



**State of Louisiana
Coastal Protection and Restoration Authority
Office of Coastal Protection and Restoration**

2011 Operations, Maintenance, and Monitoring Report

for

Timbalier Island Dune/Marsh Restoration (TE-40) Project

State Project Number TE-40
Priority Project List 10

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Operations, Maintenance, and Monitoring Report
For
Timbalier Island Dune/Marsh Restoration Project
(TE-40)

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Preface

This report includes monitoring data collected through March 2010, and annual Maintenance Inspections through December 2011.

The 2010 report is the first report in a series of reports. For additional information on Timbalier Island Dune/Marsh Restoration Project (TE-40), please refer to the Monitoring Plan on the LDNR web site.

I. Introduction

Timbalier Island is considered part of the Bayou Lafourche barrier system and lies about 47 miles (75 km) west of the mouth of the Mississippi River and about 50 miles (80 km) south of New Orleans (figure 1). The island originated from the westward progradation of the Caminada-Moreau headland. When the spit breached during storms, the island was detached from the headland. Erosion from the Caminada-Moreau headland remains the primary source of sand to Timbalier Island.

An important function of barrier islands is to protect wetland areas from waves, storm surges, and salt water intrusion (McBride et al. 1992). Timbalier Island acts as a buffer for the bays, estuaries, and wetlands of the Terrebonne Basin, reducing the wave energy the marshes experience by shielding Timbalier Bay from the Gulf of Mexico. These bays, estuaries, and wetlands are important for commercial and recreational fisheries and wildlife, and as protection against storm damage to nearby oil and gas facilities and other infrastructure farther inland. In addition, barrier islands provide important stop over habitat for neotropical trans-gulf migrants and permanent homes for many native bird species.

Hurricane Andrew made official landfall in Louisiana as a category 3 hurricane at 0330 CDT on the morning of August 26, 1992 20 miles (32.19 km) west-southwest of Morgan City. The northeastern quadrant of Hurricane Andrew passed directly over the Isles Dernieres and Timbalier Islands and cut a 27.96 mile (45 kilometer) swath of destruction from Fourchon, through Cocodrie and Morgan City to Baton Rouge. Timbalier Island had much of its sand substrate removed, devastating much of the beach and dune habitat.

The long-term (1887 - 1988) gulfside average erosion rate was documented at -7.9 ft yr^{-1} (-2.4 m yr^{-1}) and the short-term (1978 - 1988) was documented at -22.9 ft yr^{-1} (-7.0 m yr^{-1}) (McBride et al. 1992). The impact of Hurricane Andrew temporarily accelerated the gulfside shoreline change rate between December 1990 and October 1992 to $-137.1 \text{ ft yr}^{-1}$ (-41.8 m yr^{-1}) (Penland et al. 1999). Bayside, (McBride et al. 1992) documented long-term (1887-1988) and short-term (1978-1988) shoreline change rates at -16.4 ft yr^{-1} (-5.0 m yr^{-1}) and -46.3 ft yr^{-1} (-14.1 m yr^{-1}) respectively. The Timbalier Island bayside shoreline change rate as a result of Hurricane Andrew was measured at -28.5 ft yr^{-1} (-8.7 m yr^{-1}) (Penland et al. 1999).

McBride et al. (1992) calculated the long-term (1887-1988) and short-term (1978-1988) area loss rates for Timbalier Island at $-23.0 \text{ acres yr}^{-1}$ (-9.3 ha yr^{-1}) and $-112.9 \text{ acres yr}^{-1}$ (-45.7 ha yr^{-1})

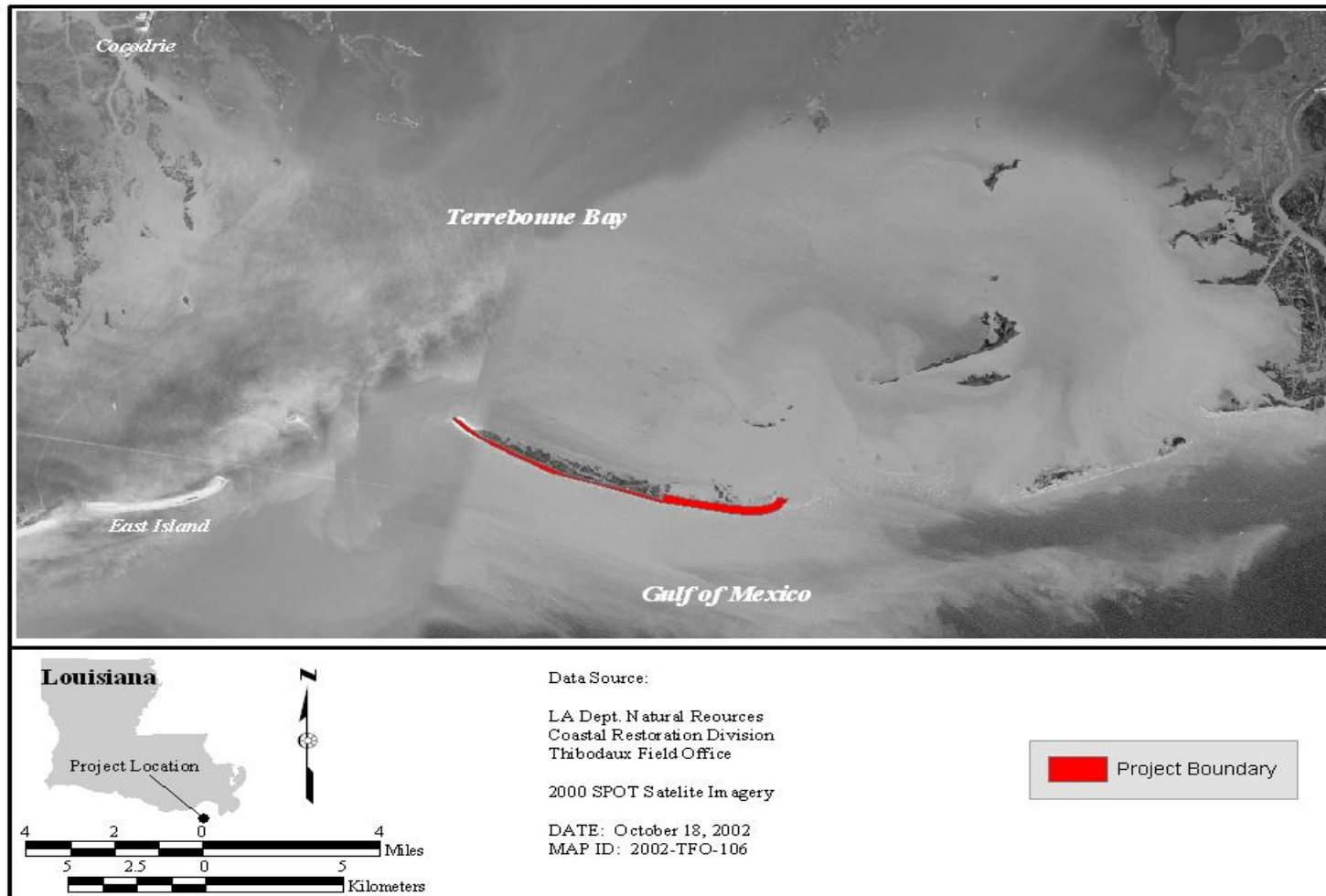


Figure 1. Satellite Image of Timbalier Island and Timbalier Island Marsh/Dune Restoration (TE-40) project location.

respectively. The area loss rate measured for Hurricane Andrew (1990-1992) was $-106.5 \text{ acres yr}^{-1}$ (-43.1 ha yr^{-1}). Hurricane Andrew changed the long-term (1887-1993) loss and short-term (1978-1993) loss rates to $-25.2 \text{ acres yr}^{-1}$ (-10.2 ha yr^{-1}) and $-65.7 \text{ acres yr}^{-1}$ (-26.6 ha yr^{-1}) respectively. Between 1988 and 2002, the short-term erosion rate accelerated to -13.4 ft yr^{-1} with a range of $-118.7 \text{ ft yr}^{-1}$ to $+31.9 \text{ ft yr}^{-1}$ (Penland and Campbell 2004). These high rates of change reflect the impact of the 1992 Hurricane Andrew and 2002 Hurricanes Isidore and Lili. The short-term erosion rate from 1996-2005 was even greater, at -25.0 ft yr^{-1} , describing the impact of Hurricanes Katrina and Rita (Martinez et. al. 2009).

A longshore sediment transport model for Timbalier Island demonstrates net sediment transport is westward (Stone and Zhang 2001). This suggests that sand being eroded from the east flank is being transported to the west where it is deposited along the west flank of the island and in Cat Island Pass (Miner et al. 2009). The majority of passes are serving as sinks to longshore transport (Levin 1993). As the model results show (figure 2), the eastern flanks of the Timbalier Islands and the Isles Dernieres are serving as sediment sources for transport of sediment to spit ends and to the passes (Stone and Zhang 2001).

The barrier islands on the Timbalier and Isles Dernieres chain have entered a final phase of disintegration that involves a complex structured longshore sediment transport system. Timbalier Island has decreased in size by 58% over the last century (Townson et al 1999). Coupled with the massive destruction of a major hurricane such as Hurricane Andrew, Timbalier Island could disappear by year 2050 without restoration (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998).

The Timbalier Island Dune/Marsh Restoration (TE-40) project is a 20-year project designed to restore the eastern end of Timbalier Island through dedicated dredging of local sediment sources, and stabilization of the newly deposited sediment through sand fencing and vegetative plantings in Terrebonne Parish, Louisiana (figure 3). The final design of the TE-40 project [2.4 m (8 ft) dune height, 122 m (400 ft) dune width, and 244 m (800 ft) marsh platform] was compared to two alternative designs using the SBEACH model, which estimates the impacts of tropical and extra-tropical storms along sandy shorelines. Three hurricane events (Category 1, Category 2, and Category 3) were simulated along the historic Hurricane Andrew (1992) track, and two cold front scenarios [72 KPH (45 MPH) and 97 KPH (60 MPH) winds] were generated. The model output predicted that the final design would provide the greatest resistance to erosion and would reduce the probability of storm induced overwash (T. Baker Smith 2002). The project is sponsored by the United States Environmental Protection Agency (EPA) and the Louisiana Office of Coastal Protection and Restoration (OCPR) under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA, Public Law 101-646, Title III). The proposed plan would deposit dedicated dredge sediments to create beach, dune, and marsh habitat. This project would also aid in restoring the structural integrity of Timbalier Island through restoration of the littoral drift system and addition of sediment into the nearshore environment.

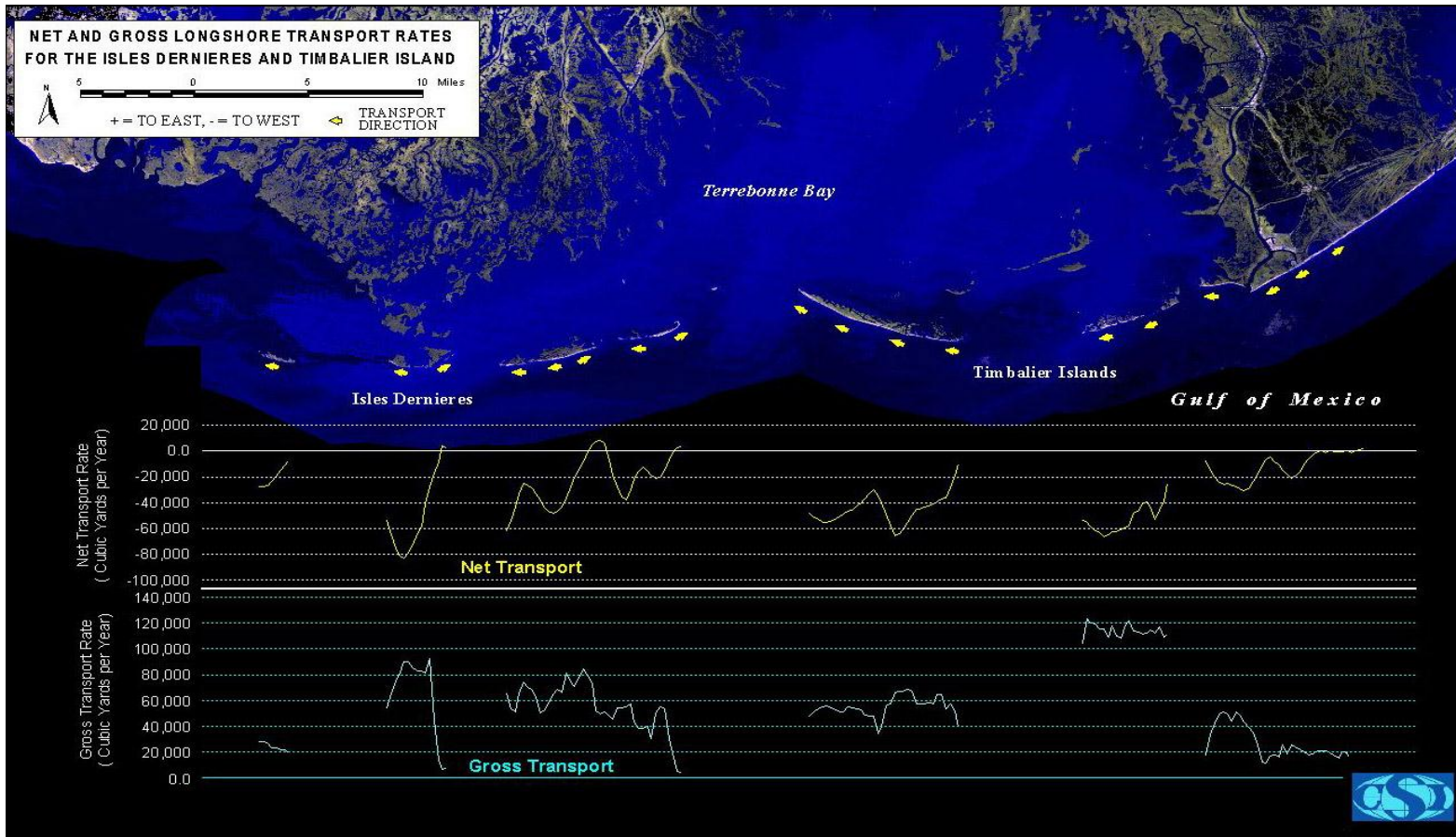


Figure 2. Net and gross longshore transport rates along the study area with longshore transport vectors indicating transport direction and cell location (Stone and Zhang 2001).

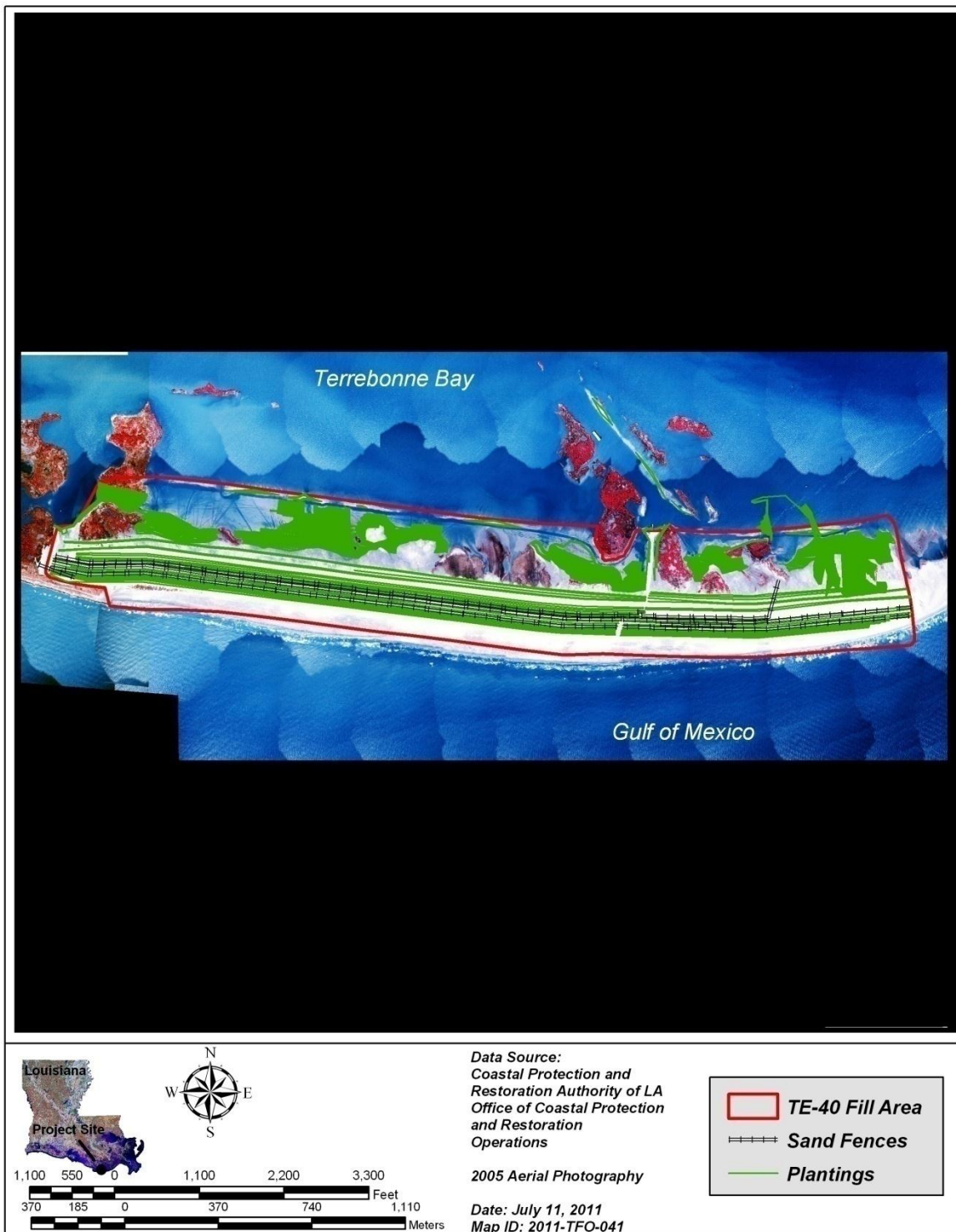


Figure 3. Location of the Timbalier Island Dune/Marsh Restoration (TE-40) project features.

The Timbalier Island Dune/Marsh Restoration (TE-40) project consists of beach, dune, and marsh creation features (figure 3). Construction began by building containment dikes on the Terrebonne Bay side of Timbalier Island and placing beach fill along the Gulf of Mexico shoreline. The beach fill extended the TE-40 project area southward and provided a substrate to construct containment dikes and the dune on the gulf shoreline. Approximately, 7010 m (23,000 ft) of containment dikes were constructed for the TE-40 project. After construction of these earthen dikes, dredged materials were hydraulically pumped inside the dune/marsh creation area and the dune feature was shaped into a 122 m (400 ft) wide dune with a 2.4 m (8 ft) NAVD 88 crest. During construction, Hurricane Ivan (September 2004) and Tropical Storm Matthew (October 2004) eroded portions of the dune, containment dikes, and beach (figure 4). As a result of these tropical storms, an additional 152,911 m³ (200,000 yd³) of fill material were pumped into the fill area to replace sediment volume removed during these events and 914 m (3000 ft) of the dune and containment dikes were repaired. Moreover, beach erosion incurred during this time led to the addition of 764,555 m³ (1,000,000 yd³) of sediments to the TE-40 fill area beach and shoreface. The TE-40 project enhanced the fill area by creating a 69 m (225 ft) wide beach, an 122 m (400 ft) wide dune, and a 244 m (800 ft) wide marsh. Approximately, 2,599,487 m³ (3,400,000 yd³) of sand was placed inside the TE-40 fill area during construction. Once the dune was constructed, 6934 m (22,750 ft) of sand fencing were installed (two rows) along the entire 3,414 m (11,200 ft) length of the dune and vegetation was planted along the dune and in the marsh creation area to stabilize these features and increase vegetation cover (figure 3). After sediment consolidation, the bay containment dike was gapped every 500 ft to a 0.3 m (1.0 ft) NAVD 88 elevation. Construction of the TE-40 project began on June 6, 2004 and ended on December 27, 2004.

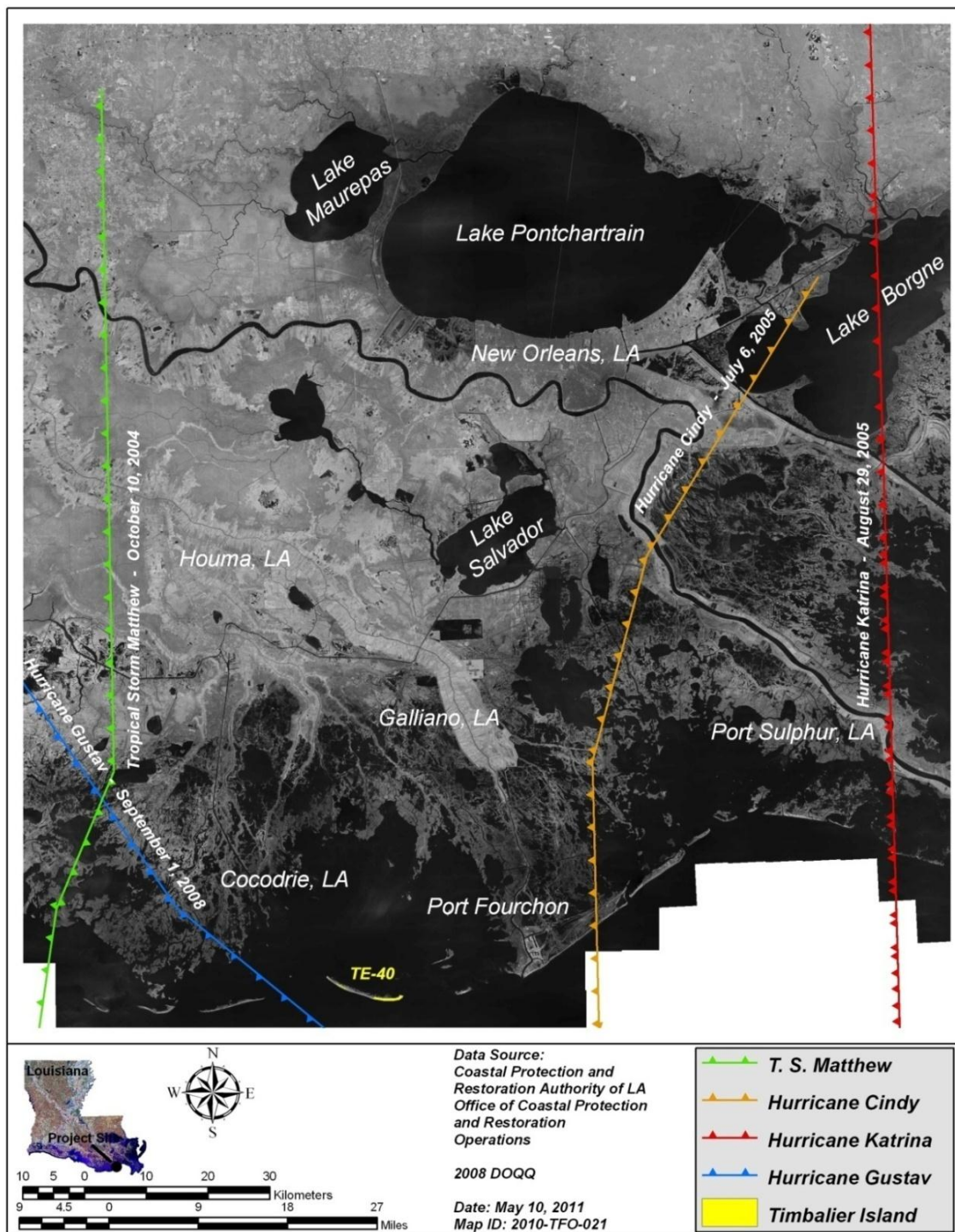


Figure 4. Pre-construction (2004) and post-construction (2005 and 2008) tropical storms impacting the Timbalier Island Dune/Marsh Restoration (TE-40) project area shoreline. Hurricanes Ivan (2004), Rita (2005), and Ike (2008) are not shown because the eye wall of these storms traveled further to the south (off the map).

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the annual inspection of the Timbalier Island Dune/Marsh Restoration (TE-40) project is to evaluate the constructed project features, identify any deficiencies, and prepare a report detailing the condition of the project features including recommendations for corrective actions, as needed. Should it be determined that corrective actions are required, CPRA shall provide in the inspection report, a detailed cost estimate for engineering, design, bidding, construction oversight and supervision, project contingencies, and an assessment of the urgency of such repairs. The annual inspection report also contains a summary of the completed maintenance projects and an estimated projected budget for the upcoming three (3) years for operations, maintenance and rehabilitation. The three (3) year projected operations and maintenance budget is shown in Appendix B. A summary of completed operation and maintenance projects are outlined in Section IV of this report.

An inspection of the Timbalier Island Dune/Marsh Restoration (TE-40) project was held on December 1, 2011 under sunny skies. In attendance were Darin Lee, Adam Ledet, and Jason Curole from CPRA. The attendees launched at LUMCON and were transported to Timbalier Island, where winds, shoaling of canals, and water levels prevented access to the island.

The field inspection included a visual inspection of constructed features from the boat offshore, and thus prevented documentation of shoreline positions at selected locations. Photographs of the project features were taken during the field inspection and are shown in Appendix A.

b. Inspection Results

Overall the fill area continues to show erosion, particularly on the east end due to long-shore transport, pass migration, and tropical cyclone impacts. The fill area has had impacts from at least 5 hurricanes since construction (figure 4), and this year Tropical Storm Lee in September 2011 made landfall on the Louisiana shoreline west of Timbalier Island, placing the project area on the worst side of the storm.

While shoreline measurements are unavailable for this inspection, past inspections in 2007 and 2008 show high erosion rates for the gulf shoreline. No breaches were observed and the dune feature did roll back in most instances where marshes were in place to capture the sediment. The eastern end was overwashed in 2005 due to Hurricane Rita, and again was the only area that showed severe overwash in 2008 due to Hurricane Gustave with almost 1,100 ft of complete template removal from station 167+00 to station 178+00 and removal of approximately one-half the template for 1,300 ft from station 154+00 to station 167+00. These 2,400 ft also had complete removal of the sand fencing and plantings.

The most severe shoreline erosion in 2008 occurred on the eastern end of the area from station 167+00 to station 178+00, with less erosion as one proceeds westerly (figure 5). The average erosion measured since the 2007 inspection was approximately -99.7 ft. BICM data shows an average erosion rate of -25.0 ft for this portion of the coast in the last decade (1990's to 2005) and +29.0 ft of shoreline gain between 2004 and 2005, even with Hurricanes Katrina and Rita. Removing the short-term erosion rate from that measured gives us an erosion rate of -74.7 ft. This confirms that these storms caused erosion that exceeded the 2005 Hurricanes (Katrina and Rita).

The backmarsh areas appeared in good shape and had captured significant amounts of overwash sediments. Additionally, the remaining dunes appeared in good shape with plant cover and sediment fences forming dunes.

As previously noted the access canal and dock cannot be accessed due to sedimentation from storm overwash and sediment transport behind the islands.

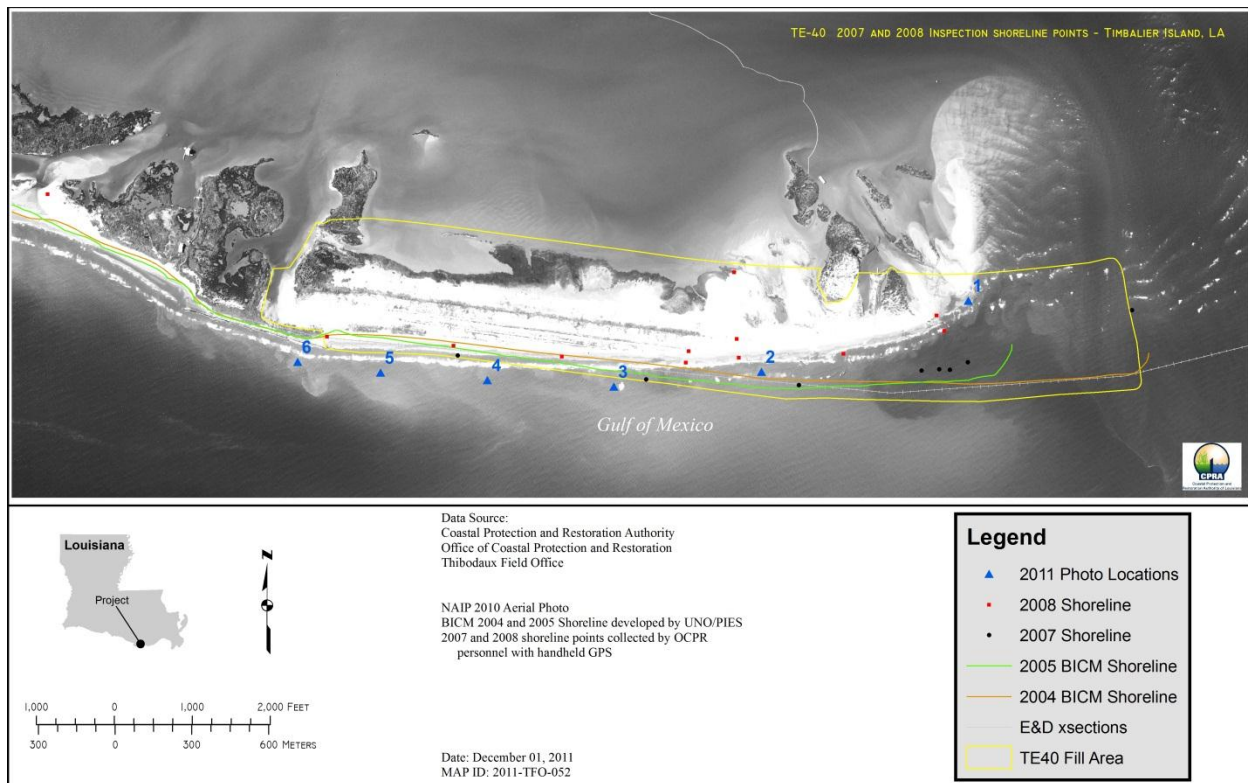


Figure 5. 2011 Inspection photo locations and 2008 Shoreline positions obtained during the post-Ike Assessment, along with 2007 inspection data and the BICM 2004 and 2005 shorelines at the Timbalier Island Dune/Marsh Restoration CWPRRA Project (TE-40).

c. Maintenance Recommendations

i. Immediate/ Emergency Repairs

None.

ii. Programmatic/ Routine Repairs

None. No repairs are proposed at this time due to the nature of the volume changes and shoreline position adjustments. Costs associated with these activities would require a separate project under current CWPPRA program procedures. Additionally, due to an increasing tidal prism and pass migration toward the west, placement of sediment in this area, at this time, could not insure long-term retention. Timbalier Island within the short-term would be better served by placing material to the west of the project area along the beach, and filling of canals behind the island to prevent potential breaches, thereby maintain sediment along the shoreline and in the system for a longer period.

d. Maintenance History

There has been no maintenance activity on this project and there is no maintenance budget available. However, post hurricanes Gustave and Ike in 2008, additional sand fencing was placed on the island in 2010 thru the State Barrier Island Maintenance Program (BIMP). Approximately, 5000 linear feet of fencing was installed in April 2010 and no sign of the fencing was noted on this 2011 inspection post Tropical Storm Lee.

III. Operations Activity

a. Operation Plan

None. There are no operable features and no Operations and Maintenance budget.

b. Actual Operations

None. There are no operable features and no Operations and Maintenance budget.

IV. Monitoring Activity

a. Monitoring Goals

The specific project goals of the Timbalier Island Dune/Marsh Restoration (TE-40) Project are (1) to restore the eastern end of Timbalier Island and (2) to maintain the lateral migration of Timbalier Island. These project goals are consistent with the Coast 2050 Region 3 ecosystem strategy to restore barrier islands and gulf shorelines. Construction of the dune and salt marsh will increase the area, width, and sediment/soil volume of Timbalier Island. Construction of the dune will immediately increase the area of dune and the maximum and average elevation on the island and construction of the salt marsh will immediately increase the area of salt marsh on the island. Planting vegetation and installing sand fencing should reduce the rate of loss of sand from treated areas.

The specific measurable monitoring goals established to evaluate the effectiveness of the project are:

1. Determine the area, average width, length, and position of Timbalier Island and the project area over time.
2. Determine the effectiveness of project features in reducing the rate of erosion as compared to historical rates of erosion and maintaining the littoral transport of the shoreline.
3. Determine sediment characteristics and their change over time.
4. Determine the evolution of tidal channel development.
5. Determine elevation and habitat classes in the project area.

b. Monitoring Elements

The following monitoring elements will provide the information necessary to evaluate the specific goals listed above:

Topography and Bathymetry

Topographic and bathymetric surveys were employed to document elevation and volume changes inside the Timbalier Island Dune/Marsh Restoration (TE-40) fill area. Pre-construction (June 2004), and as-built (January 2005) elevation data were collected in the fill area using cross sectional (500 ft intervals in June 2004 and 100 ft intervals in January 2005) and real time kinematic (RTK) survey methods. A subsequent post-construction topographic survey was conducted using Light Detection and Ranging (LiDAR) procedures (Brock et al. 2002). The July 2006 survey and a separate bathymetric survey were funded through the Barrier Island Comprehensive Monitoring (BICM) program in

2006 (Troutman et al. 2003). The bathymetric survey recorded subaqueous elevations in the shoreface, inlet, and bay regions surrounding Timbalier Island. The 2006 LiDAR and bathymetric surveys were joined to form a single continuous elevation contour of this barrier island. In addition to the fill area elevation analysis, three 152 m (500 ft) study areas were established on the marsh platform to verify tidal creek formation on the northern side of the TE-40 fill area. The study areas were spaced 457 m (1500 ft) apart and were surveyed using cross sectional [15 m (50 ft) intervals] and RTK methods. These study areas were designated as the Eastern Tidal Creek Area, the Central Tidal Creek Area, and the Western Tidal Creek Area based on their location. Two tidal creek area surveys were conducted in the post-construction period, one in April 2008 and one in March 2010. All survey data were established using or adjusted to tie in with the Louisiana Coastal Zone (LCZ) GPS Network.

Survey data were re-projected horizontally and vertically to the UTM NAD83 coordinate system and the NAVD 88 vertical datum in meters using Corpscon[®] software. The re-projected data were imported into ArcView[®] GIS software for surface interpolation. Triangulated irregular network models (TIN) were produced from the point data sets. Next, the TIN models were converted to grid models (2.0 m² cell size), and the spatial distribution of elevations were mapped. The grid models were clipped to the TE-40 fill area and the tidal creek area polygons to estimate elevation and volume changes.

Elevation changes from June 2004-January 2005 and January 2005-July 2006 in the fill area were calculated by subtracting the corresponding grid models using the LIDAR Data Handler extension of ArcView[®] GIS. Tidal creek area elevation changes were calculated using the aforementioned procedures for the April 2008-March 2010 interval. After the elevation change grid models were generated, the spatial distribution of elevation changes in the TE-40 fill area and the tidal creek areas were mapped in half meter elevation classes. Lastly, volume changes in the fill and tidal creek areas were calculated in cubic meters (m³) using the Cut/Fill Calculator function of the LIDAR Data Handler extension of ArcView[®] GIS. Note, these elevation and volume calculations are valid only for the extent of the survey area.

Summary Statistics and Shoreline Change

Aerial photographs from January 2005 (as-built), November 2005 (after the 2005 hurricane season), and October 2008 (after the 2008 hurricane season) were utilized to determine the area, width, and dune length of the Timbalier Island Dune/Marsh Restoration (TE-40) fill area over time. The areal extent of the fill area was estimated by drawing a polygon around the subaerial land within the fill area at a 1:2000 scale. Once drawn the area inside the polygons were calculated. The subaerial width of the fill area was calculated for each interval by measuring the width of the subaerial part of 22 transects [152 m (500 ft) intervals] at a 1:2000 scale. Once measured the widths were averaged for each time period. The dune length was evaluated by measuring the length of the dune for the three time periods.

Shoreline position data were analyzed to estimate shoreline changes in the Timbalier Island Dune/Marsh Restoration (TE-40) fill area and on the western end of Timbalier Island using the Digital Shoreline Analysis System (DSAS version 2.1.1) extension of ArcView® GIS (Thieler et al. 2003). Shoreline positions were determined by digitizing aerial photographs at a 1:2000 scale as per the Steyer et al. (1995) method. Only the October 2008 aerial photograph was digitized using this method. A November 2005 shoreline was obtained from Martinez et al. (2009) and compared to the October 2008 shoreline to establish change rates.

Habitat Mapping

Habitat analysis was performed using the same methods as the Barrier Island Comprehensive Monitoring Program's (BICM) analyses for the time periods after 1996. The objective of the 2005 (as-built) and 2006 (1 year post- construction) Timbalier Island Dune and Marsh Restoration Project (TE-40) habitat mapping is to document existing habitats within the project's boundaries. Because the methods are the same as BICM, comparison will be possible between project specific and BICM analyses, allowing longer term analysis of habitat change and better monitoring of project effectiveness.

The OCPR obtained aerial photography to document habitat within the project boundaries and allow comparisons between the 2005 (as-built) and 2006 (2 year post-construction) habitats. These images were acquired on January 18, 2005 and November 9, 2006 and are accurate to 1 meter. The 2005 (as-built) and 2006 (1 year post-construction) images were classified by the University of New Orleans-Ponchartrain Institute of Environmental Sciences (UNO/PIES) through OCPR Interagency agreement No. 2512-06-06, and funded by the project specific monitoring budget of Timbalier Island Marsh and Dune Restoration Project (TE-40) under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA).

The photography was mosaiked to create a complete image of the project area to be classified and then clipped to remove surrounding gulf waters from the image. Signatures were created, supervised, and unsupervised classifications were done and manual cleaning provided the final differentiation between habitat classes. Habitat analyses for both years were completed with ERDAS Imagine software, version 9.2. The Penland et al. (2004) habitat classification used eight categories for the purpose of mapping change.

Sediment Properties

Push core sediment samples were obtained along four cross-shore transects in the Timbalier Island Dune/Marsh Restoration (TE-40) fill area and six transects on the western end of Timbalier Island in 2008 to characterize the median grain size and grain size distributions in the shoreface and other barrier island habitats. These sediment transects were separated on 914 m (3000 ft) intervals and were funded through the Barrier Island Comprehensive Monitoring (BICM) program (Troutman et al. 2003). One sample

was collected from each distinguishable location: -5 m (-15 ft) contour, middle of shoreface, upper shoreface at mean low water, beach berm, dune, and back-barrier marsh. However, no laboratory analysis has been performed on these sediment samples to date. In the future, the core samples will be analyzed to determine sediment grain size, sorting, percent sand and fines, organic matter content, and bulk density (Troutman et al. 2003).

c. Preliminary Monitoring Results

Elevation

The Timbalier Island Dune/Marsh Restoration (TE-40) fill area experienced volume reductions and shoreline transgressions since construction was completed in 2005. Elevation change and volume distributions for the TE-40 fill area are shown in figure 6 (June 2004-January 2005) and figure 7 (January 2005-July 2006). Elevation grid models for the June 2004, January 2005, and July 2006 surveys are also provided in appendix C. Approximately, 2,586,303 m³ (3,382,756 yd³) of sediment were deposited during construction in the fill area (figures 5 and 7). In the post-construction period, sediment volume decreased by 66% from January 2005 to July 2006 (figures 7 and 8). The total sediment volume loss in the fill area from January 2005 to July 2006 was approximately 1,714,990 m³ (2,243,122 yd³). A major cause of this large volume loss in the fill area is shoreline erosion produced during the passage of the 2005 hurricanes.

The Timbalier Island Dune/Marsh Restoration (TE-40) tidal creek areas have incurred varied sedimentation responses from 2008 to 2010. Elevation and volume changes for the tidal creek areas are delineated in figures 9 and 10. Elevation grid models for the April 2008 and March 2010 surveys are also provided in appendix C. The eastern and central tidal creek areas gained sediment volume while the western tidal creek area displayed volume losses during the study period (figures 9 and 10). Therefore, it seems that the cross-shore transport processes are greatest on the eastern side of the island and progressively decline in the western direction. The tidal creek surveys did not provide evidence supporting tidal creek formation and evolution but did show that cross-shore transport of sediment is occurring within the TE-40 fill area.

Summary Statistics and Shoreline Change

The area, width, dune length, and shoreline of the Timbalier Island Dune/Marsh Restoration (TE-40) fill area decreased over time. The acreage inside the fill area contracted from 147 ha (364 acres) immediately after construction to 130 ha (320 acres) after the 2005 hurricanes, 139 ha (345 acres) in 2006, and 90 ha (223 acres) after the 2008 hurricanes (table 1). The width of the TE-40 fill area also narrowed and the dune length receded after the major tropical cyclone events in 2005 and 2008 (table 1). Similarly, the TE-40 fill area shoreline transgressed considerably during the interval from 2005 to 2008 while the Timbalier Island shoreline west of the fill area did not erode (table 2). Interestingly, the area and width of the TE-40 fill area expanded in 2006 showing a post 2005 hurricane season recovery (table 1).

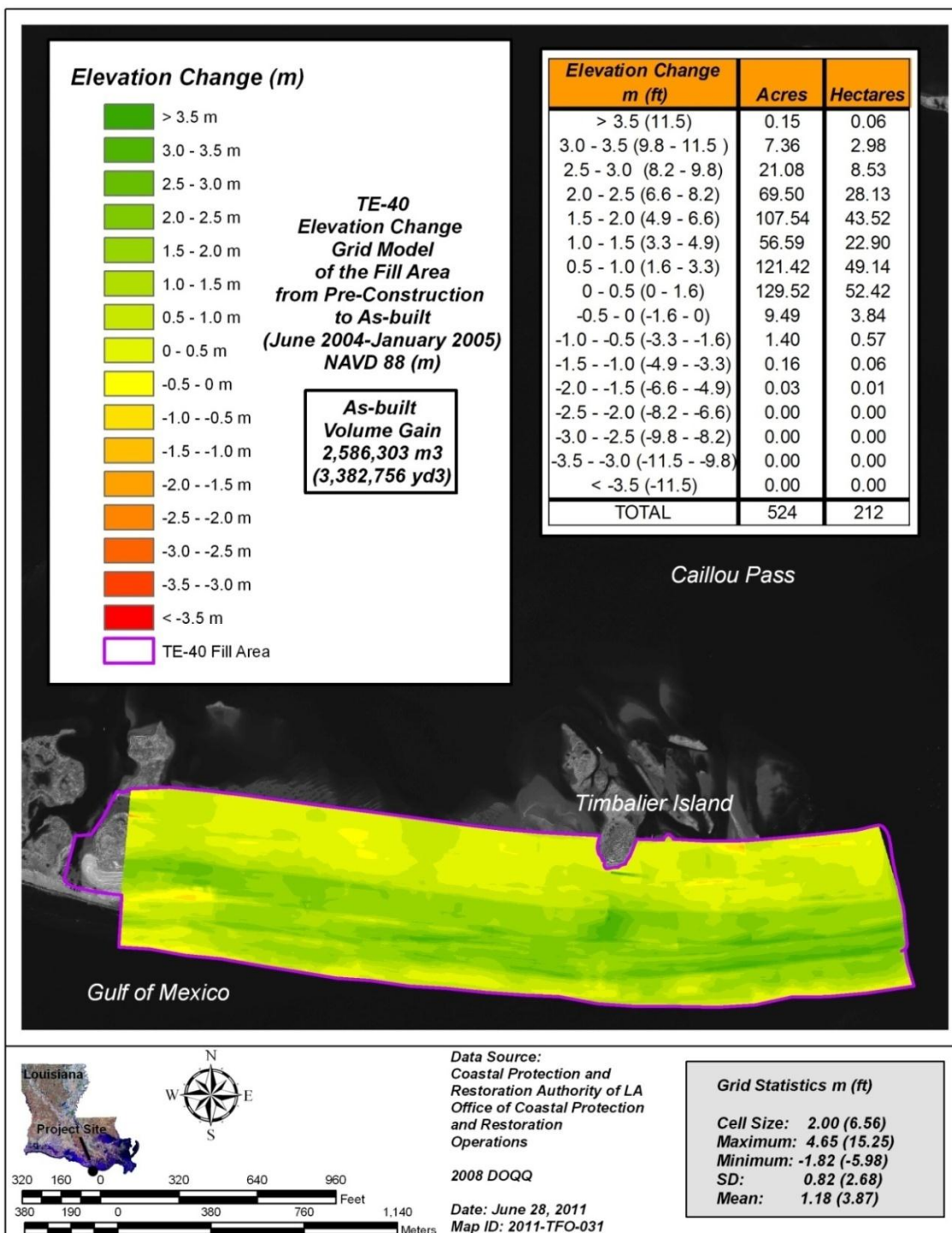


Figure 6. Elevation and volume change grid model inside the Timbalier Island Dune/Marsh Restoration (TE-40) fill area from pre-construction (June 2004) to as-built (January 2005).

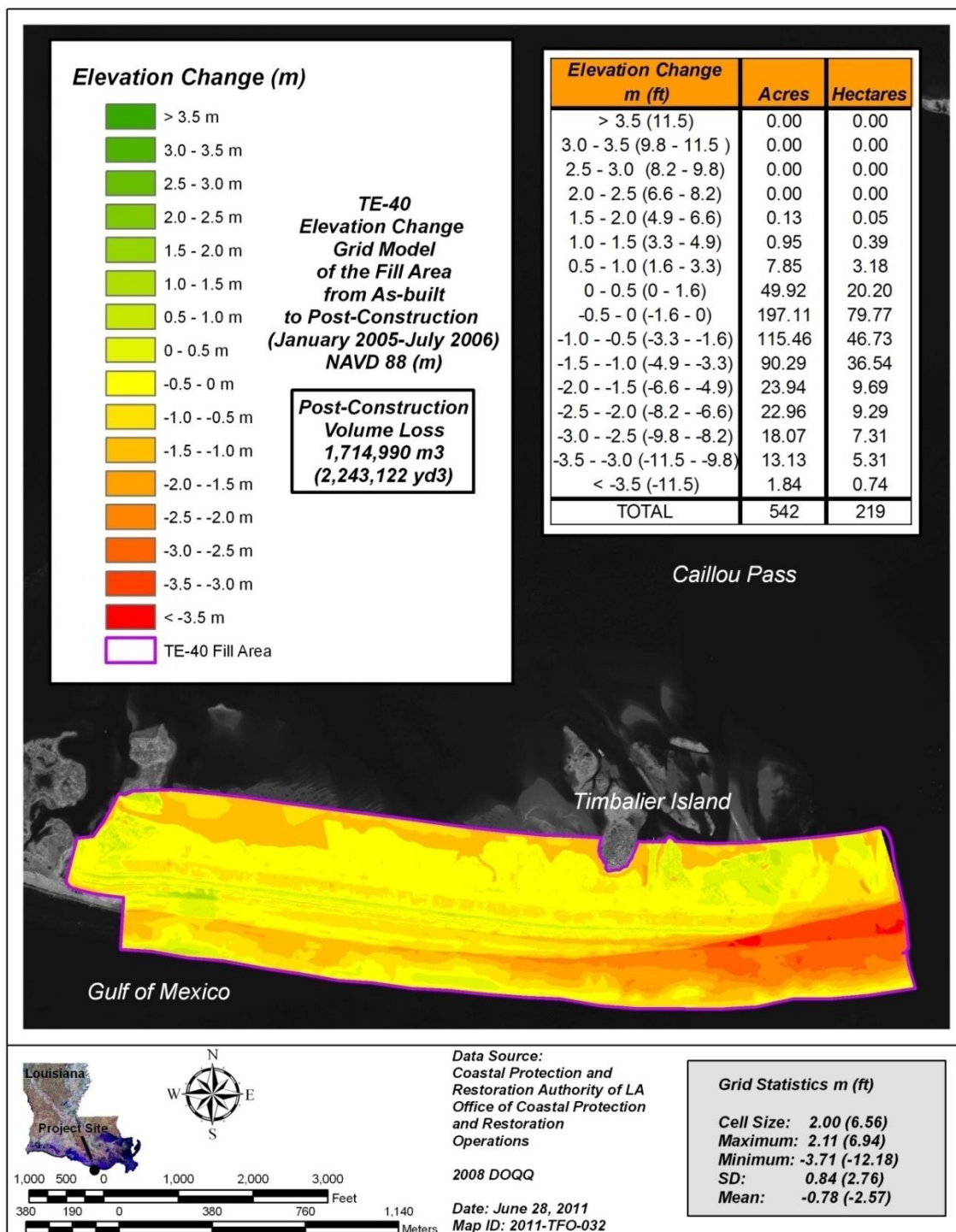


Figure 7. Elevation and volume change grid model inside the Timbalier Island Dune/Marsh Restoration (TE-40) fill area from as-built (January 2005) to post-construction (July 2006).

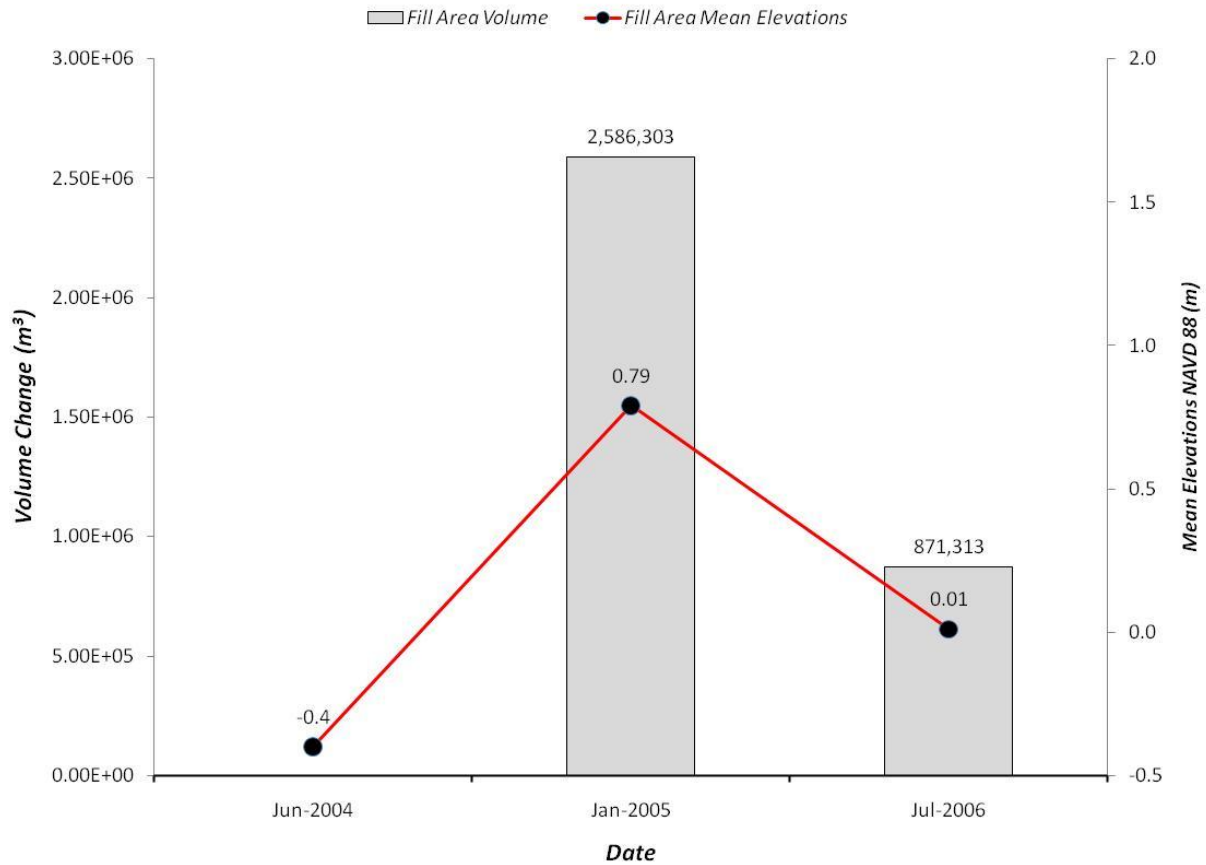


Figure 8. Sediment volumes and mean elevations over time inside the Timbalier Island Dune/Marsh Restoration (TE-40) fill area.

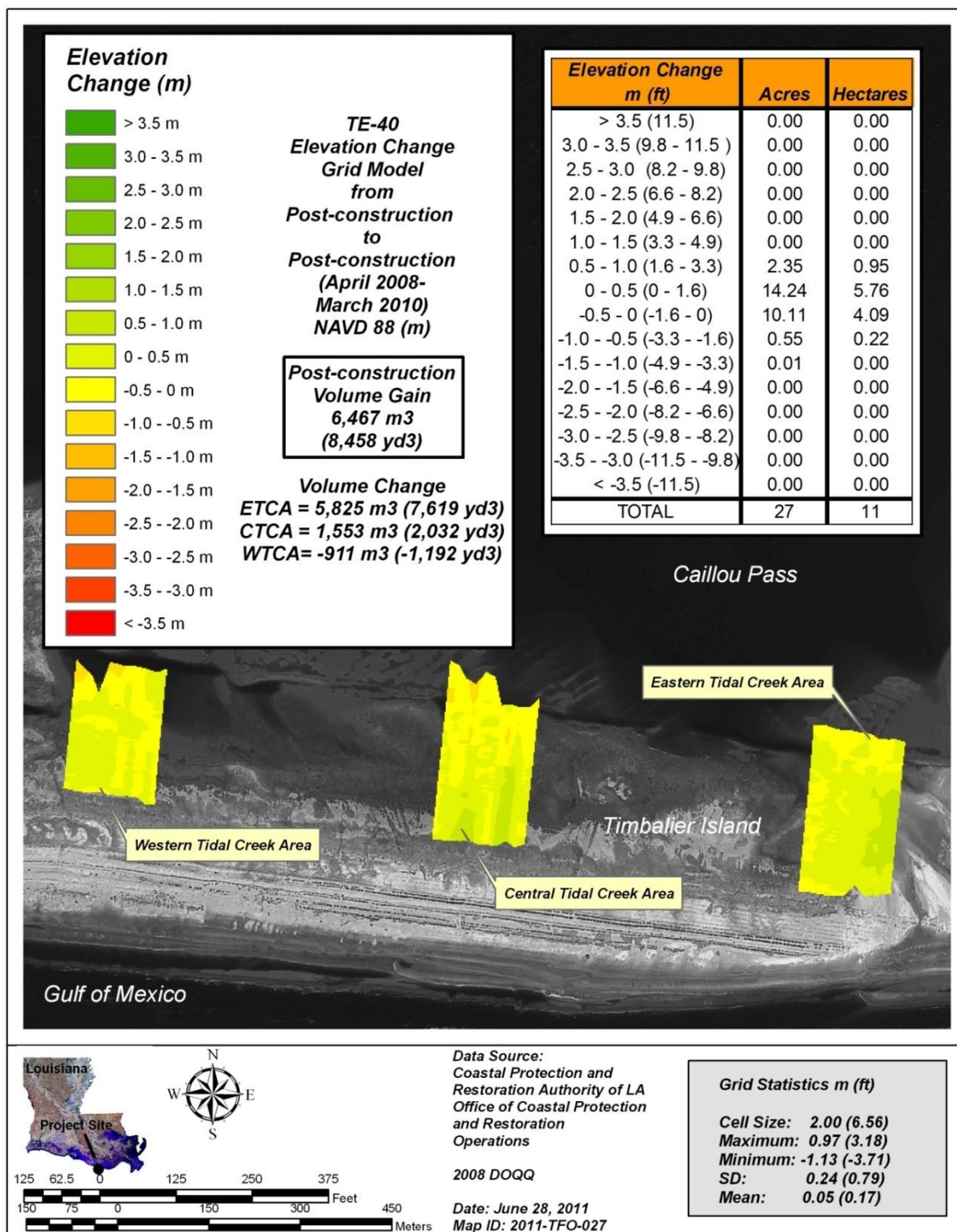


Figure 9. Post-construction elevation and volume change grid model from April 2008 to March 2010 at the Timbalier Island Dune/Marsh Restoration (TE-40) tidal creek areas.

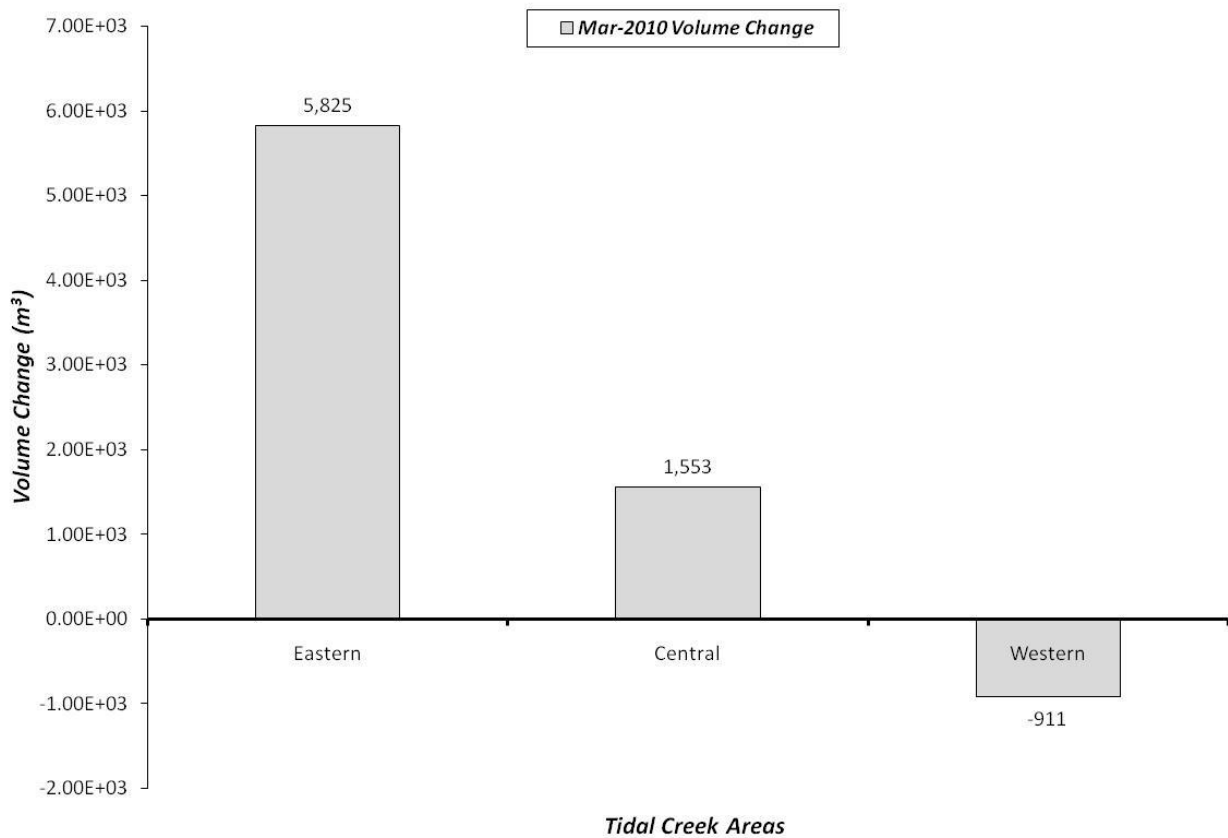


Figure 10. Sediment volume change inside the Timbalier Island Dune/Marsh Restoration (TE-40) tidal creek areas.

Table 1. Mean width, area, and dune length inside the Timbalier Island Dune/Marsh Restoration (TE-40) fill area over time.

TE-40 Fill Area Summary Statistics	Jan-2005	Nov-2005	Nov-2006	Oct-2008
Area ha (acres)	147 (364)	130 (320)	139 (345)	90 (223)
Width m (ft)	432 (1,418)	397 (1,302)	417 (1,370)	351 (1,151)
Dune Length m (ft)	3,414 (11,200)	2,926 (9,600)	2,804 (9,200)	1,829 (6,000)

Table 2. Shoreline Change inside the Timbalier Island Dune/Marsh Restoration (TE-40) fill area and the western reaches of Timbalier Island.

<i>Shoreline Change</i>	<i>Nov 2005 - Oct 2008</i>
<i>TE-40 Fill Area</i>	-15 m/yr (-51 ft/yr)
<i>Western Timbalier Island</i>	0.02 m/yr (0.07 ft/yr)

Habitat Mapping

The Timbalier Island Dune/Marsh Restoration (TE-40) fill area habitats were reshaped during the first two post-construction years. The change in habitats from January 2005 to November 2006 is shown in figure 11 and table 3. Habitat maps for the January 2005 and November 2006 periods are also presented in appendix D. Approximately, 15 ha (37 acres) of beach and 16 ha (40 acres) of marsh habitat were created from 2005 to 2006 while acreages of bare land (dune) -11 ha (-26 acres), intertidal flat -8 ha (-20 acres), and water -12 ha (-30 acres) habitats declined. During this interval, the width of the TE-40 fill area expanded and the length diminished. Moreover, the shoreline transgressed considerably to the west leaving the eastern tip of Timbalier Island (outside of the fill area) and bare land (dune), beach, and intertidal habitats within the TE-40 fill area subaqueous (figure 11). The width of the TE-40 fill area seems to have increased through cross-shore transport of sediments from the shoreface, beach, and dune (bare land) infilling intertidal flat and shallow open water areas on the bay side of the fill area (figure 11). The 2005 hurricanes (Cindy, Katrina, and Rita) are probably the primary cause forcing the redistribution and loss of sediments in the fill area and on the eastern edge of Timbalier Island for the 2005-2006 period (figure 4). Furthermore, East Isle Dernieres and Whiskey Island also exhibited considerable shoreline transgressions and land loss on the eastern edge of their shorelines following the 2005 hurricanes (Barras 2006; Rodrigue et al. 2008a; and Rodrigue et al. 2008b; Fearnley et al. 2009; Martinez et al. 2009). Longshore transport processes also probably induced some of the shoreline losses because the eastern shorelines of Timbalier Island have historically been erosional (Peyronnin 1962; Stone and Zhang 2001; Georgiou et al. 2005; Martinez et al. 2009).

Sediment Properties

The sediment cores collected by the BICM program have not been analyzed to date. When the soil data becomes available, the distribution of the sand resources will be mapped.

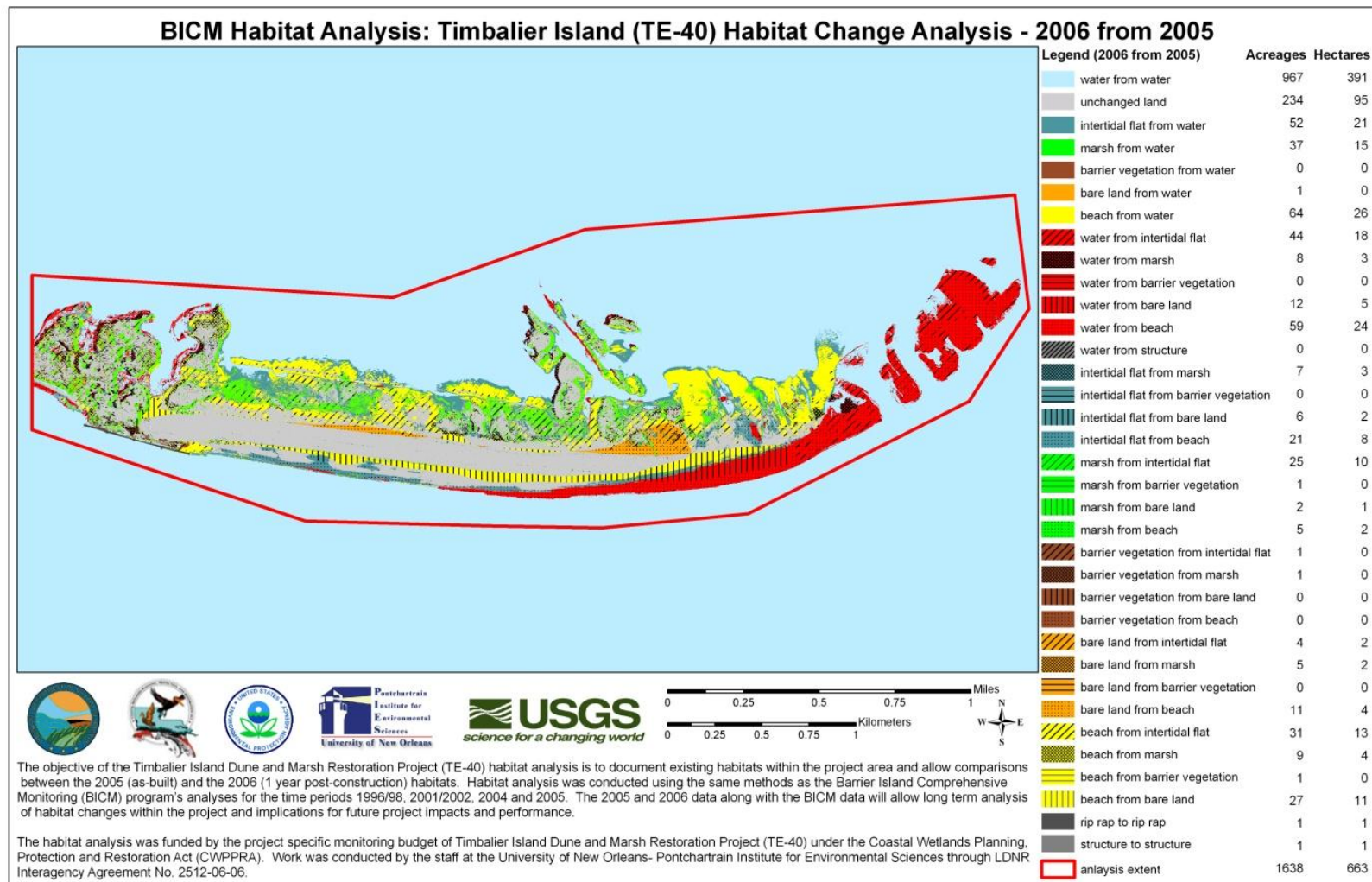


Figure 11. Habitat change analysis of Timbalier Dune/Marsh Restoration (TE-40) project from Jan 2005 to Nov 2006.

Table 3. BICM habitat classes, acreages, and changes photo-interpreted from 2005 and 2006 aerial photography for the Timbalier Island Dune/Marsh Restoration (TE-40) project.

Habitat Class Project Area	2005 Ha (Acres)	2006 Ha (Acres)	Change Ha (Acres)
<i>Water</i>	454 (1121)	442 (1091)	-12 (-30)
<i>Intertidal Flat</i>	51 (127)	43 (107)	-8 (-20)
<i>Marsh</i>	38 (93)	59 (133)	16 (40)
<i>Barrier Vegetation</i>	1 (3)	1 (3)	0 (0)
<i>Bare Land</i>	54 (134)	44 (108)	-11 (-26)
<i>Beach</i>	64 (158)	79 (195)	15 (37)
<i>Rip Rap</i>	0.4 (1)	0.4 (1)	0 (0)
<i>Structure</i>	0.4 (1)	0.4 (1)	0 (0)
<i>Total</i>	663 (1639)	663 (1639)	0 (0)

d. Discussion

The massive sediment volume loss inside the Timbalier Island Dune/Marsh Restoration (TE-40) fill area was primarily the result of cross-shore transport induced shoreline erosion on the eastern edge of Timbalier Island. The increased tropical storm activity occurring during 2005 and 2008 hurricane seasons reshaped the eastern part of Timbalier Island. Barras (2006), Fearnley et al. (2009), and Martinez et al. (2009) have shown that the eastern portion of the Timbalier Island shoreline was impacted during the 2005 hurricane season. The shoreline transgressed an estimated 731 m (2400 ft) to the west leaving 18 ha (44 acres) of the fill area subaqueous (figure 7 and table 1). The dune receded approximately 488 m (1600 ft) to the west (table 1) after the passage in quick succession of Hurricane Cindy (July), Hurricane Katrina (August), and Hurricane Rita (September) in 2005 (figure 4). Therefore, 2926 m (9600 ft) of the dune remained after the 2005 hurricane season. East Isle Dernieres and Whiskey Island also exhibited considerable shoreline transgressions and land loss on the eastern edge of their shorelines following the 2005 hurricanes (Barras 2006; Rodrigue et al. 2008a; and Rodrigue et al. 2008b; Fearnley et al. 2009; Martinez et al. 2009). Approximately one year after the 2005 hurricanes, beach and marsh habitats increased their areal extent while bare land (dune) and intertidal flat habitats declined (figure 11 and table 3). Moreover, the width and acreage of the TE-40 fill area expanded in 2006 suggesting that cross-shore transport was extending the fill area's back barrier subaerial habitats and allowing the island's geomorphology to recover from the 2005 hurricanes. In 2008 Hurricanes Gustav (September) and Ike (September) also forced the Timbalier Island shoreline to transgress in the western direction. Hurricane Gustav, which passed within 8 km (5 mi) of Timbalier Island (figure 4), probably induced the greatest erosion and land loss on the TE-40 fill area. The eastern shoreline of Timbalier Island transgressed by 1128 m (3700 ft), 39 ha (97 acres) of the fill area became subaqueous, and the dune transgressed an additional 1402 m (4600 ft) after the 2008 tropical storms (table 1). Therefore, elevation and subaerial habitats are declining in the Timbalier Island Dune/Marsh Restoration (TE-40) fill area and their goal is not being attained at this time.

Although cross-shore transport of sediment is the foremost cause of the large volume loss in the fill area, longshore transport also likely contributed to the movement of sediment out of the TE-40 fill area because net longshore transport flows in the western direction on Timbalier Island (Peyronnin 1962; Stone and Zhang 2001; Georgiou et al. 2005). The historical record shows that the western shorelines of Timbalier Island have consistently regressed [1934-2005 m/yr (7.2 ft/yr), 1996-2005 m/yr (13.6 ft/yr), and 2004-2005 m/yr (21.1 ft/yr)] while the eastern shorelines have transgressed [1934-2005 m/yr (-13.9 ft/yr), 1996-2005 m/yr (-25.0 ft/yr), and 2004-2005 m/yr (29.9 ft/yr)] (Martinez et al. 2009). The large shoreline gain on the eastern part of Timbalier Island for the 2004-2005 interval is probably due to construction of the TE-40 project and land loss on the eastern tip of the barrier island. Indeed, the western shorelines of Timbalier Island maintained their position during this intense period of hurricane activity while the eastern shorelines transgressed (table 2). Therefore, it is plausible to infer that a considerable volume of sediments from the TE-40 fill area were retained in the Timbalier Island sediment budget since the western portion of the island seems to have been nourished in the post-construction period. As a result, the longshore transport monitoring goal is currently being realized.

In addition to the cross-shore and longshore transport of sediments along the TE-40 fill area Gulf of Mexico shoreline, figure 7 provides evidence showing a modest quantity of bay erosion inside the TE-40 fill area. Bay shoreline erosion along barrier islands in Louisiana's deltaic plain has been postulated as being mainly caused by extra-tropical cold fronts (Boyd and Penland 1981; Dingler and Reiss 1990; Georgiou et al. 2005). The narrow width and small marsh platform make Timbalier Island particularly susceptible to bay side erosion. As a result, it seems that other weather events besides the 2005 and 2008 hurricanes events affected the geomorphology of the TE-40 fill area.

The above geomorphic processes have led to the progressive decline in the TE-40 fill area width, area, and dune length (table 1) since construction. In conclusion, Timbalier Island Dune/Marsh Restoration (TE-40) fill area has narrowed and contracted since construction primarily due to the increased hurricane activity in the area. However, sediments removed from the fill area seem to be nourishing the western part of Timbalier Island. Therefore, the area, average width, length, and position monitoring goal is not being achieved in the TE-40 fill area at this time.

Preliminary results do not confirm tidal creek formation inside the Timbalier Island Dune/Marsh Restoration (TE-40) fill area. No depressions fitting the sinusoidal pattern of tidal creeks were found within the three tidal creek areas (figure 9). Two of the three tidal creek areas gained sediment volume for the study period signifying that cross-shore transport is taking place and sediments are being conserved within the fill area. However, this cross-shore transport may be infilling embryonic tidal creeks and curtailing their evolution. Therefore, the tidal creek development monitoring goal is not currently being attained.

V. Conclusions

a. Project Effectiveness

The results of the Timbalier Island Dune/Marsh Restoration (TE-40) reveal that one of the project goals was attained and three have not been achieved to date. The first goal the area, average width, length, and position monitoring goal is not being achieved in the TE-40 fill area at this time. Cross-shore transport induced by the 2005 and 2008 hurricanes are the primary reason why this goal is not being realized. Although the width and acreage of the TE-40 fill area expanded after the 2005 hurricanes, no elevation or habitat data has been collected since the 2008 hurricanes. Limited shoreline position data collected during the Annual Inspections indicates continued declines in volume and the inability to hold the eastern ends position. Therefore, future monitoring will determine the extent of the TE-40 fill area's geomorphic recovery. The second goal to maintain the longshore transport of the Timbalier Island shoreline is currently being attained. The western shorelines of Timbalier Island maintained their position during this intense period of hurricane activity while the eastern shorelines transgressed. Therefore, a considerable volume of sediments from the TE-40 fill area were retained in the Timbalier Island sediment budget since the western portion of the island seems to have been nourished in the post-construction period. The third goal the tidal creek development monitoring goal is not currently being attained. No depressions fitting the sinusoidal pattern of tidal creeks were found within the three tidal creek areas. However, cross-shore transport may be infilling embryonic tidal creeks and curtailing their evolution. The fourth goal the elevation and habitats goal is not being realized at this time. Elevation and subaerial habitats are declining in the TE-40 fill area principally due to the magnitude and frequency of tropical storm activity in the vicinity of the Timbalier Island Dune/Marsh Restoration (TE-40) project.

b. Recommended Improvements

Two improvements are recommended for future barrier island restoration projects. The first improvement is that all construction and monitoring elevation surveys should extend beyond the fill area boundary. Expanding the survey area, would eliminate two volume calculation challenges encountered while monitoring the Timbalier Island Dune/Marsh Restoration (TE-40) project. The pre-construction survey did not cover the entire length of the fill area (figure 6 and appendix C). Approximately, 7 ha (18 acres) of the fill were not surveyed in the pre-construction period. Therefore, the as-built volume for this acreage was extrapolated using the mean elevation. The second volume calculation problem encountered was that during construction sediment was relocated outside of the fill area via longshore and/or cross-shore processes. A considerable quantity of this sediment was transported to the east settling just outside the fill area (figure 3 and appendix D). However, there was no mechanism in place to estimate the volume of this sediment with the pre-construction and as-built elevation surveys because these surveys did not extend beyond the fill area. The second

improvement is data collection efforts should be more cohesive. Although the as-built (2005) and the first post-construction (2006) elevation surveys and habitat mapping events were conducted within a few months of each other, later sampling events were limiting and fragmented. Moreover, no surveys of the fill area or habitat maps have been created after the 2008 hurricane season, which substantially altered the TE-40 fill area. As a result, only summary statistics and shoreline change data can be used to describe the impacts of the 2008 hurricanes. The TE-40 fill area volume and habitat loss data cannot be reported.

c. Lessons Learned

One very important lesson was learned from the Timbalier Island Dune/Marsh Restoration (TE-40) project. This lesson is that the magnitude and frequency of the recent tropical storm activity redistributed considerable amounts of the sand placed in the TE-40 fill area. Although portions of the fill area did recover and expand after the 2005 hurricanes, large scale recovery of subaerial habitat within the fill area probably will not occur following the 2008 hurricanes. Indeed, Hurricane Gustav passed within a few miles of Timbalier Island and substantially altered the geomorphology of the fill area. The passage of four 100 year storms within a three year period (Katrina, Rita, Gustav, and Ike) is a great deal for any restoration project to withstand especially for a project built on the erosional end of a barrier island.

Additional lessons should include that the location of access canals and docks should be planned more in consideration of island geomorphology and processes, rather than project convenience. Location of an access corridor and dock on the western end of the island where the island is growing would therefore allow multiple efforts to coordinate and use this access corridor and insure longer-term use and low maintenance. Additionally, construction of these features without any maintenance doubly insures that they will become a waste of funds as the canals become silted and docks are damaged and inaccessible.

Lastly, annual inspections should include the whole project area and not just the constructed features. Additional shoreline position stations should be established along the shoreline west of the fill area such that the long-shore transport goals can be better accessed.

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Appendix A

(Inspection Photographs)



Photo 1. Site #1 looking north east near station 185+00. Note complete removal of the dune.

Digital Photo (3535)



Photo 2. Site #1 looking north near station 185+00. Note east end of island now located here with complete removal of the dune and marsh to the east.

Digital Photo (3536)



Photo 3. Site #1 near station 185+00 looking west. Note remnant marsh platform at gulf shoreline. This is the marsh area immediately east of the project dock.

Digital Photo (3537)



Photo 4. Site #2 near station 155+00 looking North. Note narrow beach and east end of dune feature. Remnant dune is narrow and back marsh visible with good vegetative cover.

Digital Photo (3538)



Photo 5. Site #2 near station 155+00 looking North. Note narrow beach and east end of dune feature with end of third row of sand fencing (northern most row of fence).

Digital Photo (3539)



Photo 6. Site #2 near station 155+00 looking east northeast. Note narrow beach and low overwash areas remain in eastern fill area.

Digital Photo (3540)



Photo 7 Site #2 near station 155+00 looking northwest. Note narrow beach and scarping at the toe of the dune feature. Both remnant dune and back marsh exhibit good vegetative cover..

Digital Photo (3541)



Photo 8. Site #3 near station 138+00 looking north. Note slightly wider beach at this location, but still scarping at the dune toe. Dune feature is wider in this area.

Digital Photo (3542)



Photo 9. Site #3 near station 138+00 looking north. Note slightly wider beach at this location, but still scarping at the dune toe. Dune feature is wider in this area.

Digital Photo (3543)



Photo 10. Site #3 near station 138+00 looking northeast. Note slightly wider beach at this location, but still scarping at the dune toe. Dune feature diminishes as you proceed east along the beach.

Digital Photo (3544)



Photo 11. Site #3 near station 138+00 looking northwest. Note slightly wider beach at this location, but still scarping at the dune toe. Dune feature becomes less scarped as you proceed west along the beach.

Digital Photo (3545)



Photo 12. Site #4 near station 122+00 looking north. Note wider beach with less scarping of the dune. Dune feature is wider with good vegetative cover.

Digital Photo (3546)



Photo 13. Site #4 near station 122+00 looking north. Note wider beach with less scarping of the dune. Dune feature is wider with good vegetative cover.

Digital Photo (3547)



Photo 14. Site #4 near station 122+00 looking northeast. Note wider beach with less scarping of the dune. Dune feature is wider with good vegetative cover.

Digital Photo (3548)



Photo 15. Site #4 near station 122+00 looking northwest. Note wider beach with less scarping of the dune. Dune feature is wider with good vegetative cover.

Digital Photo (3549)



Photo 16. Site #5 near station 107+00 looking north. Note wide beach with no scarping of the dune. Dune well vegetated and wide.

Digital Photo (3550)



Photo 17. Site #5 near station 107+00 looking north. Note wide beach with no scarping of the dune. Dune well vegetated and wide. Second and third rows of fencing visible with some deterioration.

Digital Photo (3551)



Photo 18. Site #5 near station 107+00 looking northeast. Note wide beach with no scarping of the dune. Dune well vegetated and wide.

Digital Photo (3552)



Photo 19. Site #5 near station 107+00 looking northwest at Canal 19 rocks. Note wide beach with little scarping of the dune. Typical erosional pocket behind east end of rocks, but little beach erosion on this west end of project.

Digital Photo (3553)



Photo 20. Site #5 near station 107+00 looking northwest at east end of Canal 19 rocks. Note typical erosional shadow behind end of rocks, but overall little erosion on the west end of the project.

Digital Photo (3554)



Photo 21 Site #6 near station 97+00 looking north at east end of Canal 19 rocks. Note typical erosion pocket at end of rocks, but very little erosion noted at east end of project. Large dunes remain with evidence of newly deposited sand.

Digital Photo (3555)



Photo 22. Site #6 near station 97+00 looking north at east end of Canal 19 rocks. Large dunes remain with evidence of newly deposited sand.

Digital Photo (3556)



Photo 23. Site #6 near station 97+00 looking north at east end of Canal 19 rocks. Large dunes remain with evidence of newly deposited sand.

Digital Photo (3557)



Photo 24. . Site #6 near station 97+00 looking northeast at east end of Canal 19 rocks. Note wide beach on western end of fill area and large dunes.

Digital Photo (3558)



Photo 25. Site #6 near station 97+00 looking northwest at west end of Canal 19 rocks.

Digital Photo (3559)



Photo 26. Site #6 near station 97+00 looking north at Canal 19 rocks and west end of dune feature.

Digital Photo (3560)



Photo 27. *Looking north at Canal 19 rocks west end. Note typical erosional shadow downdrift of structure.*

Digital Photo (3561)

Appendix B

(Three Year Budget Projection)

No Operations and Maintenance Budget Exists

Appendix C

(TE-40 Elevation Grid Models)

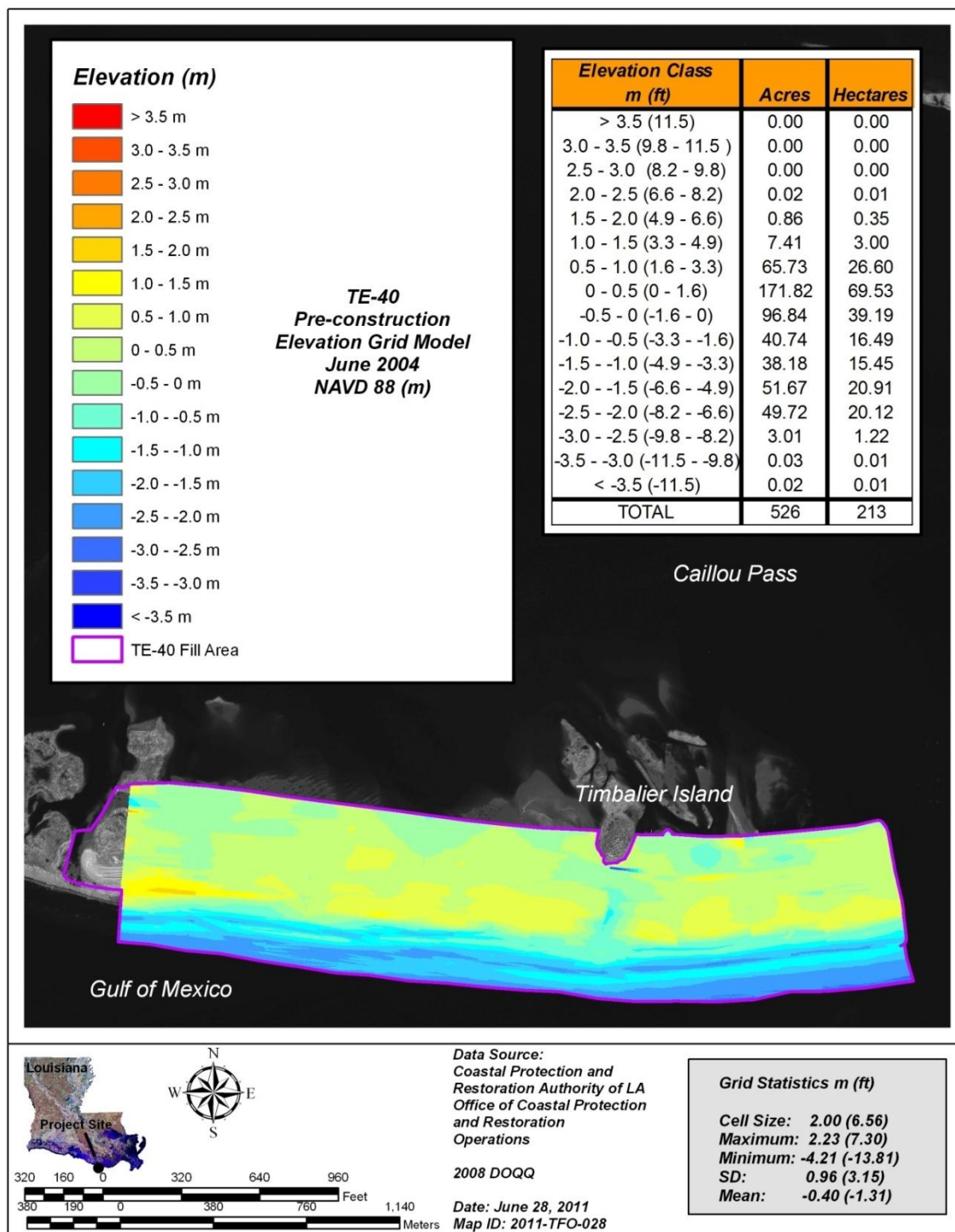


Figure. Pre-construction (June 2004) elevation grid model of the Timbalier Island Dune/Marsh Restoration (TE-40) fill area.

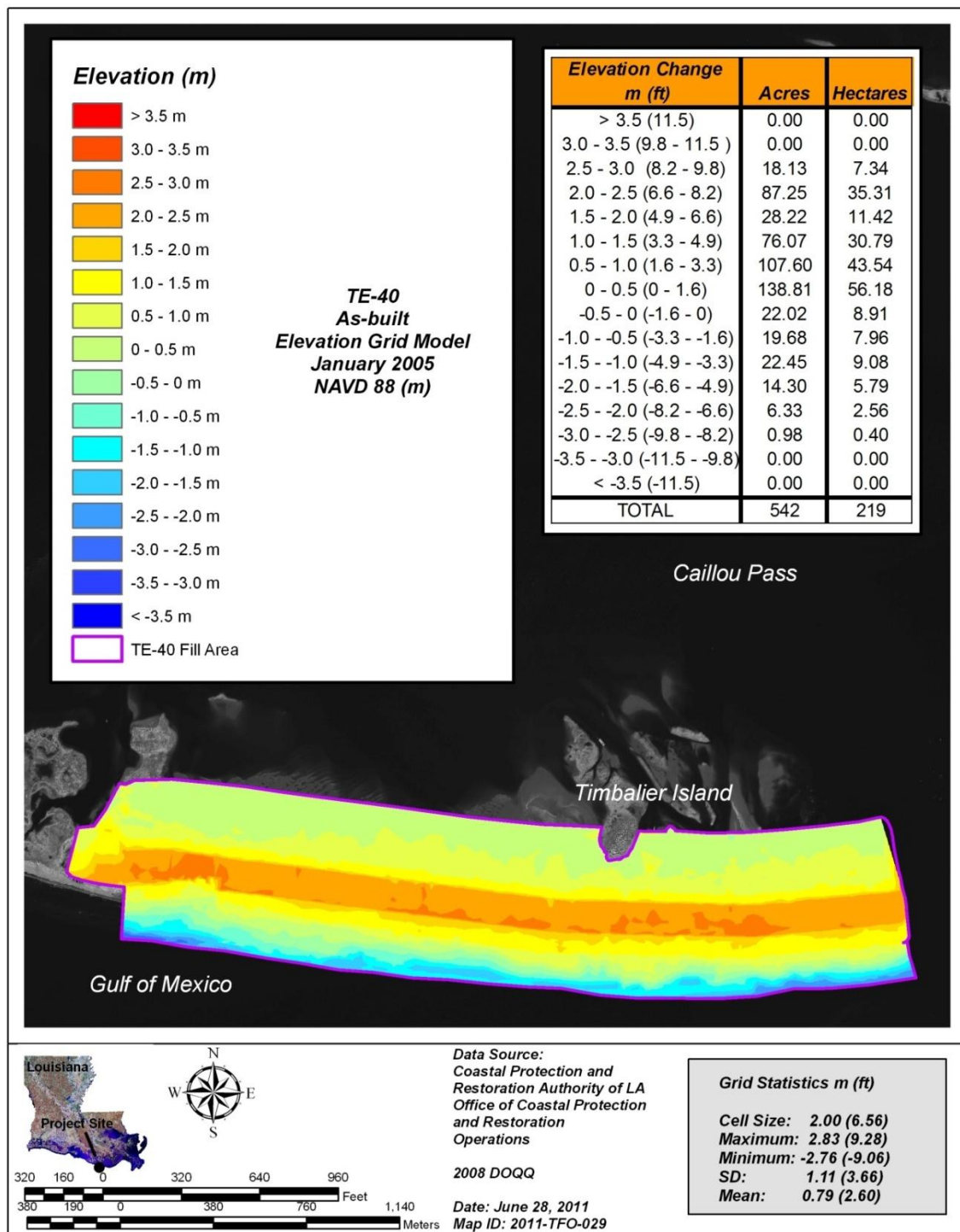


Figure. As-built (January 2005) elevation grid model of the Timbalier Island Dune/Marsh Restoration (TE-40) fill area.

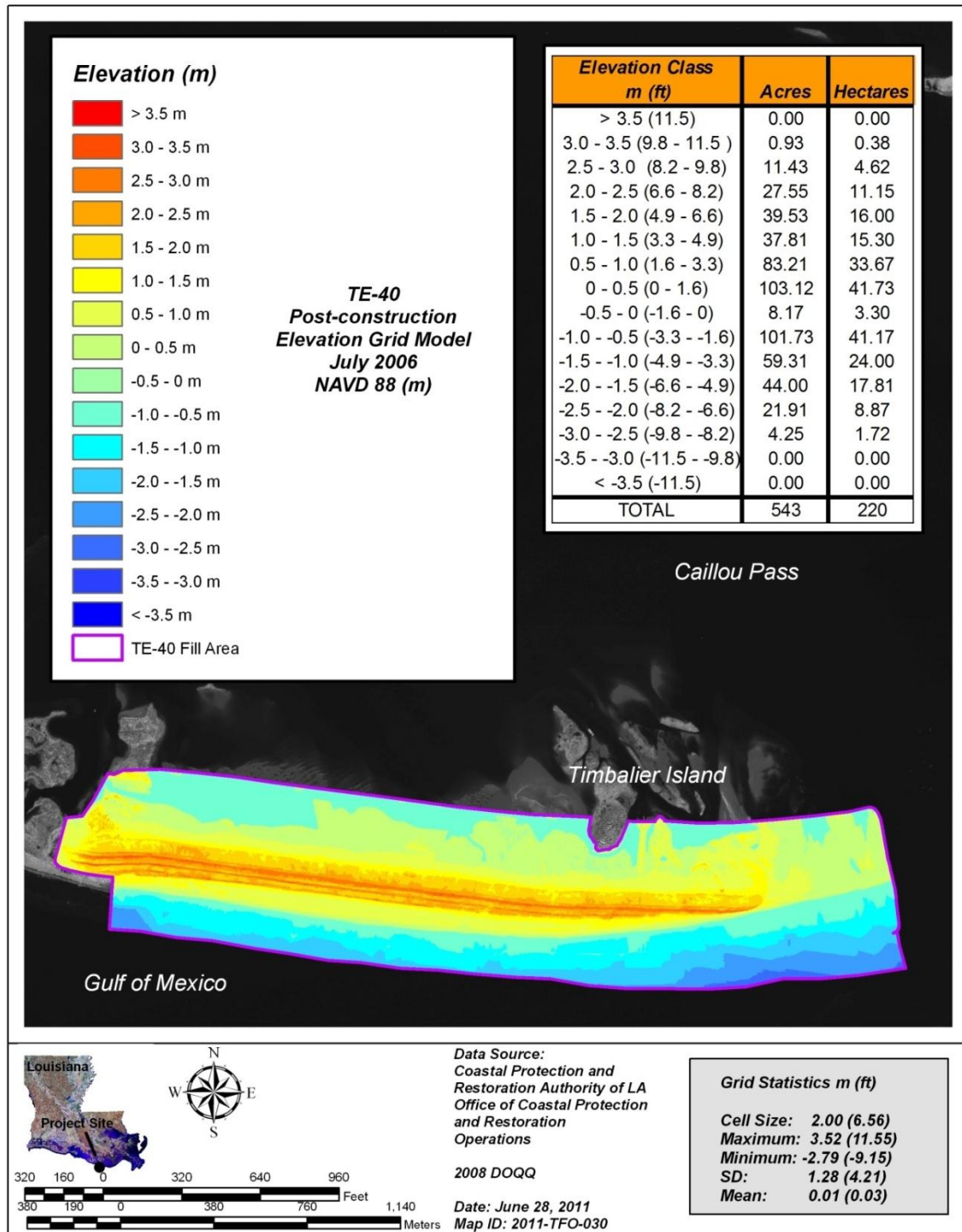


Figure. Post-construction (July 2006) elevation grid model of the Timbalier Island Dune/Marsh Restoration (TE-40) fill area.

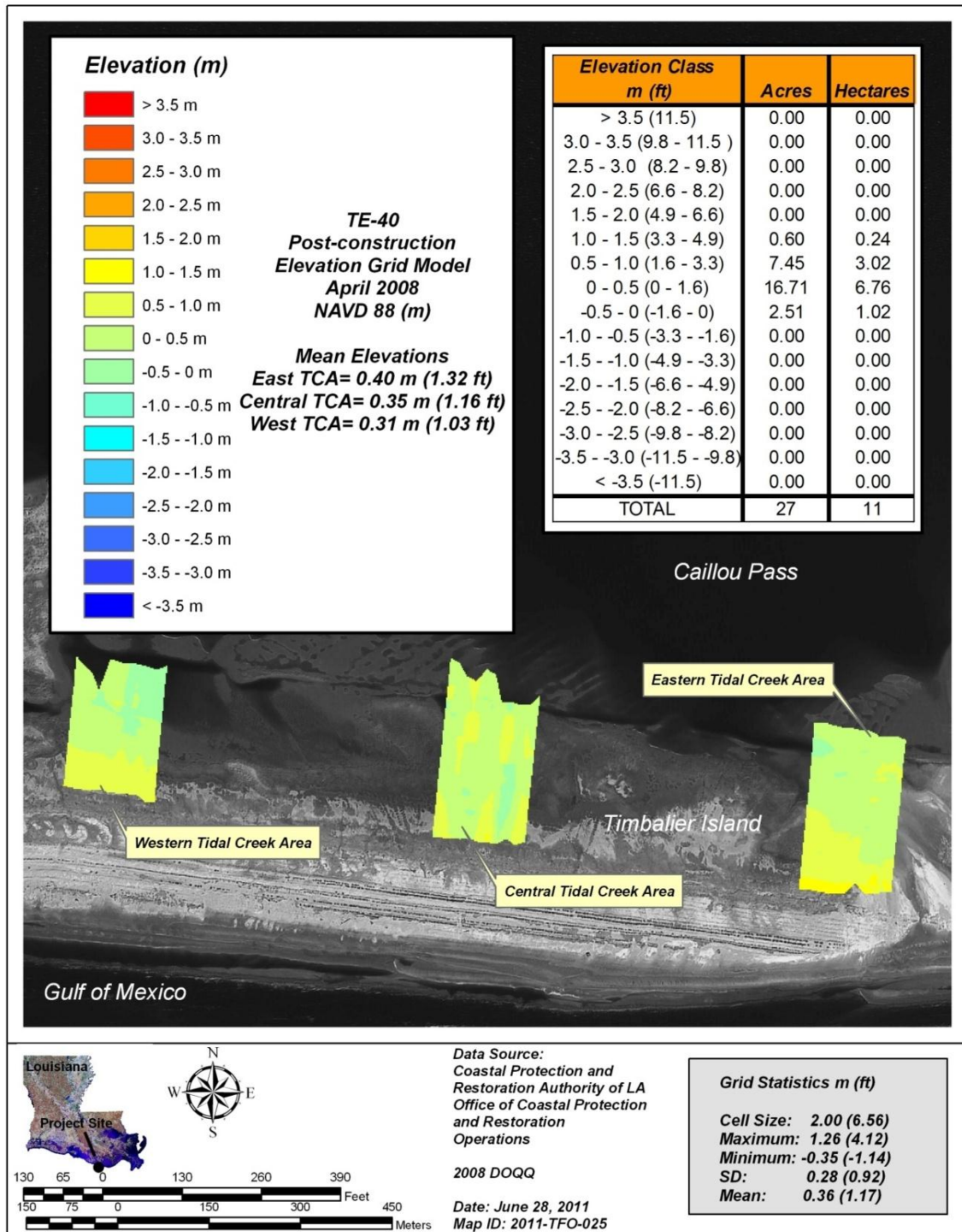


Figure. Post-construction (April 2008) elevation grid model of the Timbalier Island Dune/Marsh Restoration (TE-40) tidal creek areas.

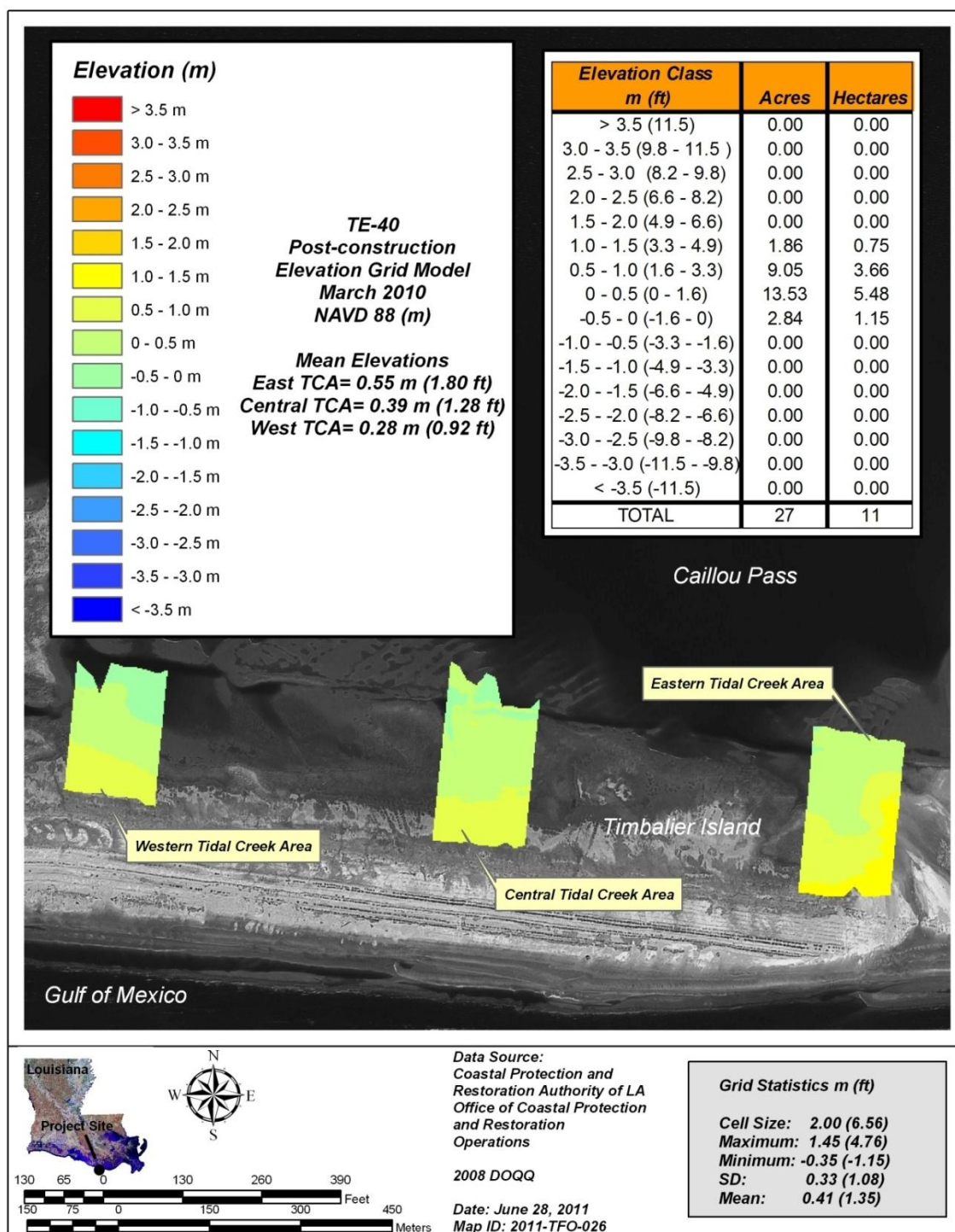


Figure. Post-construction (March 2010) elevation grid model of the Timbalier Island Dune/Marsh Restoration (TE-40) tidal creek areas.

Appendix D

(TE-40 Habitat Maps)

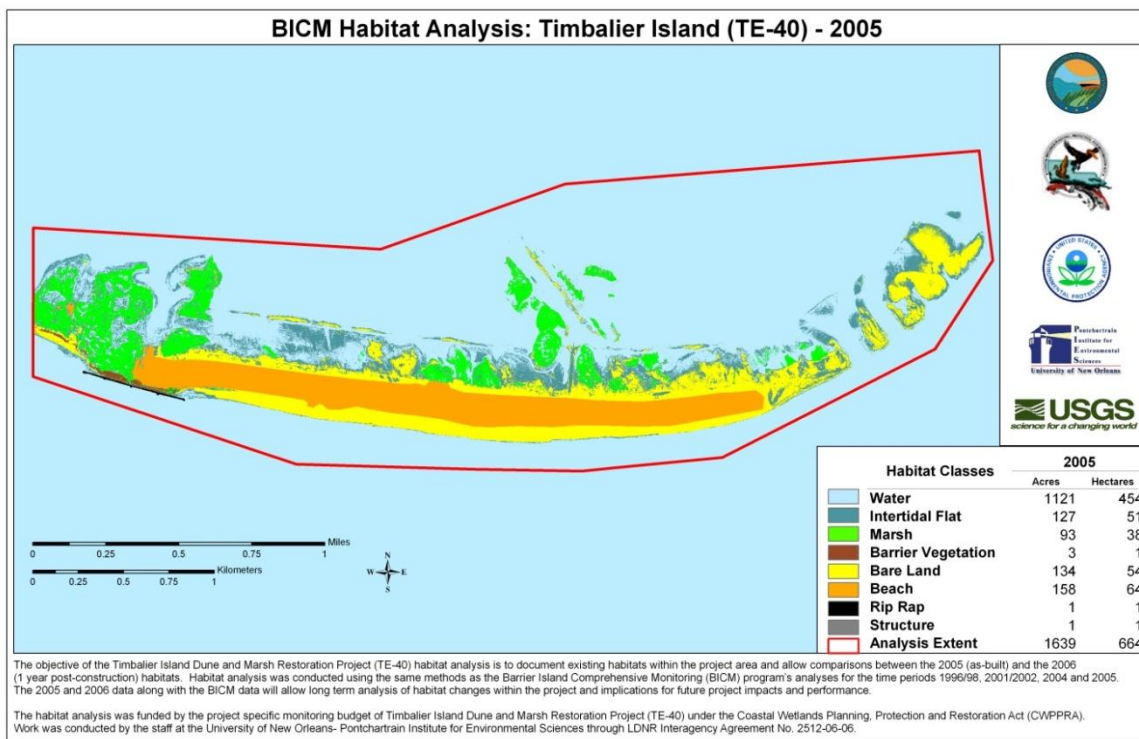


Figure. Jan 2005 habitat classification of Timbalier Dune/Marsh Restoration (TE-40) project.

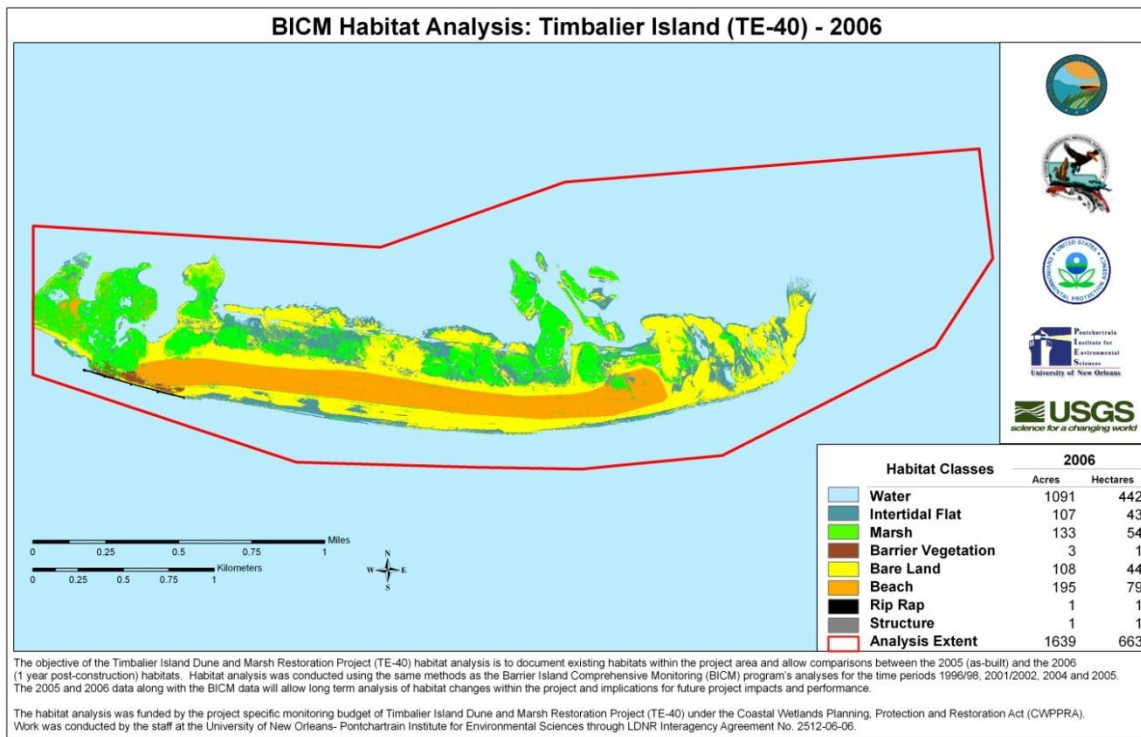


Figure. Nov 2006 habitat classification of Timbalier Dune/Marsh Restoration (TE-40) project.