Survey and Spatial Data
In the Vicinity of the
Mississippi River Gulf Outlet (MRGO)

Prepared for

Plaintiffs in *Robinson v. United States*

By

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July 13, 2008

I have been retained by Plaintiffs in *Robinson v. United States* to review survey data, spatial data, aerial photography, LIDAR data, etc. related to the flooding of Greater New Orleans in the wake of Hurricane Katrina. The primary focus of this report is to obtain and interpret key survey related data for use in examining the relationship between the Mississippi River-Gulf Outlet (MRGO) and the flooding of the Greater New Orleans area during and after Hurricane Katrina. I have furnished relevant data to other members of the *Robinson* expert team.

Professional Qualifications:

I am a Professional Land Surveyor registered to practice in Louisiana and Texas. I have over 17 years of experience in the field of surveying and mapping. My experience includes traditional surveying, Global Positioning System (GPS) surveying including static, differential (DGPS) and real time kinematic (RTK) techniques, extensive work with photogrammetric data, use of Light Detection and Ranging (LIDAR) data. I also have extensive experience in performing and supervising inland hydrographic surveys, and experience in dealing with vertical datum issues unique to southern Louisiana.

I graduated with honors from the University of Florida in 1991 with a Bachelor of Science Degree in Surveying and Mapping. While at the University of Florida, I received the national Schonstedt Scholarship in Surveying.

In August, 2006, I established CMor Consulting, LLC, specializing in litigation support and specialty industrial surveying. I have performed, or am currently performing, litigation support on cases involving an oil spill in Chalmette, Louisiana, a case involving an oil spill in Coffeyville, Kansas, Katrina related cases against Mercy Hospital in New Orleans, in addition to cases related to the flooding of Greater New

Orleans. I have also performed quality control reviews of highly critical projects in industrial sites, including recently completed reviews of 3D Laser Scanning projects in Fawley, England and Torrance, California.

I was the Vice President of LandSource, Inc., a Baton Rouge, Louisiana, surveying and mapping firm from 2004 to 2006. I was Project Coordinator and later Operations Manager for Hydro Consultants, a Baton Rouge, Louisiana surveying and mapping firm from 1991 to 2004.

I currently serve on the ASTM E57.03 Committee which is working to establish standards and best practices for the 3D Imaging (Laser Scanning) industry.

I am a member and past-president of the Louisiana Society of Professional Surveyors (LSPS). I served as President of LSPS in 2003 to 2004, and as Secretary-Treasurer of LSPS in 2002 to 2003. I was Chairman of the LSPS State Convention Committee in 2001 to 2002. I served as LSPS District 6 Chairman in 2001. I have held several other LSPS offices and have served on a number of other committees.

I prepared maps, which won the nation-wide American Congress on Surveying and Mapping (ACSM) – National Society of Professional Surveyors (NSPS) Map and Plat Competition in 2001, 1999 and 1997.

I have written several articles which were published in the Louisiana Engineering and Survey Journal in 2003 and 2004.

I have testified as an expert in surveying and mapping in both state and federal courts.

I have previously prepared expert reports in this litigation concerning the Mississippi River Gulf Outlet (MRGO) and they are included here by reference.

Coordinate System, Units and Datum

Horizontal coordinates for spatial data provided in this report refer to the Louisiana State Plane Coordinate System, South Zone, NAD 83. The unit of measurement is the U.S. Survey Foot. Elevations are in feet and refer to the North American Vertical Datum of 1988 (NAVD88-2004.65).

1.0 LIDAR Data

I obtained Light Detection and Ranging (LIDAR) data of the Greater New Orleans area from the U.S. Army Corps of Engineers IPET Web site https://ipet.wes.army.mil/. The LIDAR data sets listed below were each downloaded from the IPET web site.

(A) 5 meter resolution Pre Katrina LIDAR of the entire area adjusted to NAVD88, 2004.65 datum.

(B) 1 foot resolution Pre Katrina LIDAR of the levees adjusted to NAVD88, 2004.65 datum.

(C) 3 foot resolution Pre Katrina LIDAR of metro New Orleans adjusted to NAVD88, 2004.65 datum

(D) 2 foot resolution Post Katrina LIDAR of the levees adjusted to NAVD88, 2004.65 datum

(E) 3 foot resolution Post Katrina LIDAR of the levees adjusted to NAVD88, 2004.65 datum.

These LIDAR data sets were geo-referenced into the Louisiana State Plane Coordinate System, NAD83, South Zone. The horizontal unit of measurement utilized was the U.S. Survey Foot.

LIDAR data is helpful in analyzing the spatial relationship and elevation of features throughout the area. Figures 1-1 through 1-3 are LIDAR images depicting portions of the earthen berms along the southwesterly side of Reach 2 of the MRGO before and after Hurricane Katrina. These images are intended to show some of the ways that LIDAR can be utilized.

Figure 1-1 and Figure 1-2 depict the same location before and after Katrina. Note that the earthen berm is heavily damaged in the post Katrina image, and that the top elevation was reduced from approximately 17' NAVD 88 (2004.65) to approximately 5' NAVD 88 (2004.65).

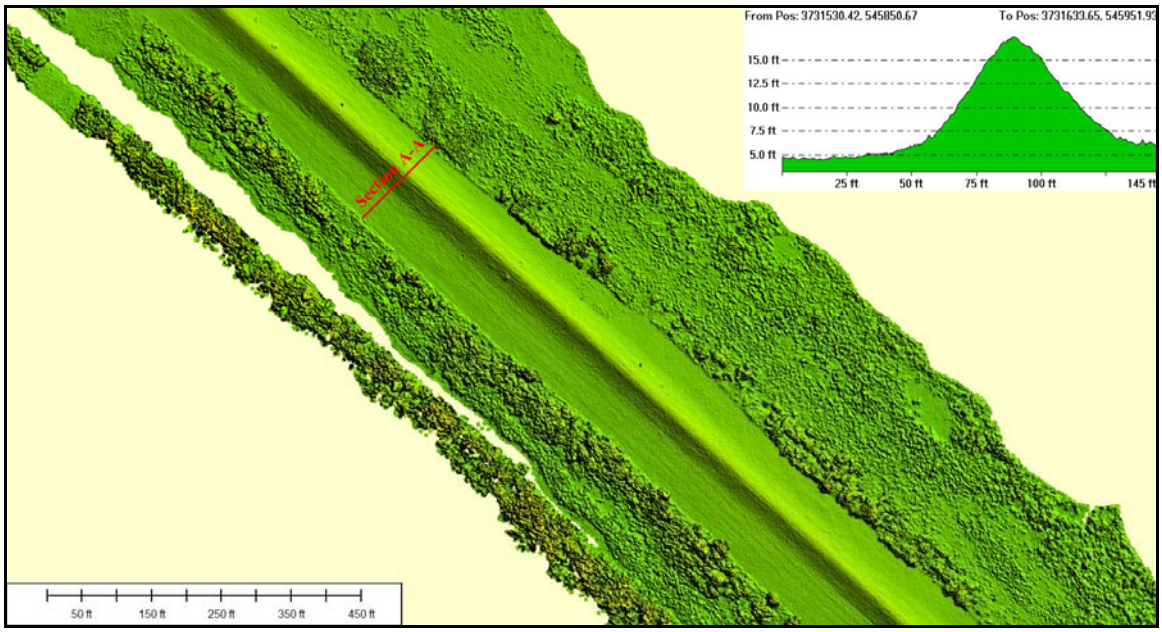


Figure 1-1 Pre-Katrina LIDAR Section A-A

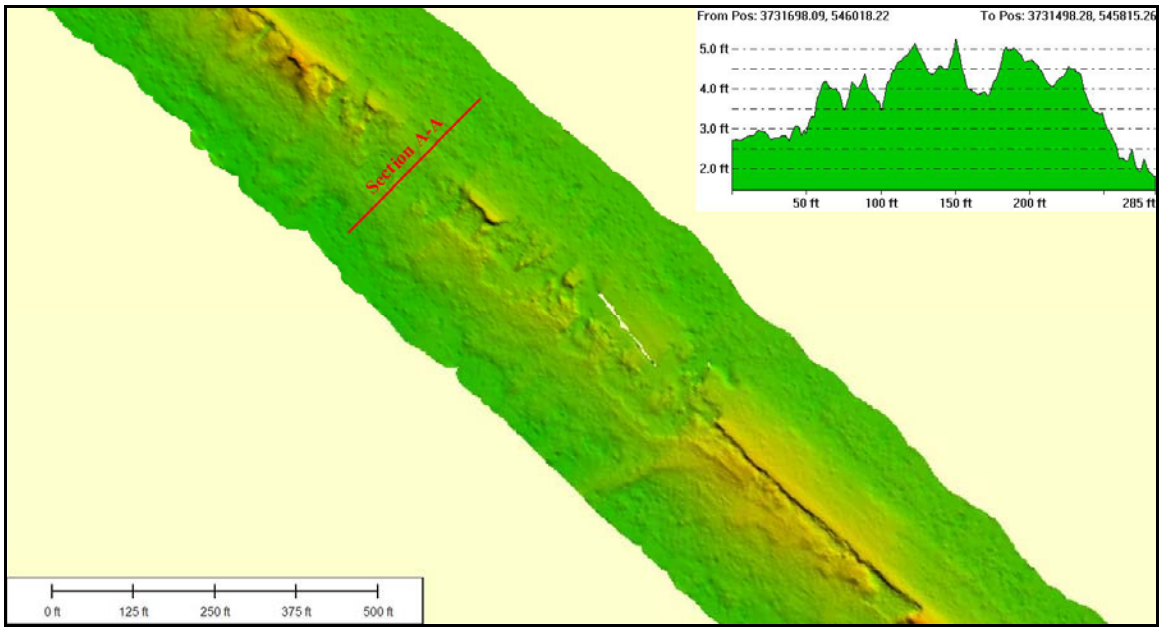
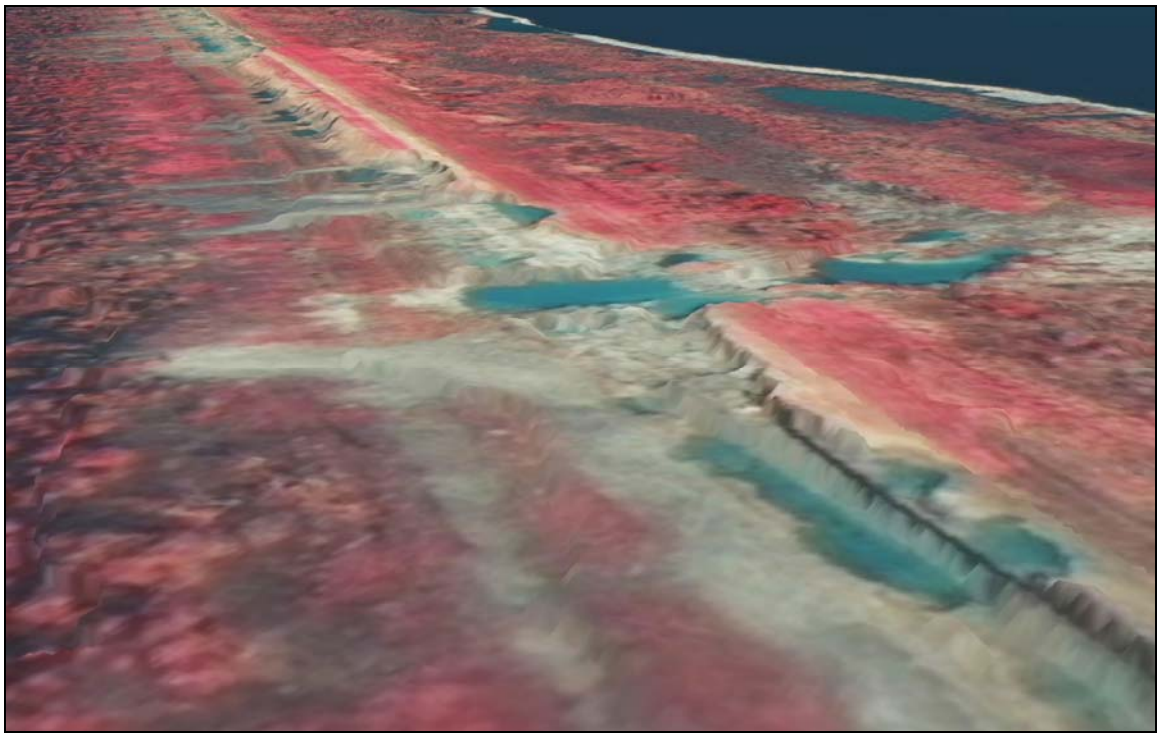


Figure 1-2 Post Katrina LIDAR Section A-A

Figure 1-3 depicts a heavily damaged area of the MRGO earthen berm by utilizing the post Katrina LIDAR with Color IR photography draped over it.


Figure 1-3 Color IR Photography Draped over Post Katrina LIDAR

2.0 Aerial Photography

Aerial photography of the area was obtained from several sources. The primary aerial sets utilized in this report are listed below:

(A) Pre Katrina 2004 1 meter ground resolution DOQQ aerials downloaded from the www.atlas.lsu.edu web site.

(B) Post Katrina 2005 1 meter ground resolution DOQQ aerials downloaded from the www.atlas.lsu.edu web site.

(C) Post Katrina 1 foot ground resolution 8/31/05 and 9/2/05 GE Energy aerial photography which is available on the IPET web site.



Figure 2-1 Post Katrina Color IR Photo of Damaged Portion of MRGO Earthen Berm

Figure 2-1 depicts the same area shown in Figure 1-3 viewed from directly overhead. This is an example of the GE Energy aerial photography which was flown on August 31st and September 2nd, 2005.



Figure 2-2 Post Katrina Color IR Photograph of Bayou Bienvenue Structure

Figure 2-2 is a Color IR GE Energy Photograph taken at 11:53 AM on August 31, 2005. The GE Imagery covers most of the greater New Orleans area and is available in Black & White, Natural Color and Color IR formats.

3.0 Flood Protection System

Utilizing the Pre Katrina 1 foot resolution LIDAR and the 1 foot resolution GE Imagery, we prepared a map of the levee and floodwall and other man-made structures (including earthen berms) around the greater New Orleans area. This mapping was

prepared utilizing Esri ArcView software. A raster image of the limits of this mapping is shown in Figure 3-1.

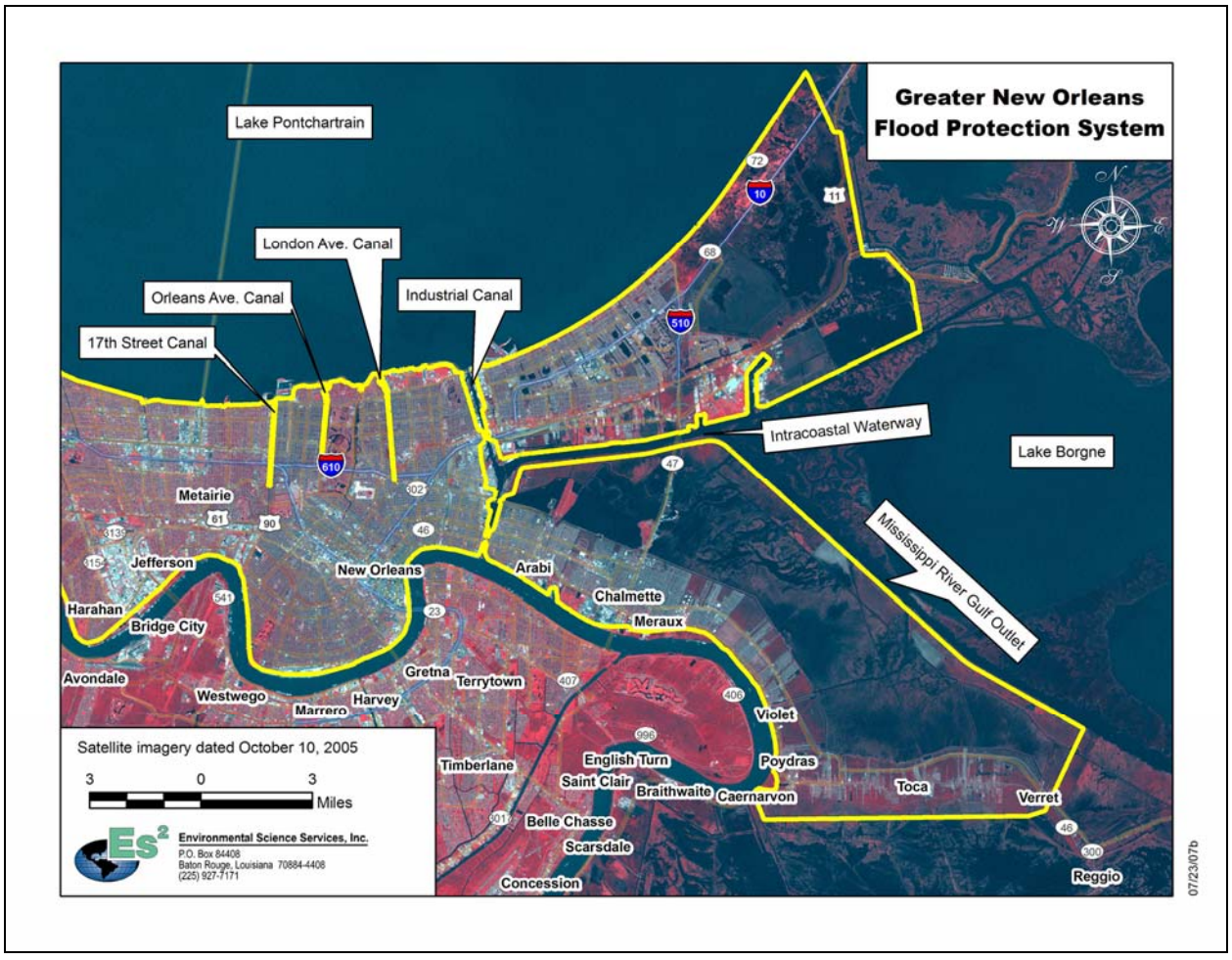


Figure 3-1 Greater New Orleans Flood Protection System

4.0 Breach Mapping

Using a combination of the Post Katrina LIDAR and the GE Imagery, we mapped the location and sill height elevation of all visible breaches in the so-called Greater New Orleans Hurricane Flood Protection System. It should be noted that the elevation of the sill could not be mapped in this manner on breaches which extended below the water level at the time of the LIDAR flight. For those breaches, we utilized eye witness

accounts of the depths of the breaches, which were provided by Dr. Ivor Van Heerden. We also received Corps of Engineers survey data at some of the underwater breach sites.

Figure 4-1 shows the overall extent of our breach mapping.

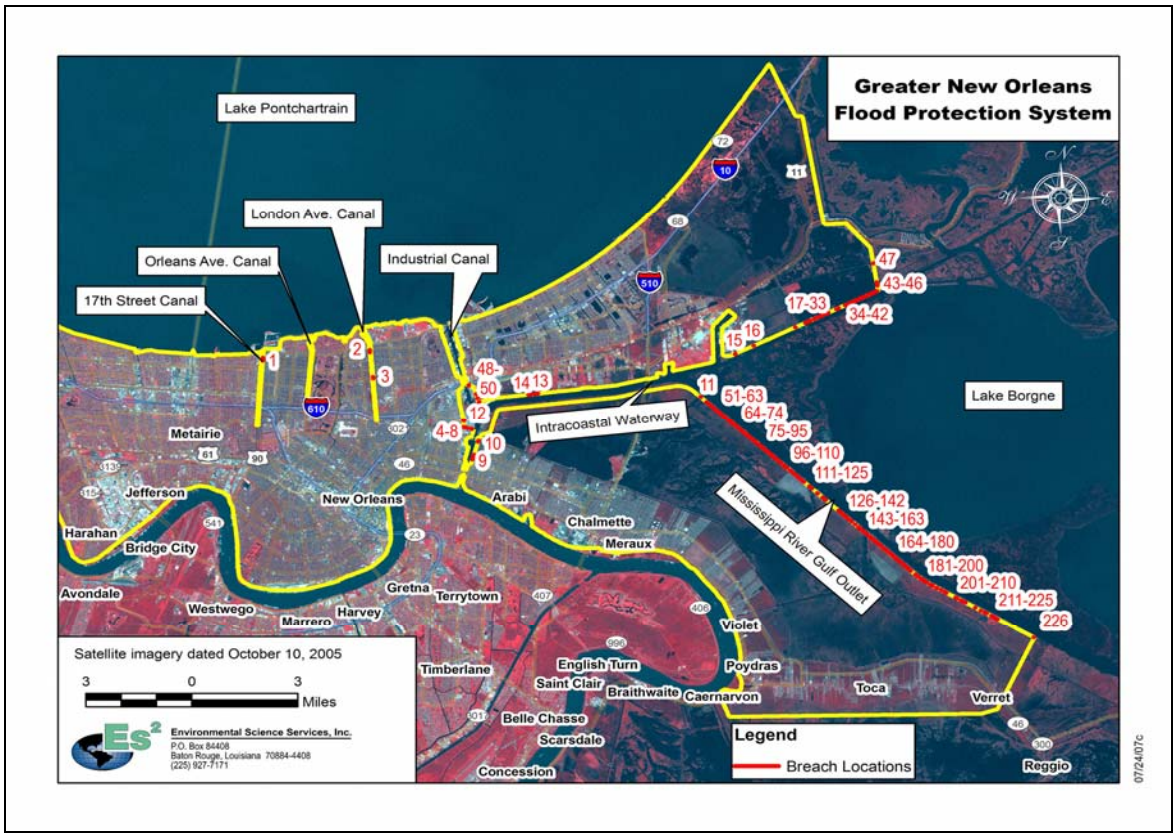


Figure 4-1 Breaches in Flood Protection System After Katrina

Note that other than the flood wall breaks on the easterly side of the IHNC, all significant breaches of the flood control structures which protected St. Bernard Parish and the Lower 9th Ward happened along Reach 2 of the MRGO. It is especially significant to note that there were no breaches in the structure which runs southwesterly away from the MRGO at Verret. This section of levee was subjected to the very nearly the same storm surge height and overtopping as the EBSB. The major difference is that this section of levee was better protected by natural vegetation and that it was not subjected to the wave action caused by the wide MRGO channel.

Figures 4-2 and 4-3 show examples of mapped breaches.

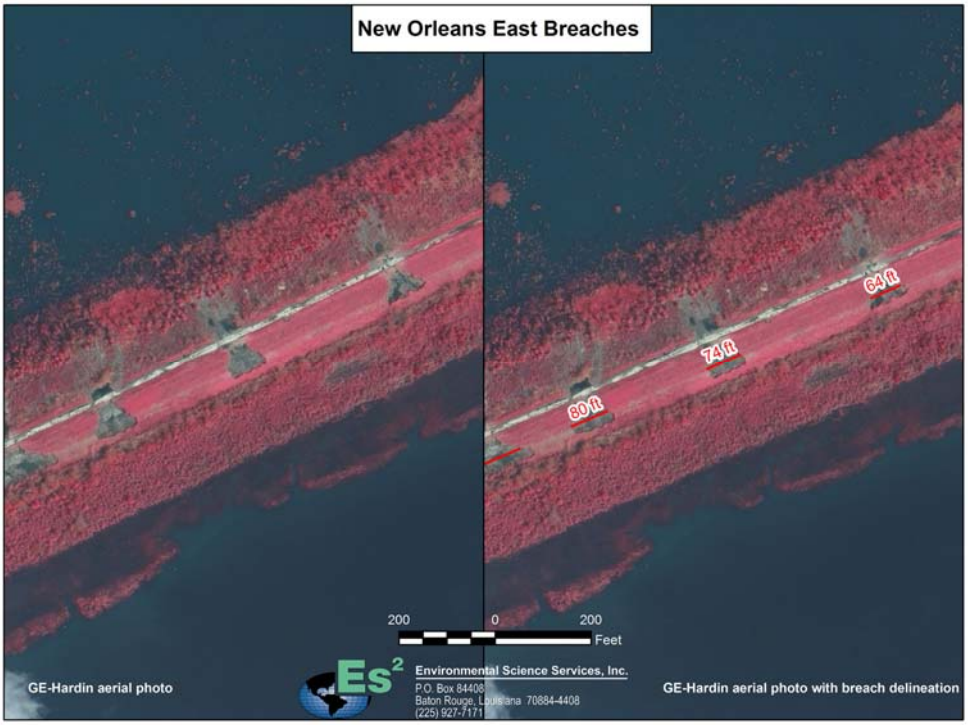


Figure 4-2 Examples of Levee Breaches

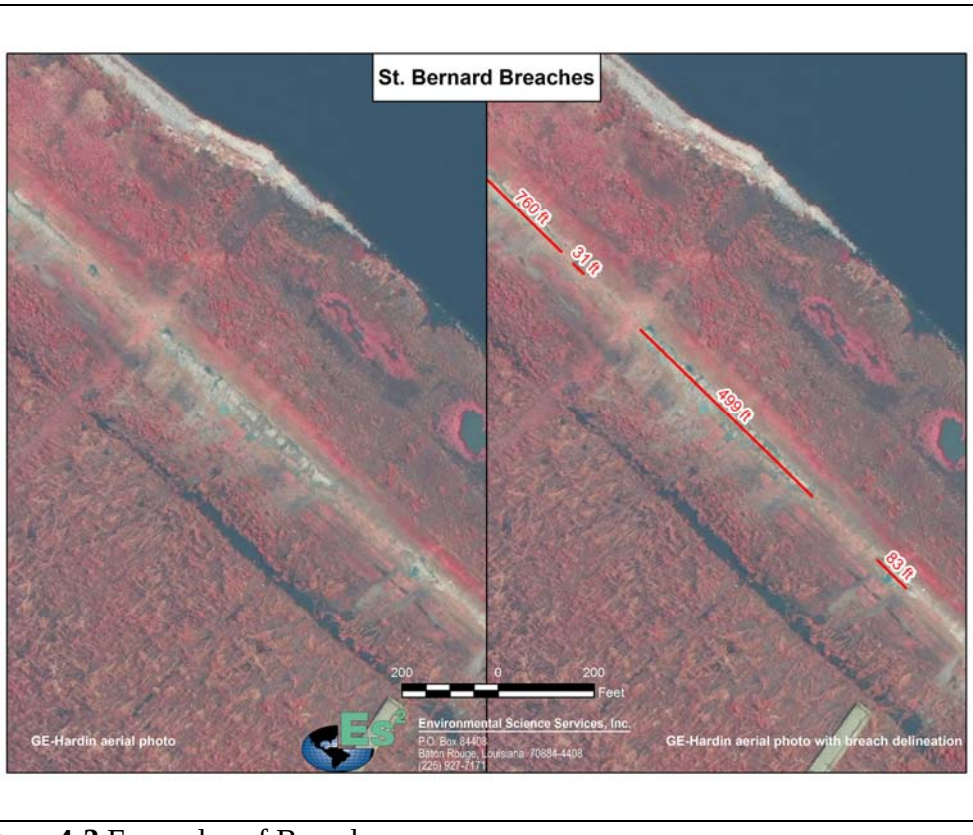


Figure 4-3 Examples of Breaches

5.0 Sheet Pile Along MRGO

While the Corps of Engineers has not yet provided Plaintiffs with the construction drawings and specifications for the placement of sheet pile along Reach 2 of the MR-GO, we can see in photographs and in the LIDAR imagery that it was present in some areas of the earthen berms along the southwesterly side of Reach 2 of the MRGO. It appears to have been installed in areas where the crown of the berm was lower than average in an attempt to raise the low areas to the height of the nearby berms.

Figure 5-1 is a LIDAR image near the southerly end of the Reach 2 MRGO berm where sheet pile was installed in a low section of the crown of the berm. Figures 5-2, 5-3 and 5-4 show cross sections B-B, C-C, and D-D prior to Katrina.



Figure 5-1 Sheet pile Portion of Reach 2 Prior to Katrina.

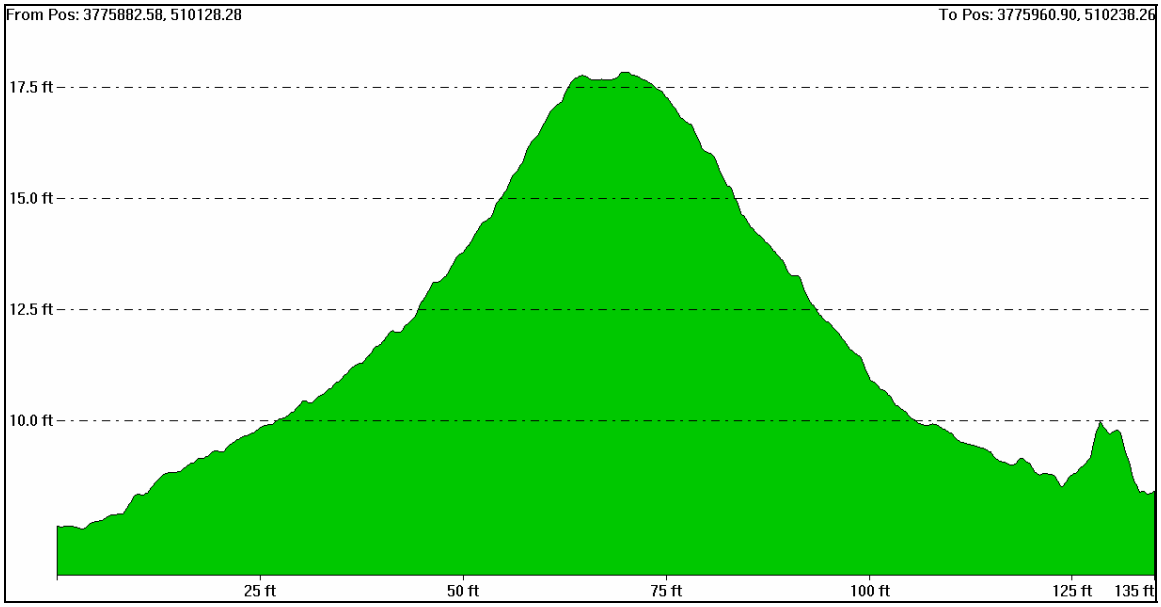


Figure 5-2 Section B-B Prior to Katrina – Note that the crown reaches an elevation of approximately 17.5' NAVD 88 (2004.65).

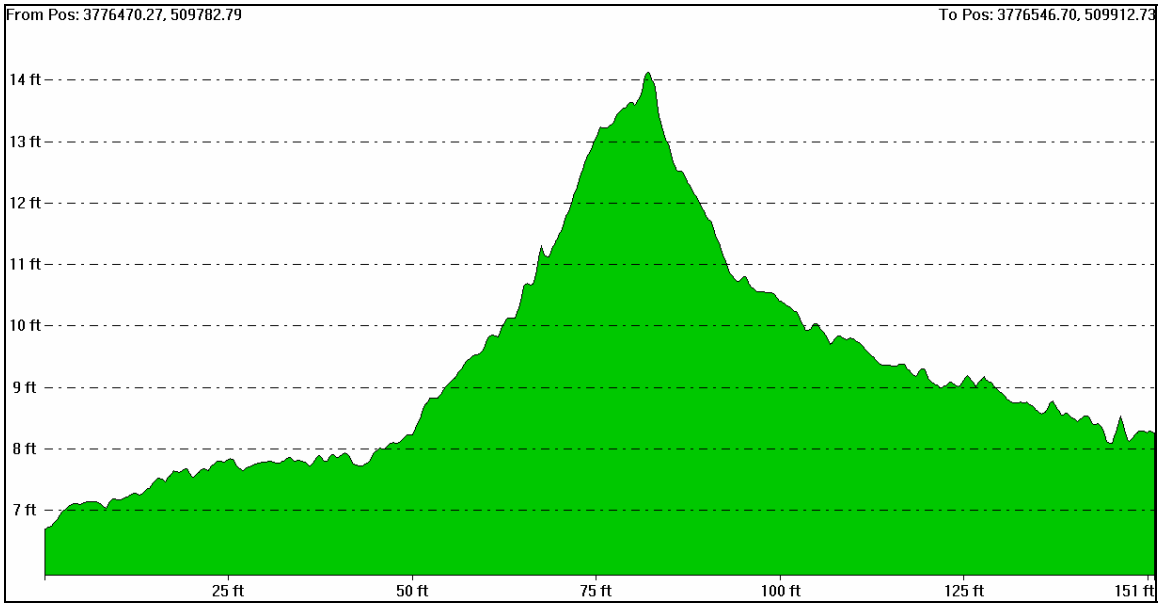


Figure 5-3 Section C-C Prior to Katrina – Note the berm is not as wide in this area and that there is a thin finger projecting up from an average elevation significantly lower than section B-B or D-D. It should be noted that LIDAR is limited in its ability to accurately obtain the elevation of a thin structure such as sheet pile.

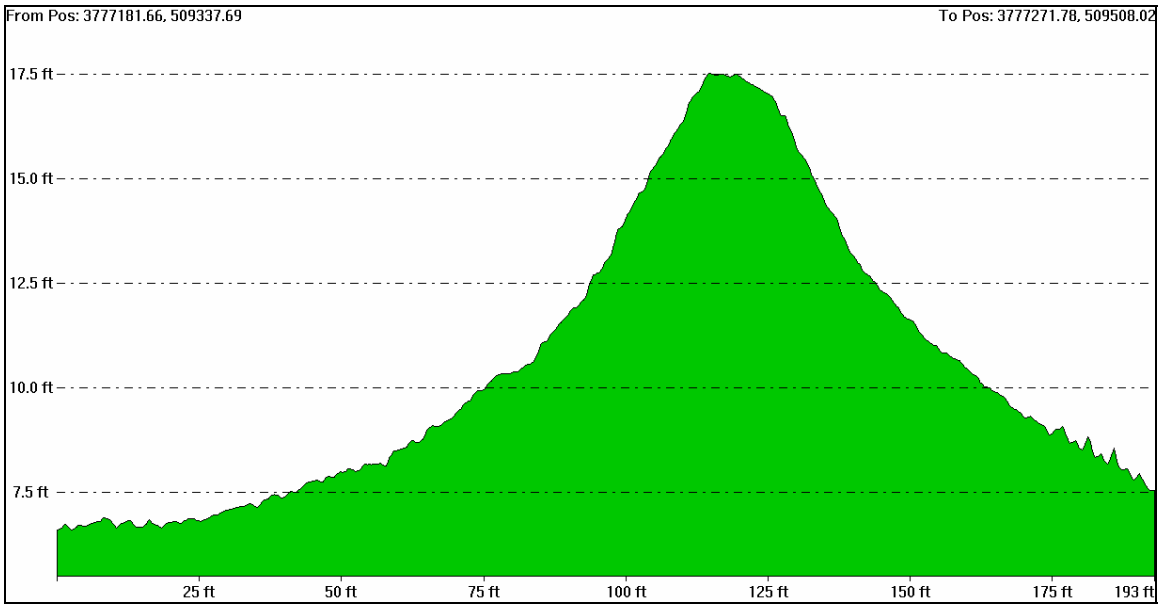


Figure 5-4 Section D-D Prior to Katrina - Note that like Section B-B this area reaches an elevation of approximately 17.5 feet without a sheet pile projection.

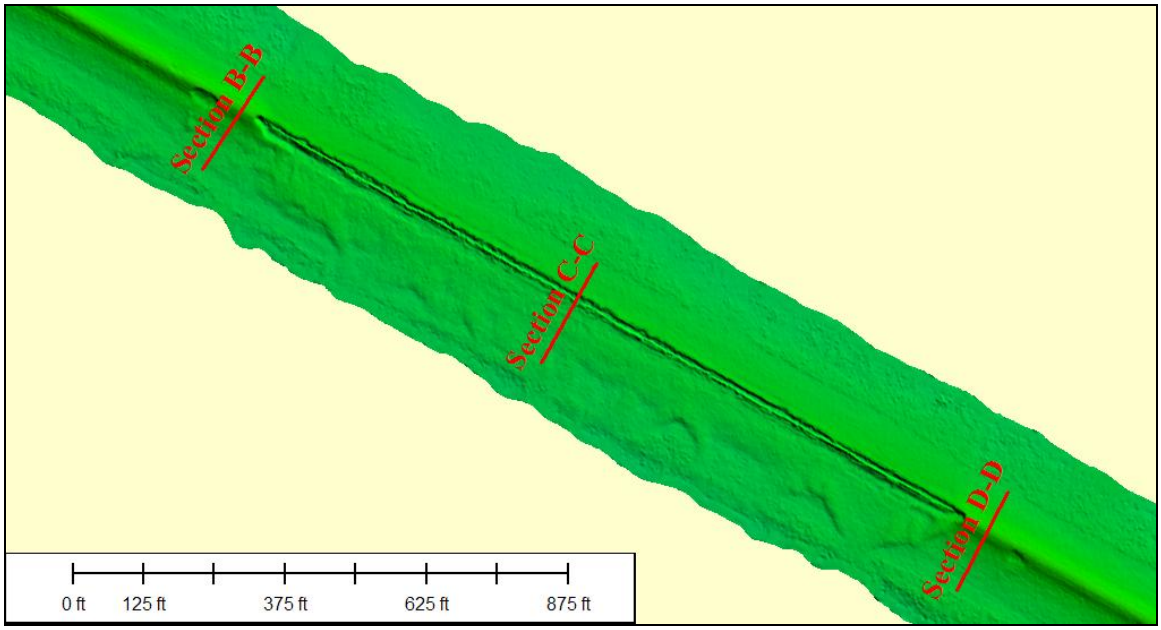


Figure 5-5 Sheet Pile Portion of Reach 2 of MRGO After Katrina – Note that there is considerable erosion in the vicinity of the sheet pile.

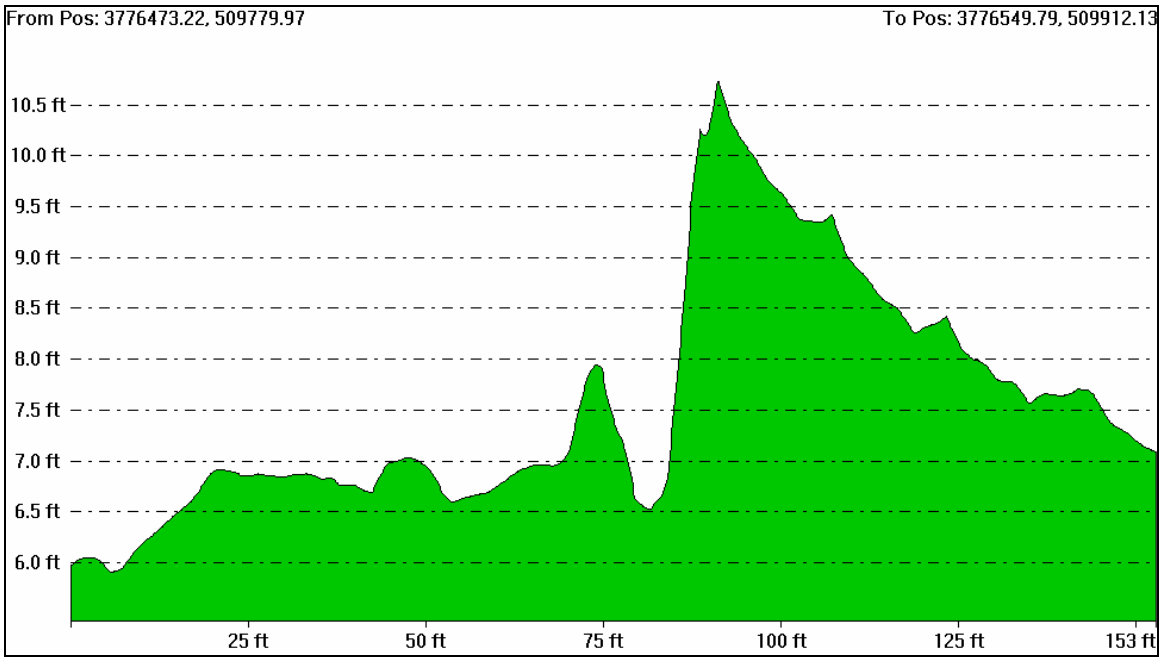


Figure 5-6 Cross Section C-C After Katrina – Note the erosion of the crown along with the scour hole on the back side of where the sheet pile was located.



Figure 5-7 Destroyed sheet pile along the bank of the MRGO. This image was provided by the U.S. Army Corps of Engineers on a hard drive which they produced for Plaintiffs. While it is not the same area as Section C-C, it does show how ineffective the sheet pile was at keeping the storm surge out of the populated areas. The stains on the remaining remnants of sheet pile show that it was sticking out of the ground prior to the storm.



Figure 5-8 Shows a ground level view of a portion of the Reach 2 MRGO berm that is simply gone. Thousands of feet of this berm were very heavily damaged. This image was contained on the hard drive provided by the U.S. Army Corps of Engineers to Plaintiffs.

6.0 Hydrographic Survey Data

Hydrographic survey data was requested for use in modeling the effects of the MR-GO on storm surge and wave action.

The U.S. Army Corps of Engineers provided detailed hydrographic survey data in the vicinity of the Inner Habor Industrial Canal (IHNC). This data was made available for download through the IPET web site. The IHNC was surveyed by Chustz Surveying in February, 2006. The data was provided in ERDAS Imagine format. The horizontal datum for the data was the Louisiana State Plane Coordinate System, South Zone (1983, US Survey Feet). The vertical datum was NAVD88 2004.65, US Feet. This data was provided to the Delft Team for their modeling efforts.

U.S. Army Corps of Engineers survey data along the Intracoastal Waterway and the MRGO Canal was limited to the bottom of the channel. It didn't include the required geometry up the banks of the channels. For this reason, we performed a hydrographic survey in January, 2008 of the IntraCoastal Waterway and a portion of the MRGO channel to capture the required geometry. The results of this survey were transmitted to the Delft Team for use in their modeling efforts. Appendix 1 contains a report of the control, equipment and procedures utilized in performing this survey.

7.0 Pre-Katrina Structure Elevations

An analysis of the top elevations of the structures shows that the most of them were significantly below design grade, and incomplete at the time of Hurricane Katrina. This is especially distressing when we consider that many of the structures were started approximately 40 years ago.

My analysis of structure heights vs. design grades was based on top of structure elevation data which was provided to the Plaintiffs by the U.S. Army Corps of Engineers. The data was checked against the Pre-Katrina LIDAR data for consistency. Design height of the structures was based on the original authorizations as shown in Table 3-4 on page 3-11 of the Decision-Making Chronology for the Lake Pontchartrain & Vicinity Hurrican Protection Project, by Douglas Wooley and Leonard Shabman, dated June, 2007.

Figure 7-1 depicts the structures in the vicinity of Chalmette. There are approximately 31 miles of structures depicted on this map. Over 70% were below design grade at the time of Hurricane Katrina.

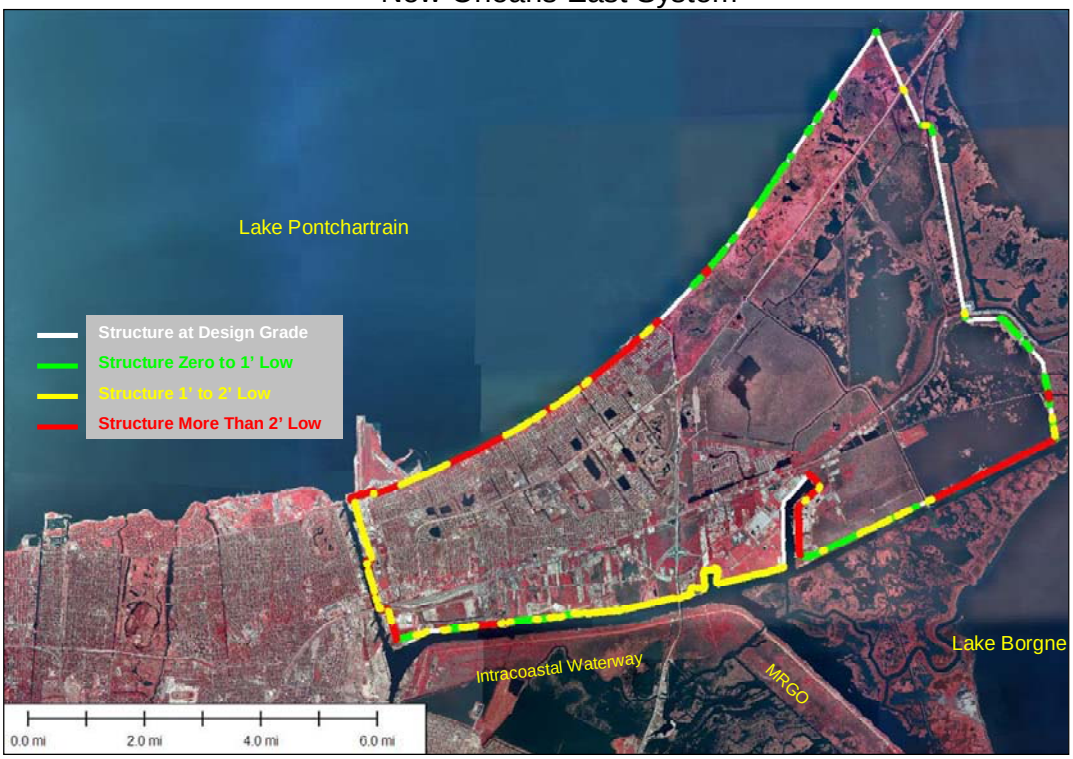


Pre-Katrina structure elevations shown with respect to design grade based on U.S. Army COE levee elevation data.
Structure elevations taken from COE Shape file entitled "Pre_Katrina_Levee_Floodwall_Max_Elev.shp"
Design Heights based on original authorizations (Corrected for MSL to NAVD difference)

Figure 7-1

Figure 7-2 depicts the structures in the vicinity of New Orleans East. There are approximately 39 miles of structures depicted on this map. Over 65% were below design grade at the time of Hurricane Katrina.

Lake Pontchartrain and Vicinity Hurricane Protection Project
New Orleans East System



Pre-Katrina structure elevations shown with respect to design grade based on U.S. Army COE levee elevation data.
Structure elevations taken from COE Shape file entitled "Pre_Katrina_Levee_Floodwall_Max_Elev.shp"
Design Heights based on original authorizations (Corrected for MSL to NAVD difference)

Figure 7-2

Figure 7-3 depicts a portion of the Earthen Berm Spoil Bank (EBSB) along Reach 2 of the MRGO where the canal bank was allowed to erode to the point that the water's edge was within 200 feet of the toe of the EBSB. This area is approximately 1300 feet long. The elevation of the EBSB in this area was approximately 13 feet just prior to Katrina, or more 4 feet below the design elevation.

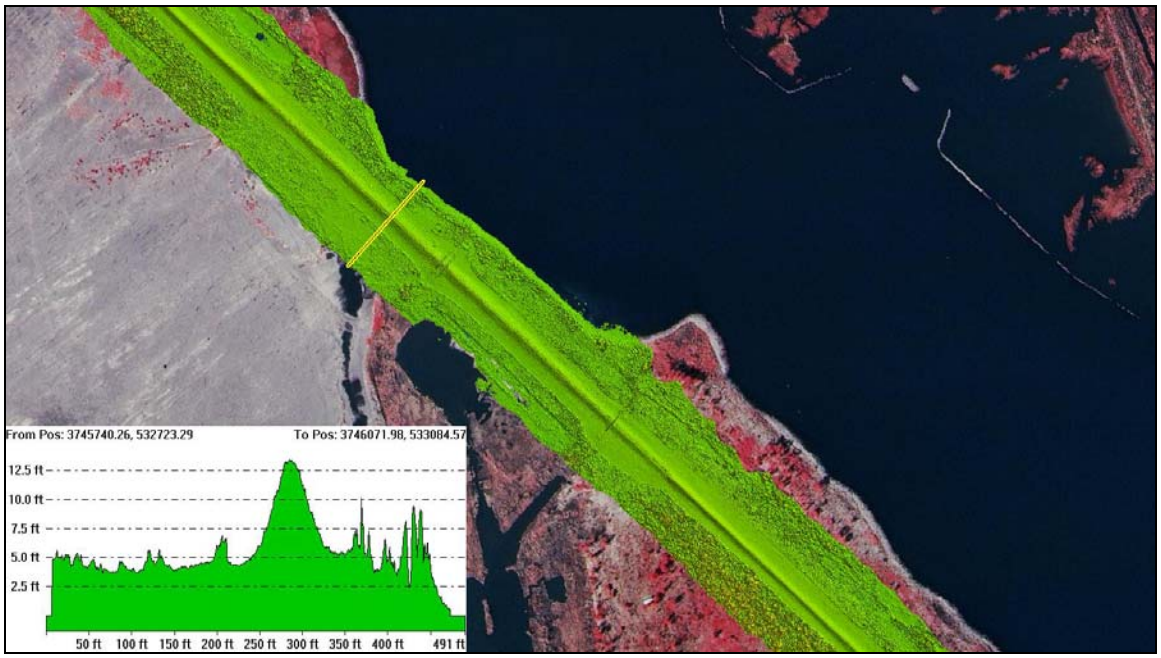


Figure 7-3

8.0 Brush and Trees Along MRGO

A strip of brush and in some cases trees existed on the northeasterly side of the EBSB along Reach 2 of the MRGO immediately prior to Katrina. It varied from approximately 200 to approximately 300 feet wide. In some areas the brush was thick and reached an elevation of more than 10 feet. In other areas the brush was sparse and didn't reach more than 1 or 2 feet above the ground. The trees in some areas were higher than the EBSB, but in most areas were sparse. Information regarding the location and elevation of trees and brush in this area was obtained from a combination of aerial photography overlaid with Pre-Katrina 1 foot resolution LIDAR.

Figure 8-1 shows and area of the EBSB along Reach 2 of the MRGO with high vegetation. The Pre-Katrina LIDAR cross section shown in the image depicts vegetation higher than the EBSB in this area.

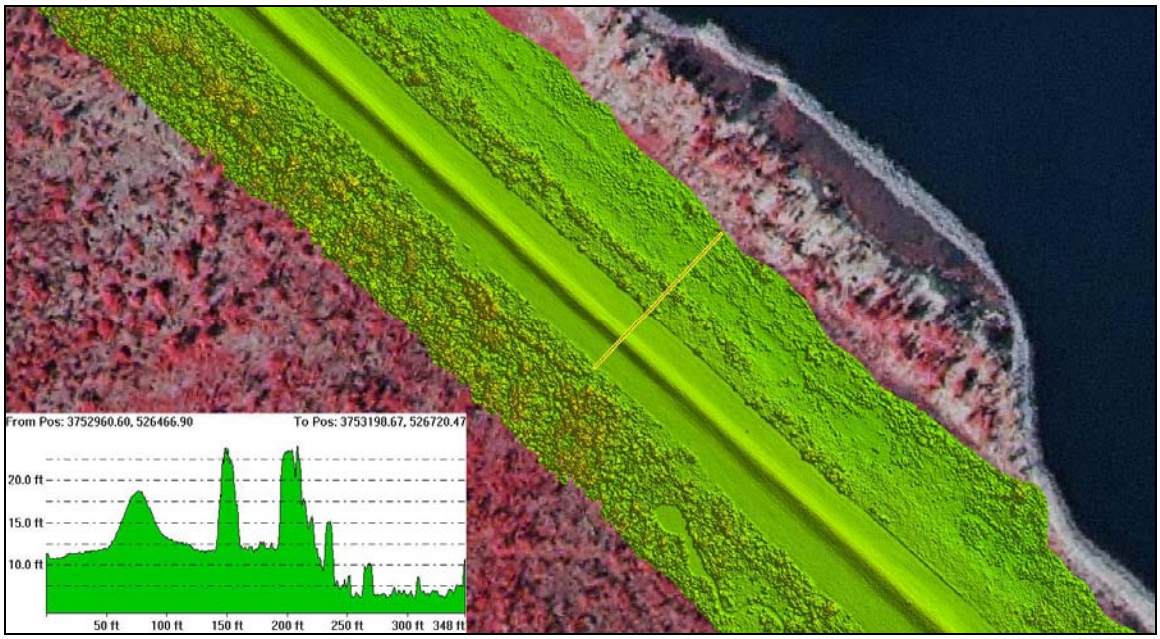


Figure 8-1 High Vegetation Between EBSB and MRGO

Figure 8-2 shows the same area with Post-Katrina Lidar draped over the image. The LIDAR image and cross section show relatively little damage to this portion of the EBSB. It should be noted that the trees were removed from the Post-Katrina LIDAR during processing by the COE's contractor. That is why they are not visible in either the image or the cross section.

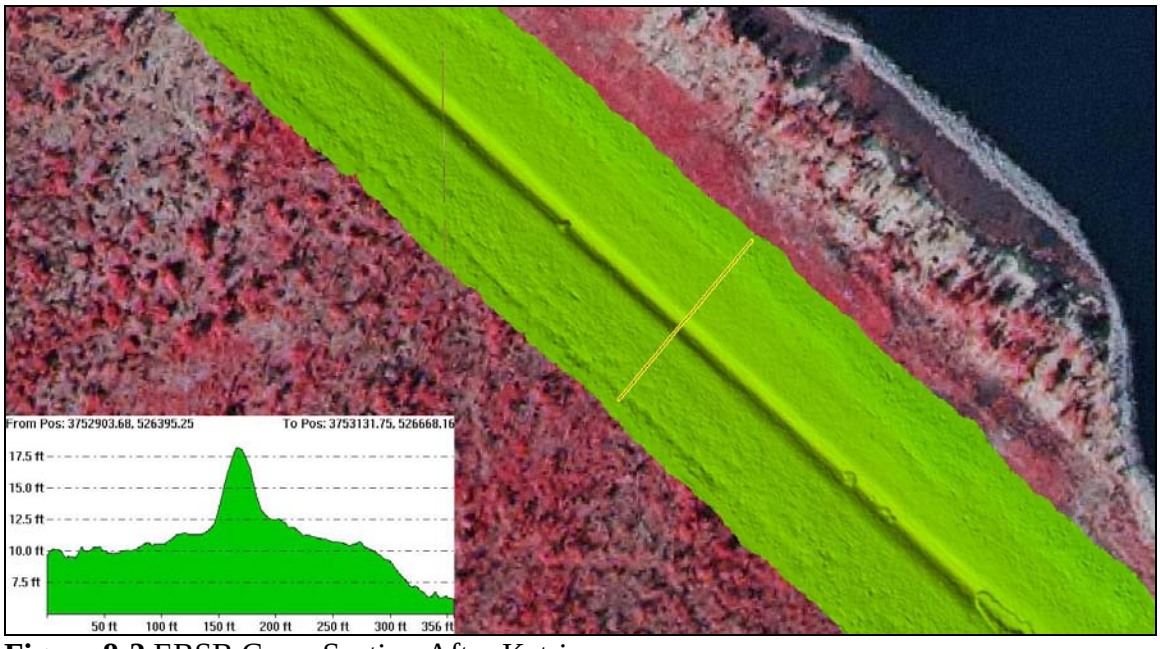


Figure 8-2 EBSB Cross Section After Katrina

Figure 8-3 depicts another area of Reach 2 of the MRGO where very little vegetation was present between the EBSB and the MRGO canal before Katrina. The limited nature of the vegetation is visible in both the image and in the cross section.

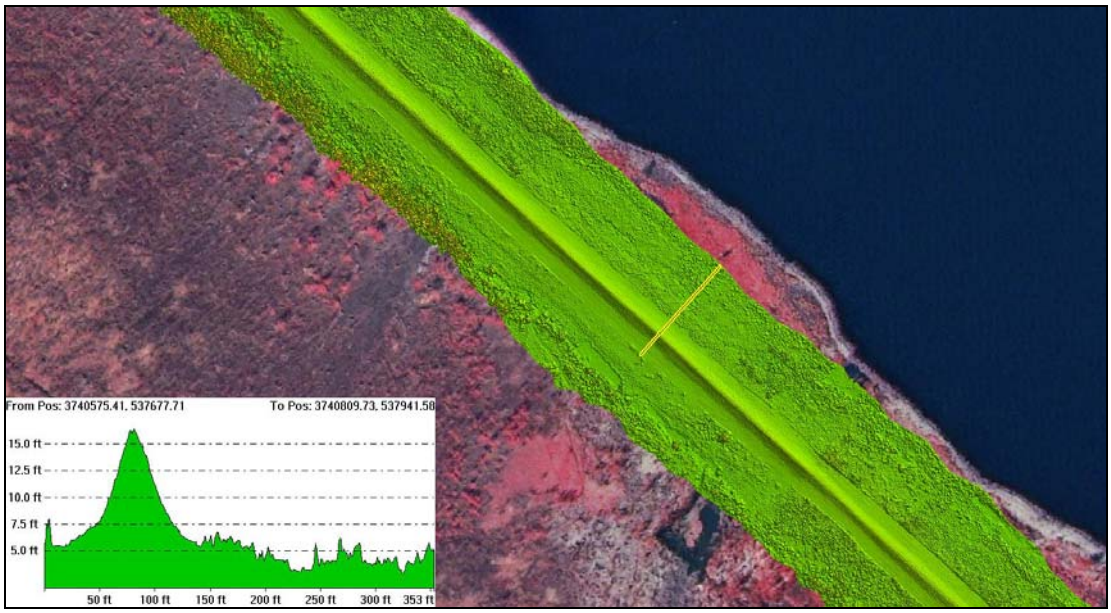


Figure 8-3 Low Vegetation Between EBSB and MRGO

Figure 8-4 depicts the same area as figure 8-3 with Post-Katrina LIDAR draped over the image. A large amount of breaching is visible in the LIDAR image and the cross section shows that the elevation of the EBSB was greatly reduced.

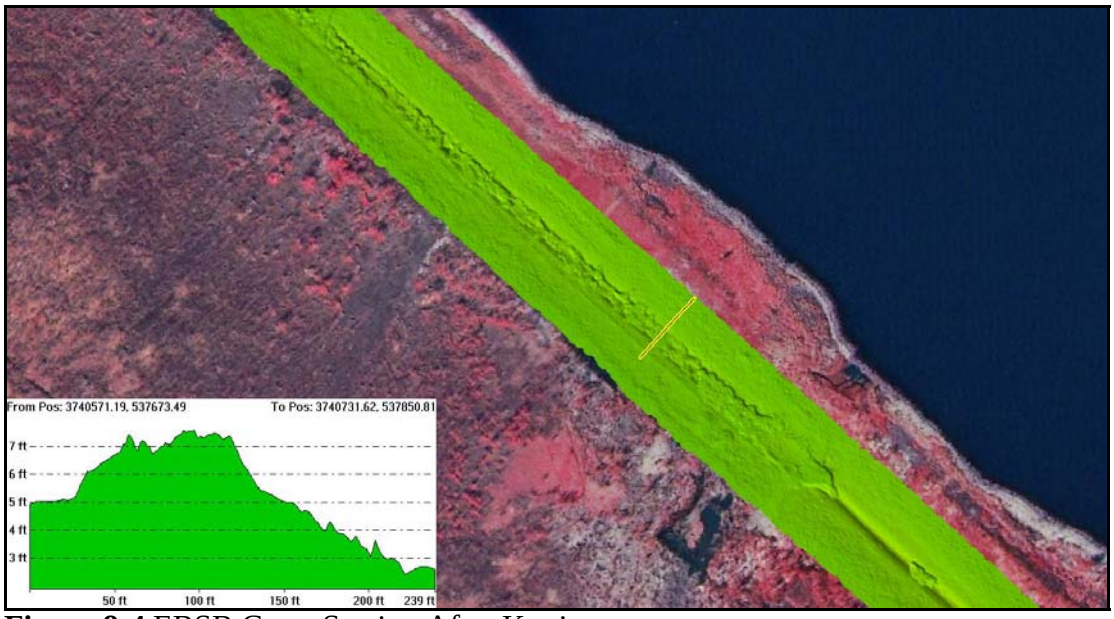


Figure 8-4 EBSB Cross Section After Katrina

9.0 Location of Design MRGO Canal With Respect to EBSB

The authorized design channel top bank is 725 feet from the toe of the EBSB. That is to say that had the channel been maintained at its authorized size there would be 725 feet between the water's edge of the channel and the toe of the EBSB. Unfortunately, the banks of the channel have been allowed to erode to the point that the water's edge of the channel comes to within 200 feet of the EBSB in some areas. A channel which was authorized to be 650 feet wide at the top is now over 2500 feet wide in several areas. Figure 9-1 depicts an area along Reach 2 in which the erosion has been allowed to progress to the point that the channel is between 2500 and 3700 feet wide. It should be noted that major breaching of the EBSB occurred in this area.

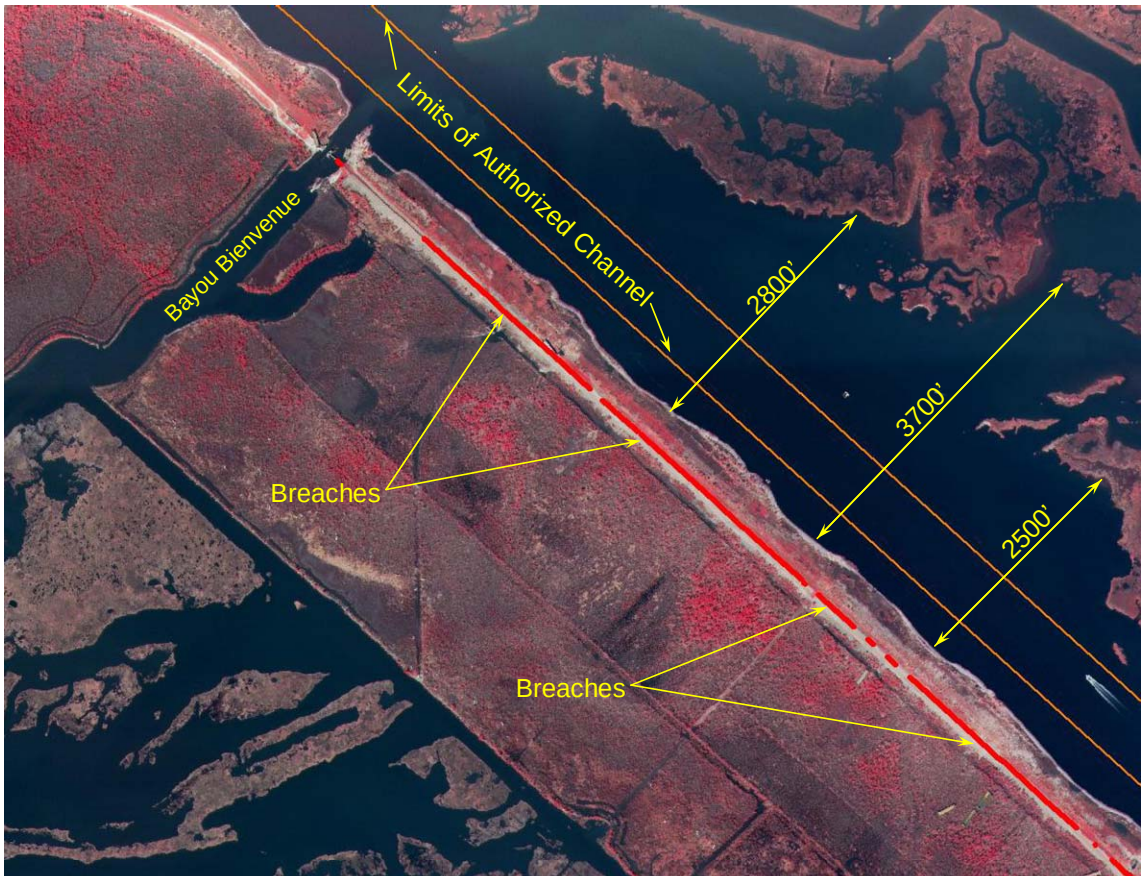


Figure 9-1 MRGO Channel Erosion

The authorized channel dimensions were taken from a letter dated September 25, 1951 from the Secretary of the Army to the U.S. House of Representatives, 82nd Congress 1st Session, House Document No. 245. The specific channel location was based on U.S. Army Corps of Engineers design drawings which were provided to Plaintiffs by the COE.

10.0 Effect of MRGO Channel on Breaches at West End of Funnel

The westerly end of the funnel shaped area near the intersection of the MRGO and the Intracoastal Waterway provides a unique opportunity to compare how two similar sections of the hurricane protection system performed during Hurricane Katrina. The EBSB along Reach 2 of the MRGO was severely damaged; much of it was almost totally washed away. By contrast, the levee along the northerly side of the Intracoastal Waterway, near the end of the funnel, was left almost totally intact. There were only a few small breaches in this section, and they did not cut very deeply into the levee crown. The fact that these areas are so close to each other indicates that they would have been subject to very similar storm surges both in terms of height and duration of high water. Both areas were overtopped during the storm. The areas were protected by very similar wetlands and the levee heights are very close to the same in both areas. Both areas also have channels running parallel with and only a few hundred feet from the hurricane protection structures. The storm conditions endured by the two sections of the protection system during Katrina would have been very similar except for one feature – the much wider and deeper MRGO channel. This expanded channel allowed the waves, which had been diminished somewhat by the wetlands, to regain size and strength for their devastating attack on the EBSB. Figure 10-1 shows the westerly end of the funnel area, the wetlands, the MRGO, the Intracoastal Waterway, and the levee breaches.

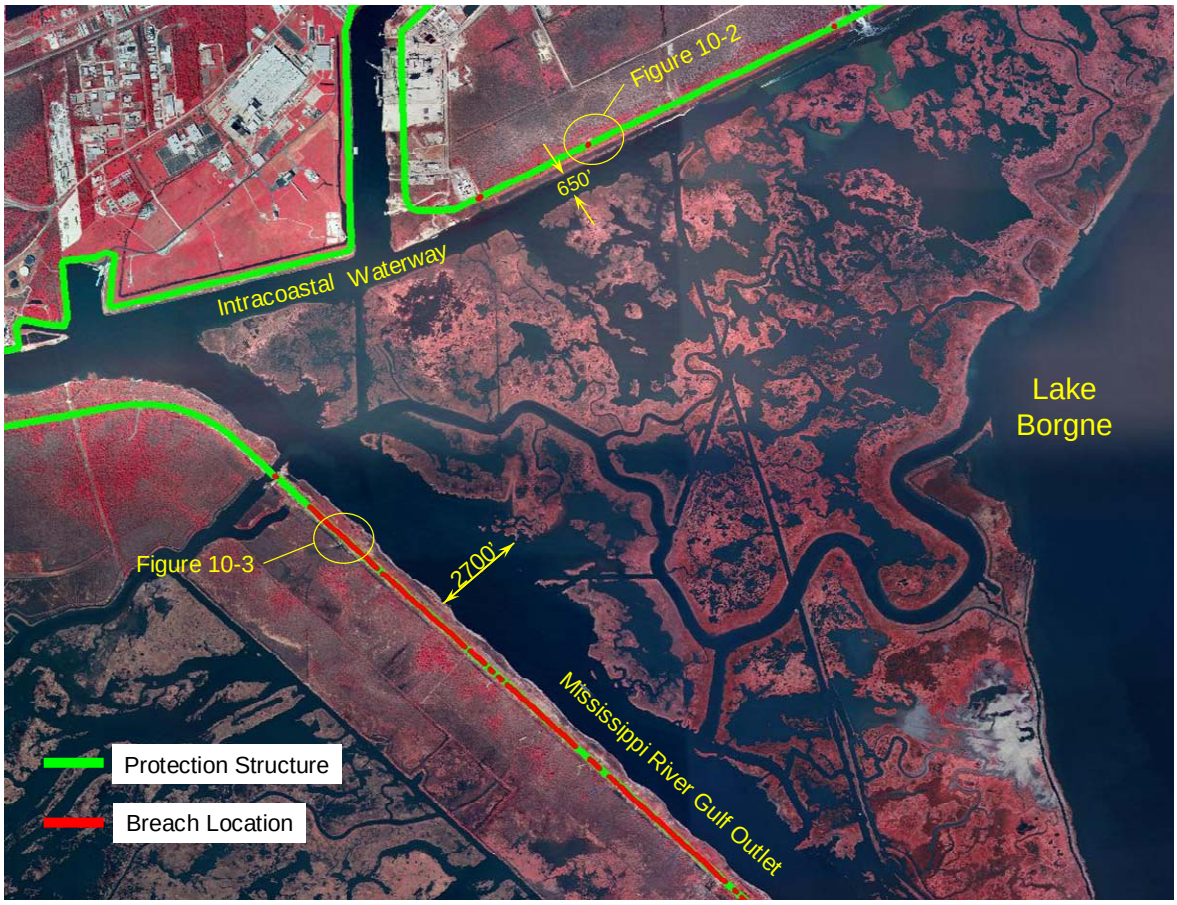


Figure 10-1 Effect of Wide MRGO on Breaching

Figure 10-2 is a close up view of a breach located on the northerly side of the Intracoastal Waterway. Except for a few small, incomplete breaches, this section of levee was generally in good shape following Katrina. As the cross section shows, the sill height of the depicted breach was at an elevation of approximately 11 feet. Compared with the extensive breaching along Reach 2 of the MRGO, a relatively small amount of water would have passed through this breach during the brief period of peak storm surge water levels. Figure 10-3 is a close up view of a section of the EBSB along Reach 2 of the MRGO. The EBSB in this area shows extensive damage. In stark contrast to the levee along the Intracoastal, very little of this structure was left standing. As the cross section shows, the sill height of the depicted breach was reduced to an elevation of 4 feet. The massive amounts of water which flowed through this and numerous other breaches

of the EBSB along Reach 2 of the MRGO during the brief period of peak storm surge caused the floodwaters to top the 40 Arpent Levee and flood the populated areas of St. Bernard Parish.

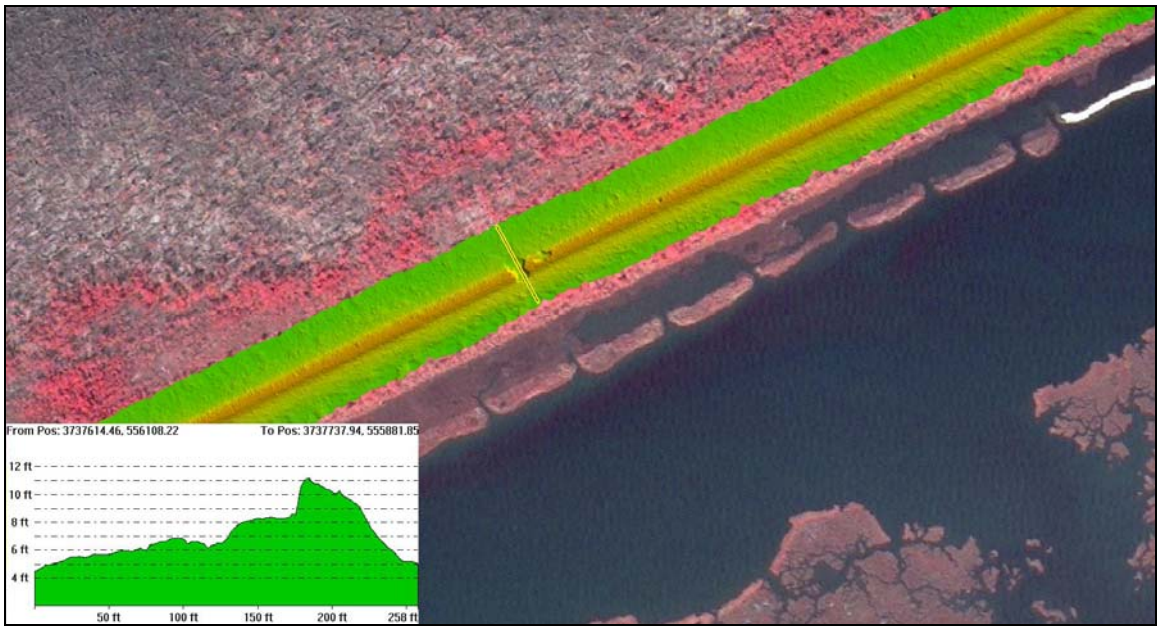


Figure 10-2 Small Breach of Levee at Intracoastal Waterway

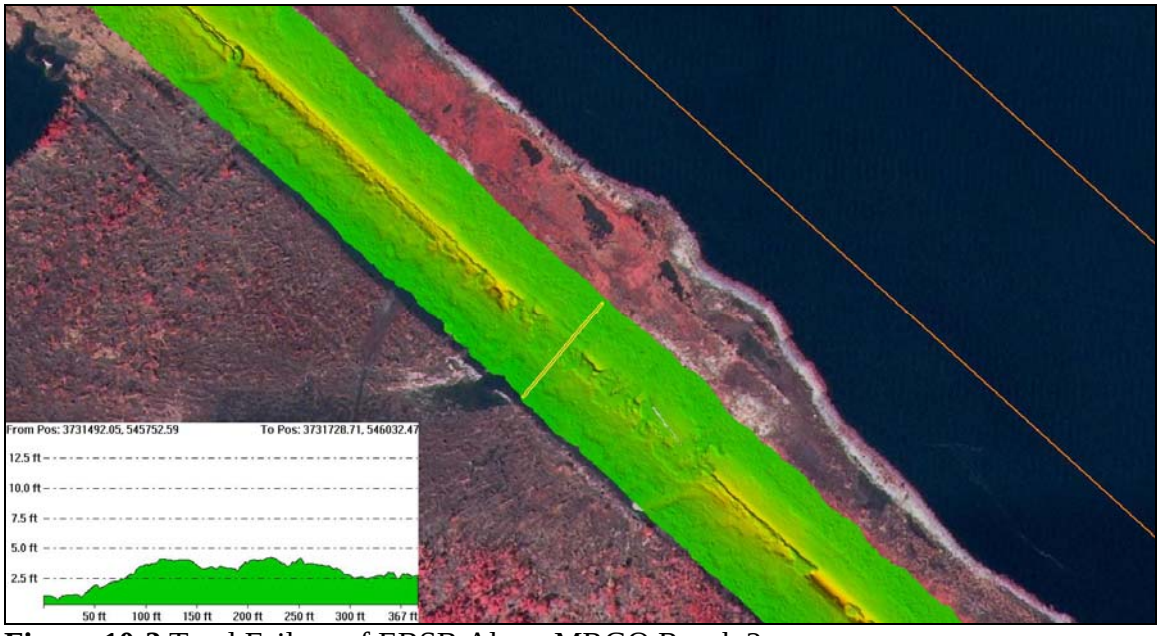


Figure 10-3 Total Failure of EBSB Along MRGO Reach 2

It should be noted that the existing width of the Intracoastal Waterway is approximately 650 feet, which was the authorized width of the MRGO, and that the

protection structure there faired much better than the one along the MRGO. It is also important to note that calculations and modeling contained in reports by Dr. Kok and Dr. Bea, as well as independent calculations performed by Dr. Gordon Boutwell in a report prepared for Turner Vs. Murphy Oil, all conclude that had the EBSB along the MRGO been simply overtopped, very little if any water from the storm surge would have overtopped the 40 Arpent Levee, and thus the populated areas of St. Bernard Parish would have been spared from much of the catastrophic flooding which they suffered.

I declare under the penalty of perjury under the laws of the United States of America that the foregoing is true and correct.



Dated: July 13, 2008

Chad A. Morris P.L.S.