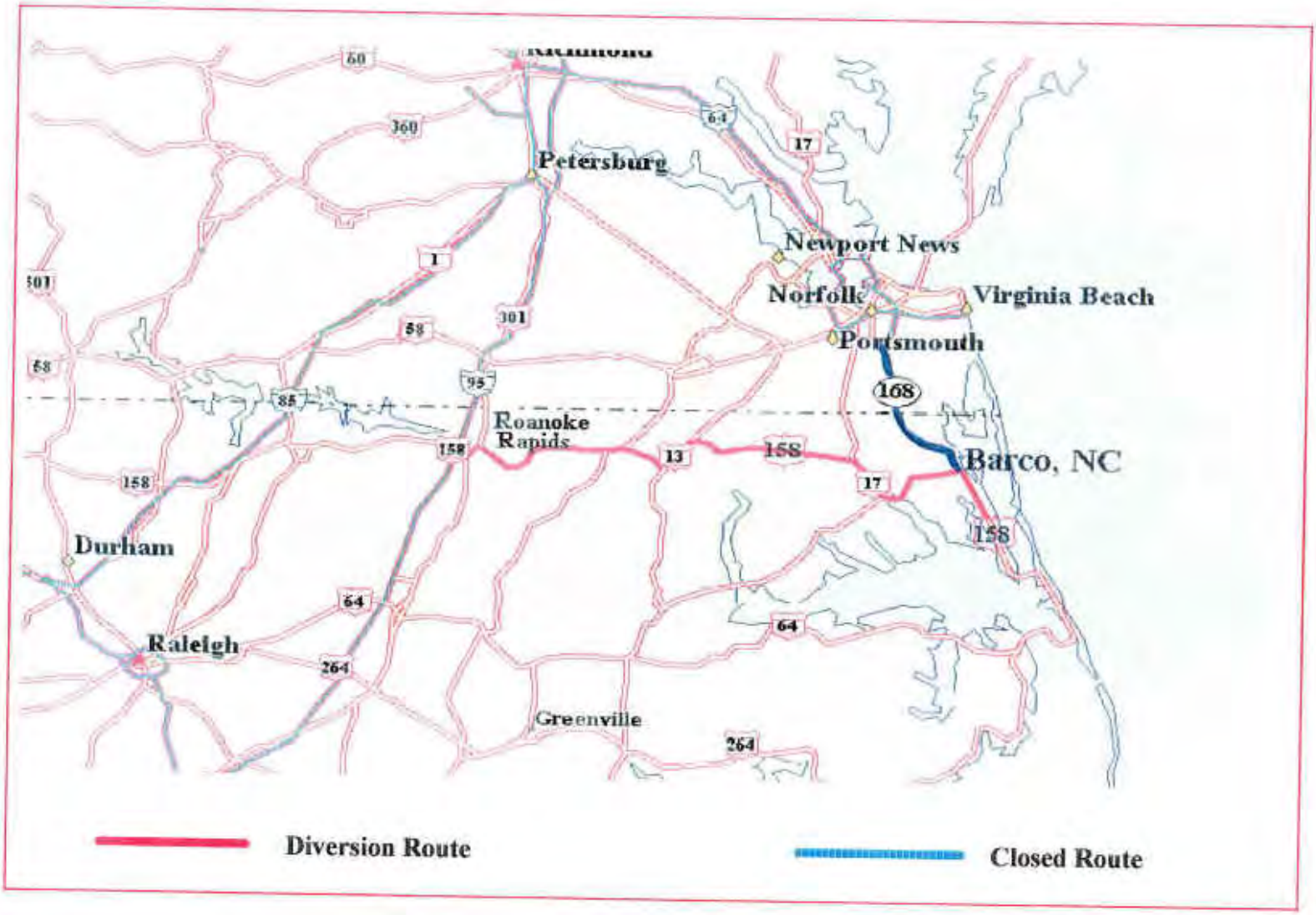
Figure 6-1
"Barco Diversion Plan"
(drafted by the NC Highway Patrol)

''In the event Virginia authorities deem it necessary to evacuate Tidewater, Virginia, it is their plan to . . . implement a metering system for access to their evacuation route. It is their estimate approximately two million or more people will evacuate their area. Prompting their request, no evacuation traffic will be allowed to enter Tidewater, Virginia, on NC-168 or US-17.''

''Should Virginia's evacuation plan be implemented, North Carolina's traffic must be directed westward to Interstate 95 because there are no pre-storm shelters that will be opened east of Interstate 95, and Interstate 95 is a main access route north and south. To accomplish this, all traffic northbound from Hatteras Island will be diverted west on US-64 through Manteo, Columbia and Williamston to Interstate 95 in Rocky Mount. All northbound evacuation traffic through Currituck County will be diverted west on US-158 to Interstate 95 in Roanoke Rapids or continue south on US-17 to Williamston, there continuing west on US-64 to Interstate 95 to Rocky Mount.''

''This evacuation traffic will be managed by Highway Patrol personnel and Sheriff's Deputies in Camden County, and in Pasquotank County by Highway Patrol personnel, Elizabeth City Police Officers, and Pasquotank County Sheriff's Deputies.''

Figure 6-1 Barco Diversion Route



The "Barco Diversion Plan" encourages/forces traffic to go westbound on US 158 at Barco, North Carolina when evacuations are ongoing in Virginia - diverting evacuation traffic on Route 168 away from the North Carolina/Virginia border. This strategy was proposed because the (1987) North Carolina HES estimates that 15,000 vehicles evacuating Dare and Currituck Counties, NC (the Outer Banks) will likely travel north on Route 168 or US 17 and enter Virginia in the City of Chesapeake. From that point, the evacuees either reach their destination in the Tidewater, Virginia area, or will continue through the area to I-64 and I-95 leading away from the coast.

In southeastern Virginia, the metropolitan area of Hampton Roads (including the cities of Virginia Beach, Chesapeake, Portsmouth, Norfolk, Suffolk, Hampton, Newport News, and Poquoson) is also vulnerable to the effects of hurricanes. The designated evacuation routes from the southern portion of the Tidewater area include westbound I-64, which is intersected by the evacuation routes from North Carolina (Route 168 and US 17), and westbound US 58. The Virginia HES (1992) estimates that 80,000 vehicles may evacuate from the southern portion of the region. The "Barco Diversion Plan" is designed to lessen the influence of North Carolina's evacuating traffic on Virginia's evacuation network when Virginia is also evacuating.

When the "Barco Diversion Plan" was implemented during Bertha, Virginia was not evacuating. Route 168 was closed at 4:00 p.m. for approximately 2 hours. After obtaining a great deal of negative criticism, North Carolina and Virginia officials reopened the route at 6:00 p.m. All parties concerned have since developed communications and coordination protocols for future evacuations.

Several important recommendations came out of the meeting:

- 1) There is a need for traffic monitoring during an evacuation at this location which will be critical for decision making and public information.
- 2) The North Carolina restudy must look at clearance times with and without Route 168 and US 17 being available.
- 3) Traffic control/communication support must be improved between "the field" and each state EOC. Also, adequate

lead time must be allowed for implementing the plan.

- 4) There is a need for public education regarding why the diversion plan would ever be implemented.
- 5) There is a real need for an update of the Virginia HES based on growth in the Chesapeake and Virginia Beach areas.
- 6) The Virginia hurricane evacuation restudy should address the benefit of an 1-64 reverse lane plan even though it is controversial.

Figure 2-1 Hurricane Bertha Storm Track Go Back

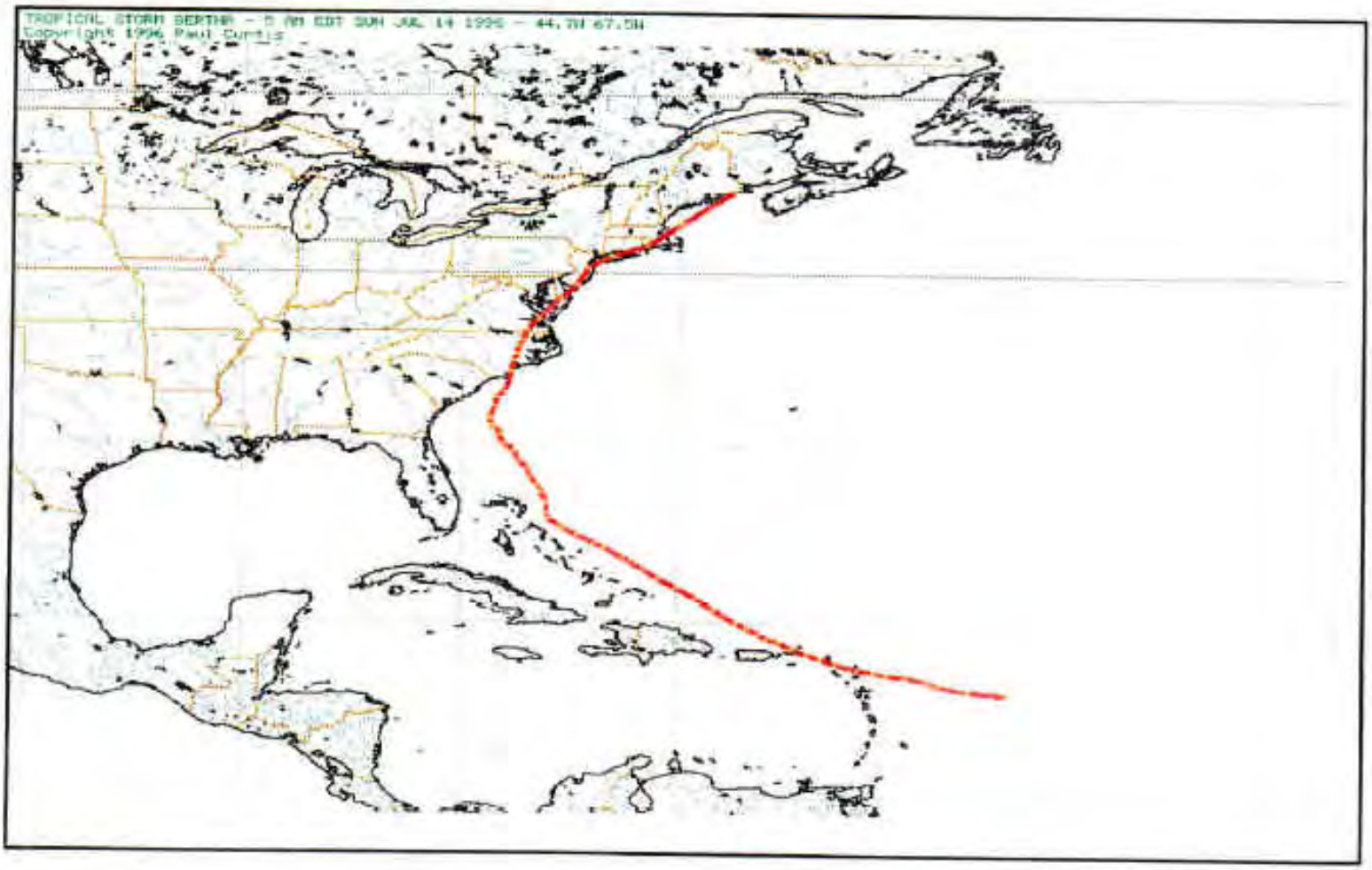


Figure 2-1
Hurricane Bertha Storm Track

Figure 2-2 Hurricane Bertha - Radar Imagery [Go Back](#)

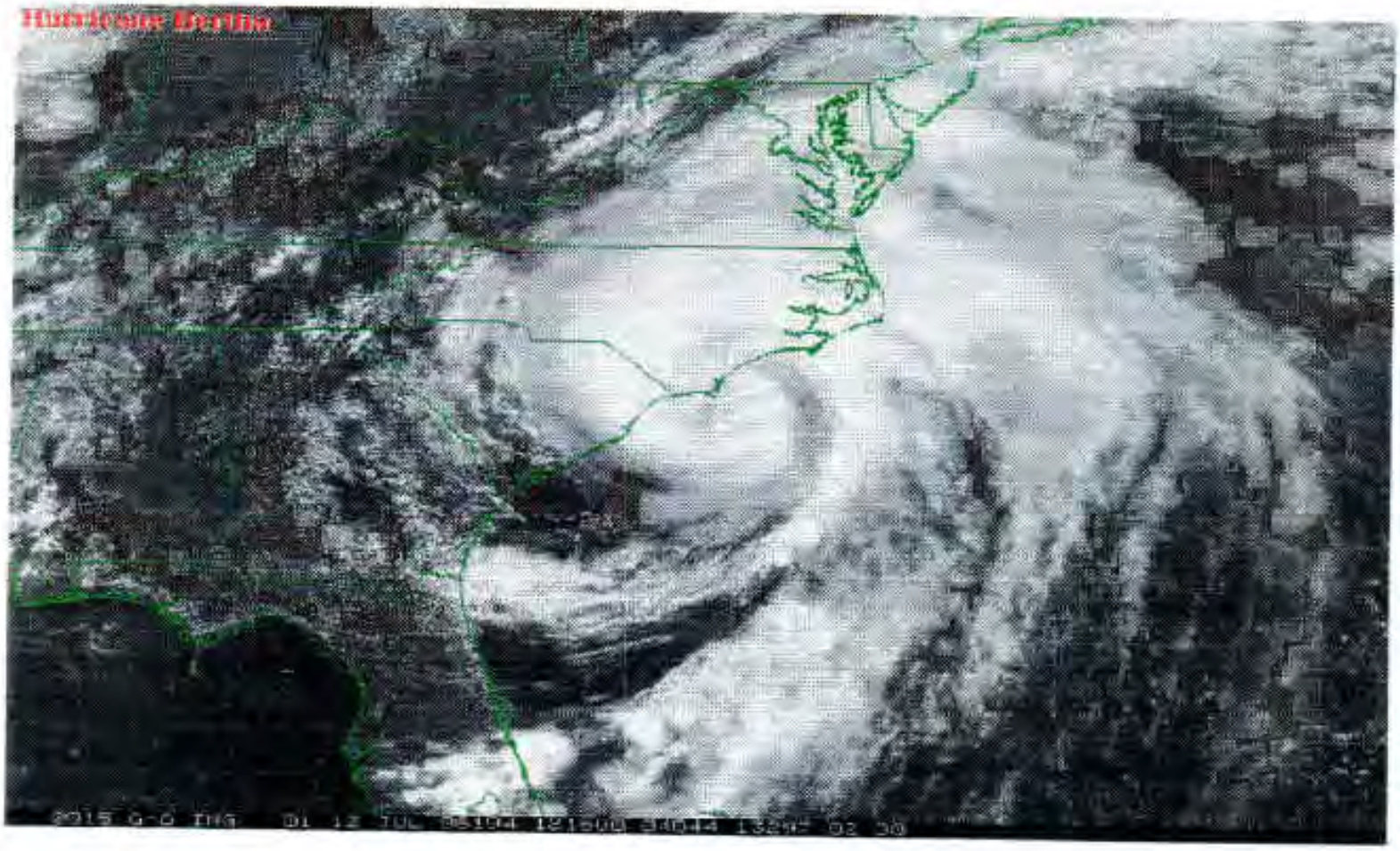


Figure 2-2
Hurricane Bertha - Radar Imagery

Figure 2-3 Hurricane Fran Storm Track [Go Back]

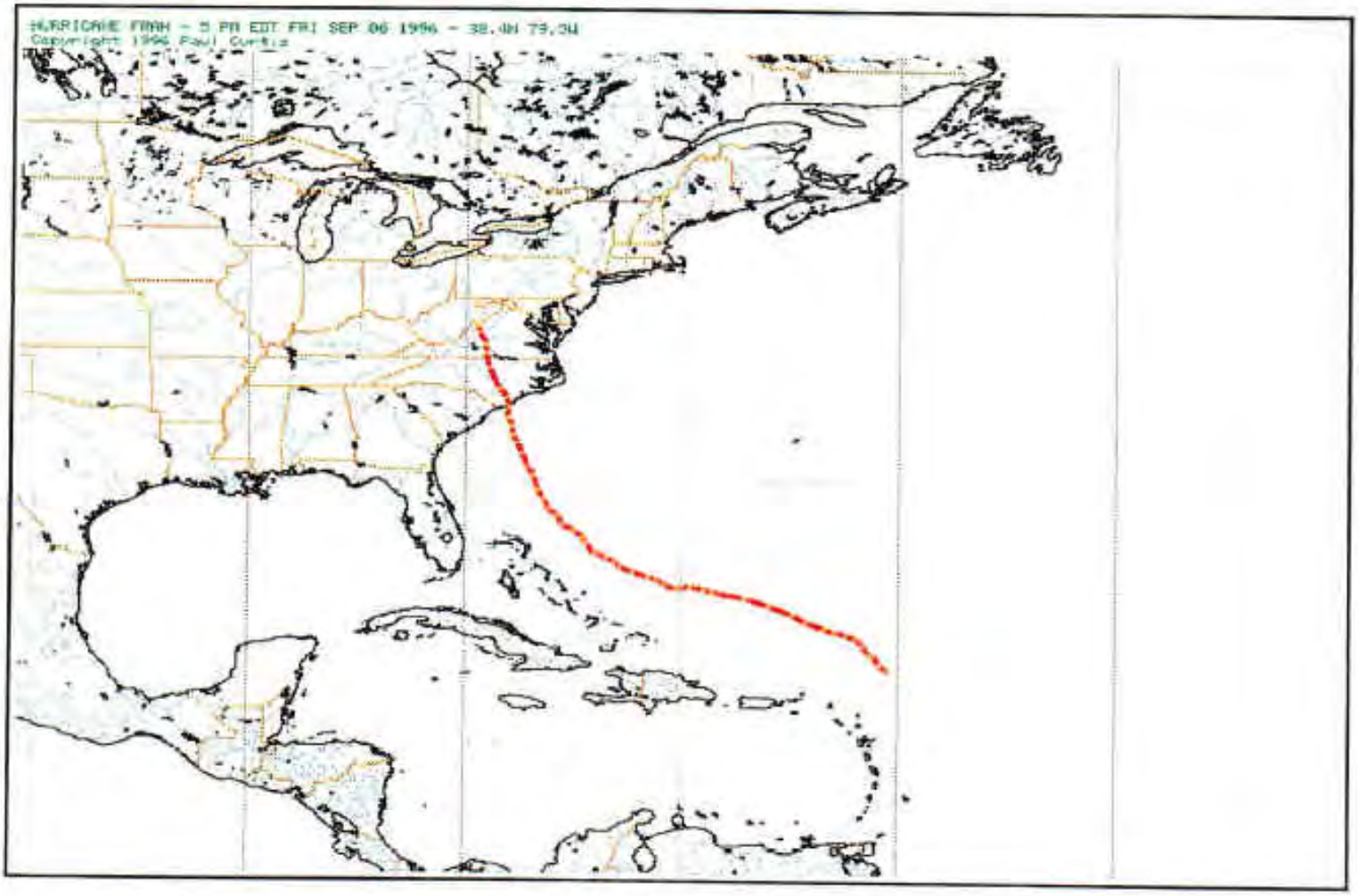


Figure 2-3
Hurricane Fran Storm Track

FIGURE 2-4 Hurricane Fran - Radar Imagery [Go Back]

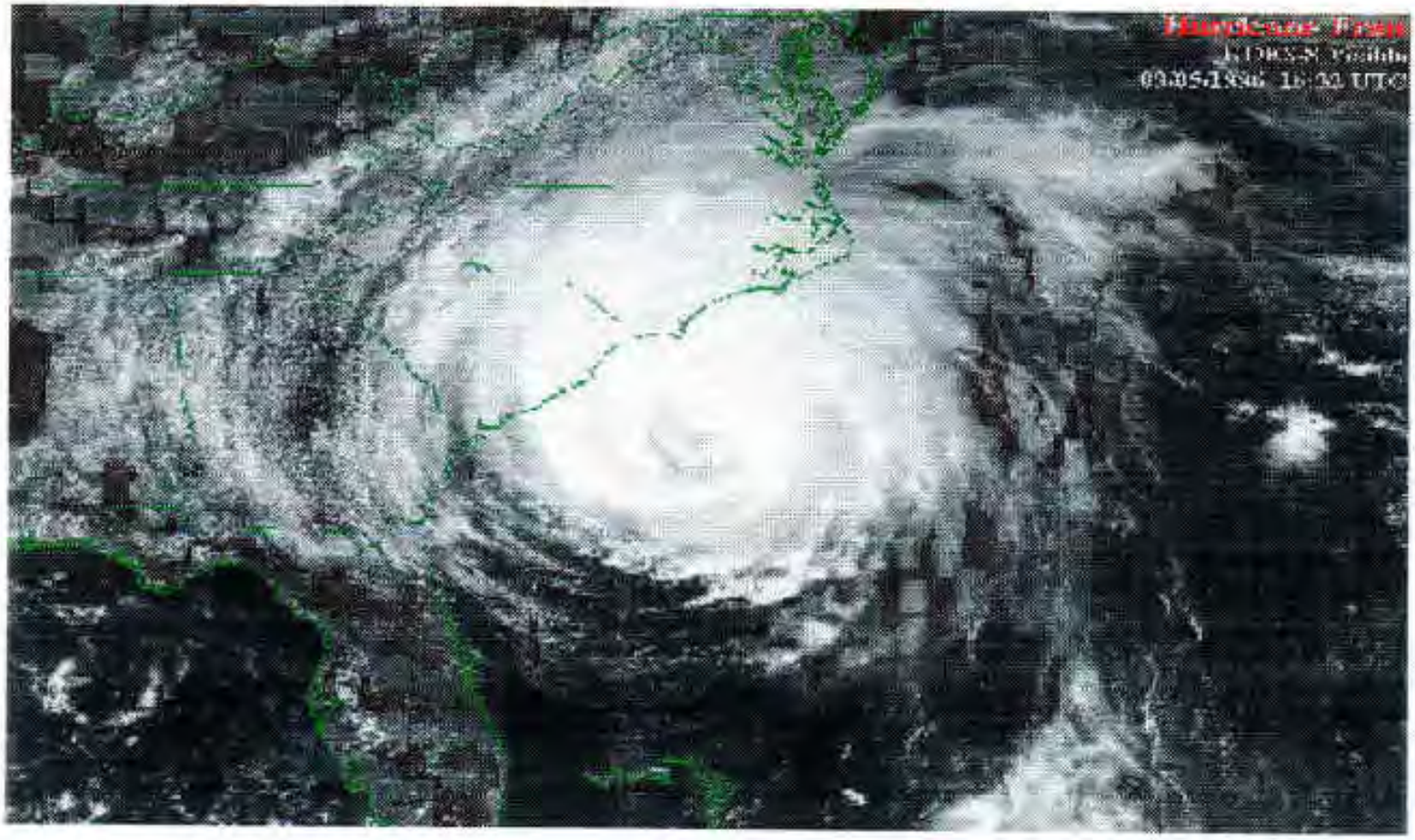
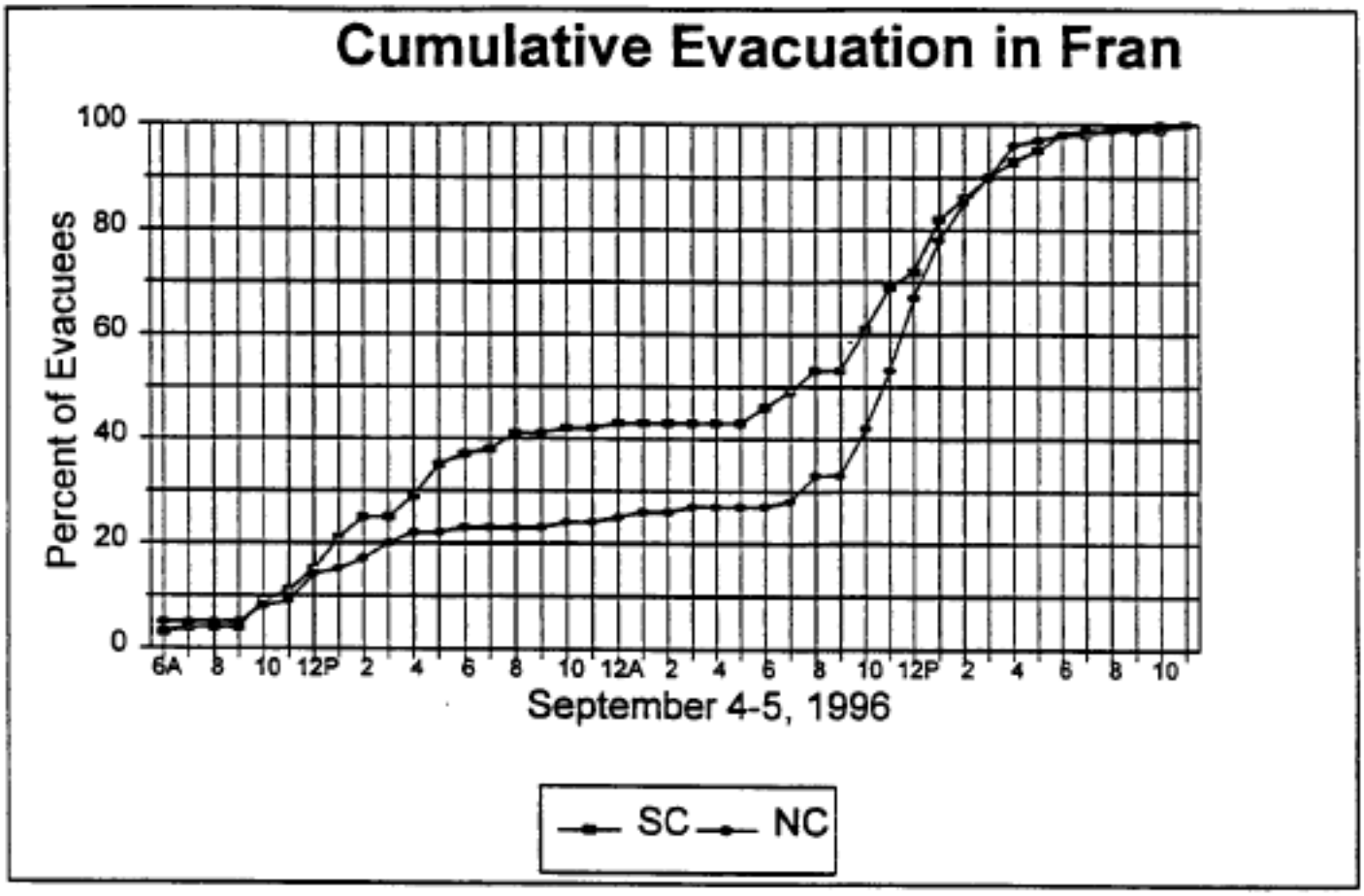


FIGURE 2-4
Hurricane Fran - Radar Imagery

Figure 4-1 Cumulative Evacuation in Fran Go Back



•	9-3-96	11 PM	Hurricane watch for South Carolina
•	9-4-96	7 AM	Evacuation recommended in South Carolina
		11 AM	Hurricane watch for North Carolina
		4 PM	Mandatory evacuation for South Carolina
		5 PM	Hurricane warning for North and South Carolina
		10 PM	Evacuation recommended for N. Topsail Beach, NC
•	9-5-96	8 AM	Evacuation for most of southeastern North Carolina

Figure 4-1
Cumulative Evacuation in Fran

Figure 4-2 Example Traffic Count Curve

Go Back

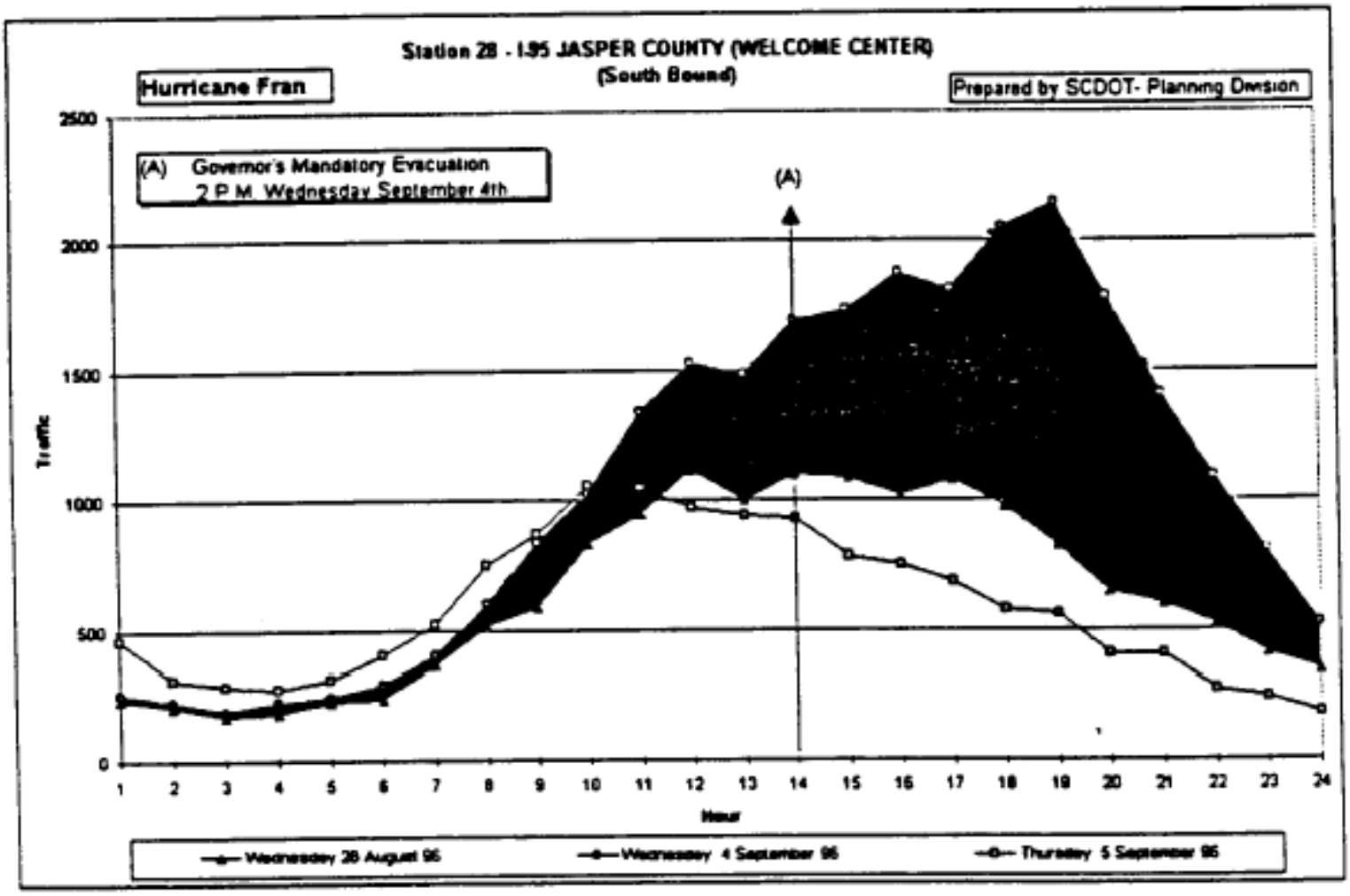
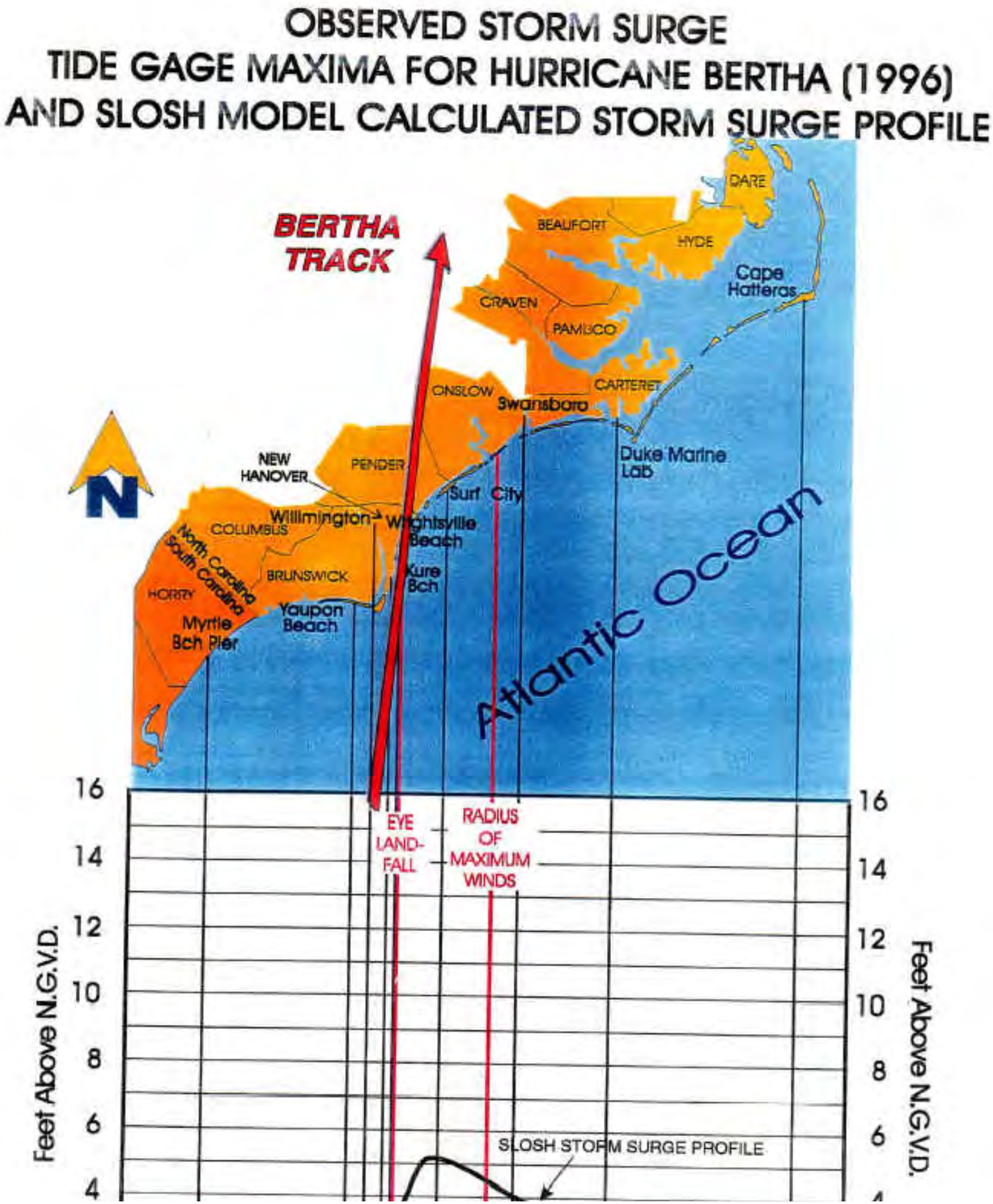


Figure 4-2
Example Traffic Count Curve

Figure 5-1

Go Back



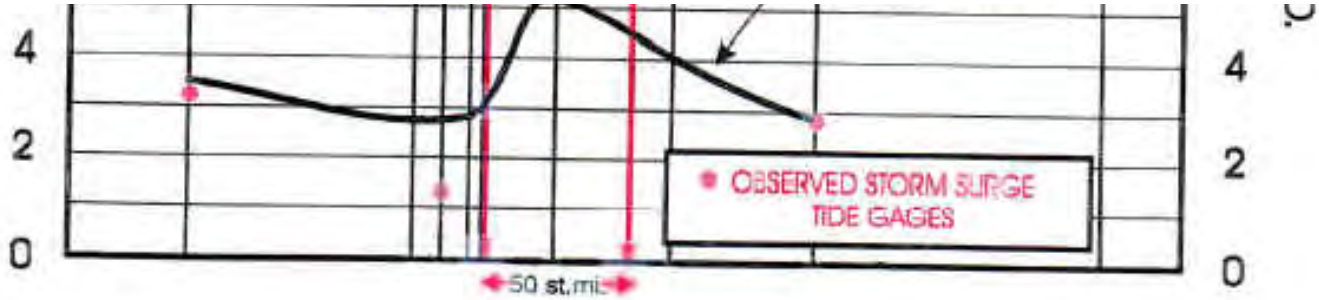


Figure 5-1

Go Back

Figure 5-2

Go Back

OBSERVED STORM TIDE HIGH WATER MARKS FOR HURRICANE FRAN (1996) AND SLOSH MODEL CALCULATED STORM TIDE PROFILE

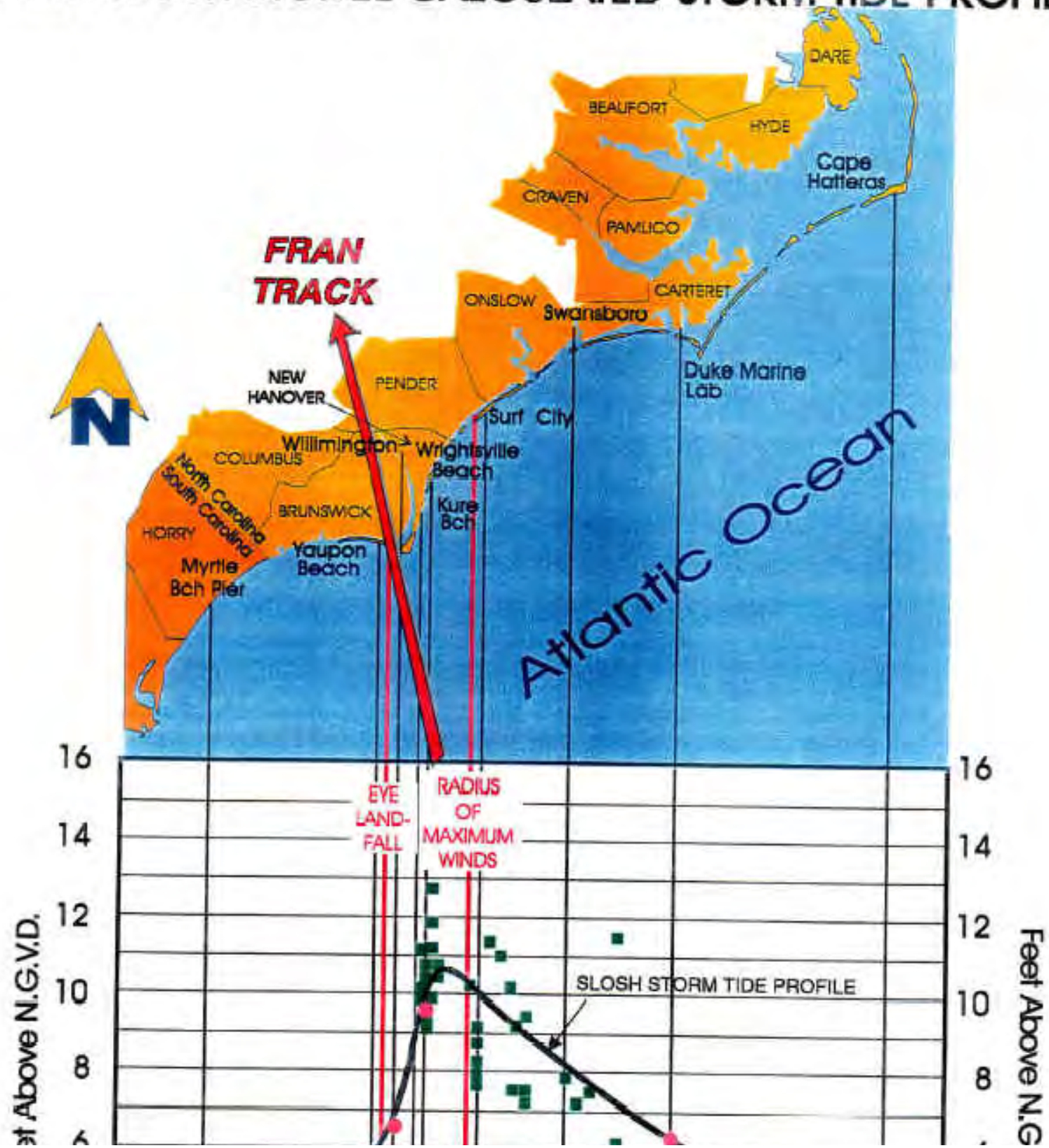


Figure 5

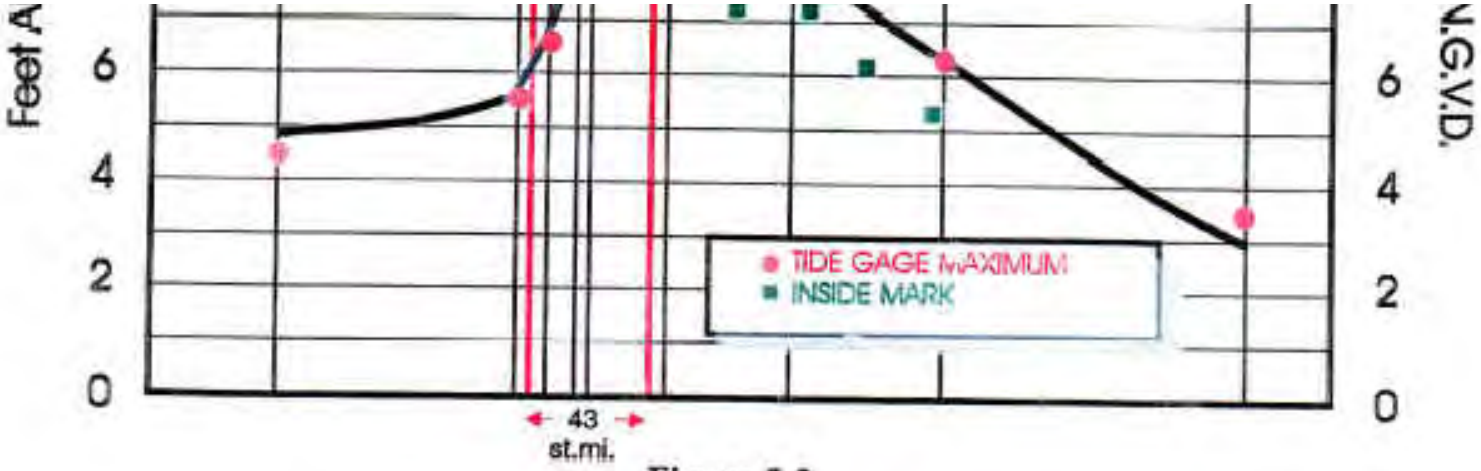


Figure 5-2

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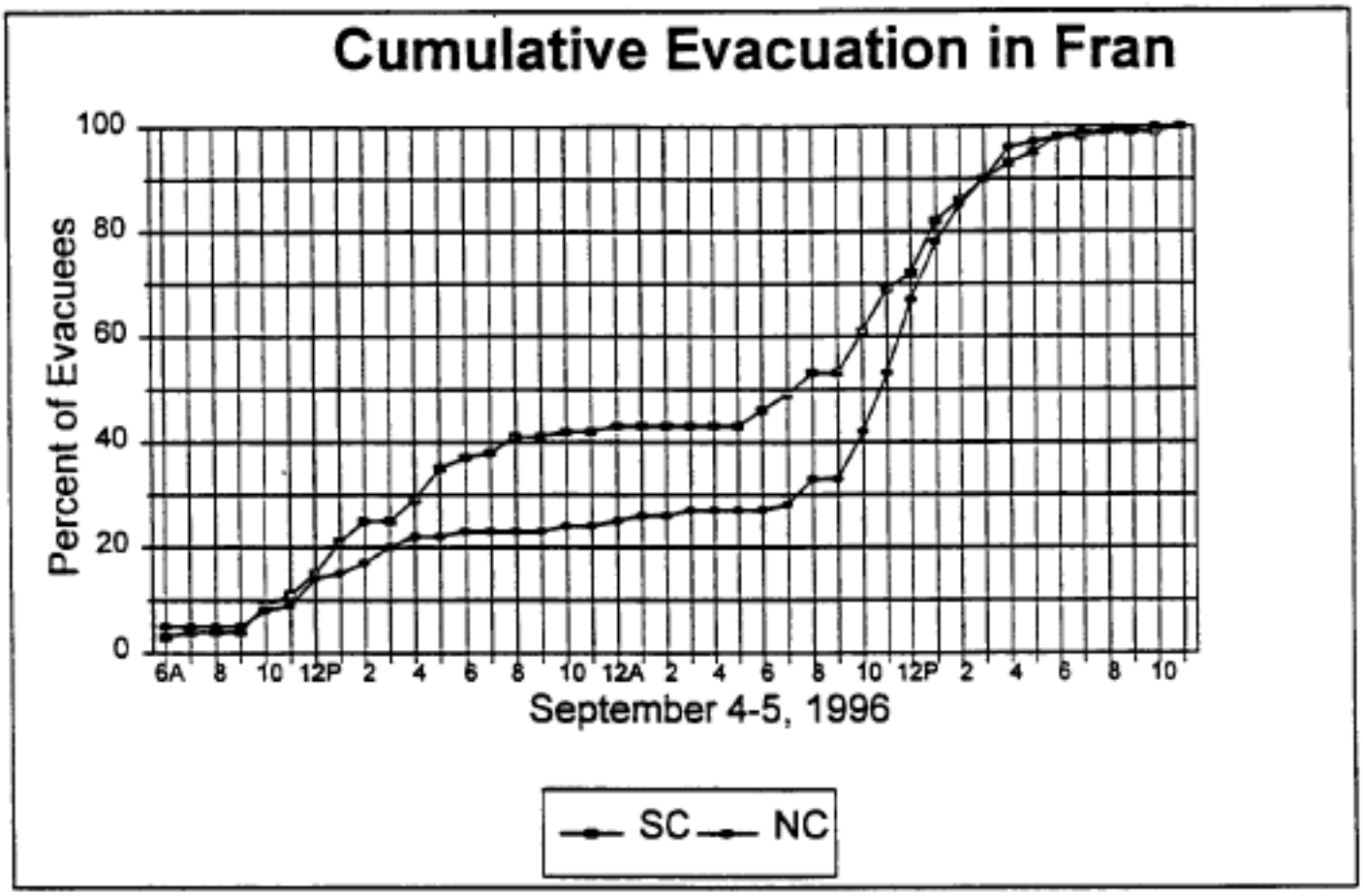
Figure 5-3 Cumulative Evacuation in Fran Go Back



•	9-3-96	11 PM	Hurricane watch for South Carolina
•	9-4-96	7 AM	Evacuation recommended in South Carolina
		11 AM	Hurricane watch for North Carolina
		4 PM	Mandatory evacuation for South Carolina
		5 PM	Hurricane warning for North and South Carolina
		10 PM	Evacuation recommended for N. Topsail Beach, NC
•	9-5-96	8 AM	Evacuation for most of southeastern North Carolina

Figure 5-3
Cumulative Evacuation in Fran

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- 1. The most often given comment from officials on public information was the need to add a "Press" component to hurricane evacuation studies. The component should include presentation materials, camera ready graphics, photograph or slides of previous and potential hurricane damage, and other materials which will aid in educating the public about the dangers of hurricanes, the need for early evacuation, the importance of mitigative efforts, etc. Other critical items which will be useful for public information officers, include easily extractable information on the numbers of people who are vulnerable and the number of people who are being asked to evacuate during a particular storm. New technology developments are already underway to address some of these issues.
- 2. There is a severe deficiency in the availability of public information tools and materials for inland county use in educating the public on inland preparedness and inland hazards associated with hurricanes. The HES program should provide assistance and materials to inland areas to aid in the education of this target audience.

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Table 1-1
Assessment Area Distribution

	State Offices	Coastal Counties	Inland Counties	Total Interviews
Georgia	1	6	4	11
South Carolina	1	6	5	12
North Carolina	1	15	12	28
Virginia	1	1*		2
TOTAL	4	28	21	53

*City of Chesapeake

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TABLE 2-1 - HURRICANE BERTHA EVACUATION CHRONOLOGY

July 5 (Friday)		**Bertha becomes a tropical storm.**
July 8 (Sunday)		**Bertha reaches hurricane status.**
July 9 (Tuesday)	8 AM	Beaufort County, SC activates EOC.
	11 PM	**Tropical storm warnings issued - north of Deerfield Beach, FL to Brunswick GA.** **Hurricane watch issued - north of Brunswick GA to NC/VA border including Pamlico and Albermarle Sounds.**
	12 PM	
July 10	1 AM	Bertha's track became north-northwestward and moved parallel to the coast of Florida and Georgia.
	2 PM	
W	3 AM	
E	4 AM	
D	5 AM	
N	6 AM	
E	7 AM	Beaufort County, SC issues voluntary evacuation order at 7:30 am. Orangeburg County, SC activates EOC.
S	8 AM	Dillon County, SC activates EOC.
D	9 AM	Williamsburg County, SC activates EOC.
A	10 AM	Colleton, Charleston, Georgetown and Horry Counties, SC activate EOC's (time approximated.) Charleston and Horry Counties, SC open public shelters (time approximated.) Georgetown County, SC begins evacuation (time approximated.)
Y	11 AM	**Hurricane warning issued - Sebastian Inlet, FL to Cape Romain, SC.** Onslow County, NC requests voluntary evacuation of tourists at 11:30.
	NOON	
	1 PM	Governor of GA declares State of Emergency for Bryan, Camden, Chatham, Glynn, Liberty and McIntosh Counties. Camden and Glynn Counties, GA issue voluntary evacuation orders at 1:30.
	2 PM	McIntosh County, GA issues voluntary evacuation order. Colleton and Florence Counties, SC open public shelters.
	3 PM	Chatham County, GA issues voluntary evacuation order. Beaufort County, SC issues mandatory evacuation order. Hampton County, SC activates EOC and opens public shelters.
	4 PM	
	5 PM	**Hurricane warning issued - Cape Romain, SC to NC/VA border including Pamlico and Albermarle Sounds.** **Tropical storm warning discontinued - south of Sebastian Inlet, FL.** Liberty County, GA issues voluntary evacuation order at 5:30. Beaufort County, SC opens public shelters.
	6 PM	Orangeburg County, SC opens public shelters.

	7 PM	SC Governor requested a voluntary relocation of the entire coastline of SC, all barrier islands, and manufactured homes and recreational vehicles in coastal counties.
	8 PM	
	9 PM	
	10 PM	
	11 PM	**Hurricane watch issued - NC/VA border to Chincoteague VA including southern Chesapeake Bay.**
	MIDNIGHT	
July 11	1 AM	
	2 AM	
T	3 AM	
H	4 AM	
U	5 AM	**Hurricane warning discontinued south of Brunswick, GA.**
R	6 AM	Beaufort County, SC evacuees allowed to return except Fripp Island and Hilton Head Island. Dare County, NC begins evacuation.
S	7 AM	Beaufort County, NC activates EOC.
D	8 AM	Onslow County, NC requests evacuation of residents.
A	9 AM	
Y	10 AM	New Hanover County, NC issues mandatory evacuation order.
	11 AM	Brunswick County, NC recommends evacuation.
	NOON	SC Governor issues mandatory evacuation order at 12:20 for Horry and Georgetown Counties areas east of the Intercoastal Waterway. Pender County, NC issues mandatory evacuation order.
	1 PM	SC Governor declares State of Emergency. Dillon, Georgetown Counties open public shelters.
	2 PM	Marion County, SC opens public shelters.
	3 PM	
	4 PM	
	5 PM	
	6 PM	Dare County, NC completes evacuation.
	7 PM	
	8 PM	
	9 PM	
	10 PM	
	11 PM	
	MIDNIGHT	
July 12	1 AM	
	2 AM	
F	3 AM	
R	4 AM	
I	5 AM	**Hurricane warning discontinued - Savannah, GA southward.**
D	6 AM	
A	7 AM	
Y	8 AM	
	9 AM	
	10 AM	
	11 AM	**Tropical storm warning issued - NC/VA border to Chincoteague, VA including southern Chesapeake Bay.**
	NOON	
	1 PM	
	2 PM	Beaufort County, SC returns to normal activity.
	3 PM	**Hurricane warning discontinued - Cape Romain, SC southward.**

4 PM	**Hurricane Bertha makes landfall midway between Wrightsville and Topsail Beaches, NC.**
5 PM	Dillon and Orangeburg Counties, SC closed EOC. **Hurricane warning - NC/VA border to Chincoteague, VA including the Hampton Roads area.**
6 PM	Marion County, SC closed shelters.
7 PM	
8 PM	
9 PM	
10 PM	
11 PM	
MIDNIGHT	

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TABLE 2-2 - HURRICANE FRAN EVACUATION CHRONOLOGY

Aug. 28		**Fran reaches hurricane status at 8:00 pm.**
Sept. 3		Georgia activates EOC in Atlanta, GA. Charleston and Orangeburg Counties, SC activate EOC.
	11 PM MIDNIGHT	**Hurricane watch issued - north of Sebastien Inlet, FL to Little River Inlet, SC.**
Sept. 4	6 AM	Chatham County, GA activates EOC. SC Governor issues voluntary relocation request at 6:46 for barrier islands, beach front and low-lying areas along the entire coast. Beaufort, Georgetown and Colleton Counties, SC activate EOC.
W	7 AM	New Hanover County, NC - limited activation of EOC and Media Center at 7:30 am.
E	8 AM	Liberty and McIntosh Counties, GA activate EOC. Dillon County, SC activates EOC.
D	9 AM	
N	10 AM	
E	11 AM	**Hurricane watch extended northward - Little River Inlet, SC to Oregon Inlet, NC including Pamlico Sound.** Beaufort and Colleton Counties, SC open public shelters.
S	NOON	Chatham County, GA issues voluntary evacuation order. Florence and Williamsburg Counties, SC activate EOC Orangeburg County, SC opens public shelters.
D	1 PM	
A	2 PM	NWS Public Advisory # 44A indicates that "a hurricane warning is likely to be issued this evening or tonight for a portion of the watch area."
Y	3 PM	GEMA office in Savannah, GA activates at 3:30. Liberty County, GA issues voluntary evacuation order "prior to Chatham County." Chatham County, GA issues partial mandatory evacuation order at 3:45.
	4 PM	SC Governor issues mandatory evacuation order for entire coast of SC including Jasper, Beaufort, Colleton, Charleston, Georgetown and Horry Counties. Hampton County, SC activates EOC. Hampton, Georgetown, Florence, Williamsburg and Dillon Counties open public shelters.
	5 PM	**Hurricane warning issued - north of Brunswick, GA to Cape Lookout, NC.** **Hurricane watch issued - north of Cape Lookout, NC to Currituck Beach Light, NC including Pamlico and Albermarle Sounds.** **Tropical storm warning issued - Flagler Beach, FL to Brunswick, GA** **Hurricane watch discontinued - south of Cape Lookout NC** Marion County, SC opens public shelters.
	6 PM	New Hanover County, NC issues voluntary evacuation for beach communities and low lying areas and opens public shelters.
	7 PM	Onslow County, NC voluntary evacuation request issued "in the evening".
	8 PM	
	9 PM	
	10 PM	Charleston County, SC opens public shelters. Georgetown County, SC begins evacuation. New Hanover County, NC issues mandatory evacuation order of beach communities and low lying areas to begin at 7 am on Sept. 5th and complete by noon.
	11 PM	**Hurricane warning extended northward - north of Cape Lookout, NC to NC/VA border including the Pamlico and Albemarle Sounds**

		Hurricane watch issued - north of NC/VA border to Chincoteague, VA including the Greater Hampton Roads area.
Sept. 5	MIDNIGHT	Horry and Beaufort Counties, SC evacuations completed at 12:30 am.
	1 AM	
T	2 AM	
H	3 AM	
U	4 AM	Georgetown County, SC evacuation completed.
R	5 AM	**Tropical storm warning discontinued - Flagler Beach, FL to Brunswick, GA.**
S	6 AM	New Hanover County, NC - full activation of EOC and Media Center.
D	7 AM	Beaufort, New Hanover and Dare Counties, NC activates EOC. Pender, Beaufort and Brunswick Counties, NC open shelters New Hanover County, NC begins evacuation. Brunswick County, NC recommends evacuation.
A	8 AM	Greene, Duplin and Columbus Counties, NC activates EOC. Columbus County, NC opens public shelters. Brunswick and Onslow Counties, NC issue mandatory evacuation orders at 8:30.
Y	9 AM	Pender County, NC declares State of Emergency and issues evacuation order.
	10 AM	
	11 AM	**Tropical storm warning issued - north of the NC/VA border to Chincoteague, VA including the Greater Hampton Roads area.** **Tropical storm warning issued - lower Chesapeake Bay.** **Hurricane warning downgraded to tropical storm warning - north of Brunswick, GA to just south of Edisto Beach, SC.** NWS Public Advisory #48 indicates that "tropical storm winds will reach coast shortly. Rainbands are spreading over coastal areas of the Carolinas."
	NOON	Carteret County, NC opens public shelters.
	1 PM	Jones Counties, NC open public shelters.
	2 PM	
	3 PM	
	4 PM	Cumberland County, NC activates EOC and opens public shelters.
	5 PM	NWS Public Advisory #49 indicates that "hurricane force winds are beginning to spread across the coast in hurricane warning areas. Rainbands are spreading inland. Isolated tornadoes possible over portions of NC and SC."
	6 PM	Duplin and Wayne Counties, NC opens public shelters. Carteret County, NC completes evacuation.
	7 PM	NWS Advisory #49A indicates that "hurricane force winds are affecting the coast in hurricane warning area."
	8 PM	**Fran made landfall around 8:30 over the Cape Fear area.**
	9 PM	**Hurricane and tropical storm warnings discontinued - Cape Romain, SC southward.** NWS Advisory #49B gives an unconfirmed report of a tornado at Topsail Beach, NC.
	10 PM	
	11 PM	**Hurricane warnings discontinued - south of Cape Fear, NC.** **Hurricane watch discontinued - north of the NC/SC border to Chincoteague, VA including the Greater Hampton Roads area.**
	MIDNIGHT	
Sept. 6	5 AM	**Hurricane warning discontinued - remainder of NC coast.**
F	NOON	
R	1 PM	
I	2 PM	**Tropical storm warning discontinued - remainder of US east coast.**

		Fran downgraded to a tropical depression.
D	3 PM	
A	4 PM	
Y	5 PM	Orangeburg County, SC closes EOC. Dillon County, SC closes EOC. Marion County, SC closes shelter.

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Table 3-2
Georgia Hazards and Vulnerability Evaluations

AGENCY OR COUNTY	HAZARDS IDENTIFICATION SOURCES/ DECISION MAKING TOOLS	VULNERABILITY ANALYSIS	COMMENTS
Georgia Emergency Management Agency (GEMA)	Used Inland Winds model, DTN, NWS, Weather Channel, Technical Data Report and surge maps. HURREVAC needs to be revised to include time line data for reacting to specific actions in OPCONS. HES data is in need of updating.		Has confidence in HES products but would like to see Flood Insurance Rate Map (FIRM) flood information overlaid on SLOSH maps. Need more and periodic training (including elected officials) on hurricane software and evacuation decision making. Technical capability of conference calls should be increased to allow more access.
Chatham	Used HURREVAC, weather wire, faxes and phone calls from NHC and NWS, Weather Channel, consultation with local meteorologists and SLOSH maps.	**Bertha**: voluntary evacuation countywide with special emphasis on islands, mobile homes, flood prone areas and waterfronts. 20,000 evacuated. **Fran**: voluntary evacuation countywide and mandatory for islands, mobile homes, flood prone areas, and waterfronts. Some nursing homes refused to take action.	Products worked well but would like additional NHC products. Had problems with HURREVAC 6.0 - some maps were not correct. Local officials need evacuation decision making training. Evacuation decisions were made too late.
Bryan	Used data provided by HES, Weather Channel, NOAA weather radio, Decision Arcs and HURRTRAK. HURREVAC should be easier to use and should have better graphics for presentations.	No areas were evacuated. Asked residents at Magnolia Manor Retirement Village to voluntarily relocate.	HES products, generally, provided a good depiction of hazards. Fresh water flooding should be depicted on surge maps. Decision Arcs was easier to present to officials. Could not download information from GEMA for HURREVAC. Would like more training in information on weather patterns and would like to integrate it into public information.
Liberty	Used HURREVAC, Decision Arcs, Inland Winds, Surge Maps, but relied mostly on DTN.	Voluntary evacuation conducted for low-lying areas and mobile homes east of Hwy 17.	It takes too long to access and download information for HURREVAC. Data provided by HURREVAC, Inland Winds, and rainfall and tide information should be merged into one data source. Need periodic training on HURREVAC and Inland Winds.
McIntosh	Used NWS faxes, DTN and GEMA for information. (Does not have HURREVAC because does not have a computer.) Would use surge maps if strike was imminent within 24 hours.	Voluntary evacuation conducted for islands, low-lying areas and mobile homes. Believes areas evacuated were appropriate.	Need information from sources faster because people watching Weather Channel got information quicker. Need assistance and evacuation recommendations from GEMA, NHC, NWS, etc. HES data is adequate to identify hazards.
Glynn	Used HURREVAC, DTN, Weather Channel, and NOAA flood maps. Has not received formal training on use of HURREVAC and Inland Winds.	Voluntary evacuation conducted for barrier islands and low-lying mainland. Believes evacuation area was appropriate. Did not use evacuation zones as they are believed to be too erratic.	Information such as tides, wind driven wave heights, surge heights, etc. should be incorporated into HURREVAC. Generally, decision tools worked well, but SLOSH data overestimates potential surge - too far inland. Used experience to identify areas to be evacuated.
Camden	Used NWS information, Decision Arcs, HURREVAC and evacuation maps developed by Coastal Area Planning Commission.	**Bertha**: evacuated low-lying areas.	HES tools worked well and would use them again. Received adequate training from GEMA on HURREVAC but would like to see precipitation data added to HURREVAC.
Laurens	Gets hazards information from GEMA, Chatham County, NWS, HURREVAC, the Weather Channel, and DTN.	**Fran**: evacuated nursing home on Tybee Island.	Warnings from NWS are usually after the fact. Has had little training on Inland Winds model. Would like more recommendations and information from GEMA during event.
Bibb	Gets hazards information from the Weather Channel, DTN, and NWS. Has not had formal training on Inland Winds model and HURREVAC.	No evacuations - host county.	Need assistance from GEMA on making models work. Need more communication between GEMA, the public, and risk and host counties. HURREVAC and Inland Winds are not user friendly.
Columbia	Weather Channel and DTN are primary sources of information. Does not have Inland Winds or HURREVAC but needs them.	No evacuations.	Need better coordination with NWS. Would like to see a public information brochure developed for hurricane hazards in inland counties. County is not designated as risk or host county, yet hotels were full of evacuees during Hurricane Fran.
Richmond	Has Inland Winds model but did not use it. Relies on DTN, Weather Channel and the Savannah River Site	No evacuations - host county.	Need better coordination with NWS. Would like more information from GEMA during storm approach

	DTN, Weather Channel and the Savannah River Site Weather Center for weather information.		from GEMA during storm approach.

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Table 3-3
Georgia Shelter Evaluations

Agency or County	# Shelters Opened*	# Evacuees Sheltered	Time Opened	Duration Open	Comments
Chatham	Bertha: 3	5			Shelters opened were for fresh water flooding.
Liberty	Bertha: 2 Fran: 1	one family 12		Less than 1 day	
Camden	Bertha: 2	40		1.5 days	
Laurens	Fran: 1	0		until midnight same day	**Bertha**: hotels were full. Made preparation to open shelters but never had to open them. **Fran**: opened one shelter, no one came. Received special needs evacuees in VA and Fairview Park Hospitals and nursing home. Special needs is a big problem. Hotels filled up a day before storm arrival with people from South Carolina and Savannah.
Bibb	Fran: 1	12			There are more than 4400 hotel/motel rooms in area. Have never sheltered more than 200 or 300 people in area. Sheltered 50 animals from South Carolina at City Park. During Fran, hotels in Macon were fulll with the vast majority of the people from South Carolina. Officials had no means of alerting I-16 travelers that shelters were open in county. After landfall, got electronic message sign from DOT.
Columbia					Hotels were full during Fran. Were prepared to open shelters during Fran.
Richmond	Fran: 1	4			Hotels were full during Bertha and Fran. Is a host county for special needs population from Effingham and medical facilities shelter for Savannah. Need more coordination with South Carolina.
Brantley	Bertha: 1	5			
Bulloch	Bertha: 2	5			
Coffee	Bertha: 3	6			
Ware	Bertha: 4	500			
McIntosh					No Red Cross shelters in County. Need alternative shelters for Category 1 or 2 storms. People on fixed incomes can not afford to evacuate 100 miles on a "maybe" hit. County is willing to open their own shelters

					evacuate 100 miles on a "maybe" hit. County is willing to open their own shelters.

*Data does not represent all sheltering in the state. Information provided only for counties included in the post-storm analysis.

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Table 3-4
Georgia Traffic Counts

	(A) Georgia DOT factored up count I-16 WB	(B) South Carolina I-16 WB traffic from I-95	Georgia only traffic (A) minus (B)
11AM	540	400	140
NOON	1,860	500	1,360
1PM	1,560	600	960
2PM	2,280	600	1,680
3PM	4,320	800	3,520
4PM	2,100	700	1,400
5PM	1,880	1,000	880
6PM	2,480	1,400	1,080
Total vehicles	17,020	6,000	11,020

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Table 3-5
Georgia Traffic/Clearance Times Data

County	Time Evacuation Order Effective	Duration of Substantial Evacuating Traffic*	Comments
Chatham	**Bertha**: 7/10, 3:00 p.m. **Fran**: 9/4, 3:45 p.m.	**Bertha**: 14 hrs **Fran**: 8.5 hrs	Believes HES underestimates clearance times because numerous evacuees from other counties and South Carolina filtered through roadway network.
Bryan		**Bertha**: 11.5 hrs **Fran**: 8.5 hrs	Major evacuation route indicated in HES floods. Had to redo the routing. No signs on new route.
Liberty	**Bertha**: 7/10, 5:30 p.m. **Fran**: 9/4 "prior to Chatham Cnty"	**Fran**:	Had voluntary evacuation of areas east of Hwy 17 in both storms.
McIntosh	**Bertha**: 7/10, 2:00 p.m.	**Bertha**: 12 hrs **Fran**: 12 hrs	There is only one road out of county. In Category 4 or 5 hurricane, could be a problem because the road goes thru a low-lying area and could flood.
Glynn	**Bertha**: 7/10, 1:30 p.m.	**Fran**: 2 hrs	
Camden	**Bertha**: 7/10, 1:30 p.m.	12 hrs	
Laurens			Signs were used to direct evacuees. Had no major traffic problems. I-16 was congested. Chatham County informed county that people may be coming from Savannah and South Carolina, but did not know how many. There was no coordination between County and State Troopers. There were no major backups.
Bibb			Officials had no means of alerting I-16 travelers that shelters were open in Bibb County. Need an electronic message board to help direct traffic.

*Duration of substantial evacuating traffic was provided by local officials during interviews.

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Table 4-2
South Carolina Hazards and Vulnerability Evaluations

AGENCY OR COUNTY	HAZARDS IDENTIFICATION SOURCES/DECISION MAKING TOOLS	VULNERABILITY ANALYSIS	NUMBER EVACUATED	COMMENTS
South Carolina Emergency Preparedness Division	Used HURREVAC, Inland Winds, NWS, GTE Weather Satellite, and NHC.	**Bertha:** voluntary relocation for Horry and Georgetown Counties east of the Intracoastal Waterway requested. **Fran:** entire SC coastline including Jasper, Beaufort, Colleton, Charleston, Georgetown and Horry Counties ordered to evacuate.		State conference calls need more access. Need more graphics with HES products. Evacuation zones not used - too complicated. Need bulletin boards for HES information and give counties passwords.
Horry	Used Weather Channel, DTN, and NWS.	**Bertha**: areas east of Atlantic Intracoastal Waterway (AIWW) requested to voluntarily relocate. **Fran**: all areas east of Hwy 17 bypass ordered to evacuate.	**Bertha**: 150,000 **Fran**: 75,000	HES analyses need to be updated based on new population numbers.
Georgetown	Used HURREVAC, Contel weather line, GTE weather satellite, Weather Channel, and NWS. Need more training in use of decision making tools.	**Bertha**: areas east of AIWW (Waccamaw Neck area) requested to voluntarily relocate. **Fran**: areas east of Hwy 17 ordered to evacuate.	**Bertha**: 20,000 **Fran**: 10,000	Need new evacuation zones and resolve problems with new computerized surge maps. Evacuation zones not used. Need more lead time before evacuation order given.
Charleston	Used HURREVAC, Inland Winds, Contel weather wire, inundation maps, and NWS.	**Bertha**: voluntary relocation of barrier islands, low-lying areas and mobile homes requested. **Fran**: mandatory evacuation of barrier islands, low-lying areas and mobile homes ordered.	Bertha: ? Fran: ?	HES evacuation zones were not used. Study needs a major update. Areas to be evacuated need to be better defined.
Colleton	Used NWS, HURREVAC, Inland Winds, Contel weather wire, and coordination with Beaufort County.	**Bertha**: voluntary relocation for Edisto Beach and mobile homes. **Fran**: mandatory evacuation for Edisto Beach and mobile homes.	**Bertha**: 1000+ (600 permanent and 500 tourists)	Study products worked well.
Beaufort	Used HURREVAC, NHC, GDS, NWS, and Decision Arcs.	**Bertha**: voluntary relocation for barrier islands, low-lying areas, mobile homes requested. **Fran**: barrier islands, low-lying areas, and mobile homes evacuated.	**Bertha**: 100,000 **Fran**: 60,000	Need updated clearance times, digital surge maps and probability graphics incorporated into HURREVAC.
Dillon	Used NWS, SC Law Enforcement Division teletype and faxes, state conference calls and faxes, and Weather Channel. Has Inland Winds but did not use.	**Bertha**: voluntary relocation of mobile homes and low-lying areas. **Fran**: voluntary relocation of mobile homes and low-lying areas.	Bertha: ? Fran: ?	
Marion	Used NWS, phone communications with Horry County, state conference calls and faxes, and Weather Channel. Has Inland Winds but did not use because data was generally unavailable.	**Bertha**: evacuation of mobile homes recommended. **Fran**: evacuation of mobile homes recommended.	Bertha: ? Fran: ?	Believes more timely information is needed. Agencies could use Internet to disseminate information.
Florence	Used state conference calls and faxes, SC Law Enforcement Division teletype, NWS, and HES technical data (reviewed informally.) Has Inland Winds but did not use. Would like more contact with NWS.	**Bertha**: voluntary relocation of mobile homes requested. **Fran**: mandatory evacuation of mobile homes.	Bertha: ? Fran: ?	Probably not enough mobile home evacuated.
Williamsburg	Used state conference calls and faxes, Weather Channel, and NWS.	**Bertha**: voluntary relocation. **Fran**: mandatory evacuation.	Bertha: ? Fran: ?	Generally, HES information was adequate. Would like Inland Winds and training on the model.
Orangeburg	Used HURREVAC for shelters and storm plot, Inland Winds, Weather Channel, and NWS. Had problems importing data to Inland Winds.	**Bertha**: recommended mobile home residents evacuate. **Fran**: recommended mobile home residents evacuate.	Bertha: ? Fran: ?	Area evacuated was appropriate. HES products accurately depicted hazards.
Hampton	Used conference calls with state and Beaufort County, Inland Winds, faxes from Colleton County and Weather Channel.	**Bertha**: evacuated mobile homes. **Fran**: evacuated mobile homes.	Bertha: ? Fran: ?	HES products worked okay.

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Table 4-3
South Carolina Shelter Evaluations

Agency or County	# Shelters Opened	# Evacuees Sheltered	Time Opened	Duration Open	Comments
Horry	Bertha: 11 Fran: 10	Bertha: 4312 Fran: 4300	Bertha: 7/10 10 am Fran: 9/4	Bertha: 24 hrs Fran: 36 hrs	
Georgetown	Bertha: 2 Fran: 2	Bertha: 400 Fran: 1000	Bertha: 7/11 1 pm Fran: 9/4 4 pm	Bertha: 30 hrs Fran: 30 hrs	
Charleston	Bertha: 10 Fran: 12	Bertha: ? Fran: 849	Bertha: 7/10 10 am Fran: 9/4 10 pm	Bertha: 20 hrs Fran: 20 hrs	Less than 1% of evacuees used public shelters. Need to solve problem of sheltering pets.
Colleton	Bertha: 4 Fran: 4	Bertha: 12 Fran: 36	Bertha: 7/10 2 pm Fran: 9/4 11 am	Bertha: 2 days Fran: 2 days	No problems encountered.
Beaufort	Bertha: 3 Fran: 0	Bertha: 1000	Bertha: 7/10 5 pm Fran: 9/4 11 am		During Fran had no local Red Cross shelters.
Dillon	Fran: 3	Bertha: 200 Fran: 835	Bertha: 7/11 1 pm Fran: 9/4 4 pm	Bertha: 2 days Fran: 2 days	
Marion	Bertha: 4 Fran: 5	Bertha: 336 Fran: 1000	Bertha: 7/11 2 pm Fran: 9/4 5 pm	Bertha: 28 hrs Fran: 2 nights	
Florence	Bertha: 2 Fran: 5	Bertha: 100 Fran: 1100	Bertha: 7/10 2 pm Fran: 9/4 4 pm	Bertha:2 nights Fran: 2 nights	
Williamsburg	Bertha: 6 Fran: 8	Bertha: 250 Fran: 1150	Bertha: 7/10 Fran: 9/4 4 pm	Bertha: 2 days Fran: 2 days	
Orangeburg	Bertha: 16 Fran: 16	Bertha: 0 Fran: 220	Bertha: 7/10 6 pm Fran: 9/4 noon	Bertha: 1 day Fran: 2-3 days	
Hampton	Bertha: 4 Fran: 3	Bertha: 300 Fran: 522	Bertha: 7/10 3 pm Fran: 9/4	Bertha: 2.5 days Fran: 2.5 days	

	Fran: 3	Fran: 522	Fran: 9/4 4 pm	Fran: 2.5 days	

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Table 4-4
South Carolina Traffic/Clearance Time Data

County	HES Clearance Times*	Time Evacuation Order Effective	Duration of Substantial Evacuating Traffic**	Estimated Clearance Times ***	Comments
Horry	15.75 hrs	**Bertha**: 7/11 12:20 pm **Fran**: 9/4 4:00 pm	**Bertha**: 14 hrs **Fran**: 8.5 hrs	**Bertha:** 13 hrs **Fran:** 9 hrs	Roadway network was accurately depicted by HES. Law enforcement manned key intersections. During Bertha, roads backed up with outgoing traffic. During Fran, roads were not as backed up, traffic moved evenly.
Beaufort	North of Broad River: 7 hrs South of Broad River: 12 hrs	**Bertha**: 7/10 2:00 pm **Fran**: 9/4 4:00 pm	**Bertha**: 11.5 hrs **Fran**: 8.5 hrs	**Bertha:** 12 hrs **Fran:** 10.5 hrs	During Bertha had large tourist population, especially on Hilton Head. Experienced gridlock traffic on mainland. It took many hours for evacuees to reach planned destinations. Mainland roadway network proved inadequate to accommodate Hilton Head traffic volume. Too many people left at the same time. Some returned home when they encountered gridlock traffic.
Charleston	17 hrs	**Fran**: 9/4 4:00 pm	**Fran**:	**Fran:** 12 hrs	New roadway network not depicted in HES. SCDOT traffic count data indicates minimal evacuation spread out over 12 hrs.
Georgetown	7.5 hrs	**Bertha**: 7/11 12:20 pm **Fran**: 9/4 4:00 pm	**Bertha**: 12 hrs **Fran**: 12 hrs	**Bertha:** 13 hrs **Fran:** 8 hrs	A detour was placed in Andrews due to road construction. During Fran, traffic was not allowed to go north on Hwy. 17, it was stopped at the Intercoastal Waterway. Hwy. 521 had bottleneck traffic, some of it was diverted up Hwy. 51 to Florence. Law enforcement manned key intersections. There was bumper-to-bumper traffic from Pawleys Island through Georgetown.
Colleton	11.75 hrs	**Fran**: 9/4 4:00 pm	**Fran**: 2 hrs		Only Edisto Beach evacuated. Roadway network depicted accurately in HES.
Dillon	N/A		12 hrs		HES evacuation routes worked well. There was an 8 mile backup into town. Police routed traffic through residential areas.
Marion	N/A				There are three main routes through county: Hwys 501, 9 and 378. Hwy. 76 into Marion had bottleneck traffic. Rerouted traffic to alternate routes.
Florence	N/A				Roadways were marked well but not specifically designated for use by specific areas. Hwy. patrol would not provide traffic control for voluntary order during Bertha.
Williamsburg	N/A				No major problems. Had heavy traffic but managed it well.
Orangeburg	N/A				HES accurately depicted roadway network.

Orangeburg	N/A				HES accurately depicted roadway network. Evacuation essentially complete before storm affected area.
Hampton	6.5 hrs		5 to 6 hrs.		HES accurately depicted roadway network.

*Clearance times based on high tourist occupancy, medium evacuee response, category 3 storm.

**Duration of substantial evacuating traffic was provided by local officials during interviews.

***Actual clearance times estimated from SCDOT traffic count data.

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Table 5-10
Northern North Carolina Traffic/Clearance Time Data

County	HES Clearance Times*	Time Evacuation Order Effective	Duration of Substantial Evacuating Traffic**	Comments
Beaufort	9 hrs	Fran: 9/5 7 am		Evacuation network was accurate.
Pitt	NA			Did not experience traffic problems.
Dare	12.5 hrs	Bertha: 7/11 6 am		Heavy tourist population during Bertha. Response was good. Evacuation network was accurate. Virginia stopped evacuation at Rte. 168 into Virginia.
Chowan	10.75 hrs			During mandatory evacuation of Hatteras Island, traffic was extremely heavy. Traffic flow was into and through Chowan with US 17 as the main route.
Bertie	15.5 hrs			During Bertha, response timing was bad. Traffic was heavy. Most traffic was on US 17.
Hertford	NA			Need better traffic signs. Message boards are needed to assist in traffic control at key locations.
Washington	10.5 hrs			Had no evacuation or traffic problems.
Currituck	9.5 hrs			Heavy traffic on US 158 into Camden and Pasquatank Counties to Elizabeth City. Also heavy traffic up US 17 N into Virginia.

*Clearance times based on high tourist occupancy, medium evacuee response, category 3 storm.
**Duration of substantial evacuating traffic was provided by local officials during interviews.

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Table 5-11
Southern North Carolina Traffic/Clearance Time Data

County	HES Clearance Times*	Time Evac. Order Effective	Duration of Substantial Evacuating Traffic**	Comments
NC Division of Emergency Management - Area C Office	NA			Timing of local evacuation orders were delayed as a result of the information in the advisories. Accuracy of advisories were slow. Traffic flow was heaviest on I-40 (bumper-to-bumper.)
Bladen	NA			There were no significant problems with traffic. Was able to keep reasonable flow with use of law enforcement.
Wayne	NA			Traffic flowed well. EOC is notified in advance of Craven and Carteret evacuations so that law enforcement can be positioned. Hwy 70 is main evacuation route.
Craven	7.5 hrs			
Lenior				Traffic was bottlenecked along US 70 in Kinston at intersections of other highways.
Carteret	10.75 hrs			Roadway network was accurate. Evacuees used routes indicated. No roadblocks encountered. Used highway patrol and traffic lights on blink to speed traffic flow.
Brunswick	7.75 hrs (revised in 1996 during restudy to 15 hrs)	**Bertha**: 7/11 11 am (voluntary) **Fran**: 9/5 7 am (voluntary) 8:30 am (mandatory)	5 hrs for both storms	Evacuation was extremely smooth. Voluntary evacuation went so well that mandatory evacuation order was not necessary. Road system to barrier island is adequate. Clearance time was less than estimated in HES. Long Beach was difficult to evacuate during Fran. Received excellent assistance from Sheriff's Department and Highway Patrol. Roadway network was accurately depicted. Manned key intersections. Sealed off bridges to barrier islands after evacuation.
New Hanover	6.75 hrs (revised in 1996 during restudy to 8.24 hrs)	**Bertha**: 7/11 10 am **Fran**: 9/4 6 pm (voluntary) 9/5, 7 am (mandatory)	**Bertha**: 7 hrs **Fran**: 9 hrs	By the time the evacuation order was given for Bertha, the clearance time was cut very close. Traffic flow was good out of county. Some evacuees went as far as Raleigh. No Brunswick evacuees effected the New Hanover evacuation process. The evacuation network was accurate, however, the road systems were not adequate. Brunswick County traffic was rerouted along Hwy 421 to I-95. During Bertha, traffic from Brunswick tried to get to I-40 through Wilmington.
Greene	NA			No study in area.
Cumberland	NA			Evacuation problems were limited because no major highway routes feed directly inland into county. Law enforcement was directed to abandon road operations and were removed from road system once winds reached 50 mph. The evacuation network was accurate.
Columbus				No projected routes. Little impact on roadway. No problems.
Pender	6 hrs (revised in 1996 during restudy to 6.25 hrs)	**Bertha**: 7/11 noon **Fran**: 9/5 9 am		Evacuation went okay with no major bottlenecks. Phased evacuation, moving most remote and inaccessible evacuees first. Evacuation roadway was accurate. State troopers were stationed at critical intersections. Evacuation order directed evacuees to "travel US 17 to NC 210 in Hampstead and travel west on NC 210 exiting on I-40, US 117 north or US 421 north."
Onslow	10.5 hrs (revised in 1996 to 6.25	**Bertha**: 7/11 8 am **Fran**: 9/4		Evacuation went okay with no major bottlenecks. Evacuation network was accurate. Evacuation was complete just prior to landfall

	(revised in 1996 to 6.25 hrs)	8 am **Fran**: 9/4 7 pm		Evacuation network was accurate. Evacuation was complete just prior to landfall.
Duplin	NA			No traffic problems. Had minor problems with people traveling through to coast. Used law enforcement to speed traffic flow.

*Clearance times based on high tourist occupancy, medium evacuee response, category 3 storm.

**Duration of substantial evacuating traffic was provided by local officials during interviews.

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Table 5-2
Northern North Carolina Hazards and Vulnerability Evaluations

AGENCY OR COUNTY	HAZARDS IDENTIFICATION SOURCES/DECISION MAKING TOOLS	VULNERABILITY ANALYSIS	NUMBER EVACUATED	COMMENTS
Beaufort	Received information from State and NWS. Also used HURREVAC.	**Bertha:** voluntary evacuation for low-lying areas and riverfront property. Belhaven had voluntary evacuation. **Fran:** Town of Belhaven issued mandatory evacuation order. County issued voluntary evacuation notice for low-lying areas and other areas where roads flood early, limiting access.	**Bertha**: 6,000 **Fran**: 2,850	Considerable time delay in receiving information from NHC. NWS had good forecasting. Products worked well. Need update and more riverine time history points.
Pitt	Primary source of information came from conference call with State which was very successful. Did not use HURREVAC or Weather Channel much.	**Bertha:** no evacuation order. **Fran:** no evacuation order. One mobile home/trailer park evacuated.	N/A	More areas actually flooded inland than expected. HES needs to be updated to reflect larger flood problems.
Dare	Used HURREVAC but feels it is old and needs updating. Used HURRTRAK which has better maps and graphics for tracking storms. These are important for public evacuation demonstrations. Also used SLOSH data and Inland Winds.	**Bertha:** evacuated Hatteras Island. **Fran:** did not evacuate.	Bertha:	Had difficulty in getting HURREVAC information downloaded. Evacuation zones not useful, too complicated. Need better information in defining low-lying areas.
Chowan	Used Internet to obtain hurricane information.	**Bertha:** voluntary evacuation. **Fran:** voluntary evacuation.	Bertha: Fran:	Would like to see a method developed to automatically download information directly to HURREVAC.
Martin	Used Inland Winds but did not have much confidence in it. Also used HURREVAC, conference calls with EM personnel, and local NWS.	**Bertha:** recommended evacuation of mobile homes into local shelters. **Fran:** recommended evacuation of mobile homes into local shelters.	Bertha: Fran:	HURRTRAK is a better tool than HURREVAC for tracking purposes. Hurricane plan and system worked well.
Bertie	Used Internet to get information which was very valuable. HURRTRAK is superior to HURREVAC for tracking storms.	**Bertha:** **Fran:**	Bertha: Fran:	
Hertford			Bertha: Fran:	Received 3 ft surges in Bertha and 4 ft surges in Fran.
Camden	Used NHC and NWS.		Bertha: Fran:	
Washington	All available hurricane products used.	Did not evacuate.	N/A	
Currituck		Supported evacuation of Outer Banks in Dare County.		Technology needs to be improved both in hurricane computer models and in methods to obtain information for models.

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Table 5-3
Southern North Carolina Hazards and Vulnerability Evaluations

AGENCY OR COUNTY	HAZARDS IDENTIFICATION SOURCES/DECISION MAKING TOOLS	VULNERABILITY ANALYSIS	NUMBER EVACUATED	COMMENTS
State Office	Used Weather Channel, HURREVAC, Inland Winds, conference calls with NHC and area offices, NWS, and storm surge atlases.			Satisfied with products. Anxious for updated information.
Bladen	Received information from faxes from regional EOC and Internet, NWS, DTN, HURREVAC, Inland Winds, and Weather Channel.	**Bertha**: voluntary evacuation. **Fran**: voluntary evacuation.	**Bertha**: 1,000 **Fran**: 3,000	HURREVAC worked very well but needs to be enhanced. Inland Winds was accurate. Weather Channel good for public but not for decision making.
Wayne	Used DTN, faxes from regional EOC and from Seymour Johnson Air Force Base. Also used HURREVAC and Inland Winds, state conference calls (best way to get information), NWS, flood maps, FIRM's, and Weather Channel.	Voluntary relocation from mobile homes, low-lying areas and flood prone areas.		Weather Channel good for public but little value for county. Inland Winds was fairly accurate.
Craven	Used conference calls from state, HURREVAC, NWS, and Inland Winds.	Issued voluntary evacuation order. Used general descriptions of areas to be evacuated such as road descriptions and subdivisions. Did not use evacuation zones.	10,000 to 15,000	HURREVAC and other study products did not correctly identify areas actually flooded by storm. Will need to evacuate more people in future.
Lenior	Used HURREVAC, Inland Winds, faxes from regional EOC, Weather Channel, and NWS.	No evacuation orders given.		There was a time delay in Weather Channel and NWS information.
Carteret	Used HURREVAC which worked well.	Evacuated Bogue Banks, mobile homes and low-lying areas. No evacuation zones used.		
Brunswick	Used NHC information and phone calls, HURREVAC, NWS, DTN and Weather Channel.	**Bertha**: voluntary evacuation. **Fran**: mandatory evacuation for barrier islands, .5 miles inland of AIWW, low-lying areas, and mobile homes.	**Fran**: 90% of residents on barrier islands.	Did not use evacuation zones - tourists not familiar with zones.
New Hanover	Used HURREVAC, conference calls, NWS, Weather Channel, DTN, and GTE wire for NWS/NHC products. Relied mainly on NHC products.	**Bertha**: evacuated Carolina, Kure, Wrightsville, Wilmington, Hamby Beaches and Figure Eight Island, adjacent AIWW communities and associated low-lying areas. **Fran**: mandatory evacuation.	**Bertha**: **Fran**:	Products worked okay, but would like electronic download of marine advisories to HURREVAC and camera ready GIS maps of evacuation areas.
Jones	Used NWS and state conference calls.	Voluntary evacuation of mobile homes.		No hurricane evacuation study conducted in this area.
Greene	Used conference calls, HURREVAC, Inland Winds, and NWS.	Voluntary evacuation of mobile homes.		No hurricane evacuation study conducted in this area.
Cumberland	Used area conference calls (very productive), HURREVAC, Inland Winds and NWS.	**Fran**: Voluntary evacuation of mobile homes.		No hurricane evacuation study conducted in this area.
Columbus	Used Area C input, NWS, and television reports.	Asked River Road, Crusoe Island areas, and mobile homes to evacuate for potential flooding.	25 out of potential 500	No hurricane evacuation study conducted in this area.
Pender	Used HURREVAC, Inland Winds, DTN, Internet, new SLOSH maps, Weather Channel, and NWS.	Evacuated Surf City, Topsail Beach, low-lying areas and houses that are susceptible to wind damage. Area evacuated was about right.	**Bertha**: 30,000 **Fran**: 10,000	HES data provided good depiction of hazards. Did not use evacuation zones but rather locally recognized landmarks.
Onslow	Used HURREVAC, Inland winds, new SLOSH maps, conference calls.	Evacuated barrier islands, low-lying areas and flood prone areas.		HES products worked well and provided a good depiction of hazards. EOC flooded during hurricane.
Duplin	Used faxes from NWS and regional office and HURREVAC.	Voluntary evacuation of mobile homes and low-lying areas. Did not use evacuation zones.		HES products worked well but did not use them to choose area to evacuate.

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Table 5-8
Northern North Carolina Shelter Evaluations

Agency or County	# Shelters Opened	# Evacuees Sheltered	Time Opened	Duration Open	Comments
Beaufort	Bertha: 3 Fran: 3	Bertha: 300 Fran: 550	Bertha: 7/10 Fran: 9/5	Bertha: 20 hrs Fran: 20 hrs	
Pitt	Bertha: 5 Fran: 5	Bertha: 500 Fran: 500			
Chowan	Bertha: 2 Fran: 2	Bertha: 100 Fran: 150		Bertha: 24 hrs Fran: 24 hrs	
Martin	Bertha: 3 Fran: 4	Bertha: 250 Fran: 350		Bertha: 32 hrs Fran: 36 hrs	
Bertie	Bertha: 1 Fran: 1	100 or less			
Hertford	Bertha: 1 Fran: 1	100 or less			
Washington	Bertha: 3 Fran: 3	46			
Camden	Bertha: 1 Fran: 1				

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Table 5-9
Southern North Carolina Shelter Evaluations

Agency or County	# Shelters Opened	# Evacuees Sheltered	Time Opened	Duration Open	Comments
Bladen	Bertha: ? Fran: 4		Fran: 9/4 evening		
Wayne	Bertha: 1 Fran: 4	Bertha: 60 Fran: 500-600	Fran: 9/5 6pm		
Craven	Bertha: ? Fran: ?	Bertha: 800 Fran: 1600			
Lenior	Bertha: 1 Fran: 2	Bertha: 25 Fran: 150-250			
Carteret	Fran: 5	Fran: 400-500	Fran: 9/5 noon	Fran: 2 days	
Brunswick	Bertha: 3 Fran: 4	Bertha: 1800 Fran: 2276	Bertha: ? Fran: 9/5 7am	Fran: 31 hrs	
New Hanover	Bertha: 3 Fran: 4	Bertha: 536 Fran: 1083	Bertha: 7/11 noon Fran: 9/5 6pm	Fran: until 9/11	
Jones	Bertha: 0 Fran: 3	Fran: 400-500	Fran: 9/5 1 pm	Fran: 24 hrs	
Green	Bertha: 0 Fran: 1	Fran: 220		Fran: 24 hrs	
Cumberland	Bertha: 4 Fran: 6	Bertha: 40 Fran: 1000+	Bertha: ? Fran: 9/5 4pm	Fran: 24 hrs	
Columbus	Bertha: 0 Fran: 7	Fran: 1500	Fran: 9/5 8am	Fran: 36-40 hrs	
Pender	Bertha: 3 Fran: 2 and 1 special needs	Bertha: 738 Fran: 631	Bertha: 7/11 noon Fran: 9/5 10am	Bertha: 4 days Fran: 11 days	
Onslow	Bertha: 6 Fran: 6	Bertha: 1692 Fran: 1600		Bertha: 2 days Fran: varied	
Duplin	Fran: 5	Fran: 1370	Fran: 9/5 6pm	Fran: 20 hrs	

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