HURRICANE CHARLEY
CHARACTERISTICS and STORM TIDE EVALUATION

By

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I. Synoptic History

Hurricane Charley developed from a tropical depression on 9 August , 2004, and strengthened into Tropical Storm Charley early on 10 August. Fairly steady strengthening continued while the storm moved into the central Caribbean Sea, and when Charley approached Jamaica on 11 August, it became a hurricane. It continued to strengthen, reaching Category 2 status around 1500 UTC 12 August, just after passing northeast of Grand Cayman. After Charley crossed western Cuba with a maximum wind near 120 mph, the hurricane passed over the Dry Tortugas around 1200 UTC 13 August with maximum winds around 110 mph. It then turned north-northeastward and accelerated toward the southwest coast of Florida (Figure 1).

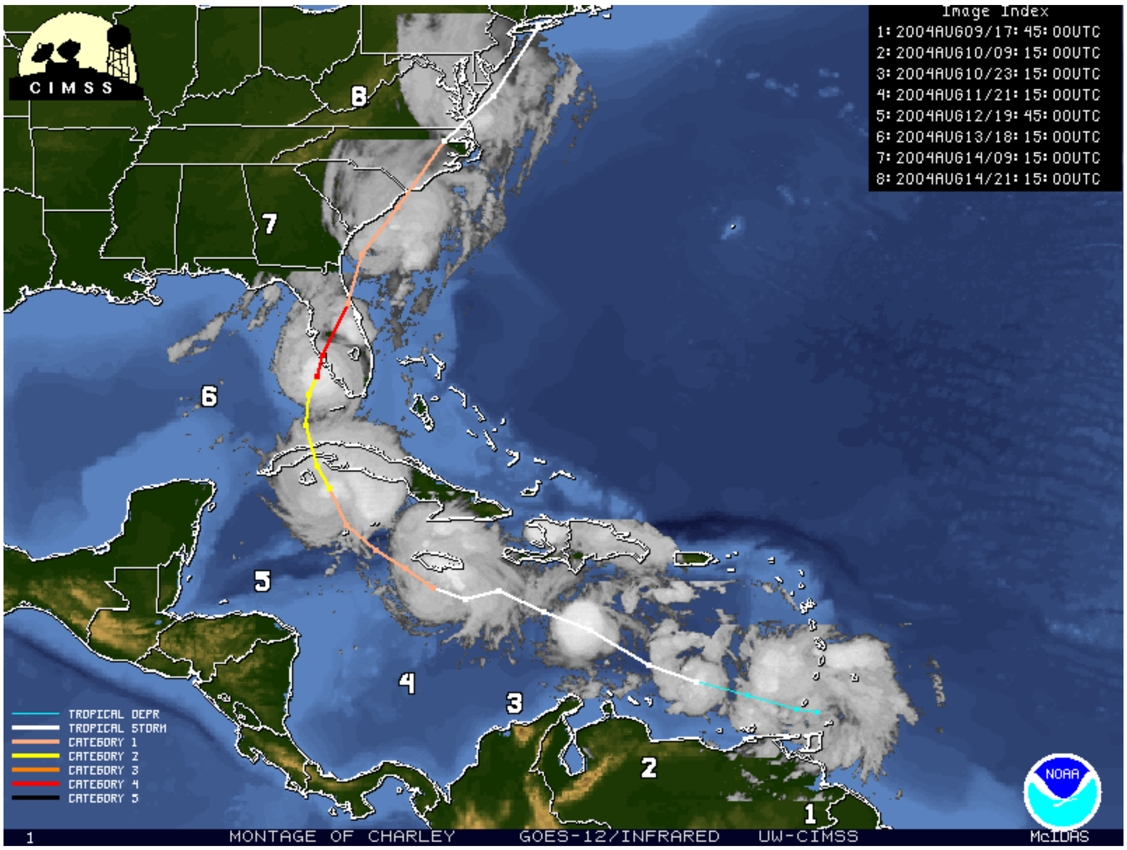

Figure 1. Hurricane Charley track, 9-14 August 2004. (Source: CIMSS, UW-Madison)

By 1400 UTC 13 August, the maximum wind had increased to near 127 mph. Just three hours later, Charley's maximum wind had increased to Category 4 strength of 144 mph. Since the eye shrank considerably in the 12 hours before landfall in Florida, these extreme winds were confined to a very small area – within only about 6 n. mi. of the center. Moving north-northeastward at around 21 mph, Charley made landfall on the southwest coast of Florida near Cayo Costa, just north of Captiva, around 1945 UTC 13 August with maximum sustained winds near 150 mph. Charley's eye passed over Punta Gorda at about 2045 UTC, and the eyewall struck that city and nearby Port Charlotte with devastating results (Figures 2, 3). Continuing north-northeastward at a slightly faster forward speed, the hurricane traversed the central Florida peninsula, resulting in a swath of destruction across the state. Charley was still of hurricane intensity, with maximum sustained winds of 75-80 mph, when the center moved off the northeast coast of Florida near Daytona Beach at around 0330UTC 14 August (Pash et al., 2005).

The winds of Charley are presented in the wind swath map show in Figure 4. The data was prepared and provided by the Hurricane Research Division (HRD) at the Atlantic Oceanographic and Meteorological Laboratory (AOML) of the National Oceanographic and Atmospheric Administration. The graph given in Figure 5 depicts the best track central barometric pressure and wind speed history for Charley based on data obtained from Tropical Cyclone Report of Hurricane Charley, National Hurricane Center (Pasch et al., 2005). Wind speed dropped and central pressure rose dramatically right after landfall.

Figure 2. Hurricane Charley track passing over the Florida Coast.

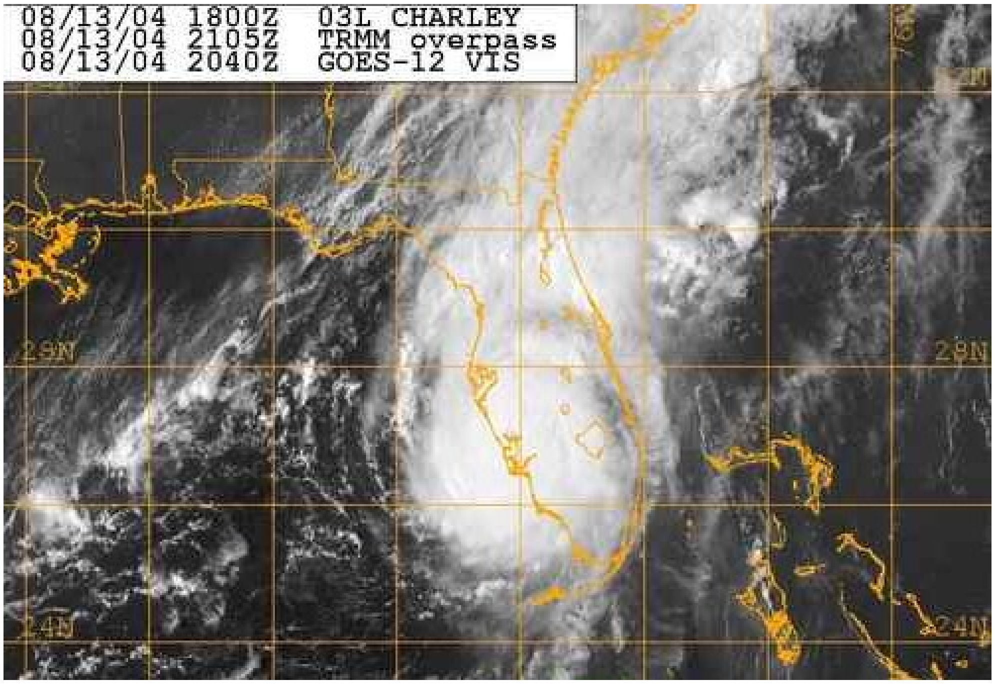

Figure 3. Eye of Hurricane Charley at landfall (Source: Naval Research Laboratory).

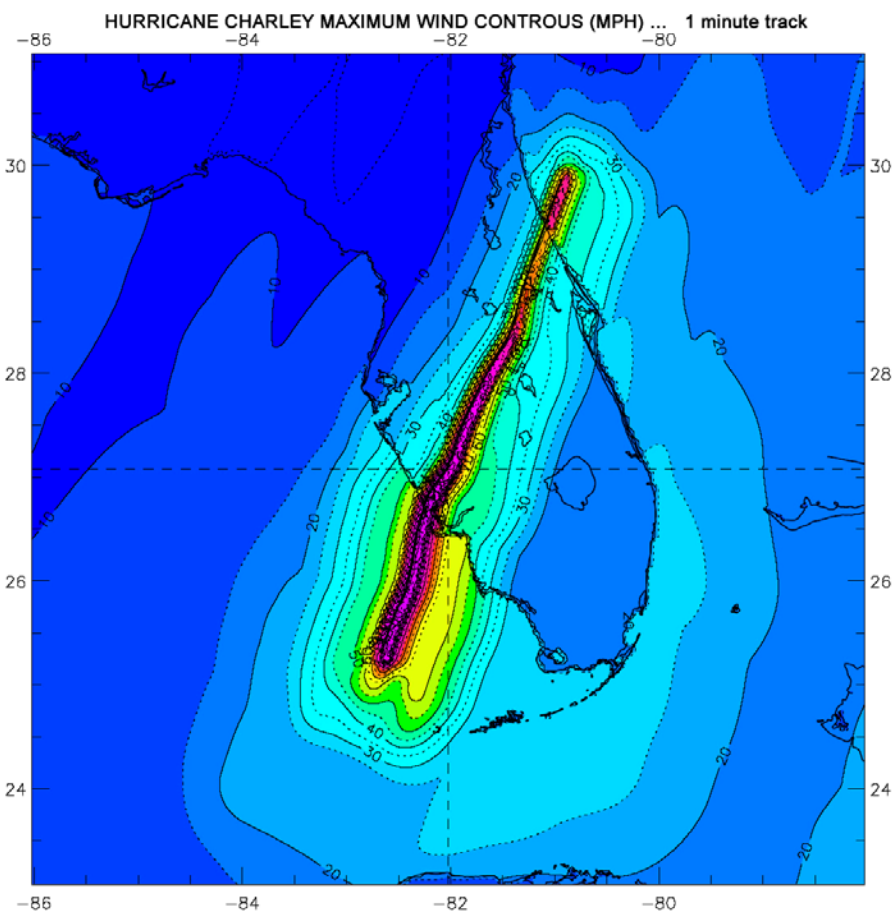

Figure 4. Surface Wind Fields Associated with Hurricane Charley at landfall.

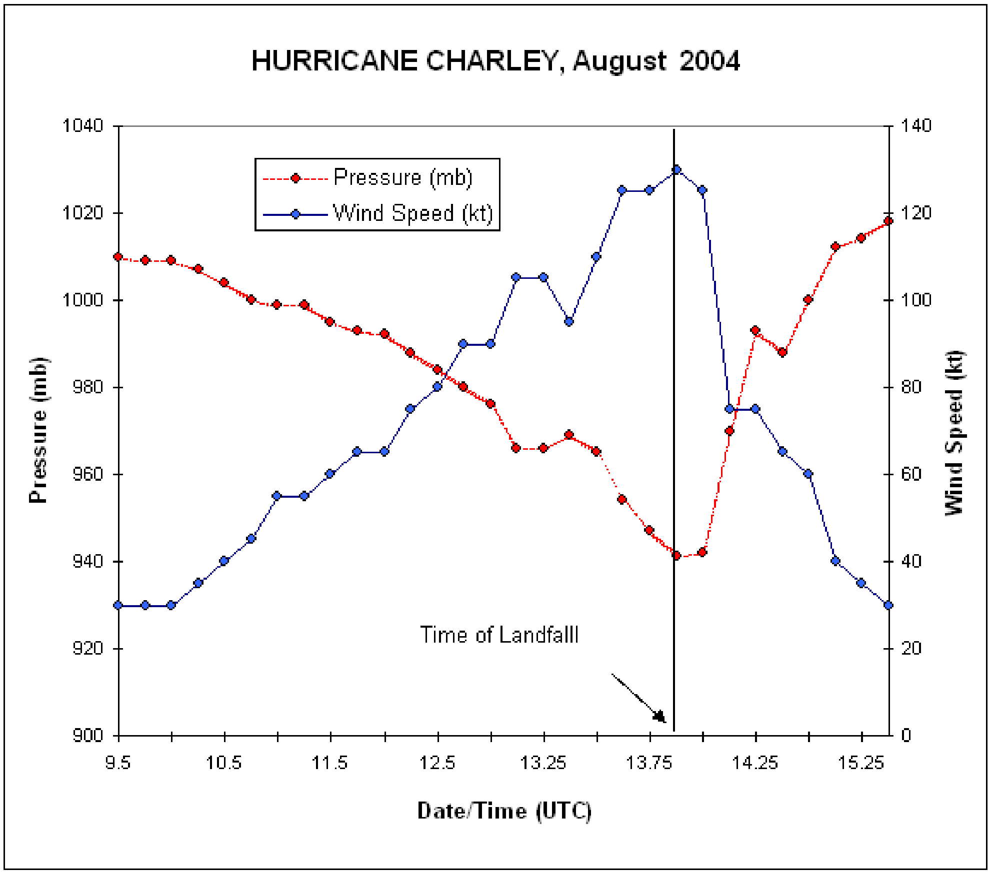

Figure 5. Best track Pressure and Wind Speed for Hurricane Charley, 9-15 September, 2004.

II. Storm Tide Records

Hurricane Charley was the strongest hurricane in terms of wind speed to hit the United States since Hurricane Andrew in 1992. It caused catastrophic wind damage along the path of its highest wind, which was located on the south east side of its eye.

URS Group, Inc. was contracted by the Federal Emergency Management Agency (FEMA) to collect and survey Coastal High Water Marks (CHWMs) in the Charley Impacted areas. A total of 69 CHWMs were surveyed in Charlotte (11), Collier (9) and Lee (39) counties (FEMA, 2004).

The NOAA tide gauge at Ft. Myers, Caloosahachee River, was in operation during the time of the hurricane. The Peak Elevation was measured as 4.36 feet above NGVD.

For the purpose of this report, only the interior High Water Mark (HWM) data from beach areas or flooded areas with wave setup were selected to evaluate the storm tide associated with Hurricane Charley. Two inside HWM observations are available from FEMA's report for Ft. Myers and Ft. Myers Beach. Another two inside HWM data were estimated by Ralph Clark

(BBCS, 2004) on North Captiva Island and Captiva Island. Table 1 lists these 4 HWM data and their location descriptions.

Table 1 High Water Marks data in Lee County during Hurricane Charley

Location	Peak Surge (ft-NGVD)	Position		HWM Object
		Lat.(N)	Lon.(W)	
Ft. Myers Beach	9.4	26.45062	81.94958	Mud line of interior wall
Ft. Myers	4.8	26.48764	82.01187	Mud line of interior wall
North Captiva Island, South End	9.0			Water line of interior wall
Captiva Island, North End	7.0 ~ 8.0			Water line of interior wall

III. Storm Tide Evaluation

Since there are only four Interior HWM data available on the beach side at the present time for Hurricane Charley, it is not possible to generate a trend line of the storm tide distribution. It is, however, possible to predict that North Captiva Island, Captiva Island, Sanibel Island and nearby areas would received the worst impact by maximum wind and associated storm surge from its track and the Radius to the Maximum Wind (RMW), which was estimated as 6.9 miles (Pasch et al., 2005).

To verify the HWM data and to provide the un-surveyed area with estimated storm tides, the 2-D Storm Surge Model of BSRC was employed to calculate the total storm tide, i.e. surge generated from barometric pressure and wind stress plus dynamic wave setup and astronomical tide. The 2-D grid systems and associated hydrological data of Lee County from the CCCL study were used to cover the study area. Hurricane track, pressure deficit, RMW of Charley for the last 26 hours before and 10 hours after landfall were input to the 2-D storm Surge Model. The Model was then run and the total storm tide calculated for 15 locations in Lee County. Figures 6 to 10 display the results of model calculated total storm tides and the surveyed HWM.

Figure 6. Peak Surge Levels in Lee County for Hurricane Charley.

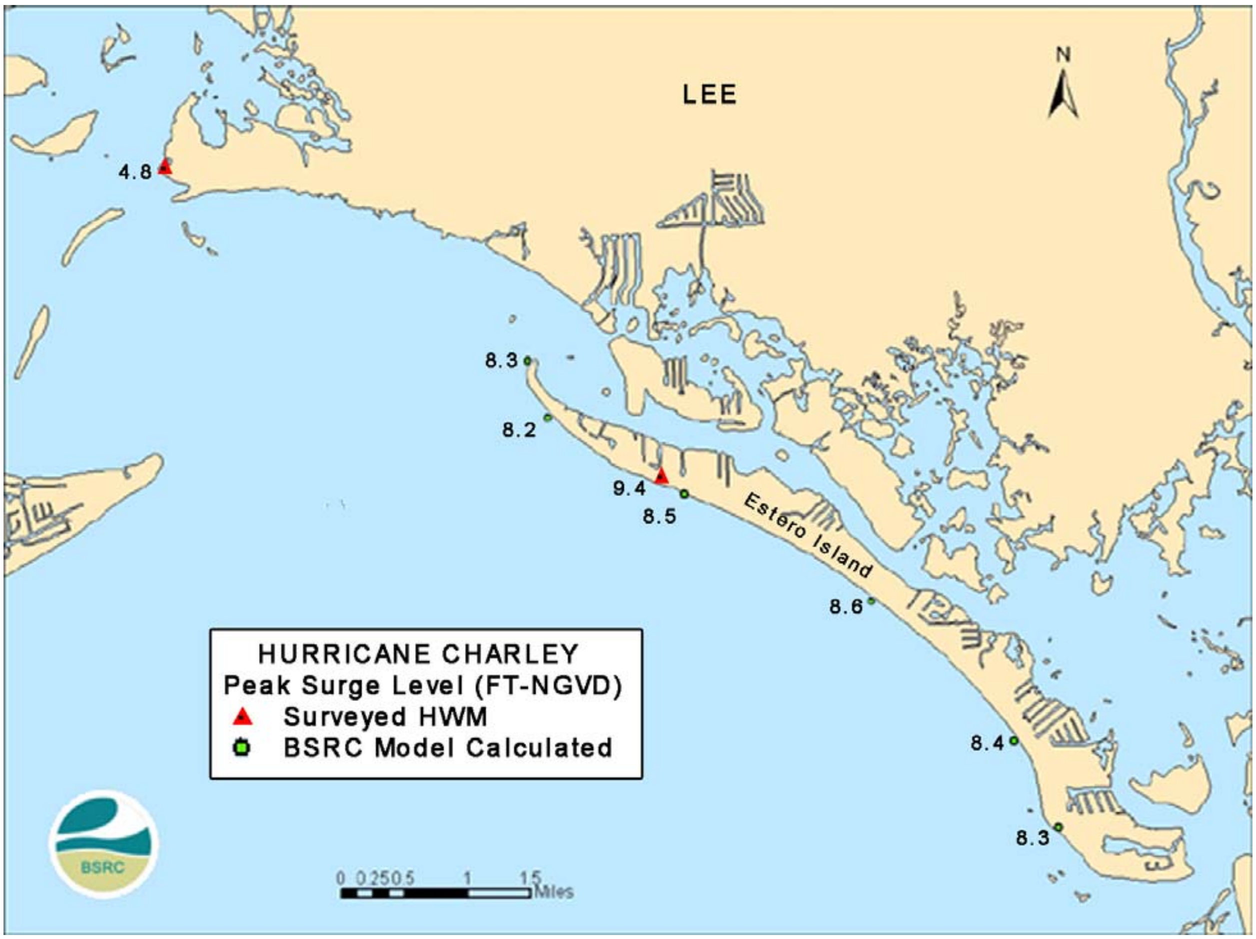

Figure 7. Peak Surge Level in the Estero Island area for Hurricane Charley.

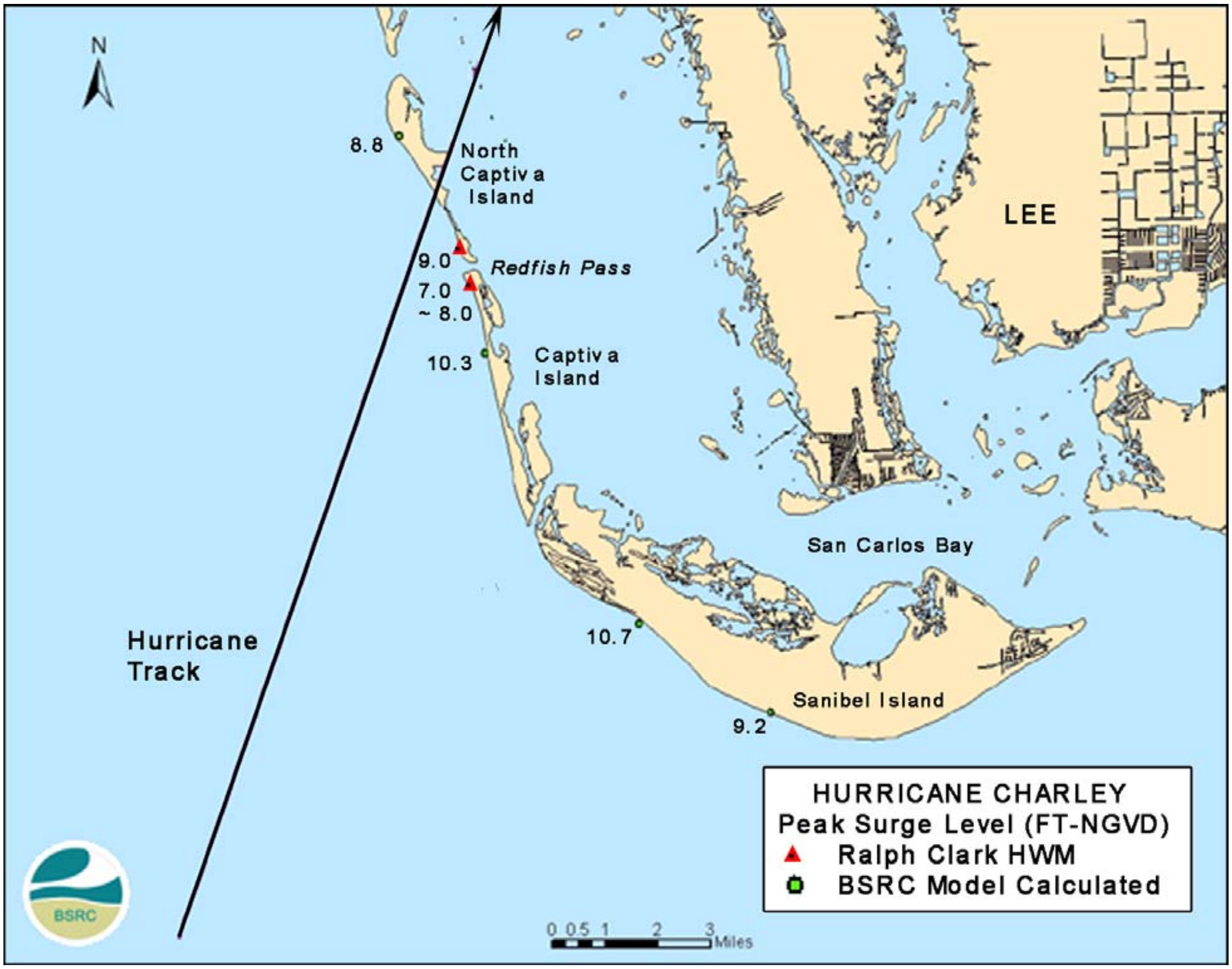

Figure 8. Peak Surge Levels for Captiva and Sanibel Islands for Hurricane Charley.

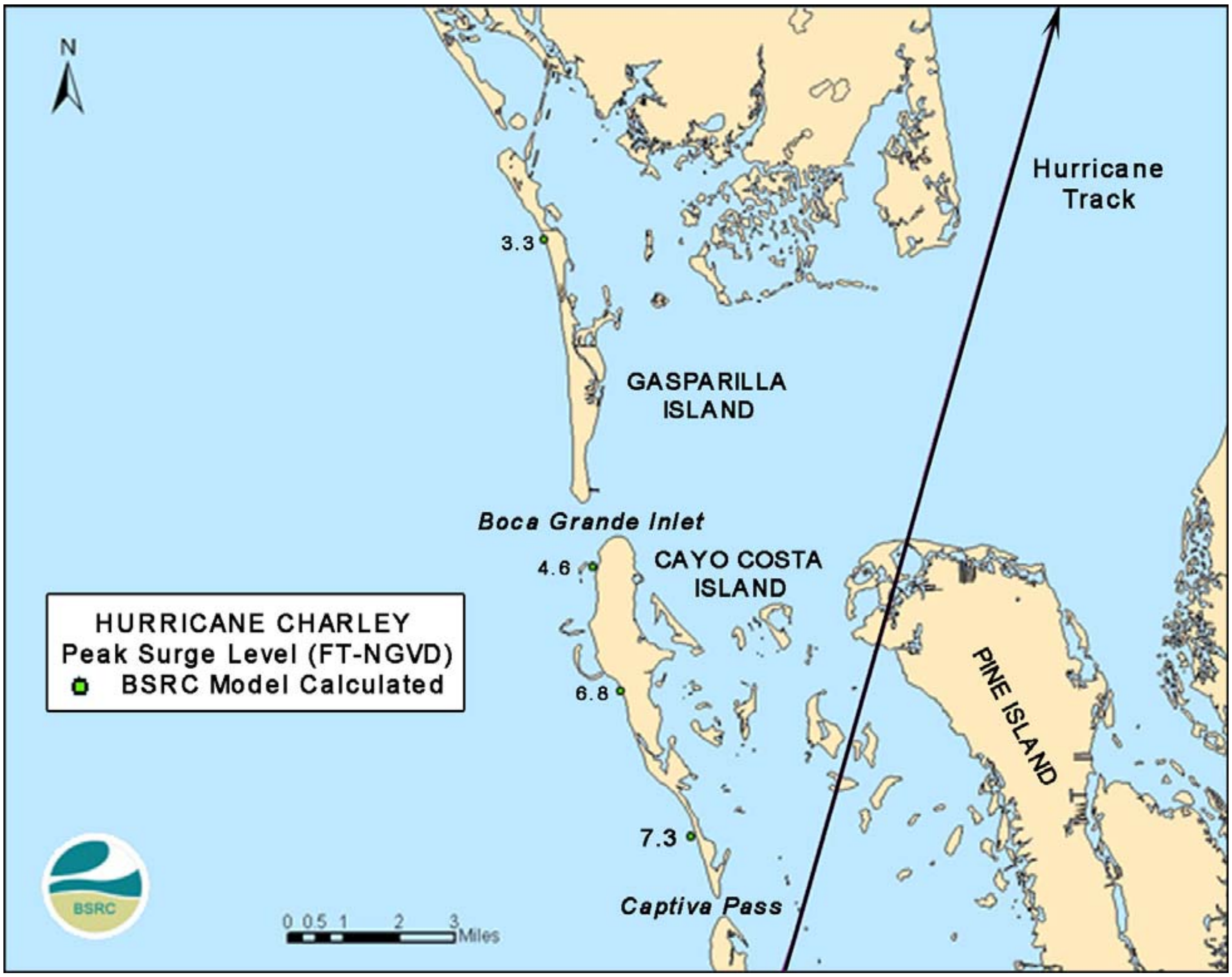

Figure 9. Peak Surge Level in the Cayo Costa Island area for Hurricane Charley.

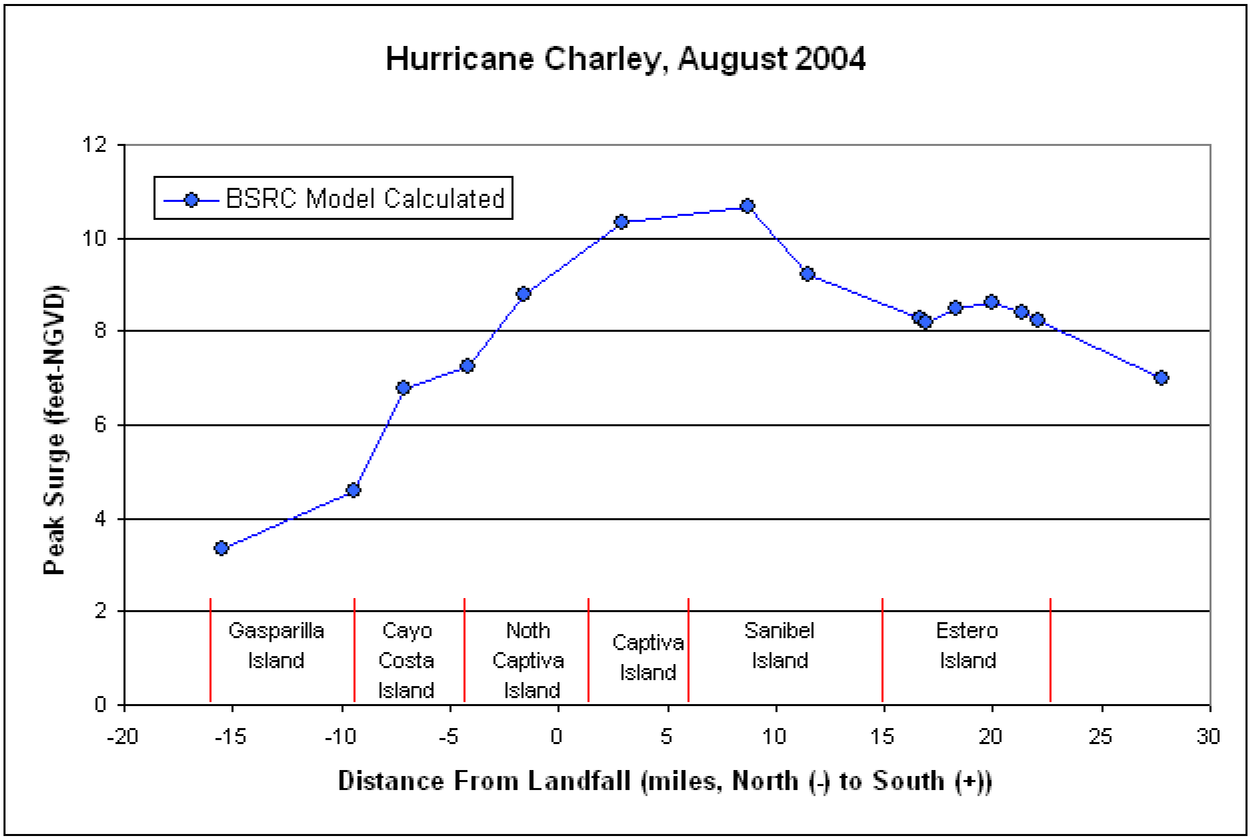

Figure 10. Peak Surge Levels Calculated from the BSRC Model for Hurricane Charley.

IV. Storm Tide Return Period

Figures 7 and 8 show that the BSRC Model calculated Total Storm Tide by Hurricane Charley agrees closely with the surveyed HWM data. The BSRC Model results are validated herein, hence the previous CCCL study return period curves can be used with the model results to evaluate the Total Storm Tide Values for Various Return Periods in Lee County.

A total of 18 storm tides in 6 profile transact lines from the CCCL studies for Lee County were selected to generate return periods of 10, 20 and 50 years. Figure 11 depicts a comparison between the calculated storm tide for Charley and the CCCL's total storm tide for various return periods and shows that Hurricane Charley generated a storm tide ranging between 10 and 50 years return period for the Lee County area. The storm tide realized Lee County, especially in the hard impacted Captiva Island area, was due to two factors: a fast moving hurricane and a narrow RMW. Hurricane Charley moved quickly at about 25 mph before and after landfall with a narrow RMW of 6.9 miles, which caused a lower storm tide than a slow moving and large RMW hurricane.

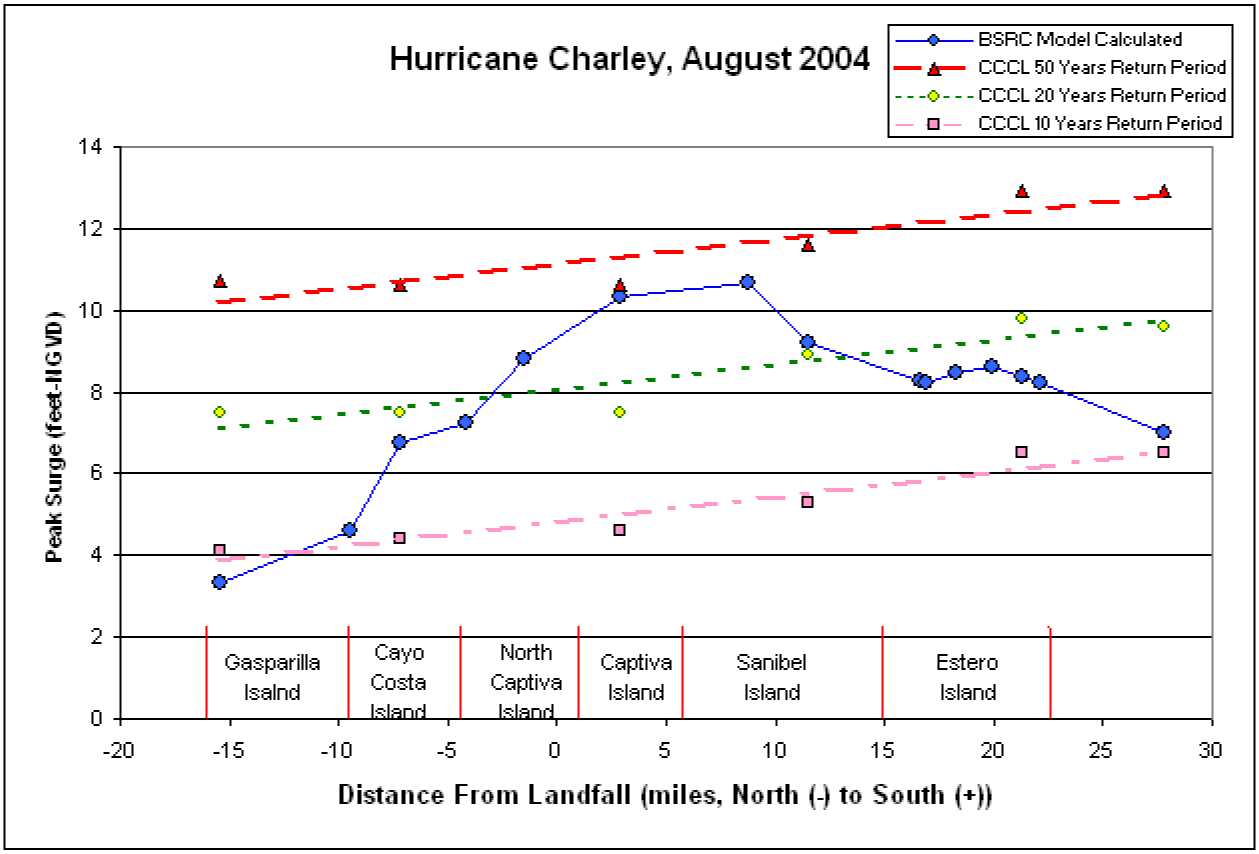

Figure 11. Hurricane Charley Storm Tide Return Period.

V. Reference

BBCS, "Hurricane Charley Post-Storm Beach Conditions and Coastal Impact Report with Recommendations for Recovery and Modifications of Beach Management Strategies", Division of Water Resource Management, Florida Department of Environmental Protection, August 2004.

FEMA, "Hurricane Charley Rapid Response, Florida Coastal High Water Mark (CHWM) Collection, Task Order 326, Final Report", FEMA-1539-DR_FL, November 2004.

Pasch, R. J., Brown, D. P. and Blake E. S, "Tropical Cyclone Report, Hurricane Charley, 9-14 September ,2004", Tropical Prediction Center, National Hurricane Center, January 2005.