State of Louisiana
Coastal Protection and Restoration Authority

2017 Operations, Maintenance, and Monitoring Report

for

Channel Armor Gap Crevasse (MR-06)

State Project Number MR-06
Priority Project List 3

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Preface

The Channel Armor Gap Crevasse (MR-06) project is funded through the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA), with the United States Army Corps of Engineers (USACE) as the federal sponsor and the Coastal Protection and Restoration Authority of Louisiana (CPRA) as the state sponsor. This project was included on the 3rd CWPPRA priority project list (PPL 3). The 2017 Operations, Maintenance, & Monitoring (OM&M) Report for MR-06 is the fourth in a series that includes some monitoring data and analyses presented previously in the 2004, 2008, and 2012 OM&M reports (Rodrigue 2004, Kaintz 2008, Gossman 2012), plus additional project-specific and CRMS data collected since the previous report. For additional information on lessons learned, recommendations and project effectiveness please refer to the 2004, 2008, and 2012 OM&M Reports, which are accessible through CPRA's Coastal Information Management System (CIMS) website at *http://cims.coastal.louisiana.gov*.

I. Introduction

Channelization of the Mississippi River (MR) has had negative impacts on the hydrography of the river and its wetland-building processes. The prolonged existence of artificial levees has caused rapid sedimentation onto the continental shelf and seaward progradation of the river mouth at rates up to 328 ft/yr (100 m/yr) within the past several decades. An abundance of small, bifurcating distributaries throughout the Mississippi River Delta (MRD) has caused a loss in stream gradient, which is critical to efficient sediment transport. Growth of the MRD has not been limited by the size of the receiving basin, but by insufficient sediment delivery. The MR currently delivers 50 to 60 percent less sediment to the delta than it did in the early 1900's (Wells and Coleman 1987). Much of this sediment loss has been due to the trapping of coarse sediment material, essential to building subaerial land, in upstream dams and reservoirs. Better conservation practices by farmers in the Arkansas, Missouri, and Ohio River basins have also decreased river sediment availability in the MRD.

Rapid wetland deterioration in the MRD is likely due to a combination of the above factors in conjunction with eustatic sea-level rise, which is estimated to be 0.37 in/yr (0.94 cm/yr) (Penland and Ramsey 1990). The subsidence rate for the entire MRD, approximately 0.43 in/yr (1.1 cm/yr; Day and Templet 1989), is exacerbated by frequent canal dredging for navigation purposes and mining of mineral resources. The most recent land loss rate estimate for the MRD is 1.39 mi^2/yr (Couvillion et al. 2017).

The MR levee south of Venice, Louisiana has been reinforced with stone over the last few decades. Some shallow gaps were left in the river-bank armor to assist in crevasse development and the subsequent overflow of freshwater into adjacent marshes during periods of high water. Crevasses provide sediment-laden river water to shallow interdistributary ponds creating subaerial land (or deltaic splays) that become colonized with marsh vegetation over time. A natural crevasse splay has a life span of 20 to 175 years, depending on the size of the crevasse and adjacent parent pass, water discharge, sediment volume, and wind and tidal influences (Wells and Coleman 1987). Between 1750 and 1927, regularly occurring crevasse splays were responsible for building more than 80% of the MRD wetlands (Davis 1993).

Since the early 1980s, artificial crevasses have been used as a management tool to combat wetland loss in the MRD. Artificial crevasses emulate the natural process of deltaic splay formation and marsh creation. The Louisiana Department of Natural Resources, Coastal Restoration Division (LDNR/CRD) constructed three crevasses within the Pass-a-Loutre Wildlife Management Area in 1986 that produced over 657 acres (266 hectares) of emergent marsh from 1986 to 1991, and four crevasses in 1990 that produced over 400 acres (162 hectares) of emergent marsh in three years (LDNR 1993; Trepagnier 1994). Results from the LDNR Small Sediment Diversions project indicate that land gains from 1986 to 1993 from thirteen artificial crevasses ranged from 28 to 103 acres (11.3 to 41.7 hectares) for older crevasses (4 to 10 years old) and 0.5 to 12 acres (0.2 to 4.9 hectares) for younger crevasses (0 to 2 years old) (LDNR 1996). Results from the Delta Wide Crevasses (MR-09) CWPPRA project which created or maintained 18 small crevasses throughout the MRD indicate an average land gain of 29 ac per crevasse and a rate of 2.6 ac/yr for the 11-yr monitoring period (Gossman and Breaux 2013).

Crevasse construction is recognized as both cost-effective and highly successful at creating new wetlands. The average cost per crevasse constructed by LDNR in 1990 was approximately $48,800, or $433/acre of wetland created. Boyer et al. (1997) reported that the average cost per area of land gain for 24 constructed crevasses in Delta National Wildlife Refuge declines with age as new land builds and may be only $19/acre if all the receiving bays revert to marsh.

The Channel Armor Gap Crevasse project area is located in the MRD, south of Venice in Plaquemines Parish, Louisiana, and is within the boundary of the Delta National Wildlife Refuge between Mississippi River and Main Pass (Figure 1). The crevasse is located on the left descending bank of the MR at mile 4.7 above Head of Passes. Based on the 1996 land/water analysis, the project receiving bay (Mary Bowers Pond) comprises 70% of the total 1,567 acres (634 hectares) in the project area.

The natural gap in the Mississippi River channel bank armor was enlarged to a length of 3,400 ft (1,036 m), a bottom width of 80 ft (24 m), a top width of 130 ft (40 m), and a minimum depth of –4.0 ft (-1.2 m) NGVD. The crevasse channel is estimated to allow an average flow of 2,400 cfs (68 cms) to enter the outfall area. Approximately 70,000 yd^3 (53,522 m^3) of material was excavated from the outfall channel. The dredged material was deposited in a non-continuous fashion adjacent to the channel at an elevation not exceeding +4.0 ft (1.2 m) above existing surface elevations with several 50-ft wide gaps. Construction of the crevasse was completed in October 1997.

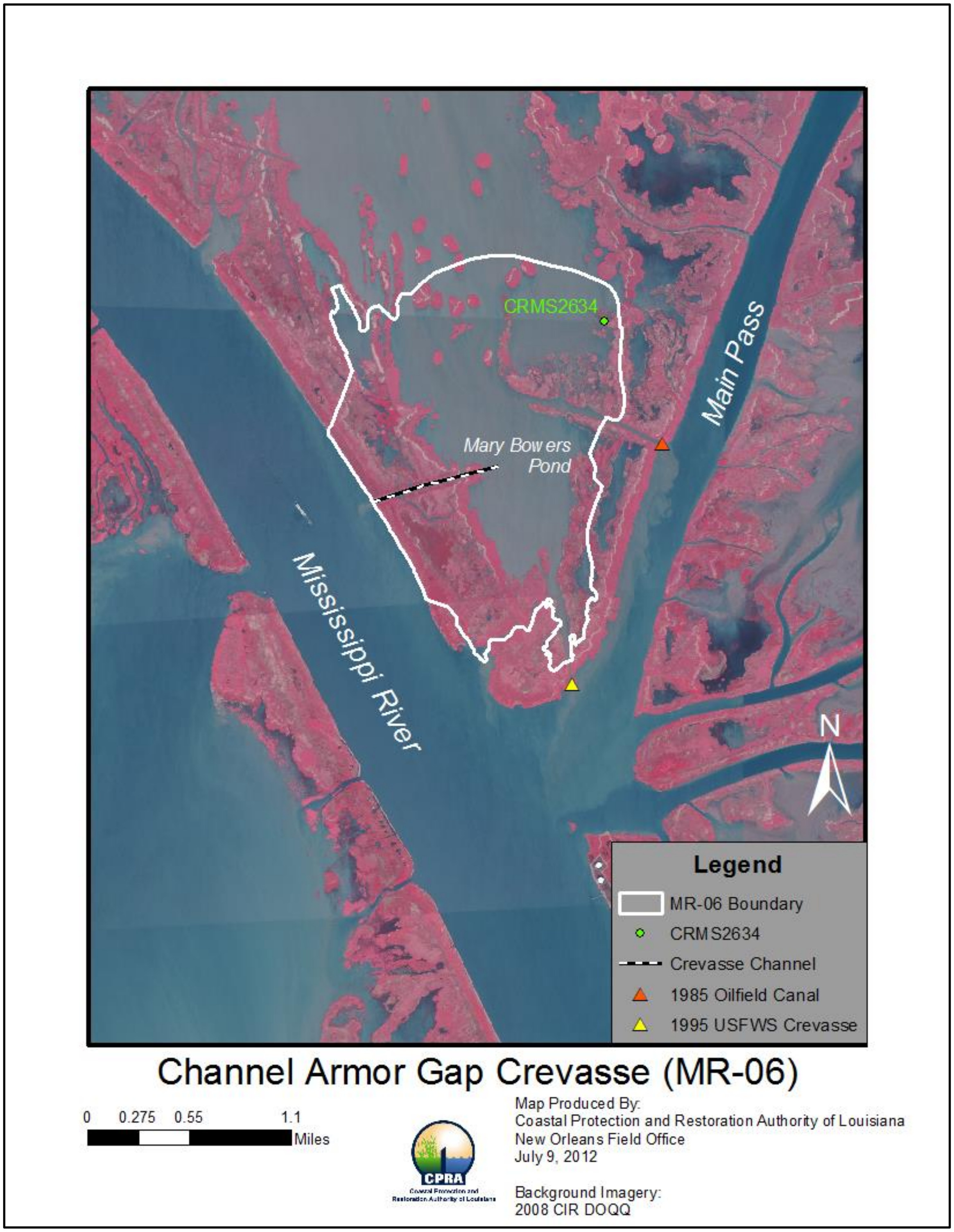

Figure 1. Channel Armor Gap Crevasse (MR-06) project location.

II. Maintenance Activity

a. Inspection Purpose and Procedures

There are no Operations and Maintenance activities associated with this project, therefore inspections have not been routinely performed. However, in order to better describe conditions in the project area for the final OM&M report, an inspection was performed by Bryan Gossman and Luke Prendergast of CPRA on July 28, 2016. Photographs from that inspection are included in Appendix A of this report.

b. Summary of Past Operation and Maintenance Projects

Since completion of construction, there have been no maintenance events.

c. Inspection Results

The crevasse channel remains open from the Mississippi River to the receiving bay. Water flow was observed through the channel at the time of the inspection. Several distributary channels are apparent in the receiving bay, with the flow from the crevasse channel moving generally to the north. The flow from the crevasse channel then joins the flow entering through the oilfield canal from Main Pass, and exits the project area to the north. Emergent vegetation was observed throughout the receiving bay, with the greatest concentrations in the area at the mouth of the crevasse channel, extending to the north. Several large roseau cane (*Phragmites australis*) islands are present at the mouth of the crevasse channel. Other areas were primarily dominated by delta duck potato (*Sagittaria platyphylla*) and giant cutgrass (*Zizaniopsis miliacea*). The area to the south of the crevasse mouth was primarily shallow open water bordered by roseau cane. Multiple species of submerged aquatic vegetation (SAV) were observed throughout the project area.

III. Operation Activity

a. Operation Plan

There are no water control structures associated with this project; therefore a Structure Operation Plan is not required.

b. Actual Operations

There are no water control structures associated with this project; therefore, there are no required structure operations.

IV. Monitoring Activity

a. Monitoring Goals

The objective of this project is to promote formation of emergent freshwater marsh in place of the shallow, open water area of Mary Bowers Pond by increasing the flow of sediment-laden river water into the receiving bay.

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

1. To increase sediment elevation in the project area.

2. To increase cover of emergent wetland vegetation within the project area.

b. Monitoring Elements

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

Water Discharge and Suspended Sediments
Based on a CWPPRA Task Force decision, monitoring of suspended sediment and discharge was discontinued after 1998. Results of discharge and suspended sediment monitoring can be found in the first progress report for this project (Troutman 1999), and will not be reported here.

Sediment Elevation
Elevation, reported in North American Vertical Datum of 1988 (NAVD), was surveyed in the project area in November, 1997 to determine pre-construction elevation. Post-construction surveys were conducted in October 2001, March 2008, and October 2016. According to the monitoring plan, the second post-construction survey was scheduled for 2007; however, due to funding issues, it was postponed until the spring of 2008. It will be referred to as the 2007 elevation survey in this report.

In the 1997 survey, eleven transect lines were established perpendicular to the crevasse channel, 500 ft (152 m) apart, and extended the entire length of the open water areas in the receiving bay (Figure 2). Land elevations were not measured during this survey. Elevations were recorded at 500-ft intervals along each transect and at any significant change in elevation within those intervals. For the 2001, 2007, and 2016 surveys, the same transect lines were used, but elevations were recorded at 250-ft intervals and at any significant change in elevation within those intervals (Figure 2). Elevations of the entire project area (open water and land) were collected during the 2001, 2007, and 2016 surveys. However, only the immediate receiving bay was used to compare the mean elevations among all four years. Using the smaller receiving bay for analysis was done to eliminate portions of the project area that may have been influenced by freshwater and sediment sources other than the MR-06 crevasse. Additionally, this ensured that elevation comparisons for all 4 survey events covered the same spatial extent. ArcMap© Version 10.2.1 was used to for spatial analysis and mapping. JMP© Version 11 was used to compare mean elevations among years.

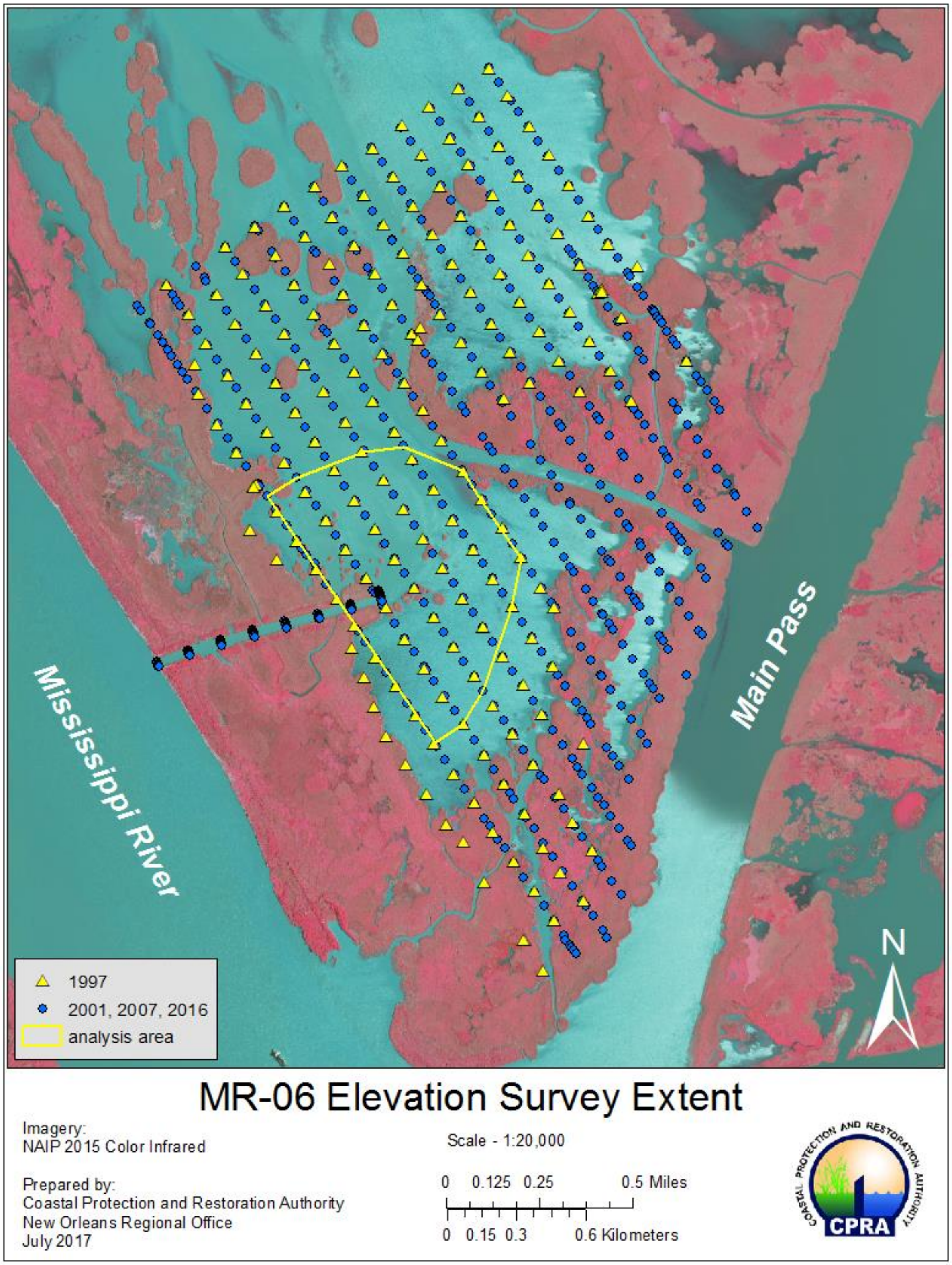

Figure 2. Location of elevation sampling stations in 1997 (yellow triangles), and 2001/2007/2016 (blue circles) in the Channel Armor Gap Crevasse (MR-06) project area.

During the 2016 survey, Real Time Kinematic (RTK) check of the "MR-09-SM-60" survey monument used in all 4 MR-06 surveys detected a difference in ellipsoid height from the published 2002 data sheet of -0.6 ft, indicating settlement of the monument. Therefore, a correction factor was applied to the 2007 and 2016 data. The 2016 data were adjusted -0.6 ft. Assuming a constant rate of settlement for the time period between ellipsoid height checks (2002 – 2016), the 2007 data were adjusted -0.214 ft. As a result, the 2007 elevation values reported in this report will differ from previous OM&M reports.

Land/Water Analysis and Habitat Mapping

Color Infrared aerial photography of the MR-06 project area was obtained in January 1996 (preconstruction), and December 2001, December 2007, and October 2016 (post construction). The 1996, 2001, and 2007 photography were collected at 1:12,000 scale and used to determine the distribution of habitat types and the land to open water ratio via the following methodology. At the U.S. Geological Survey's National Wetlands Research Center (NWRC), the aerial photographs were scanned at 300 pixels per inch and georectified with ground control data collected with a differential global positioning system (DGPS) capable of sub-meter accuracy. Individual georectified frames were then mosaicked to produce a single image of the project area. To determine habitat types and their distributions, the photomosaic was interpreted by NWRC personnel and classified to the subclass level using the National Wetlands Inventory (NWI) classification system (Anderson et al. 1976). Habitat classifications were then transferred to 1:12,000 scale Mylar base maps, digitized, and checked for quality and accuracy. In addition, the photomosaic was classified according to pixel value and analyzed to calculate the land to water ratio of the project area. All areas characterized by emergent vegetation, wetland forest, or scrub-shrub were classified as land, while open water, aquatic beds, and nonvegetated mud flats were classified as water.

The 2016 land/water analysis was conducted using photography obtained as part of the CRMS-*Wetlands* program (Folse et al. 2014). Land to water ratios in the project area are determined using CRMS aerial photography (Z/I Imaging digital mapping camera) with 1-meter resolution. The photography is georectified using standard operating procedures described in Steyer et al. (2000).

Vegetation

Plant species composition, percent cover, and relative abundance were evaluated to document vegetation succession on the newly created crevasse splay and to ground-truth aerial photograph interpretations. Vegetation surveys followed the Braun-Blanquet method (Folse et al. 2014). Transects were established once the splay islands became subaerial. Additional transects and sample stations were established over time as new land was created. Annual vegetation surveys began in October, 2001, after the first subaerial crevasse splay formed, and continued through 2010.

CRMS Supplemental

Additional data were collected at CRMS-*Wetlands* stations, which can be used as supporting or contextual information for this project. Data types collected at CRMS sites include hydrologic, emergent vegetation, physical soil characteristics, discrete porewater salinity, marsh surface elevation change, vertical accretion, and land:water analysis of the 1-km^2 area encompassing the station (Folse et al. 2014). One CRMS site, CRMS2634, is located within the project area (Figure 1). This CRMS site is influenced primarily by the oilfield canal entering the project area from Main Pass, however it serves as a good analog for conditions at the mouth of the crevasse channel (i.e. nearby source of fresh water and sediment). For this report, surface elevation, land/water analysis, and vegetation data from CRMS2634 were used to assess project goals.

c. Monitoring Results and Discussion

<u>Sediment Elevation</u>

Average elevation of the immediate receiving bay in 1997 (pre-construction) was -3.39 NAVD 88 (ft; Figure 3 and 4). Post-construction, the average elevation of the receiving bay in 2001 was -0.41 NAVD 88 (ft), -0.05 NAVD 88 (ft) in 2007, and 0.28 NAVD88 (ft) in 2016 (Figures 3 and 4). There was a significant difference in elevation among all four years ($p < 0.0001$). Comparison of individual means indicate significant increases in elevation between each survey; 1997 – 2001 ($p < 0.0001$), 2001 – 2007 ($p = 0.0018$), 2007 – 2012 ($p = 0.0040$). Elevations ranged from -4.70 to -2.30 NAVD 88 (ft) in 1997, -2.10 to 0.50 NAVD 88 (ft) in 2001, -2.01 to 0.94 NAVD 88 (ft) in 2007, and from -2.51 to 2.04 NAVD88 (ft) in 2016.

The greatest increase in elevation occurred from 1997 to 2001. There were elevation gains across the entire receiving bay for this period, with most of the area experiencing gains in the 2.5 – 3.5 ft range (Figure 5). Elevation gains were more modest in for the 2001 – 2007 time period (Figure 6). Most of the receiving bay saw gains ranging from 0 to 1.5 ft, with the exception of several small areas near the center and northeast portions of the receiving bay, as well as the mouth of the crevasse channel where there was an elevation loss of < 0.5 ft. These areas correspond to the formation of distributary channels within the receiving bay, with the majority of the flow moving to the north and northeast of the mouth of the crevasse channel. There was also a net positive elevation gain of 0.33 ft for the 2007 – 2016 time period (Figure 7). There was elevation gain ranging from 0 to 2.5 ft for much of the receiving bay, particularly near the mouth of the crevasse channel and the area to the north. There were two areas of elevation loss ranging from 0 to 2.0 ft near the center and northeast of the receiving bay. These areas correspond to the distributary channels apparent in the previous survey, although the increased elevation loss in these areas indicates that the channels are deepening. There was also an area of slight (0 to 0.5 ft) elevation loss in the southern portion of the receiving bay. The arrangement of the distributary channels along with the location of subaerial land and emergent vegetation indicate that the majority of the flow from the MR-06 crevasse moves to the north and east upon entering the receiving bay. The slight loss of elevation within the southern portion of the receiving bay would support this, and may also indicate that the USFWS crevasse at the southern end of the project area (Figure 1) is filling in and becoming less efficient at moving sediment into the receiving bay. For the entire length of the project, from 1997 – 2016, the receiving bay saw a net mean elevation gain of 3.67 ft (Figure 8). The entire receiving bay gained elevation, with some areas gaining 5 ft.

The MR-06 crevasse channel was surveyed post-construction in 2001, 2007, and 2016 (Figures 9 and 10). Across subsequent surveys, the crevasse channel has, at a minimum, maintained its constructed elevation along its entire length and decreased in elevation (i.e. deepened) in several places. Examination of cross-sections of the crevasse channel reveals that the elevations at the channel midpoint have remained largely unchanged from 2001 to 2016 (Figure 10). However, cross-sections at the ends of the crevasse channel where it joins the Mississippi River and the receiving bay show that elevations in these areas have decreased up to 6 ft over the same time period.

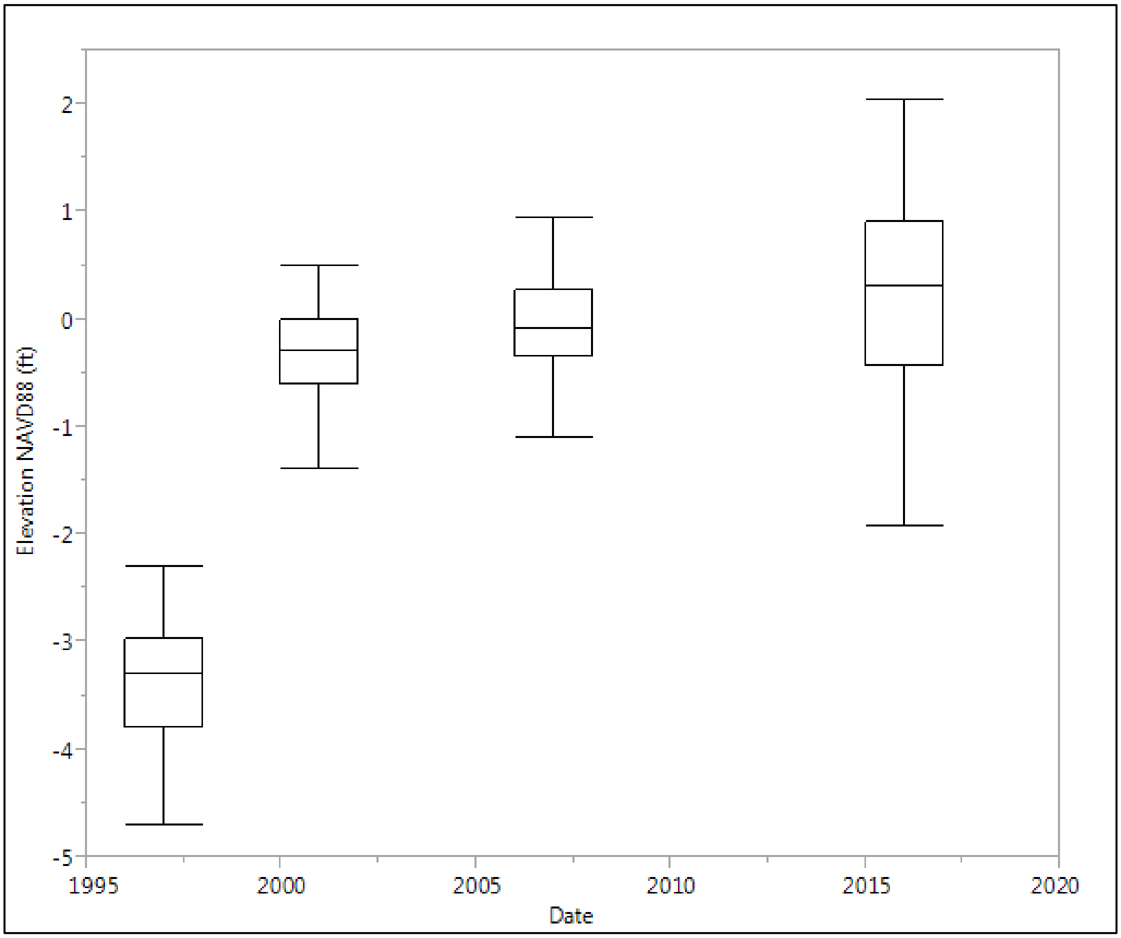

Figure 3. Mean sediment elevation (NAVD 88) (ft) in the immediate crevasse outfall area in 1997 (pre-construction), 2001, 2007, and 2016 (post-construction) for the Channel Armor Gap Crevasse (MR-06) project.

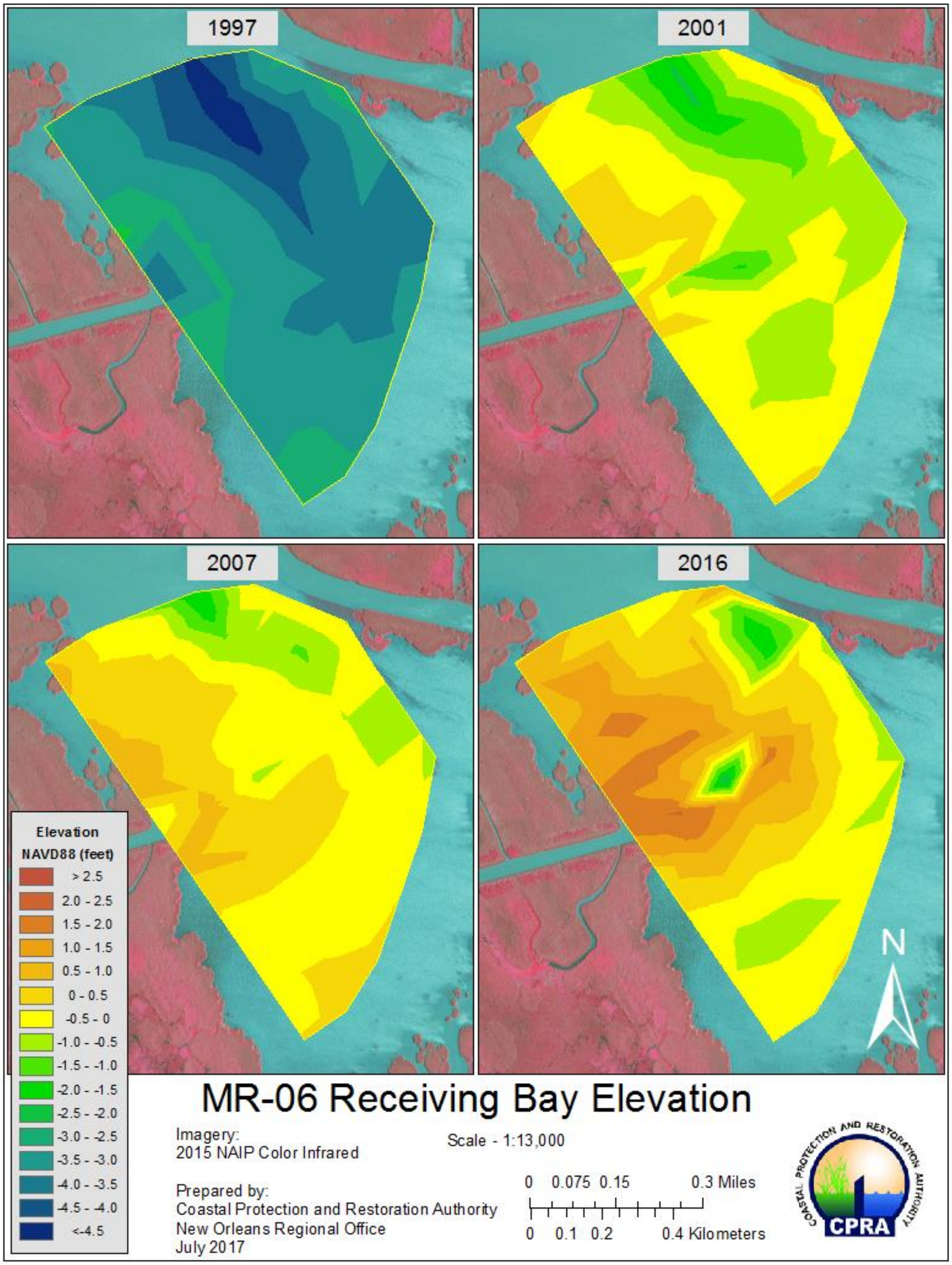

Figure 4. Elevation within the MR-06 receiving bay (NAVD88, feet) for 1997 (preconstruction), 2001, 2007, and 2016 (postconstruction).

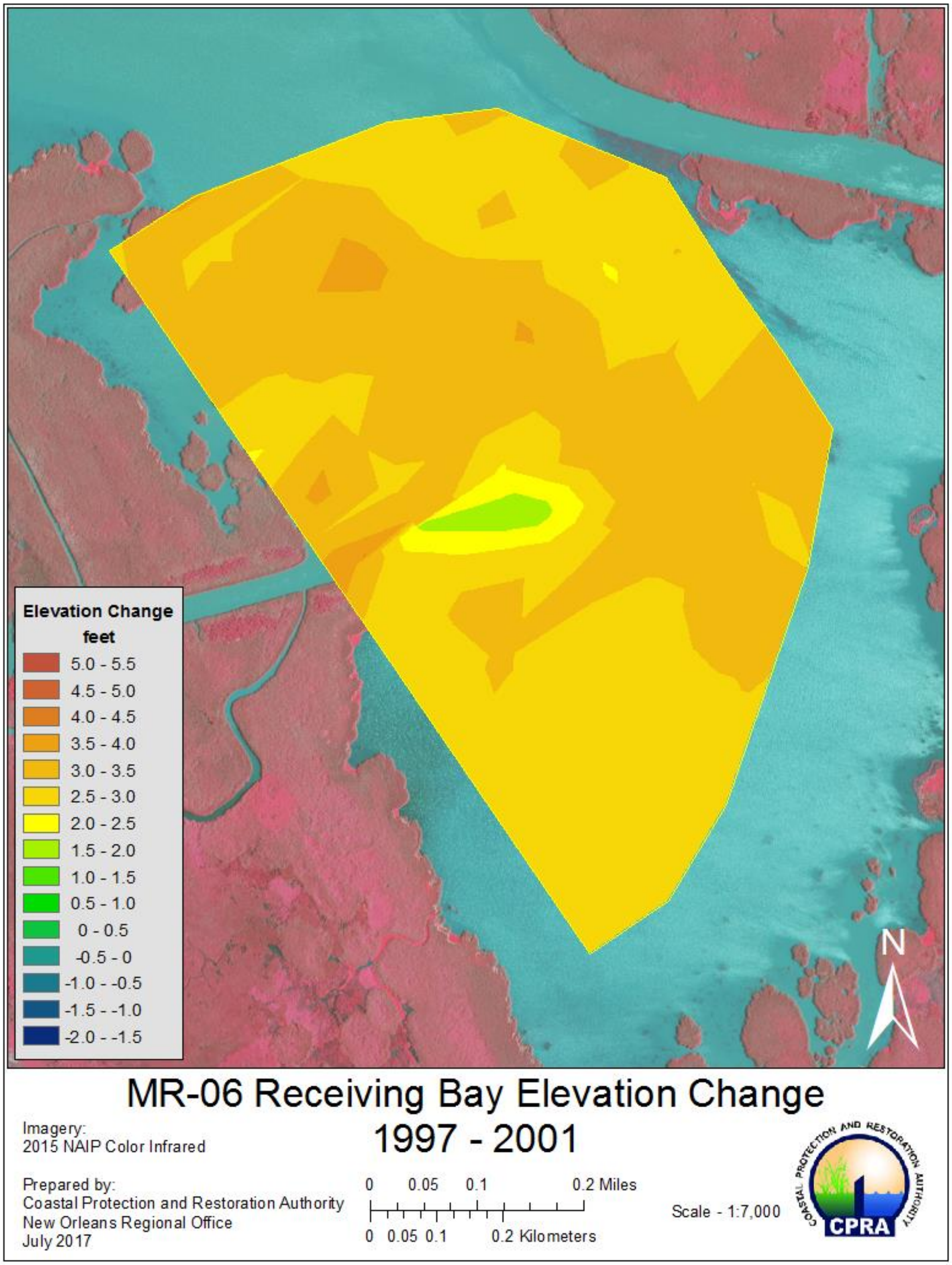

Figure 5. Change in MR-06 receiving bay elevation (feet) from 1997 – 2001.

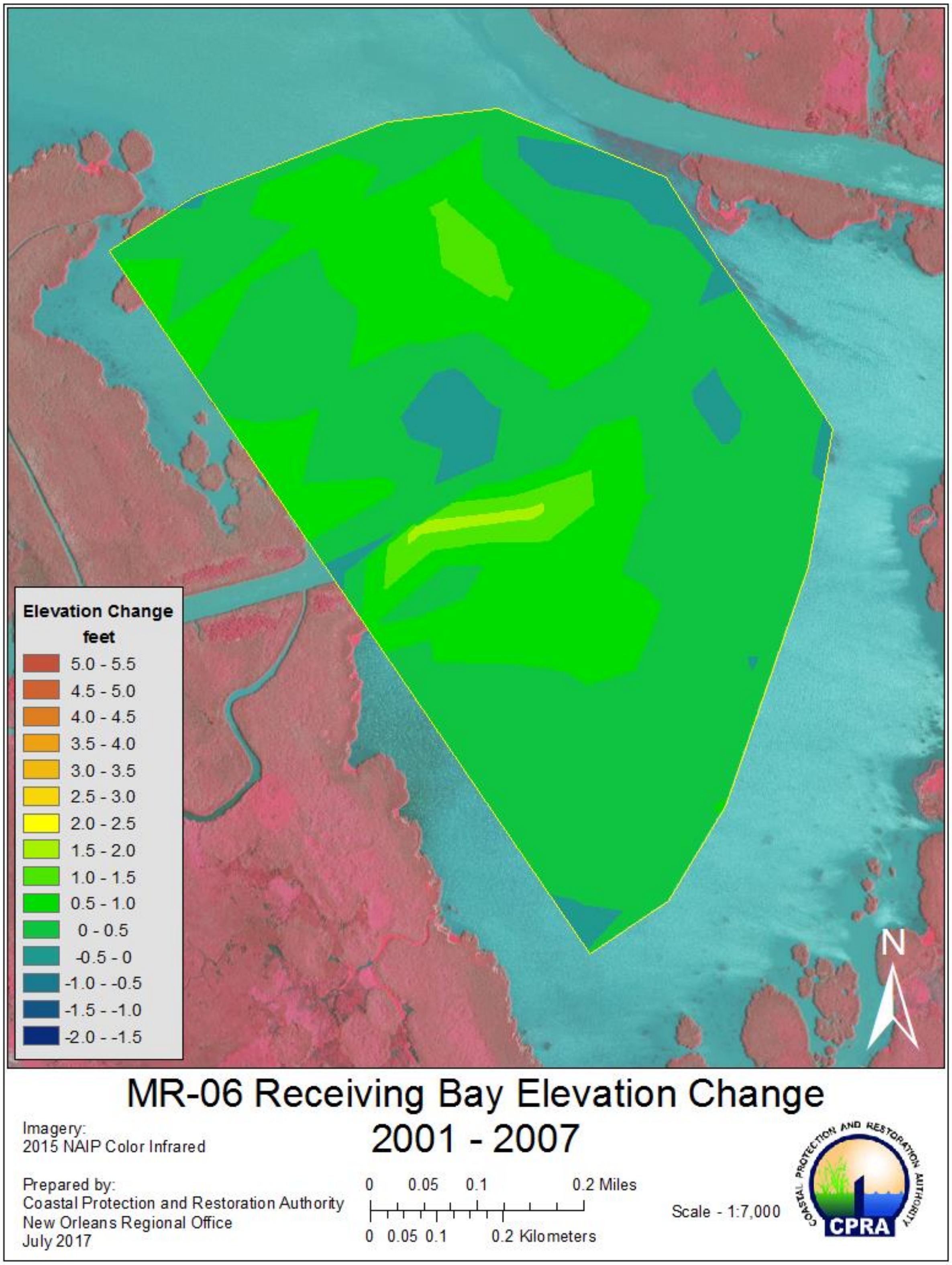

Figure 6. Change in MR-06 receiving bay elevation (feet) from 2001 – 2007.

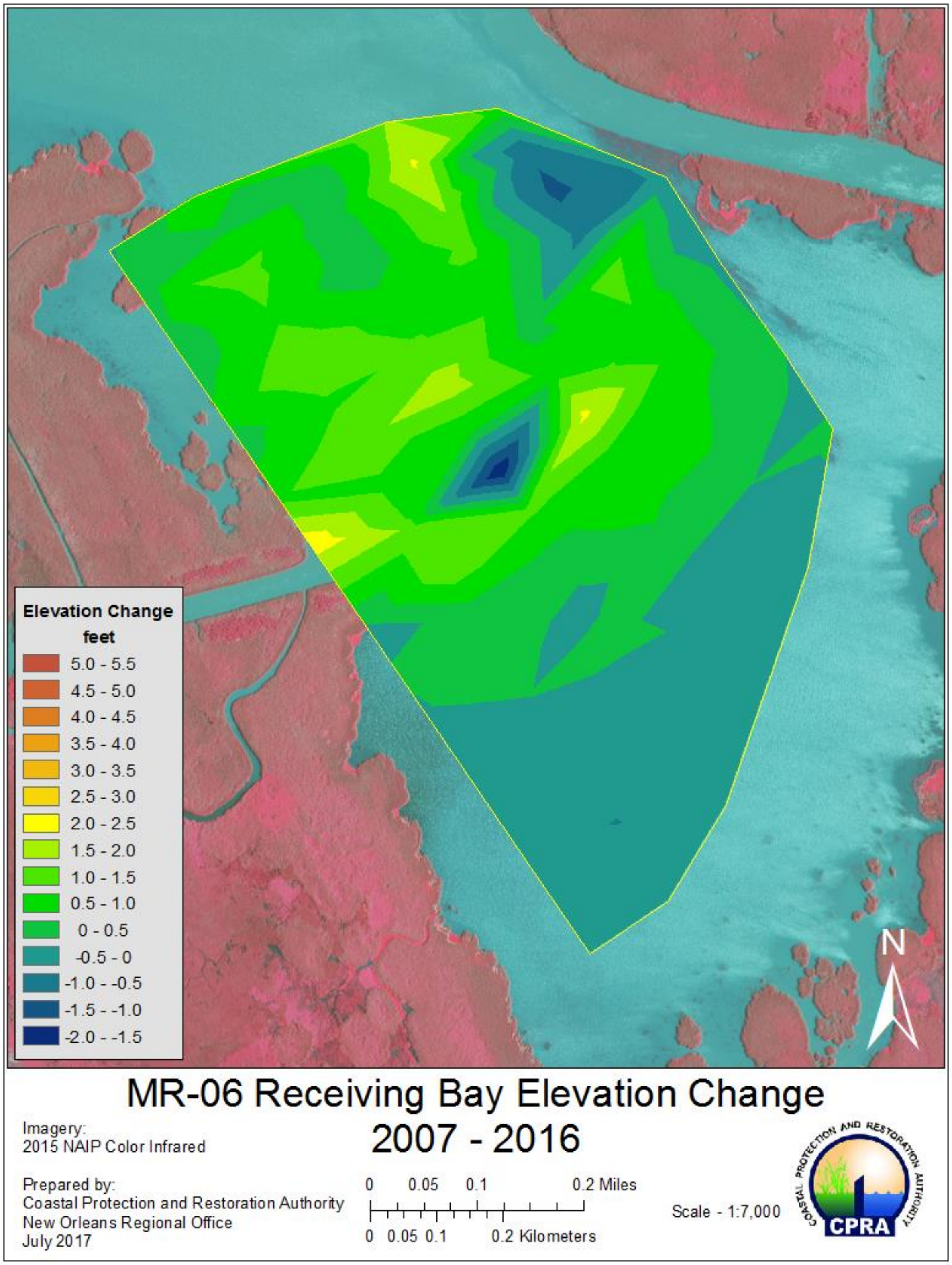

Figure 7. Change in MR-06 receiving bay elevation (feet) from 2007 – 2016.

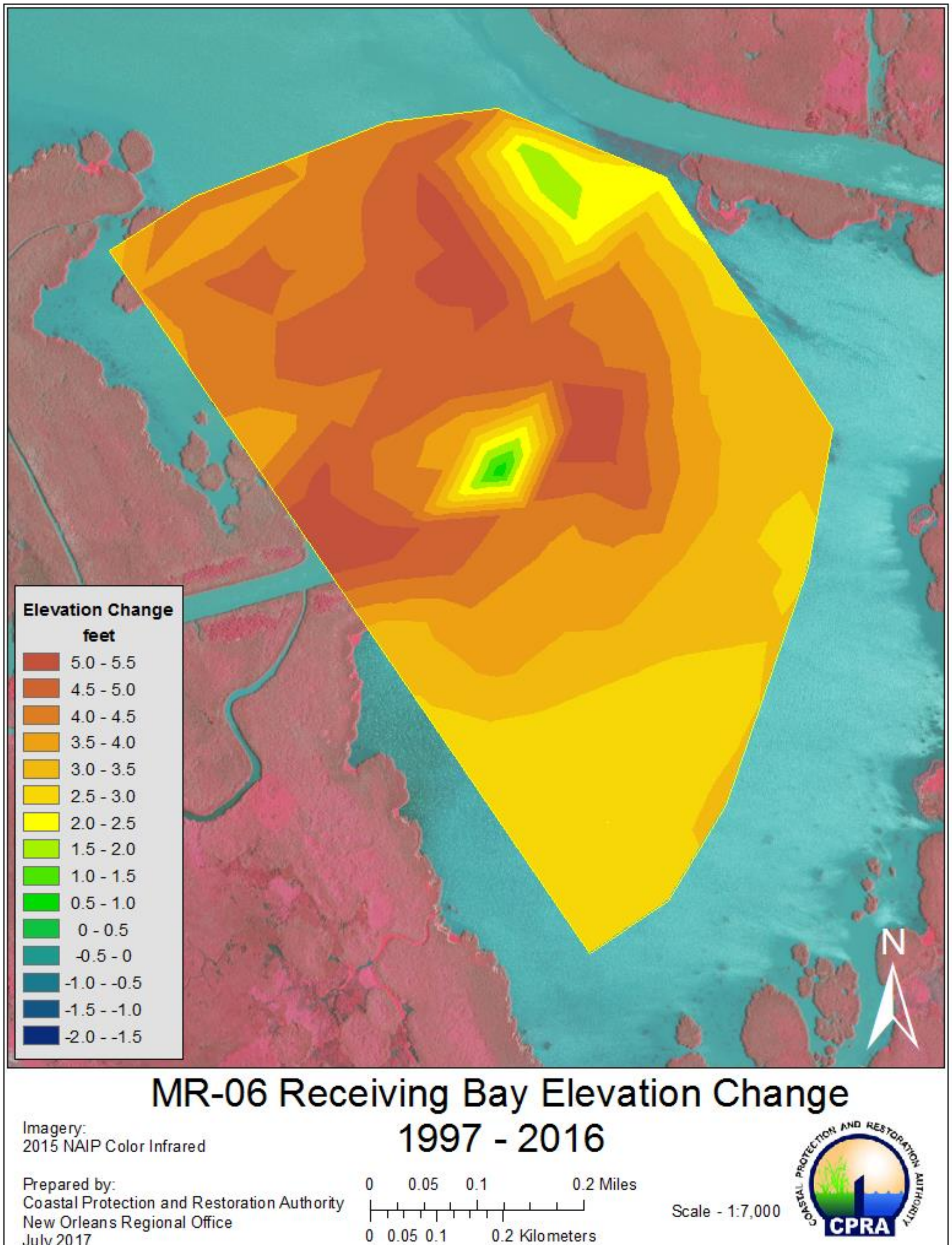

Figure 8. Change in MR-06 receiving bay elevation (feet) from 1997 – 2016.

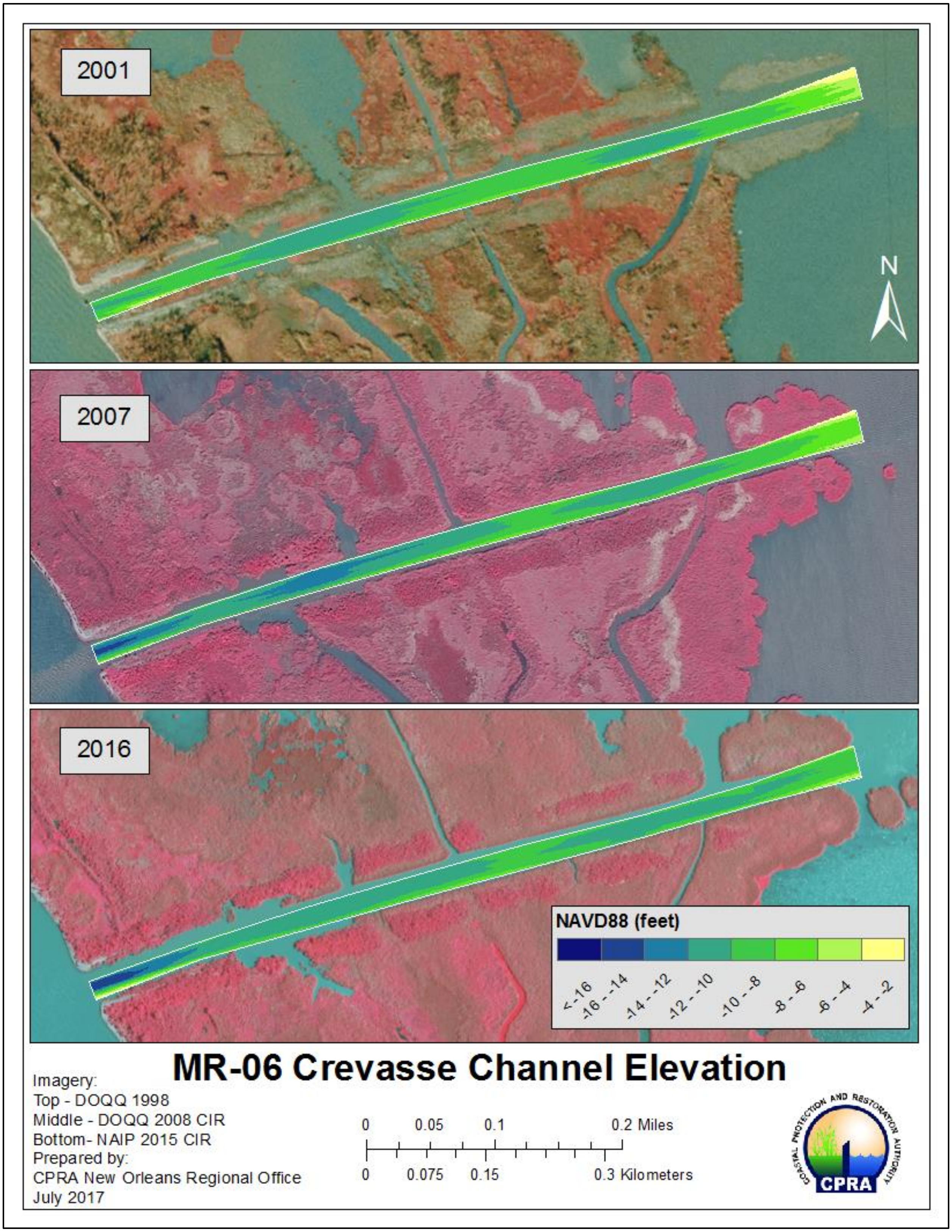

Figure 9. Elevation within the MR-06 crevasse channel (NAVD88, feet) for 2001, 2007, and 2016

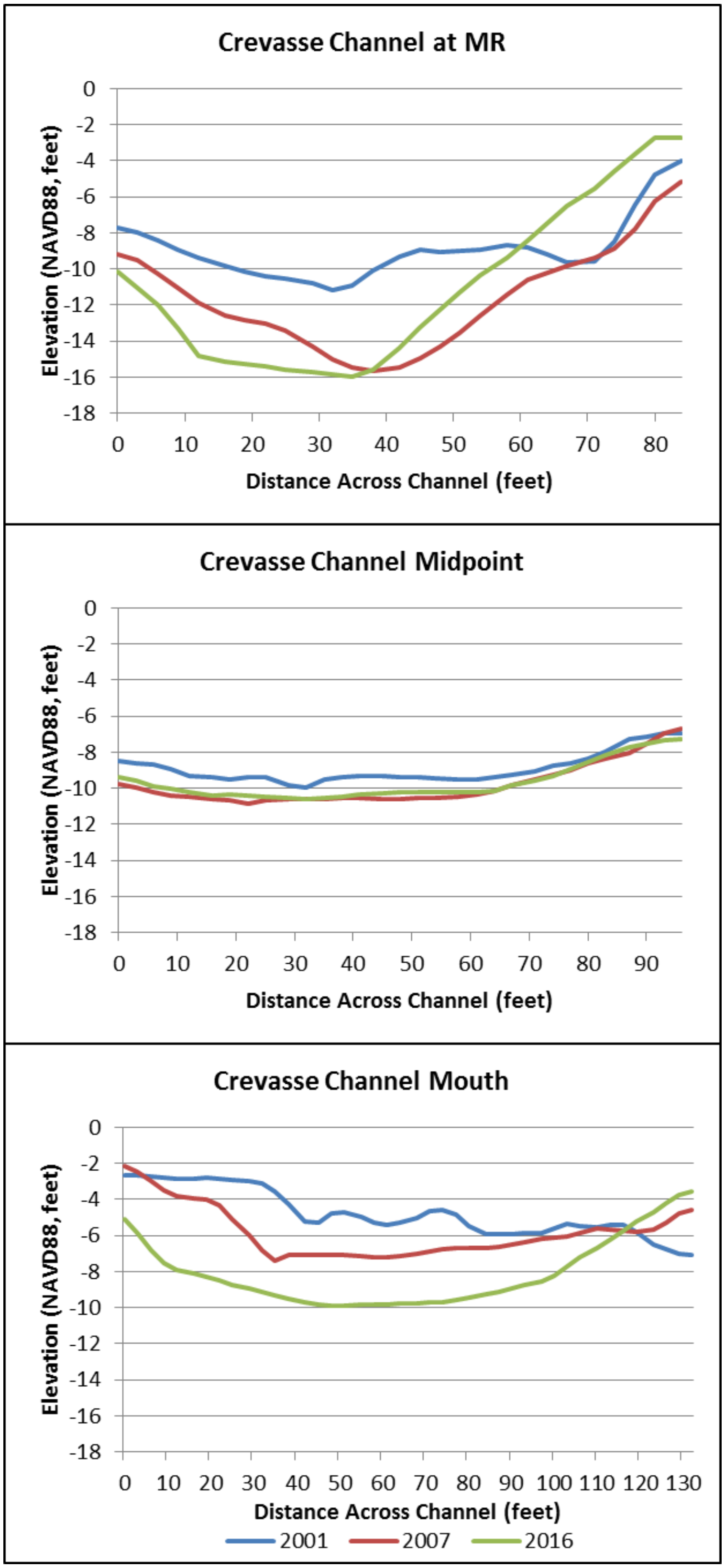

Figure 10. Elevation profile of MR-06 crevasse channel for 2001, 2007, and 2016 at three locations: Crevasse Channel at Mississippi River (top), Crevasse Channel Midpoint (middle), and Crevasse Channel Mouth (bottom).

Rod Surface Elevation Table (RSET) data have been collected bi-annually at CRMS2634 since fall of 2008 (Figure 11) in order to determine the rate of surface elevation change. For the time period from fall 2008 to spring 2017, the rate of surface elevation change was +2.06 cm/yr.

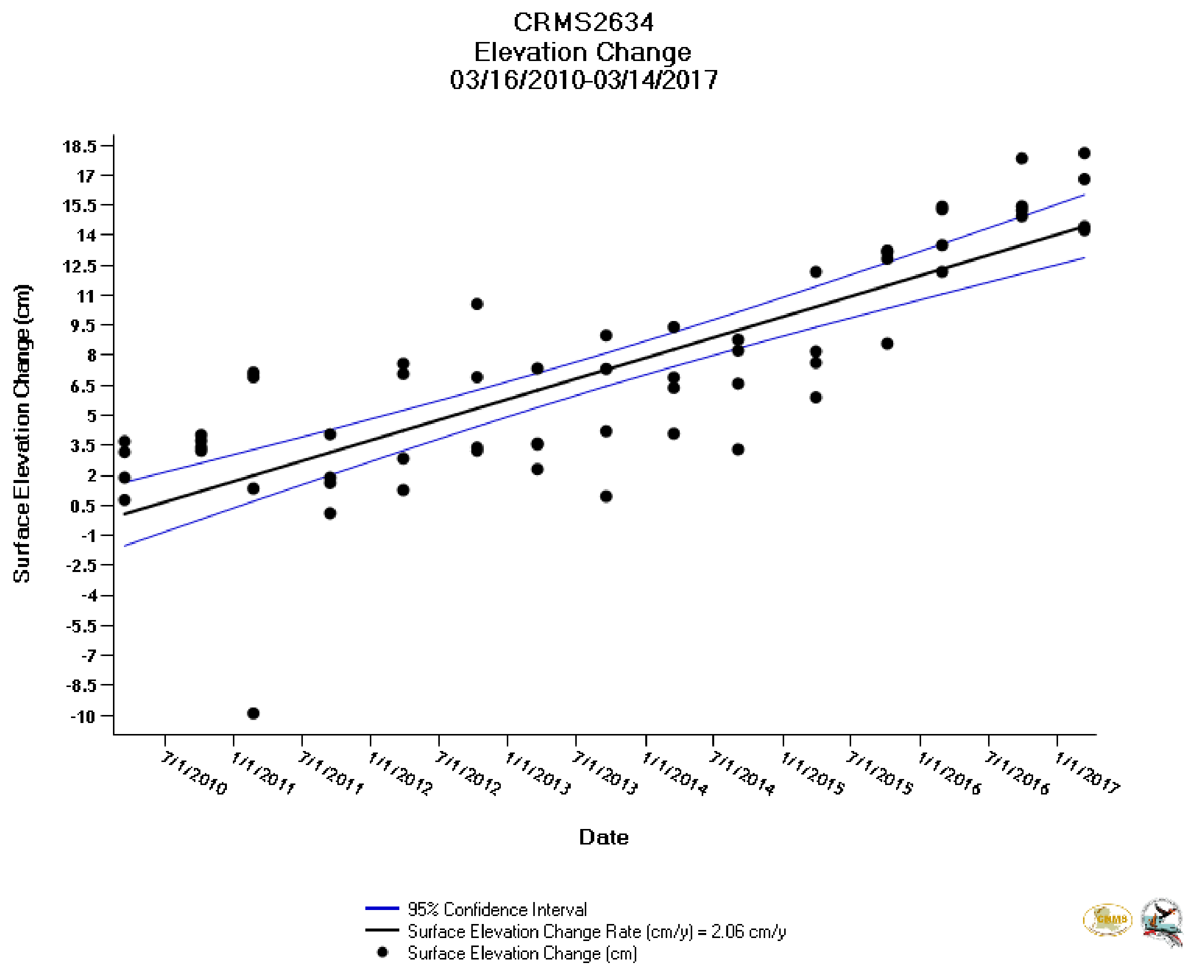

Figure 11. Surface elevation change at CRMS2634 from 2008 – 2017.

Land/Water Analysis and Habitat Mapping

Results from the 1996 preconstruction land/water analysis indicated that 474 acres of the project area were land, and 1,091.8 acres were open water, a ratio of 30% land to 70% open water (Figure 12). In the 2001 analysis, 526.4 acres were land and 1,039.8 acres were open water, increasing the ratio to 34% land to 66% open water (Figure 13). In the 2007 analysis, 667 acres were classified as land and 899 acres were open water, increasing the ratio to 43% land to 57% open water (Figure 14). In the 2016 analysis, 834 acres were classified as land and 732 acres were open water, again increasing the ratio to 53% land and 47% open water (Figure 15).

Since construction, the land area within the MR-06 project area has increased by 76%; a total of 360 acres. The rate of land formation within the project are for the 20-yr period from 1996 – 2016 is 18 ac/yr. The 2016 land/water analysis is the first indication of significant subaerial land formation in the immediate crevasse outfall. The small spoil island at the end of the crevasse channel on the northern side has expanded, and additional land has formed to the north. Two small islands that were barely visible in the 2007 land/water analysis have also expanded and joined other islands in the crevasse outfall along the southern bank and among the bifurcations of the distributary channels. Prior to the 2016 analysis, the majority of the new subaerial land in the project area had formed away from the MR-06 crevasse channel, in the vicinity of two other crevasses that feed into the project; one at the southern end and the other on the eastern side entering from Main Pass (Figure 1). The success of these two crevasses in creating new land can likely be attributed to two factors: age and location within the receiving bay. The crevasse on the eastern side of the project area was created in 1985 by the Superior and Mobile Oil Company and re-dredged in 1995 by USFWS. In the 1996 pre-construction land/water analysis for MR-06, land formation from this crevasse (12 years old at the time) was already evident. The crevasse at the southern end of the receiving bay was created in 1995 by USFWS. Although only 2 years older than MR-06, this crevasse had been successful in creating land more rapidly, mostly through the expansion of the marsh on the southern and eastern edges of the project area. As noted in the first progress report for MR-06 (Troutman 1999), the area adjacent to this crevasse was the shallowest in the receiving bay.

Land/Water analysis of CRMS2634 took place in 2005, 2008, and 2012 (Figure 16). The 1-km^2 analysis are for CRMS2634 falls within the project area for MR-06, and although it receives a greater influence from the canal entering the project area from Main Pass than from the crevasse channel, conditions here are similar to those found at the mouth of the crevasse channel. The 2005 analysis indicated the area was 67 ac (27%) land and 181 ac (43%) water. By 2008, land area had increased to 94 ac (38%) while water acreage had decreased to 154 ac (62%). The most recent analysis from 2012 indicated 106 ac (43%) of land and 142 ac (57%) of water. For the entire 7-yr period of analysis (2005 – 2012) there was a gain of 39 ac of land at CRMS2634, or an increase of 16%.

Habitat analysis of the 1996 aerial photographs indicated seven habitat classes (Figure 17). Approximately two thirds of the project area consisted of fresh open water, including 0.3 acres of submerged aquatic vegetation. Fresh marsh made up the majority of the remaining acreage. Most fresh marsh was located on the western side of the project area, as were nearly all of the wetland forest and scrub-shrub habitats. Upland barren and jetty made up the remaining 4.2 acres (1.7 hectares). Habitat analysis of the 2001 aerial photographs yielded seven habitat classes (Figure 18). Most of the fresh marsh increase was adjacent to two, previously constructed, crevasses on the eastern and southern fringes of the project area. Forested wetlands decreased from 35.3 acres (14.3 hectares) to 23.7 acres (9.6 hectares), and fresh wetland scrub shrub increased from 18.9 acres (7.6 hectares) to 37.9 acres (15.3 hectares). Upland scrub shrub, jetty, and forested uplands made up the remaining 9.7 acres (3.9 hectares).

Habitat mapping indicates that the vegetative community types remained largely unchanged in the early years following crevasse construction. The majority of the project area was fresh marsh prior to and following construction. The 2001 analysis indicated that a 6.2 ac of upland scrub shrub habitat had formed on either side of the crevasse channel, likely the result of spoil placement from crevasse construction. Since habitat mapping was discontinued after the 2001 analysis, it is unknown if this upland community is still present, however it is likely that it has or will convert to wetland vegetation as the spoil material consolidates and subsides.

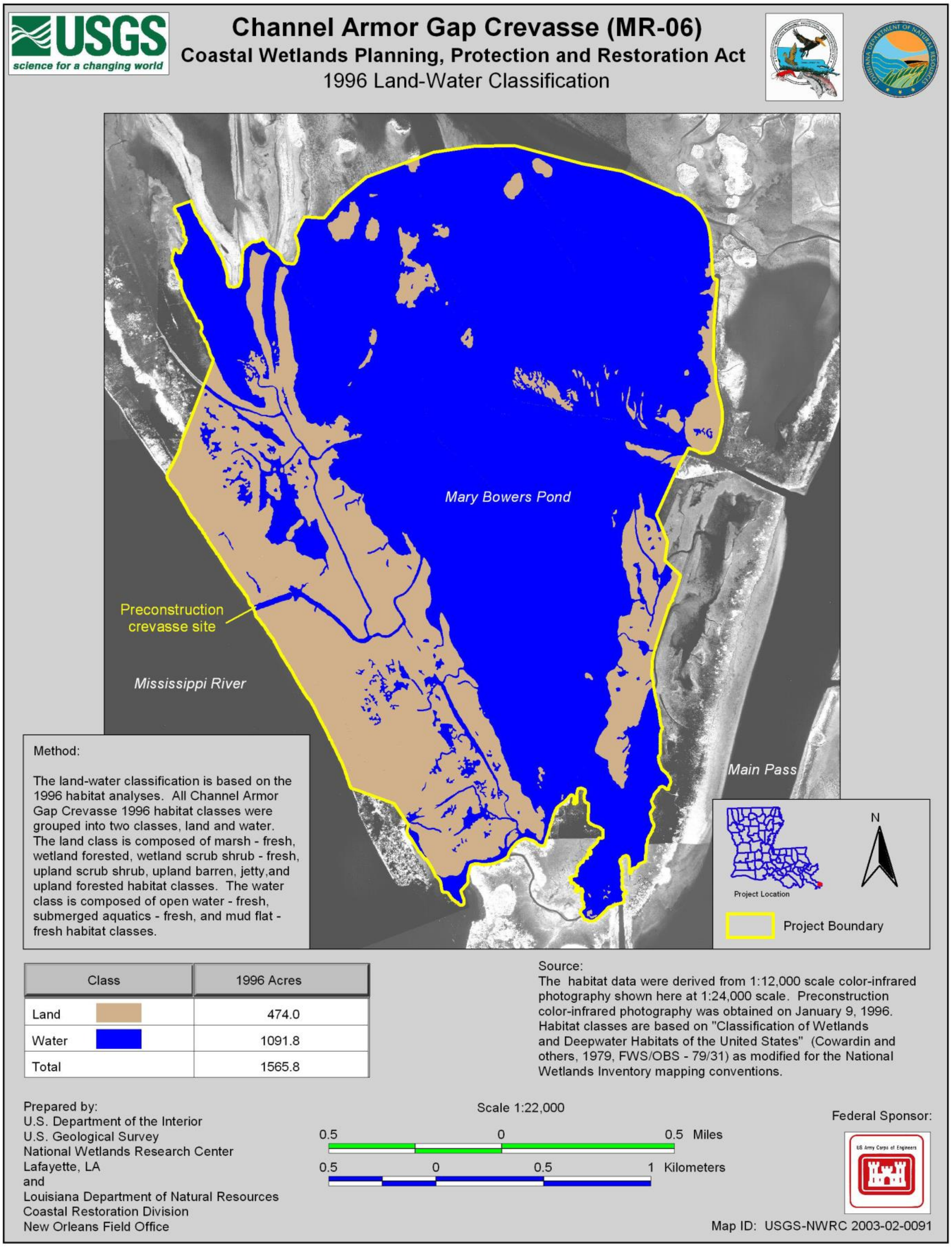

Figure 12. 1996 (preconstruction) land/water analysis of the Channel Armor Gap Crevasse (MR-06) project area.

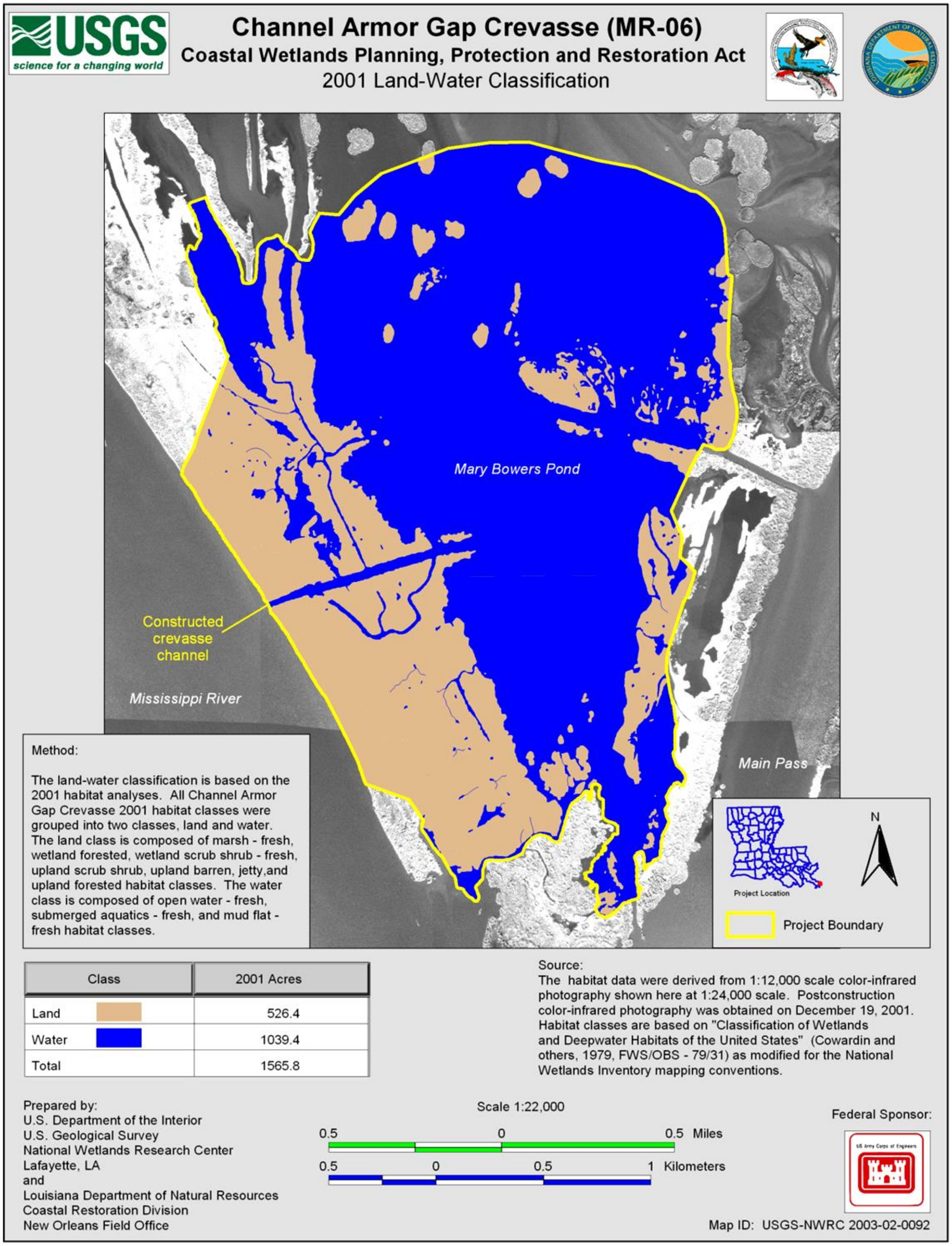

Figure 13. 2001 (post construction) land/water analysis of the Channel Armor Gap Crevasse (MR-06) project area.

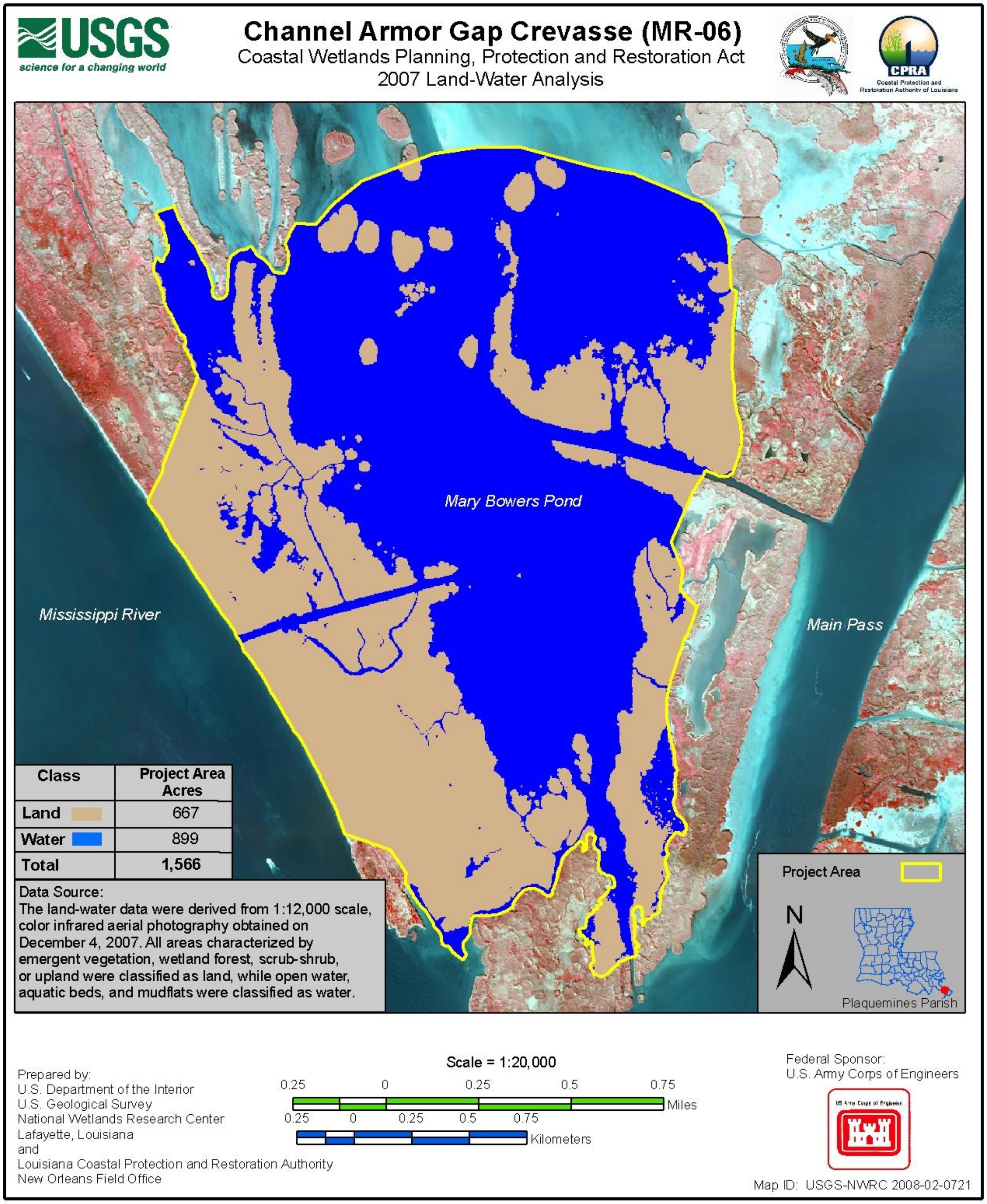

Figure 14. 2007 land/water analysis of the Channel Armor Gap Crevasse (MR-06) project area.

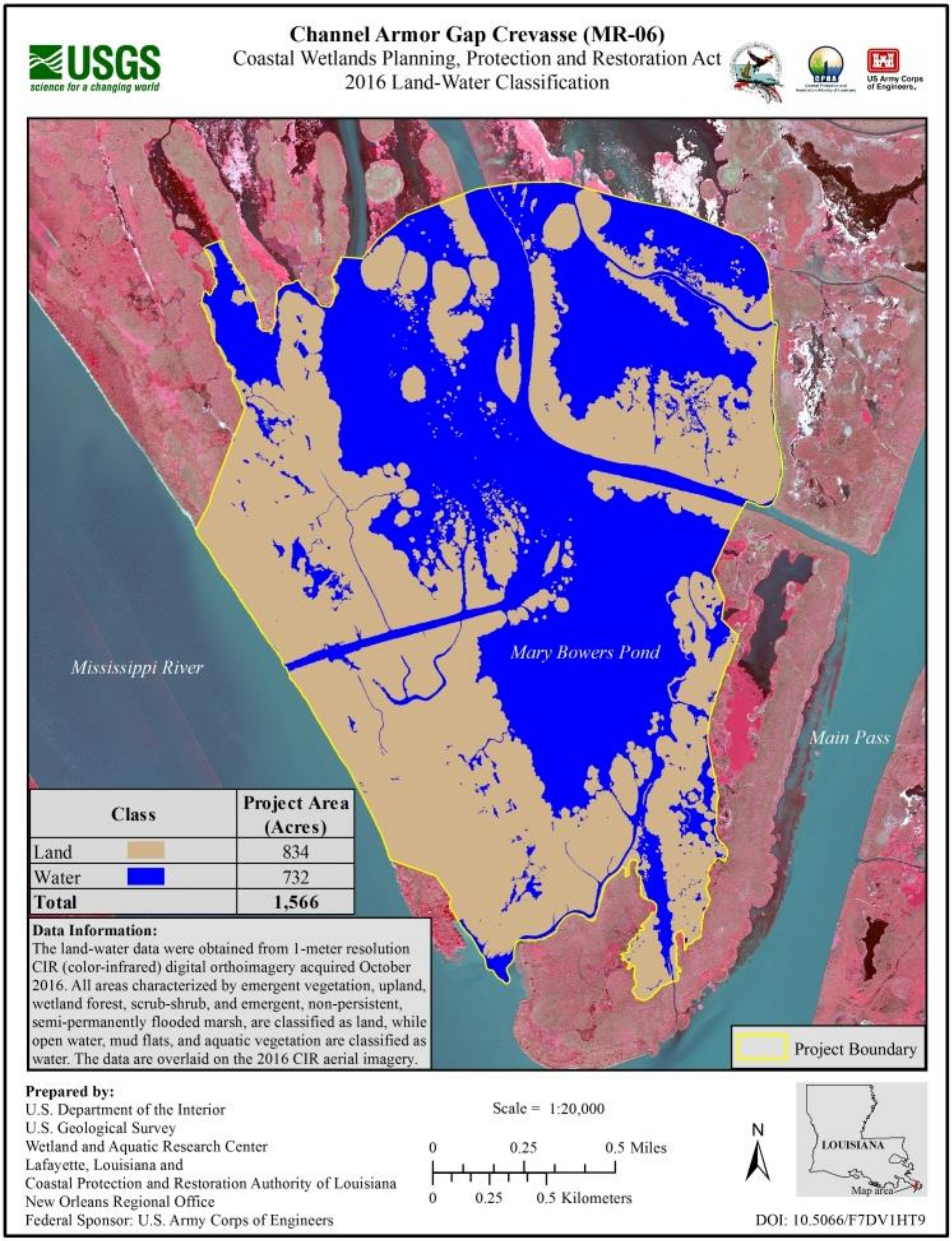

Figure 15. 2016 Land/Water analysis of the Channel Armor Gap Crevasse (MR-06) Project Area

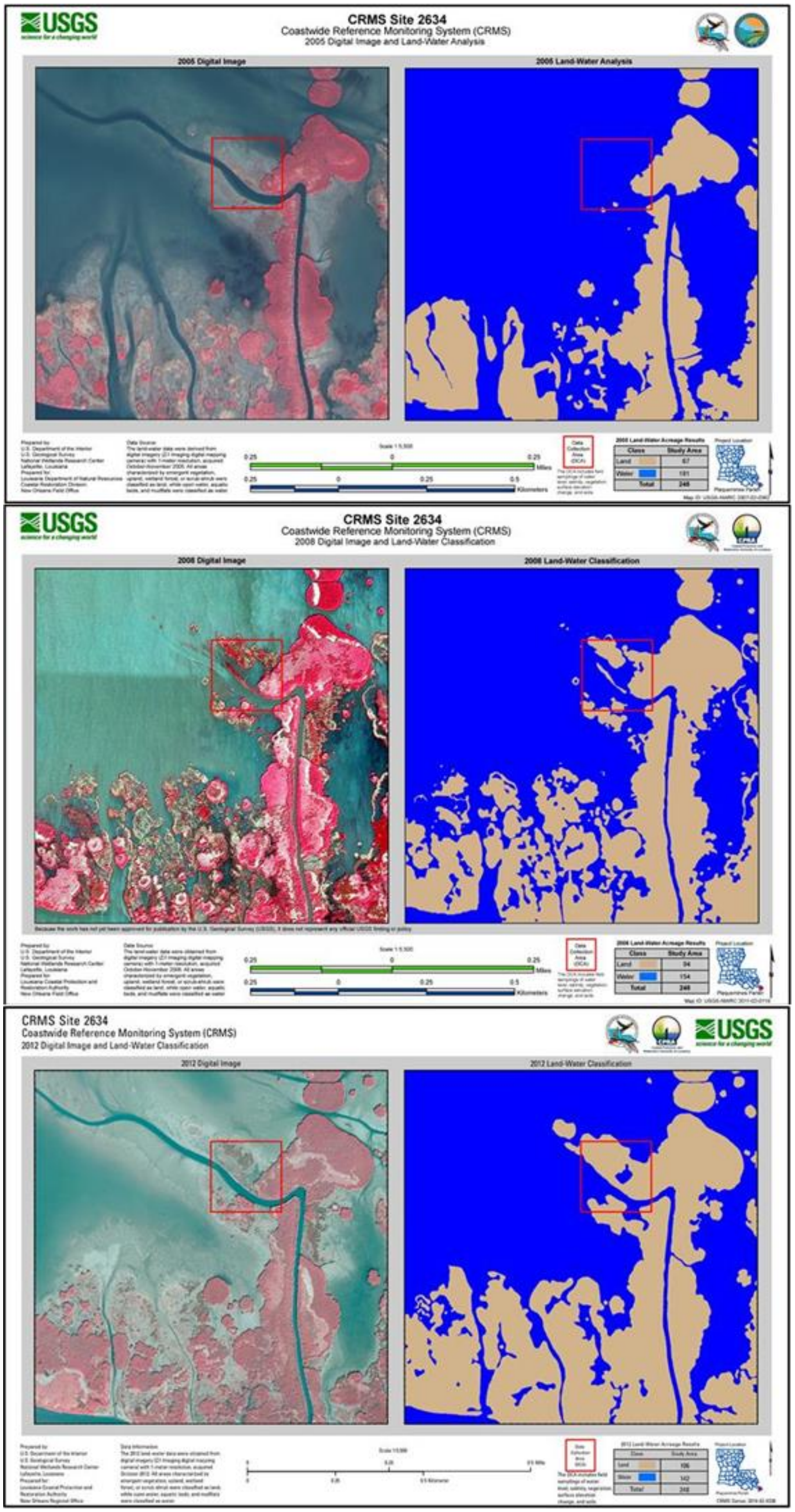

Figure 16. Land/Water analysis of CRMS2634 for 2005 (top), 2008 (middle), and 2012 (bottom)

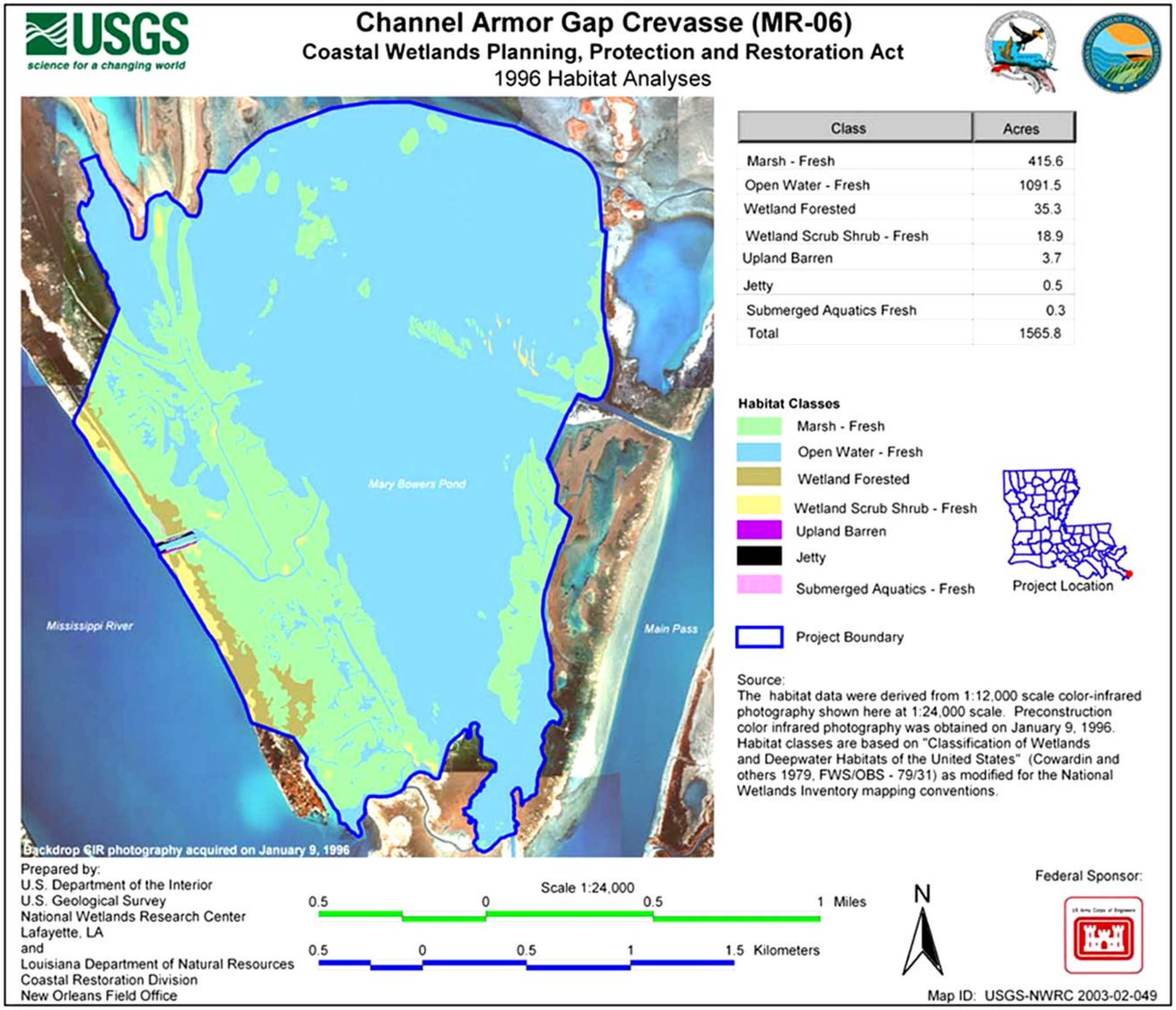

Figure 17. Preconstruction habitat analysis of the Channel Armor Gap (MR-06) project area.

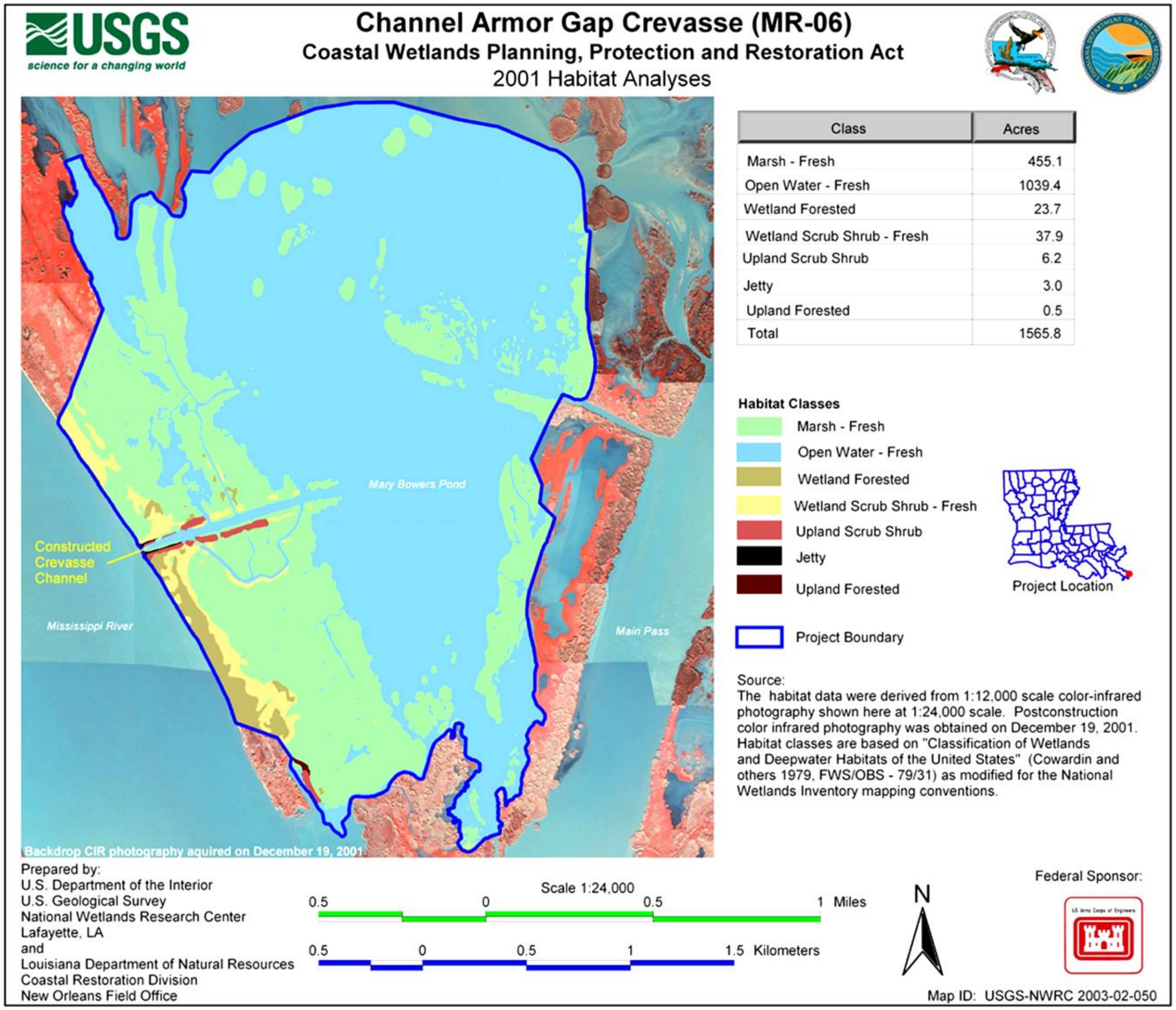

Figure 18. Post construction habitat analysis of the Channel Armor Gap (MR-06) project area.

Vegetation

The first two vegetation stations were established in October, 2001 when subaerial land was first observed adjacent to the end of the crevasse channel. These stations were placed in Transect 1, which is oriented perpendicular to and near the end of the crevasse channel. Station MR06-0101, located on the southeast side of the crevasse channel, had 75% coverage of *Sagittaria* sp. (bulltongue) and station MR06-0102, located on the northwest side of the crevasse channel, had 60% coverage of *Sagittaria* sp. (Figure 19). During the 2002 survey however, no subaerial land or emergent vegetation was observed in the area adjacent to the crevasse channel where vegetation stations had been established the previous year.

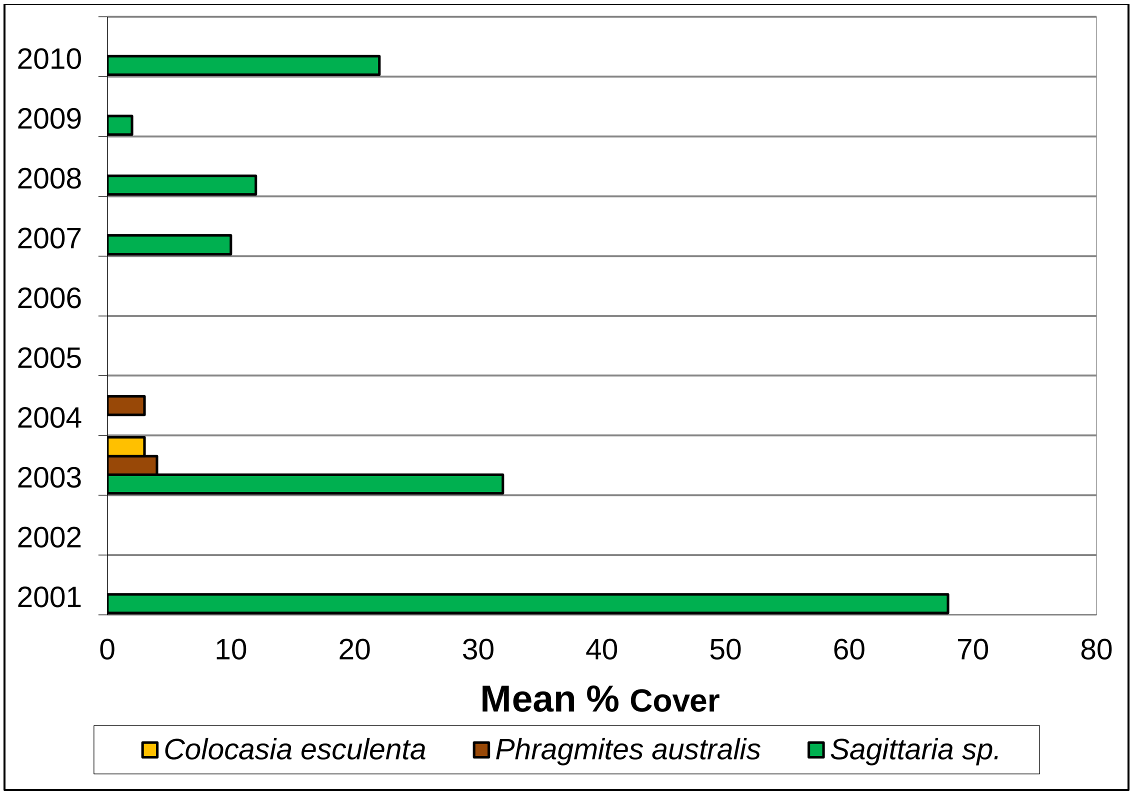

Figure 19. Mean percent cover of emergent vegetation species from 2001 to 2010 (2001 – 2002 n=2; 2003 – 2007 n=7; 2008 – 2009 n=8; 2010 n=9). No vegetation was observed in 2002, 2005, or 2006

Five new vegetation stations and a second transect were established during the 2003 survey due to an increase in emergent vegetation near the mouth of the crevasse channel. Transect 2 is located parallel to Transect 1 farther out in the receiving bay. Vegetation was present in 6 of the 7 vegetation stations. Most of the observed vegetation was *Sagittaria* sp., but *Phragmites australis* (common reed) and *Colocasia esculenta* (elephant ear) were also present. In 2004, there was a marked decrease in vegetative cover, with vegetation present at only 1 station. In the 2005 and 2006 surveys, no vegetation was observed.

Vegetative cover recovered somewhat in the 2007 – 2010 surveys, although in each of these years vegetation was found in 2 or fewer plots. Mean percent cover ranged from 2% to 22% (Figure 19) across all stations. One new station was added to Transect 1 in 2008, along with another in 2010; both were located on the northern end of the transect. The only species observed during these surveys was *Sagittaria* sp.

During the period of vegetative monitoring (2001 – 2010), vegetative cover was inconsistent in the receiving bay. For example, in several cases stations were established during one survey, only to have no vegetation present in any subsequent surveys. Some of this inconsistency can likely be attributed to the numerous disturbances that affected the area during the monitoring period. Most of the vegetation surveys in which vegetation was absent entirely occurred following disturbances. For example, no vegetation was observed during the 2002 survey, which followed the passage of Tropical Storm Isidore and Hurricane Lili earlier the same year. Low vegetative coverage in 2004 was most likely caused by Hurricane Ivan. Hurricanes Katrina and Rita heavily impacted the area in 2005. Vegetation was absent in the 2005 and 2006 surveys. Until the crevasse has sufficient time to generate a stable vegetative community; storm events will likely impede any progress. It is clear from the 2016 land/water analysis and inspection that vegetation community development in the crevasse outfall area has continued beyond the monitoring period.

One tool that has been used to assess the quality of the vegetation community at the CRMS sites is the Floristic Quality Index (FQI) (Cretini et al. 2011). The FQI is calculated by assigning each species a CC score, or coefficient of conservatism, which is scaled from 1 to 10 and reflects a species' tolerance to disturbance and habitat specificity. A modified FQI was developed by the CRMS Vegetation Analytical Team, which assembled a team of experts to assign CC scores to Louisiana's wetland plant species. The modified FQI equation takes into account not only the CC scores, but also the percent covers of species at a site, and the resulting score is scaled from 0 to 100.

FQI scores at CRMS2634 remained relatively stable from 2007 to 2011, ranging from a low of 43 in 2010 to a high of 58 in 2007 (Figure 20). Total mean percent cover values showed a general upward trend for the same period, with the highest values seen in 2009 and 2011. There was also a shift in the species composition, from a community dominated by *Schoenoplectus deltarum* (delta bulrush) and *Sagittaria* sp. (bulltongue) to one dominated by *Phragmites australis* (common reed) and *Typha domingensis* (southern cattail). For the period from 2012 to 2016, FQI scores and total percent cover followed a generally downward trend with a slight uptick in 2013 and 2014. This was accompanied with another shift in species composition as percent cover of *Phragmites australis* was absent or greatly reduced while *Typha domingensis* and *Zizaniopsis miliacea* (giant cutgrass) increased. FQI scores for the MR-06 project area were mostly higher than other fresh marsh CRMS project and reference sites within the MRD hydrologic basin from 2007 to 2016 (Figure 21), with the exception of 2015 and 2016. The decrease in FQI observed at CRMS2634 in recent years appears to be consistent with a general downward trend in FQI among MRD CRMS sites.

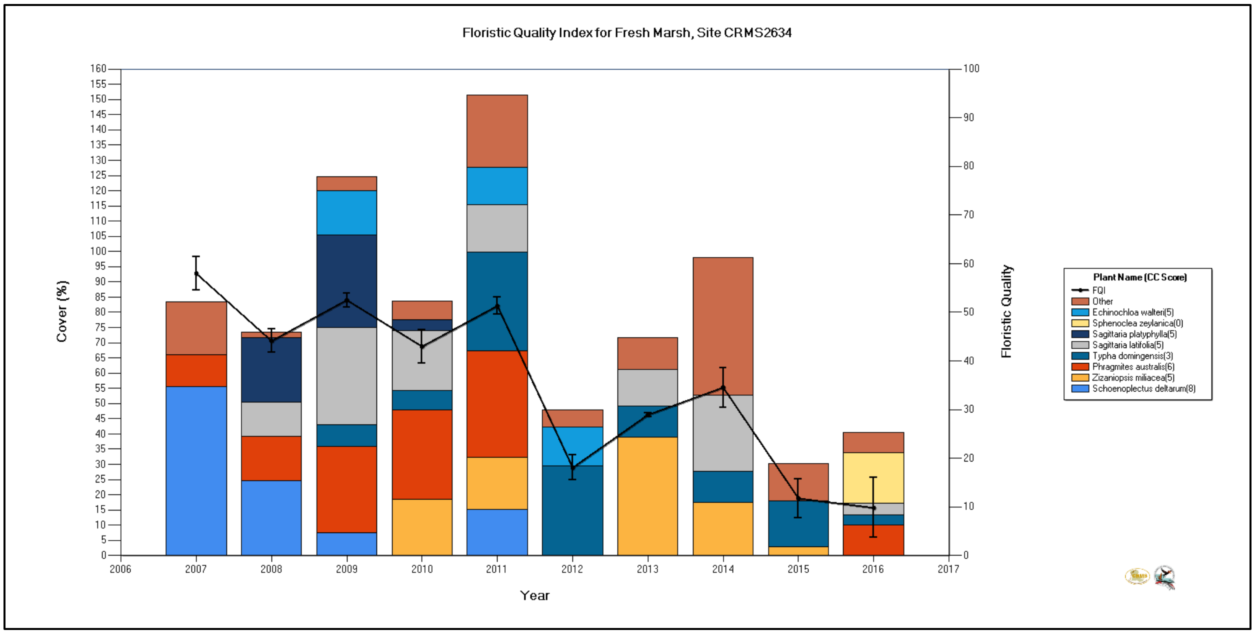

Figure 20. Mean % cover of major species and FQI score at CRMS2634 vegetation plots in years 2007 through 2016.

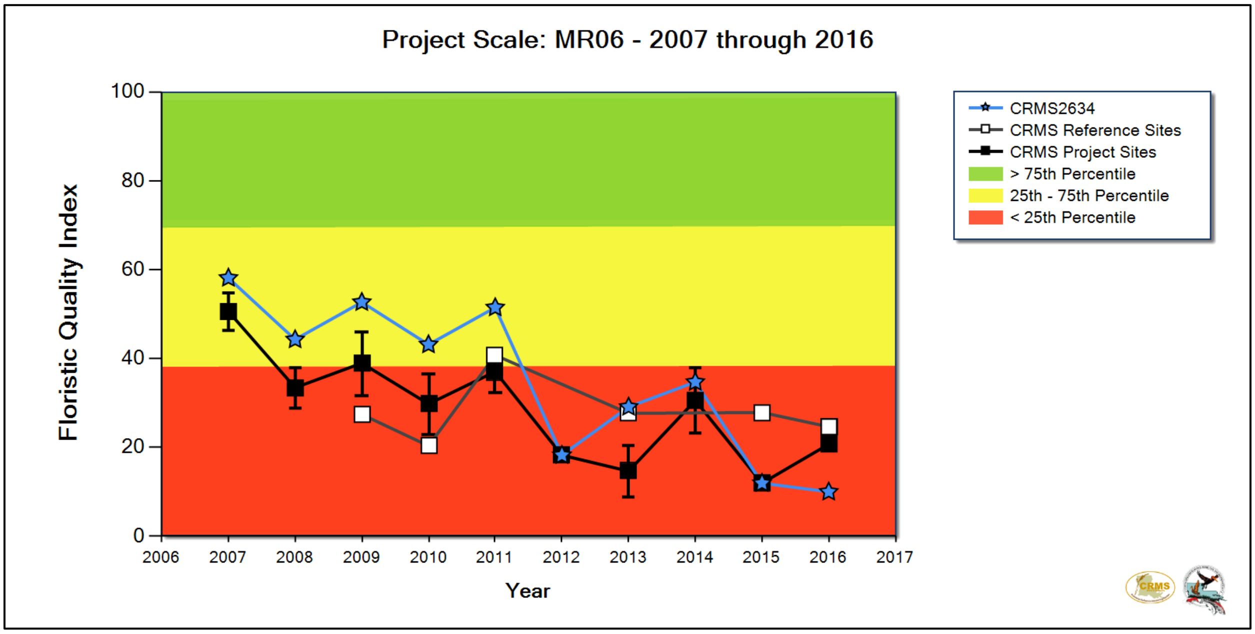

Figure 21. FQI scores of CRMS sites within the MR-06 project area (blue stars) are shown over time relative to all other fresh marsh CRMS sites within the Mississippi River Delta hydrologic basin. Black squares represent CRMS sites located within restoration projects; white squares are CRMS reference sites outside of restoration projects. Project and reference site scores are the mean (± SE) FQI scores by year for all sites with similar marsh types within Mississippi River Delta Basin.

V. Conclusions

a. Project Effectiveness

It is clear that the goal of increasing sediment elevation is being met. Sediment elevation has significantly increased within the entire project area since project construction was completed in 1997. Also, using only the immediate receiving bay for elevation analyses has eliminated concern regarding how much of the elevation increase was a direct result of the MR-06 project. Land area has increased by 76% (360 ac.) within the MR-06 project area. Although it is unknown how much of this can be directly attributed to the project due to multiple freshwater and sediment inputs into the receiving area, there has been subaerial land formation in the immediate vicinity of the crevasse channel. Emergent wetland vegetative cover was slow to develop and, therefore, was not fully captured by project-specific monitoring; however vegetation did develop in the crevasse outfall during the monitoring period. Also, CRMS data and the increase in land acreage in the immediate crevasse outfall area indicate that vegetative development has continued during the post-monitoring period. The most recent elevation survey of the project area confirms that the crevasse channel remains open and functional, so the benefits of the crevasse should continue into the future.

b. Recommended Improvements

None

c. Lessons Learned

In this project, more time was required for subaerial land to appear than in previously studied crevasses. Mary Bower's Pond was a relatively deep receiving area, averaging nearly 3.5 ft deep prior to construction. Subaerial expression of crevasse splays may be delayed with increasing pre-construction water depth. More sediment is required to fill a relatively deep receiving basin as opposed to shallower basins. Furthermore, many factors affect the rate of sediment retention and sediment distribution in receiving basins. Measuring and modeling sediment elevation is an effective short-term indicator of project success rather than relying solely on aerial photography to monitor visible land gain.

Suspended sediment and discharge measurements were dropped because their sampling frequency was not sufficient to give us accurate and reliable data. However, we suggest that funding for these variables be provided for future projects. The quantity and quality of sediment being transported into the project area can be combined with land gain data, modeled, and used to increase predictive capabilities of crevasse splay development.

Vegetation monitoring was conducted annually for the first 10 years following construction. Since significant land development did not occur until later in the crevasse outfall area, much of the vegetative development was not captured by the monitoring. It is recommended that, for future projects, vegetation monitoring be conducted for the entire 20-yr project life. If necessary, frequency of sampling could be reduced in order to achieve this.

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Appendix A

Inspection Photographs

Photo 1. View of the MR-06 crevasse channel from the Mississippi River toward receiving bay

Photo 2. View from the mouth of the MR-06 crevasse channel toward receiving bay

Photo 3. Roseau cane islands at the mouth of the crevasse channel

Photo 4. Emergent vegetation in the receiving bay to the north of the crevasse mouth

Photo 5. Emergent vegetation in the receiving bay to the north of the crevasse mouth

Photo 6. Submerged aquatic vegetation in the receiving bay