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Coastal Protection and Restoration Authority of Louisiana

Office of Coastal Protection and Restoration

2010 Operations, Maintenance, and Monitoring Report

for

Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37)

State Project Number BA-37
Priority Project List 11

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Lafourche Parish

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Operations, Maintenance, and Monitoring Report
For
Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake
(BA-37)

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I. Introduction

The Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project is a shoreline protection, marsh creation, and marsh nourishment restoration project located in the southwestern portion of the Barataria Basin in Lafourche Parish, LA (figure 1). The project area consists of 556 ha (1,374 acres) of intermediate marsh and open water habitat found along the southern lake rim of Little and Round Lakes. The project was federally sponsored by the National Marine Fisheries Service (NMFS) and locally sponsored by 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 shoreline protection phase of this restoration project extends for 7,917 m (25,976 ft) from the eastern bank of the Breton Canal to the western bank of John the Fool Bayou along the southern shoreline of Little and Round Lakes (figure 2). The marsh creation and nourishment phase of the BA-37 project forms its eastern border with the western bank of John the Fool Bayou, its western border with the eastern bank of the Tennessee Gas Pipeline Canal, and its northern border with the southern Round Lake shoreline (figure 2). The Bayou L'Ours Ridge lies directly south of the project, and the Louisiana Offshore Oil Port's (LOOP) oil storage caverns and brine retention pond are situated southwest of the project (figure 2).

The Bayou L'Ours subdelta was formed during the Lafourche deltaic lobe period (Gagliano and Wicker 1989). During this time, Bayou Lafourche and its network of distributaries comprised the main channel of the Mississippi River. Nutrient rich sediments were deposited along the banks of these distributaries primarily through overbank flooding (Sasser and Evers 1995). As a result, a ridge network (natural levees) was established along these channels creating enclosed basins encircled by elevated ridges (Gagliano and Wicker 1989).

In the years since the creation of the Lafourche delta, the sediment and freshwater supply to the Bayou L'Ours subdelta has decreased considerably. The Mississippi River changed its course to form the Plaquemine and Balize deltaic lobes, a dam was placed at the junction of the Mississippi River and Bayou Lafourche in 1904, and the Mississippi River was channelized by the construction of artificial levees along its banks. In addition, Bayou L'Ours has become a relict distributary of Bayou Lafourche (Sasser and Evers 1995). Therefore, the hydrology of the Barataria Basin as well as the Bayou L'Ours subdelta has been altered by natural and anthropogenic changes in freshwater and sediment distributions.

The reduced freshwater and sediment supply has been a major influence in the formation of highly organic freshwater and intermediate marshes surrounded by slowly subsiding ridges and lake rims composed of mineral sediment deposits (Gagliano and Wicker 1989; Sasser and Evers 1995). These impounded organic marshes formed a floating marsh mat (flotant) overlying a layer of peat and organic muck (Gagliano and Wicker 1989; Sasser and Evers 1995). Sediment-poor organic soils accrete vertically predominately through slow oxidation

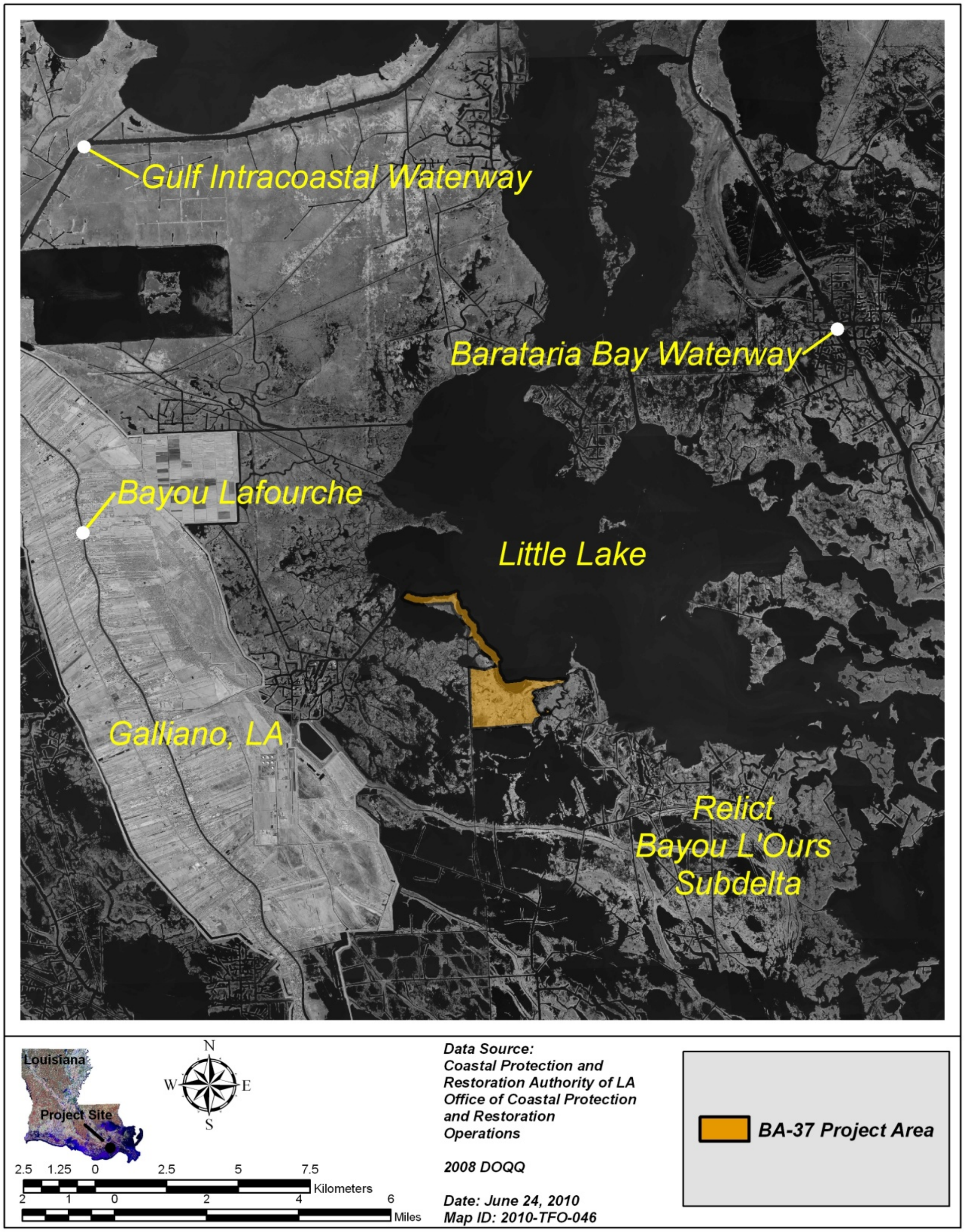


Figure 1. **Location and vicinity of the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

Figure 2. Location of the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project area.

of decaying plant matter and vegetative growth (root elongation) (Nyman et al. 1993; Delaune et al. 1993).

The soils found in the BA-37 project area are composed of a Lafitte-Clovelly association. These organic soils are generally found in very poorly drained brackish marshes (USDA 1984). Chabreck and Linscombe classified the project area as intermediate marsh in 1997, brackish to intermediate marsh in 1988, and brackish marsh in 1978. The area was also classified as brackish marsh by Chabreck et al. in 1968 and as floating three corner grass marsh by O'Neil in 1949. This area has been mapped as *Spartina patens (Ait.) Muhl.* (saltmeadow cordgrass) and *Schoenoplectus americanus (Pers.) Volk. ex Schinz & R. Keller* (chairmaker's bulrush) brackish marsh (Sasser and Evers 1995; USDA 1984). *Eleocharis parvula (Roemer & J.A. Schultes) Link ex Bluff, Nees & Schauer* (dwarf spikerush), *Bacopa monnieri (L.) Pennell* (herb of grace), and *Ipomoea sagittata Poir.* (saltmarsh morning-glory) have also been found to inhabit Lafitte-Clovelly association soils (USDA 1984).

There was very little marsh degradation in the Bayou L'Ours basin until the advent of canal dredging for pipeline construction and oil field access in the 1940's (Gagliano and Wicker 1989). During the 1950's and 1960's, several rather deep access canals were allowed to breach the Bayou L'Ours ridge creating large gaps in the ridge which significantly altered the hydrology in the semi enclosed basin (Gagliano and Wicker 1989; Sasser and Evers 1995). These canals decreased the marsh surface elevations of the highly organic marsh mats, and introduced saltwater into a fresh and intermediate marsh environment. Tidal scouring of organic sediments, vegetation die-back, and subsidence resulted in extensive interior wetland loss (Gagliano and Wicker 1989; Sasser and Evers 1995). Land loss data indicate that wetland area in the Bayou L'Ours basin decreased by 6,085 acres (2,434 ha) and total open water increased by 6,197 acres (2,509 ha) during the period from 1945 to 1989 (Sasser and Evers 1995). Specifically, the marshes between the Bayou L'Ours ridge and the Little and Round Lake rims showed considerable interior wetland loss from 1956 to 1978 (Sasser and Evers 1995). The marsh creation and nourishment area continued to experience large scale inland wetland loss from 1978 to 1990 (figure 3) (Barras et al. 1994). These marshes are reportedly subsiding at a rate of 0.006-0.011 m/yr (0.021-0.035 ft/yr) (Sweeney 2001). The Little and Round Lake rims have continually transgressed from 1956 to1990 and are reportedly eroding at a rate of 6-12 m/yr (20-40 ft/yr) (Sweeney 2001).

The Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project consist of two major features, a shoreline protection structure and marsh creation and nourishment area. A 7,917 m (25,976 ft) foreshore rock dike was constructed along the -0.6 m (-2 ft) NAVD 88 contour of Little and Round Lakes (figure 3). The rock dike was constructed by placing rocks on top of a geotextile foundation. The dike was constructed using three lifts. All segments of the 7,917 m (25,976 ft) dike received the first two rock lifts, and 5,804 m (19,041 ft) of the dike was recapped during the third lift (figure 3). Approximately, 145,528 tons of 250 lbs class rocks were used to construct the first two lifts

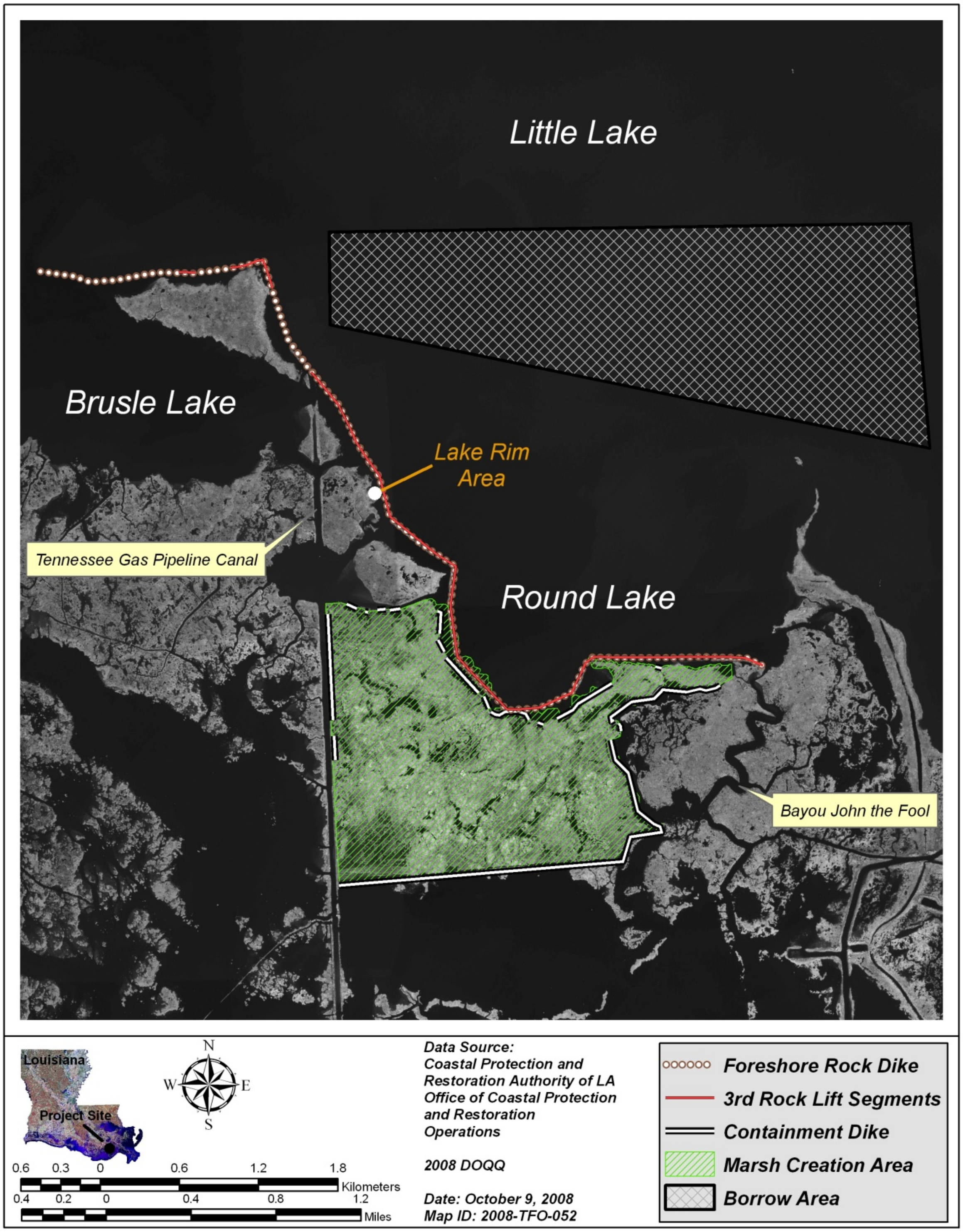


Figure 3. Location of the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project features.

and 29,762 tons of R650 class rocks were used to construct the third lift. The two lift segments of the dike were built to an elevation of 0.8 m (2.5 ft) NAVD 88 while the third lift segments were built to elevations of 1.1 m (3.5 ft) NAVD 88 and 1.2 m (4.0 ft) NAVD 88. Fish dips (breaches in the rock structure) were installed in the foreshore rock dike every 305 to 457 m (1,000 to 1,500 ft) for fisheries access. Construction of the BA-37 foreshore rock dike began on March 21, 2006 and was completed by February 11, 2007. The marsh creation and nourishment phase of this project consisted of three project features: containment dikes, marsh creation in open water areas, and marsh nourishment over existing marsh. Several earthen containment dikes were placed along border of the marsh creation and nourishment area (figure 3). These structures were built to an elevation of 1.1 m (3.5 ft) NAVD 88. The sediments dredged from Little Lake were pumped into the marsh creation and nourishment disposal area (figure 3). Approximately, 372 ha (920 acres) of marsh platform were created and nourished during construction. These constructed marshes were raised to a 0.72 m (2.36 ft) NAVD 88 elevation. After sediment consolidation, the containment dike was gapped in several locations. Construction of the BA-37 marsh creation and nourishment area began on November 26, 2005 and ended on August 14, 2006. A Coast-wide Reference Monitoring System-*Wetlands* (CRMS) site (CRMS6303) was added to the marsh creation and nourishment area after construction on October 24, 2008 (figure 2).

II. Maintenance Activity

a. Inspection Purpose and Procedures

The purpose of the annual inspection of the Little Lake Shoreline Protection / Dedicated Dredging near Round Lake Project (BA-37) is to evaluate the constructed project features in order to identify any deficiencies. The inspection results are used to prepare a report detailing the condition of the project features and recommending any corrective actions considered necessary. Should it be determined that corrective actions are needed, the OCPR shall provide, in the report, a detailed cost estimate for engineering, design, supervision, inspection, construction, and contingencies and an assessment of the urgency of such repairs (O&M Plan, 2008). The annual inspection report also contains a summary of maintenance projects which were completed since completion of constructed project features and an estimated projected budget for the upcoming three (3) years for operation, maintenance, and rehabilitation. The three (3) year projected operation and maintenance budget is shown in Appendix A. A summary of past operation and maintenance projects completed since construction of the Little Lake Shoreline Protection / Dedicated Dredging near Round Lake Project is outlined in Section IV.

The annual inspection of the Little Lake Shoreline Protection / Dedicated Dredging Near Round Lake Project (BA-37) took place on May 11, 2010. In attendance were Daniel Dearmond and Glen Curole from OCPR; Joy Merino, Lisa Abernathy, and Rick Hartman with NMFS. The attendees met at the Clovelly Canal Public Boat Launch and traveled to the project site by boat. A water elevation reading of 1.38 ft was taken at BA02-SG-57 at approximately 10:15 am. The annual inspection began at approximately 10:30 a.m. at the west end of the rock shoreline protection at Segment 1 in Bay L'Ours and ended at the southwest corner of the marsh creation area. The field trip included a visual inspection of the 24 rock dike segments of the shoreline protection, all warning signs, and the outer edges of the marsh creation area. The marsh creation area was viewed from the northern boundary along the south shoreline of Round Lake and at the southwest corner of the marsh creation area. Water elevation readings were 1.7 ft at 11:20 a.m. at the Bayou John the Fool gage and 1.6 ft at 11:55 a.m. at the gage near the camp in the Tennessee Gas Pipeline (TGP) Canal. A water elevation reading of 1.6 ft was also taken from the CRMS 6303 gage at 12:20 pm. The inspection ended at approximately 12:30 pm. Photographs from the inspection are located in Appendix B.

b. Summary of Past Operation and Maintenance Projects

Below is a summary of completed maintenance projects and operation tasks performed since completion of the Little Lake Shoreline Protection / Dedicated Dredging Near Round Lake Project (BA-37).

May 2008 – Survey of marsh creation area was performed by Shaw Coastal, Inc. The marsh elevations at the grid points within the marsh creation area as well as top elevations of the 24 rock dike settlement plates were collected. This survey represents the first of the scheduled O&M surveys to be performed but is actually the second post-construction survey. The first post-construction survey was performed by Shaw Coastal, Inc. in May 2007 with remaining construction funds immediately following acceptance of the project. The actual surveying consultant costs associated with the 2008 survey was $36,007.28.

July 2009 – Survey of marsh creation area was performed by Shaw Coastal, Inc. The marsh elevations at the grid points within the marsh creation area as well as top elevations of the 24 rock dike settlement plates were collected. This survey represents the second of the scheduled O&M surveys to be performed but is actually the third post-construction survey. The first post-construction survey was performed by Shaw Coastal, Inc. in May 2007 with remaining construction funds immediately following acceptance of the project. The actual surveying consultant costs associated with the 2009 survey was $42,590.40.

July 2010 – Survey of marsh creation area was performed by Morris Hebert, Inc. The marsh elevations and the grid points within the marsh creation area as well as the tops elevations of the rock dike settlement plates were collected. This survey represents the third of the scheduled O&M surveys to be performed but is actually the forth post-construction survey. The first post-construction survey was performed by Shaw Coastal, Inc. in May 2007 with remaining construction funds immediately following acceptance of the project. The actual surveying consultant costs associated with the 2010 survey is $23,500.

c. Inspection Results

Rock Segments 1 – 24 (Photos 1 – 18, 20 - 25, Appendix B)
All rock segments were inspected by boat. During the time the rock segments were inspected, the water elevation was approximately EL 1.7 ft. NAVD88 according to the construction project tide gage at Bayou John the Fool. Using the water elevation as a reference, the following approximate rock segment elevations were estimated by observations:

Rock Segment	**Approximate Estimated** Elevation (FT, NAVD88)	As-Built Elevations (FT, NAVD88)
Segments 3, 4, 5, 8, and 9*	< EL 2.5*	EL 2.5 – 3.0
Segments 1, 2, 6 and 7	≈ EL 2.5 – 3.0	EL 2.5 – 3.0
Segments 10 – 24	≥ EL 3.0	EL 3.2 – 4.0

* Portions of these segments are at or below EL 2.5 ft. NAVD88 but not less than EL 2.0 ft.NAVD88 based on observed tide gage readings.

It appears that all segments have experienced some amount of settlement as is expected. Clearly the segments that did not receive a third lift during construction (1 - 5, 8, and 9) are the lowest elevation segments with some portions of the segments below EL 2.5 ft. Check points along the rock segments will be collected during the 2011 O&M survey to verify the rock segment elevations observed. No maintenance will be required along the rock dike at this time. The segments should continue to be monitored for settlement.

As described above, the elevations of the settlement plates were surveyed in 2008, 2009, and 2010. See Figure 4. Comparing the final construction survey elevations of the settlement plates (February 2007) to the latest settlement plate survey (July 2010) indicates an average settlement of 0.30 feet across the 24 segments. The settlements observed varied from no change to a maximum of 0.5 feet. The time between the surveys was 1261 days. As per the O&M Plan, the settlement plates will continue to be surveyed annually for the first five years (along with the marsh creation area) and then in years 10 and 15. And as noted above we will also obtain the top of rock dike check elevations along with the settlement plates to better determine settlement since construction and possible maintenance lift needs.

Spoil that was placed behind the rock dike segments has fully vegetated. Also, it appears from aerial photographs that the SAV (submerged aquatic vegetation) has increased behind the rock dike segments as well.

<u>Marsh Creation Area</u> (Photos 19, 26 – 28, Appendix B)

The fill material in the marsh creation area has fully vegetated. As mentioned above, marsh creation area grid point "O&M" surveys were performed in May 2008, June 2009, and July 2010 as well as "as-built" and 9-month post-placement (May 2007) surveys. Figure 5 is a map showing the elevations associated with the "as-built", 9-month post-placement (May 2007), and May 2008 surveys of the marsh creation area. Additionally, Figure 6 is a map showing elevations from the last two surveys (2009 and 2010). The average grid elevations for the marsh creation area surveys are shown in the table below.

Survey	Average Grid Elevation (FT, NAVD88)
As-Built (May-Aug 2006)	2.2
Post-Construction (May 2007)	1.49
Post-Construction (May 2008)	1.40
Post-Construction (June 2009)	1.14
Post-Construction (July 2010)	1.23

Although there are two additional "O&M" surveys scheduled (of the five annual surveys for the first five years), we recommend only one of the remaining surveys be performed. A survey was performed in May 2007 with remaining construction funds, and this data serves as the first of the five annual surveys after construction completion. There will also be "O&M" surveys of the marsh creation area in Years 10 and 15 as per the O&M Plan.

SETTLEMENT PLATES

		CONSTRUCTION						POST-CONSTRUCTION				POST-CONSTRUCTION				POST-CONSTRUCTION			
S.P. #	STATION	DATE INSTALLED	ELEV. INST.	FINAL ELEV.	DATE OF FINAL ELEV.	Δ (FT) (INST. TO FINAL)	TIME (DAYS)	2008 ELEV.	DATE OF 2008 ELEV.	Δ (FT) (FINAL TO 2008)	TIME (DAYS)	2009 ELEV.	DATE OF 2009 ELEV.	Δ (FT) (FINAL TO 2009)	TIME (DAYS)	2010 ELEV.	DATE OF 2010 ELEV.	Δ (FT) (FINAL TO 2010)	TIME (DAYS)
1	14+23	11/27/06	**6.48**	**5.87**	02/11/07	-0.61	76	**5.71**	05/02/08	-0.16	446	**5.62**	08/20/09	-0.25	921	**5.60**	07/26/10	-0.27	1261
2	23+93	11/14/06	**6.32**	**3.95**	02/11/07	-2.37	89	**3.60**	05/02/08	-0.36	446	**3.48**	08/20/09	-0.48	921	**3.56**	07/26/10	-0.39	1261
3	34+22	11/09/06	**7.02**	**5.17**	02/11/07	-1.85	94	**4.93**	05/02/08	-0.23	446	**4.94**	08/20/09	-0.23	921	**4.94**	07/26/10	-0.23	1261
4	44+41	11/06/06	**6.96**	**4.57**	02/11/07	-2.39	97	**4.41**	05/02/08	-0.16	446	**4.46**	08/20/09	-0.12	921	**4.32**	07/26/10	-0.25	1261
5	54+75	11/06/06	**7.71**	**5.90**	02/11/07	-1.81	97	**5.66**	05/02/08	-0.23	446	**5.65**	08/20/09	-0.25	921	**5.48**	07/26/10	-0.42	1261
6	63+17	11/05/06	**6.98**	**4.70**	02/11/07	-2.28	98	**4.70**	05/02/08	0.00	446	**4.61**	08/20/09	-0.09	921	**4.56**	07/26/10	-0.14	1261
7	71+47	11/05/06	**7.92**	**4.42**	02/11/07	-3.50	98	**4.08**	05/02/08	-0.34	446	**4.03**	08/20/09	-0.39	921	**4.20**	07/26/10	-0.23	1261
8	82+37	10/25/06	**6.98**	**5.51**	02/11/07	-1.47	109	**5.32**	05/02/08	-0.19	446	**5.29**	08/20/09	-0.22	921	**5.33**	07/26/10	-0.18	1261
9	92+32	10/26/06	**6.70**	**5.84**	02/11/07	-0.86	108	**5.82**	05/02/08	-0.02	446	**5.82**	08/20/09	-0.02	921	**5.83**	07/26/10	-0.01	1261
10	102+21	09/28/06	**6.96**	**5.28**	02/11/07	-1.68	136	**5.18**	05/02/08	-0.10	446	**5.08**	08/20/09	-0.20	921	**5.26**	07/26/10	-0.02	1261
11	112+90	09/01/06	**6.40**	**4.19**	02/11/07	-2.21	163	**3.82**	05/02/08	-0.37	446	**3.69**	08/20/09	-0.50	921	**3.86**	07/26/10	-0.33	1261
12	123+14	07/09/06	**7.74**	**6.16**	02/11/07	-1.58	217	**5.74**	05/02/08	-0.41	446	**5.68**	08/20/09	-0.48	921	**5.66**	07/26/10	-0.50	1261
13	133+25	07/06/06	**7.32**	**3.61**	02/11/07	-3.71	220	**3.24**	05/02/08	-0.37	446	**3.09**	08/20/09	-0.53	921	**3.14**	07/26/10	-0.48	1261
14	144+18	06/27/06	**6.68**	**5.56**	02/11/07	-1.12	229	**5.38**	05/02/08	-0.18	446	**5.40**	08/20/09	-0.16	921	**5.29**	07/26/10	-0.27	1261
15	154+23	06/16/06	**7.02**	**5.17**	02/11/07	-1.85	240	**4.93**	05/02/08	-0.24	446	**4.96**	08/20/09	-0.21	921	**4.71**	07/26/10	-0.45	1261
16	164+05	06/03/06	**6.95**	**6.10**	02/11/07	-0.85	253	**5.93**	05/02/08	-0.17	446	**5.86**	08/20/09	-0.24	921	**5.82**	07/26/10	-0.28	1261
17	175+51	05/21/06	**7.53**	**6.36**	02/11/07	-1.17	266	**6.27**	05/02/08	-0.10	446	**6.27**	08/20/09	-0.09	921	**6.15**	07/26/10	-0.21	1261
18	190+71	05/18/06	**7.68**	**5.97**	02/11/07	-1.71	269	**5.74**	05/02/08	-0.23	446	**5.60**	08/20/09	-0.38	921	**5.58**	07/26/10	-0.39	1261
19	203+43	05/06/06	**8.51**	**6.27**	02/11/07	-2.24	281	**6.09**	05/02/08	-0.18	446	**5.94**	08/20/09	-0.33	921	**5.85**	07/26/10	-0.41	1261
20	216+05	04/11/06	**7.80**	**5.65**	02/11/07	-2.15	306	**5.52**	05/02/08	-0.13	446	**5.34**	08/20/09	-0.30	921	**5.28**	07/26/10	-0.37	1261
21	229+62	04/05/06	**7.31**	**4.81**	02/11/07	-2.51	312	**4.65**	05/02/08	-0.15	446	**4.34**	08/20/09	-0.47	921	**4.41**	07/26/10	-0.40	1261
22	240+24	03/31/06	**8.38**	**4.58**	02/11/07	-3.80	317	**4.35**	05/02/08	-0.24	446	**4.26**	08/20/09	-0.32	921	**4.21**	07/26/10	-0.38	1261
23	250+46	03/26/06	**7.64**	**5.16**	02/11/07	-2.49	322	**4.99**	05/02/08	-0.17	446	**4.62**	08/20/09	-0.54	921	**4.79**	07/26/10	-0.37	1261
24	262+76	03/21/06	**8.26**	**6.71**	02/11/07	-1.55	327	**6.69**	05/02/08	-0.02	446	**6.51**	08/20/09	-0.20	921	**6.51**	07/26/10	-0.20	1261

Δ (FT) – Change in Elevation between noted surveys in feet

TIME (DAYS) – Time Elapsed between noted surveys in days

Figure 4. Rock Dike Settlement Plate Data.

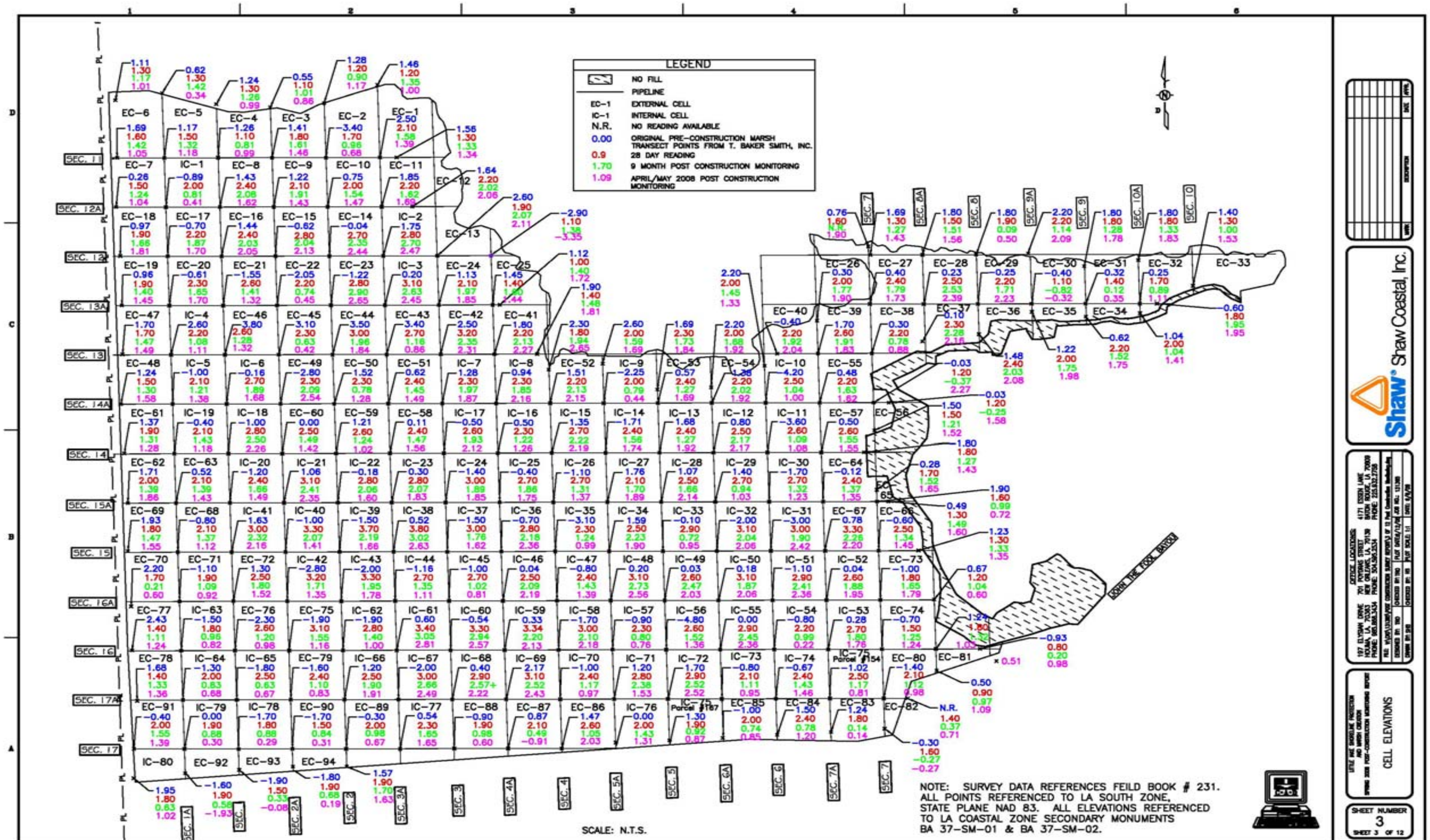


Figure 5. Marsh Creation Area Grid Survey showing Pre-Construction, As-Built (May-Aug 2006), May 2007, and May 2008 Elevations.

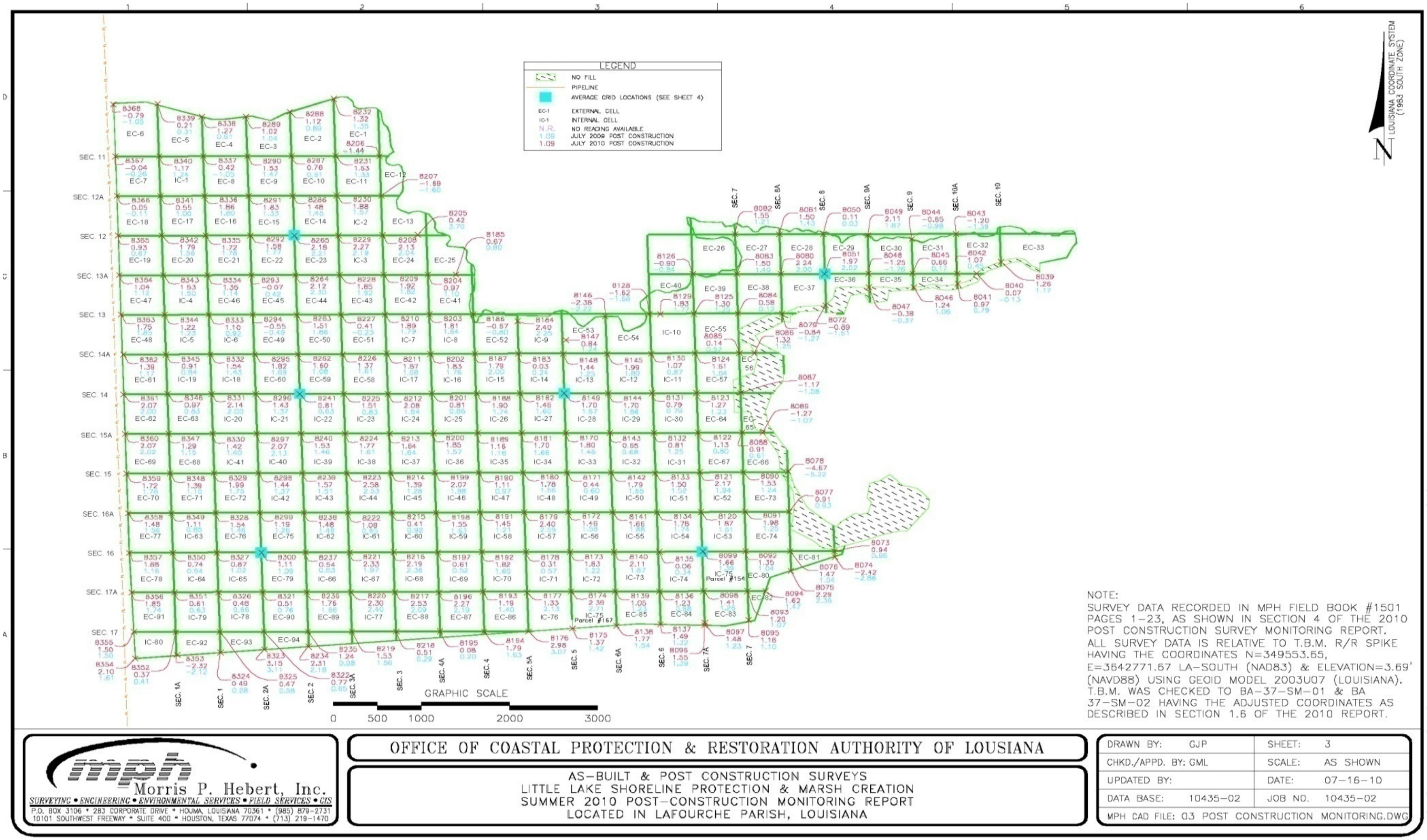


Figure 6. **Marsh Creation Area Grid Survey showing June 2009 and July 2010 Elevations.**

III. Operation Activity

No operation activities are required for the BA-37 project.

IV. Monitoring Activity

a. Monitoring Goals

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

1. Reduce the marsh edge erosion rate along the Little and Round Lake shorelines.

2. Create approximately 551 acres (223 ha) of marsh at suitable elevations for growth and establishment of intermediate or brackish emergent vegetation.

3. Nourish approximately 406 acres (164 ha) of existing marsh to enhance the growth and establishment of intermediate or brackish emergent vegetation.

4. Maintain 799 acres (323 ha) of emergent marsh at the end of the 20 year project life.

b. Monitoring Elements

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

Elevation

Topographic surveys were employed to document elevation and volume changes inside the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project area. Pre-construction (December 2005), and as-built (August 2006) elevation data were collected in the marsh creation area using cross sectional (500 ft intervals) and real time kinematic (RTK) survey methods. Subsequent post-construction topographic surveys were performed in June 2007, May 2008, August 2009, and August 2010. In addition, twenty-four (24) settlement plates were surveyed using RTK methods to estimate foreshore rock dike subsidence. The settlement plates were surveyed during installation (March to November 2006), during the second rock lift (August 2006 to January 2007), during the as-built survey (February 2007), and during the post-construction period in May 2008, August 2009, and July 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 m^2 cell size), and the spatial distribution of elevations were mapped. The grid models were clipped to the BA-37 marsh creation area and settlement plate polygons to estimate elevation and volume changes.

Elevation changes from December 2005-August 2006, August 2006-June 2007, August 2006-May 2008, August 2006-August 2009, and August 2006-August 2010 in the marsh creation area were calculated by subtracting the corresponding grid models using the LIDAR Data Handler extension of ArcView® GIS. Settlement plate elevation changes were calculated using the aforementioned procedures in November 2006-January 2007, November 2006-Feburary 2007, November 2006-May 2008, November 2006-August 2009, and November 2006-July 2010. After the elevation change grid models were generated, the spatial distribution of elevation changes in the BA-37 marsh creation area and on the settlement plates were mapped in quarter meter elevation classes. Lastly, volume changes in the marsh creation area were calculated in cubic meters (m^3) using the Cut/Fill Calculator function of the LIDAR Data Handler extension of ArcView® GIS. Volumes changes were not calculated for the settlement plates because foreshore rock dike subsidence was the parameter investigated. Note, these elevation and volume calculations are valid only for the extent of the survey area.

Shoreline Change

Shoreline position data were analyzed to estimate shoreline changes inside the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project area 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 1:800 scale as per the Steyer et al. (1995) method, which defines shoreline position as the edge of the live emergent vegetation. The resulting polylines established the shoreline positions in UTM NAD 83 coordinates. Pre-construction and post-construction aerial photographs were acquired over an eleven year period to discern the foreshore rock dike's affect on shoreline erosion rates. Pre-construction aerial photographs were collected on February 4, 1998; April 15, 2003; January 25, 2004; and November 1, 2005 while post-construction aerial photographs were captured on September 20, 2007 (6 months post-construction) and October 29, 2008 (1.5 years post-construction). All images were georectified using UTM NAD 83 horizontal datum.

The February 1998, April 2003, January 2004 and November 2005 shorelines were created in ArcView® GIS software to establish pre-construction shoreline change rates, and the September 2007 and October 2008 shorelines were created to establish post-construction shoreline change rates. Secondly, an offshore baseline was generated from an offset of the February 1998 shoreline. Thirdly, the DSAS attribute editor was populated by identifying shorelines and the baseline and dating shorelines. Next, 1000 m (3280 ft) simple transects were cast from the baseline at 50 m (164 ft) intervals producing shoreline change, intersect, and transect shapefiles. Then, these shapefiles were edited by eliminating transects that intersect the shorelines at irregular angles. Finally, shoreline change data were imported into Excel® to calculate average and annual erosion rates for each period. Shoreline change rates were assessed and mapped for the ensuing periods February 1998-April 2003, April 2003-January 2004, January 2004-November 2005, February 1998-November 2005, and September 2007-October 2008 for the area behind the 7,925 m (26,000 ft) BA-37 foreshore rock dike. In addition to this holistic rate (combined total), the post-construction change rates (2007-2008) were also calculated for the marsh creation area and the lake rim area (project shoreline outside of marsh creation area) (figures 2 and 3) independently.

Land/Water Classification CRMS6303

Because of the inclusion of a Coast-wide Reference Monitoring System-*Wetlands* (CRMS) site (CRMS6303) inside the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project area (figures 2 and 7), land/water analysis was performed on a 1.0 km^2 (0.4 mi^2) portion of the marsh creation area. The U.S. Geological Survey's National Wetlands Research Center (USGS/NWRC) obtained 1.0 m (3.3 ft) resolution color infrared (CIR) aerial photography to delineate land and water habitats over time. A pre-construction aerial image was captured on November 1, 2005. This image was analyzed, interpreted, processed, and verified for quality and accuracy using protocols established in Folse et al. (2008). Specifically, habitats in the 1 km^2 (0.4 mi^2) were condensed to a land or water classification. Land was considered to be a combination of emergent marsh, scrub-shrub, wetland forested, and upland habitats. The open water, beach/bar/flat, and submerged aquatics (SAV) habitat classes were considered water. Once grouped into these two classes, the percentage of land and water and the land to water ratio for the pre-construction period were calculated. After the analysis was complete, the classification data and the photomosaic were mapped to spatially view the data.

Vegetation CRMS6303

Because of the inclusion of a Coast-wide Reference Monitoring System-*Wetlands* (CRMS) site (CRMS6303) inside the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project area (figures 2 and 7), vegetation data was collected in the marsh creation area. Vegetation stations were established in the BA-37 marsh creation area to document species composition and percent cover over time. Ten (10) plots were placed inside the 200 m^2 (239 yd^2) square, which is nested within the 1.0 km^2 (0.4 mi^2) square, as per Folse et al. (2008) (figure 7). Vegetation data were collected in October 2008 (2 year post-construction) and July 2009 (3 years

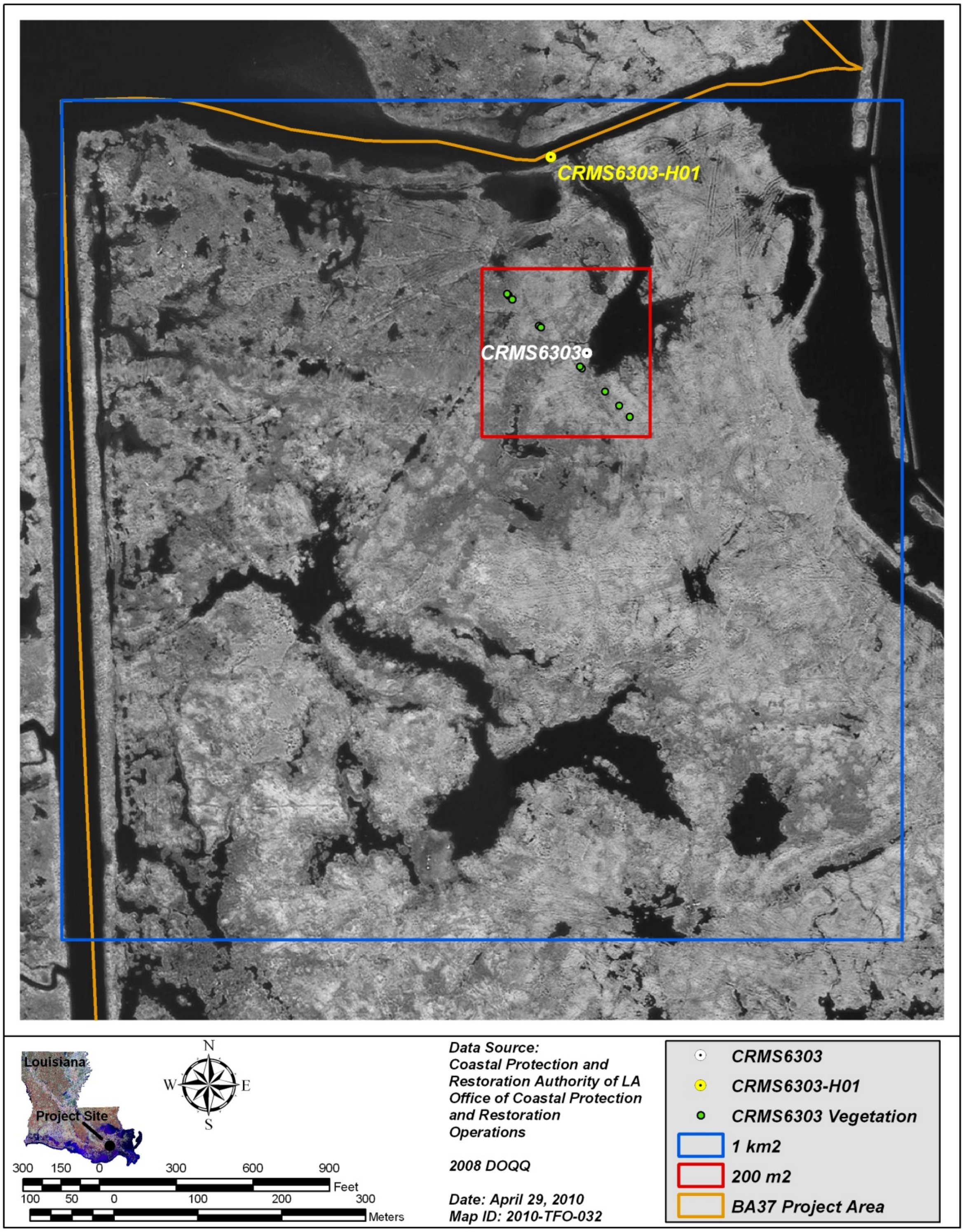


Figure 7. Location of CRMS6303 inside the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

post-construction) via the semi-quantitative Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974; Sawyer and Keeler-Wolf 1995; Barbour et al. 1999). Plant species inside each 4m^2 plot were identified, and cover values were ocularly estimated using Braun-Blanquet units (Mueller-Dombois and Ellenberg 1974) as described in Folse et al. (2008). The cover classes used were: solitary, <1%, 1-5%, 6-25%, 26-50%, 51-75%, and 76-100%. After sampling the plot, the residuals within a 5 m (16 ft) radius were inventoried.

Relative cover was calculated to summarize the vegetation data and was grouped by year. Relative cover represents the cover of each species as a percentage of total cover (Barbour et al. 1999). Since relative cover is relative measure, each species earns a value ranging from 0 to 100.

Hydrologic Data CRMS6303

Because of the inclusion of a Coast-wide Reference Monitoring System-*Wetlands* (CRMS) site (CRMS6303) inside the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project area (figures 2 and 7), hydrologic data is being collected in the marsh creation area. One (1) continuous recorder station was installed north of the 200 m^2 (239 yd^2) square and on the inner perimeter of the 1.0 km^2 (0.4 mi^2) square and the BA-37 project area using procedures established in Folse et al. (2008). The continuous recorder was adjusted to collect date/time (MM/DD/YYYY, hh:mm:ss) in central standard time (CST), temperature (°C), specific conductance (μS/cm), salinity (ppt), water level (ft), and battery voltage (V) data on an hourly interval. The station was deployed and serviced, and the data was processed and verified for quality and accuracy in accordance with the Folse et al. (2008) protocol. The continuous recorder station was established on October 24, 2008 and has been under constant operation since that time. Monthly mean water level and salinity data were calculated to summarize the data collected from this hydrologic monitoring station during the period from October 2008 to January 2010.

c. Preliminary Monitoring Results and Discussion

Elevation

The Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation and nourishment area experienced volume reductions since construction was completed in 2006. Elevation change and volume distributions for the BA-37 marsh creation area are shown in figure 8 (Dec 2005-Aug 2006), figure 9 (Aug 2006-Jun 2007), figure 10 (Aug 2006-May 2008), figure 11 (Aug 2006-Aug 2009), and figure 12 (Aug 2006-Aug 2010). Elevation grid models for the Dec 2005, Aug 2006, Jun 2007, May 2008, Aug 2009, and Aug 2010 surveys are also provided in appendix C. The volume and mean elevation changes inside the BA-37 constructed marsh are also plotted in figure 13. Approximately, 2,739,280 m^3 (3,582,843 yd^3) of sediment were deposited during construction in the marsh creation area (figures 8 and 13). In the post-construction period, sediment volume decreased by 29% from Aug 2006 to Jun 2007 (figures 9 and 13), by 35% from Aug 2006 to May 2008 (figures 10 and 13), by 44% from Aug 2006 to Aug 2009 (figures 11 and 13), and by 41% from Aug 2006 to Aug 2010 (figures 11 and 13). The total sediment volume loss in the marsh creation area from Aug 2006 to Aug 2010 was approximately 1,126,440 m^3 (1,473,328 yd^3). The corresponding post-construction mean elevation change inside the marsh creation area is graphically shown in figures 13 and 14 and the grid models in appendix C. Comparing the measured mean elevation changes to estimated values derived from consolidation curves for fill elevations of 0.55 m (1.80 ft), 0.64 m (2.10 ft), 0.72 m (2.36 ft) and 0.91 m (3.00 ft), reveal that marsh creation area is settling and subsiding in agreement with its fill elevation consolidation curve, 0.72 m (2.36 ft) (figure 14). These preliminary results provide evidence suggesting that marsh creation area is condensing at a sustainable rate. Therefore, the goals to create marsh at suitable elevations and nourish existing marsh were achieved, and the goal to maintain emergent marsh at the end of the 20 year project life is still attainable.

The Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) foreshore rock dike has incurred minor settlement since construction was completed in 2007. Elevation changes for the foreshore rock dike are delineated in figure 15 (Mar 2006-Feb 2007), figure 16 (Mar 2006-May 2008), figure 17 (Mar 2006-Aug 2009), and figure 18 (Mar 2006-Jul 2010). The rock dike settled 0.61 m (2.00 ft) during construction. This primary settlement of the dike occurred from settlement plate installation to the as-built survey (Mar 2006-Feb 2007) (figure 15). Post-construction secondary settlement of the foreshore rock dike has shown settlement of 0.06 m (0.23 ft) from Feb 2007 to May 2008 (figure 16), 0.09 m (0.30 ft) from Feb 2007 to Aug 2009 (figure 17) , and 0.09 m (0.30 ft) from Feb 2007 to Jul 2010 (figure 18). The rate of secondary settlement does not fit the predicted rock dike settlement curve established by Eustis (2003) during pre-construction. The measured value of secondary settlement is moderately larger than the estimated value (figure 19). However, the measured rate of secondary settlement has decreased from May 2008 to

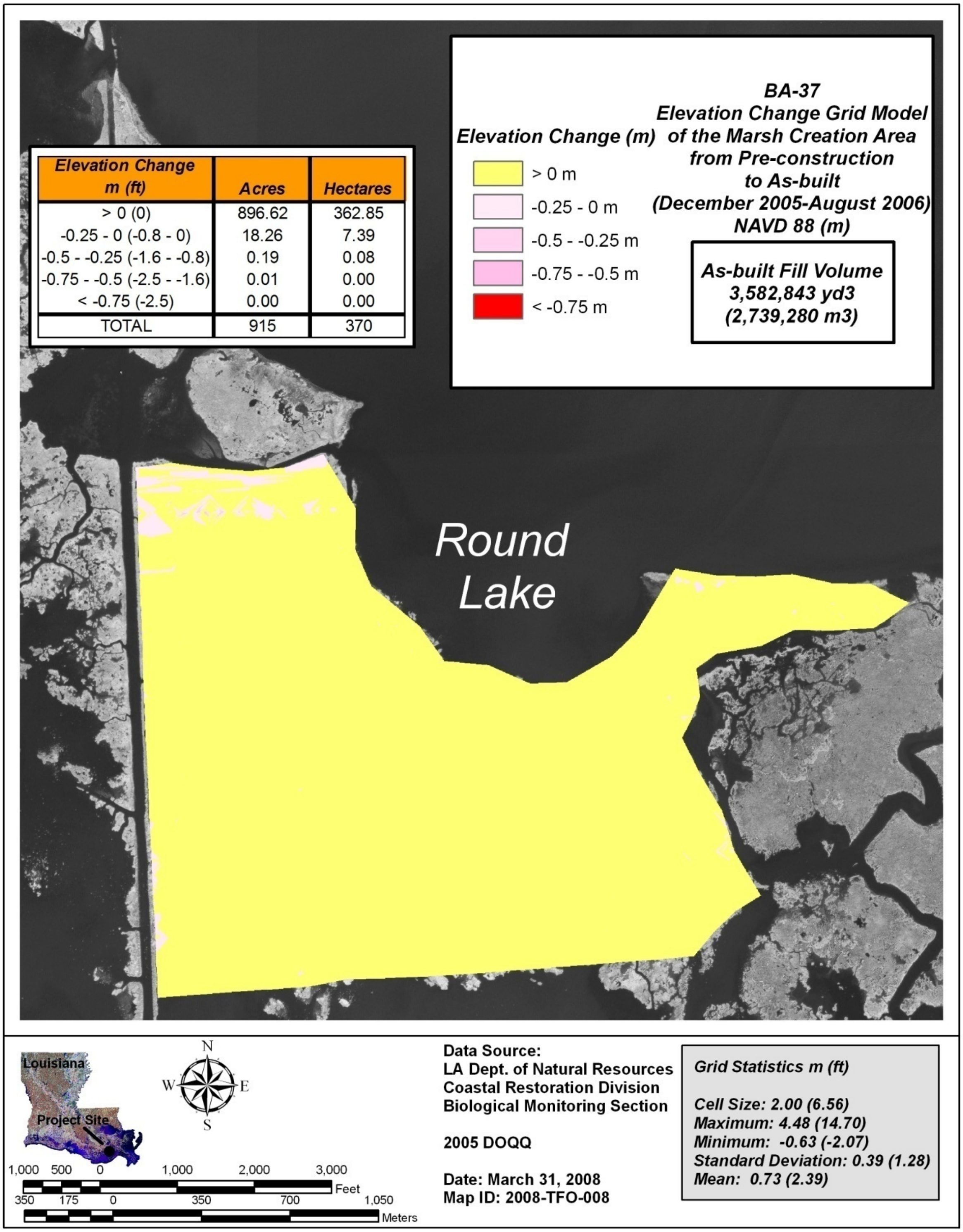
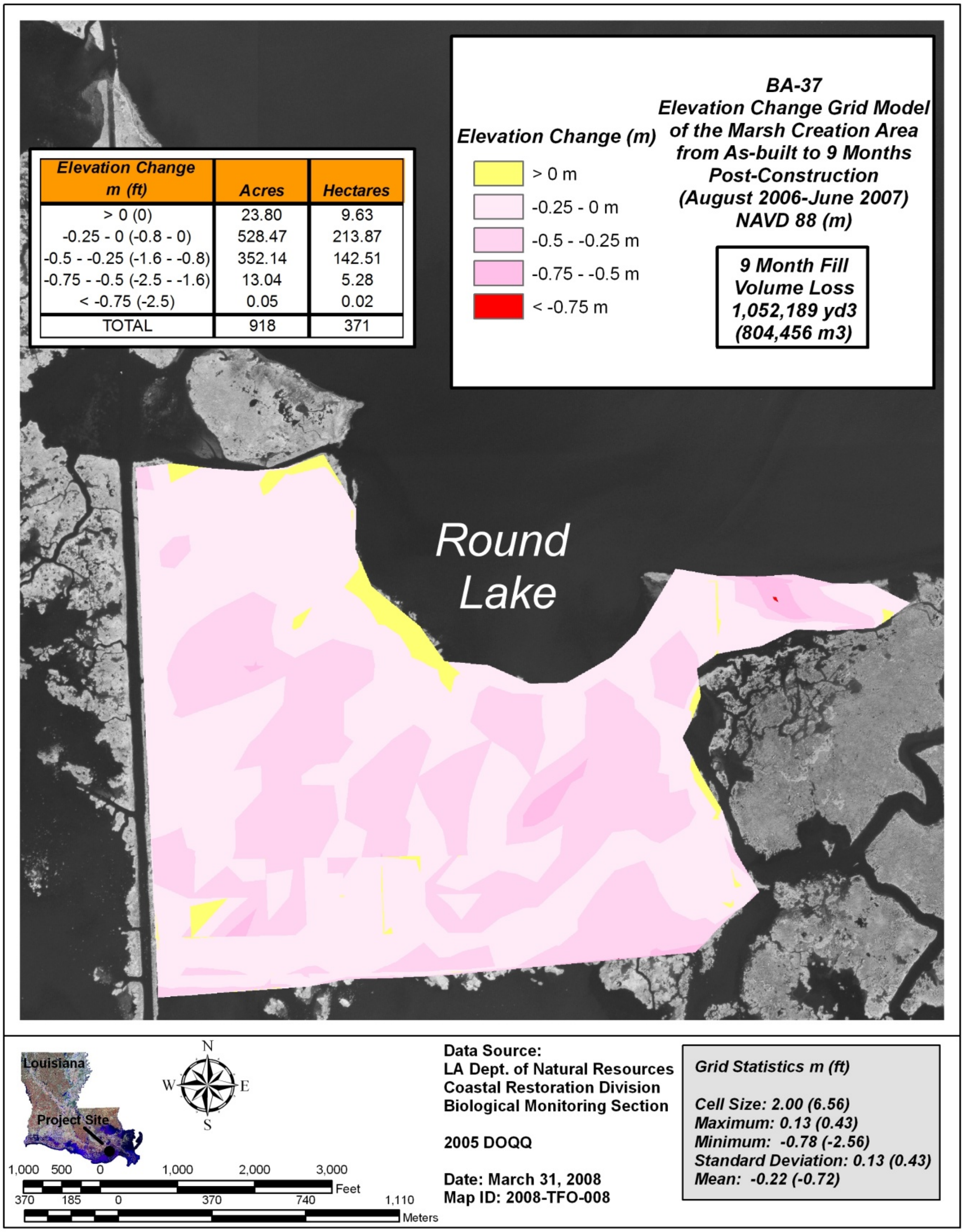


Figure 8. **Elevation and volume change grid model from pre-construction (Dec 2005) to as-built (Aug 2006) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**



Elevation Change m (ft)	Acres	Hectares
> 0 (0)	23.80	9.63
-0.25 - 0 (-0.8 - 0)	528.47	213.87
-0.5 - -0.25 (-1.6 - -0.8)	352.14	142.51
-0.75 - -0.5 (-2.5 - -1.6)	13.04	5.28
< -0.75 (-2.5)	0.05	0.02
TOTAL	918	371

Figure 9. **Elevation and volume change grid model from as-built (Aug 2006) to post-construction (Jun 2007) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

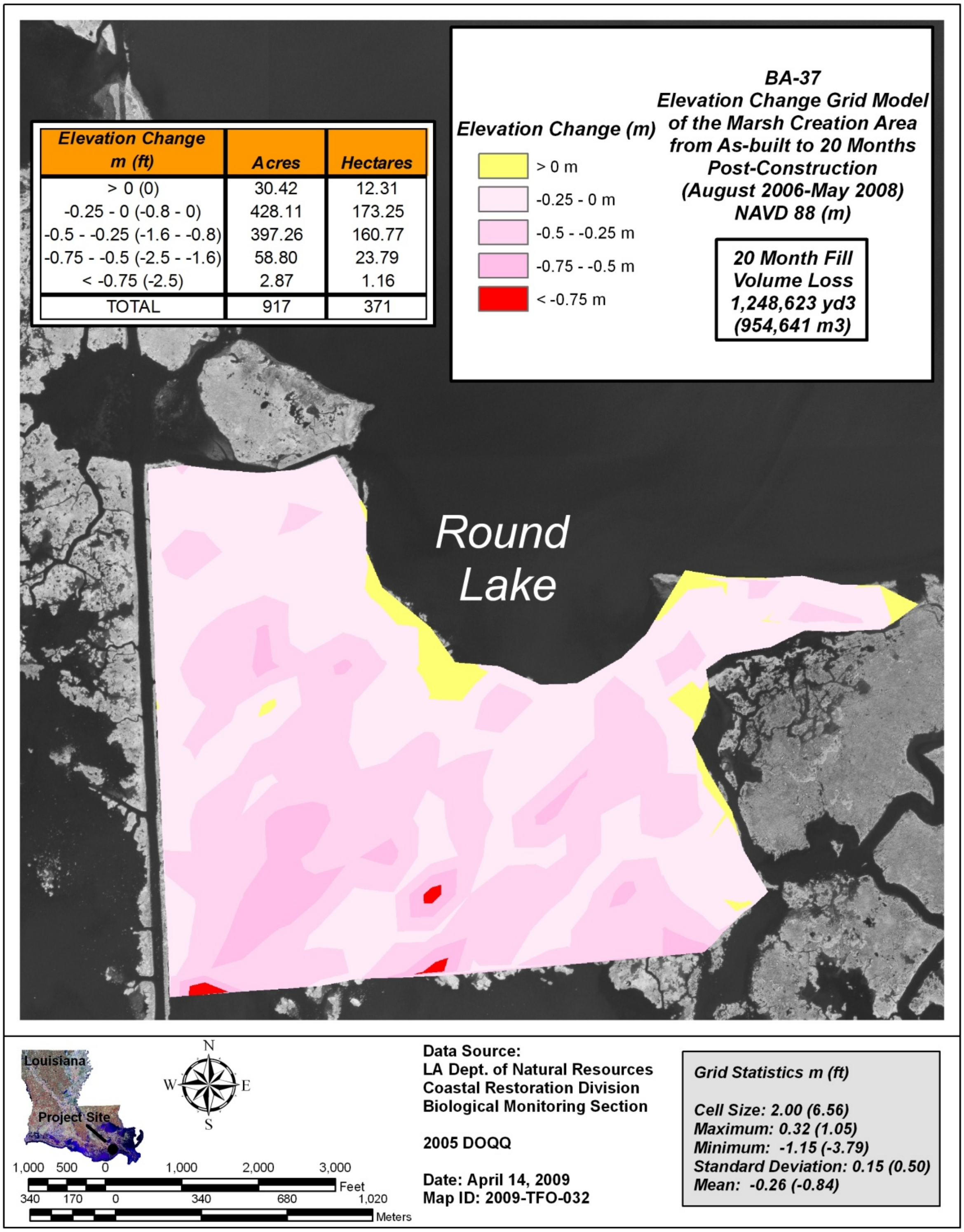


Figure 10. **Elevation and volume change grid model from as-built (Aug 2006) to post-construction (May 2008) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

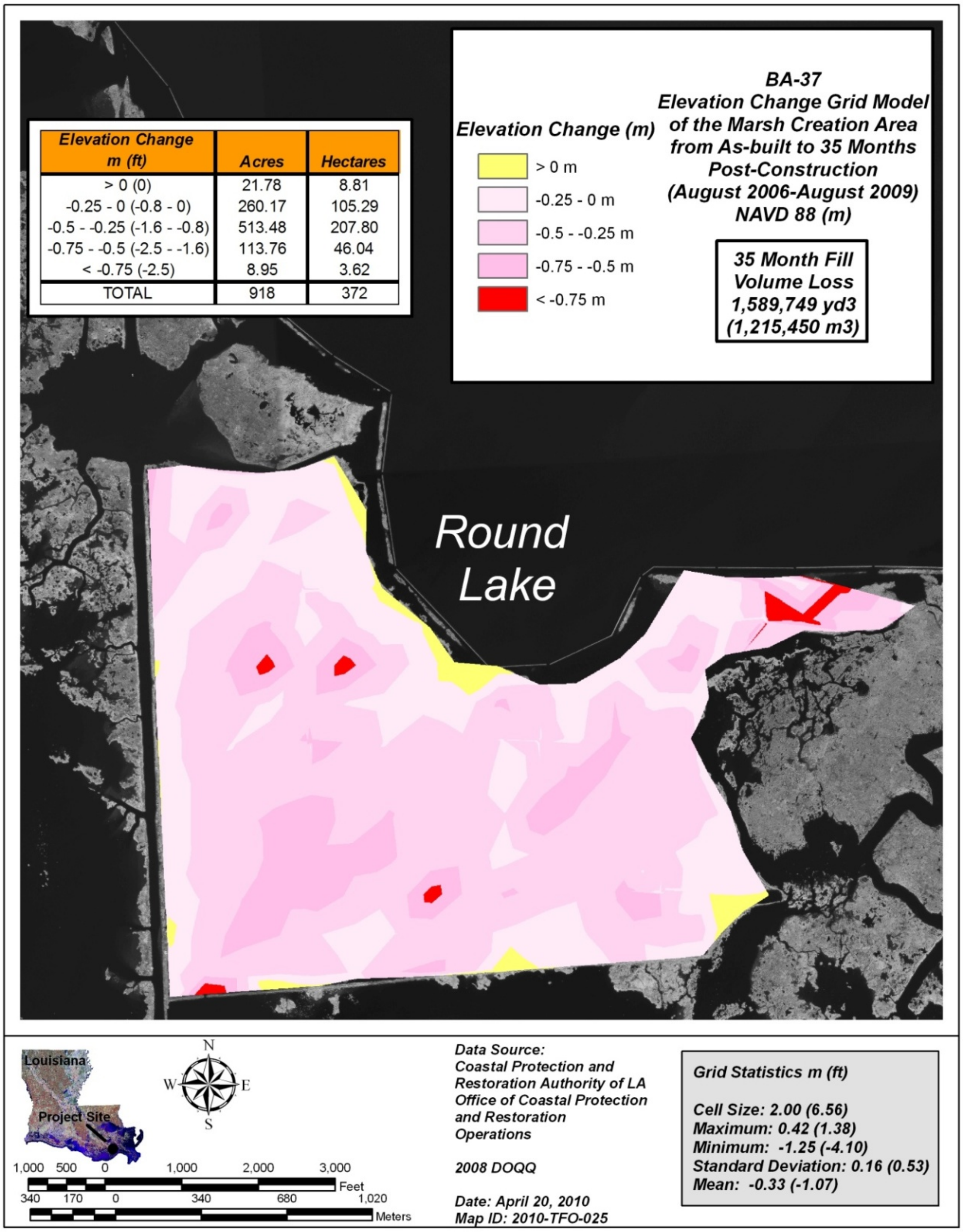


Figure 11. **Elevation and volume change grid model from as-built (Aug 2006) to post-construction (Aug 2009) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

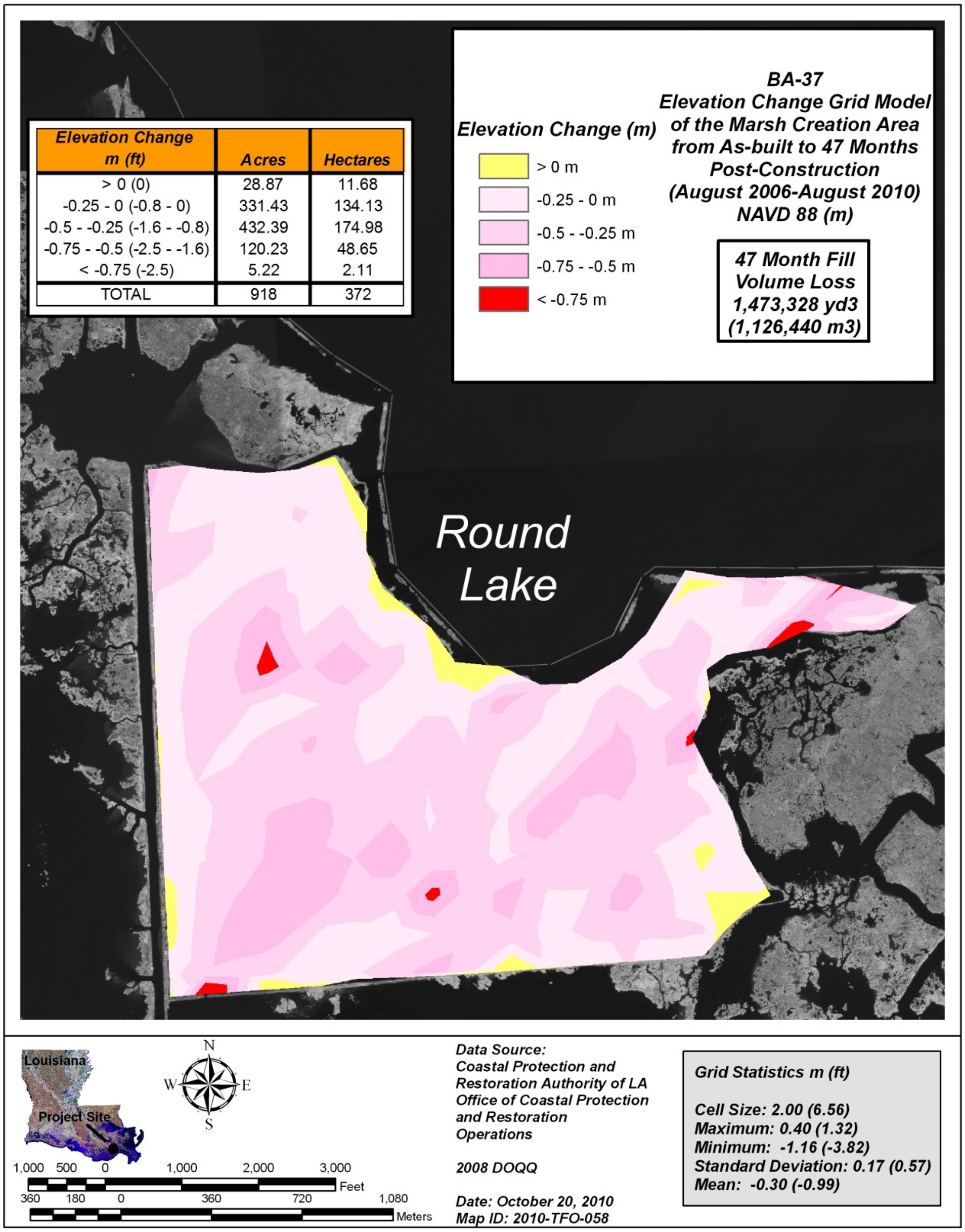


Figure 12. Elevation and volume change grid model from as-built (Aug 2006) to post-construction (Aug 2010) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

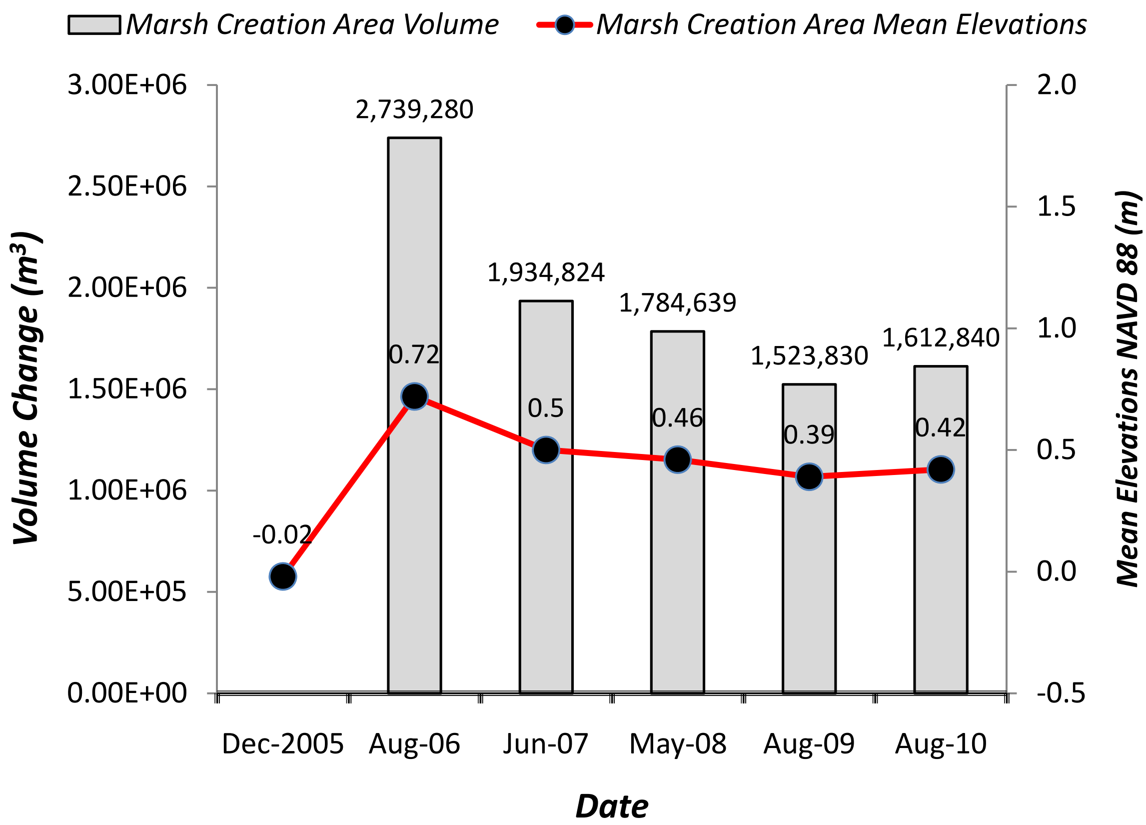


Figure 13. **Sediment volumes and mean elevations over time inside the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation and nourishment area.**

Aug 2009 (figures 16, 17, and 19), and no secondary settlement was measured during the Jul 2010 survey (figures 17, 18, and 19). The most probable reason for the rock dike's deviation from the settlement curve is the addition of 28,762 tons of rock to 19,041 ft (73%) of the dike. This third rock lift was necessitated by primary settlement of the dike during construction and added a load of 1.56 tons/ft to the sections of the rock dike that were recapped. The total overburden on the underlying soils below the third lift portions of the dike is 7.16 tons/ft while the dike segments only receiving two lifts have an overburden of 5.60 tons/ft. Future settlement plate surveys will monitor the post-construction settlement rate of the foreshore rock dike.

Shoreline Change

Preliminary pre and post-construction shoreline position data indicate that the foreshore rock dike has not appreciably reduced shoreline erosion rates in the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project area since construction was completed in Mar 2007. Pre-construction shoreline erosion rates averaged -13 m/yr (-44 ft/yr) in the project area from Jan 1998 to Nov 2005 (8

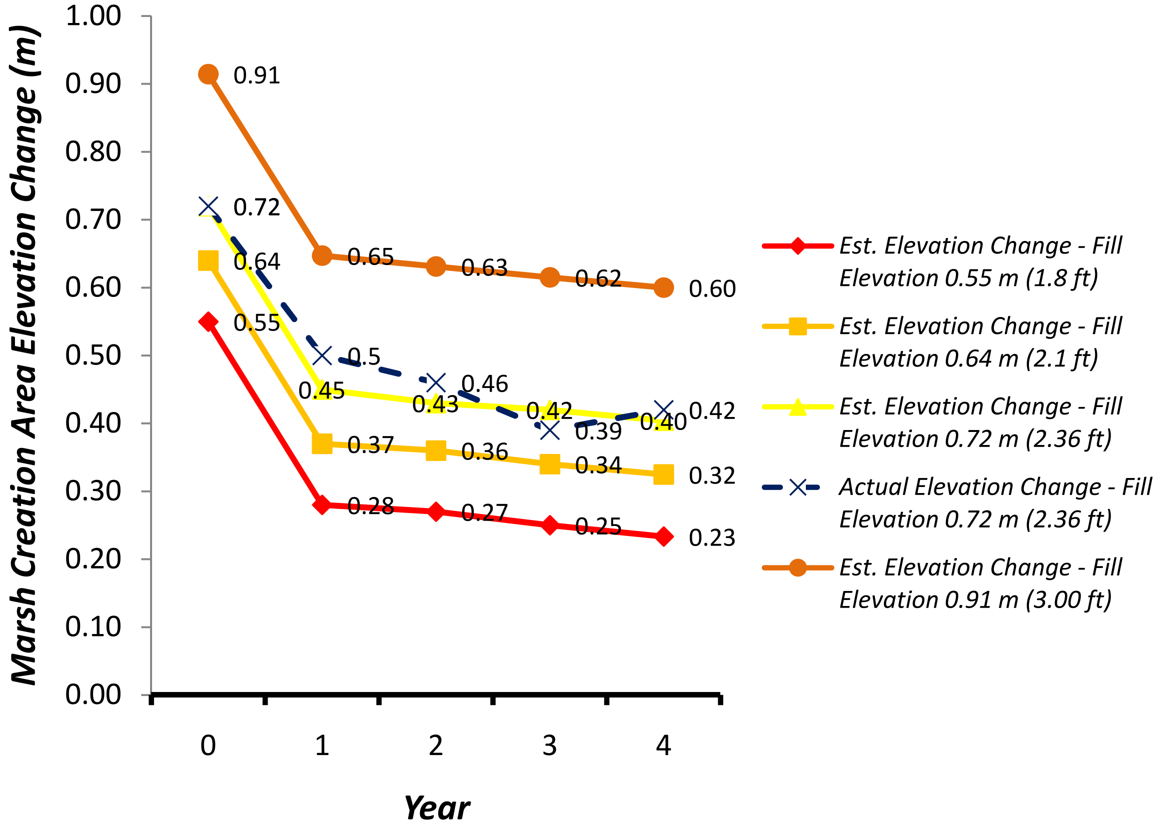


Figure 14. **Estimated and actual sediment consolidation inside the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation and nourishment area.**

years) (figure 20). Post-construction results for the period from Sep 2007 (6 months post-construction) to Oct 2008 (1.5 years post-construction) show average erosion rates (combined total) of -7 m/yr (-23 ft/yr) behind the foreshore rock dike (figure 21). Although the pre-construction erosion rate is twice the post-construction rate, the BA-37 project area shoreline transgressed at -8 m/yr (-27 ft/yr) from 1998 to 2003 and -7 m/yr (-22 ft/yr) from 2003 to 2004 (figure 20).

Pre-construction data reveals that the BA-37 shoreline was transgressing at an alarming rate. The project area shoreline eroded at rates of -8 m/yr (-27 ft/yr) from 1998 to 2003, -7 m/yr (-22 ft/yr) from 2003 to 2004, -31 m/yr (-101 ft/yr) from 2004 to 2005, and -13 m/yr (-44 ft/y) from 1998 to 2005 (figure 20). During the 8 year pre-construction interval, the project area shoreline receded -103 m (-339 ft). It is apparent from the shoreline erosion data that the 2005 hurricane season significantly altered and reshaped the project area shoreline (figure 20). The passage in quick succession of Hurricane Cindy (Jul 2005) and Hurricane Katrina (Aug 2005) in close proximately to the project area (figure 22) probably eroded large sections of shoreline

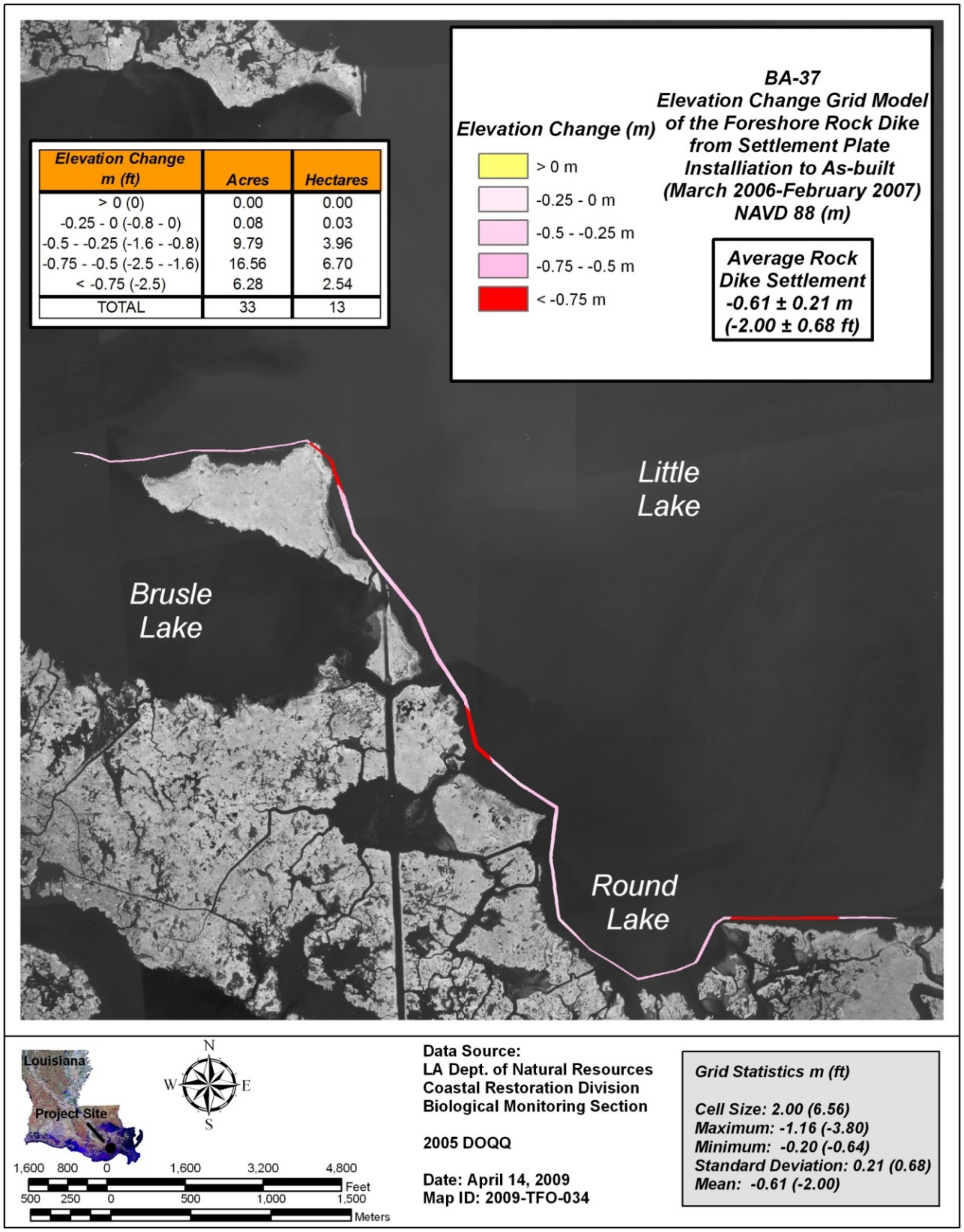


Figure 15. **Elevation change grid model of the foreshore rock dike from settlement plate installation (Mar 2006) to as-built (Feb 2007) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

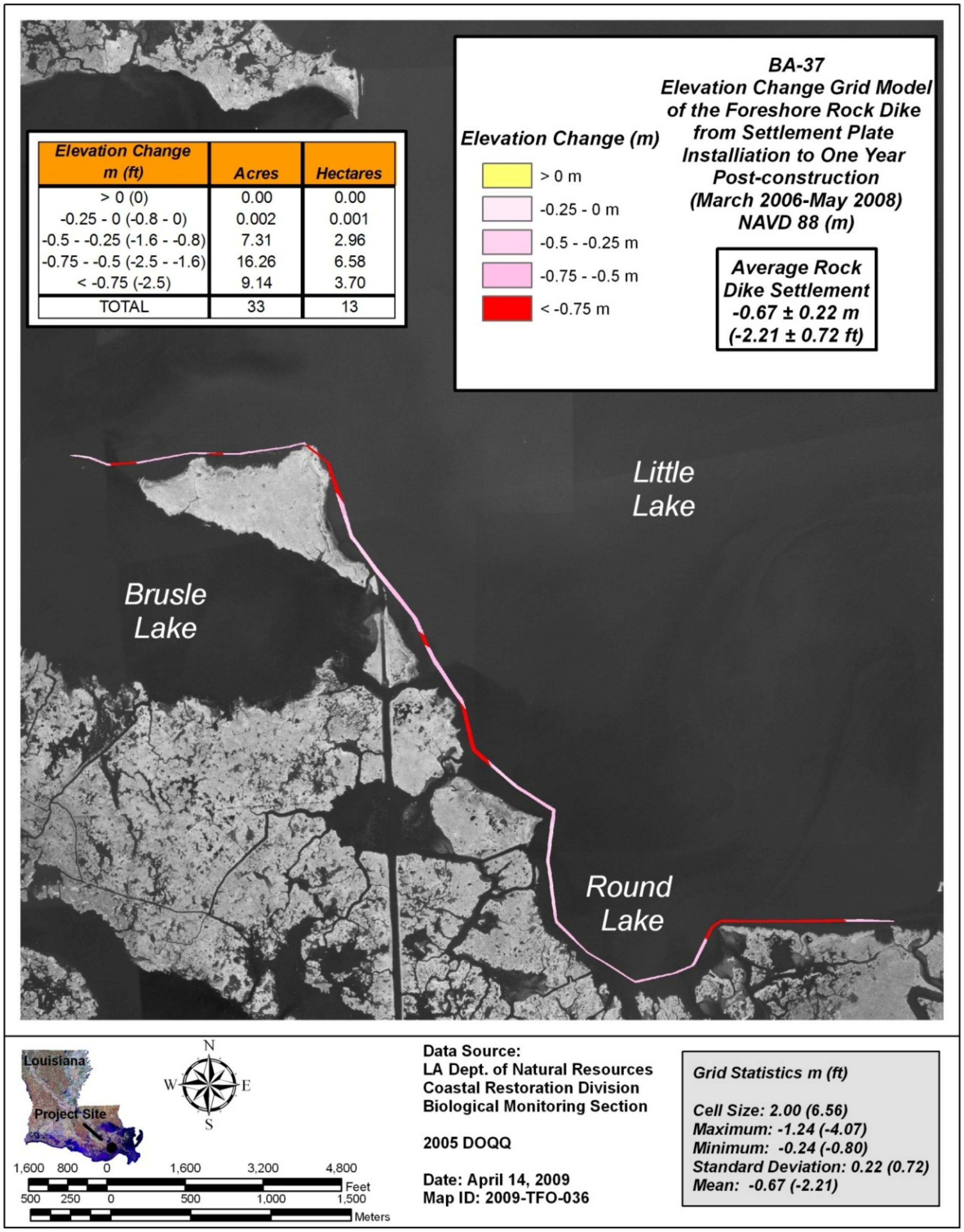


Figure 16. **Elevation change grid model of the foreshore rock dike from settlement plate installation (Mar 2006) to post-construction (May 2008) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

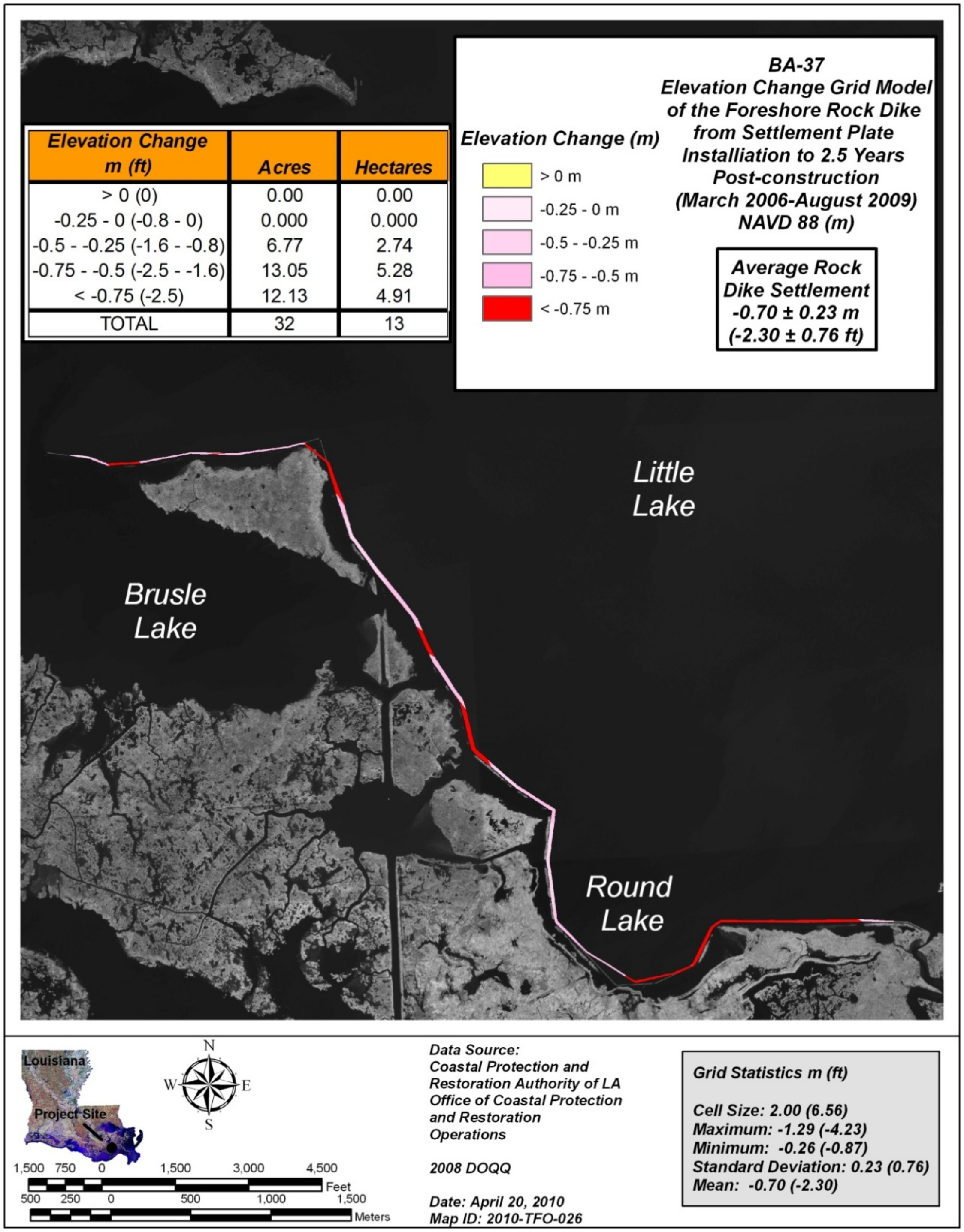


Figure 17. **Elevation change grid model of the foreshore rock dike from settlement plate installation (Mar 2006) to post-construction (Aug 2009) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

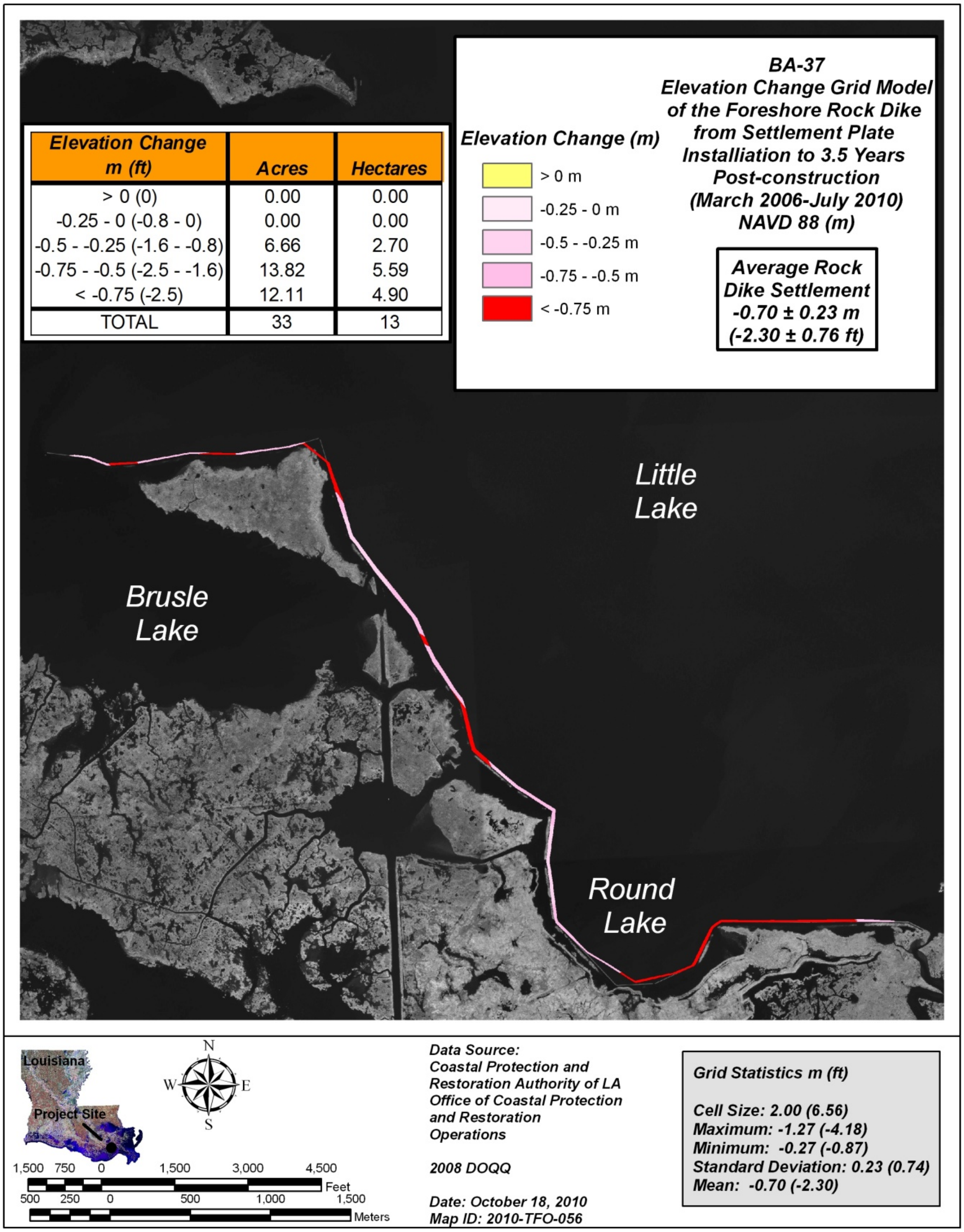


Figure 18. **Elevation change grid model of the foreshore rock dike from settlement plate installation (Mar 2006) to post-construction (Jul 2010) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

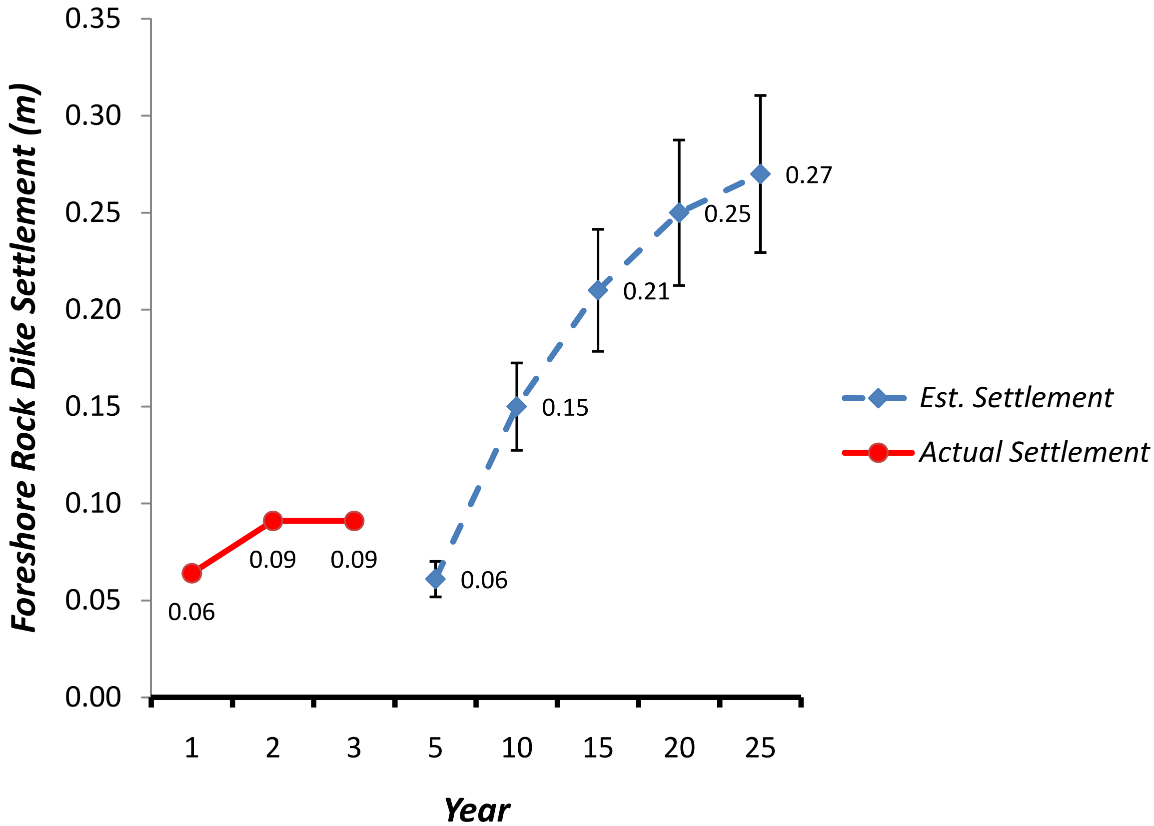


Figure 19. **Estimated and actual secondary settlement of the foreshore rock dike at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

and aided in the removal of 640 m (2,100 ft) of shoreline from the western extent of the project (figures 20 and 21). Therefore, the 2005 hurricanes hastened the shoreline retreat in the pre-construction project area and intensified the land loss along the Little Lake and Round Lake rims.

The initial post-construction shoreline analysis suggests that the shoreline behind the foreshore rock dike is transgressing at the pre 2005 rate. The average shoreline erosion rate behind the rock dike was -7 m/yr (-23 ft/yr) from Sep 2007 to Oct 2008 (figure 21) practically equivalent to the 1998-2003 and 2003-2004 erosion rates (figure 20). Although the combined total shoreline erosion is similar to the pre-construction rates, the marsh creation and lake rim shorelines transgressed at dissimilar rates. The shoreline fronting the marsh creation area (figures 2 and 3) incurred minimal shoreline erosion [-1 m/yr (-3 ft/yr)] during the initial post-construction analysis while the lake rim shoreline (figures 2 and 3) showed considerable erosion from 2007 to 2008 [-10 m/yr (-33 ft/yr)] (figure 21). The elevation of the rock dike did seem to effect the erosion rate in the lake rim area because the shoreline behind the 2nd lift segments [0.8 m (2.5 ft) NAVD 88] of the dike transgressed at a higher rate [-15 m/yr (-48 ft/yr)]

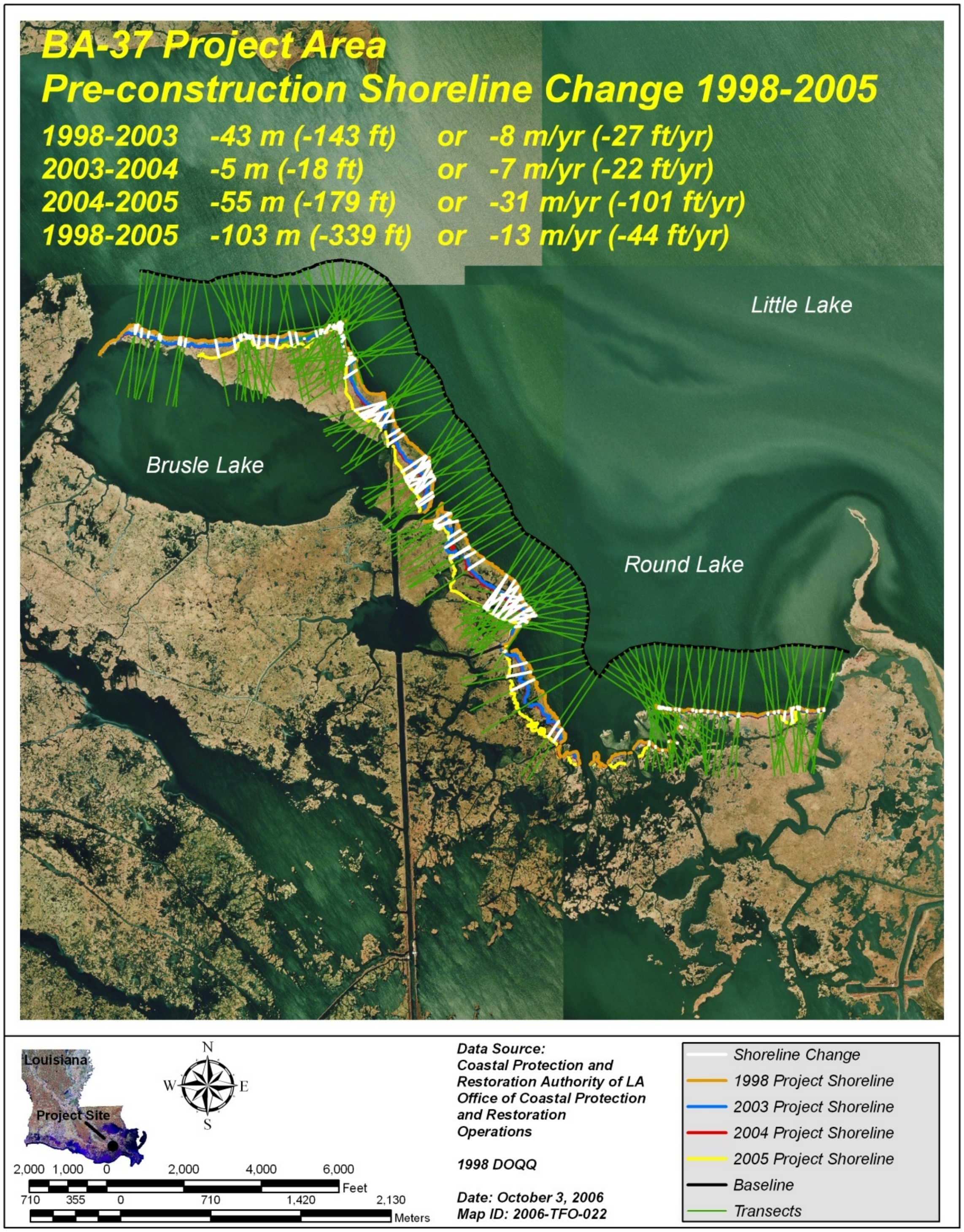


Figure 20. **Pre-construction (1998-2005) shoreline change at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

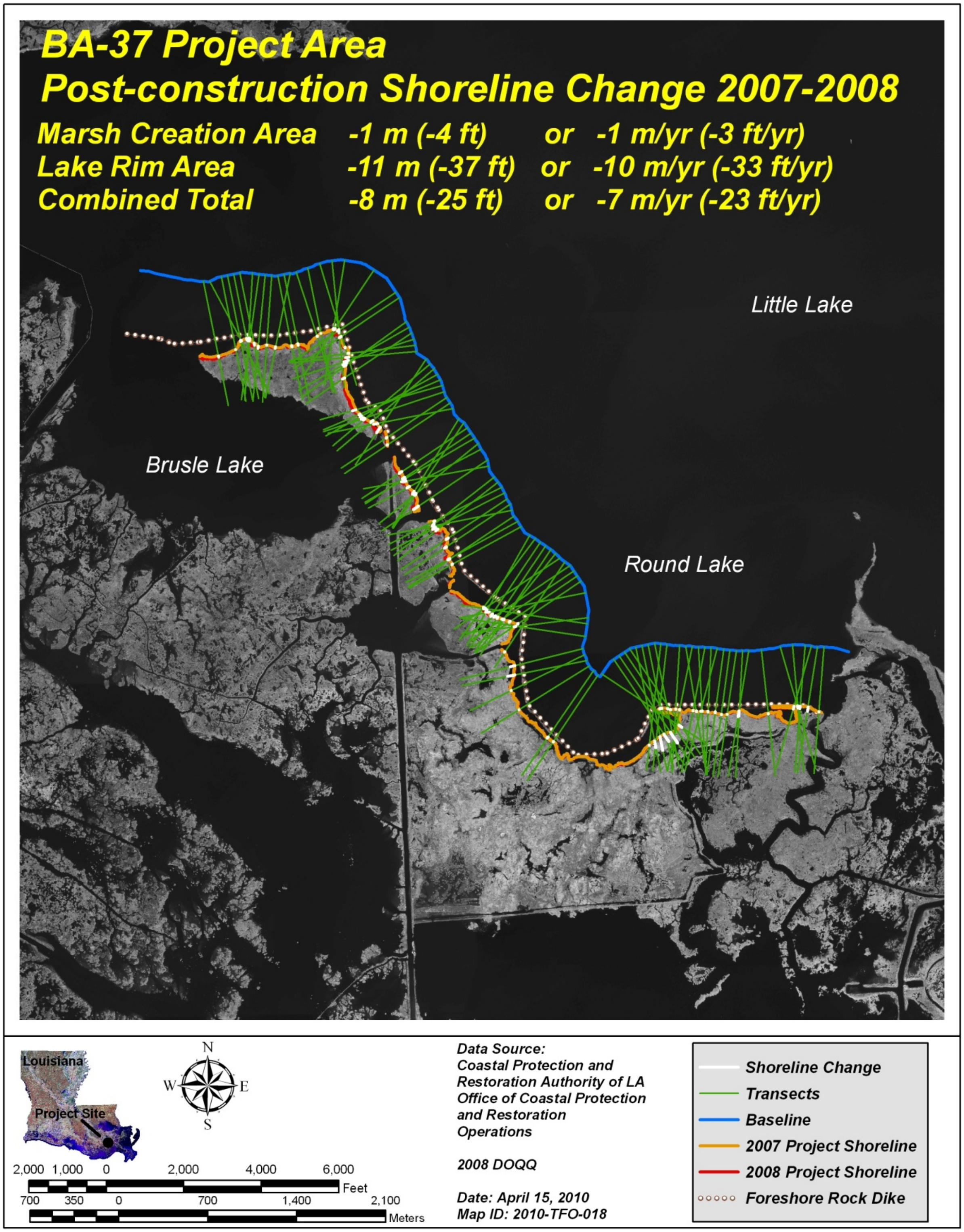


Figure 21. **Post-construction (2007-2008) shoreline change behind the foreshore rock dike at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

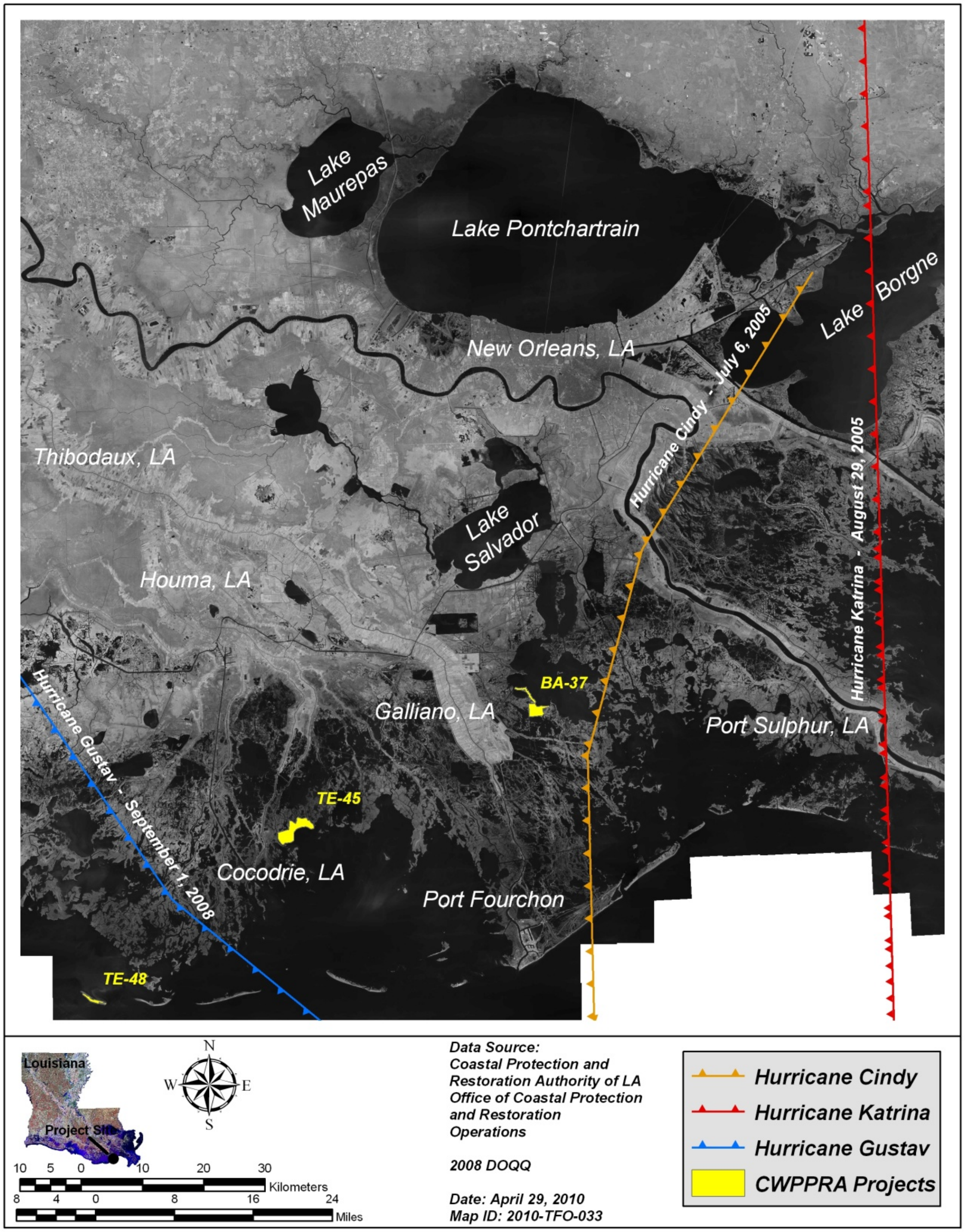


Figure 22. **Pre-construction (2005) and post-construction (2008) hurricanes impacting the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project area shoreline.**

than the shoreline behind the 3rd lift [1.1 m (3.5 ft) NAVD 88] segments of the dike [-7 m/yr (-24 ft/yr)] (figure 3). The large fetch [88 ± 4 m (288 ± 14 ft)] behind the lake rim reach of the rock dike also likely contributed to the high erosion rate behind this rock structure because waves have been shown to regenerate during high velocity winds when a large fetch lies between a coastal structure and a shoreline (Stone et al. 1999). Conversely, the marsh creation area shoreline fetch was substantially smaller [57 ± 10 m (186 ± 32 ft)]. The increased erosion in the lake rim area could have been initiated by the massive erosion that incurred during the 2005 hurricane season (figure 20) because remaining fragments of the historical mineral lake rim (Gagliano and Wicker 1989) possibly eroded leaving organic soils exposed. Moreover, the input of mineral sediments has strengthened the marsh creation area shoreline facilitating a stable and perhaps sustainable shoreline position. The high post-construction shoreline erosion rate in the lake rim area is probably an effect of Hurricane Gustav, which impacted the Louisiana coast in Sep 2008 (figure 22). Although hurricanes have been found to erode coastal marshes (Guntenspergen et al. 1995; Stone et al. 1997; Watzke 2004), cold fronts (Watzke 2004) and wind generated waves (Stone et al. 1999; Curole et al. 2002; Watzke 2004) have also been shown to cause marsh edge erosion. Therefore, it is not clear what caused the high erosion rates behind the foreshore rock dike in the lake rim area. Future shoreline position data should clarify if the erosion rates behind the structure were induced by Hurricane Gustav. Currently, the goal to reduce the marsh edge erosion rate is partially being attained because the marsh creation area shoreline is stable and the lake rim shoreline is retreating.

Land/Water Classification CRMS6303

The Land/Water classification of CRMS6303 showed that a 1.0 km^2 (0.4 mi^2) square portion of the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation area consisted of nearly equal parts land and water before construction. This analysis revealed that the 1.0 km^2 (0.4 mi^2) square enclosed 131 acres (53 ha) of land habitats and 117 acres (47 ha) of water habitats (figure 23). The percentage of land in the 1.0 km^2 (0.4 mi^2) square was 53% in Nov 2005. This percentage corresponds to a land to water ratio of 1:1. Because no post-construction land/water data has been analyzed to date, the land gain inside this 1.0 km^2 (0.4 mi^2) square section of the BA-37 marsh creation area cannot be determined. In the future, an Oct 2008 image will be classified to quantify post-construction habitats within the square.

Vegetation CRMS6303

The CRMS6303 vegetation data confirms the classification of Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation area as intermediate marsh. The dominant species found during both sampling events were *Spartina patens (Ait.) Muhl.* (saltmeadow cordgrass), *Paspalum vaginatum Sw.* (seashore paspalum), *Schoenoplectus americanus (Pers.) Volk. ex Schinz & R. Keller* (chairmaker's bulrush), and *Spartina alterniflora Loisel.* (smooth cordgrass) (figure

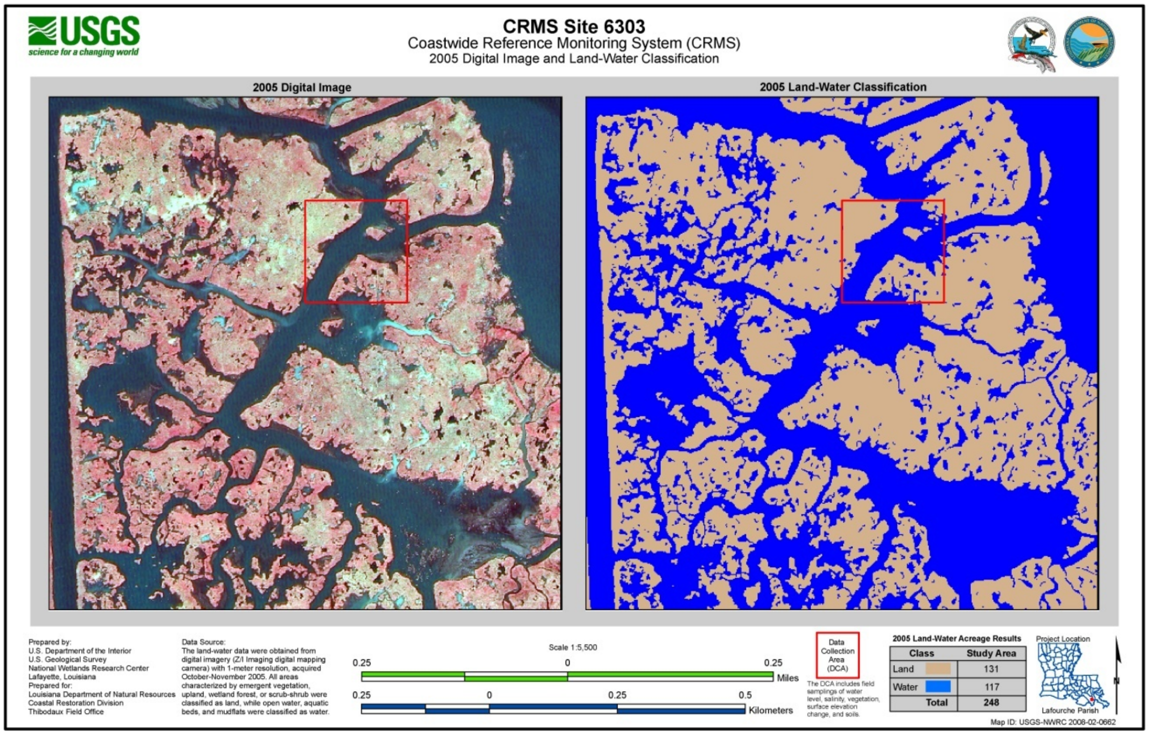


Figure 23. **Pre-construction (2005) land/water classification of the CRMS6303 1 km square inside the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation and nourishment area.**

24). *S. patens*, *P. vaginatum*, and *S. americanus* are common inhabitants and indicator species for intermediate marsh. While *S. alterniflora* is ubiquitous in salt marsh communities, this species is also known to populate brackish and intermediate communities (Chabreck and Condrey 1979). The relative cover disparities between the two sampling events are probably due to seasonal variations in species growth. The 2008 vegetation sampling occurred in October and the 2009 data were collected in July (figure 24). Some *Spartina* species have been shown to have seasonal standing crops (Kirby and Grosselink 1976). As a result, their cover values are also cyclic and vary by season. In closing, the CRMS6303 vegetation data support the assumption that the BA-37 marsh creation and nourishment goals are being attained.

Hydrologic Data CRMS6303

The CRMS6303 hydrologic data confirms the classification of Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation area as intermediate tidal marsh. The mean salinity and water level for the period from Oct 2008 to Jan 2010 were 2.97 ± 0.03 ppt and 1.33 ± 0.01 ft (0.41 ± 0.003 m) NAVD 88. The monthly mean salinities are shown in figure 25. These monthly means ranged from 0.47 ppt (Jan 2010) to 7.27 ppt (Mar 2009). Though the salinity did spike above 10 ppt, the monthly means exceeded 6 ppt only twice (Mar 2009 and May 2009)

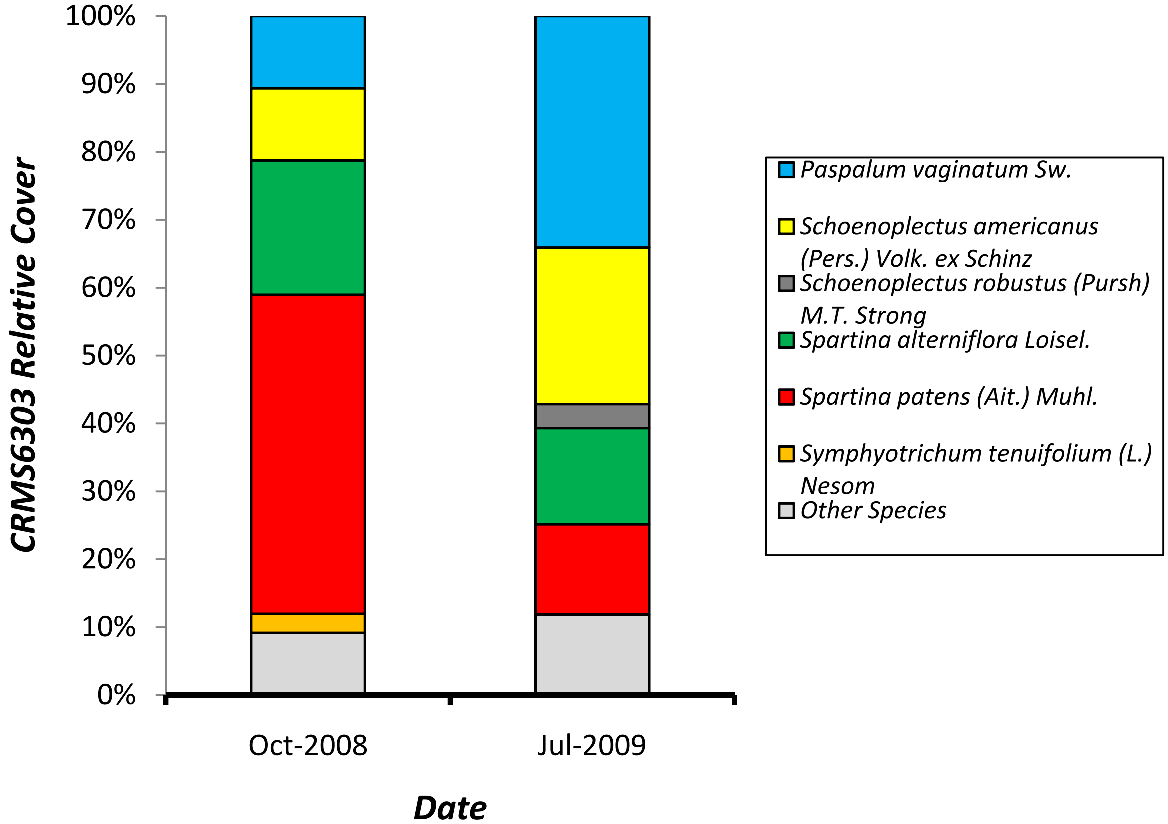


Figure 24. **Relative cover of the top five vegetation species populating the CRMS6303 200 m square inside the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation and nourishment area in 2007 to 2008. Ocular vegetation data were grouped by year.**

during the 16 months of data collection. Because intermediate marshes have been classified as having salinities ranging from approximately 0.5 to 5 ppt (Cowardin et al. 1979), the CRMS6303 hydrologic data supports an intermediate marsh classification. The monthly mean water levels are outlined in figure 26. These monthly means ranged from 0.65 ft (0.20 m) (Jan 2010) to 1.83 ft (0.56 m) (Sep 2009). The marsh elevation in the vicinity of CRMS6303 has been documented as having a 1.40 ft (0.43 m) NAVD 88 elevation. Therefore, the marshes are flooded only when the water level exceeds the mean water level. In summary, the CRMS6303 hydrologic data endorse the BA-37 marsh creation and nourishment goals.

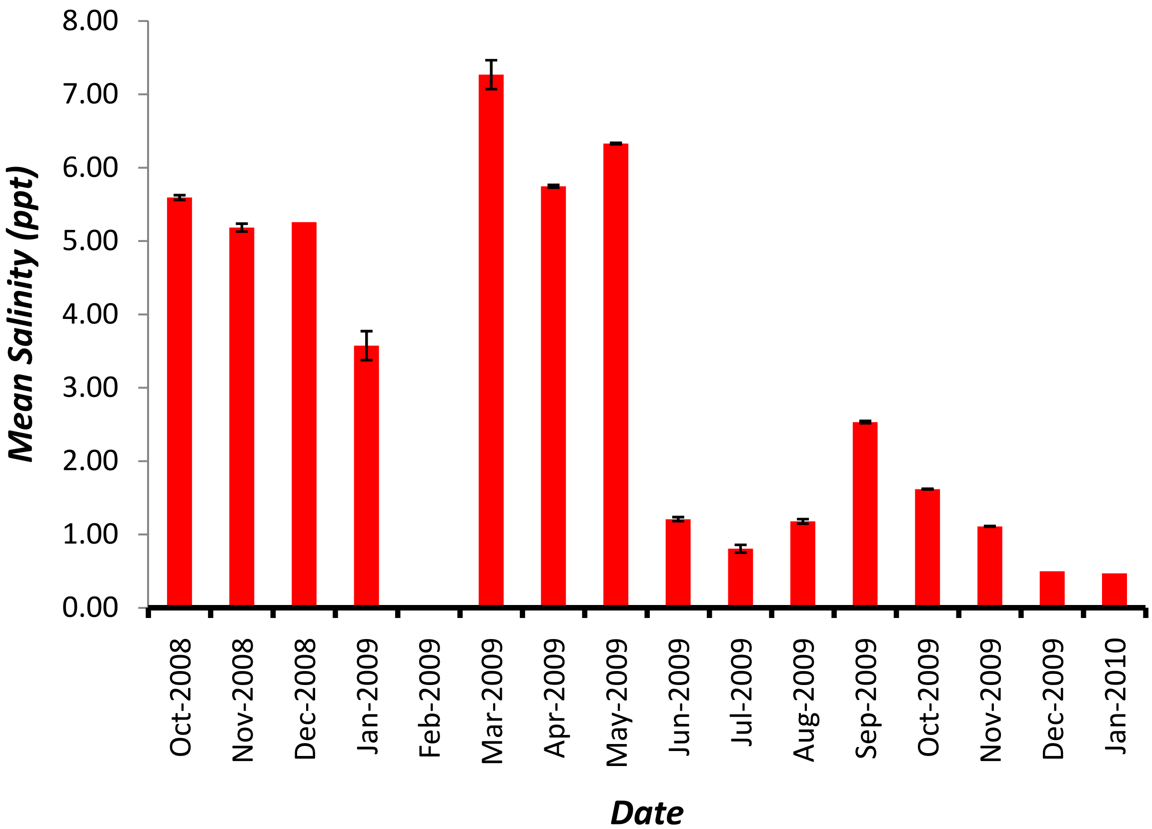


Figure 25. **Post-construction mean monthly salinity (ppt) inside the CRMS6303 1 km square and the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation and nourishment area.**

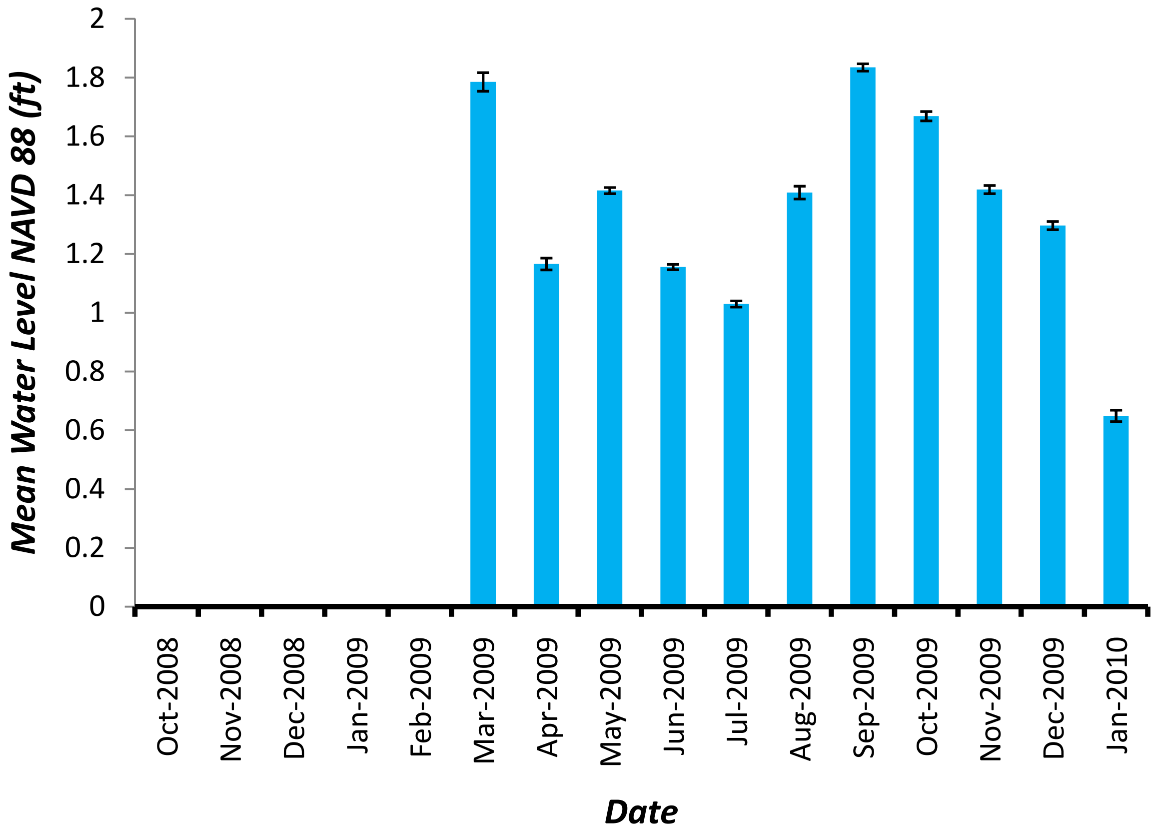


Figure 26. **Post-construction mean monthly water levels (NAVD 88 ft) inside the CRMS6303 1 km square and the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation and nourishment area.**

V. Conclusions

a. Project Effectiveness

The results of the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) reveal that two of the project goals were attained and one was partially achieved. The first goal to reduce the marsh edge erosion rate along the Little and Round Lake shorelines was partially realized because the shoreline fronting the marsh creation area incurred minimal shoreline erosion while the lake rim shoreline showed considerable erosion. The input of mineral sediments may have strengthened the marsh creation area shoreline facilitating a stable and perhaps sustainable shoreline position. In contrast, the increased erosion in the lake rim area could have been initiated by the massive erosion that incurred during the 2005 hurricane season because remaining segments of the historical mineral lake rim likely eroded leaving organic soils exposed. The elevation of the rock dike did seem to effect the erosion rate in the lake rim area because the shoreline behind the 2nd lift segments [0.8 m (2.5 ft) NAVD 88] of the dike transgressed at a higher rate than the shoreline behind the 3rd lift [1.1 m (3.5 ft) NAVD 88] segments of the dike. The large fetch behind the lake rim reach of the rock dike also likely contributed to the high erosion rate behind this rock structure because waves have been shown to regenerate during high velocity winds when a large fetch lies between a coastal structure and a shoreline (Stone et al. 1999). Hurricane Gustav probably hastened the shoreline erosion in the lake rim area, but cold fronts and wind generated waves also could have caused the shoreline transgressions. The second and third goals to create and nourish intermediate or brackish marshes were attained. Approximately, 372 ha (920 acres) of marsh were created or enhanced through construction of the BA-37 project, and the CRMS6303 vegetation and hydrologic data support an intermediate marsh classification. Furthermore, the constructed marsh is settling and subsiding in compliance with the projected consolidation curve. Therefore, these preliminary results provide evidence suggesting that marsh creation and nourishment area is condensing at a sustainable rate. The fourth goal to maintain emergent marsh at the end of the 20 year project life appears to be attainable because the marsh creation and nourishment area is following the anticipated consolidation curve. However, it will take 17 years to determine if this projection comes to fruition.

b. Recommended Improvements

Based on our analysis of the shoreline regression and fetch behind both the marsh creation area and the lake rim area, we found that erosion rate along the lake rim area was greater than the marsh creation area. As outlined in the project effectiveness section above, we believe the shoreline regression differences could be the result of both, differences in soils types and fetch. It is difficult to determine whether the differences in the rock dike elevations along the lake rim and marsh creation areas were also responsible for increased erosion along the lake rim since this area consists of a much narrower land mass which endures wave generated fetch from the large open water on the northwest side Round Lake as well. It is our recommendation to conduct a profile survey of the rock dike along the marsh creation and lake rim areas along with the final marsh survey scheduled for later this spring 2011, and continue to monitor the shoreline regression rates. The rock dike profile along with a 2011 shoreline positioning survey using 2011 aerial photography will give us additional data to analyze the rock dike elevations versus fetch and shoreline erosion rates. No other maintenance activities are recommended at this time other than annual inspections.

c. Lessons Learned

Four lessons were learned from the first three years of the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project. The first lesson is that the marsh creation and nourishment area could have been expanded to include marsh creation along the lake rim reach extending southward from the southern end of the Little Lake marsh creation area to the mouth of Breton Canal, although this would have increased the project cost considerably. The area surrounding the BA-37 project consists of large acreages of broken and subsided marsh. These areas have low contours that are conducive to marsh creation and nourishment. Nourishing the lake rim shoreline with mineral sediments may have been a viable alternative to lowering the shoreline erosion rates in the lake rim area. Adding mineral sediments to the lake rim shoreline may have reduced erosion rates along this reach because inputs of mineral sediments have substantially reduced the erosion rate along the marsh creation area shoreline. The second lesson is that the marsh creation and nourishment area is in agreement with its consolidation curve. Hopefully, this trend will continue and the future outcome of the project is already predicted. Consolidation data is site specific and dependant on many factors including soil type. The ability to accurately forecast the mean elevation in a constructed marsh twenty years after the project is built would allow engineers and scientists to build marsh creation projects to higher elevations and let them settle and subside to the desired elevation over time. This would increase the longevity and sustainability of the constructed marshes. The third lesson learned is the pre-construction geotechnical data underestimated the primary settlement in the foreshore rock dike. This led to a third rock lift and increased the project costs. Therefore, accurate and detailed geotechnical data is important particularly along shorelines with poor load-bearing soils, like a Lafitte-Clovelly association. The last lesson is that habitat mapping or land/water classification data should have been collected to monitor habitats over time. The constructed marsh created several diverse plant communities that are only being assessed through elevation data. Habitat data could have qualitatively and quantitatively estimated changes in these communities during the 20 year project life.

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Appendix A

Three (3) Year O&M Budget and Worksheet

LITTLE LAKE SHORELINE PROTECTION & DEDICATED DREDGING / BA37 / PPL11

Three-Year Operations & Maintenance Budgets 07/01/2010 - 06/30/2013

Project Manager	O & M Manager	Federal Sponsor	Prepared By
	Dearmond	*NMFS*	*Dearmond*

	2010/2011	2011/2012	2012/2013
Maintenance Inspection	$ 5,317.00	$ 5,487.00	$ 5,662.00
Surveys	$ 53,312.00		
Administration (NMFS)	$ 1,370.00	$ 1,414.00	$ 1,459.00
Maintenance/Rehabilitation			

10/11 Description: 2010/2011 Post-Construction Marsh Surveys

	2010/2011		
E&D	$ -		
Construction	$ -		
Construction Oversight	$ -		
Sub Total - Maint. And Rehab.	$ -		

11/12 Description

		2011/2012	
E&D		$ -	
Construction		$ -	
Construction Oversight		$ -	
	Sub Total - Maint. And Rehab.	$ -	

12/13 Description:

			2012/2013
E&D			$ -
Construction			$ -
Construction Oversight			$ -
		Sub Total - Maint. And Rehab.	$ -

	2010/2011	2011/2012	2012/2013
Total O&M Budgets	**$ 59,999.00**	**$ 6,901.00**	**$ 7,121.00**

O&M Budget (3-yr Total)	**$ 74,021.00**
Unexpended O&M Funds *	**$ 172,804.95**
Remaining O&M Budget (Projected)	**$ 98,783.95**

* $237,263 (presently approved O&M funding) - $64,458.05 (expenditures thru June 2010) = $172,804.95.

OPERATIONS & MAINTENANCE BUDGET WORKSHEET

Project: BA-37 Little Lake Shoreline Protection / Dedicated Dredging Near Round Lake

FY 10/11 –

Administration (NMFS)		$ 1,370
O&M Inspection & Report		$ 5,317
Surveys – Marsh Creation & Rock Settlement Plates		$ 53,312
Operation:		$ 0
Maintenance:		$ 0
E&D:	$ 0	
Construction:	$ 0	
Construction Oversight:	$ 0	

Operation and Maintenance Assumptions:

1. Administration (NMFS) - Annual Admin Costs of $1,000 obtained from NMFS; Inflation Rate of 3.2% from Little Lake O&M Cost spreadsheet for NMFS PPL11 projects @ 2001 price level.

2. Annual Inspection and Report – Inspection and Report Cost of $3,880 and Inflation Rate of 3.2% taken from Little Lake O&M Cost spreadsheet for NMFS PPL11 projects @ 2001 price level.

3. Surveys – Survey cost for marsh creation area and rock dike settlement plates taken from actual task amount of approximately $47,000 ($45,000 survey consultant cost and $2,000 LDNR Admin costs) at 2007 price level and inflated at 3.2% annually. This will be the final planned post-construction marsh survey until the survey scheduled in years 10 and 15 as indicated in the O&M Plan.

FY 11/12 –

Administration (NMFS)		$ 1,414
O&M Inspection & Report		$ 5,487
Surveys – Marsh Creation & Rock Settlement Plates		$ 0
Operation:		$ 0
Maintenance:		$ 0
E&D:	$ 0	
Construction:	$ 0	
Construction Oversight:	$ 0	

FY 12/13 –

Administration (NMFS)			$ 1,459
O&M Inspection & Report			$ 5,662
Surveys – Marsh Creation & Rock Settlement Plates			$ 0
Operation:			$ 0
Maintenance:			$ 0
	E&D:	$ 0	
	Construction:	$ 0	
	Construction Oversight:	$ 0	

Operation and Maintenance Assumptions:
Same as year 11/12 with inflation factor for 12/13

2011-2013 Accounting

Lana Report (Unexpended through February 2010)	$196,657.28
OCPR Expenditures (February through June 2010) (Note: Includes $23,500 for 09/10 Marsh Surveys)	$ 23,852.33
Unexpended Funds though June 2010	**$172,804.95**

Appendix B

Inspection Photos

Photo 1 - Rock Segment 1. Tide Reading ~ 1.7 ft NAVD88.

Photo 2 - Rock Segment 2. Tide Reading ~ 1.7 ft NAVD88.

Photo 3 - Rock Segment 3. Tide Reading ~ 1.7 ft NAVD88.

Photo 4 - Rock Segment 4. Tide Reading ~ 1.7 ft NAVD88.

Photo 5 - Rock Segment 5. Tide Reading ~ 1.7 ft NAVD88.

Photo 6 - Rock Segment 6. Tide Reading ~ 1.7 ft NAVD88.

Photo 7 - Rock Segment 7. Tide Reading ~ 1.7 ft NAVD88.

Photo 8 - Rock Segment 8. Tide Reading ~ 1.7 ft NAVD88.

Photo 9 - Rock Segment 9. Tide Reading ~ 1.7 ft NAVD88.

Photo 10 - Rock Segment 10. Tide Reading ~ 1.7 ft NAVD88.

Photo 11 - Rock Segment 11. Tide Reading ~ 1.7 ft NAVD88.

Photo 12 - Rock Segment 12. Tide Reading ~ 1.7 ft NAVD88.

Photo 13 - Rock Segment 13. Tide Reading ~ 1.7 ft NAVD88.

Photo 14 - Rock Segment 14. Tide Reading ~ 1.7 ft NAVD88.

Photo 15 - Rock Segment 15. Tide Reading ~ 1.7 ft NAVD88.

Photo 16 - Rock Segment 16. Tide Reading ~ 1.7 ft NAVD88.

Photo 17 - Rock Segment 17. Tide Reading ~ 1.7 ft NAVD88.

Photo 18 - Rock Segment 18. Tide Reading ~ 1.7 ft NAVD88.

Photo 19 - Marsh creation behind Rock Segment 19. Tide Reading ~ 1.7 ft NAVD88.

Photo 20 - Rock Segment 19. Tide Reading ~ 1.7 ft NAVD88.

Photo 21 - Rock Segment 20. Tide Reading ~ 1.7 ft NAVD88.

Photo 22 - Rock Segment 21. Tide Reading ~ 1.7 ft NAVD88.

Photo 23 - Rock Segment 22. Tide Reading ~ 1.7 ft NAVD88.

Photo 24 - Rock Segment 23. Tide Reading ~ 1.7 ft NAVD88.

Photo 25 - Rock Segment 24. Tide Reading ~ 1.7 ft NAVD88.

Photo 26 - Marsh creation area SW corner looking north from south dike. Tide Reading ~ 1.7 ft NAVD88.

Photo 27 - Marsh creation area SW corner looking west along south dike. Tide Reading ~ 1.7 ft NAVD88.

Photo 28 - Marsh creation area SW corner looking northeast from south dike. Tide Reading ~ 1.7 ft NAVD88.

Appendix C

BA-37 Elevation Grid Models

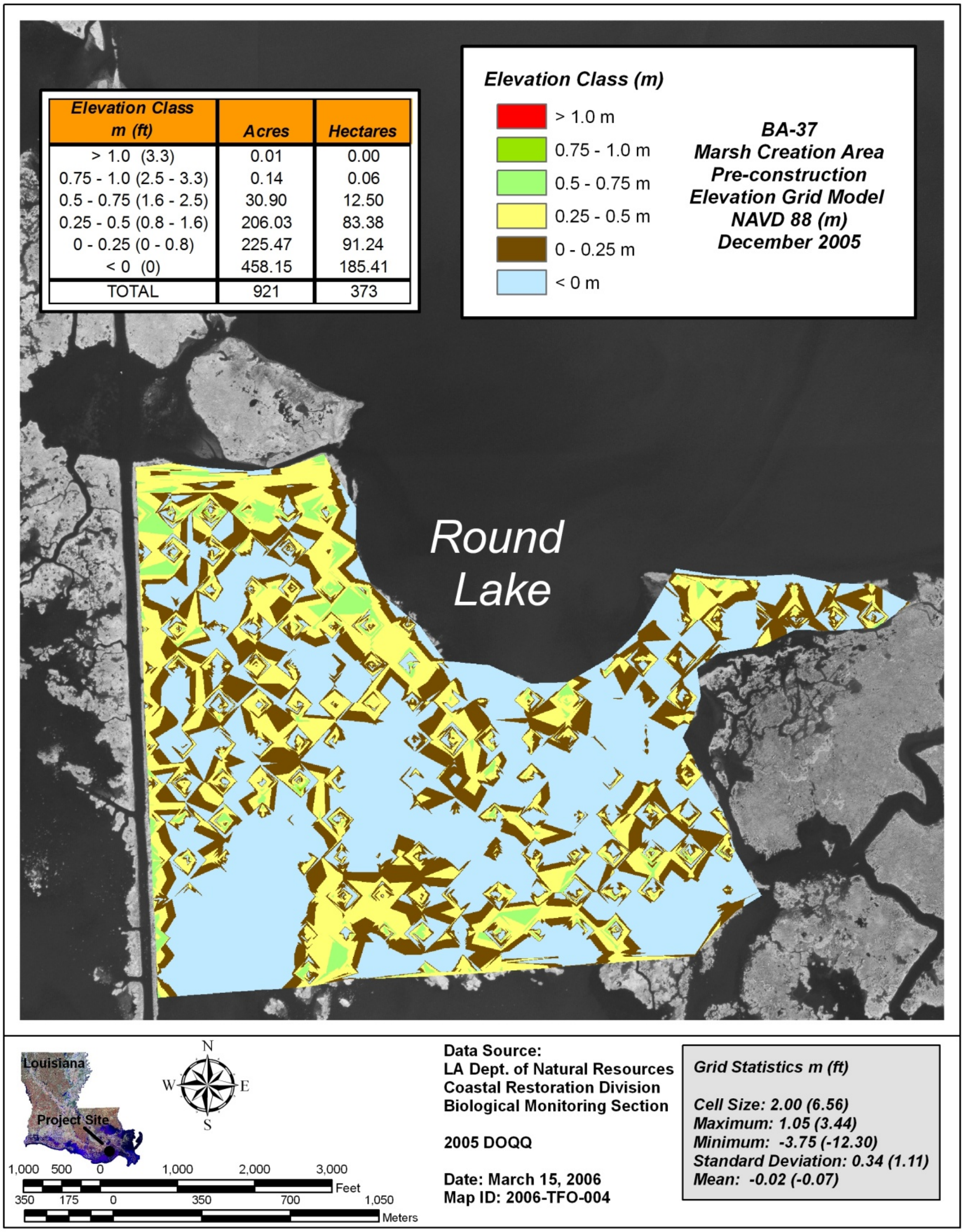

Figure. **Pre-construction (Dec 2005) elevation grid model at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

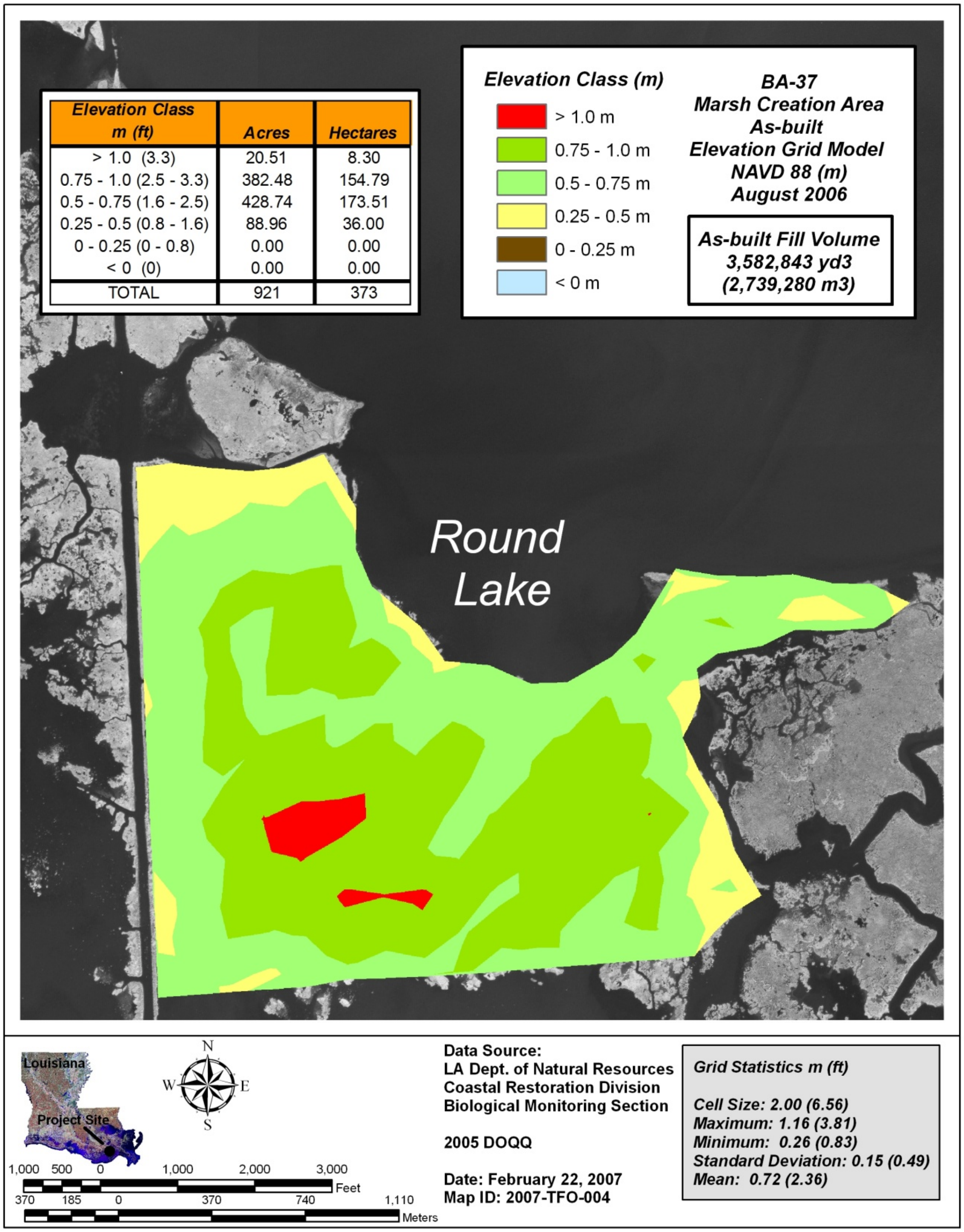

Figure. **As-built (Aug 2006) elevation grid model at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

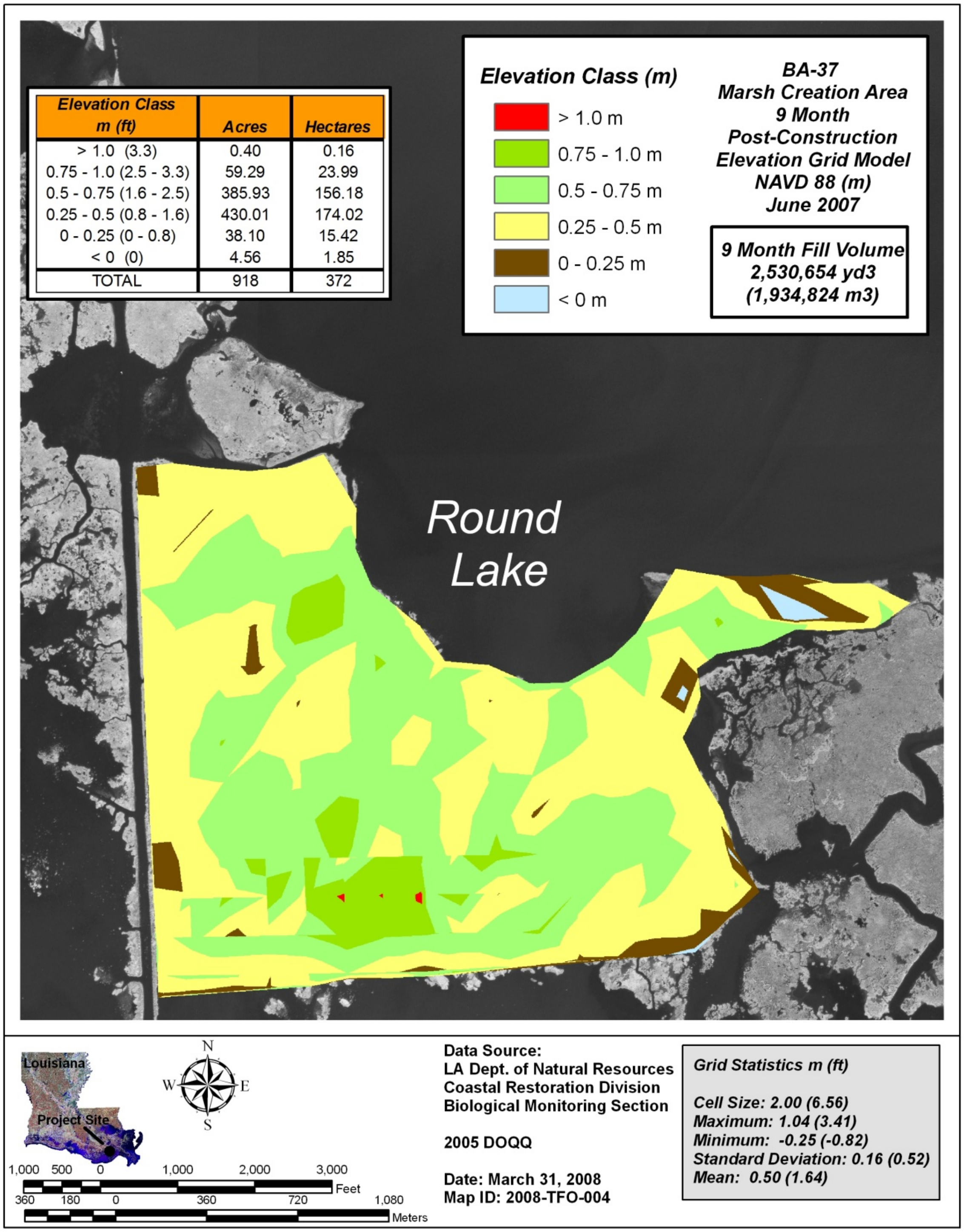

Figure. **Post-construction (Jun 2007) elevation grid model at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

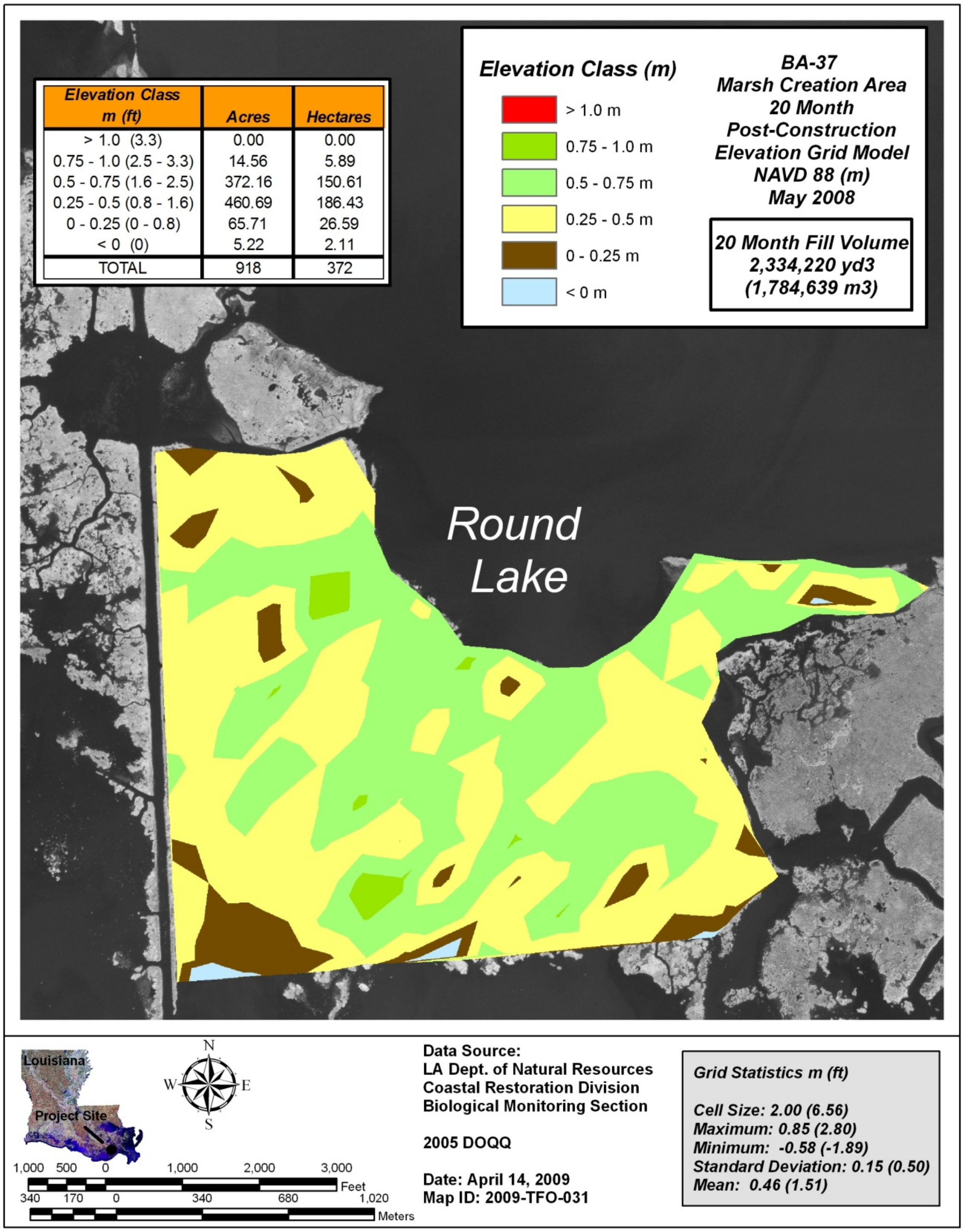

Figure. **Post-construction (May 2008) elevation grid model at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

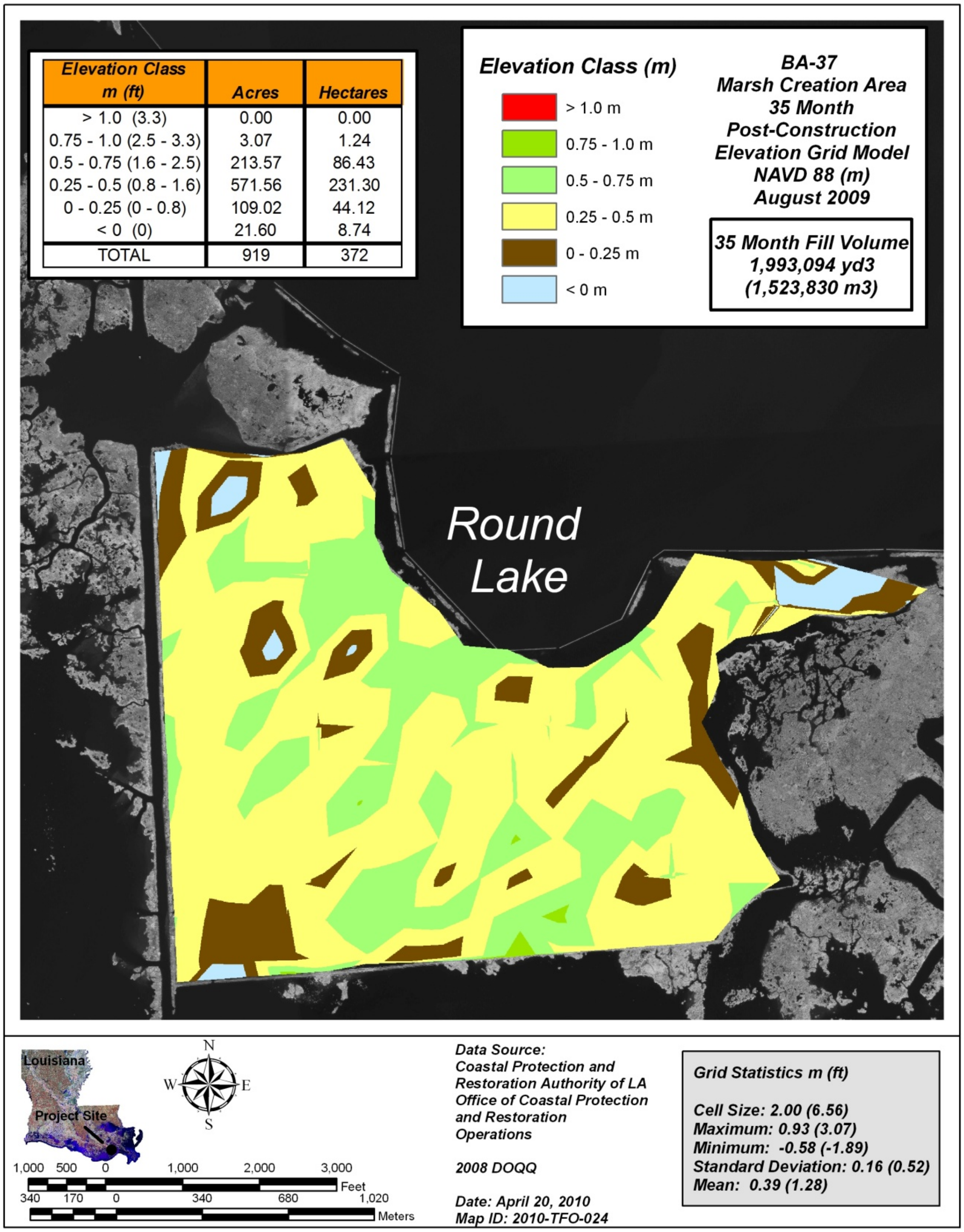

Figure. **Post-construction (Aug 2009) elevation grid model at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

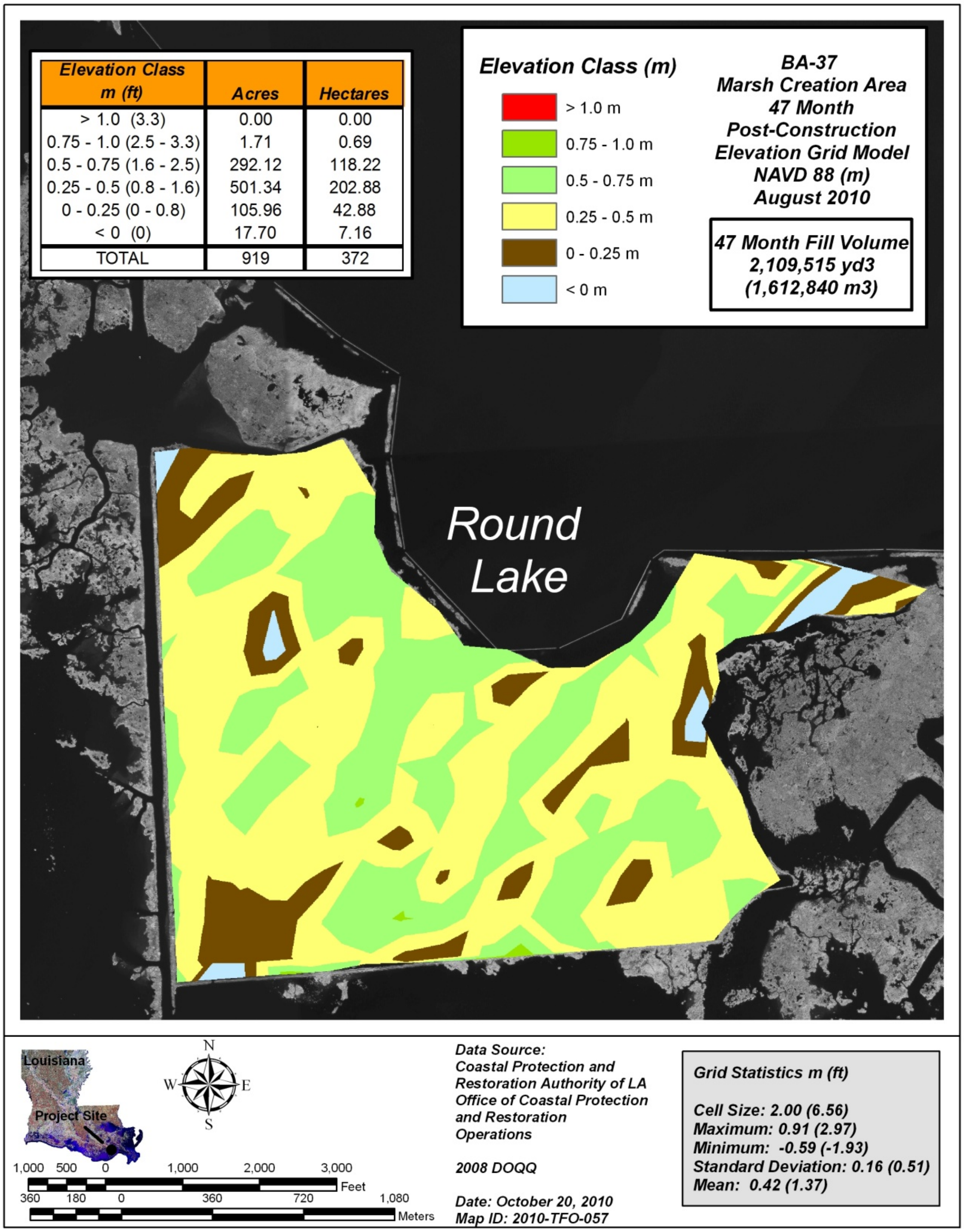

Figure. **Post-construction (Aug 2010) elevation grid model at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**