

HURRICANE RITA SURGE INUNDATION AND ADVISORY BASE FLOOD ELEVATION MAPS – SUMMARY OF METHODS

Contract No. EMW-2000-CO-0247

Task Order No. 436 (Louisiana)

1. Introduction

On September 24, 2005, Hurricane Rita made landfall near the Louisiana-Texas border as a Category 3 hurricane, with maximum sustained winds of 120 miles per hour. Reaching Category 5 status while in the Gulf of Mexico but weakening before landfall, Hurricane Rita caused extensive coastal flooding, erosion, and wind damage. Sustained, hurricane-force winds extended more than 150 miles inland, and tropical storm-force winds reached the Arkansas-Louisiana-Texas border (National Oceanic and Atmospheric Administration [NOAA], <http://www.ncdc.noaa.gov/oa/climate/research/2005/rita.html>).

Hurricane Rita produced storm surge of 5 to 14 feet, with maximum values observed approximately 60 miles east of the landfall site. The surge plus wave action caused widespread damage to infrastructure and buildings throughout low-lying coastal communities and inland parishes. The storm's flooding impacts were not limited to the landfall area; surge of up to 8 feet was observed in New Orleans, breaching levees that had been provisionally repaired after Hurricane Katrina. As the storm moved inland and became a Tropical Storm, heavy rainfall also caused localized flooding (NOAA, <http://www.ncdc.noaa.gov/oa/climate/research/2005/rita.html>).

In response to this devastating hurricane, the Federal Emergency Management Agency (FEMA) initiated a project to produce high-resolution maps that show flood impacts from the storm for portions of nine coastal Louisiana parishes: Calcasieu, Cameron, Iberia, Lafourche, St. Charles, St. John the Baptist, St. Mary, Terrebonne, and Vermilion. While flooding impacts from Hurricane Rita were also severe in Texas, recovery maps were only prepared for Louisiana because the observed coastal flooding was significantly greater than the flood levels shown on current Flood Insurance Rate Maps (FIRMs), suggesting that the FIRMs may understate the true flood risk.

This report outlines the data sources and methods used to produce the Hurricane Rita Surge Inundation and Advisory Base Flood Elevation maps (herein referred to as the "Rita Recovery Maps"). As of the date of this report, Rita Recovery Maps have been published for the following parishes: Calcasieu; Cameron, Iberia; Lafourche; St. Charles (West Bank, or south of the Mississippi River); St. John the Baptist (West Bank, or south of the Mississippi River); St. Mary; Terrebonne; and Vermilion.

2. Methodology

Rita Recovery Maps provide the following essential elements of information:

- ✓ Preliminary surveyed coastal high water mark (HWM) flood elevations from Hurricane Rita's storm surge (i.e., excluding HWMs reflecting surge plus local wave effects);
- ✓ Hurricane Rita coastal surge inundation limits; and
- ✓ Advisory Base Flood Elevations (ABFEs).

The methods for generating each of these essential elements of information are discussed in greater detail in the sections that follow. In addition to the detailed Rita Recovery Map panels that show these elements, FEMA has also produced two overview maps for the nine affected parishes mapped to date. These overview maps, which are explained in greater detail in Section 3, shows some of the same essential elements as well as regional surge elevation contours derived from the surge-only HWMs.

2.1 Hurricane Rita Coastal High Water Mark Collection

Under separate task orders, field-based flagger and survey crews from URS and URS Team subconsultants, ESP Associates, Michael Baker Jr., Inc., Dewberry, and BFM Consultants, Inc., were deployed to interview residents, find evidence of coastal high water levels, take digital photographs, and

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survey coastal HWMs from Hurricane Rita. Coastal HWMs included mud lines, water stains, debris, wrack lines, and eyewitness testimony.

For each HWM, the flaggers completed a form that contained detailed information about the mark. To the extent possible, field crews noted the coastal flooding characteristics captured by the coastal HWM, including storm surge, wave runup, and wave height. These designations represent the field crew's best estimate of this characteristic based on a combination of physical flood evidence and interviews with witnesses at the time of collection. These characteristics are described as follows:

- Surge - represents the rise in the normal water level, also called stillwater flooding
- Wave runup - represents the height of water rise above the stillwater level due to water rush up from a breaking wave
- Wave height - represents the coastal HWM elevation due to more direct wave action

Typically, storm surge coastal HWMs are associated with a slow-rising flood that causes more water damage than structural damage. Wave height usually results in a higher elevation than just storm surge. All attempts were made to flag storm surge elevations, but in areas where storm surge characteristics were not obvious, wave runup or wave height may have been captured. For example, witnesses might claim the flooding was associated with a storm surge when in fact the flooding was from wave runup or riverine flooding.

The survey crews followed the flaggers and used static Global Positioning System (GPS) methods to determine an accurate elevation for each coastal HWM. Since static GPS requires an area with no tree cover to return an accurate result, in some cases it was necessary to perform a short level loop survey from the GPS point to the coastal HWM. Coastal HWM locations were surveyed horizontally in the North American Datum of 1983 (NAD 83), Louisiana State Plane Coordinates (South Zone), and vertically in the North American Vertical Datum of 1988 (NAVD 88) US survey feet. Coastal HWM locations have been surveyed to within accuracies of ± 0.25 foot vertically and ± 10 feet horizontally, with a 95% confidence level.

A more detailed discussion of the coastal HWM collection and final results is available on FEMA's Hurricane Rita Recovery Mapping website at the following address:

http://www.fema.gov/hazards/floods/recoverydata/pdf/rita_la_hwm_public.pdf

2.2 Hurricane Rita Storm Surge Inundation Mapping

Flood inundation limits were created for the coastline for the Louisiana coastal parishes by mapping the coastal HWM elevations onto digital, pre-storm topographic data. These inundation limits represent the estimated inland extent of flooding caused by the Hurricane Rita storm surge.

Note: Hurricane Katrina inundated many of the same Louisiana parishes in August 2005; areas where HWMs show that Katrina's coastal flood levels exceeded those of Rita were mapped under a separate FEMA project. See FEMA's Katrina Recovery Mapping website for more information:

http://www.fema.gov/hazards/floods/recoverydata/katrina_la_index.shtm

The HWMs surveyed by URS and its subconsultants were imported into a Geographic Information System (GIS) as points and pre-processed prior to analysis and mapping. The pre-processing of the HWMs included the Anselin Local Moran's I statistical analysis to identify those points that did not match the general trend of elevations in each point's immediate area. These HWMs were not used for the inundation mapping. In addition, HWMs identified as including wave effects or described to be of poor quality or have a low confidence were also excluded from the surge inundation mapping. Once the HWMs

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to be used were identified, a three-dimensional, raster surface was created using a standard interpolation function (Second Power Inverse Distance Weighting).

In a parallel effort, a digital elevation model (DEM) was developed for this project using pre-Rita topographic data. The data were derived from Light Detection and Ranging (LIDAR) measurements collected in 2003 by 3001, Inc., a remote-sensing firm operating under subcontract to Watershed Concepts; this work was funded jointly by the State of Louisiana and FEMA. The LIDAR data were obtained for the recovery mapping effort from Atlas, the Louisiana statewide GIS (<http://atlas.lsu.edu/>). The LIDAR data have a posting interval of five meters, and are referenced to NAVD 88.

To create the Hurricane Rita surge inundation limit, the interpolated HWM raster surface was intersected with the LIDAR DEM and then smoothed using PAEK smoothing algorithms. The inundation limit was then refined to remove small-scale, isolated areas of inundated and non-inundated terrain based on knowledge of overland surge propagation and engineering judgment.

2.3 Hurricane Rita Surge Elevation Contour Mapping

Surge contours were mapped at one-foot intervals in the areas of the following parishes that were most severely flooded by Hurricane Rita: Calcasieu; Cameron; Iberia; Lafourche; St. Charles (West Bank); St. John the Baptist (West Bank); St. Mary; Terrebonne; and Vermilion. These contours, provided in one-foot increments, show the geographic variability of the storm's surge. To create the contours, the coastal HWMs were examined to find patterns in the coastal storm surge as it pushed against the open coast and into the inland bays and waterways. The known path and landfall location of Hurricane Rita, together with the knowledge of how storm surge propagates inland, allowed surge contours to be drawn across the areas where the coastal HWMs indicate a change in storm surge elevation. Engineering judgment had to be applied in some locations to allow the contours to "step" up or down at one-foot intervals.

Because of the inherent uncertainty in and the random and irregular spacing of coastal HWMs, the surge contours represent a generalized maximum storm surge elevation, and required professional judgment in their creation. Within certain surge contours, coastal HWMs may be higher or lower than the contours if they did not fit the overall pattern discerned from the coastal HWMs. Local wave effects (wave heights and wave runup), which increase the total water surface above the surge elevation, were not considered in this contouring effort. Coastal HWMs that include wave effects may be several feet higher than the surge contours in a particular area.

Predictive numerical models of surge flooding, such as Hurricane Rita forecasts from the National Oceanic and Atmospheric Administration's (NOAA's) Sea, Lake and Overland Surge from Hurricane (SLOSH) computer model, were used qualitatively to help refine the surge contours in areas of complex topographic and bathymetric changes. NOAA will be developing hindcasts of Hurricane Rita's surge in the coming months. Consequently, the results presented here should be viewed as preliminary and subject to update as additional data become available.

2.4 Hurricane Rita Advisory Base Flood Elevations

ABFEs are advisory flood hazard data that may be used by communities as best-available data when FEMA determines that the existing, effective Flood Insurance Rate Maps (FIRMs) understate the true flood risk. The general approach for mapping the ABFEs is described below, followed by explanations of any parish-specific mapping techniques or zones where coastal engineering judgment had to be applied.

As explained in the Flood Recovery Guidance published by FEMA for each Louisiana parish (http://www.fema.gov/hazards/floods/recoverydata/rita_la_resources.shtml), ABFEs for this project were

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generally determined by adding freeboard to the Base Flood Elevations (BFEs) shown on each community's FIRM. To apply the freeboard specified in the Flood Recovery Guidance for each parish, the flood zone boundaries and elevations were first transferred electronically from the FIRM into a GIS format, where necessary. In the GIS, the specified freeboard value (usually one foot) was then added to the BFE, and the combined value was placed on the Recovery Map in the form of "ABFE" followed by the flood zone designation (e.g., "Zone VE") and advisory elevation in feet (e.g., "EL 11"). In some cases, FEMA mapped some formerly A and AE Zones as V or VE Zones, respectively, where the increased flood levels would make damaging waves possible.

In addition to considering the FIRM data, ABFEs were determined wherever possible for Rita-inundated areas that were located outside of the 1%-annual-chance (100-year) floodplain (Zones B, C, or X) and approximate A Zone areas as shown on the effective FIRMs. Methods for developing ABFEs in each category of flood zone are described below:

Zones B/C/X: ABFE determination in these areas fell into one of three possible scenarios:

- (1) ABFEs were assigned to Rita-inundated B/C/X Zones based on the effective BFEs of the adjacent flood zones from the FIRM, plus one foot of freeboard. For example, if a specific area delineated on the FIRM had a BFE of AE 7, the same area would be mapped on the Rita Recovery Map with an ABFE of AE 8. If the Rita inundation extended farther inland into adjacent B/C/X Zones on the FIRM, those inundated areas would be included in the Rita Recovery Map advisory floodplain as a Zone A area, and be assigned an ABFE of 8, consistent with the neighboring AE 8.
- (2) In cases where the adjacent flood zone on the effective FIRM was an approximate Zone A instead of a detailed AE Zone, the Rita-inundated Zone B/C/X area and the Zone A were merged, and the combined area was assigned an ABFE based on engineering judgment or other data (see next section on Zone As). For example, a merged B/C/X Zone and an approximate A Zone could be mapped as one advisory flood zone with an ABFE of A 5.
- (3) In some instances, an adjacent detailed flood zone's ABFE could not be applied to the entire extent of the B/C/X Zone that had been inundated by Hurricane Rita; this occurred wherever the Rita surge height was significantly higher (>2 feet) than the prevailing ABFE for the area. For example, consider a recovery map panel where the estimated Rita surge elevation was 10-11 feet (NAVD 88) and the prevailing ABFEs are AE 8 and A 8. Here, FEMA would refrain from over-extending the advisory floodplain (specifically, the A 8 flood zone) to cover the entire Rita-inundated area, since it is apparent that Rita's flooding was much more severe than what would be expected in a 1%-annual-chance (100-year) event in this location. In these areas, FEMA used the high-resolution topographic data to place a more reasonable floodplain limit (that is, the landward limit of the advisory Zone A) where the ground elevation equaled the elevation of closest detailed ABFE (8 feet, in the above example).

Zone A: ABFEs in these areas were primarily based on BFEs provided by the U.S. Army Corps of Engineers (USACE), New Orleans District. The USACE calculated these BFEs during flood control projects, and these values are accepted by the local communities for flood management purposes. The BFEs are tabulated for each parish in the following subsections, including the project identification number, latitude, longitude, assigned date, effective FIRM panel number, and BFE (in feet, NAVD88). The modeled Rita surge height and the BFEs of adjacent, detailed flood zones on the effective FIRMs were also

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considered when assigning values to approximate Zone A areas. All elevation values are relative to NAVD88 and rounded to the nearest half-foot increment.

Rita Recovery Map users should note the following:

A thick yellow line labeled, "Limit of ABFEs," marks the end of the advisory floodplain, that is, the land area where the coastal-related ABFEs apply. ABFEs were not mapped in areas where riverine BFEs shown on the FIRMs are greater than the advisory coastal elevations, nor were ABFEs mapped in locations where there were insufficient technical data to support development of a reasonable, defensible elevations. In most of these cases, the Rita Recovery Maps will show a yellow and black "Limit of Coastal ABFEs" line, and any Rita-inundated areas excluded from the ABFE mapping will be labeled with "See Effective FIRM." Map users should consult the effective FIRM for the area for flood elevations that should be used during the recovery process.

Parish-Specific Approaches – Calcasieu Parish:

As specified in the Flood Recovery Guidance, one foot of freeboard was applied to all detailed flood zones shown on the effective FIRM. Advisory elevations have also been determined in areas shown as approximate A Zones on the effective FIRMs. All Zone A areas in Calcasieu Parish were assigned advisory elevations based on the surrounding effective flood zones. In riverine flooding areas, the advisory elevations were applied to riverine BFEs (plus 1 foot of freeboard) until the Rita surge height was equal to the riverine BFE. When the riverine BFE equaled the Rita surge height, the ABFEs were carried to the furthest spatial extent of that BFE (based on topography) and assigned that value. Above this extent, riverine flooding is dominant; these areas are bounded by a yellow and black line labeled "Limit of Coastal ABFEs." USACE BFEs are tabulated below (Table 1) for reference only, as USACE elevations were not used for assigning A zone elevations in Calcasieu Parish.

Table 1. USACE BFE data for Calcasieu Parish

Project ID	Latitude	Longitude	FIRM Panel	Assigned Date	BFE
693	30.312798	-93.35509269	220037 0225D	9/6/2000	19.0
707	30.147721	-93.46801682	220037 0350C	11/3/2000	10.0
750	30.193857	-93.11462231	220037 0425B	6/12/2000	18.0
851	30.188449	-93.12861508	220037 400	2/24/2000	20.0
856	30.386336	-93.59475946	220037 50B	2/3/2000	42.0
860	30.161317	-93.19016614	220037 400	1/28/2000	15.0
862	30.1413	-93.43572217	220037 0350	9/30/1999	9.0
878	30.401857	-93.13323516	220037 0125C	9/24/1999	24.0
896	30.204825	-93.3867361	220037 0350D	9/1/1999	12.0
921	30.311924	-93.35053196	220037 225	4/22/1999	19.0
994	30.210548	-93.13162926	220037 400	8/20/1999	17.0
995	30.20544	-93.12515537	220037 400	8/19/1999	17.0
1235	30.176387	-93.19716358	220040 0010D	4/25/2002	16.0
1282	30.195085	-93.38308824	220037 0350C	1/19/1999	11.5
1314	30.195436	-93.38312725	220037 0350C	1/8/1999	11.5
1373	30.176817	-93.26459404	220040 0010D	11/20/1998	9.0
1469	30.393705	-93.15201331	220037 125	5/28/1998	25.0
1486	30.401772	-93.33326571	220037 100	4/29/1998	29.0
1545	30.313107	-93.35555576	220037 225	2/11/1998	19.0

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Project ID	Latitude	Longitude	FIRM Panel	Assigned Date	BFE
1613	30.180062	-93.26724626	220040 0005	4/14/1998	9.0
1685	30.19928	-93.58605643	220042	8/25/1997	15.0
1692	30.21386	-93.19539565	220037 10	8/15/1997	14.0
1698	30.258965	-93.47878076	220037	8/12/1997	18.0
1783	30.315834	-93.34679742	220037 0225	5/19/1997	19.0
1800	30.208098	-93.12892194	220037 0400C	2/27/1997	17.0
1933	30.152893	-93.17850327	220037 0400C	7/22/1996	15.0
1981	30.393909	-93.33973153	220037 0100C	7/24/2002	28.0
2243	30.328519	-93.12840071	220037 0250B	4/25/1995	15.0
2248	30.184613	-93.37533441	220037 0350C	8/7/2002	11.5
2352	30.459204	-93.44653531	220038 0005B	3/29/1995	69.0
2353	30.460745	-93.44557067	220038 0005B	3/29/1995	66.0
2558	30.304733	-93.07993119	220037 0275C	10/30/2002	16.0
2740	30.181745	-93.20508692	220037 0010E	2/28/2003	15.0
2770	30.291344	-93.10075948	220037 0275C	3/5/2003	14.0
2892	30.176778	-93.20039927	220040 0010E	5/20/2003	14.0
3283	30.264116	-93.28734076	220037 0225D	12/5/2003	15.0
3226	30.292531	-93.09564557	220037 0275C	10/16/2003	15.0
2784	30.179357	-93.19274119	220040 0010D	12/23/1993	15.0
3041	30.399357	-93.18136154	220037 0125C	6/19/2003	26.0
2962	30.454755	-93.42397378	220037 00075	8/17/1993	58.5
3423	30.322894	-93.33015604	220037 0225D	3/18/2004	20.0
3151	30.331518	-93.36484499	220037 0225D	9/2/2003	20.0
3394	30.38459	-93.59609078	220037 0050B	2/19/2004	45.0
3361	30.216703	-93.22164058	220040 0010E	1/31/2004	9.0
3582	30.177629	-93.19999775	220040 0010E	6/28/2004	15.0
3443	30.261366	-93.36831617	220037 0225D	3/25/2004	16.0
3530	30.207301	-93.13332166	220037 400D	5/18/2004	17.0
3532	30.192053	-93.12472462	220037 425C	5/18/2004	20.0
3476	30.314847	-93.68170088	220037 0150C	4/15/2004	24.0
3462	30.302789	-93.66448121	220037 0150C	4/5/2004	26.0
4094	30.211638	-93.16855037	220040 0010E	10/20/2005	12.0
4141	30.144172	-93.24737045	220037 0400C	12/13/2005	13.0
3878	30.288916	-93.11484418	220037 0275C	2/14/2005	14.0
3635	30.231851	-93.37049616	220041 0001C	7/27/2004	14.0
3629	30.277208	-93.09788931	220037 0275C	7/23/2004	15.0
3725	30.334163	-93.07954832	220039 0275C	10/7/2004	18.0
4145	30.250783	-93.40530342	220037 0200C	12/21/2005	21.0
4137	30.166956	-93.12776253	220037 0400D	12/1/2005	22.0

Parish-Specific Approaches – Cameron Parish:

As specified in the Flood Recovery Guidance, one foot of freeboard was applied to all detailed flood zones shown on the effective FIRM. Advisory elevations have also been determined in areas shown

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as approximate A Zones on the effective FIRMs. All Zone A areas in Cameron Parish were assigned advisory elevations based on the surrounding effective flood zones, with the exception of panels EE 28-30 and FF 28-29. Elevations in A zones appearing on these panels (EL 7) were not ramped down to conform with the effective FIRM elevations because the Rita surge inundation was greater (8-9 feet) than the adjoining effective elevations (5-6 feet), and adjoining effective zones in Calcasieu Parish had higher effective elevations (AE Zones, 8 to 10 feet). USACE BFEs were not used to assign elevations to A Zone in Cameron Parish, but have been provided for reference purposes (Table 2).

Table 2. USACE BFE data for Cameron Parish

Project ID	Latitude	Longitude	FIRM Panel	Assigned Date	BFE
1976	30.028586	-93.17358215	225194 0125F	4/18/1996	6.0
2630	29.863822	-92.84722283	225194 0725F	3/3/1994	8.0

Parish-Specific Approaches – Iberia Parish:

As specified in the Flood Recovery Guidance, one foot of freeboard was applied to all detailed flood zones shown on the effective FIRM. Advisory elevations have also been determined in areas shown as approximate A Zones on the effective FIRMs. For Zone A areas south of Bayou Teche, ABFE elevations were assigned based on a combination of effective AE elevations and USACE BFEs. USACE BFE elevations were superseded if effective elevations in adjacent AE or VE Zones were greater. This was the case in western Iberia, where USACE BFEs decreased from 12 to 10 feet; however, effective flood zones to the south had an elevation of 12 feet, as well as preliminary flood zone data in Vermilion Parish (to the west). ABFE elevations along Bayou Teche were assigned according to USACE BFEs, which increased from 7 to 11.5 from east to west. In the northeastern extent of the parish, ABFE elevations were ramped from 6 to 8 feet to conform to USACE BFE guidance (see Table 3).

Table 3. USACE BFE data for Iberia Parish

Project ID	Latitude	Longitude	FIRM Panel	Assigned Date	BFE
722	29.969306	-91.61393308	220078 0150C	12/12/2000	8.0
1259	29.943828	-91.63968047	220078 0150C	5/6/2002	8.0
1684	29.994942	-91.79143432	220078 0150C	9/25/1997	10.5
1791	29.965809	-91.99206009	220078 0125C	5/5/1997	10.0
2001	29.974933	-91.81391282	220082 0005C	5/15/1996	13.0
2249	29.920552	-91.6685789	220080 0005B	4/19/1995	7.0
2369	29.974599	-91.81575061	220078 0120C	3/20/1995	13.0
2371	29.97118	-91.81639487	220078 0120C	3/20/1995	12.0
2417	29.995949	-91.79368683	220078	7/11/1994	11.0
2620	29.989846	-91.7853811	220082 0005C	4/26/1994	10.0
2644	30.033915	-91.82840061	220082 0005C	3/9/1994	15.5
2646	30.014503	-91.80285132	220082 0005C	3/11/1994	11.5
2787	30.023214	-91.90297559	220078 0125C	3/17/2003	12.0
3294	29.941678	-91.79215697	220078 0150C	12/10/2003	11.0
3333	30.007223	-91.8183405	220082 0005C	1/21/2004	11.5
3707	30.114447	-91.72282402	220082 0050C	10/4/2004	8.0

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Parish-Specific Approaches – Lafourche Parish:

As specified in the Flood Recovery Guidance, one foot of freeboard was applied to all detailed flood zones shown on the effective FIRM. Advisory elevations have also been determined in areas shown as approximate A Zones on the effective FIRMs. Within Lafourche Parish, values assigned to approximate Zone A areas differed. For areas northeast of Bayou Lafourche, Zone A areas were assigned a value of 5 feet from the Lafourche/Assumption Parish boundary to the town of Mathews. From Mathews to Larose, Zone A areas were assigned a value of 6 feet, in accordance with the USACE BFE data (see Table 4). To the southwest of Bayou Lafourche, all approximate Zone A areas were assigned a value of 6 feet. All assigned values were based on averaged USACE BFE guidance for Lafourche Parish.

Table 4. USACE BFE data for Lafourche Parish

Project ID	Latitude	Longitude	FIRM Panel	Assigned Date	BFE
915	29.746077	-90.74345898	225202 280	4/28/1999	6.0
963	29.632628	-90.59887881	225202 315	6/3/1999	5.0
1020	29.760061	-90.90796608	225202 120	12/17/1998	6.0
1075	29.706991	-90.4541796	225202 0330C	2/14/2002	6.0
1075	29.7286	-90.46231703	225202 0330C	2/14/2002	6.0
1085	29.575723	-90.49079804	225202 0455C	2/19/2002	6.0
1085	29.572314	-90.47848193	225202 0455C	2/19/2002	6.0
1085	29.571215	-90.47375342	225202 0455C	2/19/2002	6.0
1114	29.706505	-90.73337325	225202 280	2/27/2002	6.0
1163	29.68351	-90.51309466	225202 0320C	3/23/1999	5.0
1331	29.760656	-90.90764907	225202 0120C	12/17/1998	6.0
1367	29.687306	-90.64535679	225202 295	10/13/1998	6.0
1379	29.715949	-90.61141769	225202 305	9/22/1998	5.0
1383	29.603075	-90.39655269	225202 0460C	11/19/1998	6.0
1390	29.874438	-90.82445109	225202 130	9/10/1998	5.0
1498	29.85594	-90.65253781	225202 160	3/30/1998	4.0
1561	29.606091	-90.6362389	225202 425	3/10/1998	5.5
1680	29.709466	-90.48332651	225202 330	10/1/1997	4.0
1778	29.543325	-90.40468204	220105 470	3/20/1997	7.5
1936	29.55918	-90.5697986	225202 0440C	7/19/1996	6.0
2191	29.780264	-90.52293359	225202 200	8/9/1995	4.0
2930	29.748662	-90.64814739	225202 0285C	10/19/1993	4.0
2711	29.880356	-90.73204751	225202 0065C	2/3/2003	4.0
3250	29.684049	-90.64785256	225202 0295C	11/18/2003	6.0

Parish-Specific Approaches – St. Charles Parish (West Bank):

As specified in the Flood Recovery Guidance, one foot of freeboard was applied to all detailed flood zones shown on the effective FIRM. Advisory elevations have also been determined in areas shown as approximate A Zones on the effective FIRMs. For St. Charles Parish, all approximate A Zones were assigned an ABFE of 5 feet. The USACE BFEs located within the Rita inundation area were 4

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feet (see Table 5). The ABFE was raised from 4 feet to 5 feet in consideration of the Rita surge height achieved in the area, the adjacent effective FIRM BFEs, and the USACE BFEs for St. John the Baptist Parish.

Table 5. USACE BFE data for St. Charles Parish

Project ID	Latitude	Longitude	FIRM Panel	Assigned Date	BFE
1587	29.919920	-90.375027	220160 0125C	10/25/1997	4.0
808	29.896306	-90.381223	220160 0125C	8/18/2000	4.0

Parish-Specific Approaches – St. John the Baptist Parish (West Bank):

As specified in the Flood Recovery Guidance, one foot of freeboard was applied to all detailed flood zones shown on the effective FIRM. Advisory elevations have also been determined in areas shown as approximate A Zones on the effective FIRMs. For St. John the Baptist Parish, all approximate A Zones were assigned an ABFE of 5 feet. Although the USACE provides a BFE of 6.5 feet for this section of St. John the Baptist Parish, only a single value was available in the area of Rita surge inundation (see Table 6). A lower ABFE of 5 was assigned to this advisory flood zone in light of the modest Rita surge height in the area, and a USACE BFE collected in St. Charles Parish.

Table 6. USACE BFE data for St. John the Baptist Parish

Project ID	Latitude	Longitude	FIRM Panel	Assigned Date	BFE
2991	29.914961	-90.620162	220164 0275C	7/22/1993	6.5

Parish-Specific Approaches – St. Mary Parish:

As specified in the Flood Recovery Guidance, one foot of freeboard was applied to all detailed flood zones shown on the effective FIRM. Advisory elevations have also been determined in areas shown as approximate A Zones on the effective FIRMs. Zone As south of Bayou Teche were assigned values based on adjacent Zone AE elevations. On panels Z70 and Z71, areas that were previously in the 0.2%-annual-chance (500-year) floodplain and shown as inundated by Rita were reclassified as V Zones based on the uniform 1-foot freeboard and the adjacent VE Zones. North of Bayou Teche, an ABFE elevation of 6 feet was assigned to A Zones east of panel BB75. USACE BFEs increase from 6 feet to 8 feet at the western extent of the parish (see Table 7). To conform to this increase, A Zone ABFE elevations were ramped from an elevation of 6 feet to an elevation of 8 feet between panels BB75 and BB74/CC74.

Several areas in St. Mary parish were excluded from the ABFEs due to insufficient information to assign advisory elevations. Rita-inundated areas without advisory elevations are overlaid with a transparent blue layer with a dark blue outline. Many of these areas have riverine flooding elevations that are greater than coastal flooding. These areas are bounded with a yellow and black dashed line and labeled "Limit of Coastal ABFEs." For St. Mary Parish, these areas include: 1) along the west Atchafalaya spillway to west of State Highway 70 at Morgan City; 2) the extent of the Lower Atchafalaya between Morgan City and Berwick; and 3) along Bayou Teche, throughout the parish. The southern half of Bayou Teche was not assigned ABFEs because the riverine BFEs are greater than the Rita inundation and greater than any estimates of 1%-annual-chance (100-year) coastal flood elevations in the vicinity.

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Table 7. USACE BFE data for St. Mary Parish

Project ID	Latitude	Longitude	FIRM Panel	Assigned Date	BFE
689	29.859807	-91.52747913	220192 0125C	8/28/2000	9.0
842	29.721546	-91.18973727	220196 0001D	2/25/2000	6.0
877	29.901394	-91.52205131	220192 0050B	10/4/1999	6.0
960	29.876926	-91.55315792	220192 50	6/8/1999	7.0
986	29.76242	-91.39795731	220192	8/23/1999	6.0
987	29.687377	-91.10764936	220192 0175E	8/23/1999	6.0
1006	29.931008	-91.55118612	220192	2/23/1999	6.0
1317	29.901413	-91.52419436	220192 0050B	1/7/1999	6.0
1355	29.678124	-91.29123524	220192 0150D	10/22/1998	5.0
1366	29.902282	-91.63619547	220192 0050B	10/8/1998	7.0
1438	29.890925	-91.52638892	220192 125C	7/17/1998	7.0
1539	29.854186	-91.52994051	220192 0001B	2/13/1998	9.0
1592	29.639979	-91.10108632	220192 0175E	12/10/1997	7.0
1639	29.889577	-91.52479992	220192	11/12/1997	7.0
1699	29.75668	-91.46205676	220192 0150D	8/8/1997	10.0
1785	29.877597	-91.45554285	220192 0050B	3/26/1997	6.0
2051	29.699261	-91.36891109	220192	2/13/1996	5.0
2246	29.755542	-91.39133942	220192 0150C	4/7/1995	6.0
2263	29.73994	-91.44196863	220192 250	3/21/1995	9.0
2319	29.934154	-91.55192351	220192 0050B	10/14/1994	6.0
2426	29.682411	-91.1084897	220192 0175D	5/2/1994	6.0
2974	29.908348	-91.53805018	220192 50B	8/30/1993	6.0
2945	29.770183	-91.49117226	220192 0125C	9/7/1993	9.0
2945	29.780383	-91.50532489	220192 0125C	9/7/1993	9.0
2945	29.784909	-91.51762874	220192 0125C	9/7/1993	9.0
2913	29.789735	-91.51379799	220192 00125	9/2/1993	9.0

Parish-Specific Approaches – Terrebonne Parish:

As specified in the Flood Recovery Guidance, one foot of freeboard was applied to all detailed flood zones shown on the effective FIRM. Advisory elevations have also been determined in areas shown as approximate A Zones on the effective FIRMs. Only a single USACE BFE point of reference (BFE of 8.0 feet) was available within Terrebonne Parish, located north of Dulac (see Table 8). Northeast of Bayou Terrebonne, Zone A elevations were assigned a value of 5 feet based on USACE BFEs in Lafourche Parish. West of Bayou Terrebonne, approximate Zone A elevations were decreased incrementally from a value of 8 feet to 6 feet from Dulac to Houma. All Zone A areas northwest of Houma to the Terrebonne/Assumption Parish boundary were assigned a value of 6 feet. This value was based on USACE BFEs in St. Mary Parish, as well as effective FIRM BFEs.

Table 8. USACE BFE data for Terrebonne Parish

Project ID	Latitude	Longitude	FIRM Panel	Assigned Date	BFE
2573	29.4725	-90.70166	225206 0290C	11/18/2002	8.0

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Parish-Specific Approaches – Vermilion Parish:

As specified in the Flood Recovery Guidance, one foot of freeboard was applied to all detailed flood zones shown on the effective FIRM. Advisory elevations have also been determined in areas shown as approximate A Zones on the effective FIRMs. Zone As in the eastern extent of the parish were typically surrounded by AE or VE zones; values were assigned to these areas based on the adjacent Zone AE/VE elevations. On panels CC54-56 and DD56, Zone As were assigned an ABFE of 10 feet based on the average elevation of the surrounding zones (elevations of 9, 10, and 11 feet) and the existence of a Zone AE10 on panels CC/DD56. Effective gutters were extended on panels CC/DD50 and DD/EE47 to ramp ABFE elevations in approximate Zone As.

ABFE elevations in the western extent of Vermilion parish were assigned based on a combination of USACE BFE values and adjacent effective FIRM elevations. ABFEs of EL 10 were assigned to panels FF47-50 and EE59 based on USACE BFEs of 10 feet. Gutters were added on panel FF47 to ramp ABFEs down from 10 feet to 7 feet to the south, and 9 feet to the west. ABFEs were ramped down to the west along the Vermilion and Acadia Parish border to an elevation of 7 feet (joining effective Zone AE 7, Panel GG41) at the western extent of the parish. Areas covered by panels CC to GG, 42 to 47 were assigned ABFEs of 6, 7, and 8 feet based on the USACE BFE of 6 feet on EE45, and 10 feet on FF47. ABFEs were stepped down between these BFEs and the existing effective FIRM elevations. USACE BFEs are tabulated below (Table 9).

Table 9. USACE BFE data for Vermilion Parish

Project ID	Latitude	Longitude	FIRM Panel	Assigned Date	BFE
716	30.045092	-92.01845568	220221 0175D	11/13/2000	19.0
726	29.989555	-92.00389977	220221 0300D	5/15/2000	11.0
745	30.029063	-91.98817818	220221 0175D	5/12/2000	18.0
764	30.032516	-91.98207037	220221 325	5/24/2000	14.0
820	30.043697	-92.10376711	220221 0175D	8/10/2000	13.0
907	30.14292	-92.24150804	220221 0025D	1/5/2000	23.0
958	30.121493	-92.22336125	220221 150	6/3/1999	23.0
1008	29.991447	-92.12256216	220221 300	2/20/1999	14.0
1024	30.107835	-92.14786363	220221	12/4/1998	20.0
1202	29.995998	-92.10388855	220264 0300D	4/8/2002	14.0
1228	30.107891	-92.15088894	220221 0150D	4/18/2002	20.0
1294	30.088858	-92.3433805	220221 0125D	5/14/2002	15.0
1295	30.096406	-92.07669379	220221 0175D	5/14/2002	14.0
1322	30.102447	-92.18766371	220221 0150D	5/21/2002	20.0
1345	30.107757	-92.14883606	220221 0150D	12/4/1998	20.0
1512	29.843527	-92.17587987	220264 0425D	6/10/2002	11.0
1529	30.076949	-92.18445622	220221 0150D	2/19/1998	19.0
1540	29.969405	-92.12118977	220221	2/18/1998	12.0
1572	29.991492	-92.12461249	220221	1/23/1998	14.0
1582	30.123729	-92.08896363	220221 175	1/5/1998	16.0
1588	29.955089	-92.00690073	220221 0300D	10/25/1997	11.0
1611	29.990551	-92.12504018	220221 275	4/17/1998	14.0
1770	30.031719	-92.18713792	220221 0150D	5/1/1997	18.5

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Project ID	Latitude	Longitude	FIRM Panel	Assigned Date	BFE
1832	30.035244	-92.39928226	220221 100	11/19/1996	12.0
1842	30.04977	-92.00832536	220221 175	11/12/1996	19.0
1847	30.106116	-92.29666126	220221	10/16/1996	16.0
1927	30.109009	-92.15010127	220221 0150	7/24/1996	20.0
2490	30.048223	-92.12369576	220227 0175D	8/29/2002	15.0
2500	30.049055	-92.37935789	220221 0100D	9/9/2002	10.0
2513	29.787346	-92.15019708	220221 0425D	9/16/2002	12.0
2547	30.108826	-92.15894908	220221 0150D	10/22/2002	21.0
2629	29.757962	-92.264276	220221 0400D	3/3/1994	9.0
2705	30.034011	-91.98743481	220221 0325D	2/5/2003	14.0
2772	30.038835	-92.19865052	220221 0150D	3/5/2003	18.0
2800	29.988405	-92.16004897	220221 0275D	3/21/2003	13.0
2837	30.03553	-92.44667953	220221 0100D	4/16/2003	10.0
3019	30.063006	-92.19599417	220221 0150D	6/6/2003	18.2
3165	30.035507	-92.02313387	220221 0175D	9/16/2003	19.0
3280	30.103999	-92.31933349	220221 0125D	11/17/2003	16.0
3347	30.14164	-92.24360496	220221 0025D	1/16/2004	22.0
3358	30.101947	-92.21632353	220221 0150D	1/27/2004	20.0
3852	30.110479	-92.14946997	220221 0150D	1/24/2005	21.0
3908	30.066093	-92.11922836	220221 0175D	3/18/2005	17.0
3943	30.016772	-92.52885806	220221 0075D	3/5/2005	6.0
3944	30.09904	-92.19462601	220221 0150D	5/3/2005	20.0
3947	30.043375	-92.37078865	220226 0125D	5/4/2005	10.0
4167	30.04703	-92.01064939	220221 0175D	1/18/2005	19.0
4168	30.119016	-92.277814	220221 0125D	12/18/2005	21.0

3. Presentation of Results

The results of the technical analysis are presented in a series of Rita Recovery Maps, on a regional overview map, and in the form of GIS files. Each of these products is summarized below:

- **Hurricane Rita Surge Inundation and ABFE Maps** (*1,102 panels covering Calcasieu, Cameron, Iberia, Lafourche, St. Charles [West Bank], St. John the Baptist [West Bank], St. Mary, Terrebonne, and Vermilion Parishes*): When plotted at their native size (ANSI D, 34 inches by 22 inches), the data on these maps are shown at a scale of 1 inch = 500 feet. Each map depicts the coastal HWMs used in the inundation mapping, the surge inundation limit, and ABFEs, all shown on a base map of aerial photographs collected by the U.S. Department of Agriculture (USDA) National Agriculture Imagery Program in 2004.
- **Parish Index Maps** (*nine maps, one each for each parish*): The maps' native size is ANSI E (44 inches by 34 inches), but can be scaled to print on smaller sheets. Each map depicts geographic boundaries of the parish, corporate limits, the Rita Recovery Map paneling scheme (or index), the coastal HWM locations, the surge inundation limit, and the surge elevation contours.
- **Overview Maps**: Like the parish index maps, the native size is ANSI E (44 inches by 34 inches). The overview maps show the geographic boundaries of the parishes, corporate limits, the coastal

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HWM locations, the Hurricane Rita surge inundation limit, and the estimated surge elevation contours.

- **GIS Data:** GIS-compatible data for the following themes are provided for download on FEMA's Rita Recovery Map site (www.fema.gov/hazards/floods/recoverydata/rita_la_gis.shtm):
 - Surge inundation limits for each parish;
 - ABFEs for each parish;
 - Surge elevation contours for the nine-parish region; and
 - HWMs for the nine-parish region, including both the surge-only points used in the inundation mapping and points with wave effects or quality concerns. To see the comprehensive HWM report for Hurricane Rita in Louisiana, see http://www.fema.gov/hazards/floods/recoverydata/pdf/rita_la_hwm_public.pdf.