State of Louisiana
Coastal Protection and Restoration Authority

2017 Operations, Maintenance, and Monitoring Report

for

Dedicated Dredging on the Barataria Basin Landbridge (BA-36)

State Project Number BA-36
Priority Project List 11

December 2017
Jefferson Parish

Prepared by:
Melissa K. Hymel

Operations Division
New Orleans Regional Office
CERM Bldg, Suite 309
2045 Lakeshore Drive
New Orleans, LA 70122

Suggested Citation:

Hymel, M. K. 2017. *2017 Operations, Maintenance, and Monitoring Report for Dedicated Dredging on the Barataria Basin Landbridge (BA-36).* Coastal Protection and Restoration Authority of Louisiana, New Orleans, Louisiana. 53 pp, including Appendices.

Operations, Maintenance, and Monitoring Report
for
Dedicated Dredging on the Barataria Basin Landbridge
(BA-36)

Table of Contents

Preface

The Dedicated Dredging on the Barataria Basin Landbridge (BA-36) project was funded through the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) on the 11th Priority Project List (PPL) with the United States Fish and Wildlife Service (USFWS) as the federal sponsor. Additional funding for the BA-36 project was also provided by the State of Louisiana's Coastal Impact Assistance Program (CIAP), as well as the State of Louisiana's Surplus Funds.

The 2017 Operations, Maintenance, & Monitoring (OM&M) report for the BA-36 project is the first OM&M report for this project, which includes monitoring data collected throughout the life of the project (2010-present). There are no planned Operations and Maintenance activities for the life of the BA-36 project. Additional documents pertaining to the BA-36 project may be accessed on the Coastal Protection and Restoration Authority (CPRA) website at http://coastal.la.gov/ resources/library/ .

I. Introduction

The Dedicated Dredging on the Barataria Basin Landbridge (BA-36) project is located at the southern end of Bayou Rigolettes and Bayou Perot (Figure 1) in Jefferson Parish, Louisiana. This project was proposed to create new emergent marsh and to nourish existing marsh using hydraulically dredged sediments in an area of critical land loss within the Barataria Basin. The Barataria Basin is bounded on the north and east by the Mississippi River, on the west by Bayou Lafourche, and on the south by the Gulf of Mexico. The upper portion of the Barataria Basin is largely a freshwater-dominated system of natural levee ridges, bald cypress - water tupelo swamps, and fresh to intermediate marsh habitats. The lower portion of the basin is dominated by marine/tidal processes, with barrier islands, saline/brackish marshes, tidal channels, and large bays and lakes. Historically, a landmass extending southwest to northeast across the basin provided limited hydrologic connection between the freshwater dominated upper basin and the tidally influenced lower basin. However, with the leveeing of the Mississippi River, the closure of Bayou Lafourche, and the creation of the Barataria Bay Waterway and Harvey Cut, the landmass gradually began deteriorating due to sediment deprivation, saltwater intrusion, subsidence, and increased wave action. Substantial erosion and interior marsh loss occurred along the shorelines of Bayou Perot and Bayou Rigolettes, which transformed from meandering, riverine waterways to wide, high wave-energy water bodies separated by only a thin peninsula of marsh (Figure 2). From 1932 to 2010, the Barataria Basin lost approximately 269,894 acres (109,222 ha) of land (Couvillion et al 2011), which represents about 28% of the total 1932 landmass and translates to a land loss rate of 3,460 ac/yr. The BA-36 project is located within a critical land barrier separating Bayous Perot and Rigolettes to the north from Turtle Bay/Little Lake to the south.

The purpose of the BA-36 project was to create emergent wetlands by hydraulically dredging sediments from Bayous Perot and Rigolettes, and depositing that material in shallow open water areas. In addition, fragmented marsh habitat in the project area was nourished by adding a layer of sediment to the marsh surface to increase elevation and improve vegetative health

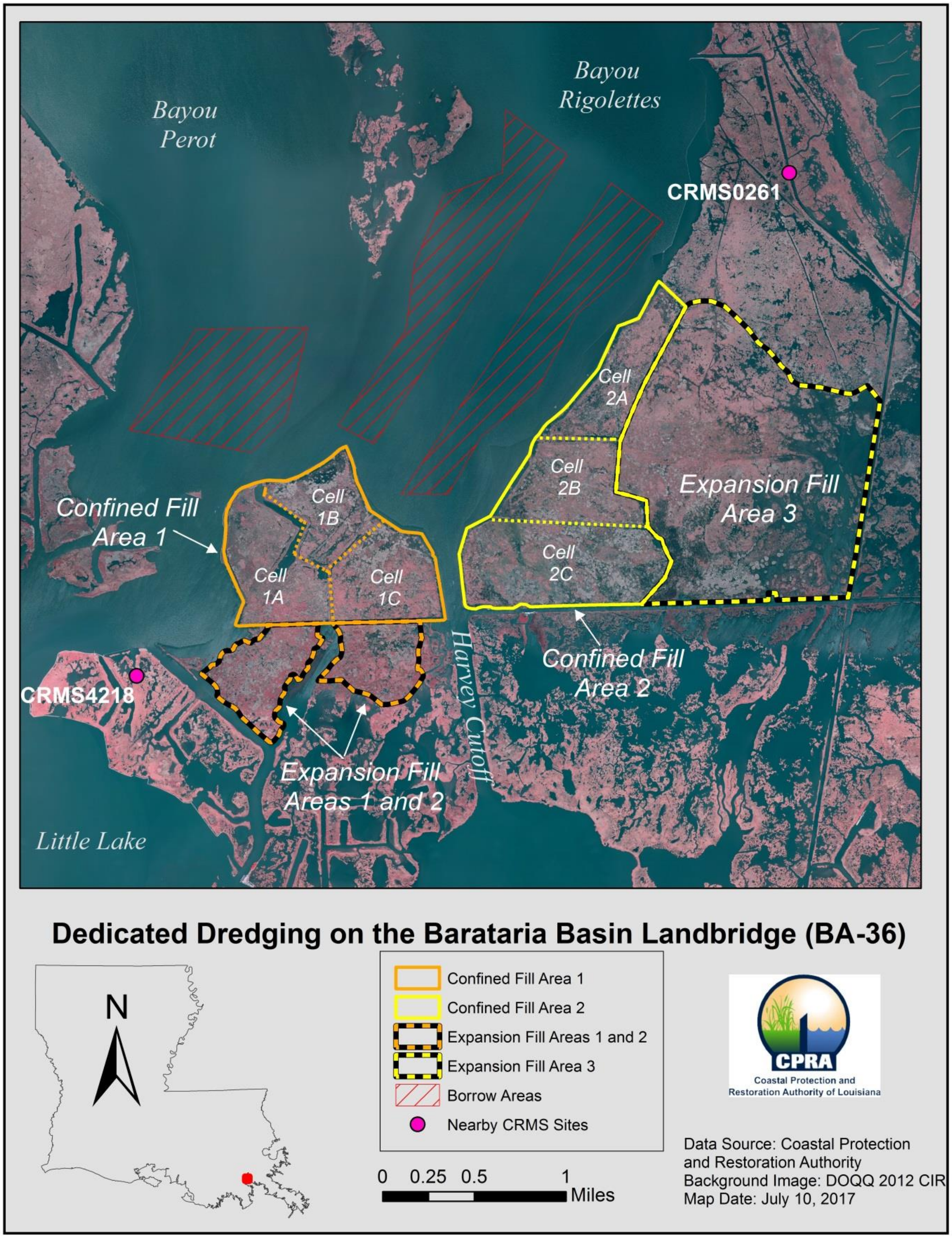


Figure 1. Dedicated Dredging on the Barataria Basin Landbridge (BA-36) project area and features.

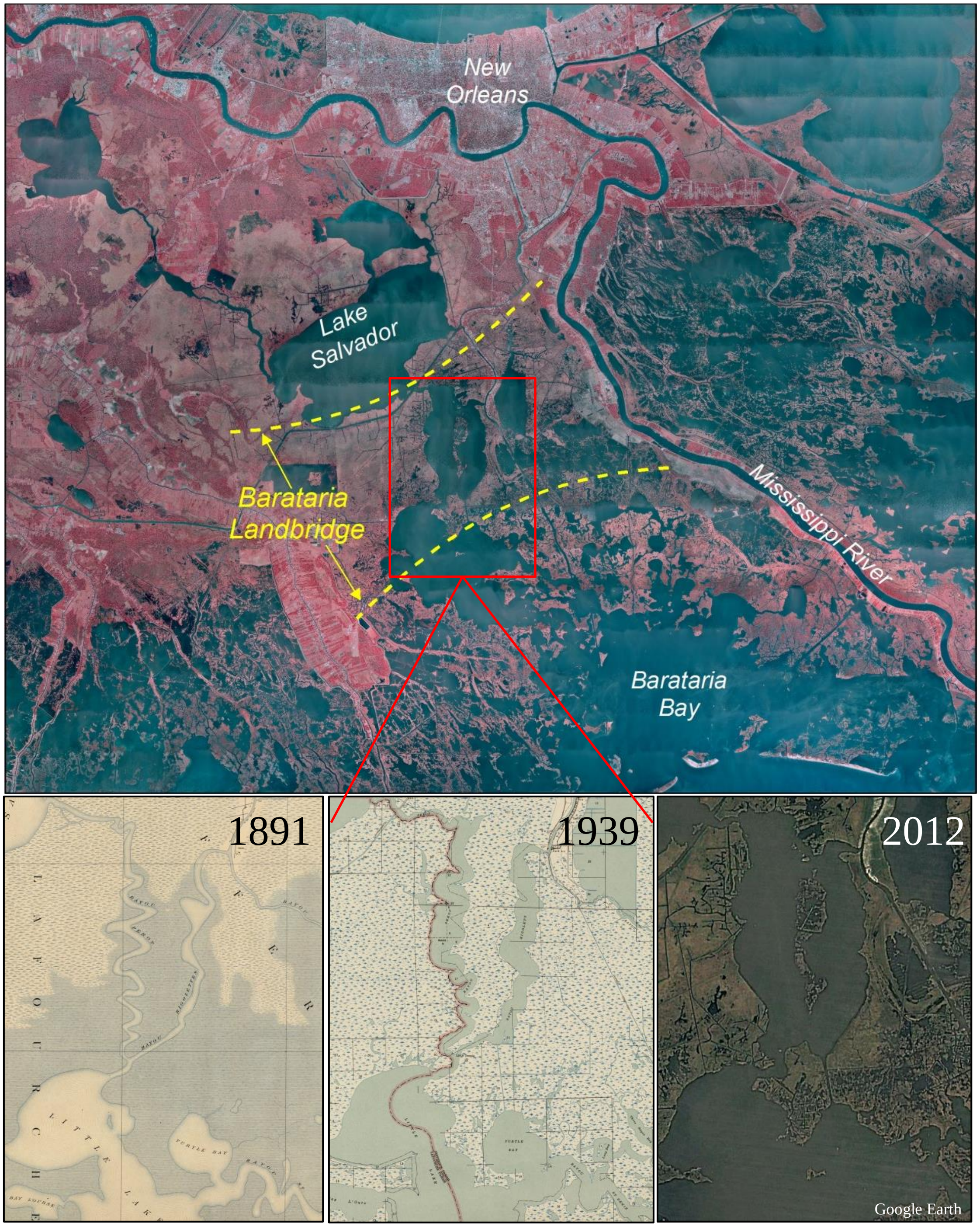


Figure 2. General location of the 'Barataria Landbridge'. USGS Barataria quadrangles demonstrate progressive widening of Bayou Perot and Bayou Rigolettes from 1891 to 2012.

and marsh productivity. The benefits provided by the project include the creation of important wetland habitat and the enhancement of storm protection for inland areas. Additionally, this project served to demonstrate the feasibility of using dredged sediment to create sustainable marsh. The original CWPPRA project boundary contained approximately 1,245 acres within Confined Fill Areas 1 and 2 only, with additional funding for Confined Fill Area 2 provided by the State of Louisiana's Coastal Impact Assistance Program (CIAP). During construction, the project area was expanded through the application of surplus dredge material to two adjacent, unconfined areas (Expansion Fill Areas 1 and 2, Figure 1). These expansions were jointly funded through CWPPRA, CIAP, and the State of Louisiana's Surplus Funds. The actual constructed project footprint as shown in Figure 1 contained 1,171 acres within Confined Areas 1 and 2 and 1,318 acres within the expansion areas for a total of 2,489 acres.

Construction on the BA-36 project began in September 2008 and was completed in April 2010. Construction activities within the original CWPPRA/CIAP-funded project area (Confined Fill Areas 1 and 2) consisted of constructing and maintaining 67,700 linear feet of containment dikes from in-situ material, pumping 5,367,600 cubic yards of borrow material from Bayous Perot and Rigolettes, and placing it into the two contained marsh creation areas to a target elevation of +2.5 ±0.3 ft NAVD 88 (Geoid99) (Barowka & Bonura 2010, Table 1). Each of the two confined fill areas was further broken down into 3 sub-cells which were managed independently during construction (Figure 1). The target elevation was achieved for each sub-cell using a total of two lifts. Each sub-cell was pumped to the target elevation, then the dredge pipe was moved to the next sub-cell while the previous one dewatered for a minimum of 28 days. Dewatering occurred sequentially to adjoining cells to maximize effluent retention times. In addition to the two contained fill areas, approximately 3,543,300 cubic yards of borrow material was placed in unconfined, expansion areas to the south of Fill Area 1 and to the east of Fill Area 2. An additional 454,000 cubic yards of borrow material was placed in the open water area between Confined Fill Area 2 and the shoreline protection wall along Bayou Rigolettes. The total project quantity of dredge material was 9,364,000 cubic yards and the construction cost for the project was $34,988,690.

Table 1. As-built features for sub-areas within the BA-36 project (Barowka & Bonura 2010).

Confined Fill Area 1	**Confined Fill Area 2**
• ~500 acres of marsh created/nourished • ~32,507 linear feet of containment • ~2,030,100 yd^3 dredge material	• ~711 acres of marsh created/nourished • ~35,151 linear feet of containment • ~3,337,500 yd^3 dredge material
Expansion Fill Area 1 and 2	**Expansion Fill Area 3**
• ~404 acres of marsh created/nourished • ~907,000 yd^3 dredge material	• ~1,174 acres of marsh created/nourished • ~2,636,300 yd^3 dredge material

The BA-36 project is considered a 'marsh creation' project within the CWPPRA classification. Additional descriptive information regarding this project can be found in documents prepared by the USFWS and LDNR, including an Environmental Assessment (Roy 2005) and Ecological Review (Belhadjali 2003). The BA-36 project will work synergistically with other planned and existing CWPPRA projects in the area to maintain the hydrologic and ecological integrity of the Barataria Basin. The Barataria Basin Landbridge Shoreline Protection Project (BA-27) was approved on PPL's 7, 8, 9, and 11, as a critical first step in maintaining the Barataria Basin Landbridge. Completed in 2017, the BA-27 project provides approximately 119,290 ft (36,360 m) of shoreline protection to the Barataria Basin Landbridge area. The BA-27 project protects the marsh shoreline from the high wave energy of Bayou Perot and Bayou Rigolettes, including the shoreline surrounding the BA-36 project area. The Northwest Turtle Bay Marsh Creation (BA-125) project was approved on PPL 21 and was approved for construction by the CWPPRA Task Force in January 2017. The BA-125 project is expected to create approximately 484 acres of marsh habitat and nourish approximately 216 acres in the area immediately south of the BA-36 project using dredged material from Turtle Bay.

II. Operation and Maintenance Activity

There are no planned Operation and Maintenance (O&M) activities for the life of the BA-36 project.

III. Monitoring Activity

CWPPRA projects authorized for construction after April 16, 2003 were to be monitored with Coast-wide Reference Monitoring System (CRMS) stations, other existing data collection, and any additional data-collection specifically added to the project monitoring budget. Initially, no additional monitoring funds were added to the BA-36 project budget for project-specific monitoring. However, a funding request was approved by the CWPPRA Task Force in 2011 for additional project-specific monitoring which will allow for more accurate determination of project success. There are no CRMS monitoring sites located within the project area boundary; however, there are two CRMS sites located less than one mile to the northeast (CRMS0261) and to the southwest (CRMS4218) of the project area (Figure 1). Data parameters collected at the CRMS stations include surface water depth and salinity, soil porewater, sediment accretion, and emergent vegetation (Folse et al 2014).

a. Monitoring Goals

The following project goals were developed for the original CWPRRA/CIAP-funded project area only (Confined Fill Areas 1 and 2):

1. Within the 1,245-acre project area, create 1,217 acres of emergent marsh by filling open-water areas and fragmented marsh with dredged material. The remaining 28 acres are to remain as open water.

2. Of the 1,217 acres created, maintain 995 acres 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 goals listed above:

i. Aerial Photography

Land to water ratios within the BA-36 project area will be monitored over the life of the project to aid in evaluating project success. A timeline of past and future analyses is detailed below:

- In the pre-construction period (2008), high resolution (1:6,000) aerial photography of the project area was acquired through the BA-27 project. BA-36 monitoring funds were used to analyze additional frames that were collected but not analyzed for the BA-27 project.

- A geospatial analysis of the BA-36 project was conducted through a CIAP-funded study conducted by Louisiana State University (LSU) under contract for the CPRA titled, *Controls on the Successful Use of Dredged Sediments for the Restoration and Rehabilitation of Brackish Marshes on the Barataria Basin Landbridge* (Mendelssohn et al. 2015). In this study, successional changes in land/water ratios within the BA-36 project area were determined from four base maps (2008, 2010, 2011, and 2012). The 2008 pre-construction imagery was constructed from 12 digital orthophoto quarter-quads (DOQQ) flown by the U.S. Geological Survey (USGS) at 1:12,000-scale with a 1-meter pixel ground resolution. The 2010, 2011, and 2012 low-altitude color-infrared aerial photos were flown by Aero-Data Corporation, LLC (Baton Rouge, LA) at a 1:4,000-scale with a 0.076-meter pixel ground resolution. Using ESRI ArcGIS 9.1 software, individual surface features, which included vegetation, open water, and bare soils, were drawn as contiguous polygons and quantified for each of the four aerial datasets.

- In post-construction years 10 and 20 (2020 and 2030), land/water data will be obtained from digital imagery (Z/I Imaging digital mapping camera) with 1-meter resolution to be collected during CRMS coast-wide flights. CRMS coast-wide photography is collected approximately every 3 years; therefore, the actual years analyzed will be the closest available to 2020 and 2030. CRMS photography will always be acquired in fall to early winter to adjust for some seasonality differences. The photography will then be geo-rectified using standard operating procedures described in Folse et al. (2014), and land/water ratios will be determined.

ii. Marsh Elevation

To monitor soil settlement in the BA-36 project area over time, topographic surveys have been conducted with a real time kinematic (RTK) GPS during project design, construction, and in the post-construction monitoring period. A timeline of survey events within the BA-36 project area is detailed below and summarized in Table 2:

- To facilitate the design of the borrow and confined fill areas, a hydrographic and topographic survey was performed in April and May 2003 by SJB Group, Inc. and Coastal Engineering Consultants, as shown in Appendix A-1. Horizontal datum was Louisiana State Plane, South Zone, NAD83 (ft), and vertical datum was NAVD88, Geoid99 (ft).

- In September 2008, a pre-construction survey was conducted by T. Baker Smith which involved laying out baselines, transects, and staking out containment dikes, grid points, and conducting hydrographic surveys of the borrow areas. Grade stakes and twelve settlement plates were installed at the locations shown in Appendix A-2. Horizontal datum was Louisiana State Plane, South Zone, NAD83 (ft), and vertical datum was NAVD88, Geoid99 (ft).

- In the fall of 2009, HydroTerra Technologies, LLC provided as-built grade stake elevations (Appendix A-2) of the confined fill areas 28 days after fill deposition was completed in each of the cells. Horizontal datum was Louisiana State Plane, South Zone, NAD83 (ft), and vertical datum was NAVD88, Geoid99 (ft). As-built data collected in March 2010 is also available from 14 gradestakes located in the expansion fill areas.

- In the fall of 2011, Mendelssohn et al. (2015) surveyed replicate sampling stations with a real time kinematic (RTK) GPS at specific elevation ranges (high, medium, low, very low) within the confined and unconfined fill-areas, as well as within 'healthy' and 'degraded' reference areas that did not receive sediment (Appendix A-3). Ten sites were established in the confined fill areas, 15 sites were established in the unconfined fill areas, 5 stations were established in healthy reference marsh, and 5 stations were established in degraded reference marsh (35 stations in total). Stations were surveyed relative to NAVD88 (m) (Geoid09) and later converted to Geoid12A for comparison purposes within that report.

- In the fall of 2012, a survey of the BA-36 unconfined, expansion fill areas was conducted in association with the design of the BA-125 project (Appendix A-4). Horizontal datum was Louisiana State Plane, South Zone, NAD83 (ft), and vertical datum was NAVD88, Geoid12A (ft).

- In post-construction years 4 (2014) and 6 (2016), HydroTerra Technologies, LLC surveyed transects within the confined fill areas along a subset of the gradestake gridlines (Appendix A-5). Twelve settlement plates were also resurveyed. Horizontal datum was UTM, NAD83, Zone 15, in meters, and vertical datum was NAVD88, Geoid12A in U.S. feet.

- One final topographic survey will be conducted in post-construction year 20 (2030) along the same transects surveyed by HydroTerra shown in Appendix A-5.

Table 2. Summary of topographic and bathymetric datasets collected within the BA-36 project area.

Collection Date	Source	Area Surveyed	Geoid
5/2003	BA-36 Design	Confined Fill Areas	99
Fall 2008	BA-36 Pre-Construction	Confined Fill Areas	99
Fall 2009	BA-36 As-Built	Confined Fill Areas	99
Fall 2011	Mendelssohn et al. (2015)	Confined and Expansion Areas	12A
Fall 2012	BA-125 Design	Expansion Areas	12A
3/2014	BA-36 Monitoring	Confined Fill Areas	12A
2/2016	BA-36 Monitoring	Confined Fill Areas	12A

Vertical adjustments were applied to convert the 2003, 2008, and 2009 surveys from the GEOID99 to the current GEOID12A model so that all surfaces could be directly compared. Each survey dataset was re-projected horizontally and vertically to the UTM NAD83 coordinate system and the NAVD88 vertical datum in meters using Corpscon® software. The re-projected data were imported into ESRI ArcGIS® 10.2.1 software for surface interpolation. Triangulated irregular network (TIN) models were then produced from the point data sets. Next, the TIN models were converted to grid models [1.0 m^2 (3.3 ft^2) cell size], which were clipped to polygons for the extent of the fill areas. The spatial distribution of elevations was then mapped in 0.5 foot (0.15-m) elevation classes and the resulting elevation grid models (Appendix C) were used to estimate elevation and volume changes.

Elevation change grids (Appendix D) were created by subtracting the corresponding grid models using the Spatial Analyst>Math>Minus tool. After the elevation change grid models were generated, the spatial distribution of elevation changes in the fill areas were mapped in 0.5 foot (0.15-m) elevation classes. Lastly, volume changes were calculated in cubic meters (m^3) using the 3D Analyst>Raster Surface>Cut/Fill function within ArcGIS®. It should be noted that the grid models are limited by the extent of the survey points for each of the surveys as shown in Appendix A. The extent of the resulting grid models ranged from 1,025 ac to 1,116 ac and change models were limited to the extent of the smaller grid. This causes volume change to be slightly underrepresented for some periods.

Target elevations and settlement predictions were adjusted from GEOID99 to GEOID12A by calculating the average separation between the two geoid surfaces across the project area. Approximately 4,500 elevation points within the confined fill areas were converted from GEOID12A to GEOID99 using NOAA's Vertical Datum Transformation Tool (VDatum, Version 3.7). The mean separation between the two geoid surfaces within the project area was determined to be 0.54 ft and ranged from 0.51 to 0.56 ft; therefore, the target fill elevation of 2.5 ft (NAVD88, GEOID99) was adjusted by -0.5 ft to 2.0 ft (NAVD88, GEOID12A).

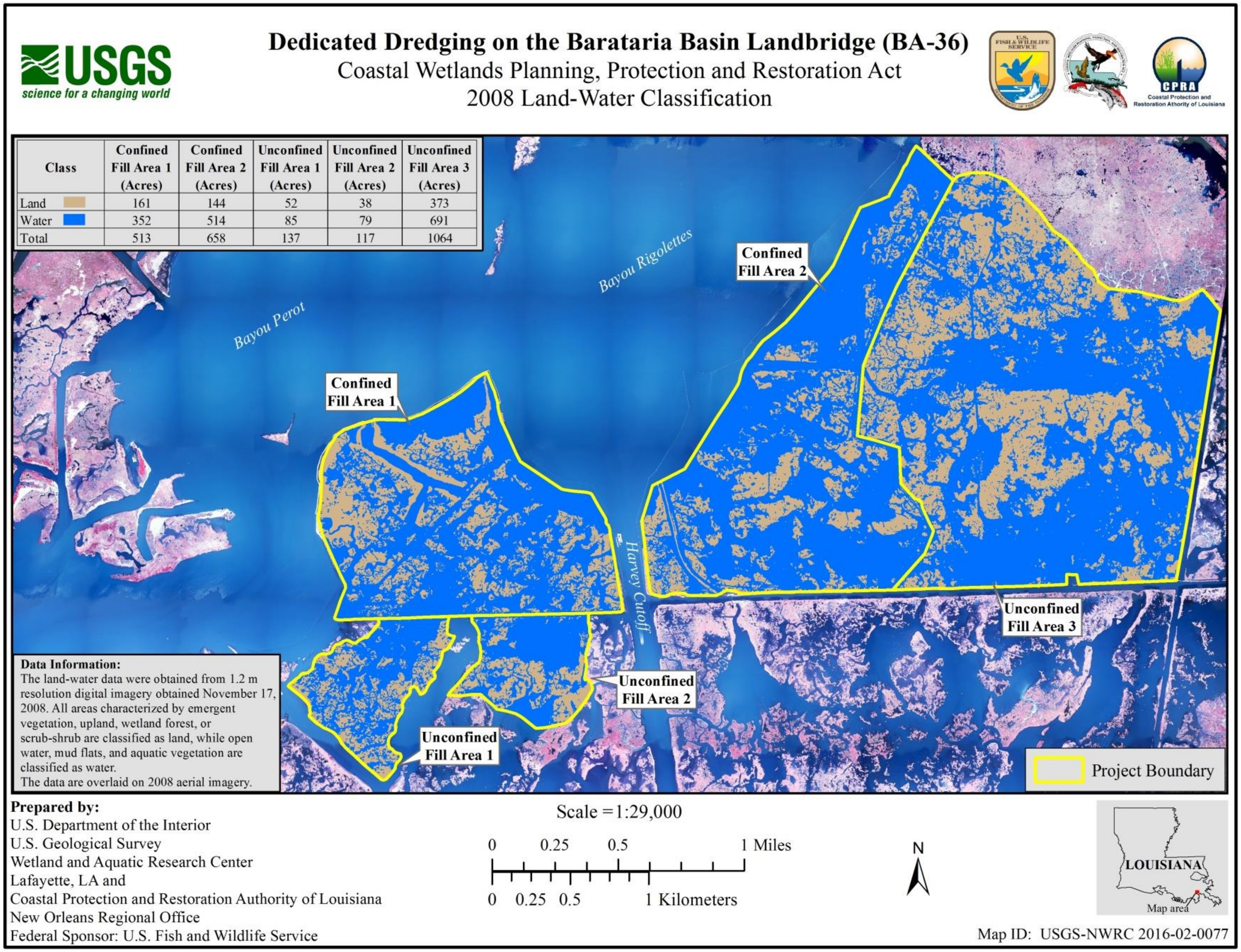
iii. Supplemental CIAP Study

The CPRA contracted Louisiana State University (LSU) to conduct a 3-year research study, which was funded through the Coastal Impact Assistance Program (CIAP), on the effects of the application of dredged sediments on hydrology, soil quality, and vegetation establishment within the Dedicated Dredging on the Barataria Basin Landbridge (BA-36) project (Mendelssohn et al. 2015). Main objectives were to 1) assess the hydrologic-elevation effects on vegetative recovery, 2) assay the physico-chemical nature of the sedimentary environment, 3) determine vegetative structural and functional recovery, 4) quantitatively assess spatial and hydrologic changes, and 5) determine surface elevation changes over time. Three years of field sampling were conducted during the fall season from 2011-2013 during which 35 sampling sites were established and sampled for soil physical and chemical properties, above- and belowground vegetative measurements, and soil elevation and accretion assessments. Soil analyses conducted within each sample year included bulk density, % moisture, % organic, soil texture, accretion, and chemical properties. Vegetative analyses included biomass, production, decomposition, species composition, and canopy height. To measure marsh inundation, three hydrologic recorders were installed and sampled quarterly for a period of 15 months. Acquisition and spatial analysis of 2008, 2010, 2011, and 2012 high-resolution infrared aerial imagery was also conducted as described above in the Aerial Photography section. Final results were provided in a report titled, *Controls on the Successful Use of Dredged Sediments for the Restoration and Rehabilitation of Brackish Marshes on the Barataria Basin Landbridge* (Mendelssohn et al. 2015).

c. Monitoring Results and Discussion

i. Aerial Photography

Pre-construction photography acquired in 2008 of the BA-36 project area, which was analyzed by the USGS Wetland and Aquatic Research Center (Figure 3), showed that Confined Fill Areas 1 and 2 contained 161 acres (31%) and 144 acres (22%) of land, respectively, for a total of 305 acres of land (26%). The three unconfined fill areas contained a total of 463 acres of land (35%). Land acreage in 1998 within the confined fill areas reported in the Wetland Value Assessment (WVA) (Roy 2005) was 517 acres, which equates to a loss of 21 acres/yr (5%/yr) within the confined fill areas between 1998 and 2008. This observed loss rate from 1998-2008 is higher than the estimated loss rate of 2.0%/yr reported in the WVA and used in loss projection calculations during project planning. Applying the 2% loss rate, the confined fill areas were projected to contain 390 acres of emergent marsh by the end of the 20 year project life if the BA-36 project was not constructed; however, the 2008 analysis showed only 305 ac of land in these areas just before project construction. It should be noted that the BA-36 project area at the time of project design was limited to the confined fill areas only, and contained a total of 1,245 acres. The confined fill area boundary was later reduced to 1,171 acres due to changes in containment dike



Class	Confined Fill Area 1 (Acres)	Confined Fill Area 2 (Acres)	Unconfined Fill Area 1 (Acres)	Unconfined Fill Area 2 (Acres)	Unconfined Fill Area 3 (Acres)
Land	161	144	52	38	373
Water	352	514	85	79	691
Total	513	658	137	117	1064

Figure 3. Pre-construction (2008) land/water analysis of the BA-36 project area.

placement; however, the 74 acres that were removed were primarily open water within Bayou Rigolettes.

Land/water analyses within the project boundaries shown in Figure 3 will be conducted again in post-construction years 10 and 20. Additional spatial analyses, however, were conducted by Mendelssohn et al. (2015) of the confined fill areas and a portion of the unconfined fill areas in the pre-construction (2008) and immediate post-construction years (2010, 2011, and 2012). Spatial classifications included Water, Vegetated, and Bare Ground for each year analyzed, and a 188-acre control area was also analyzed for comparison. Classification maps for each year are presented in Appendix B. Pre-construction land acreage (2008) in the two confined fill areas was reported to be 362 acres (Table 3), which is slightly higher than reported by the USGS analysis for 2008 (305 ac) but still lower than projected during project design.

As expected, the 2010 analysis showed a dramatic land gain within the project area, with 545 acres gained in the confined fill areas (151% increase) and 45 acres gained in the unconfined fill areas (16% increase) (Table 3, Figure 4a and 4b). Interestingly, the Bare Ground category was not present in years 2008 and 2010, so the acreage gain observed in 2010 consists entirely of vegetated marsh following one growing season

Table 3. Land acreage changes within the BA-36 fill and control areas from 2008 to 2012 calculated from Mendelssohn et al. 2015.

Year	Confined Fill Areas		Unconfined Fill Areas (partial)		Control	
	Total Land (ac)	% Land	Total Land (ac)	% Land	Total Land (ac)	% Land
2008	362	31	289	47	92	49
2010	907	77	335	55	74	39
2011	1086	92	587	96	68	36
2012	1092	93	599	98	63	34
Period	**Land Change (ac)**	**% Increase**	**Land Change (ac)**	**% Increase**	**Land Change (ac)**	**% Decrease**
2008-2010	+545	151%	+45	16%	-18	-20%
2010-2011	+179	20%	+253	75%	-6	-8%
2011-2012	+6	1%	+12	2%	-5	-7%
Overall (2008—2012)	+731	202%	+310	107%	-29	-32%

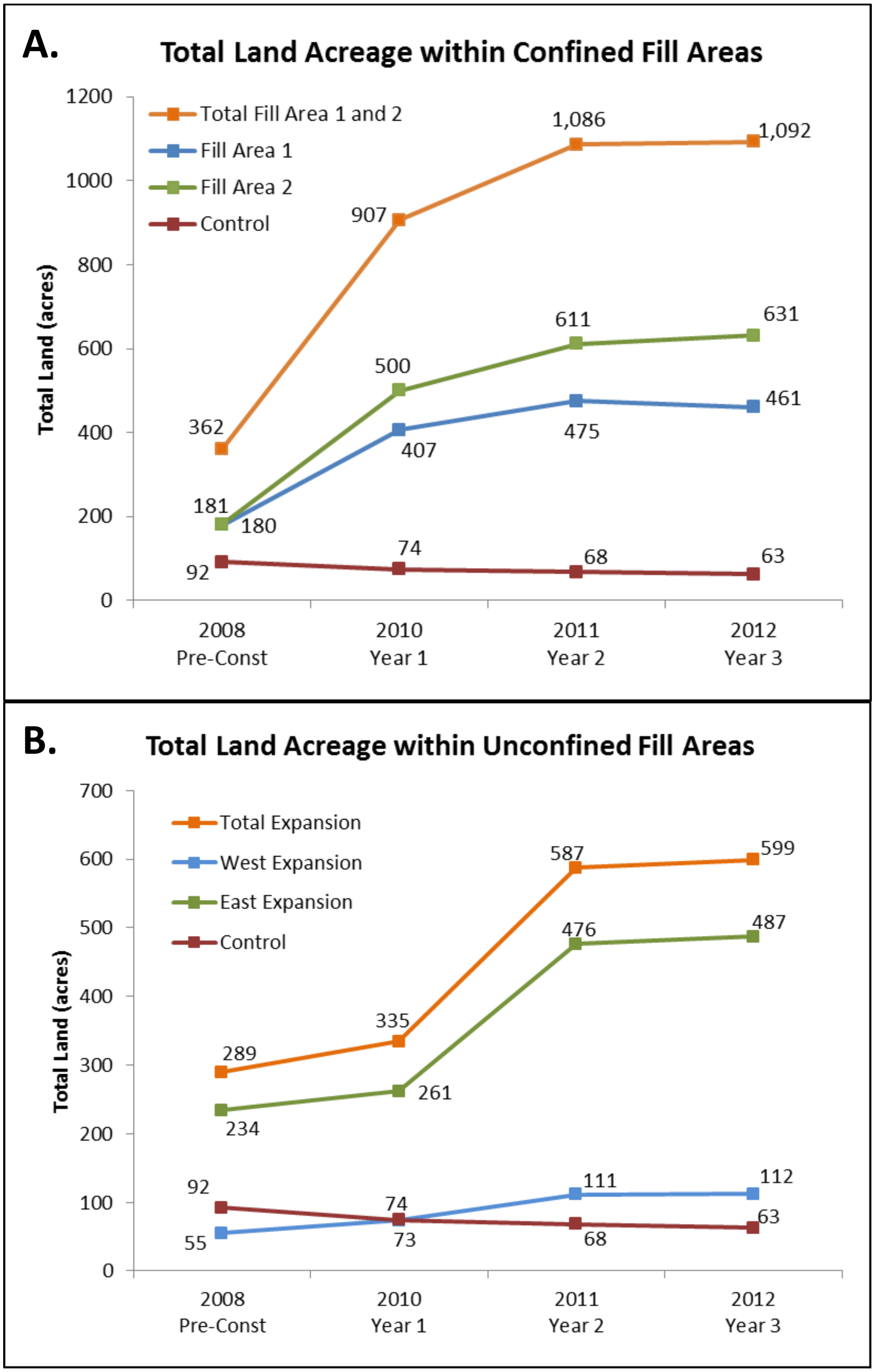


Figure 4. Total land acreage (vegetated and bare ground) from 2008 to 2012 within **(A.)** the BA-36 Confined Fill Areas and **(B.)** the BA-36 Unconfined Fill Areas as reported by Mendelssohn et al. (2015).

post-construction. From 2010 to 2011, there was a further increase in total land in all fill areas; however, in the confined fill areas the vegetated marsh decreased by 10-15% while the bare ground category increased by ~28% to 323 acres (Figure 5).

While the confined fill areas showed the most land gain in the first year after construction, the unconfined fill areas showed the most significant land gain after the second growing season (2010-2011) with a 75% increase in total land (+253 ac) and ~30% increase in vegetated marsh (Figure 4B, Figure 5). Although the lower fill elevations within the unconfined fill area took longer to vegetate than the confined fill areas, by the end of the second growing season the percentage of vegetated land was slightly higher in the unconfined fill areas than the confined fill areas (Figure 5). From 2011 to 2012, additional gains in land were minimal as the percentage of land in the confined and unconfined fill areas was already over 90% by 2011 (Figure 5). In Confined Fill Area 2 and both unconfined fill areas, there was a drop in vegetated land and an increase in bare ground from 2011 to 2012. It should be noted that there was also an increase in bare ground in the control area in 2011 and 2012, although an overall loss of land was observed in those years (Figure 5).

From 2008 to 2012, there was an overall gain of 731 acres of land (+202%) within the confined fill areas (Table 3) as a result of BA-36 project construction. Of the 1,092 acres of land present within the confined fill areas in 2012, 746 of these acres (68%) consisted of vegetated marsh. The partial unconfined fill area boundary showed an overall increase of +310 acres of land (+107%) from 2008 to 2012, with 465 acres of vegetated marsh out of 599 total land acres (78%) present in 2012. By comparison, the 188-acre control area lost a total of 29 acres of land from 2008 to 2012 (7.25 acres/yr) (Figure 4, Table 3) at a 9%/yr loss rate. At this loss rate, the confined fill areas would potentially have contained only 248 acres of land by 2012 had the BA-36 project not been constructed; therefore, in 2012, there were 844 more acres of land than would have been expected within the confined fill areas as a result of the BA-36 project. Similarly, the partial unconfined fill areas would potentially have contained only 198 acres in 2012 without the BA-36 project and now contain 401 more acres than would have been expected.

A comparison of observed and predicted land acreage shows that the BA-36 project was performing well by Year 3 post-construction. Predictions of vegetated and unvegetated land acreage within the confined fill areas at post-construction years 1, 3, 5, and 20 were made during project planning (Roy 2005). The confined fill areas vegetated much more quickly than was anticipated at Year 1 post-construction, although there was 21% less total land coverage than predicted (Figure 6). By Year 3, however, the total percent land was only 1% less than predicted and vegetated marsh coverage was 35% greater than predicted. By Year 5, it was anticipated that the created marsh platform would be completely vegetated. Actual conditions at Year 5 were not analyzed; however, to achieve this target the 30% of unvegetated land present within the confined fill areas (~347 acres) at Year 3 would have had to become vegetated over the following two growing seasons.

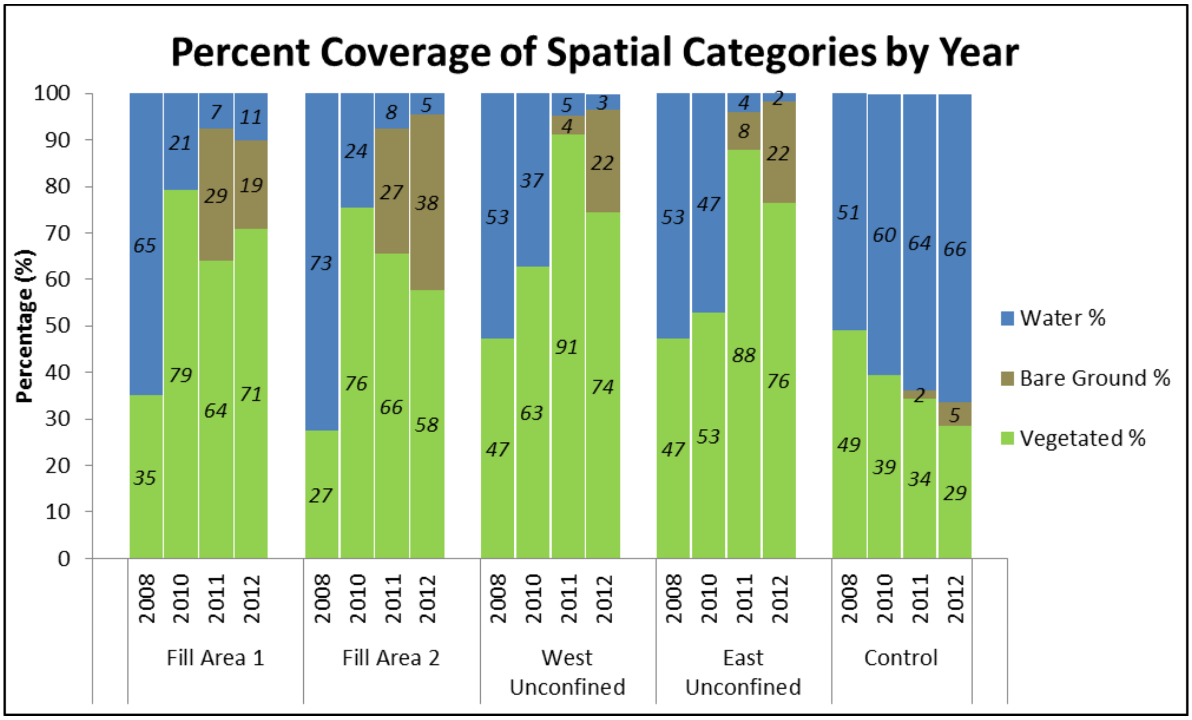


Figure 5. Percent coverage of water, bare ground, and vegetated categories by year in the BA-36 confined and unconfined fill areas and control area.

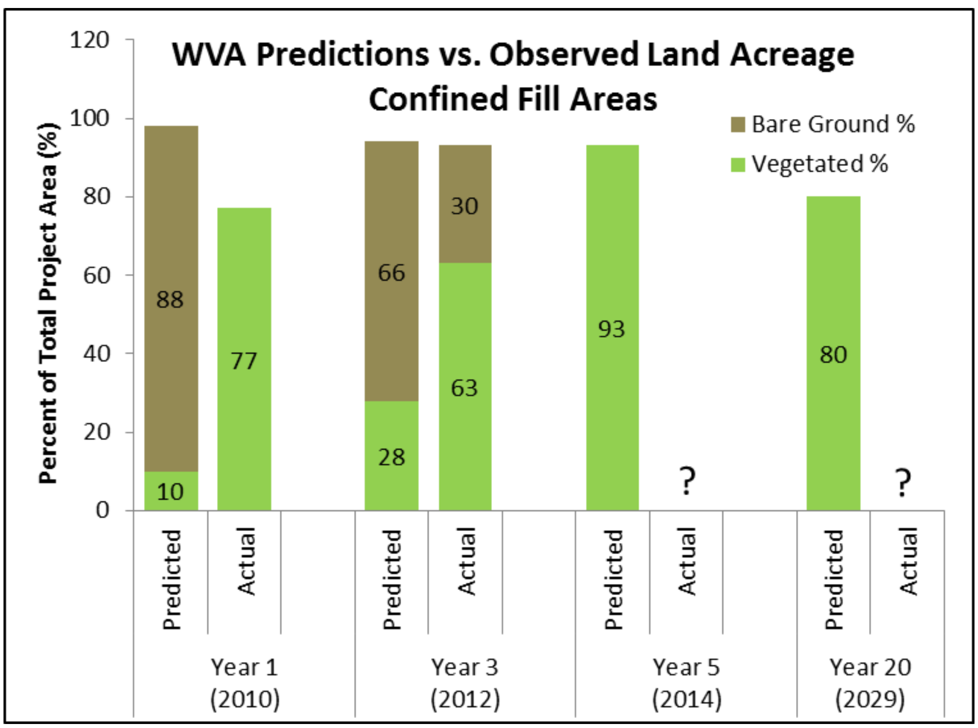


Figure 6. Predicted versus observed percent land coverage within the BA-36 confined fill areas.

ii. Marsh Elevation

Following a geotechnical investigation of the soils within the BA-36 project and borrow areas and determination of local marsh elevation and water levels, the target fill elevation for the confined fill areas was set at +2.5 ft NAVD GEOID99 (+2.0 ft NAVD GEOID12A) accounting for settlement over a 20-year project life (STE 2003, LDNR 2004). Initially, the created marsh platform would be above the existing mean marsh elevation which was determined to be +1.0 ft NAVD GEOID99 (+0.5 ft NAVD GEOID12A) (STE 2003), but would settle to this elevation by approximately year 10 of the project life (Figure 7a). Recent surveys of two nearby CRMS sites in 2014 show slightly higher mean marsh elevations of 0.65 (CRMS4218) and 0.58 (CRMS0261) ft NAVD GEOID12A. According to design settlement curves, this higher elevation would be achieved by years 6-8 (Figure 7b).

Determination of local water levels is an essential factor in maximizing the ecological function of marsh creation projects. Optimally, the elevation of the marsh fill should settle to within the intertidal range as soon as possible and remain intertidal for the duration of the 20 year life of the project. During project design, mean high water (MHW) and mean low water (MLW) were determined to be 0.86 and 0.35 ft NAVD GEOID99 (0.30 and -0.21 ft NAVD GEOID12A) based on nearby CPRA station BA01-07. This estimation appears abnormally low based on updated water level calculations and would have required 17 years of settlement for the marsh fill to reach intertidal range (Figure 7a). A more recent analysis of local, historic water levels was conducted during BA-125 project design (Gillen 2013) and was based on an average of mean water levels from CRMS4218 and BA01-07 from 2007 to 2012. MHW and MLW values were calculated to be 0.81 and 0.27 ft NAVD GEOID12A, which appears to be a more appropriate estimation of local water levels and the mean marsh elevation of the local CRMS sites falls within this range (Figure 7b). Applying this updated water level range to the BA-36 design settlement curve shows that the marsh fill would be expected to be intertidal at year 4 and remain within the intertidal range for most of the 20-year project life (until year 19) (Figure 7b).

For ease of reporting, all elevations will hereafter be reported in NAVD88 relative to the GEOID12A model only. Changes in volume and mean elevation in the BA-36 confined fill areas from 2003 to 2016 are summarized in Figure 8 for each survey year as determined by elevation grid models (Appendix C) and elevation change models (Appendix D). During the pre-construction period from 2003 to 2008, elevation models showed a slight loss in mean elevation and volume, with a greater loss observed in Fill Area 2 than Fill Area 1 (Appendix C1-C2, Appendix D1). Total estimated volume loss in the combined fill areas during this period was 388,428 yd^3 (296,975 m^3). Mean elevation dropped by 0.07 ft (0.02 m) within Fill Area 1 and by 0.30 ft (0.09 m) within Fill Area 2 during the pre-construction period (2003 to 2008). During that same period, construction of shoreline protection features associated with project BA-27 was completed in phases, which would have provided some protective effect from edge erosion.

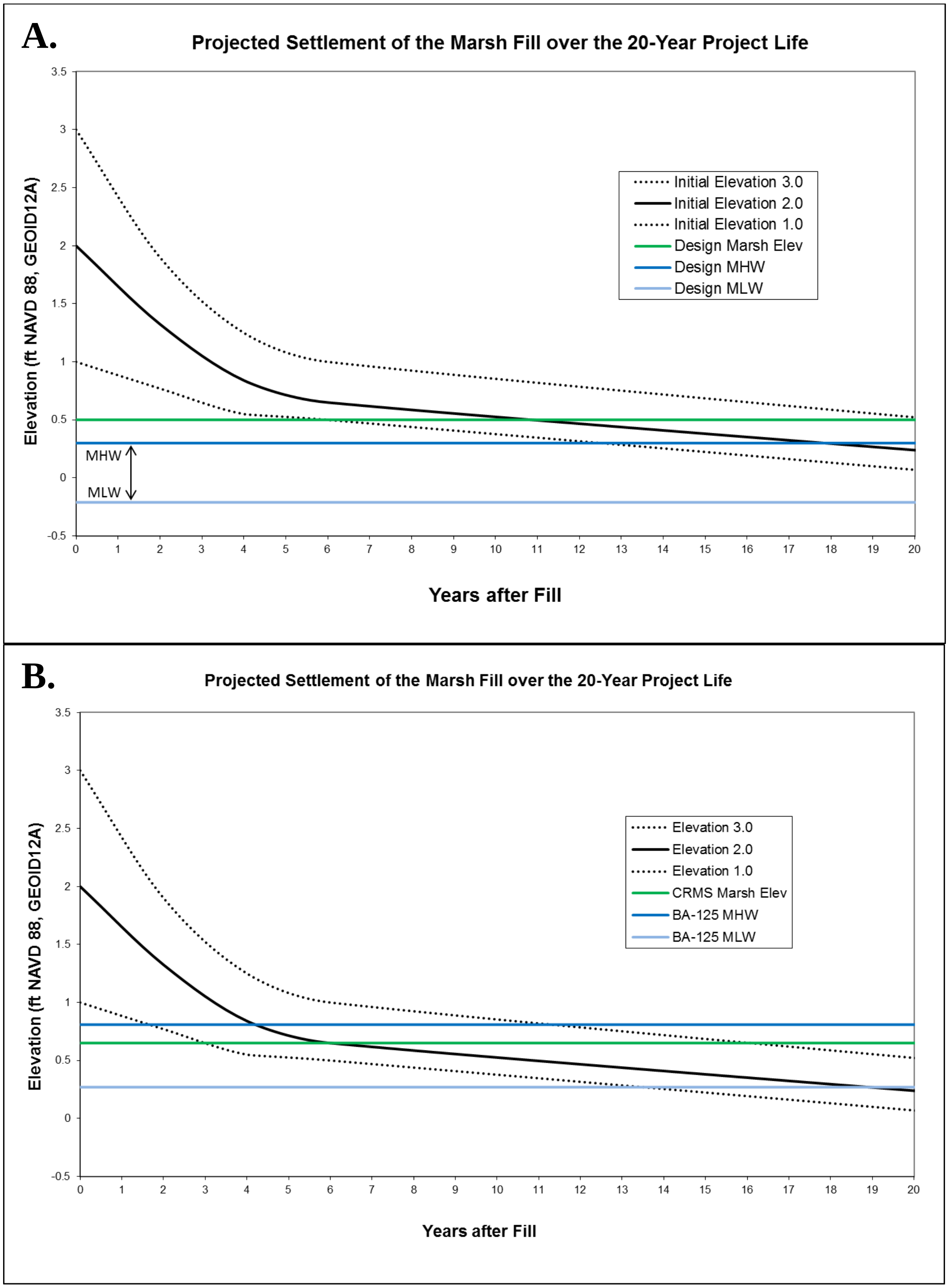


Figure 7. Projected settlement of the marsh fill at three different elevations over the 20-year project life as determined during project design. Settlement is shown in relation to water level range and mean marsh elevation determined during project design **(A)** and in relation to updated water level range and current CRMS site mean marsh elevation **(B)**.

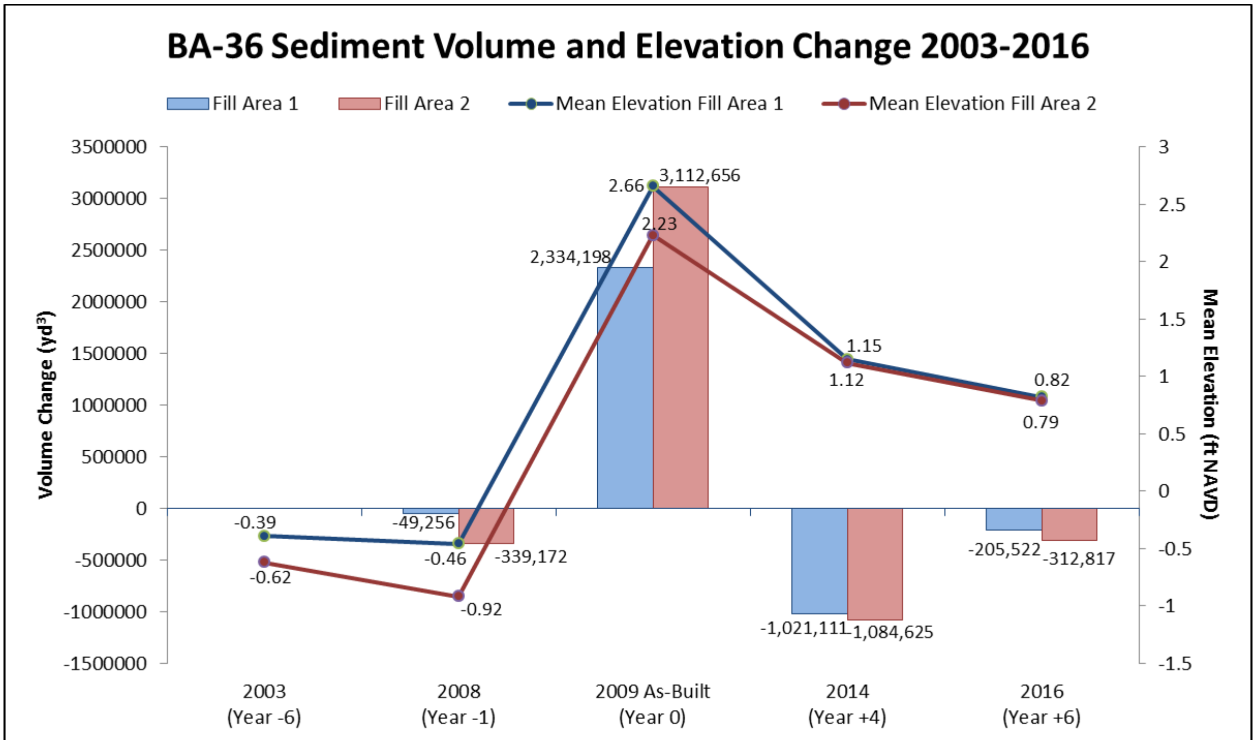


Figure 8. Summary of changes in sediment volume (yd^3) and mean elevation (ft NAVD88, GEOID12A) in the BA-36 confined fill areas from 2003 to 2016.

The 2009 as-built grid model (Appendix C3) and the 2008-2009 elevation change model (Appendix D1) show significant sediment gains resulting from BA-36 project construction. From 2008 to 2009, sediment volume increased by +2,334,198 yd^3 (+1,784,623 m^3) in Fill Area 1 and by +3,112,656 yd^3 (+2,379,797 m^3) in Fill Area 2 for a total volume gain of +5,446,854 yd^3 (+4,164,419 m^3). Estimated in-place fill quantities reported in the BA-36 project completion report (Barowka & Bonura 2010) were 13% lower within Fill Area 1 [+2,023,000 yd^3 (+1,546,695 m^3)] and 7% higher within Fill Area 2 [+3,337,500 yd^3 (+2,551,702 m^3)]. Significant volume loss occurred within the four years following construction due to primary settlement of the fill, dewatering, and subsidence. From construction to Year +4 (Appendix C4, D2), sediment volume was reduced by a total of -2,105,736 yd^3 (-1,609,951 m^3), with the loss in Fill Area 1 [-1,021,111 yd^3 (-780,696 m^3)] only slightly lower than the loss in Fill Area 2 [-1,084,625 yd^3 (-829,255 m^3)]. Between Years +4 and +6, total sediment loss was only -518,339 yd^3 (-396,299 m^3) indicating that primary settlement was mainly complete by this time (Appendix C5, D3). Total volume loss from construction to Year +6 (2016) is estimated at 2,624,075 yd^3 (2,006,250 m^3), which corresponds to 52% of the in-place volume remaining from construction.

The target fill height of the marsh fill was +2.0 ± 0.3 ft NAVD88 GEOID12A, which was accomplished using two lifts to accommodate for initial dewatering. The 2009 as-built grid model (Appendix C3) indicates that the mean elevation of Fill Area 1 immediately following construction was 0.36 ft over tolerance at +2.66 ft (+0.81 m) while the mean elevation of Fill Area 2 was within tolerance at +2.23 ft (+0.68 m) (Figure 8). As would be expected, the fill areas were 100% supratidal immediately following construction (Appendix C-3). From construction to Year +4, settlement was determined to be approximately 1.5 ft in Fill Area 1 and 1.1 ft in Fill Area 2 with a resulting mean elevation of 1.12 and 1.15 ft, respectively at Year +4. This indicates that the resulting Year +4 elevation was the same in both fill areas despite the higher as-built fill height in Fill Area 1. Additional settlement from Year +4 to Year +6 was 0.33 ft (0.10 m) in both fill areas (Figure 8) to a final elevation of 0.80 ft (0.2 m), which is at the upper limit of intertidal range.

Observed settlement of the fill was in general agreement with the predicted settlement curve based on the 2.0 ft and 3.0 ft fill levels, with the mean elevation of the fill remaining between the 2.0 ft and 3.0 ft curves through Year 6 (Figure 9). At the targeted 2.0 ft fill level, the marsh fill would have been expected to settle to natural marsh level (0.65 ft, CRMS4218) by Year 6, and the observed fill elevation by Year 6 was approximately 0.15 ft above this level. Mean fill elevation measured by Mendelssohn et al. (2015) in fall of 2011 (~Year 2) was 1.34 ft in Fill Area 1 and 1.35 ft in Fill Area 2, indicating that primary settlement of the fill may have occurred more quickly than expected within the first two years after construction (Figure 9). These elevations, however, were based on only 10 survey points that were selected based on target elevation ranges (high, medium, low); therefore, these data were not included in the full analysis. Settlement below the fill was measured by two settlement plates within Fill Area 1 and three settlement plates within Fill Area 2. These indicated that settlement below the fill was less than predicted in Fill Area 1 (Figure 10). At the 3.0 ft fill level, which was the approximate level of the fill at the time of settlement plate installation, there was 1.5 ft of settlement predicted below the fill by Year 6 due to a combination of natural subsidence and compaction of the below-fill sediments. Actual below-fill settlement was 0.9 ft in Fill Area 1 and 1.4 ft in Fill Area 2. This indicates that a greater percentage of the total settlement for Fill Area 1(Figure 9) is a result of settlement and desiccation within the slurry, and less from the foundation (below fill) sediments.

Using the tidal range calculated for project BA-125 (0.27 to 0.81 ft NAVD88 (MLW to MHW)), the percentage of the total area within intertidal range was calculated for each fill area (Figure 11). Immediately before construction (2008), only 20% of Fill Area 1 and 11% of Fill Area 2 was within the intertidal range, with the remainder being primarily subtidal. Both fill areas were 100% supratidal following construction, but by Year +6 approximately 37% of Fill Area 1 and 35% of Fill Area 2 had settled to intertidal range. Optimal marsh inundation range for intermediate marsh in Louisiana was calculated by Snedden and Swenson (2012) to be within the range of 10-90%. The natural marsh at CRMS4218 was inundated 33% of the time based on the mean water level collected at that site from 2008 to 2016. Percent inundation relative to the mean elevation of the fill areas was 7% by Year 4 and 22% by Year 6 (Figure 12), indicating that percent inundation of the created marsh platform is approaching that of the surrounding natural marsh as settlement continues.

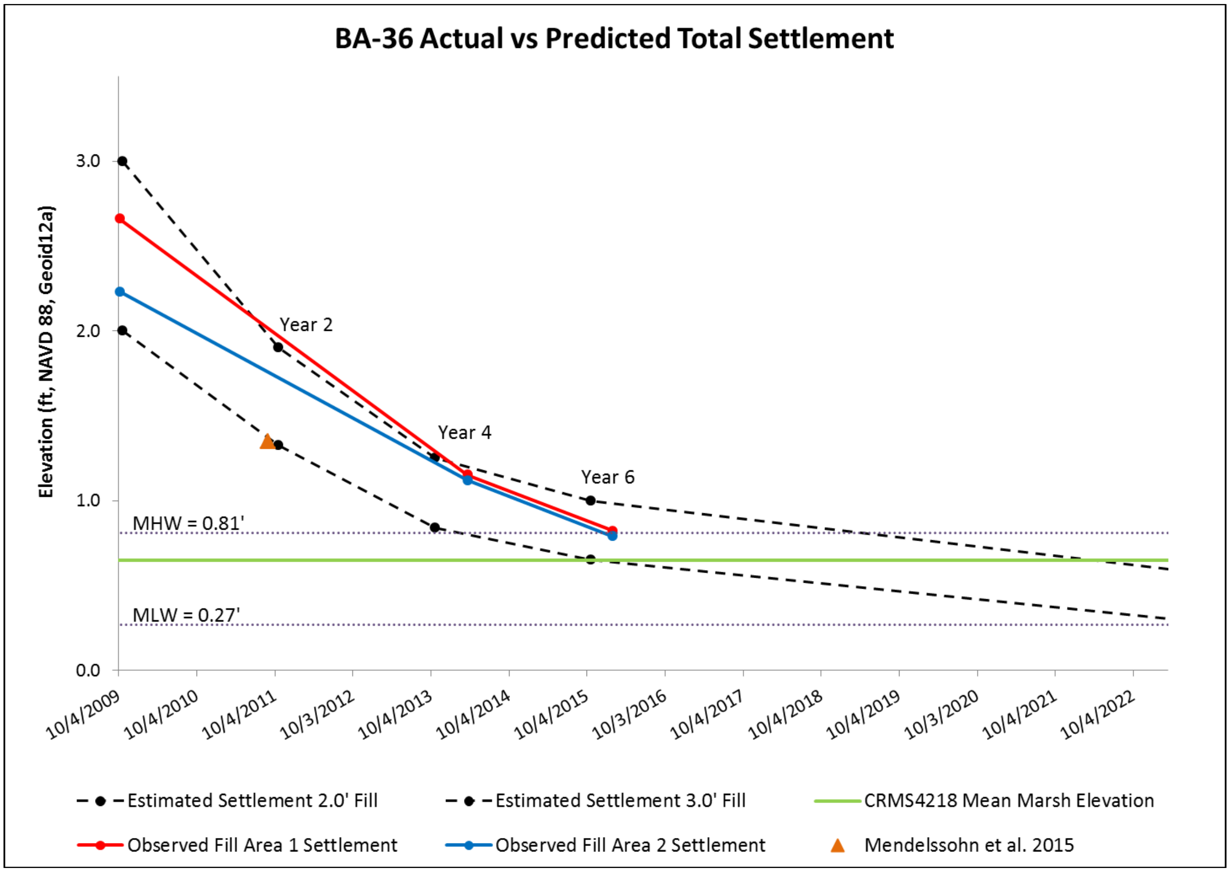


Figure 9. Actual versus predicted total settlement within the BA-36 confined fill areas.

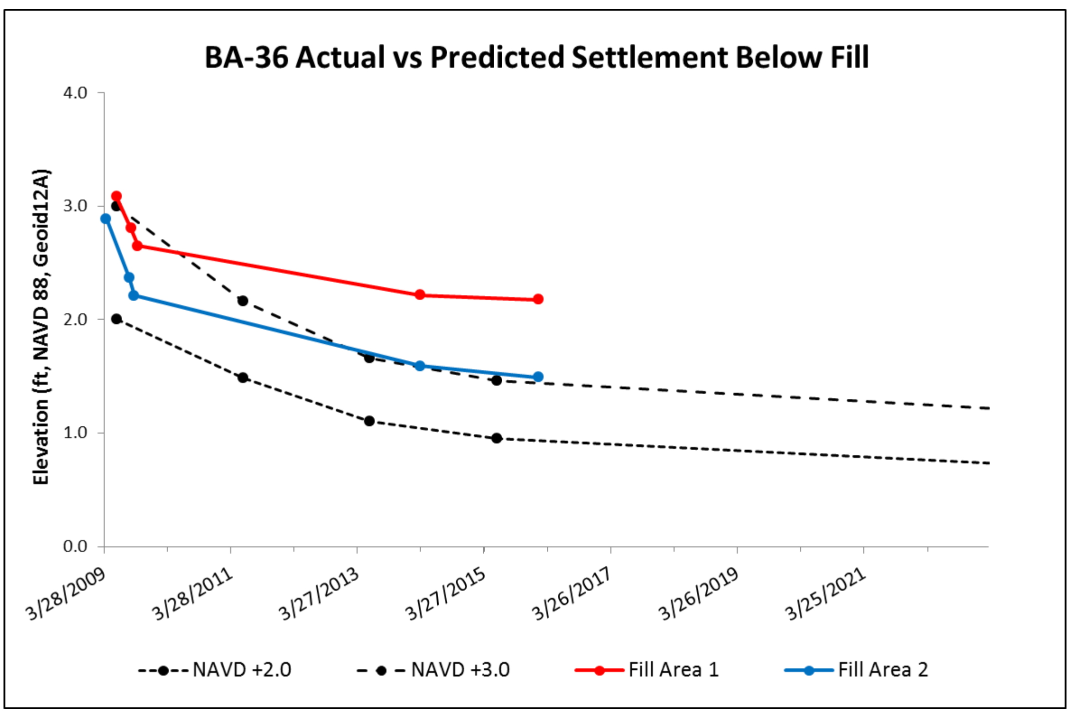
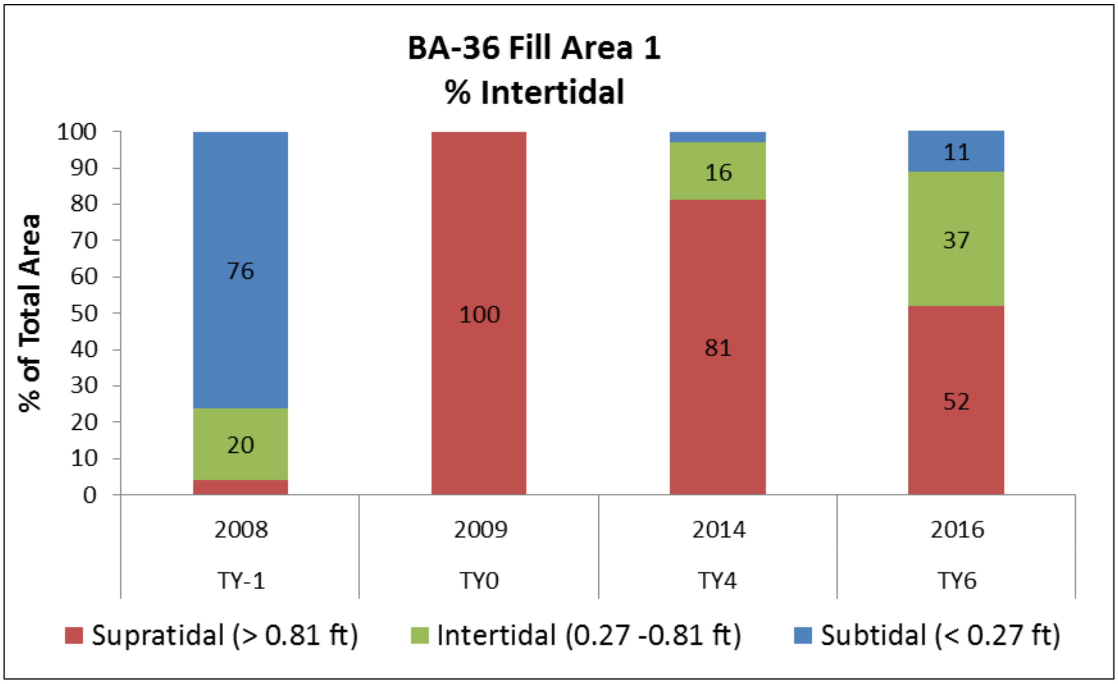


Figure 10. Actual versus predicted settlement below fill within the BA-36 confined fill areas calculated from settlement plates.



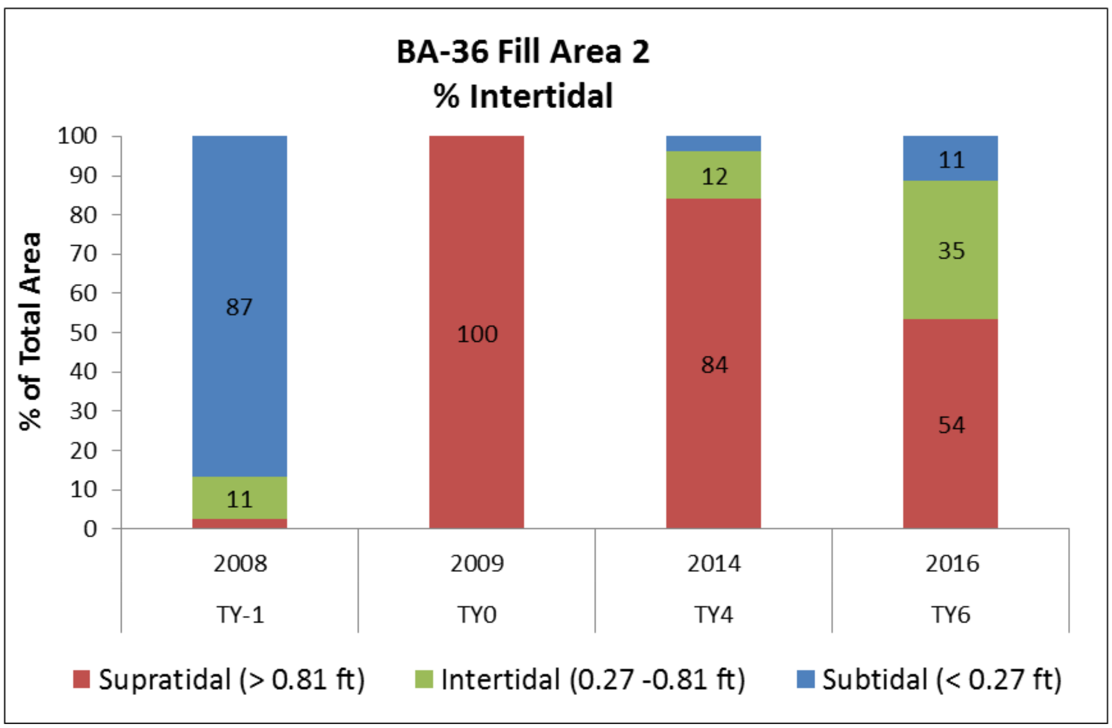


Figure 11. Percentage of intertidal area within the BA-36 confined fill areas from 2008 to 2016.

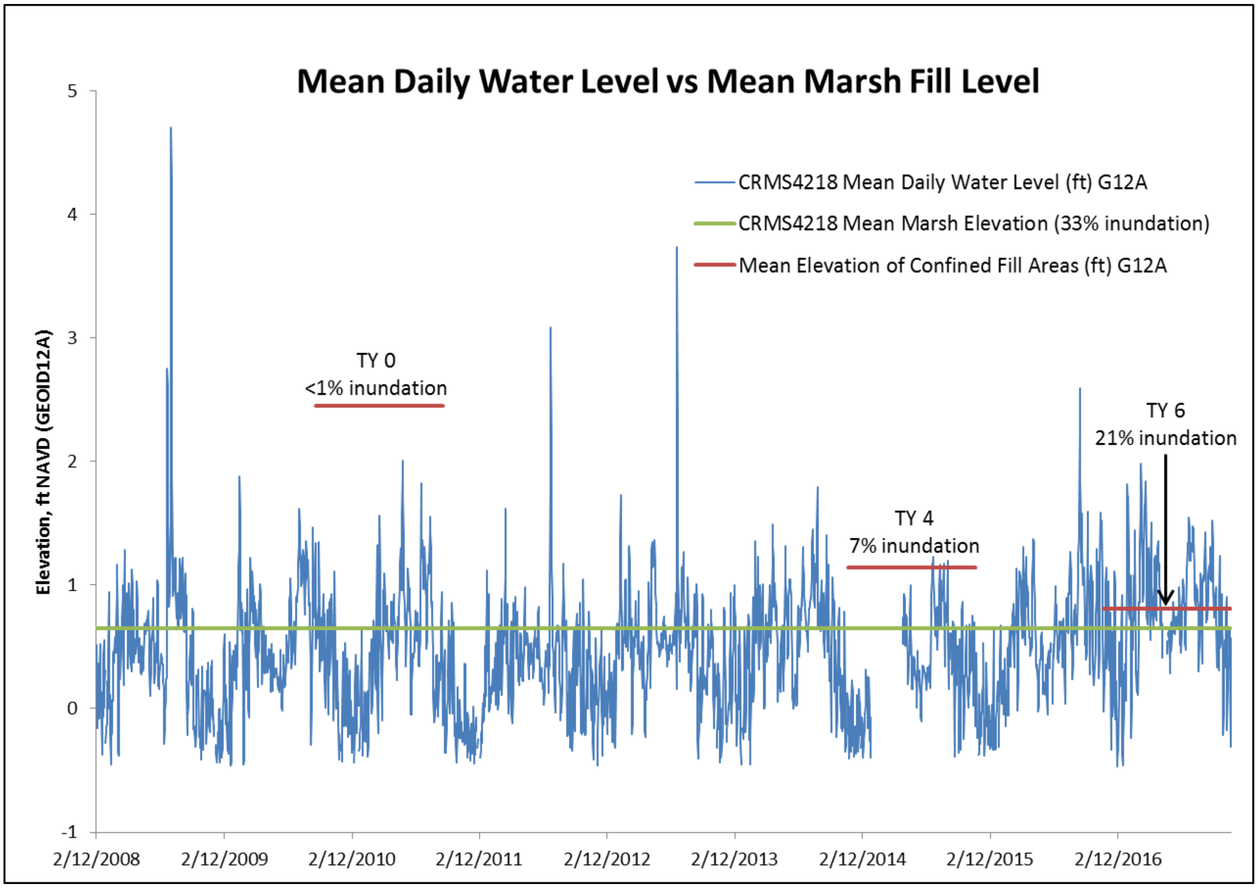


Figure 12. Percent inundation relative to BA-36 confined fill elevation at Year 0, Year 4, and Year 6 post-construction.

Expansion Areas:
Due to an underrun of material quantity and a bid that was below the estimated project cost, excess money and material were available to pump into three unconfined areas adjacent to the project site (Figure 1, Expansion Fill Areas 1, 2, and 3). Low level containment dikes were used only in strategic locations to close tidal gaps and openings to surrounding water bodies, while existing spoil banks and marsh were used as the primary containment elsewhere. Pre-construction and as-built elevation data are limited in these areas since they were not part of the initial project design. Upon the completion of construction, 'top of fill' elevation was surveyed at one location in Expansion Area 1, one location in Expansion Area 2, and along two east-west transects within Expansion Area 3 (Figure 13). These data show an as-built fill elevation (ft NAVD88, GEOID12A) of 2.58 ft in Expansion Area 1, 2.78 ft in Expansion Area 2, and a fill gradient along the Expansion Area 3 transects ranging from 2.78 ft nearest to the discharge point to 0.38 ft at the easternmost point (Figure 13). An elevation grid model was constructed from the elevation survey conducted in 2013 (Year +3 post-construction) for BA-125 project design (Appendix A-4, Appendix C-6). Although the same as-built survey points were not reoccupied in Year +3, the settlement at these points was approximated at those locations using the 2013 grid model as shown in Table 4. Settlement at the highest fill elevations in Expansion Area 3 (-1.6 to -1.9 ft) was similar to settlement in Expansion Areas 1 and 2. Settlement varied along the two transects in Expansion Area 3 and ranged from -0.13 to -1.93 ft, with higher fill heights generally experiencing greater settlement.

For comparison, the mean elevations of the expansion areas at Year +3 (2013) were plotted on the settlement curve developed for the BA-36 confined fill areas (Figure 14). Since the as-built elevations in Expansion Areas 1 and 2 are based on only one survey point at the highest fill level, actual mean settlement within these areas is likely to be lower than indicated in Figure 14. Settlement in Expansion Area 3, which was based on an average of as-built survey points along the fill gradient, was more similar to the 2.0' fill curve. By Year +3, the mean elevations of Expansion Areas 1 and 3 (0.72 and 0.59 ft) were within intertidal range and similar to the natural marsh at CRMS4218 (0.65 ft) (Appendix C-6). Mean elevation of Expansion Area 2 was approaching intertidal range at 0.95 ft. A calculation of the percentage of intertidal area within the expansion areas at Year +3 (2013) showed that Expansion Area 3 had the greatest percentage of intertidal area (47%) and subtidal area (21%) (Figure 15). This is attributable to the much larger outflow area for the unconfined fill as evidenced by the pronounced elevation gradient in Expansion Area 3 from west to east in Appendix C-6. Expansion Areas 1 and 2 showed a greater percentage of supratidal area (55% and 69%) and a percent intertidal area of 33% and 29%, respectively. Compared to the confined Fill Areas 1 and 2, which had only 16% and 12% intertidal area by Year +4, a greater percentage of the expansion fill areas was at a functional marsh elevation earlier in the project life; however, the expansion areas may be less resilient to future settlement, subsidence, and sea level rise over the 20-year life of the project.

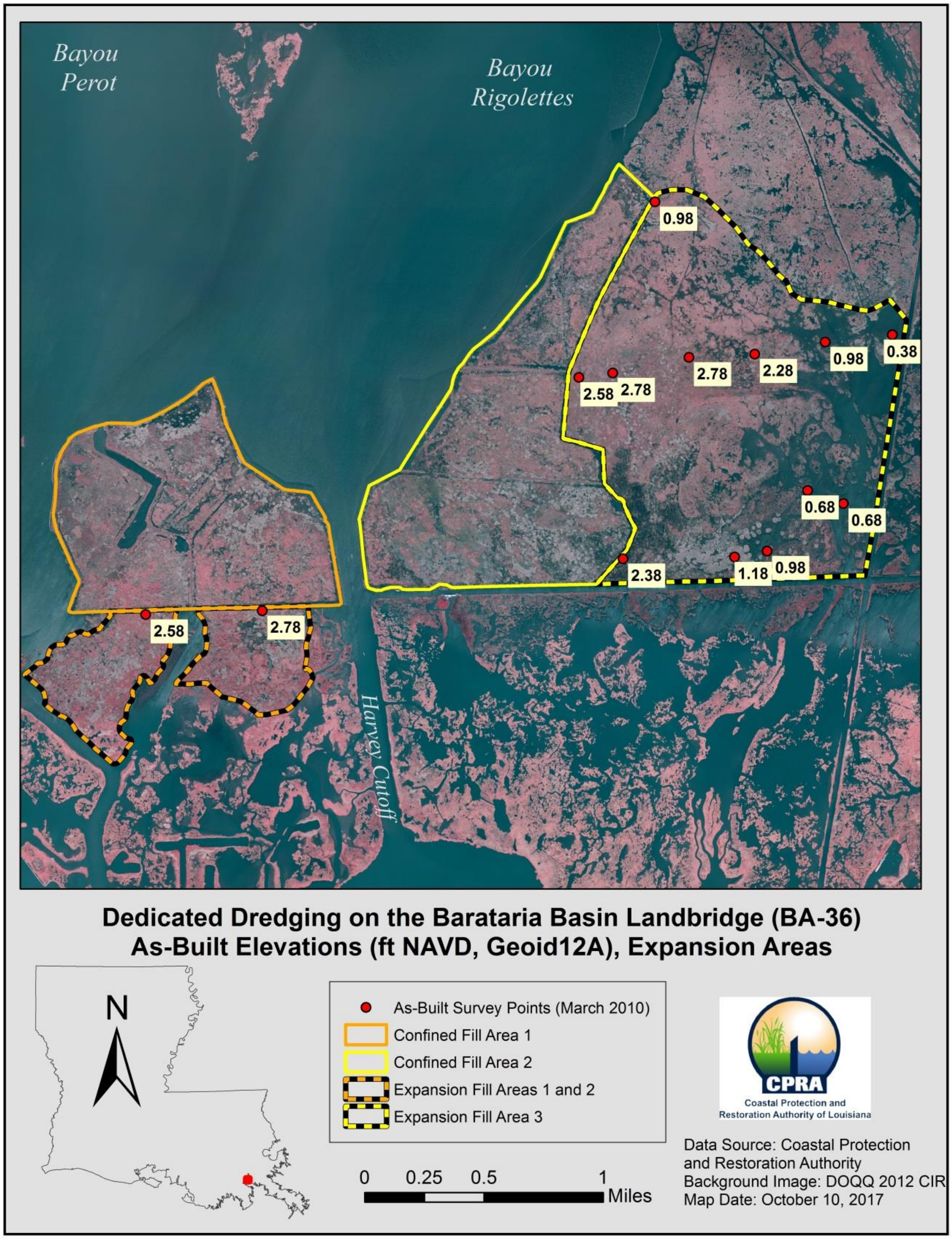


Figure 13. As-built grade stake elevations within the BA-36 unconfined expansion fill areas.

Table 4. Approximate as-built (2010) and Year +3 (2013) elevations within the BA-36 expansion areas.

	Elevation (ft NAVD88, Geoid12A)		
	2010	**2013**	**Settlement**
Expansion Area 1	2.58	1.00	-1.58
Expansion Area 2	2.78	0.86	-1.92
Expansion Area 3			
Transect 1	2.58	1.44	-1.14
	2.78	0.86	-1.92
	2.78	0.85	-1.93
	2.28	0.71	-1.57
Transect 2	2.38	0.98	-1.4
	1.18	0.81	-0.37
	0.98	0.85	-0.13
	0.68	0.05	-0.63
	0.68	0.04	-0.64
Avg Expansion 3	1.81	0.73	-1.08

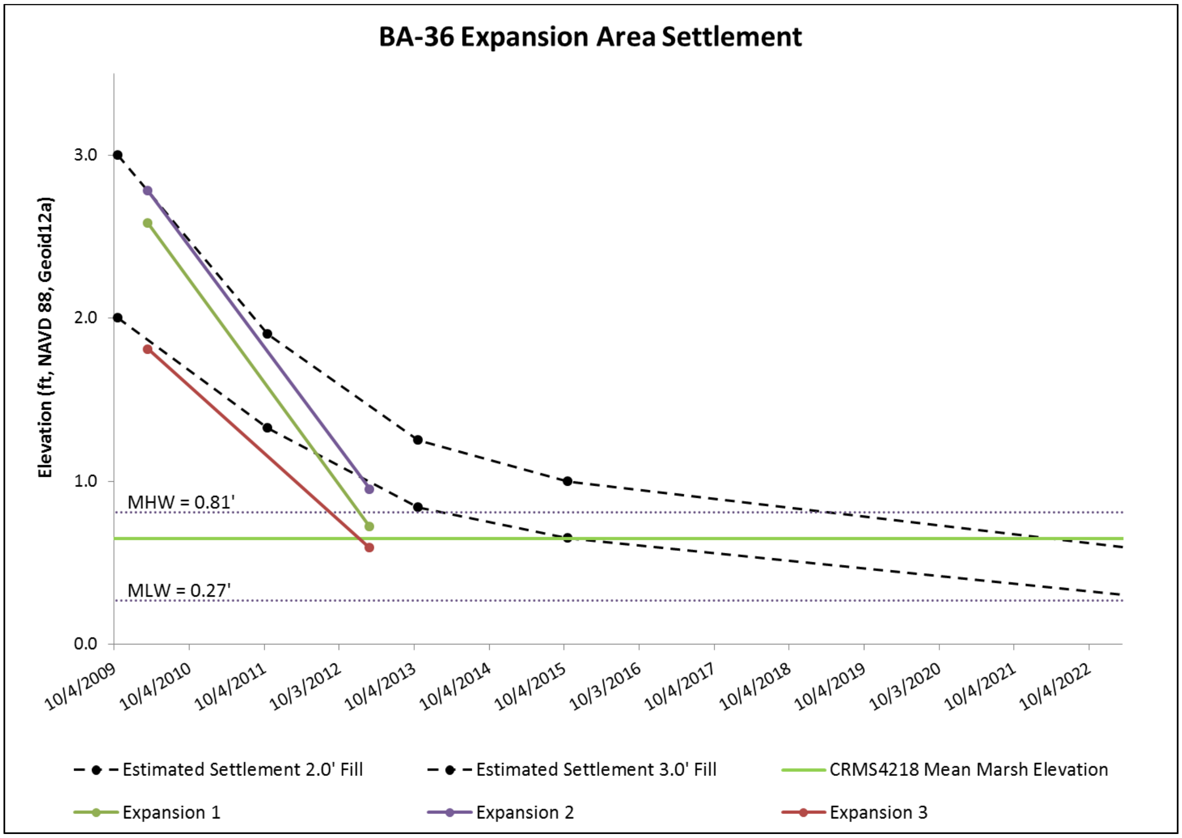


Figure 14. BA-36 expansion area settlement by Year 3 post-construction in relation to design settlement curves.

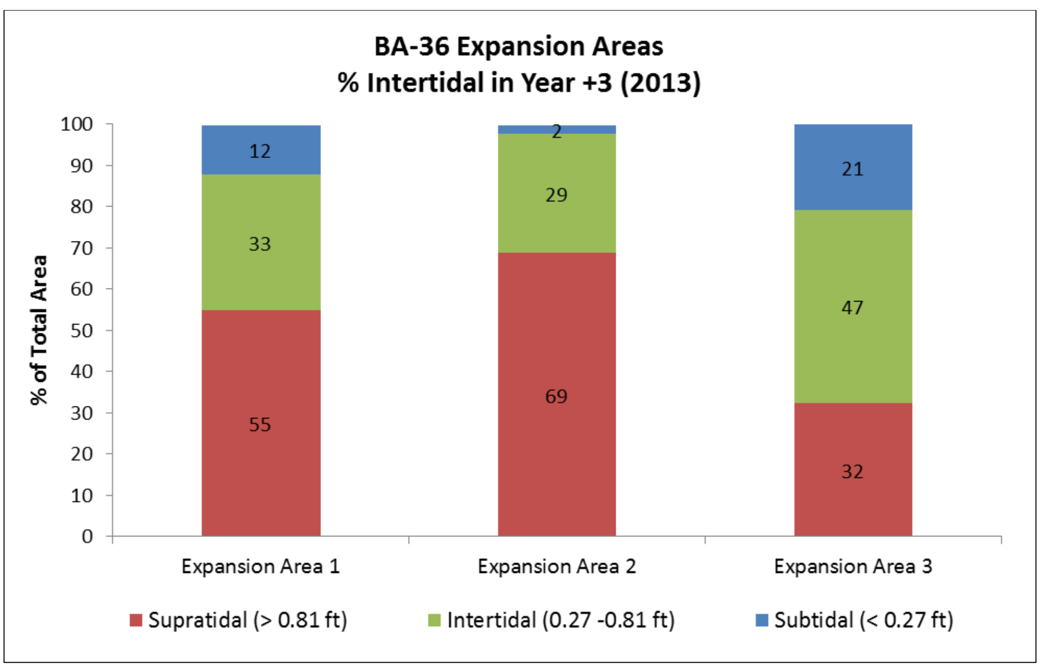


Figure 15. Percentage of intertidal area within the BA-36 expansion fill areas in 2013.

iii. <u>Supplemental CIAP Study</u>

The overall goal of the CIAP study titled, *Controls on the Successful Use of Dredged Sediments for the Restoration and Rehabilitation of Brackish Marshes on the Barataria Basin Landbridge* (Mendelssohn et al. 2015), was to evaluate the extent at which marsh restoration with hydraulically dredged sediments could restore, or at least improve, the ecological structure and function of the degraded marsh within the BA-36 project area. The effects of sediment-slurry application on several response variables were measured including vegetative cover, vegetative biomass, physical and chemical soil properties, and hydrology. The restored marsh was compared to two nearby reference marshes: a 'Healthy Reference' marsh and a 'Degraded Reference' marsh. In the restored marshes, study sites were selected and grouped into the following elevation treatments: Confined High Elevation, Confined Medium Elevation, Unconfined Medium Elevation, Unconfined Low Elevation, and Unconfined Very Low Elevation. Restoration success was based on two criteria: 1) the ability to reach ecological equivalency with Healthy Reference marsh, and 2) the ability to reach a condition of ecological improvement compared to the Degraded Reference marsh. Key findings are outlined below:

- From 2008 to 2012, the BA-36 project area (confined and unconfined) showed an increase in vegetative cover of 71%, a decrease in surface water areas by 81.8%, and an increase of 198.7 ha (24.9%) of elevated unvegetated soils. In comparison, the un-treated Control marsh lost 41.8% of its 2008 vegetative cover, increased its open water area by 29.9%, and added 3.8 ha (5.1%) of elevated, but unvegetated soils.
- Soil bulk density, mineral matter content, soil oxidation (Eh), total salts, and nutrient content increased with higher sediment-loads, while organic matter decreased. Considerable differences were apparent between the physico-chemical conditions of the restoration sites relative to the Healthy Reference marsh, although final marsh elevations in the restored marshes were at, or approaching, statistical equivalency. There was limited improvement in physico-chemical variables relative to the Degraded Reference marsh; variables that did improve were marsh elevation, soil ammonium and phosphorus, as well as iron, and potential stressors like conductivity. With respect to soil chemical variables, there was equivalency to the reference marshes for some, but certainly not all, of the restored marshes.
- Total and average plant species richness in the sediment-restored marshes were equivalent to the Healthy Reference marsh, with the exception of the Confined Medium treatment (total species richness) and Confined Medium and Unconfined Medium treatments (average species richness), which were lower. Also, the dominant plant species in the Healthy Reference marsh were dissimilar to those in the higher elevation restoration marshes, although species composition was more diverse relative to the Degraded Reference marsh.
- Total biomass (aboveground + belowground, live and dead) in the lower elevation restored marshes was equivalent to the Healthy Reference marsh and significantly higher than for the Confined High Elevation site. In contrast, aboveground biomass

(live+dead) did not differ among restoration treatments and reference marshes suggesting equivalency, although the highest (Confined High) and lowest (Unconfined Very Low) restoration treatments tended to have lower aboveground biomass then restored marshes at intermediate elevations. Belowground biomass decreased markedly with increasing elevation and was not equivalent to the Healthy Reference marsh. Marsh elevation was a critical abiotic driver of plant growth response. At higher marsh elevations, soils were drier and more oxidized, and plant total biomass was lower. In addition, higher percentages of silt and clay as well as higher concentrations of soil salts corresponded to lower total biomass.

- Accretion rates in the restoration marshes were equal to those in the Degraded Reference marsh, although the Confined High treatment tended to be lower than the reference marsh and was significantly lower than the Unconfined Very Low Elevation treatment. Aboveground production within the restoration area tended to equal that in the Degraded Reference marsh; belowground production mirrored the aboveground trend. Although differences in organic matter decomposition occurred among treatments, these differences were not quantitatively large. Cellulose degradation in the restored marshes was equivalent to the Healthy Reference marsh, except for the Confined Medium Elevation treatment, which was higher, while there were no differences compared to the Degraded Reference marsh.
- In summary, Mendelssohn et al. (2015) concluded that by 2012 the restoration marshes had not yet reached ecological equivalency with reference marshes for many of the variables and processes measured; however, the restored marshes were improved for a number of response variables, including total vegetated land cover, compared to the Degraded Reference marsh, which was highly ponded and consisted of few plant species. Thus, sediment-slurry application was successful in converting degraded fragmented marshes into marshes with contiguous vegetative cover and high species richness, more closely resembling the Healthy Reference marsh than the Degraded Reference marsh. Nonetheless, more time for functional development of the restoration marshes is necessary before ecological equivalency with the surrounding higher-quality natural marshes is completely achieved, at least relative to the response variables measured in this study.

V. Conclusions

a. Project Effectiveness

Based on aerial analyses, the Dedicated Dredging on the Barataria Basin Landbridge (BA-36) project was performing well by Year 3 post-construction. The BA-36 project succeeded in creating 731 acres of land in the confined fill areas from 2008 to 2012, while a nearby control marsh lost 29 acres during the same period at a 9%/yr loss rate. At this loss rate, there were 844 more acres of land in 2012 than would have been expected within the confined fill areas as a result of the BA-36 project. Vegetated marsh coverage exceeded WVA predictions at Year 3 with 35% greater marsh coverage than predicted, while total percent land was only 1% less than predicted. Although the entire unconfined fill area was not analyzed, results from the partial boundary (Appendix B) show that 310 acres of land were created from 2008 to 2012. Actual land gain would be expected to be higher within the full boundary. Unlike the confined areas which saw the greatest percent land gain immediately following construction, the unconfined areas saw the most significant land gain after the second growing season following construction as marsh nourishment stimulated increased vegetative growth in previously open water areas.

Elevation analyses showed that total settlement within the confined fill areas by Year 6 (2016) was in good agreement with the design settlement curve, with the observed mean fill elevation approximately 0.15 ft above the predicted target 2.0' level. Mean elevation of the Confined Fill Areas by Year 6 was approaching the upper limit of intertidal range, while mean elevation of Expansion Fill Areas 1 and 3 were already within intertidal range by Year 3. The percent of intertidal area within the Confined Fill Areas increased over time as settlement occurred, with approximately 35% of the Confined Fill Areas within intertidal range by Year 6. By comparison, approximately 31% of Unconfined Areas 1 and 2 and 47% of Unconfined Area 3 was intertidal by Year 3. These results indicate that a greater percentage of the Unconfined Fill Areas were at an elevation equivalent to an ecologically functional marsh earlier in the project life than the Confined Fill Areas; however, the percentage of intertidal area will continue to increase over time within the Confined Fill Areas as settlement continues. Since it is desired that the restored marsh surface will remain intertidal for the majority of the 20-year project life, the Confined Fill Areas may have a greater chance of meeting that goal. Finally, analyses conducted by Mendelssohn et al. (2015) concluded that both confined and unconfined marshes had not fully reached ecological equivalency with nearby reference marshes by 2012 for many of the variables and processes measured.

b. Recommended Improvements

- Future projects should consider the installation of instrumentation such as sub-surface piezometers during construction to improve upon the long term monitoring of the settlement for both the marsh fill and earthen containment dikes.
- To improve upon CPRA's adaptive management process, the design and planning of future marsh creation projects in the Barataria Basin should evaluate the design and monitoring of this project.
- Marsh creation design should allow for dewatering into adjacent marsh creation areas where possible to minimize material loss and increase material retention.
- The final topographic survey at Year 20 is only budgeted to include data collection in the confined fill areas. It would be beneficial to request additional funding to survey the expansion areas at the end of the project life.

c. Lessons Learned

- The cut to fill ratio was less than the design ratio leading to excess material in the borrow area. Fortunately, resulting excess material was able to be utilized within the expansion areas due to a highly cooperative landowner and the utilization of CWPPRA contingency funds and State Surplus Funds.
- The construction approach of pumping sequentially into sub-cells and dewatering into adjoining cells was effective and maximized the retention of effluent sediments. The determinations for fill area size and dewatering strategy are critical for constructing a successful marsh creation project.
- Unconfined placement of dredge material is significantly cheaper than confined placement due to the high cost of dike construction. Placement of dredge material in the unconfined areas yielded positive results in the immediate post-construction years, with significant marsh growth after the second growing season and a greater percentage of intertidal acreage compared to the confined areas by Year 3. Although it is not yet known how these unconfined areas will compare to the confined areas over the 20-year life of the project, unconfined dredge placement appears to be a viable, cost-savings option to consider when designing marsh creation projects. Where possible, future projects should consider permitting and design for additional marsh nourishment areas to account for overages in marsh creation quantities, which consistently occurs due to conservative designs.

VI. References

Barowka & Bonura Engineers and Consultants, LLC 2010. *Dedicated Dredging on the Barataria Basin Landbridge Project Completion Report, Project No. BA-36*. Prepared for State of Louisiana, Office of Coastal Protection and Restoration. 8 pp, plus Appendices.

Belhadjali, K. 2003. *Ecological Review: Dedicated Dredging on the Barataria Basin Landbridge*. Louisiana Department of Natural Resources. Baton Rouge, Louisiana, 11 pp.

Couvillion, B.R.; Barras, J.A.; Steyer, G.D.; Sleavin, William; Fischer, Michelle; Beck, Holly; Trahan, Nadine; Griffin, Brad; and Heckman, David 2011. Land area change in coastal Louisiana from 1932 to 2010: U.S. Geological Survey Scientific Investigations Map 3164, scale 1:265,000, 12 p. pamphlet.

Folse, T. M., L. A. Sharp, J. L. West, M. K. Hymel, J. P. Troutman, T. E. McGinnis, D. Weifenbach, L. B. Rodrigue, W. M. Boshart, D. C. Richardi, W. B. Wood, and C. M. Miller 2014. *A Standard Operating Procedures Manual for the Coastwide Reference Monitoring System-Wetlands: Methods for Site Establishment, Data Collection, and Quality Assurance/Quality Control*. Louisiana Coastal Protection and Restoration Authority. Baton Rouge, LA. 228 pp.

Gillen, Dain 2013. 30% Design Report, Northwest Turtle Bay Marsh Creation Project (BA-125), Jefferson Parish, Louisiana, August 2013. Natural Resources Conservation Service. 984 pp.

Louisiana Department of Natural Resources (LDNR) 2004. Dedicated Dredging on the Barataria Basin Landbridge Final Design Report, July 2004. LDNR and USFWS Project No. BA-36. 21pp.

Mendelssohn, I. A., M. D. Materne, S. A. Graham, S. Rohwer, and M. Kongchum 2015. *Controls on the successful use of dredged sediments for the restoration and rehabilitation of brackish marshes on the Barataria Basin Landbridge.* Submitted to: Louisiana Coastal Protection and Restoration Authority, in partial fulfillment of CPRA Contract No. 2503-11-39. 109 pp.

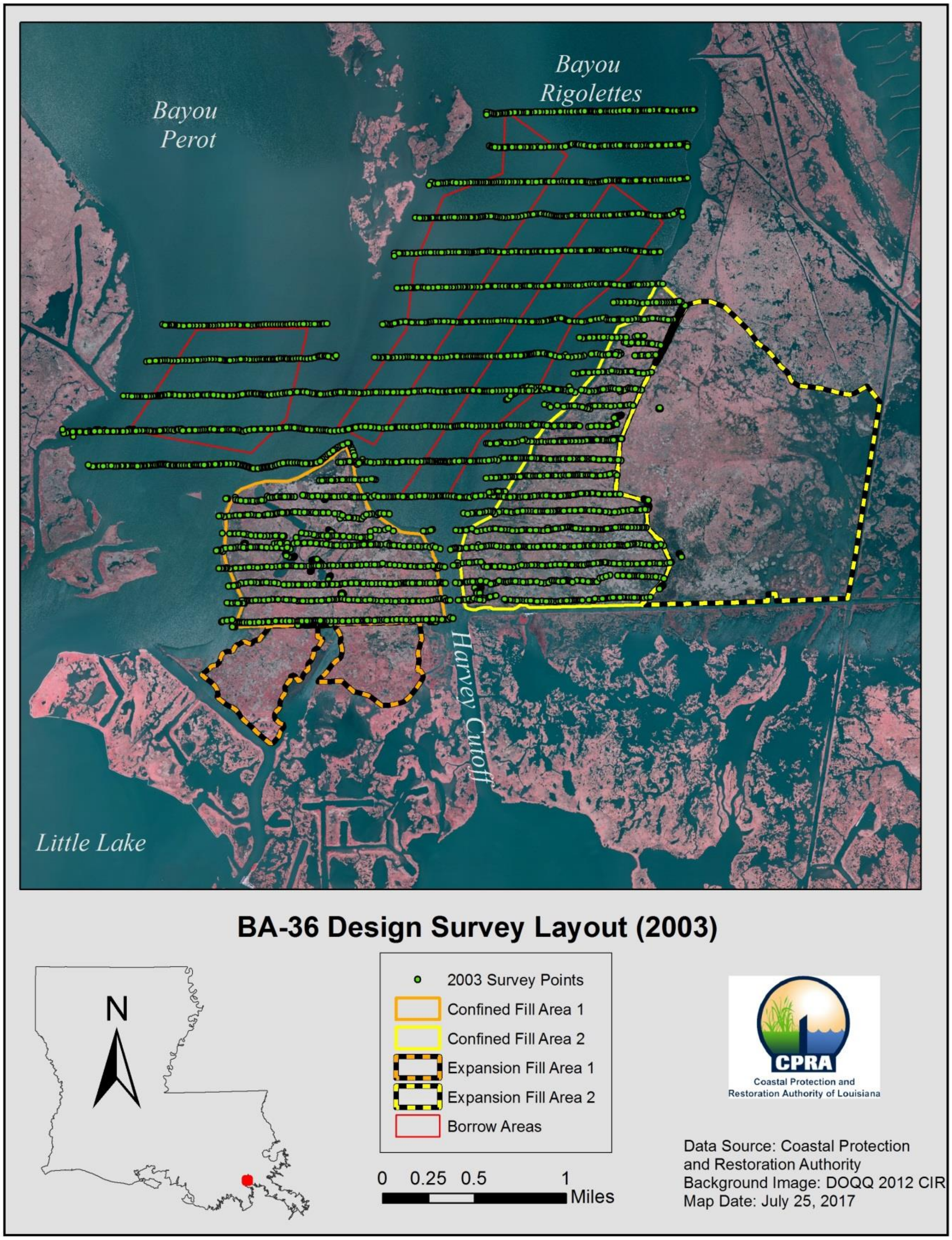
Roy, K. J. 2005. *Evironmental Assessment: Dedicated Dredging on the Barataria Basin Landbridge, BA-36*. United States Fish and Wildlife Service. Lafayette, Louisiana, 28 pp, plus appendices.

Simoneaux, R., S. Haynes, and K. Roy. (2011). A case study and lessons learned overview on the design and construction of three benchmark marsh creation projects in coastal Louisiana. The Proceedings of the Coastal Sediments 2011. *Miami, Florida, USA, 2 May – 6 May 2011.*

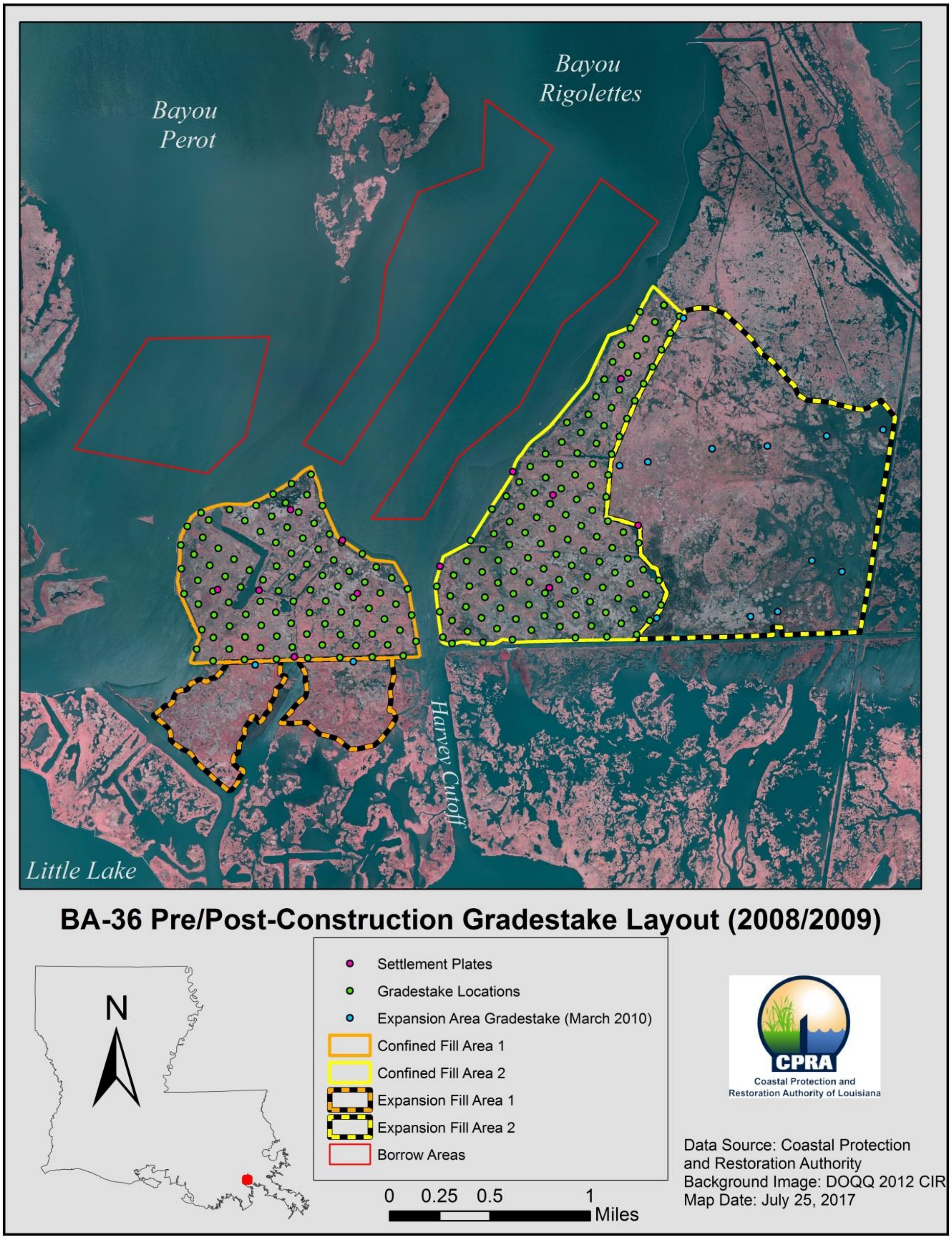
Snedden, G.A., and Swenson, E.M., 2012. Hydrologic index development and application to selected Coastwide Reference Monitoring System sites and Coastal Wetlands Planning, Protection and Restoration Act projects: U.S. Geological Survey Open-File Report 2012–1122, 25 p.

Soil Testing Engineers, Inc. (STE) 2003. Report of Geotechnical Investigation, Barataria Landbridge Project BA-36, Jefferson Parish. 94 pp.

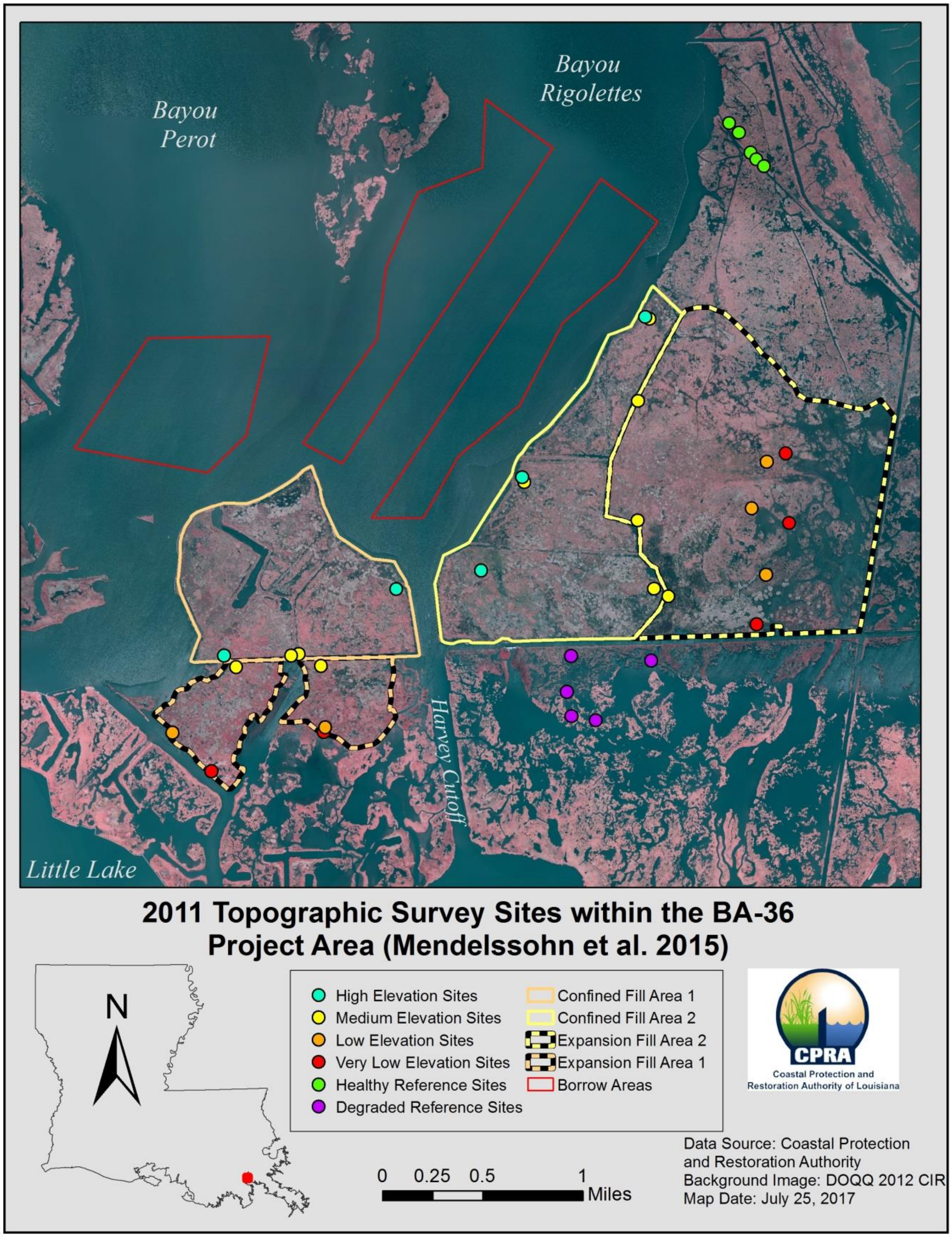
Appendix A
Elevation Survey Layout Maps



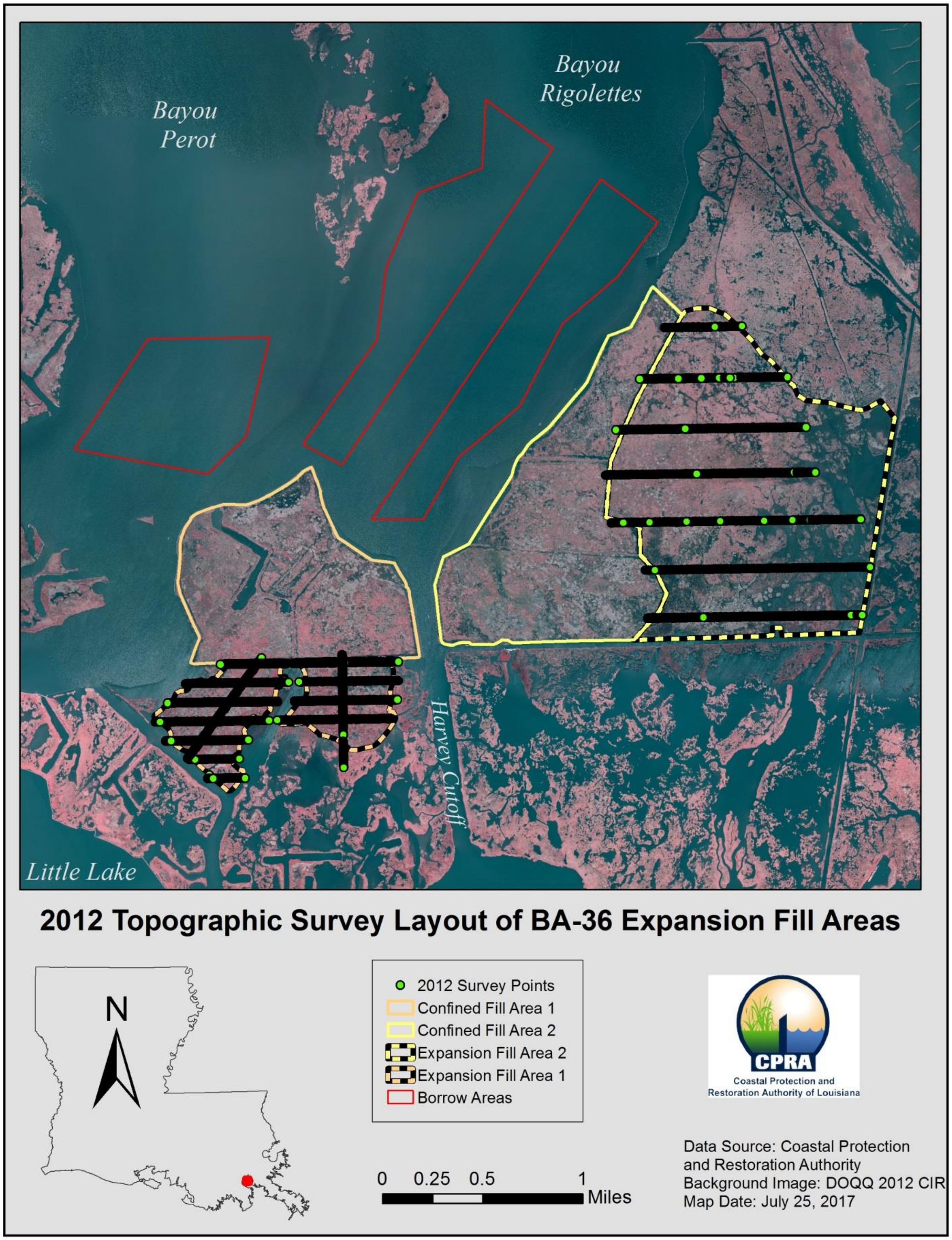
Appendix A-1. Layout of the BA-36 topographic and bathymetric survey conducted in 2003 for project design.



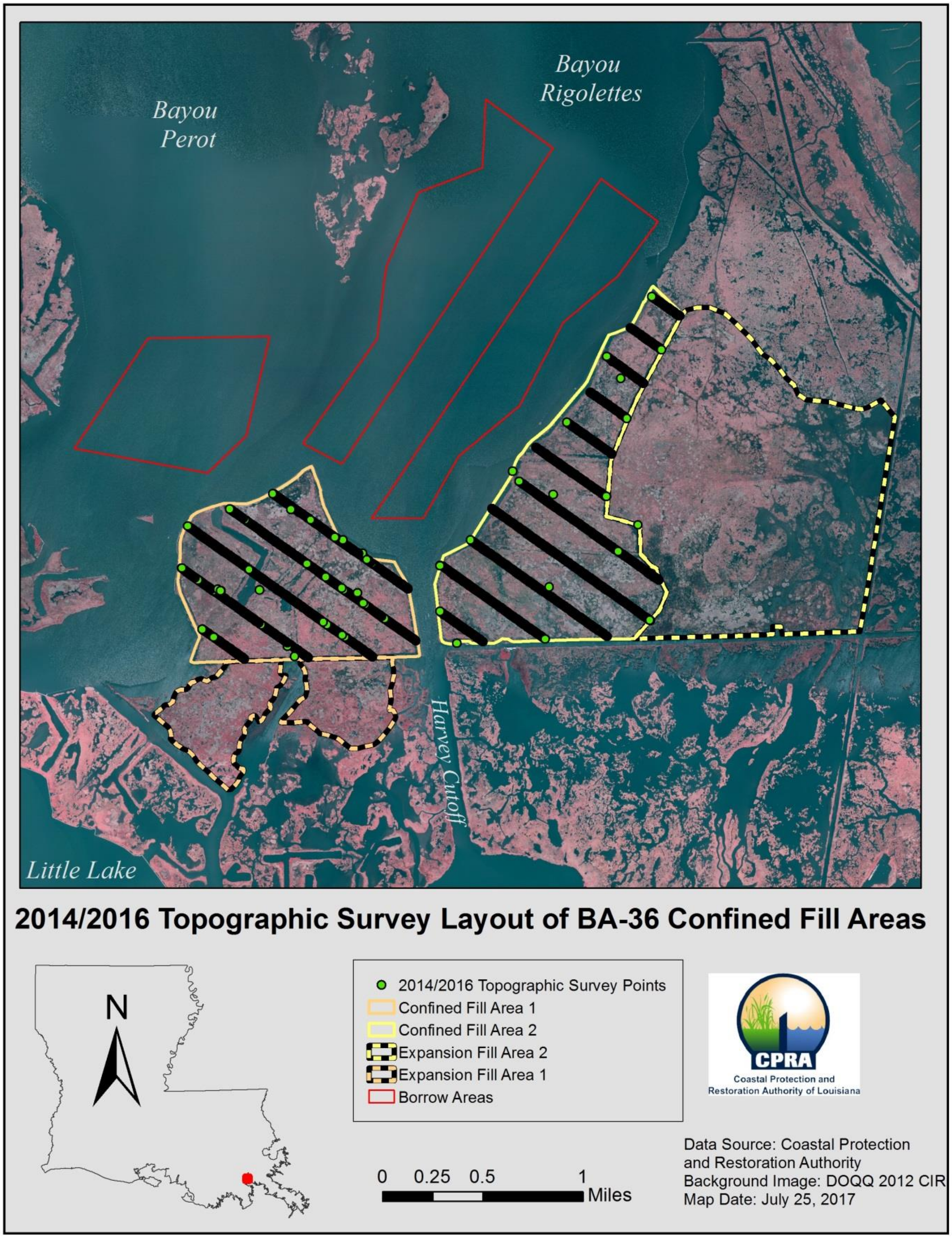
Appendix A-2. Layout of the BA-36 gradestake grid and settlement plate locations installed during project construction. Pre-construction (2008) and 28-Day Post-Fill (2009) data were collected for all gradestake locations in the Confined Fill Areas. As-built data were collected at the Expansion Area gradestakes in March 2010.



Appendix A-3. Location of 35 sites surveyed in 2011 by Mendelssohn et al. (2015). Ten sites were located in the BA-36 Confined Fill Areas, 15 sites were located in the Unconfined Fill Areas, 5 sites were located in Healthy Reference marsh, and 5 sites were located in Degraded Reference marsh.

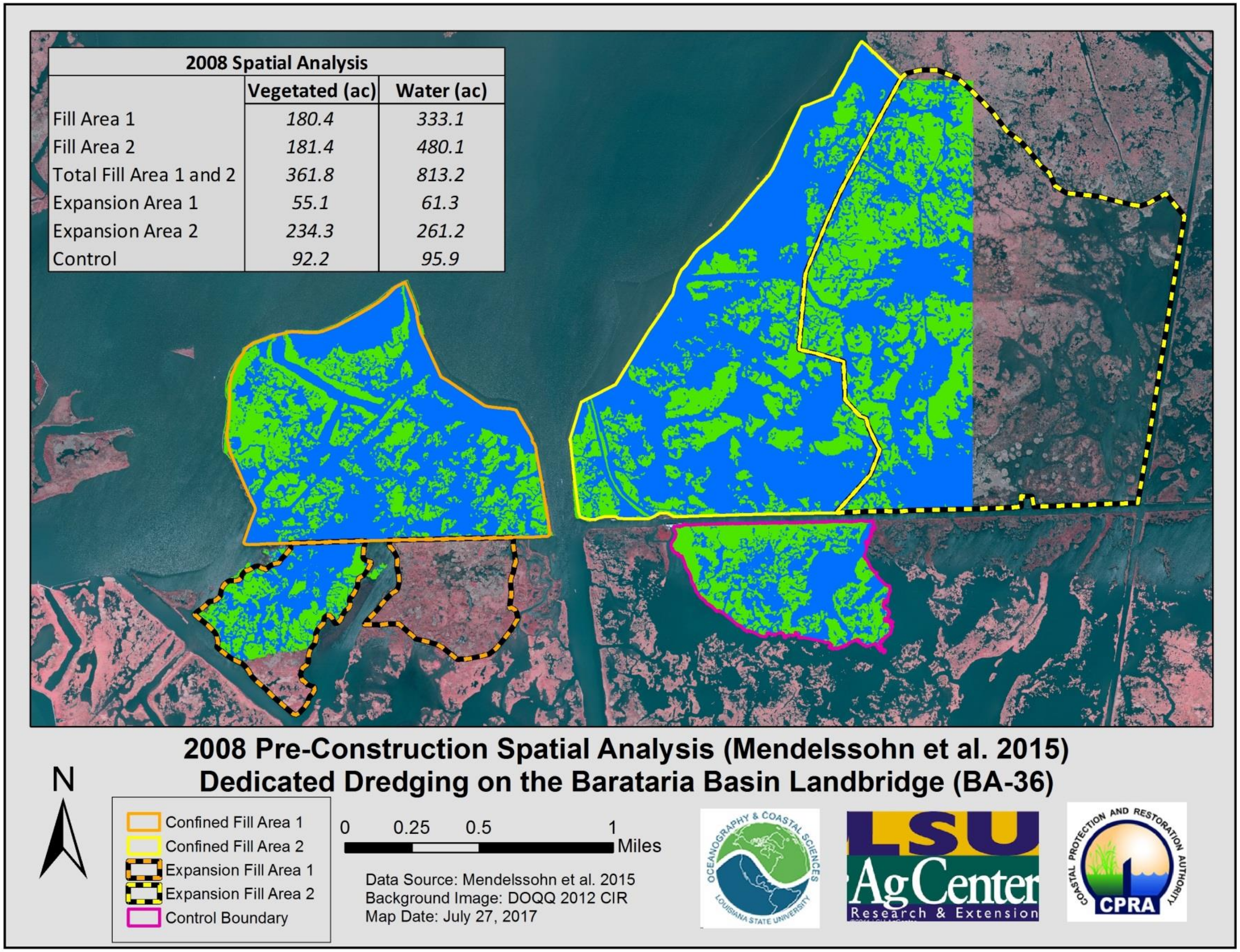


Appendix A-4. Topographic survey layout of the BA-36 Expansion Fill Areas conducted in 2012 through BA-125 project design.



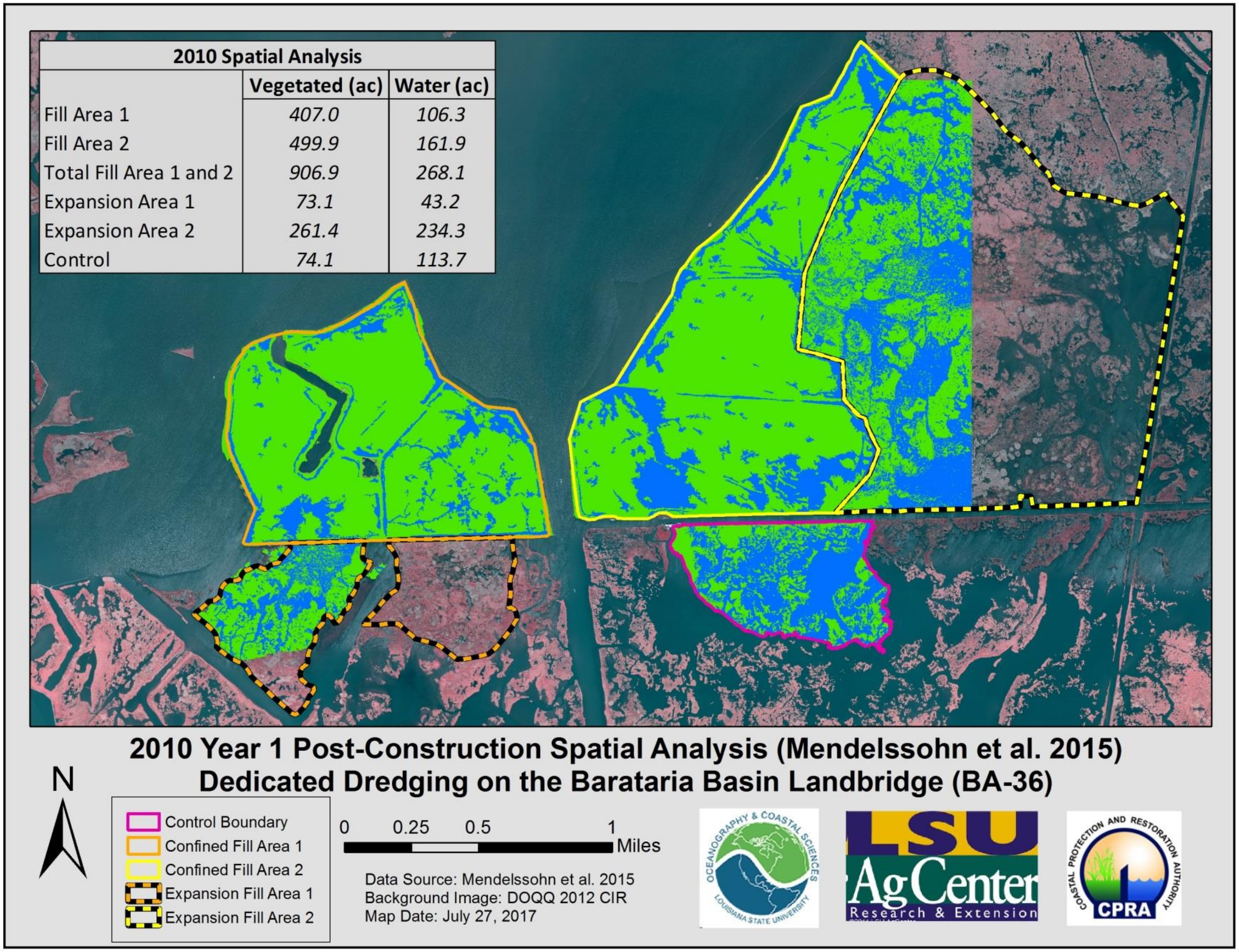
Appendix A-5. Topographic survey layout of the BA-36 Confined Fill Areas conducted in 2014 and 2016.

Appendix B
Spatial Analysis Maps
adapted from Mendelssohn et al. (2015)

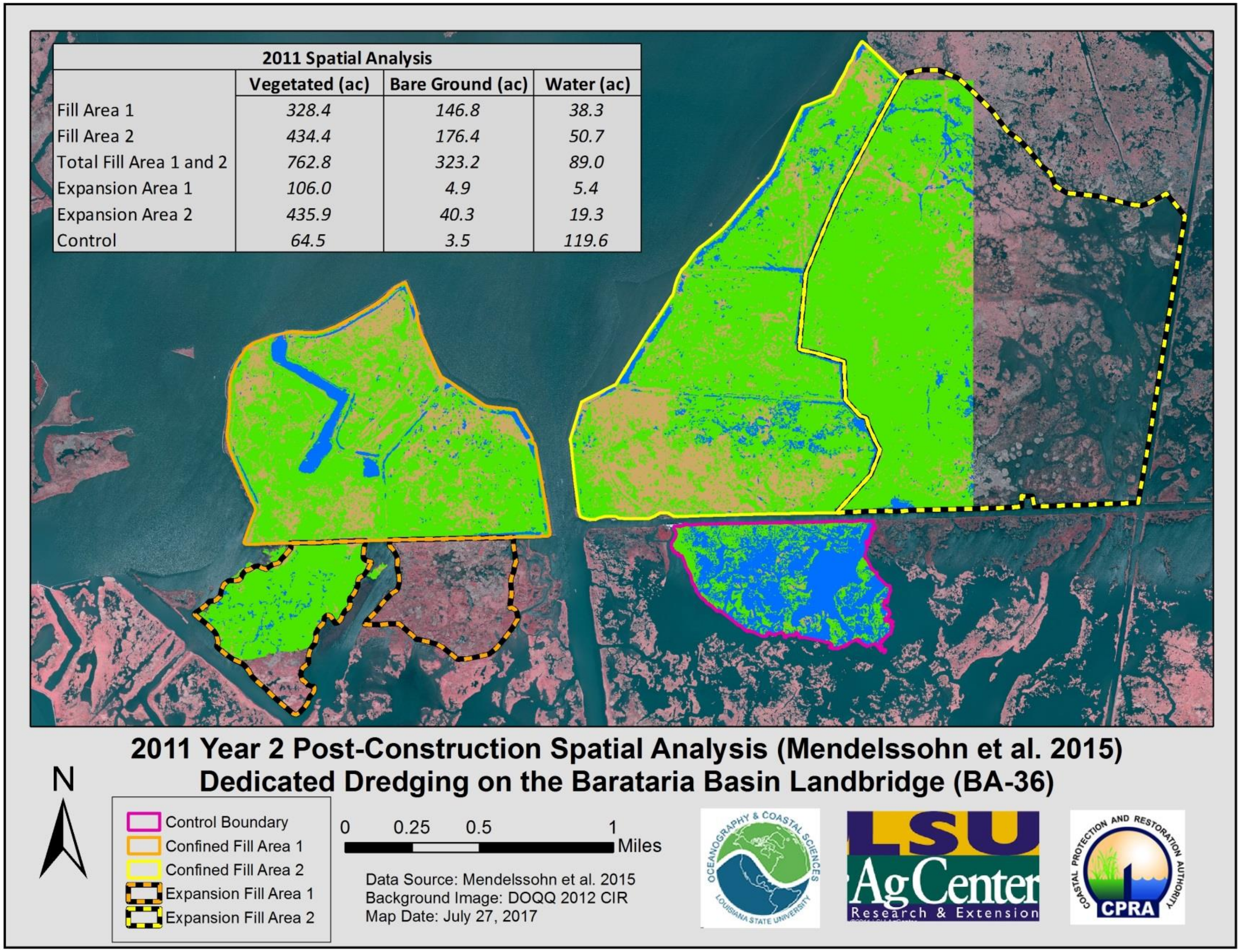


2008 Spatial Analysis		
	Vegetated (ac)	Water (ac)
Fill Area 1	*180.4*	*333.1*
Fill Area 2	*181.4*	*480.1*
Total Fill Area 1 and 2	*361.8*	*813.2*
Expansion Area 1	*55.1*	*61.3*
Expansion Area 2	*234.3*	*261.2*
Control	*92.2*	*95.9*

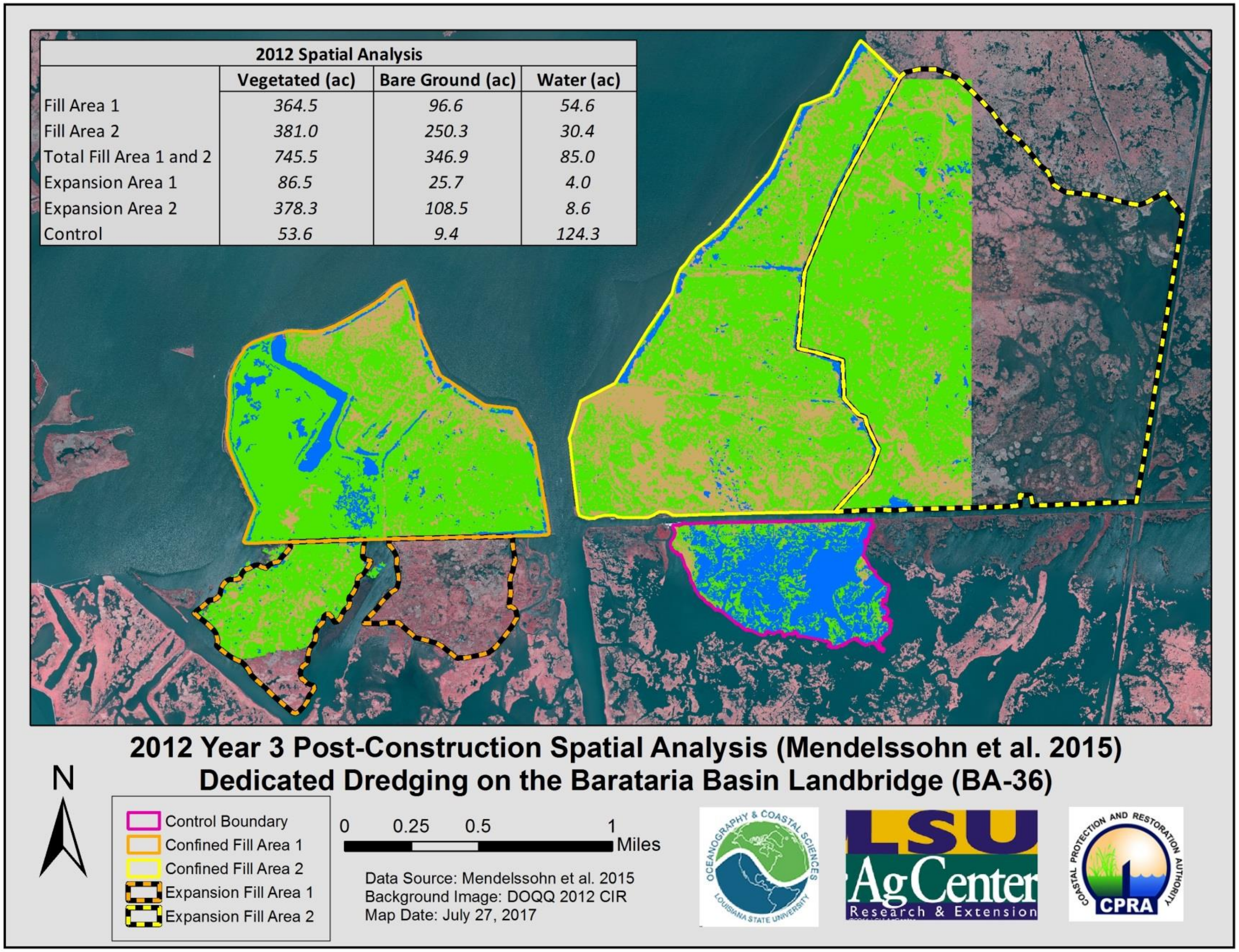
Appendix B-1. 2008 spatial analysis of the BA-36 project area conducted by Mendelssohn et al. 2015.



Appendix B-2. 2010 spatial analysis of the BA-36 project area conducted by Mendelssohn et al. 2015.



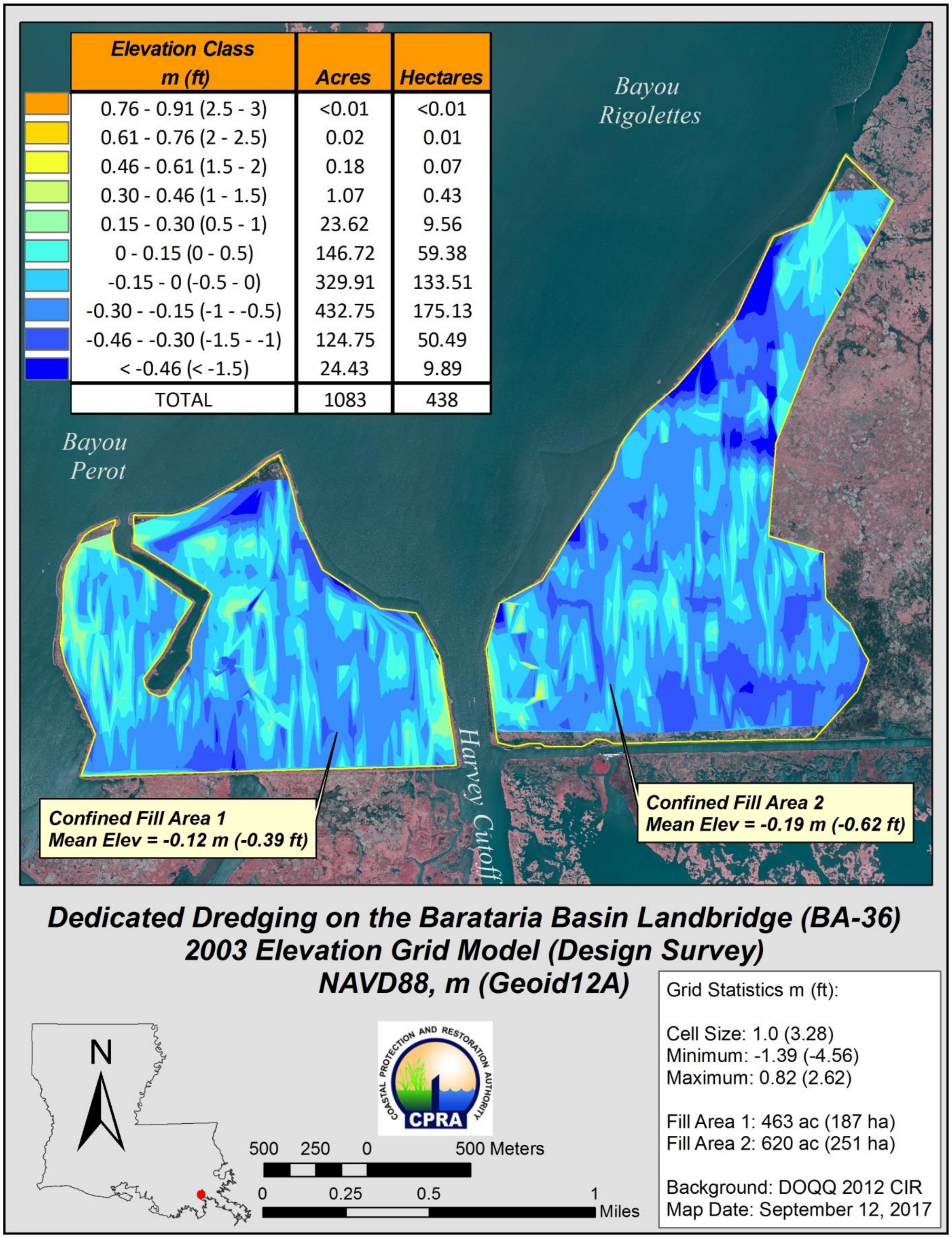
Appendix B-3. 2011 spatial analysis of the BA-36 project area conducted by Mendelssohn et al. 2015.



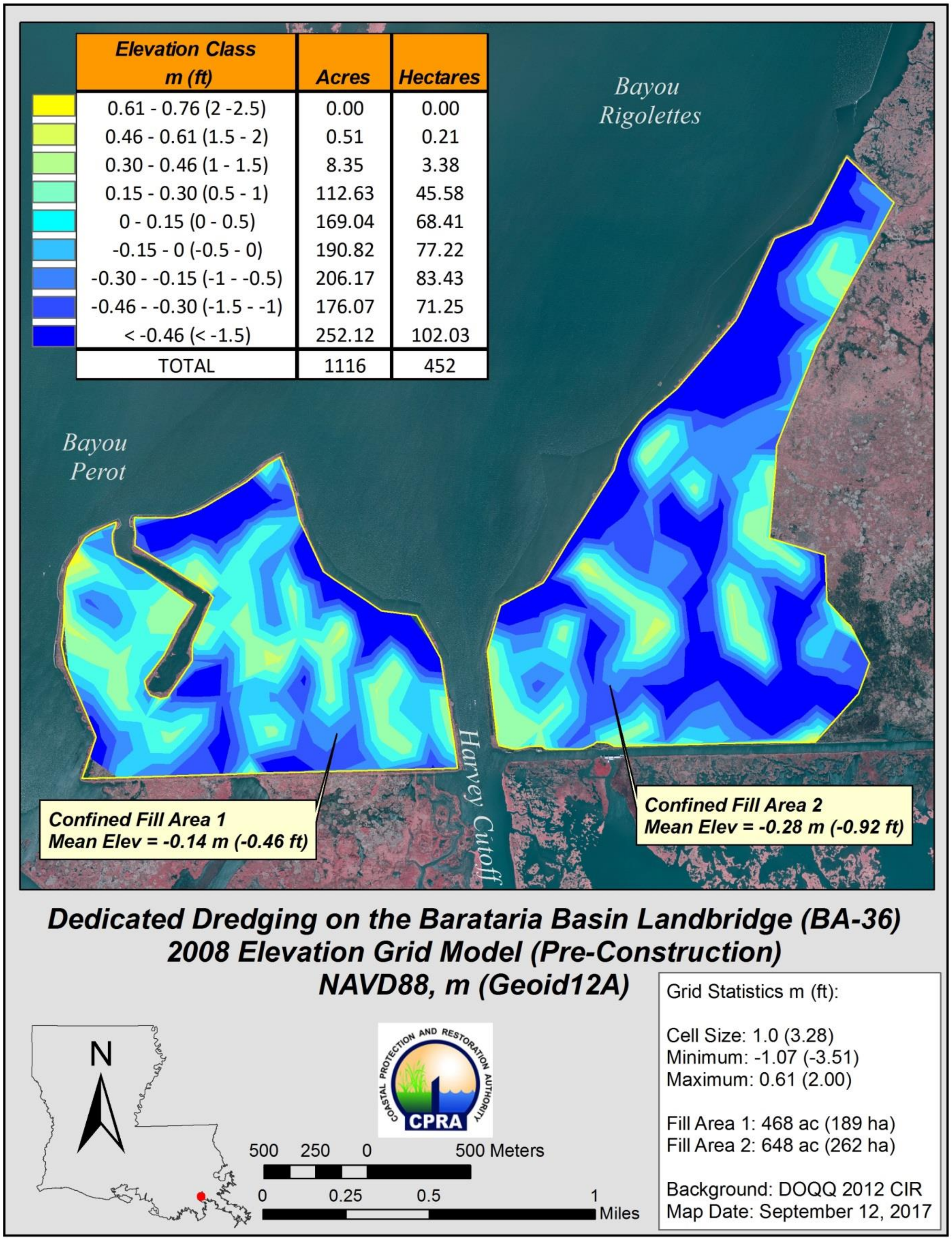
2012 Spatial Analysis	Vegetated (ac)	Bare Ground (ac)	Water (ac)
Fill Area 1	364.5	96.6	54.6
Fill Area 2	381.0	250.3	30.4
Total Fill Area 1 and 2	745.5	346.9	85.0
Expansion Area 1	86.5	25.7	4.0
Expansion Area 2	378.3	108.5	8.6
Control	53.6	9.4	124.3

Appendix B-4. 2012 spatial analysis of the BA-36 project area conducted by Mendelssohn et al. 2015.

Appendix C
Elevation Grid Models

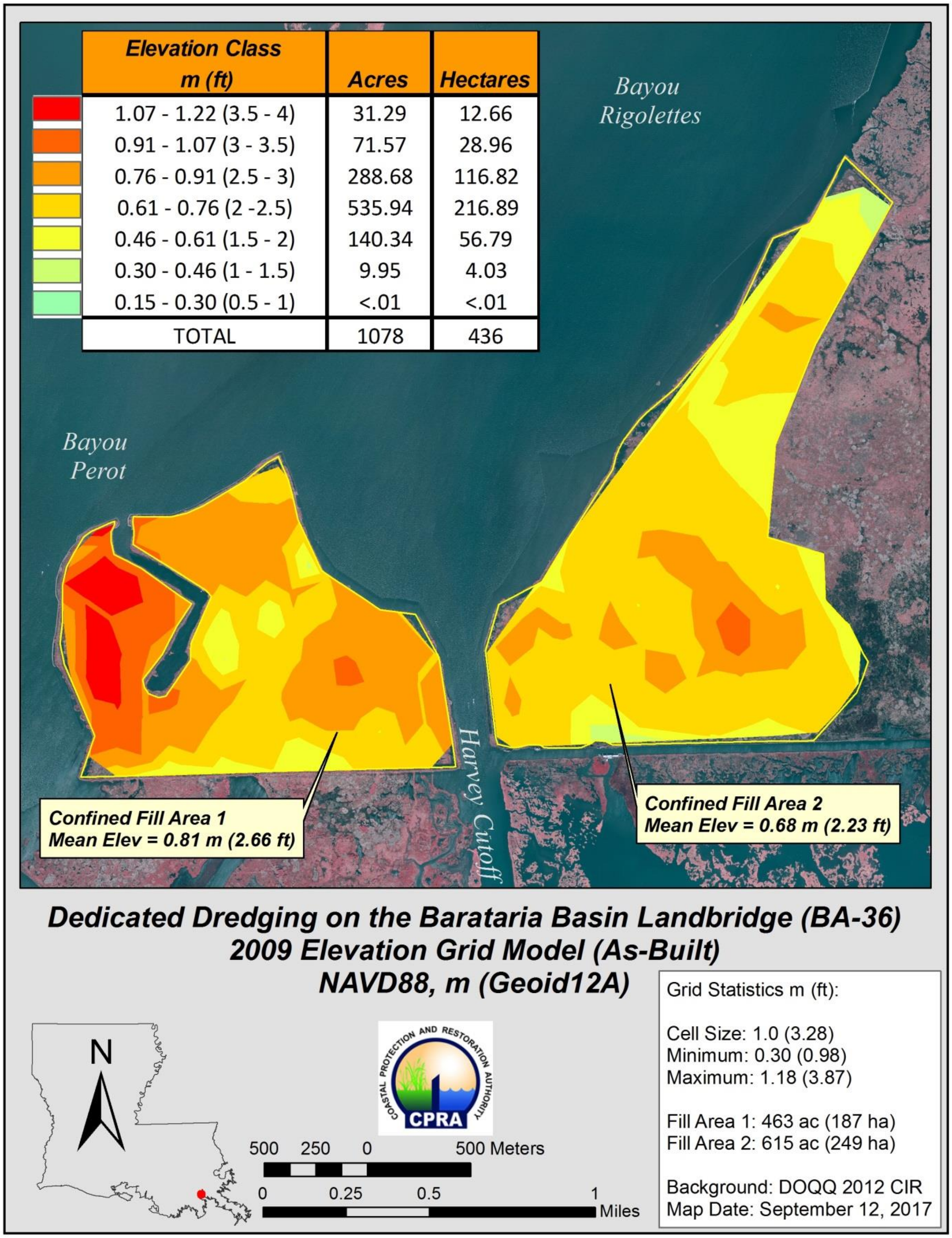


Appendix C-1. 2003 (Year -6) elevation grid model for the Dedicated Dredging on the Barataria Basin Landbridge (BA-36) confined fill areas.

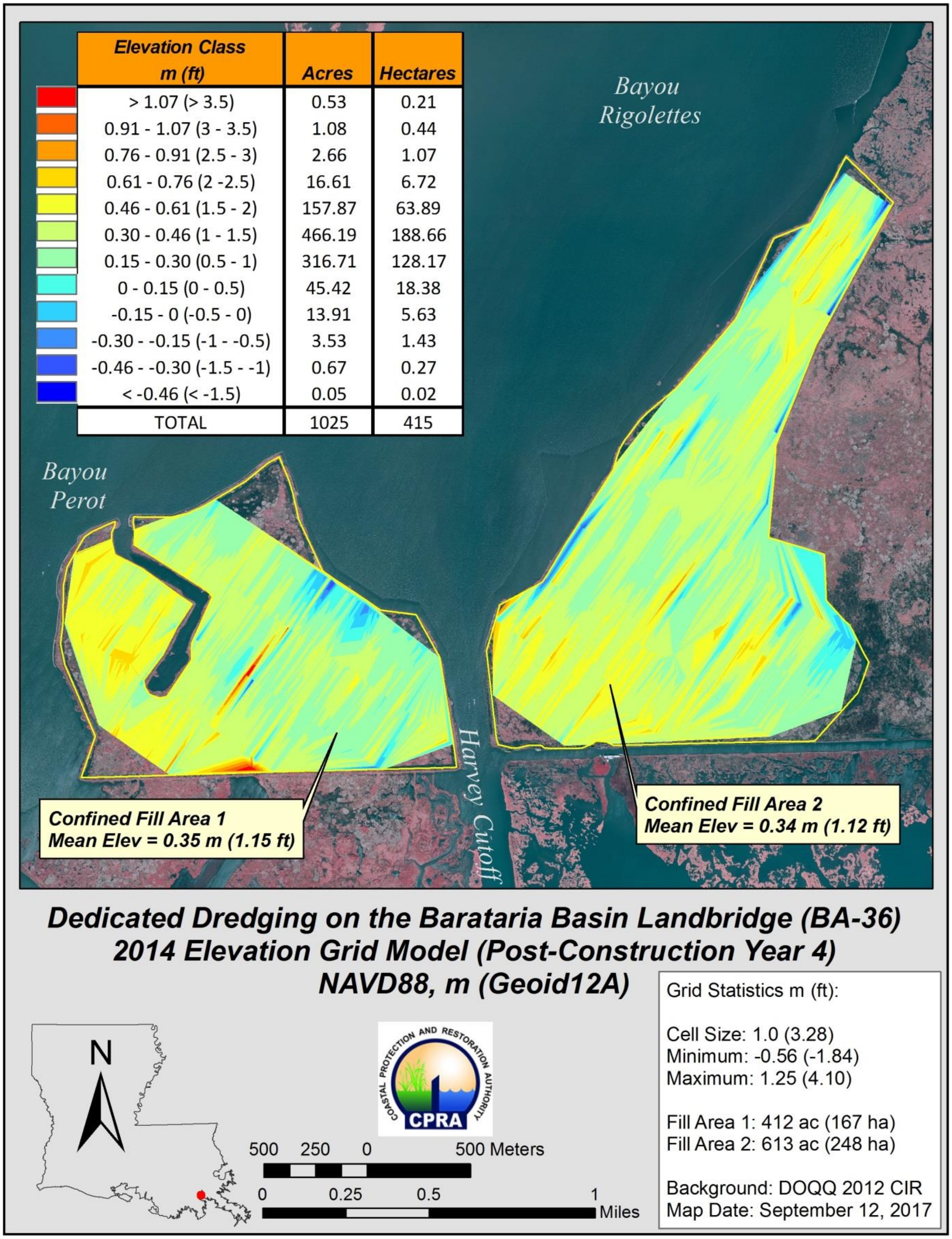


Elevation Class m (ft)	Acres	Hectares
0.61 - 0.76 (2 -2.5)	0.00	0.00
0.46 - 0.61 (1.5 - 2)	0.51	0.21
0.30 - 0.46 (1 - 1.5)	8.35	3.38
0.15 - 0.30 (0.5 - 1)	112.63	45.58
0 - 0.15 (0 - 0.5)	169.04	68.41
-0.15 - 0 (-0.5 - 0)	190.82	77.22
-0.30 - -0.15 (-1 - -0.5)	206.17	83.43
-0.46 - -0.30 (-1.5 - -1)	176.07	71.25
< -0.46 (< -1.5)	252.12	102.03
TOTAL	1116	452

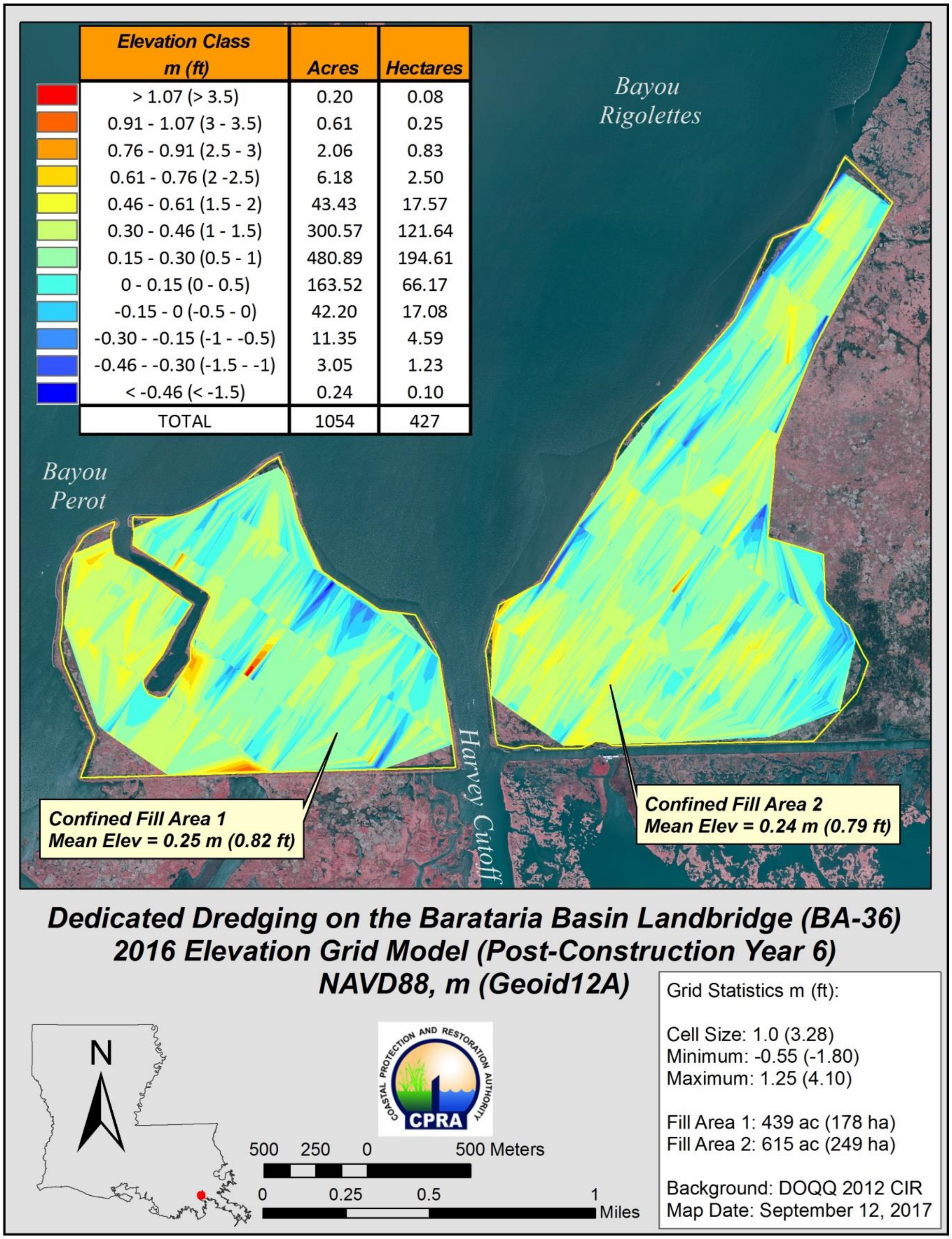
Appendix C-2. 2008 (Year -1) elevation grid model for the Dedicated Dredging on the Barataria Basin Landbridge (BA-36) confined fill areas.



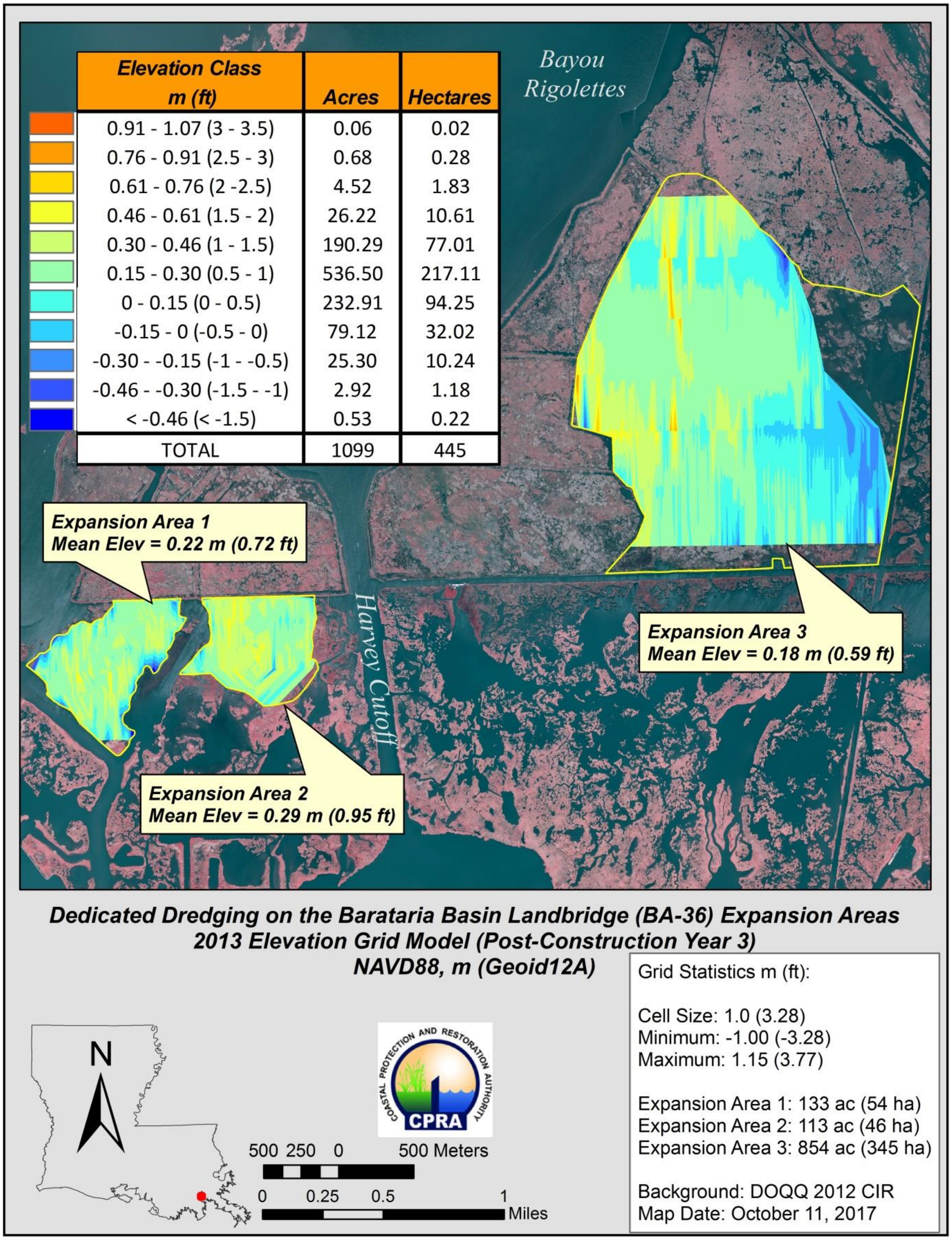
Appendix C-3. 2009 (as-built) elevation grid model for the Dedicated Dredging on the Barataria Basin Landbridge (BA-36) confined fill areas.



Appendix C-4. 2014 (Year +4) elevation grid model for the Dedicated Dredging on the Barataria Basin Landbridge (BA-36) confined fill areas.

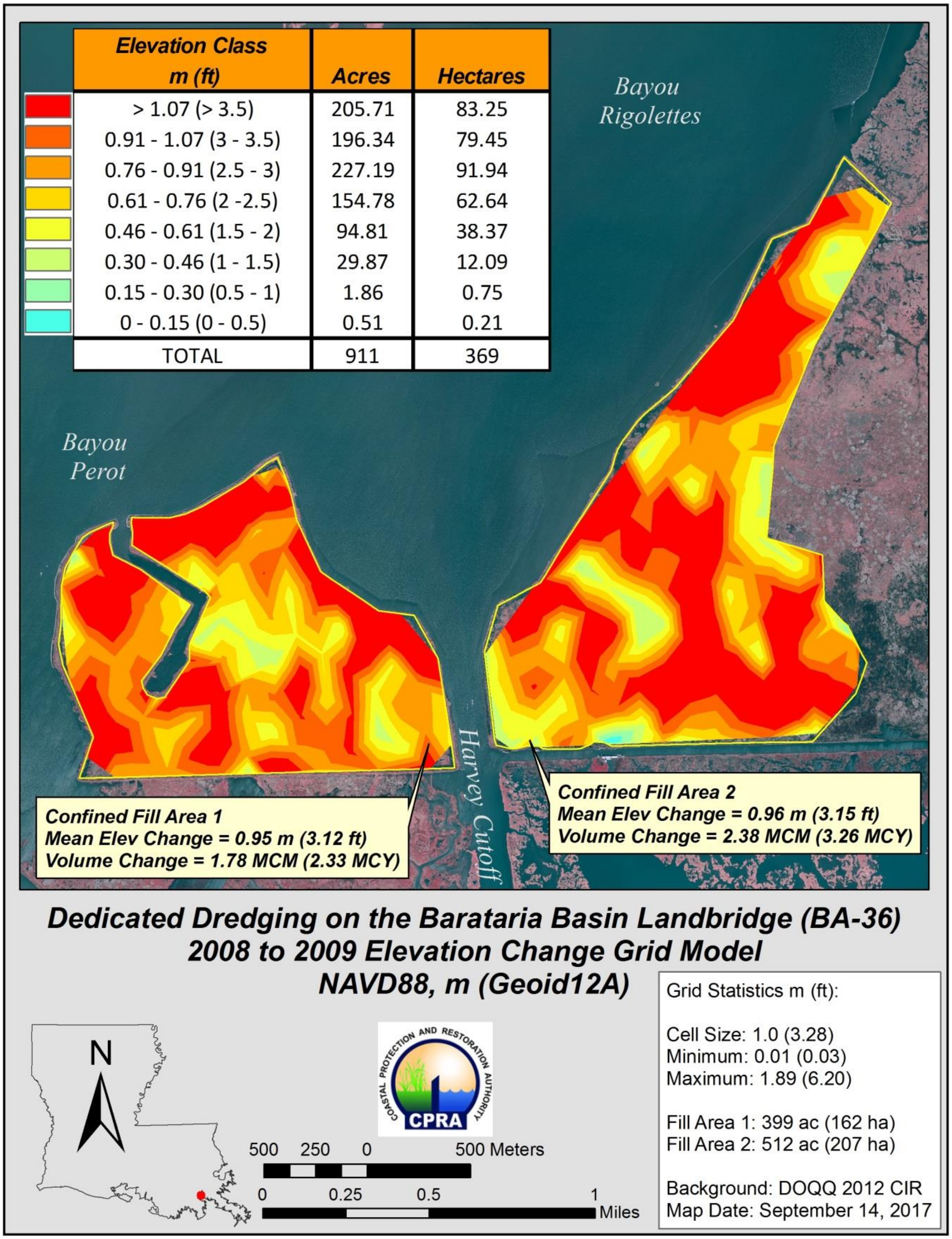


Appendix C-5. 2016 (Year +6) elevation grid model for the Dedicated Dredging on the Barataria Basin Landbridge (BA-36) confined fill areas.

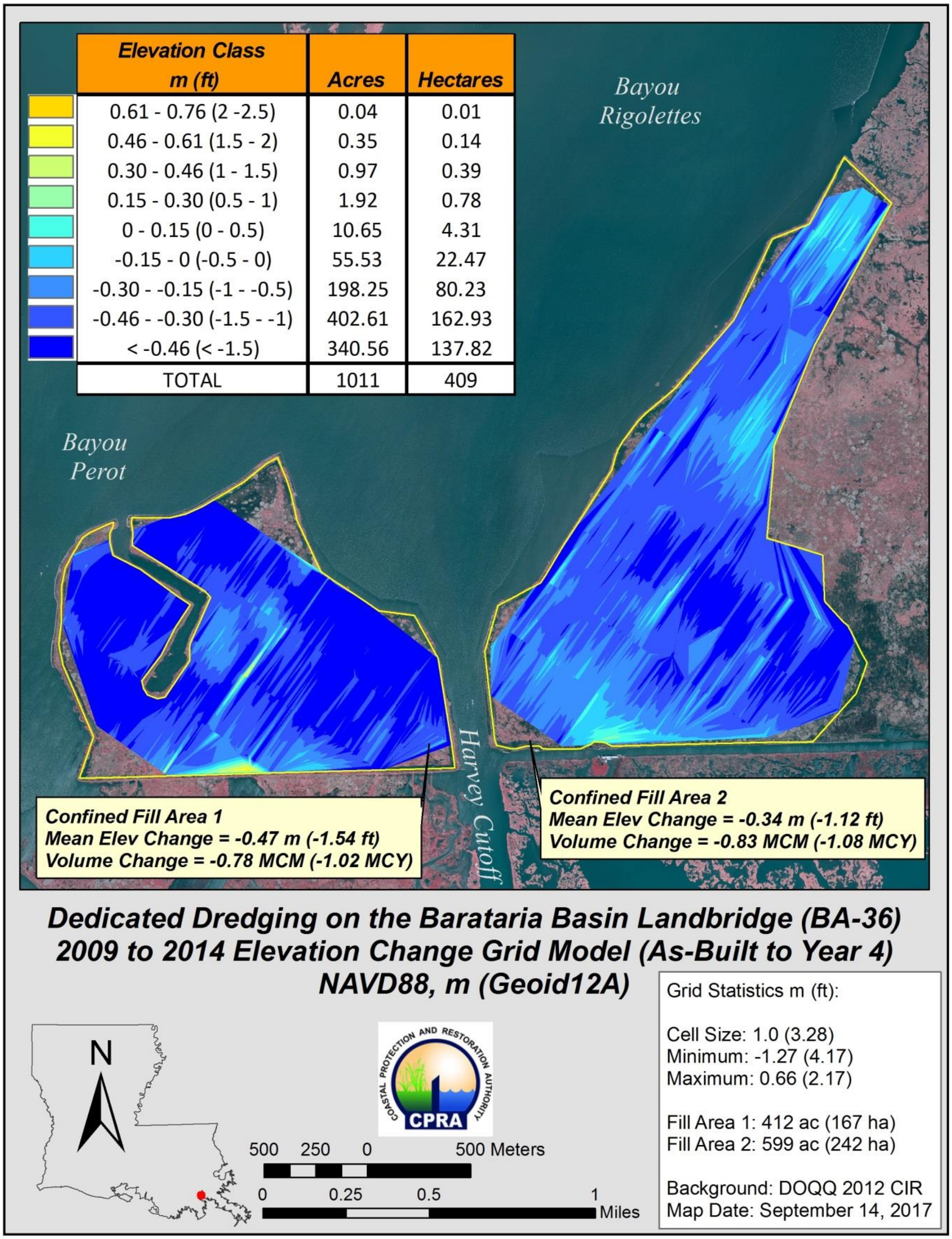


Appendix C-6. 2013 (Year +3) elevation grid model for the Dedicated Dredging on the Barataria Basin Landbridge (BA-36) unconfined Expansion Areas 1, 2, and 3.

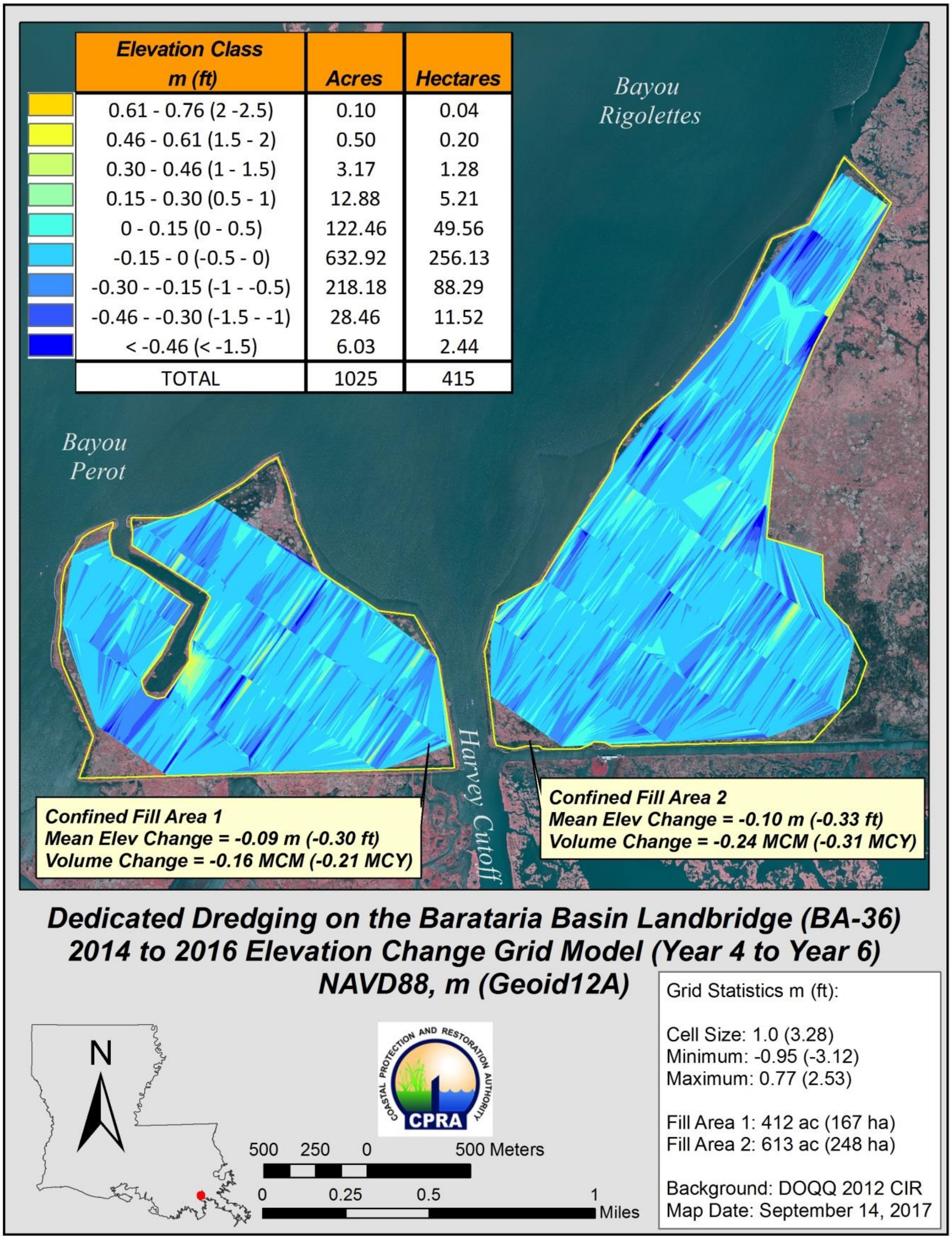
Appendix D
Elevation Change Models



Appendix D-1. 2008 to 2009 (Year -1 to As Built) elevation change model for the Dedicated Dredging on the Barataria Basin Landbridge (BA-36) confined fill areas.



Appendix D-2. 2009 to 2014 (As Built to Year +4) elevation change model for the Dedicated Dredging on the Barataria Basin Landbridge (BA-36) confined fill areas.



Appendix D-3. 2014 to 2016 (Year +4 to Year +6) elevation change model for the Dedicated Dredging on the Barataria Basin Landbridge (BA-36) confined fill areas.