Executive Summary of the 2004 Hurricane Season Post Storm Assessment Of the National Hurricane Program Study Products

November 2005

Table of Contents

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INTRODUCTION & PURPOSE

Post storm assessments serve as an avenue for FEMA to verify product results and data provided to emergency management through the Hurricane Evacuation Study (HES) Program. They also guide future enhancements to insure effective hurricane evacuation and logistical decision-making techniques. Emergency Management at all levels depends upon the evacuation decision assistance tools produced by the NHP, and the post storm assessment is the key component designed to improve those products.

The purpose of the Hurricane assessments is to evaluate the performance of existing National Hurricane Program (NHP) evacuation decision assistance products and program initiatives for emergency management at all levels, and to direct future NHP preparedness, training, and public awareness activities based on detailed post storm Transportation, Behavioral, Shelter, Evacuation Decision Making Analyses and impact assessments. The post storm assessment is a vital tool that allows the NHP to calibrate, correct, and improve models and products that serve as primary decision assistance tools for emergency managers.

HURRICANES BEING ASSESSED

During the 2004 hurricane season, the United States was impacted by 5 hurricanes and 2 tropical storms (Alex, Bonnie, Charley, Frances, Gaston, Ivan, Jeanne). This is the first time since 1886 that one state has been impacted by 4 hurricanes that caused significant multi-state evacuations to take place. The “2004 Hurricane Season Post Storm Assessment” is a comprehensive study that will focus on the impacts of hurricanes Charley, Frances, Ivan, and Jeanne. The tracks of these storms are shown in Figure 1 on the next page, Table 1 provides pertinent statistics for these four storms and Table 2 provides a brief chronology of significant events surrounding for these four storms. The assessment will concentrate study efforts in Florida, Alabama, Mississippi, and Louisiana.

Figure 1 - Charley, Frances, Ivan and Jeanne storm tracks.

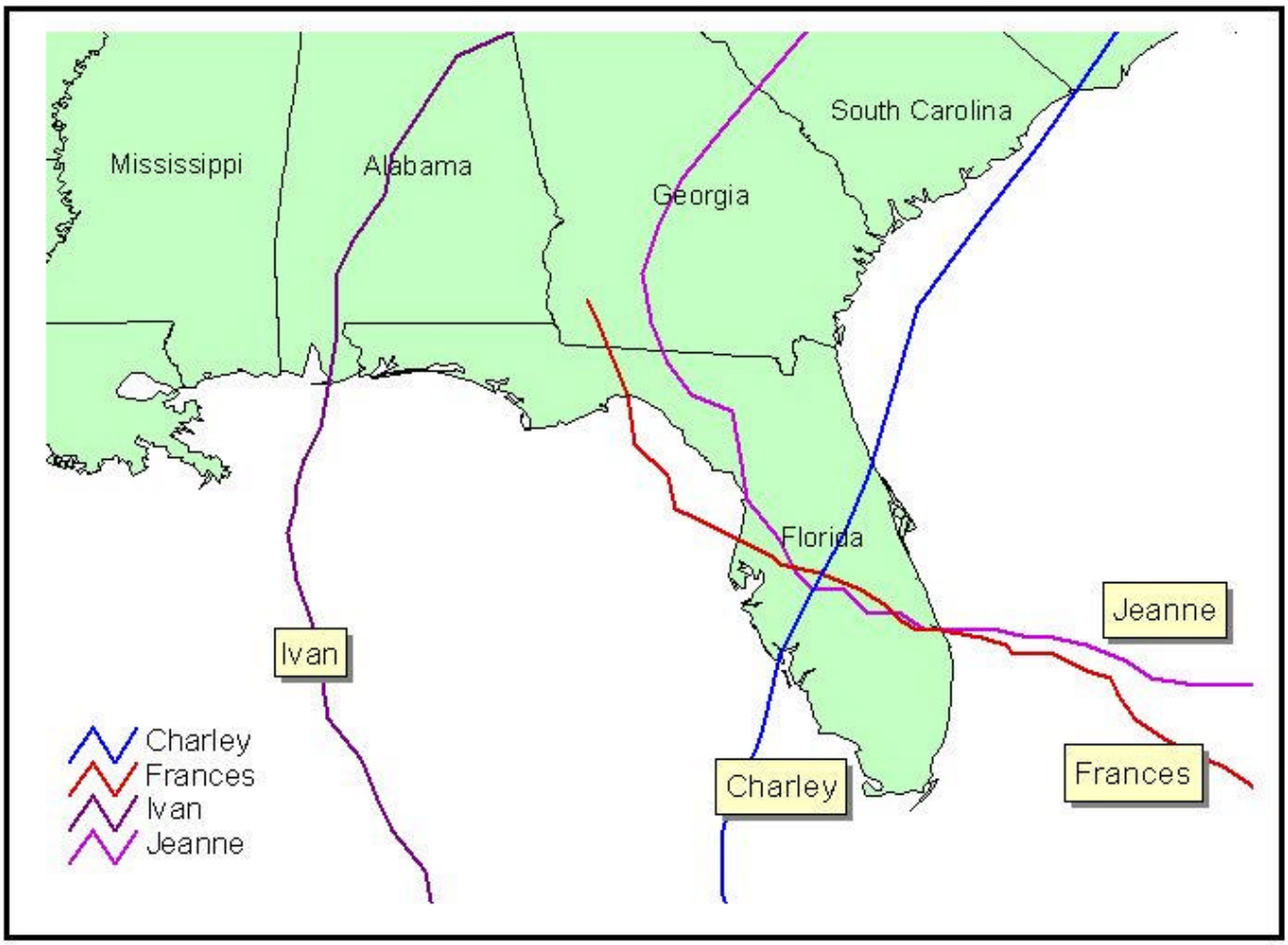


Table 1 - 2004 Atlantic Hurricane Season Statistics

NAME	DATES	MIN. PRESS (MB)	MAX. WINDS (MPH)	DIRECT DEATHS	U.S. DAMAGE ($ million)
CHARLEY	9 - 14 AUG	941	150 (4)	15	15000
FRANCES	25 AUG - 8 SEP	935	145 (4)	8	8900
IVAN	2 - 24 SEP	910	165 (5)	92	14200
JEANNE	13 - 28 SEP	950	120 (3)	3000+	6900

Table 2 – Chronology of Major Storms in 2004

Aug 9	Bonnie becomes a Tropical Storm (Central Gulf), Bonnie 3-day error cone includes Florida, Pre-Charley Depression 5-day error cone includes Florida
Aug 10	Bonnie: Tropical Storm Watch (Panhandle), Charley becomes a Tropical Storm (Eastern Caribbean), Charley 3-day error cone includes Florida
Aug 11	Bonnie: Tropical Storm/Hurricane Warning (Panhandle), Charley: Hurricane Watch (Keys, SW Florida), 1st time watches/warnings up for 2 storms in 1 state
Aug 12	Bonnie landfall (Panhandle), Charley: Hurricane Warning (Keys, SW Florida)
Aug 13	Charley: Major Hurricane, Charley landfall (SW Florida)
Aug 25	Frances becomes a Tropical Storm (Atlantic)
Aug 27	Frances: Major Hurricane
Aug 28	Frances: 5-day error cone includes Florida, Gaston forms off NE Florida coast
Aug 31	Frances: 3-day error cone includes Florida
Sep 1	Frances: Hurricane Watch (Florida East coast)
Sep 2	Frances: Hurricane Warning (Florida East coast)
Sep 3	Ivan becomes a Tropical Storm (Central Atlantic)
Sep 5	Frances landfall (Florida East coast), Ivan: 5-day error cone includes Florida Ivan: Major Hurricane
Sep 6	Frances exits Florida
Sep 8	Ivan: 3-day error cone includes Florida President Bush visits NHC
Sep 9	Ivan: Category 5
Sep 12	Ivan: Tropical Storm Watch (Keys)
Sep 13	Ivan: Hurricane Watch (Panhandle)
Sep 14	Ivan: Hurricane Warning (Panhandle), Jeanne becomes a Tropical Storm (Eastern Caribbean), Jeanne: 5-day error cone includes Florida
Sep 16	Ivan landfall and exit (Panhandle), Jeanne: 3-day error cone includes Florida
Sep 21	Jeanne: 5-day error cone includes Florida (Again)
Sep 22	Jeanne: 3-day error cone includes Florida (Again)
Sep 24	Jeanne: Hurricane Watch (Florida East coast), Jeanne: Hurricane Warning (Florida East coast)
Sep 25	Jeanne: Major Hurricane
Sep 26	Jeanne landfall (Florida East coast)
Sep 27	Jeanne exits Florida

SCOPE OF THE ASSESSMENT

The 2004 Post Storm Assessment was a multi-agency effort between FEMA, USACE and NOAA, and included cooperation and assistance from all effected States. The main items of work for the assessment include the following:

1. High water marks were identified for Charley Jeanne and Ivan. The elevations of the marks were determined to evaluate the SLOSH (Storm Surge Forecast Tool) model and aid in the rebuilding effort along the beaches.

2. The National Hurricane Center's evaluation of their forecast errors and the accuracy of the SLOSH model for predicting surge flooding.

3. Conducted interviews with effected State and County Emergency Management Offices to determine the events surrounding the decision either to evacuate or not to evacuate, decision-tools used or not used, problems encountered by those at risk, product success, and the behavioral patterns and trends that affect the accuracy of the technical data available.

4. Performed approximately 9,000 behavioral surveys (via telephone) of local citizens who were asked to evacuate to better understand the behavioral reactions and response of the impacted public. Specific questions on the behavioral study did address the mitigation measures employed by homeowners and businesses. The data will be used to direct public awareness initiatives and to build a comprehensive preparedness approach to educating hurricane vulnerable populations.

5. Performed a shelter assessment to determine if shelter assumptions found in the HES were accurate. Concentration was on communities that opened shelters. The assessment should capture information about any structural integrity issues. Information communication issues will be assessed. The primary source for this information was obtained by interviews with local officials. This information will be used to guide future shelter preparedness planning.

6. Work with Federal, State and local officials, determined the following:

- Did local officials recommend the HES-projected evacuation routes;
- Did evacuees use the projected routes;
- Were traffic control actions taken to speed up traffic;
- How long did it take to complete the evacuation;
- Were any major problems encountered during this evacuation;
- Assess how evacuees acquired real-time traffic information;
- Assess the forecasting performance of ETIS in Florida and the need to incorporate Real-Time Intelligent Traffic Systems to improve performance of traffic monitoring tools.
- Assess clearance time accuracy and timing.
- Assess the accuracy of the Bi-State model.

7. Determined the extent of damage sustained by local governments and private business industries in Escambia County, Florida and negative economic impacts experienced. Identified mitigation techniques taken to reduce storm damage. Determined if employers had adequate continuity of operations plans. Findings will be used to guide future mitigation needs, display mitigation success stories, and guide hurricane preparedness initiatives towards private industry.

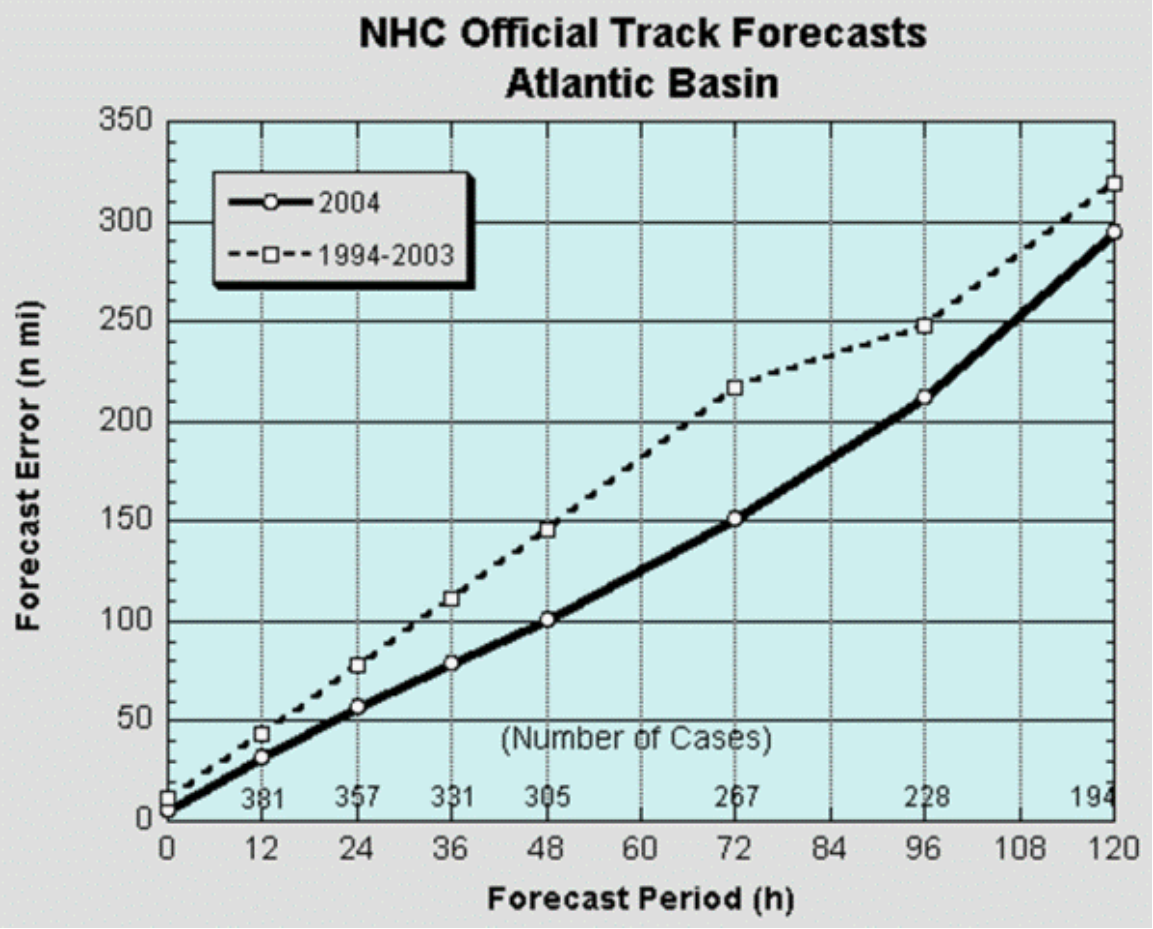
8. All data collected for the assessment is included on the following web site:

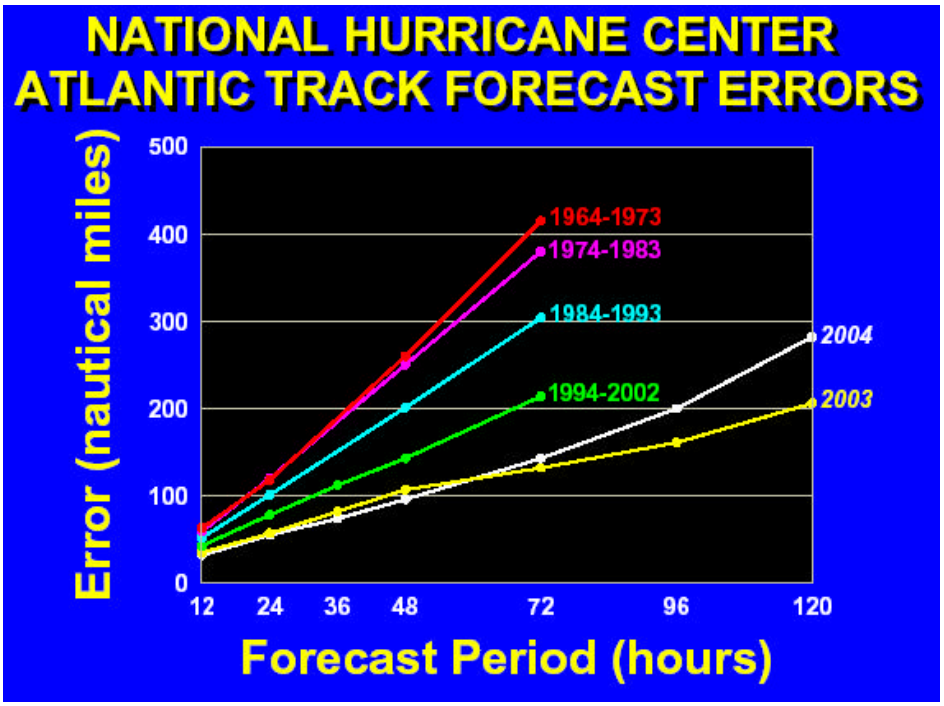
The site will be put on a CD and 100 copies made. One hundred copies of the Executive Summary will be printed.

NATIONAL HURRICANE CENTER ADVISORY ERRORS

National Hurricane Center Advisory Errors

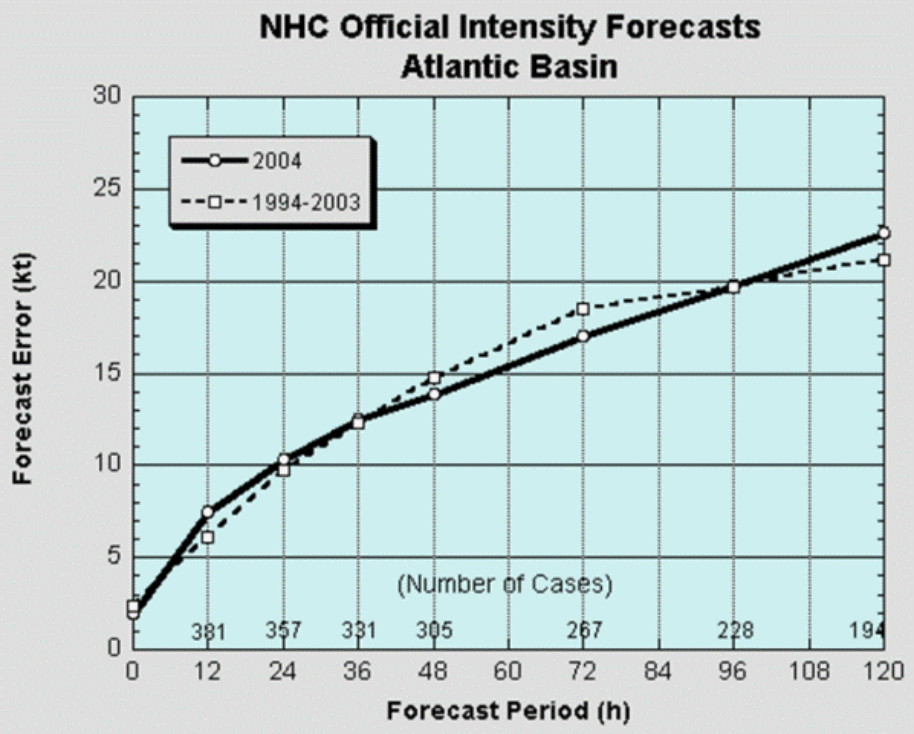
Hurricane Track Forecast Errors - In general the National Hurricane Center's Track forecast accuracy for the 2004 hurricane season was better then their long term mean as shown in the figures below.





Hurricane Intensity Forecast Errors

The National Hurricane Center made some improvement in their storm intensity forecasts for 2004 in the 12, 24 and 120 hour forecasts but did a little worse on their 48 and 72 hour forecasts as shown in the graph below.



COLLECTION OF COASTAL HIGH WATER MARKS (CHWMS)

Hurricane Charley - The collection of CHWMs was limited to Charlotte, Collier, and Lee counties in Florida. Most CHWMs in Charlotte County were low. The most points were taken in Lee County and the least in Collier County. Table 3 shows the distribution of CHWMs by County.

Table 3: Number of CHWMs Surveyed by County for Charley

County	Number of CHWMs Surveyed
Charlotte	11
Collier	9
Lee	39

A total of 59 CHWMs were obtained. The water level elevations on the open coast vary from 4½ feet NAVD on Marco Island, to 8¼ feet NAVD on the north end of Estero Island, to 2½ feet NAVD on Cayo Costa Island. In the lower reaches of the Peace River and at the mouth of the Myakka River, water levels did not reach normal high tide.

Hurricane Frances – CHWMs were collected on the east coast of Florida from New Smyrna Beach south to West Palm Beach. CHWMs on the west coast of Florida included the area from Manatee River (estuary) to Cedar Key with most effort focused on Tampa and Hillsboro Bays and estuaries. Sixty-two CHWMs were surveyed in 12 counties. These are listed by county in Table 4.

Table 4: Number of CHWMs Surveyed by County for Frances

County	Number of CHWMs	County	Number of CHWMs
Volusia	3	Manatee	5
Brevard	6	Hillsborough	9
Indian River	11	Pinellas	3
St. Lucie	4	Levy	2
Martin	9	Dixie	2
Palm Beach	7	Taylor	1
		Total	62

The highest surge-plus-wave setup elevations were in Hobe Sound and Jupiter ranging from 12-14 feet. HWM values decreased slowly northward to 6.3 feet on Edgewater Beach. At the North Fork of the St. Lucie River, elevations of 12.9 and 13.6 feet were recorded. Surge levels were greater along the coast than in bays and lagoons. CHWM levels along the central Florida Gulf coast were not as severe with levels in Tampa and Hillsboro Bays reaching 5.6 feet.

Hurricane Ivan – In Florida most CHWMs were taken in Escambia, Santa Rosa and Okaloosa Counties. A total of 135 CHWMs were collected in Florida for Ivan. Surge flooding gradually diminished as you went west from the AL/FL state line. 51 CHWMs were taken in Alabama and 9 in Mississippi. The number of CHWMs taken in each County is shown in Table 5.

Table 5 – Number of CHWMs taken by County for Ivan

County	State	Number of CHWMs Surveyed
Escambia	Florida	57
Santa Rosa	Florida	39
Okaloosa	Florida	31
Walton	Florida	3
Bay	Florida	3
Franklin	Florida	2
Baldwin	Alabama	38
Mobile	Alabama	13
Harrison	Mississippi	6
Jackson	Mississippi	3

The highest observed elevation in Escambia Bay was 16 feet at the north end of Escambia Bay. The surge elevation reached almost 13 feet near the north end of Blackwater Bay just south of I-10. The Santa Rosa southern peninsula shoreline had elevations of 11 -12 feet and 6 to 8 feet in Santa Rosa Sound. Maximum surge elevations throughout Pensacola Bay and the lower portions of Escambia and Blackwater Bays appear to have been on the order of 9-1/2 to 11 feet. CHWMs taken on the eastern shore of Choctawhatchee Bay and along the open coast east of Destin show a marked decrease in elevations. This pattern continues eastward with a maximum elevation of 5 feet recorded at Apalachicola.

The major storm surge in Alabama struck Orange Beach, Gulf Shores, and the peninsula between Bon Secour Bay and the open Gulf. The surge height in these areas ranged between 12 and 14½ feet. CHWMs decreased to 6-7 feet near Perdido Pass and 6½ feet along the eastern shore of Mobile Bay. Along the Alabama coast, CHWM elevations reached 12 feet but only ranged between 3 and 6.8 feet on the landward side of Dauphin Island. CHWMs along the Mississippi coast ranged between 6½ and 4 feet.

Hurricane Jeanne - Hurricane Jeanne resulted in both coastal and riverine flooding. Many of the river systems impacted by Frances were still well above normal when Jeanne occurred. It was determined by FEMA that Riverine High Water Marks (RHWMs) would be obtained and no CHWMs would be identified. The Area of Study included 21 counties in 16 river systems. Table 6 shows the number of RHWMs obtained in each River system. A total of 76 RHWMs were surveyed.

River System	*Number of RHWMs*
Anclote River	1
Aucilla River	2
Cannon Creek	2
Fisheating Creek	1
Hillsborough River	1
Myakka River	2
New River	2
Olustee Creek	1
Peace Creek Canal	7
Peace River	6
Rose Creek	2
Saddle Creek	4
Santa Fe River	7
St. John's River	15
Suwannee River	11
Withlacoochee River	12
Total	76

Hurricane Jeanne crossed the State of Florida on September 26, 2004. The system was relatively large with storm bands extending outward across most of the State. Jeanne produced significant amounts of precipitation throughout a large portion of the state, resulting in disaster declarations in many counties. According to the National Weather Service, Jeanne produced widespread rainfall of up to 8 inches across eastern, central, and northern Florida with a narrower band of up to 13 inches over Osceola, Broward, and Indian River Counties. A secondary rainfall maximum of around 11 inches was observed over northeast Florida in Duval and Nassau Counties.

SLOSH MODEL EVALUATIONS

The SLOSH model is a numerical storm surge model that computes water elevations generated by the wind and pressure forces in a tropical cyclone. The model (or basin) is a grid, which contains land elevations, water depths and vertical barriers. The following paragraphs give a brief description of the SLOSH model accuracy for Charley, Frances, Ivan and Jeanne

Hurricane Charley SLOSH - The basin for Southwest Florida is called the Ft. Myers SLOSH basin. Comparison of 62 observed high water marks yielded typical storm surge model errors, with differences between the observed high water marks and the SLOSH generated values showing 66% of the values between +1.6 & -1.6 feet and 97% within +3.2 to -3.2 feet. Eliminating all observations that are greater than one-standard deviation, (which includes many wave-infected marks) gave much better results. Comparison of the observed storm surge hydrographs at Estero Bay, Ft. Myers and Franklin Locks to the SLOSH model storm surge hydrographs showed reasonable results.

Hurricane Frances SLOSH - The basins covering the Florida Treasure Coast are called Cape Canaveral and Palm Beach. Actual surge heights from ten high water marks and two tide gages were compared to the Slosh model outputs. The mean difference between observed and calculated storm surge heights was -0.04 feet: and standard deviation of the mean was 0.8 ft. The statistics of the coastal surge values are in line with long-term variance with the SLOSH model. Likewise, the observed hydrographs from Trident Pier and Bear Point gages to SLOSH showed reasonable results.

Hurricane Ivan SLOSH - The basins covering the north central Gulf of Mexico, where Ivan made landfall, are called Pensacola Bay, Apalachicola Bay and updated New Orleans. Comparison of 32 observed tide gauge high water marks along the north central Gulf of Mexico coastline yielded typical storm surge model error characteristics, with differences between the observed high water marks and the SLOSH generated values showing that 66% of the values fall between plus 1.6 to minus 1.6 feet and 97% are within plus 3.2 to minus 3.2 feet. Comparison of the observed storm surge hydrographs to the SLOSH model calculated storm surge hydrographs showed reasonable results.

Hurricane Jeanne SLOSH – The basins covering the Florida Treasure Coast are called Cape Canaveral and Palm Beach. Since no high water marks were surveyed for Jeanne only two tide gages were used to compare SLOSH model results. The comparison of the observed high tide elevations at the Trident Pier and Bear Point gages compared quite well to the SLOSH calculated high water elevations. Likewise, a comparison of the observed storm surge hydrographs from the Trident Pier and Bear Point to the SLOSH model calculated storm surge hydrographs showed reasonable results.

SLOSH/Storm Surge Concerns: Storm surge has the highest potential to cause fatalities for people along the coast. Because 97% of the observed values were +/- 3.2 feet from forecast, it is recommended that local emergency managers plan for storm surge one category higher. According to the behavioral analyses findings, a majority of citizens in coastal states have never experienced a significant storm surge event and are not aware of their vulnerability. A separate concern is that FEMA, USACE and NOAA do not have the capability to timely update storm surge/SLOSH basins that have been impacted by significant hurricane events. The HES program can only update 2 to 3 storm surge basins per year. Storm Surge basins are the foundation used to create Evacuation Clearance Times.

BEHAVIORAL ANALYSES

Behavioral analyses for the assessments included 9,000 telephone surveys of citizens who were asked to evacuate or were subject to evacuation. The purpose of the surveys is to understand the behavior and response of the impacted public. There were 3,200 surveys made for Ivan, 2,951 for Charley, 1,720 for Frances and 1,719 for Jeanne. The behavioral surveys were designed to answer the following questions:

- What protective actions were taken by the impacted public?
- Were they in an evacuation zone and how safe did they feel?
- How did they make their decision to evacuate & what information did they hear?
- Did watches/warnings, pets, elderly, expenses, etc. effect your decision?
- Did work or school related issues effect your decision?
- Where did they get forecast, evacuation and safety information?
- Where did they evacuate to, what did they take & what type shelter was used?
- How did you feel about your evacuation & how long did it take?
- If you stayed, did you feel safe & what would you do differently next time?
- What mitigation did homeowners and businesses use & did they work?
- Was re-entry a problem and what adverse impacts did you have?

Surveys Taken

The surveys for each storm were divided into groups of counties or regions. These regions are shown below with the number of surveys taken in each.

Region	Counties	Surveys
CHARLIE		
Southwest Coastal	Collier, Lee, Charlotte, Sarasota	435
Tampa Bay	Pasco, Pinellas, Hillsborough, Manatee	832
Northern Coastal	Jefferson, Taylor, Dixie, Levy, Citrus, Hernando	884
Northern Non-coastal	Duval, Clay, Union, Bradford, Gilchrist	200
Southern Non-coastal	Hardee, DeSoto, Highlands, Glades, Hendry	300
Central Non-coastal	Seminole, Orange, Sumter	300
TOTAL		2951
FRANCES		
Northeast/ East Central	St. Johns, Flagler, Volusia, Brevard	194
Treasure Coast	Indian River, St. Lucie, Martin, Palm Beach	608
Southeast Coastal	Broward, Miami-Dade	298
Southwest Coastal	Collier, Lee, Charlotte, Sarasota	159
Tampa Bay/ Big Bend	Hernando, Citrus, Pasco, Pinellas, Hillsborough, Manatee	146
Southern Non-coastal	Okeechobee, Highlands, Hardee, DeSoto, Glades	156
Central Non-coastal	Seminole, Orange, Osceola, Polk, Sumter	159
TOTAL		1720

JEANNE		
Northeast	Nassau, Duval, St. Johns, Flagler	204
East Central	Volusia, Brevard	304
Treasure Coast	Indian River, St. Lucie, Martin, Palm Beach	409
Southeast Coastal	Broward, Miami-Dade	299
Tampa Bay/ Big Bend	Dixie, Levy, Hernando, Citrus, Pasco, Pinellas, Hillsborough, Manatee	194
Southern Non-coastal	Okeechobee, Highlands, Hardee, DeSoto, Glades, Hendry	150
Central Non-coastal	Seminole, Orange, Osceola, Polk	159
TOTAL		1719
IVAN		
Alabama	Baldwin, Mobile	400
Florida	Escambia, Santa Rosa, Walton, Okaloosa, Bay, Jackson, Franklin, Gulf, Monroe	1300
Louisiana	Jefferson, Orleans, Plaquemines, St. Bernard, St. Charles, St. John, St. Tammany	900
Mississippi	Hancock, Harrison, Jackson	600
TOTAL		3200

Behavioral Findings & Concerns

The most striking conclusions from the behavioral surveys are:

- too few people realize that they are being told to evacuate
- too many people believe they are safer than they actually are
- too many people place undue confidence in the forecast track of the storm

Evacuation decisions are driven mostly by subjective risk assessments rather than constraints. Many people don't understand that evacuation notices apply to them, and those misconceptions lead people to make untimely/incorrect evacuation decisions. Many people believe the storm will miss their location, sometimes placing too much faith in the forecast track of the storm, and sometimes those misconceptions are reinforced by similar misconceptions by emergency management officials. In some cases, 40% of the respondents said they have never spent anything to make their homes safer in hurricanes, and that was the case even in category 1 evacuation zones. Evacuation participation rates were low for Charley, Frances, and Jeanne. Finally, Based on behavioral studies the evacuation participation rates in surge vulnerable areas in some regions was also very low. Additional training and assistance with public awareness were the most requested items. Several jurisdictions indicated that language barriers (Spanish) were a problem during the evacuation process.

TRANSPORTATION ANALYSES

Traffic Data Collection

The 2004 hurricane assessments included a traffic analysis to determine how evacuation routes were loaded and what problems presented themselves to evacuees. The assessment included interviews with 107 counties and analysis of 103 traffic counters for the four storms as shown in the table below.

STORM	Counties Interviewed	# of traffic counters analyzed
Charley	21	16
Frances	28	40
Ivan	33	28
Jeanne	25	19

Traffic Issues and Concerns

84 of the 107 counties interviewed indicated that heavy traffic, congestion, traffic jams or gridlock characterized the road conditions during the evacuation. Based on the interviews and traffic data, we see that on most evacuation routes traffic increased above normal loads before evacuation orders were issued. This implies that many residents make their own decision to evacuate before being told to leave. Evacuation traffic was heavy in all 4 storms with above normal traffic averaging 37 hours per counter prior to the storms landfall. Traffic significantly reduced at all counters located near the track of the storm before gale force winds arrived indicating that evacuations were nearing completion or winds became hazardous and evacuees looked for refuges of last resort. In all storms except Frances the evacuating vehicle totals were less than expected primarily due to the low response to evacuation orders. Although some counties asked for evacuations of areas somewhat different from the evacuation zones developed in pre-storm studies only several counties felt their clearance times were insufficient. The majority of coastal counties that asked for evacuations believed their clearance times were adequate; however since participation rates were so low we can't conclusively state that clearance times were accurate. In general, the time it takes to safely evacuate an area involves so many variables it is extremely difficult to determine how accurate the pre-storm clearance times really are. Other predominant problems were problems obtaining gasoline, the lack of adequate road signage and road construction hindering traffic flows. Real time Intelligent Traffic System (ITS) information is inconsistent from state to state or does not exist in some coastal jurisdictions. This information is critical for EMA's and DOT officials to manage large scale evacuations.

COUNTY INTERVIEWS

Prior to 2004 Hurricane season, the Federal Emergency Management Agency (FEMA) and the U.S. Army Corps of Engineers (USACE) had completed comprehensive hurricane evacuation studies (HES) for the coastal communities in Florida, Alabama,

Mississippi and Louisiana. Interviews were conducted with state and local government emergency management officials in the four states to collect decision making and operational response data related to evacuations and other protective actions during the 2004 Hurricane season. These government officials provided information that will help to improve the products and processes currently used by the agencies and jurisdictions participating in the National Hurricane Mitigation and Preparedness Program (NHMPP).

The interviews of state and local government officials were conducted in December 2004 and January 2005. The following communities participated in the surveys:

Florida Counties: Alachua, Bay, Bradford, Brevard, Broward, Calhoun, Charlotte, Citrus, Collier, Columbia, De Soto, Escambia, Glades, Hardee, Hendry, Highlands, Hillsborough, Holmes, Indian River, Jackson, Lafayette, Lee, Leon, Liberty, Madison, Manatee, Marion, Martin, Miami-Dade, Nassau, Okaloosa, Orange, Osceola, Palm Beach, Pasco, Pinellas, Polk, Santa Rosa, St. Lucie, Sarasota, Seminole, Volusia, Walton, Washington
Alabama Counties: Baldwin, Butler, Choctaw, Coffee, Covington, Dale, Mobile, Wilcox
Mississippi Counties: Forrest, Hancock, Harrison, Jackson, Pearl River
Louisiana Parishes: Ascension, Assumption, LaFourche, Orleans, Plaquemines, St Bernard, St Charles, St James, St John the Baptist, St Tammany

The topics discussed during the interviews included: hazards and vulnerability data; protective action decision making; hurricane evacuation study and National Hurricane Program products; behavioral analysis; transportation and evacuation; sheltering; and public information and emergency communications.

<u>Hurricane Evacuation Study Concerns:</u>

- FEMA & the USACE do not have the fiscal resources necessary to maintain and update Hurricane Evacuation Studies (HES) in 22 coastal states and island territories. Nor does the program have adequate funds to address post storm recommendations after significant hurricane events.
- The 2004 post storm assessment revealed that many of the decision making officials impacted by hurricanes were using HES evacuation clearance times based on 1990 census data.
- Another important finding is a high turnover rate in the State and County Emergency Management Agencies (EMA) resulting in new personnel unfamiliar with HES products.

Evacuation Decision Making Concerns:

- Some Counties are not issuing evacuation orders that match the evacuation zones determined in the HES studies.
- As a result evacuation clearance times do not reflect evacuations issued outside of these zones.
- Nomenclature used to describe evacuation zones is not consistent from county to county.
- It was found that many citizens never heard specific evacuation warning orders which may have contributed to lower participation rates. Some EMA's may have focused too much on the forecast track and not adequately considered the error cone or Hurricane watches and warnings.
- Behavioral analyses reveal that citizens indicated watches and warnings are a major factor in their decision to evacuate. However, nearly half of the respondents cannot define what NOAA Hurricane Watches and Warnings mean.
- Behavioral analyses indicate that evacuation participation rates are higher in communities that issue “Mandatory” warning orders.

SHELTER DATA COLLECTION

The assessment collected data from Counties on shelter demand/use and the number of regular and special needs shelters opened. The actual shelter use numbers were then compared to estimates in Hurricane Evacuation Studies (HES). The survey results indicate that in most cases shelter demand was significantly less than expected. The low shelter usage is partly due to low evacuation participation rates obtained from behavioral surveys and poor warning order communications. However the behavioral analysis indicates that shelter demand rises when inland counties issue evacuation orders.

A number of reasons contribute to the differences between actual versus expected shelter use. In some cases, evacuation orders issued by a county did not include the same risk areas as those in the HES and evacuation order levels (voluntary, recommended, mandatory) and/or timing of evacuation orders may have differed from HES scenarios. Some residents may have ended up in a shelter because they couldn’t find a motel room. Prior evacuations during one of the earlier hurricanes could have influenced decisions to go to a shelter. Unfortunately, an unknown number of people obtained shelter in churches and other public and private facilities that were not officially sanctioned or operated by government or the American Red Cross.

Some coastal counties with large surge areas have fewer dry shelter sites to choose from or lack schools or public buildings that can withstand hurricane force winds and do not have funds to retrofit or upgrade these facilities. Some counties recommend that people remain at home if their residence is not in a flood prone area and can withstand high winds or go to house of a relative or neighbor that meets those requirements. Other counties require new homes to have safe rooms and new residential subdivisions

to have community hurricane shelters. Small neighborhood shelters specially built to withstand high winds and heavy rains, staffed by local volunteers and properly supplied and equipped offer and an alternative to mass sheltering in large public structures. The table below shows summary data by storm for the counties that provided estimates of their shelter openings and use. The table also shows the expected shelter demand estimated in the HES for the closest fitting scenario.

Shelter Use Summary by Storm

STORM	Counties With Data	Shelters Opened	Actual estimated Shelter Use	Estimated HES shelter demand
Charley	14	130	58,531	152,306
Frances	16	195	105,116	168,823
Ivan	13	72	30,844	115,850
Jeanne	12	116	42,318	111,860

Shelter Concerns: Nearly all of the jurisdictions interviewed stated that they were experiencing shelter deficits. Several communities also warned that there were not adequate amounts of trained management staff to properly run the current shelters. None of the NHP's shelter database tools seemed to be utilized at the local level and a better system to determine shelter need is imperative. A request for planning assistance concerning long term/post storm sheltering was made by several counties.

BUSINESS IMPACTS

Part of the post-storm assessments included an analysis of the impacts that Hurricane Ivan had on the business community in Escambia County, Florida. This effort studied the economic effects of Hurricane Ivan on the top six government and private industry employers in the county. This business impact assessment examined mitigation, preparation and evacuation activities, storm impact on facilities, operations and employees, and documented the recovery process eight months after the storm.

Business Impact Concerns: Many businesses didn’t anticipate the severity of damage they received and indicated their hurricane emergency plans were inadequate. Getting back in operation was more difficult than expected and the loss of communication, phone and cable lines, and computer connectivity was a major setback. It was found that many businesses do not maintain a continuing operations plan after a disaster strikes.

HAZUS

The County interviews included some questions on the use of HAZUS. In general, the State of Florida is the only state that indicated they have been trained and have used the HAZUS software prior to the 2004 Hurricane season. Very few local government personnel attempted to use HAZUS during the 2004 Hurricane season.

HAZUS Concerns: Users identified interrelated concerns about HAZUS use:

- Identify and prioritize HAZUS-MH analysis to support hurricane impact assessment and response;
- Identify steps to incorporate HAZUS-MH into CEMP functional planning at the State and local level
- Incorporate HAZUS-MH operations and analysis into hurricane response training and exercises
- Develop a capability (State and local) to use HAZUS-MH to assess potential impacts of hurricanes in the 2005 hurricane season, including standardization of HAZUS-MH reports
- Coordinate with the Data Acquisition and Stewardship Work Group to identify priorities for data collection

RECOMMENDATIONS

The following concerns and recommendations have been developed from all the data collection, interviews and surveys made for the 2004 hurricane assessments of Hurricanes Charley, Frances, Ivan and Jeanne. They have been broken down into the following categories: Hurricane Evacuation Studies, Hurrevac, Evacuation Decision Making, SLOSH/Storm Surge, Behavioral/ Public Awareness, Transportation, Shelters, Business Impacts, HAZUS, Training, and High Water Marks.

Hurricane Evacuation Study Recommendations

1. FEMA/USACE/States need to secure additional funding to design a timely and efficient system to update HES studies and evacuation clearance times for conditions that exist before each hurricane season.
2. FEMA/USACE/States need to conduct HES training before each season to insure EMA's are aware of current HES products and understands their evacuation zones and clearance times.
3. HES studies need to be expanded to include data for nearby inland counties to better understand regional evacuation impacts and inland hurricane hazard vulnerability.
4. Evacuation orders issued by military bases were not always coordinated with local jurisdictions. Additional coordination is needed to insure Military base actions are accounted for in evacuation clearance time computations. Evacuation clearance times in HES need to be adjusted to include military base impacts upon roadway networks.

Hurrevac Recommendations

1. Although the latest version of Hurrevac 4.0.4 has features to alert users if they are using an old version, we should still make every effort to insure older versions are updated.
2. Increase public awareness, marketing, and training efforts to insure that EMA's understand the usefulness of HURREVAC. Create a brochure/newsletter for Hurrevac users showing how to get it; what it does, component descriptions, how to get training etc. Make the brochure available on web sites. Design an effective Hurrevac training mechanism to adequately train users, improve their understanding of Hurrevac and promote optimum evacuation decisions.
3. Develop a means to determine actual numbers of users and Insure adequate server space so data download times don't become a problem.
4. Investigate possibility of furnishing users the default plug-in Evacuation/Surge data specific to the user's state without them having to download it separately and loading on their computer.
5. Market Hurrevac to the inland communities and show them how it can benefit them.
6. Provide a tool to allow user to export tables to spreadsheets or database files.

Evacuation Decision Making Recommendations

1. Evaluate and improve evacuation order communication, capability and techniques, between EMA and the community to provide the best public response. Develop evacuation order protocols, best practice procedures, and analysis capabilities for local and state decision making officials.
2. Work with NOAA to increase watch and warning public awareness.
3. Review the effectiveness of mandatory vs. voluntary evacuation orders and change terminology based on findings.
4. Improve evacuation coordination between State EMA's and other key agencies responsible for coordinating evacuations.
5. Increase awareness of the Hurricane Liaison Team (HLT) and its value to State/local EMAs. Clearly define the HLT's national roles and protocols.
6. Improve traffic information and procedures. Traffic delays are a serious problem, especially for those who evacuate in a timely manner. Contra-flow and other initiatives are underway in many areas, but the public is not sufficiently aware of them.
7. Provide assistance to local governments in the form of best practices guides for dissemination of evacuation notices and materials for communicating the locations needing to evacuate; provide multimedia materials to help people in vulnerable areas appreciate the danger of being at home during a hurricane.

SLOSH/Storm Surge Recommendations

1. Increase awareness about hurricane threats from storm surge by developing a comprehensive campaign to impress on the public and local decision-makers the hazards associated with storm surge inundation.

2. FEMA/USACE/NOAA need to evaluate various storm surge models being utilized by EMA's to make evacuation decisions. The goal of this recommendation is to keep storm surge mapping current, since it is the foundation upon which evacuation clearance times are created.
3. FEMA/USACE/NOAA should determine the best future course of action to quickly update a storm surge basin that has been significantly altered by a storm.
4. Generate new SLOSH Maximum Envelopes of Water (MEOWs) and Maximum of the Maximums (MOMs) for use in determining changes to existing hurricane evacuation zones for each revised SLOSH basin (when completed).
5. Revise the surge mapping based on new MEOWs and MOMs for each area having significant changes to surge heights.

Behavioral/Public Awareness Recommendations

1. Review, consolidate and create new Federal agency brochures and PDF web based files that educate the public on how to assess hurricane hazard vulnerability.
2. Develop community-centered campaigns on hurricane vulnerability. Prepare multi-media material such as television spots or a film intended to educate the public about the reasons for evacuating and the dangers of failing to do so. The material would be made available for long-term public education but also suitable for shorter segments that could be used when a storm is actually threatening a community, mainly for use by local television
3. Expand the hurricane evacuation studies to include regionally specific hurricane public awareness information.
4. Future HES studies should provide locals with training and development of public awareness materials specific to their locations.
5. A best-practices guide to demonstrate ways that some communities have successfully converted their HES products into public information products should be developed, including ways the communities have funded those products. The HES program should sponsor a study describing the techniques employed by communities to disseminate evacuation notices and sponsor a best-practices guide showing methods that have been most effective.
6. Given the large number of people failing to evacuate from vulnerable areas, it would be prudent for the HES program to provide local governments with technical assistance to educate the public about how to make their homes safer in a hurricane, not just more damage resistant.
7. Post-storm surveys should be conducted sooner following events to ensure the collection of perishable behavioral data. Complete these behavioral studies sooner. Research has shown that memories get lost or modified quickly. To the extent possible, budgetary and other post storm constraints should be modified to enable researchers to begin as soon as possible after a hurricane threat or impact.
8. Promote mitigation best practices and find new ways to encourage sheltering in place outside storm surge zones.
9. Embrace new technologies that would provide more accurate behavioral data at less cost.

Transportation Recommendations

1. FEMA/USACE/FHWA must evaluate support for real time evacuation traffic systems and technology, including ETIS. Determine state and local ITS needs, current traffic management capabilities, and best practices.
2. Establish an MOU that clearly defines the role and responsibility of the Evacuation Liaison Team and its relationship with states agencies.
3. Develop a centralized, nationwide network of real-time traffic counters, which can be accessed and used by all Federal, State and local officials during emergencies. Place real-time traffic counters in rural and urbanized jurisdictions that record and transmit average hourly speeds.
4. Facilitate a more proactive application of traffic management, host sheltering and public information procedures that will enhance the overall success of any evacuation effort.
5. Once the behavioral results are finalized, especially destination and participation rates, all efforts should be undertaken to ensure that they are validated and input into traffic management modeling.
6. Develop strategies for the Evacuation Liaison Team (ELT) to collect better consistent information regarding evacuation decisions from State and local governments. Develop a method for collecting these local evacuation decisions and other related variables and archiving them for future reference.
7. Evaluate procedures to inform evacuees on the roadway network/in-route of traffic problems and emergency information.
8. FEMA must work with USDOT to create transportation reentry protocol templates and plans for local governments.

Shelter Recommendations

1. Complete the development of a national shelter database and evaluation system and include a shelter management module to allow users to select available shelters and keep track of their capacities and needs to improve real-time shelter management during evacuations and share shelter data between states.
2. Review public shelter usage over the past 10 years to better document the most probable shelter usage rates and the circumstances that lead to those rates being exceeded.
3. Improve communications between shelters and county EMA’s to ensure rapid exchange of information after the storm has passed.
4. To alleviate deficits in shelter staff, train and utilize municipal, county and state employees in shelter operations.
5. Insure sufficient shelter capacity is available to avoid problems due to overcrowding.
6. Plan for long term sheltering and assistance in case extended stays become necessary due to storm damage and unsafe conditions.

7. Federal and state programs should include assistance in evaluating shelters for resistance to wind, debris and water penetration and provide recommendations for retrofits and structural improvements to shelters to insure occupants are adequately protected.
8. Insure transportation is provided for those lacking the means to reach shelters.
9. Define “Refuge of Last Resort” and develop procedures and protocols for local EMA’s in case they are threatened by rapidly intensifying storms close to shore.
10. Assist counties to insure that public knows where shelters are located.
11. Work with shelter staff to help them obtain information on evacuees in the shelter to determine where they come from and why they came to that shelter.

Business Impact Recommendations

1. Develop and deliver mitigation programs, construction guidelines and training for the business community.
2. Develop and deliver hurricane preparedness programs and training for the business community.
3. Provide guidance and assistance to the business community in the development of Business Continuity Plans.
4. Back-up plans for communication and internet access should be developed for critical business entities.
5. Develop and conduct severe weather and disaster preparedness materials and training for business leaders and employees and families.
6. Businesses should develop short and long-range recovery plans and be better educated on the specifics of the FEMA assistance programs.
7. Better and stronger building codes should be adopted for structures within 100 miles of the coast.

HAZUS Recommendations

1. Enhance HAZUS-MH Training and Capability Development. This capability should include GIS expertise and emergency management/mitigation planners.
2. Provide guidance to Florida counties that describes the potential use of HAZUS-MH and TAOS analysis and outputs.
3. Prepare a work plan and implementation strategy to identify and prioritize the acquisition of datasets.
4. Priority should be given to post-disaster studies that analyze and validate performance of essential facilities with priority given to shelters and hospitals.
5. The post-disaster information needs of three key local officials - Housing, Building, and Fire - should be considered when customizing HAZUS-MH post-disaster applications.
6. HAZUS-MH estimates of indirect losses should be validated and shared with state and local officials.
7. Provide 24 hour operational support during hurricane threats.

Training Recommendations

1. Create an accredited online suite of independent training products to educate the EM community on all HES products.
2. Develop a Hurrevac on-line independent study course to meet EMI training standards that would keep up with trainees taking the course.
3. Ask the States to notify FEMA and the Corps of all new EM directors and provide a training session for them to assure they are familiar with the Hurricane Evacuation Program and the use of Hurrevac.
4. Create a cadre of Hurrevac trainers and develop a state train the trainer program and insure training is provided to all users.
5. Update evacuation decision making products such as IS 324, community hurricane preparedness, and create a package for inland county use of hurricane products.
6. Create new independent study course to address storm surge impacts and assessing vulnerability.
7. All online training products should meet FEMA/DHS Emergency Management Institute (EMI) training standards and be incorporated into EMA certification curriculum where appropriate.

High Water Mark Recommendations

1. Compare the Hurricane Coastal High Water Marks (CHWMs) to the flood elevation data on the effective Flood Insurance Rate Maps to determine where flood hazard data was accurate or where new detailed studies should be performed.
2. An evaluation is needed of the recurrence intervals of the surge conditions across the area.
3. Compare the CHWMs and Riverine High Water Marks (RHWMs) from other significant flood events. This will identify areas of repetitive flooding that can assist FEMA in determining locations that would make good flood mitigation projects.
4. Complete detailed-engineering analyses to determine new flood elevations in the areas where deficiencies have been identified on the existing FEMA maps, or in areas where property loss occurred where no previous studies have been prepared.
5. Use CHWMs and RHWMs to identify areas of concern for future mitigation projects.
6. Use CHWMs and RHWMs to evaluate the success of completed mitigation projects. Documentation of the "damages avoided" can be used as mitigation success stories.
7. Use CHWMs and RHWMs to create flood recovery inundation mapping. The inundation maps can assist in determining the accuracy of existing FEMA flood maps and provided to community officials to assist in disaster recovery.