State of Louisiana

Coastal Protection and Restoration Authority (CPRA)

2020 Operations, Maintenance, and Monitoring Report

for

Marsh Island Hydrologic Restoration

State Project Number TV-14
Priority Project List 6

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Iberia Parish

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For
Marsh Island Hydrologic Restoration (TV-14)

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Preface

This report includes monitoring data collected through December 2019, and annual Maintenance Inspections through May 2020.

The 2020 report is the 7th and final report in a series of reports. For additional information on lessons learned, recommendations and project effectiveness please refer to previous OM&M reports (2004, 2005, 2007, 2011, 2014 and 2018) on the CPRA web site at http://coastal.Louisiana.gov/. These reports and others are available for download at the following website: http://cims.coastal.la.gov.

I. Introduction

The Marsh Island Hydrologic Restoration Project was proposed on the 6th priority list of the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) and is co-sponsored by the United States Army Corps of Engineers (USACE) and the Coastal Protection and Restoration Authority of Louisiana (CPRA). The project is located in Iberia Parish, approximately six miles south of Cypremort Point. The project area encompasses approximately 7,310 acres (2,958 ha) of wetlands on the northeast tip of Marsh Island, east of Bayou Blanc (Figure 1). It comprises 4,290 acres (1,736 ha) of brackish marsh and 3,020 acres (1,222 ha) of open water, based on the Louisiana Department of Natural Resource's GIS data for 2004 (LDNR 2004). Common plant species found in the project area include *Juncus roemerianus* (needlegrass rush), *Spartina patens* (saltmeadow cordgrass), *Bolboschoenus maritimus* (cosmopolitan bulrush), *Schoenoplectus americanus* (chairmaker's bulrush), *Spartina alterniflora* (saltmarsh cordgrass), and *Vigna luteola* (hairypod cowpea) (United States Department of Agriculture, Natural Resources Conservation Service 2002, Chabreck and Linscombe 1988).

Between 1930 and the present, the hydrology of Marsh Island has changed due to tidal influenced erosion, subsidence, and oil and gas exploration (Orton 1959, SCS 1978). Several oil field canals were constructed to facilitate oil and gas exploration in the project area during the 1950's. Recent deterioration and subsidence of the spoil banks deposited in the 1950's have resulted in cuts in the spoil banks that have become conduits for rapid tidal exchanges between the surrounding bays and the interior marshes. These rapid exchanges have resulted in tidal scouring and the loss of marsh vegetation through erosion and subsidence. Lake Sand and a number of interior lakes also supported a significant amount of submerged aquatic vegetation (SAV). Today these lakes are almost devoid of SAV, presumably due to the effects of increased tidal exchange and increased turbidity. Erosion has also lead to the deterioration of the northeast end of Marsh Island and the north rim of Lake Sand, leaving exposed a highly organic brackish marsh.

During the life of the 20 year project, 408 acres (168 ha) of wetlands will be protected (USACE 1994). The project consists of the construction of 9 closures in oil and gas canals at the northeast end of Marsh Island and free-standing rock breakwaters to isolate Lake Sand from Vermilion Bay and to provide shoreline protection to the northeastern shoreline of Marsh Island (Figure

1). Project construction began on July 25, 2001 with the construction of approximately 4,000 linear feet (1291 m) of rock breakwater to protect the north shoreline of Lake Sand. A total of seven canals were plugged with rock armor while one was plugged with an earthen closure only. An additional closure, constructed of painted steel sheetpile and rock armor, was constructed at the mouth of an oil exploration canal on the eastern end of the project area. Construction of the $2.9 million project was completed on December 12, 2001.

Hurricane Rita struck the coast of southwestern Louisiana on September 24, 2005 with a maximum storm surge of 10 ft (3.1 m) in the TV-14 project area (FEMA 2006). USGS calculated the amount of land that changed to water resulting from the storm to be 98 square miles in southwestern Louisiana, 5 square miles in the Teche/Vermilion basin (Barras 2006).

Hurricane Ike struck near Galveston, Texas on September 13, 2008. A maximum storm surge of 7 - 8 ft (2.1 – 2.4 m) NAVD 88 was reported near the TV-14 project area (East et al. 2008).

The East Marsh Island Marsh Creation Project (TV-21) was constructed within the TV-14 project area in September 2010 (Figure 1). The project consisted of the addition of sediment hydraulically dredged from East Cote Blanche Bay to create 362 acres (146.5 ha) of contained marsh and 797 acres of un-contained/nourished marsh. The primary purpose of the project is to restore emergent marsh habitat that was lost due to hurricane damage. The TV-21 project provides a synergistic effect with the TV-14 project.

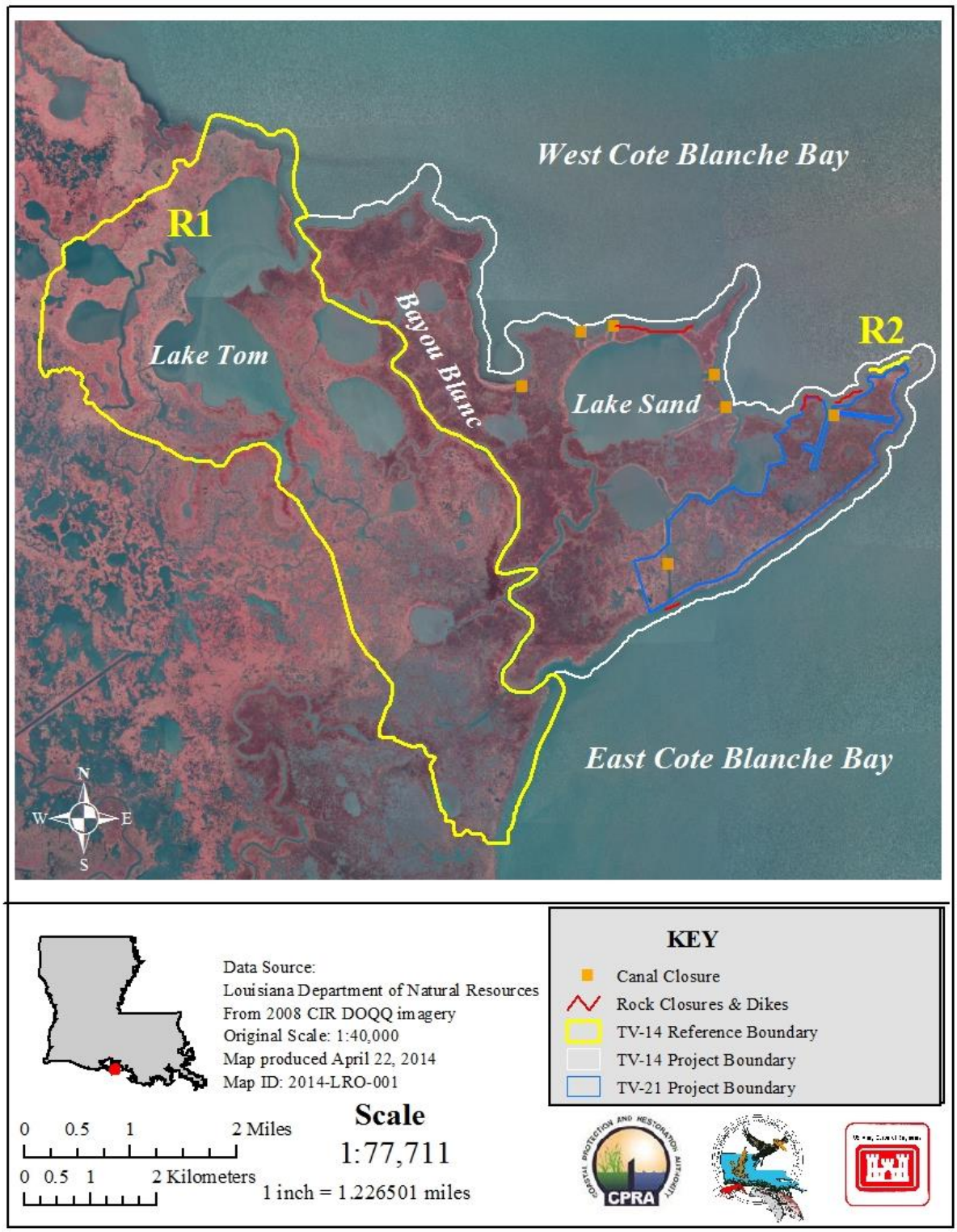

Figure 1. Marsh Island Hydrologic Restoration (TV-14) project boundary and features.

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the annual inspection of the Marsh Island Hydrologic Restoration Project (TV-14) is to evaluate the constructed project features to identify any deficiencies and prepare a report detailing the condition of project features and recommended corrective actions needed. Should it be determined that corrective actions are needed, CPRA shall provide, in the report, a detailed cost estimate for engineering, design, supervision, inspection, and construction contingencies, and an assessment of the urgency of such repairs. The annual inspection report also contains a summary of maintenance projects which were completed since completion of constructed project features and an estimated projected budget for the upcoming three (3) years for operation, maintenance and rehabilitation. The three (3) year projected operation and maintenance budget is shown in Appendix C. A summary of past operation and maintenance projects completed since completion of the Marsh Island Hydrologic Restoration Project are outlined in Section IV.

An inspection of the Marsh Island Hydrologic Restoration Project (TV-14) has not been held since May 16, 2017. The USACE and CPRA mutually agreed that no further maintenance would be done prior to project closeout, and a project extension would not be requested. Therefore, annual inspections were not continued beyond 2017.

The 2017 field inspection included a complete visual inspection of most of the project features. Staff gage readings and existing temporary benchmarks where available were used to determine approximate elevations of water, embankments and weir features. Photographs were taken at each project feature (see Appendix B) and Field Inspection notes were completed in the field to record measurements and deficiencies (see Appendix D).

b. Inspection Results

Closure No. 1

Erosion problems and Hurricane Rita damages were repaired through a maintenance project that was completed in February 2009. The dike was capped and bank paving installed on both ends of the closure. This site is in good condition since this work was performed. (Photos: Appendix A, Photo 1).

Closure No. 2

This structure is in good condition. (Photos: Appendix A, Photo 2)

Closure No. 3

This structure is in good condition. (Photos: Appendix A, Photo 3)

Closure No. 4

This structure is in good condition. (Photos: Appendix A, Photo 4)

Closure No. 5

Water is migrating around the structure on both ends. (Photos: Appendix A, Photos 5 & 6)

Closure No. 6

Water is migrating around the southern end of the structure. (Photos: Appendix A, Photos 7 & 8)

Closure No. 7

This structure is in good condition. (Photos: Appendix A, Photo 9).

Closure No. 8

A maintenance event on the adjacent TV-21 project required the closure to be removed for access. At the conclusion of the TV-21 maintenance event, the contractor replaced the closure and added additional rock to repair the breach. There has been some settlement at the canal opening. (Photos: Appendix A, Photo 10).

Closure No. 9

This rock shoreline feature functions as a breakwater protecting the earthen pipeline closure to the north. The recent construction of the TV-21 East Marsh Island Marsh Creation project has helped to reinforce the breach that had occurred on the southeast corner of the pipeline canal. (Photos: Appendix A, Photo 11)

c. Maintenance Recommendations

i. Immediate/ Emergency Repairs

- A large open water area has developed within the marsh near the western terminus of Closure No. 3 and that the bankline between that point and the eastern end of Closure No. 2 has eroded very severely and such that the "landbridge" between Vermilion Bay on the north of Marsh Island and the northwestern portion of Lake Sand proper is now narrow and may become subject to breaching thus allowing an undesirable water connection between the two bodies of water. NRCS proposed a new rock project to protect the shoreline between closure Nos. 2 & 3. The project was rejected. CPRA and USACE do not plan to pursue the matter further.

- There is a breach on the southern end of the bank paving at Closure No. 5 as well as a section of broken marsh between Closures No. 5 and No. 6, which is allowing exchange to occur between Vermilion Bay and Lake Sand. It is recommended that an additional reach of shoreline protection dike be constructed,

an estimated 1,500 to 1,800 linear feet, to connect the southern end of Closure No. 5 to the northern end of Closure No. 6. NRCS proposed a new rock project to protect the shoreline between closure Nos. 5 & 6. The project was rejected. CPRA and USACE do not plan to pursue the matter further.

ii. Programmatic/ Routine Repairs

None

d. Maintenance History

General Maintenance: Below is a summary of completed maintenance projects and operation tasks performed since December 2001, the construction completion date of the Marsh Island Hydrologic Restoration Project (TV-14).

2005 Maintenance Project–Grillot, Inc. (Through lease agreement with Bertucci Contracting Corp.) This maintenance project included the placement of paving stone (18" thick) spread out around the wingwalls of the plug at Lake Sand Canal No. 5 Closure to "harden" the area while still allowing flow in extreme tidal events to pass around the structure without washing away the existing bank. Also included was the extension of the rock dike on the southern end of Canal No. 5. Approximately 4,000 tons of 1000# stone was placed on Lake Sand Closure No. 4 to reconstruct the rock dike where stone was displaced. This maintenance project was a result of damages that occurred during Hurricane Lili in 2002. The costs associated with the engineering, design and construction of the Marsh Island Maintenance Project are as follows:

Construction (FEMA)	$267,059.11*
Construction (CWPPRA)	$ 64,092.00
E & D, construction oversight, as-builts	$ 30,262.00
TOTAL CONSTRUCTION COST:	**$361,413.11**

* This cost was reimbursed by FEMA

2008 Repair of Closure No. 8 Breach – This repair work included placing spoil material on the southern end of the rock plug from the dredging of the north-south access canal adjacent to this closure. The work was performed by Renaissance Petroleum Co. as part of their CUP application for a new oil and gas well on the east end of Marsh Island. Additional dredge material was also placed along the entire reach of the west levee of the proposed TV-21 project as well as on the northern end of Closure No. 8 towards the bay connecting to an existing rock dike. Hydraulic dredge material was also pumped behind Structure No. 7 to create marsh behind the rock dike. In addition, spoil material from the bucket dredge operation was placed on the west side of the north-south access canal to bridge a small area of marsh that connects to Structure No. 7. This work was completed in November 2008 and was performed at no cost to CWPPRA and CPRA.

2009 Maintenance Project – Antill Pipeline Construction - This maintenance project included placing 175 tons of 130# rock at Closure No. 1, 370 tons of 130# rock at Closure No. 2, 2,270 tons of 130# rock at Closure No. 4, and 570 tons of 130 # rock at Closure No. 6. Bank paving (using 30# rock) was placed at the ends of all of the closures as part of this project which was completed in February 2009. This maintenance project was a result of damages sustained from Hurricane Rita in 2005 and other required routine maintenance. The costs associated with the engineering, design and construction of the Marsh Island Maintenance Project are as follows:

Construction (FEMA)	$113,083.30
Construction (CWPPRA)	$358,041.70
E & D, construction oversight, as-builts	$ 44,627.14
Project Total	**$515,752.14**

III. Operation Activity

a. Operation Plan

There are no water control structures associated with this project, therefore no structural operation plan is required.

b. Actual Operations

There are no water control structures associated with this project, therefore no required structural operations.

IV. Monitoring Activity

As mandated in the monitoring plan, the four continuous recorders were removed at the end of 2006. Pursuant to a CWPPRA Task Force decision on August 14, 2003 to adopt the Coastwide Reference Monitoring System-*Wetlands* (CRMS-*Wetlands*) for CWPPRA, updates were made to the TV-14 Monitoring Plan to merge it with CRMS-*Wetlands* and provide more useful information for modeling efforts and future project planning while maintaining the monitoring mandates of the Breaux Act. There are no CRMS-*Wetlands* sites inside the TV-14 project area, however, there are 9 sites located on Marsh Island.

a. Monitoring Goals

The objective of the Marsh Island Hydrologic Restoration Project is to restore more natural hydrologic conditions in the project area resulting in the protection of the existing marsh.

The following goals will contribute to the evaluation of the above objective:

1. Reduce water level variability in the project area.

2. Decrease the rate of marsh loss in the project area.

3. Reduce erosion rate of the northeast shoreline of Marsh Island.

4. Increase the occurrence of submerged aquatic vegetation in Lake Sand and in shallow open water within the project area.

b. Monitoring Elements

Aerial Photography:

Near-vertical color-infrared aerial photography (1:12,000 scale) was used to measure vegetated and non-vegetated areas for the project and reference areas. The photography was obtained in 2000 prior to project construction and post-construction in years 2004, 2009 and 2016. The original photography was checked for flight accuracy, color correctness, and clarity and was subsequently archived. Aerial photography was scanned, mosaicked, and georectified by USGS/NWRC personnel according to standard operating procedures (Steyer et al. 1995, revised 2000) (Figure 2).

Percent land trends were calculated using Landsat Thematic Mapper (TM) data for 1985 – 2016. Linear regressions were calculated for the period of record. The variability in percent land data points around the slope illustrate the influence of various sources of environmental variance or classification error. Positive slopes indicate increasing percent land or historical land gain and negative slopes indicate decreasing percent land or historical land loss (Couvillion et al., 2017).

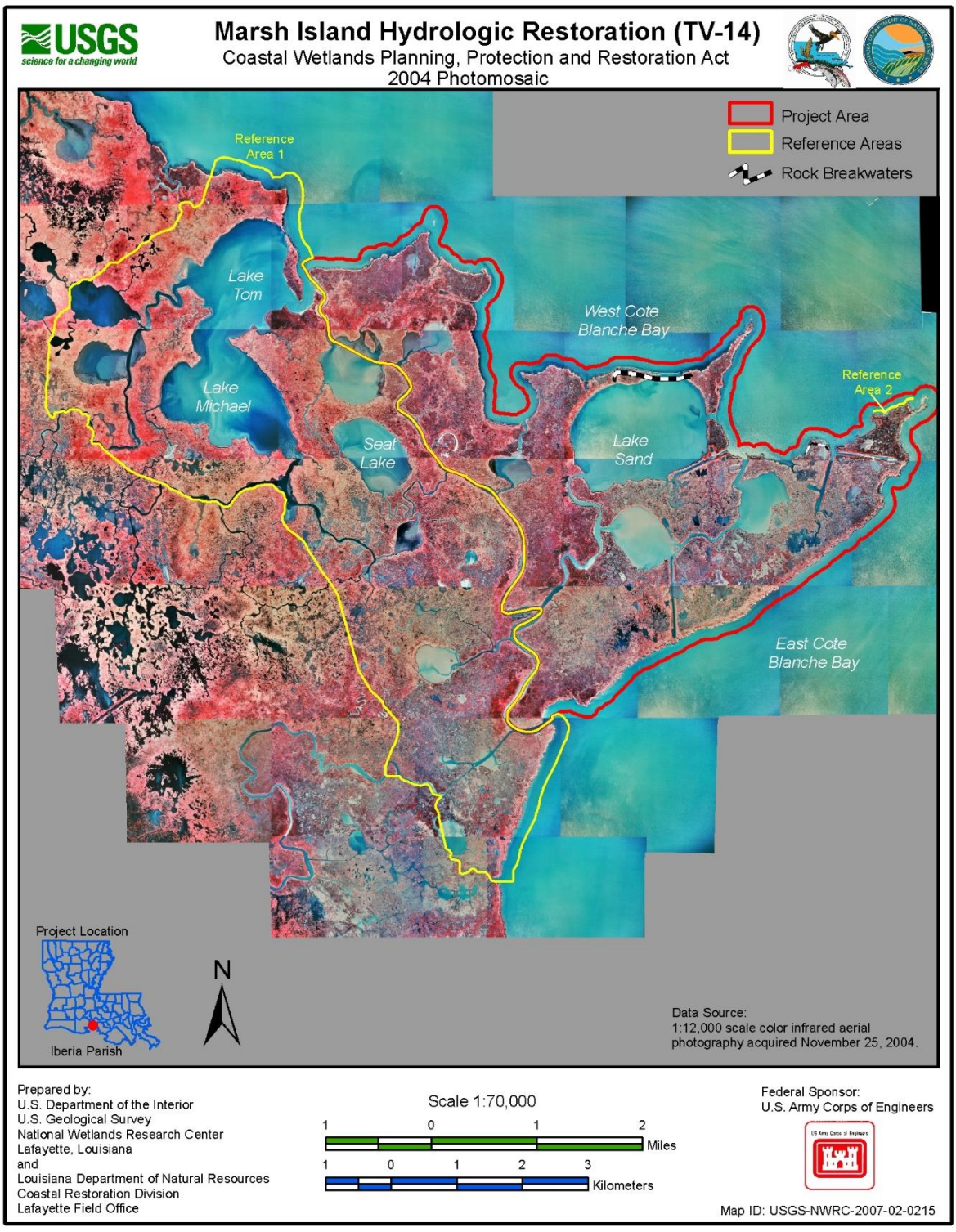

Figure 2. Photomosaic of the 2004 color-infrared aerial photography for the TV-14 project and reference areas from aerial photography taken November 25, 2004.

Shoreline Change:
To document shoreline movement along the northeast shoreline of Marsh Island, a differential GPS (DGPS) survey of unobstructed sections of shoreline was conducted at the vegetative edge of the bank to document the position of the shoreline in pre-construction year 1999 and post-construction in 2003, 2009, 2012 and 2019. A similar survey was conducted concurrently along a 2,000 ft. (609.6 m) section of reference area 2 (R2). DGPS shoreline positions were mapped.

Water Level:
Water level variability was monitored hourly at two continuous data recorders deployed in the project area and two continuous data recorders deployed in reference area 1 (R1) (Figure 3). Staff gauges adjacent to the continuous recorders were surveyed to correlate water levels NAVD88. Hourly water level data were collected at these stations for five years following project construction, from October 1999 to December 2006.

Water level is monitored hourly at station TV21CR02 within the project area and selected reference site CRMS0523, within R1. Water level data were used to document water level variability in the southern part of the TV-14 project area and the reference area.

Submerged Aquatic Vegetation (SAV):
SAV was monitored using the rake method (Chabreck and Hoffpauir 1962). Restoration of the Lake Sand shoreline is expected to influence SAV primarily in Lake Sand, while canal plugs and spoil bank repair work is expected to influence SAV primarily in other shallow open water areas. Separate tests were therefore used to evaluate SAV in Lake Sand and SAV in shallow open water areas. The frequency of occurrence of SAV in Lake Sand was compared to the frequency of occurrence of SAV in Lake Tom found in R1. Three parallel transects were established and separated by a distance approximately equal to one-fourth the pond width (Figure 3). Each transect is composed of a minimum of twenty-five equally spaced sampling stations. At each station, aquatic vegetation was sampled by dragging a garden rake on the pond bottom for one second. The presence of vegetation was recorded to determine the frequency of aquatic plant occurrence (frequency = number of occurrences/25 x 100). When vegetation was present, the species present were recorded in order to determine the frequencies of individual species (Nyman and Chabreck 1996). In shallow open water areas, three small ponds in the project area were compared to three small ponds in R1. Two parallel transects, separated by a distance approximately equal to one-third the pond width were established in each pond and investigated using similar sampling techniques as discussed above. Ancillary salinity data, collected with continuous data recorders, will be evaluated in concert with the statistical analysis to aid in the interpretation of SAV data. SAV was monitored in the fall preceding construction in 1999 and in post-construction years 2002, 2004, 2006, 2009, 2012, 2013 and 2016.

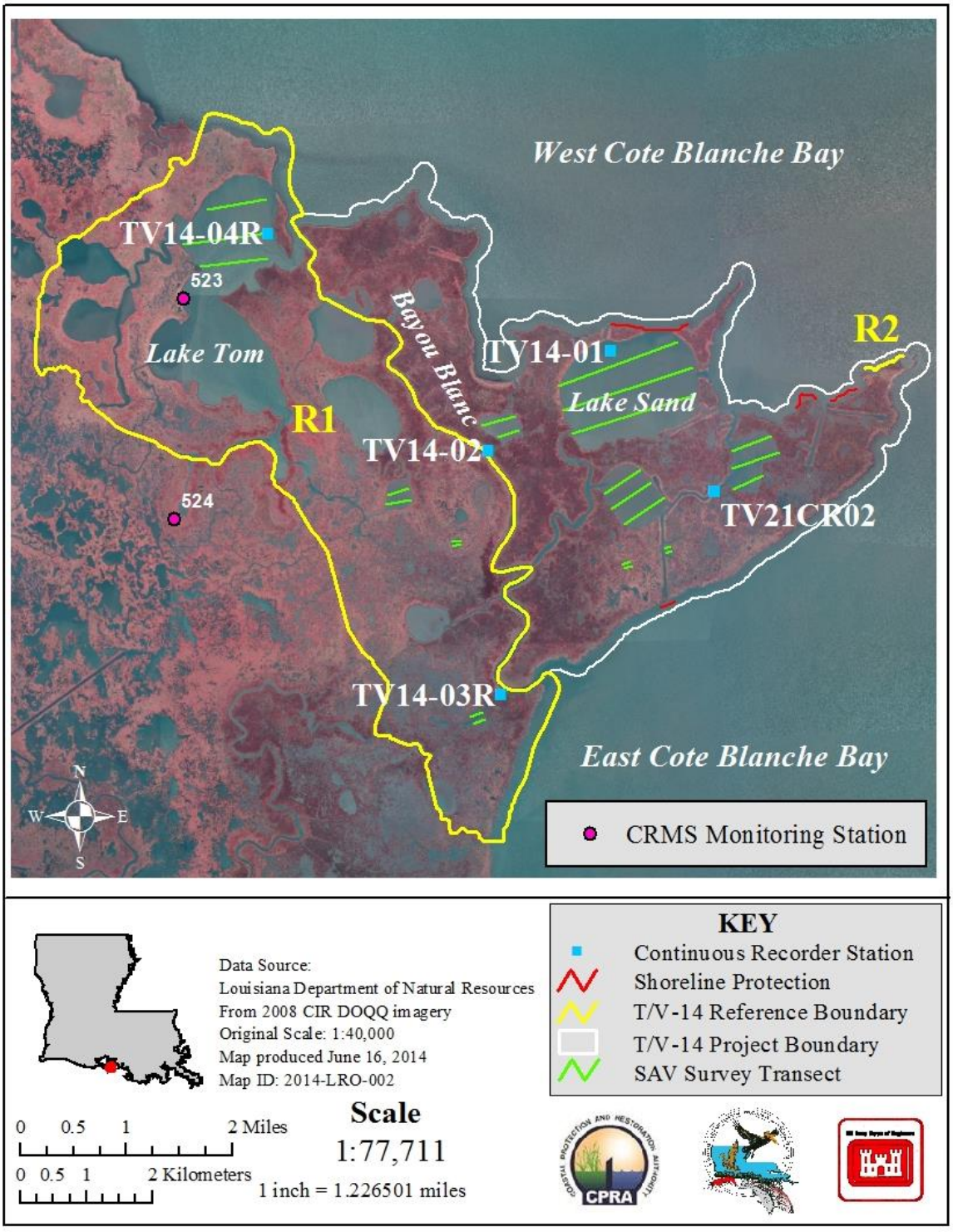

Figure 3. Continuous hydrographic monitoring stations and SAV monitoring survey transects for the TV-14 project and reference areas.

IV. Monitoring Activity (continued)

c. Monitoring Results and Discussion

Aerial Photography:

Pre-construction classification (2000) indicated 69.8% land and 30.2% water within the project area and 64.4% land and 35.6% water within R1 (Table 1, Figure 4). Post-construction classification of land area and open water, collected in November 2004, indicated 58.6% land and 41.4% water in the project area and 58.3% land and 41.7% water within R1 (Table 1, Figure 5). However, due to a correction of the project and R1 boundaries resulting in a change in acreage for both areas, the pre- and post-construction classifications are not directly comparable. The project and R1 boundaries were updated to correct inaccuracies due to the low-resolution satellite imagery used to create the boundaries during project planning. Because of the low resolution, some parts of the project and R1 were excluded. For both areas, the boundaries were expanded to include these areas as well as some open water surrounding the project area and R1. As a result, the first comparison of land and water area is being made using the 2009 data. The photography flown on December 20, 2009 indicated 56.3% land and 43.7% water within the project area and 56.2% land and 43.8% water within R1 (Figure 6). These values indicate a loss of approximately 2% land in both the project area and reference areas for the period 2004-2009 (Table 1). The 2016 photography indicated 58.1% land and 41.9% water within the project area compared with 55.5% land and 45.5% water within R1 (Figure 7). This equates to a 1.8% gain in land in the project area since the 2009 analysis compared with a -0.7% loss in the reference area. This is due in large part to the construction of the TV-21 project. Approximately 160 acres of new land were created within the TV-14 project, based on an examination of pre- and post-construction satellite land change data for TV-21 (Couvillion et al. 2017). Removing that from the 2016 land/water analysis results in 55.9% land, demonstrating the project would have had a loss of approximately 0.04% land since 2009 without the marsh creation project.

The general land trend within the project area prior to construction was negative (-0.37%/yr; 27.05 ac/yr) from 1985 to 2001 (Figure 8). Incorporating the 2001 to 2016 data, which includes the post-construction satellite imagery, shows a slightly lower loss trend compared to the pre-construction data (-0.30%/yr; 21.93 ac/yr), demonstrating the overall land change trend of the project area has improved since the construction of the project. Again this is primarily due to the construction of TV-21. If the TV-21 additional acres are excluded as above, the loss rate would be approximately -0.36%/yr, almost identical to the trend prior to construction

Table 1. Land and water area percentages and percent change for the project and R1 reference areas 2000-2009.

Date/Area	% Land	% Water	%Change Land Compared to Prior Analysis
2000 Project	69.8	30.2	N/A
2000 Reference	64.4	35.6	N/A
2004 Project	58.6	41.1	N/A
2004 Reference	58.3	41.7	N/A
2009 Project	56.3	43.7	-2.3
2009 Reference	56.2	43.8	-2.1
2016 Project	58.1	41.9	1.8
2016 Reference	55.5	44.5	-0.7

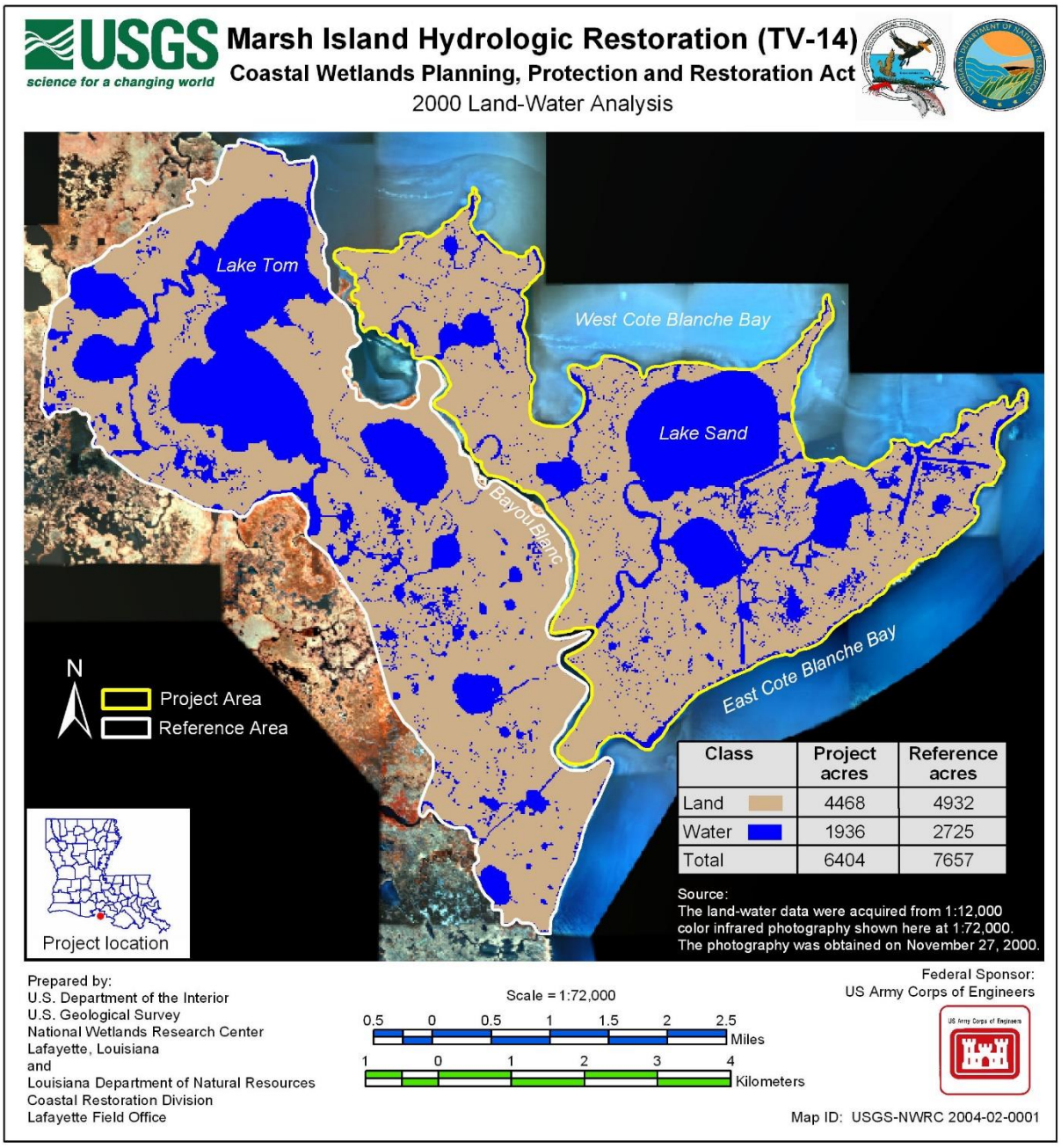

Figure 4. Results of the 2000 Land:Water GIS image classification for the TV-14 project and reference areas from aerial photography taken November 27, 2000.

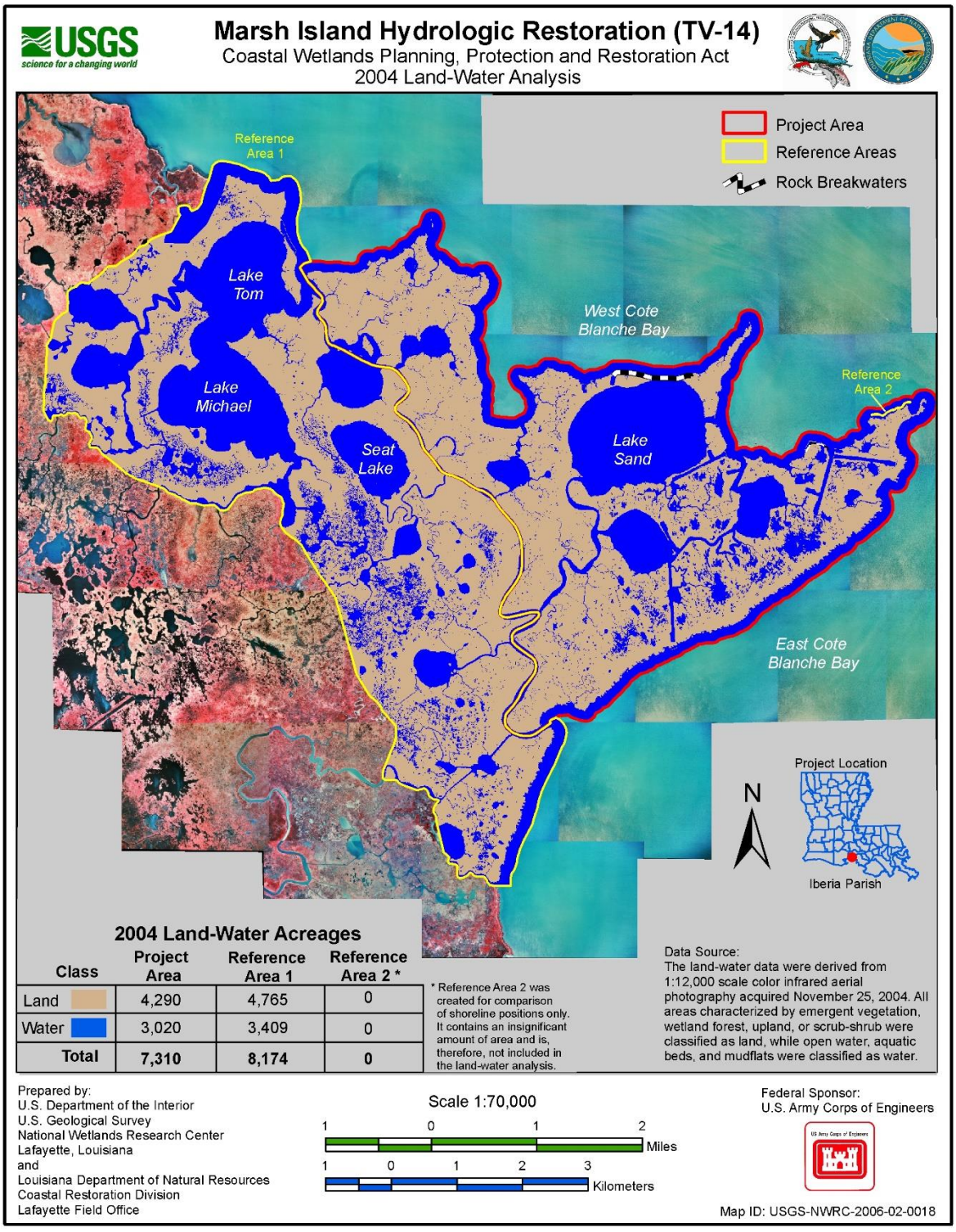

Figure 5. Results of the 2004 Land:Water GIS image classification for the TV-14 project and reference areas from aerial photography taken November 25, 2004.

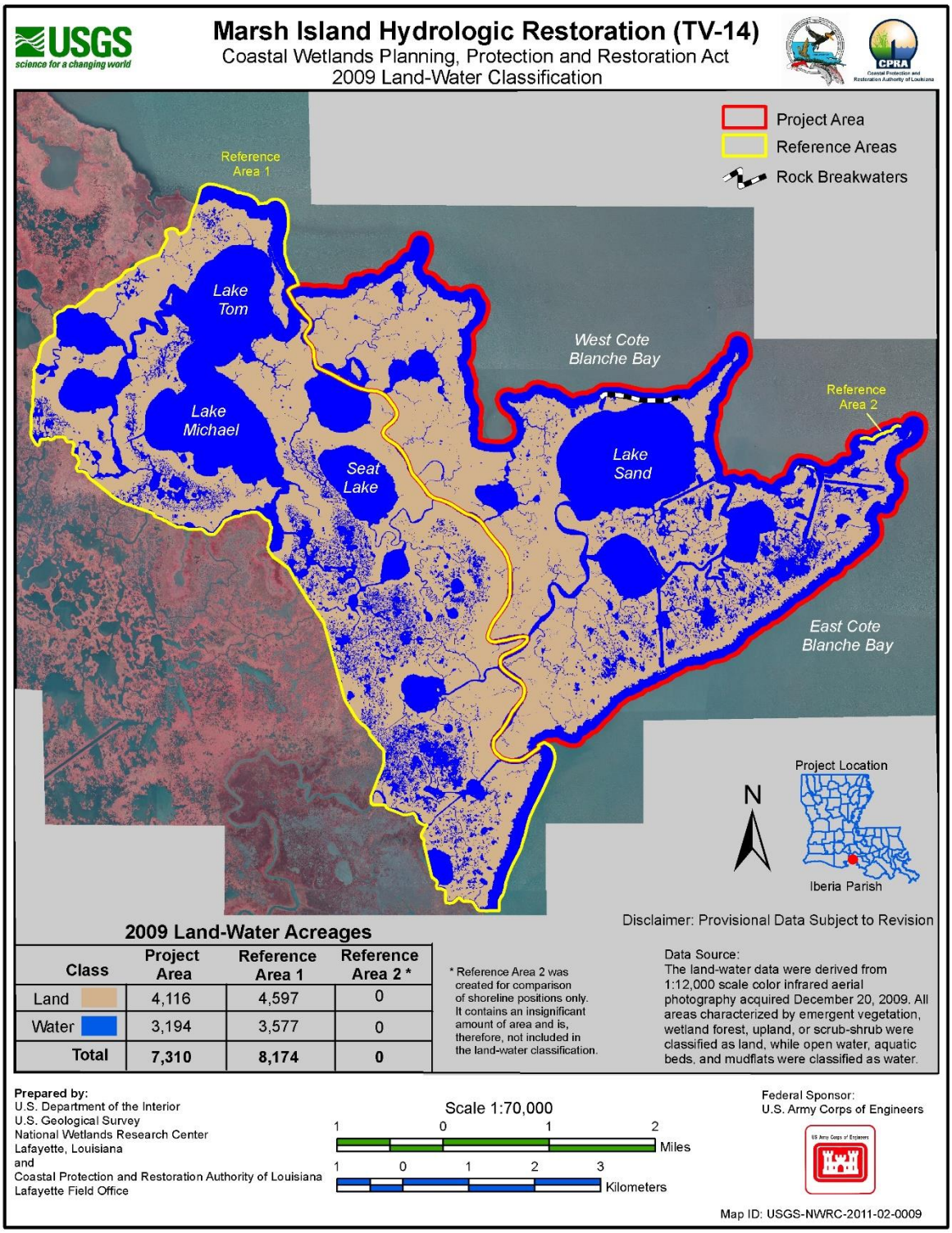

Figure 6. Results of the 2009 Land:Water GIS image classification for the TV-14 project and reference areas from aerial photography taken December 20, 2009.

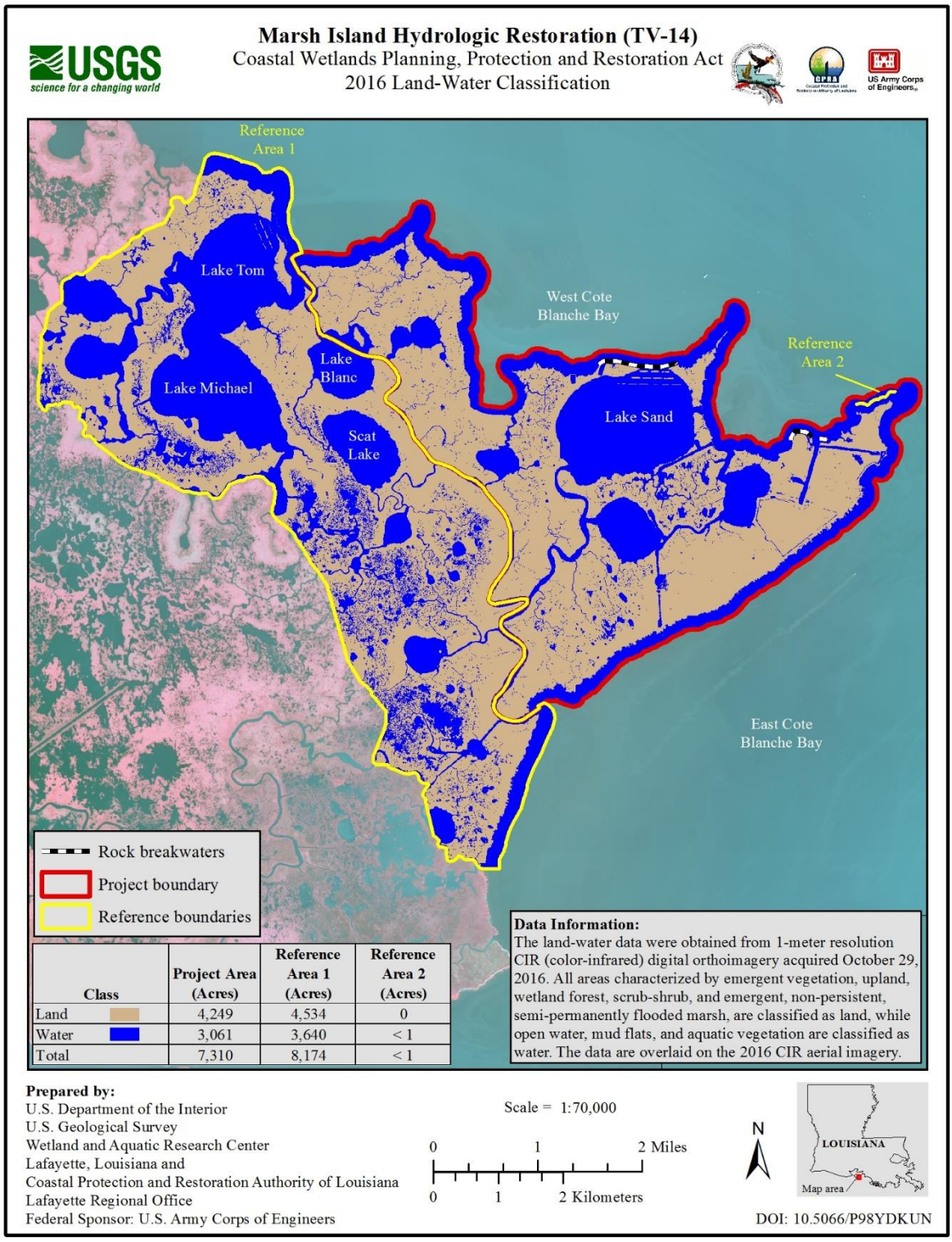

Figure 7. Results of the 2016 Land:Water GIS image classification for the TV-14 project and reference areas from aerial photography taken October 29, 2016.

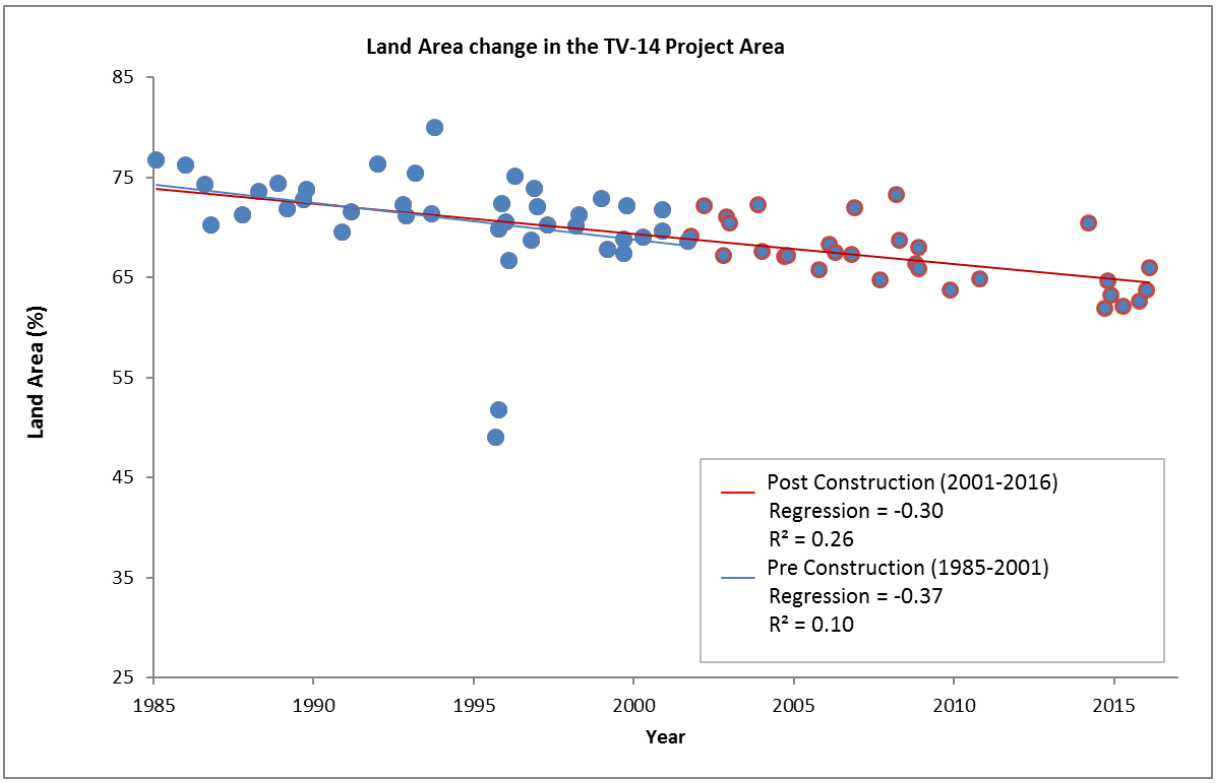

Figure 8. Project scale percent land change for TV-14. Percent land values are displayed for all cloud free TM images available from 1985-2016. The blue and red lines depict the pre- and post-construction percent land trends, respectively. Percent land calculated as percent land of total project area. See Couvillion et al. 2017.

Shoreline Position:

Comparison of the 2003 dataset to the preconstruction (1999) data indicated a gain of 1.08 m/yr in the protected section of the shoreline and a loss of -0.62 m/yr in the unprotected section. Comparing the 2009 survey (post-Hurricanes Rita and Ike) to the 2003 survey indicated a loss of -0.77 m/yr in the protected area and -3.58 m/yr in the unprotected area. The post-Hurricane recovery period (comparing 2009-2012) showed a gain of 0.99 m/yr in the protected section while the unprotected section saw a loss of -2.68 m/yr. Comparison of the most recent time period (2012-2019) resulted in a gain of 3.66 m/yr in the protected section and a loss of -5.93 m/yr in the unprotected section. Overall loss from 1999 to 2019 was -4.25 m/yr in the unprotected section, while the protected section showed a gain of 1.22 m/yr (Figure 9).

Time Period	Protected Section		Unprotected Section	
	Mean Shoreline Change (m/yr)	SE (+/-)	Mean Shoreline Change (m/yr)	SE (+/-)
1999-2003	1.08	0.54	-0.62	0.59
2003-2009	-0.77	.20	-3.58	0.37
2009-2012	0.99	0.69	-2.68	0.24
2012-2019	3.66	1.14	-5.93	0.47
1999-2019	1.22	0.51	-4.25	0.23

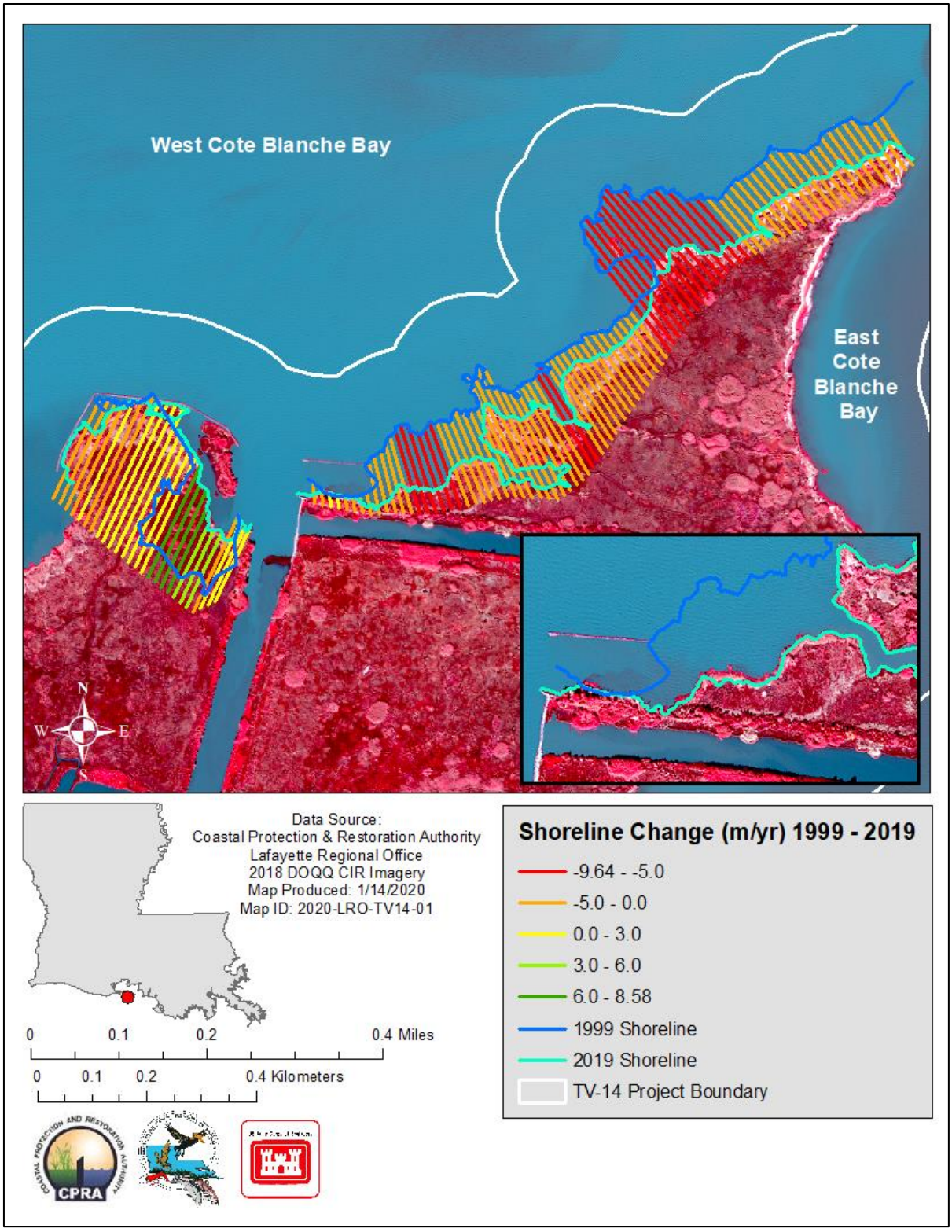

Figure 9. Marsh Island Hydrologic Restoration (TV-14) shoreline change 1999-2019.

Water Level:

Relative water level data for the pre-and post-construction time periods were analyzed from the following datasets:

Station	Data collection period
TV14-01	10/12/1999 – 12/31/2006
TV14-02*	10/12/1999 – 3/14/2002
TV14-23	3/14/2002 – 12/31/2006
TV14-03R	10/12/1999 – 12/31/2006
TV14-04R	10/12/1999 – 12/31/2006
TV21CR02	2/14/2012 – 5/16/19
CRMS0523	2/14/2012 – 5/16/19

*The continuous recorder at TV14-02 was removed because of access problems following project construction. The replacement station, TV14-23 was installed closer to Bayou Blanc, a more accessible location.

The difference in project area and R1 water level range (variability) was significantly higher post-construction than pre-construction ($p<0.0001$) (R1 had a water level range 0.16' higher than the project area post-construction and 0.06' higher preconstruction). Water level variability in the project area was found to be significantly less than that in R1, for both the pre- and post-construction periods (Figure 10). Water level variability appeared to increase following project construction in R1 and the project appears to have been successful at preventing a similar increase in the project area. It is not known what factors contributed to the increase in water level variability in R1 following project construction. However, it is not likely to be due to any effects of the project but rather variations in weather and tides. There was less variability in the project area before construction but ranges in the reference area increased relative to the project area post-construction. Thus, the project appears to have reduced water level variability as designed.

Visser (2007) determined that there was a significant decrease in flood stress based on two TV-14 project gauges in an analysis of hydrologic data on CWPPRA Hydrologic Restoration projects. Because the flooding stress was so small in the TV-14 project area, Visser determined that this was not biologically significant. Flooding stress was calculated by multiplying the stress level from flood events of different durations by the percentage of time that the stress level occurred and the percentage of plant productivity.

Water level variability at TV21CR02 was slightly higher than the reference site CRMS0523 during 2012 – 2019, indicating the project has not had an effect on variability within the southern part of the project area. This is not surprising considering the TV-21 recorder is situated within a canal that has open access to West Cote Blanche Bay, unlike the TV-14 recorders that were situated in the northern part of the project area behind the canal closures.

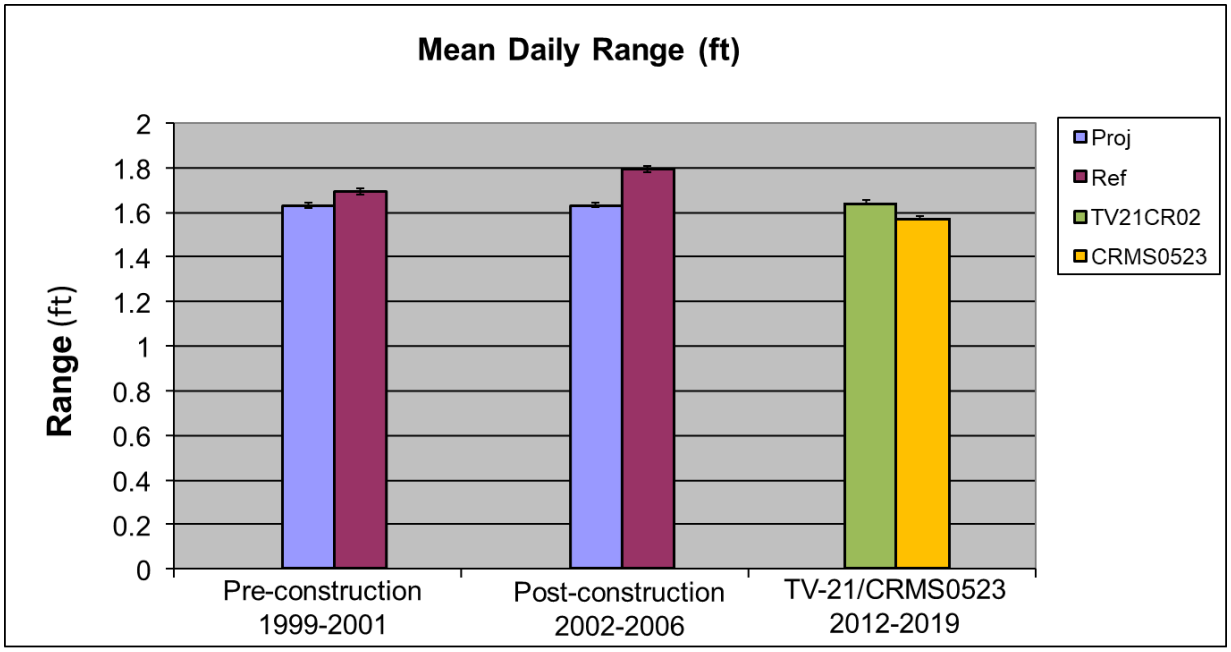

Figure 10. Mean daily water level range (variability) ± standard error during the pre- and post-construction periods for the project and R1 stations as well as the 2012-2019 monitoring period at stations TV21CR02 and reference recorder CRMS0523.

Submerged Aquatic Vegetation (SAV):

SAV was analyzed separately for large and small ponds (Lake Sand vs. Lake Tom and small ponds in the project area vs. small ponds in R1). An Analysis of Variance (ANOVA) was conducted on frequency of occurrence data for areas (project and reference), years, and interaction between the two. The results showed significantly higher SAV frequency in 2004 and 2016 ($F_{7,125} = 3.4086$, $p = 0.0023$) than other years (Figure 11). The size of ponds was the most important effect in the model with small ponds having significantly more frequent SAV than larger ones ($F_{1,125} = 6.1451$, $p = 0.0145$). There was no significant difference in SAV abundance in the project area vs the reference area. The greatest abundance of SAV was in the reference ponds in 1999, 2004, and 2016 where *Myriophyllum spicatum* dominated (Figure 12). Other species were occasionally present including *Vallisineria americana* in the large project pond in 2006 and *Potamogeton* in the large reference pond in 2009 but none were abundant. *Ceratophyllum demersum* was observed during the 2016 survey but also not in large amounts. The presence or absence of SAV appears to be directly related to variations in climate. Mean annual salinity data for the eastern side of Marsh Island, from project-specific and CRMS continuous recorders, shows a correlation between SAV abundance and annual salinity (Figure 11). Minimal SAV was observed in survey years 2006 – 2013 following the extreme weather events of Hurricanes Rita and Ike as well as the drought in 2011, which increased surface water salinities on the island. A return to normal to above average rainfall in recent years reduced salinities resulting in a significant increase in SAV during the 2016 survey.

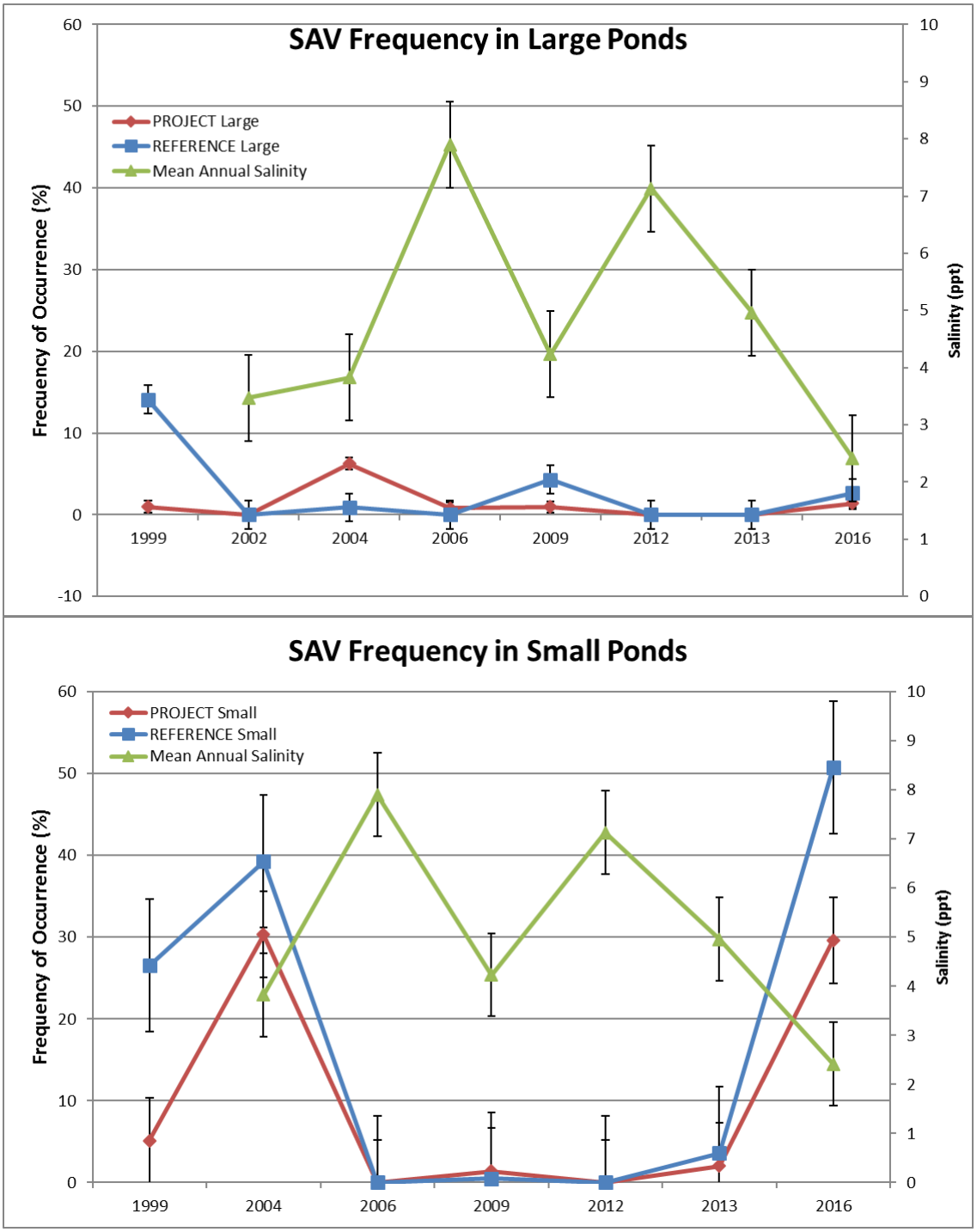

Figure 11. Submerged aquatic vegetation abundance calculated separately for small and large ponds and annual salinity for Eastern Marsh Island. Mean ± SE.

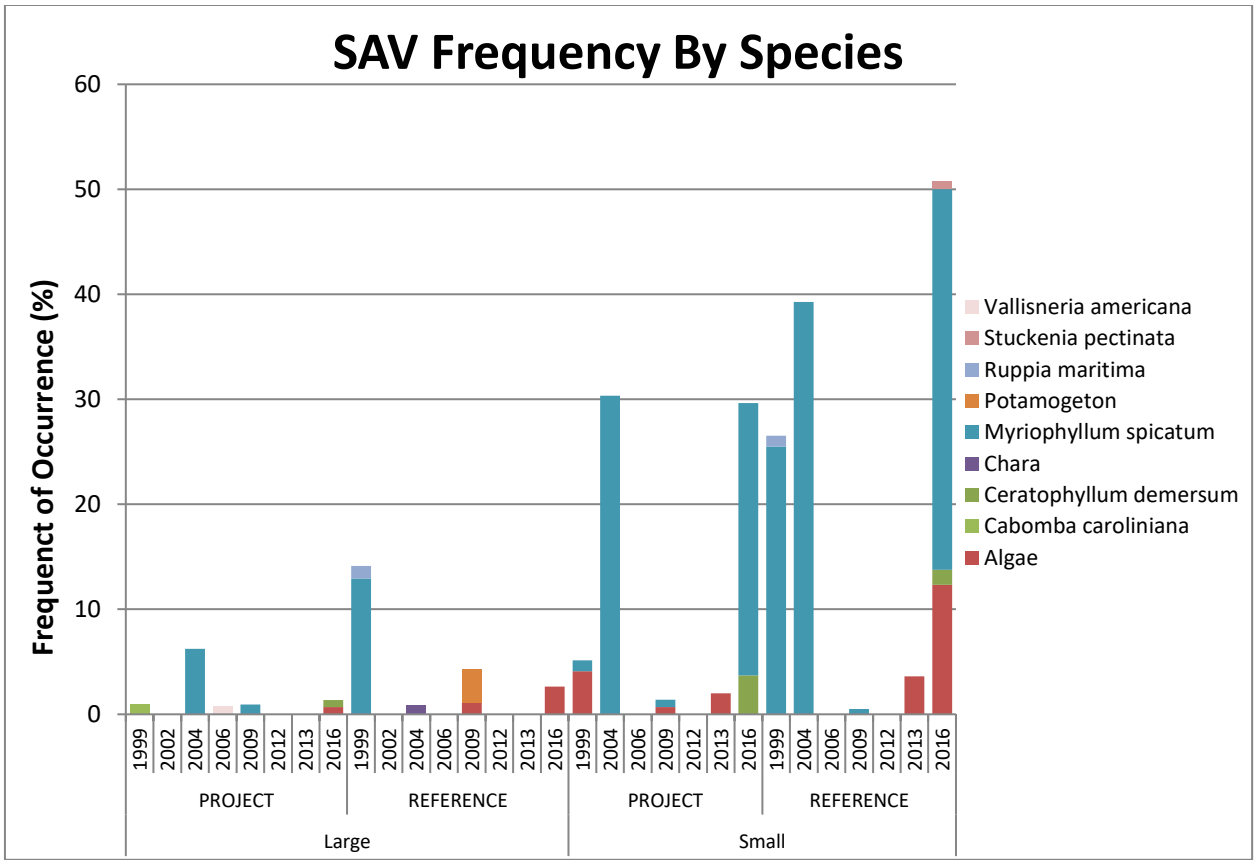

Figure 12. Submerged aquatic vegetation abundance by species for both the project and R1.

V. Conclusions

a. Project Effectiveness

The project has been effective at reducing water level variability within the northern portion of the project area as compared to an ecologically similar reference area (R1). Water level variability did not increase in the project area as it did in R1 post-construction. SAV occurrence increased within the smaller ponds of the project area in 2016, but was virtually absent in the years following Hurricanes Rita and Ike. Climate as well as pond size has had the greatest effect on SAV abundance in the TV-14 project, as SAV decreased in high salinity years and has been virtually absent in Lake Sand through all surveys.

The goal to reduce the erosion rate of the northeast shoreline was partially met. In areas that received protection from a rock dike, erosion rates were much lower than those that were unprotected. The protected areas showed erosion during Hurricanes Rita and Ike, but have been prograding since, particularly on the western side of the project area where a large open water area is filling in. However, as the protected areas showed the highest rates of progradation on the most recent shoreline survey, the unprotected areas showed the highest rates of erosion since project construction.

The goal to decrease the rate of marsh loss in the project area was met due to the construction of the TV-21 East Marsh Island Marsh Creation Project. Land to water analysis showed a slight increase in percent land in the project area from 2009 to 2016, while the reference area R1 showed a slight decrease. The percent land change analysis also showed a reduction in the loss rate for the project area since construction. Without the addition of the TV-21 project, the loss rate would likely be similar to the rate pre-construction.

b. Recommended Improvements

Overall, the Marsh Island Hydrologic Restoration Project is in good condition with most features still functioning as designed after repair. However, as noted above, there are a few areas of concern that if left unattended, could lead to more serious problems occurring. CPRA and the USACE do not intend to pursue maintenance prior to project end of life due to limited funding and the willingness of the CWPPRA program to award further funding to support the proposed maintenance.

c. Lessons Learned

The steel sheet pile, rock riprap wingwalls, and stone bank paving installed at each end of Closure No. 5 after Hurricane Lili proved to be successful in preventing erosion during the Hurricane Rita storm surge event. This application will be applied to other closure sites for bank stabilization and protection.

d. End of Project Life

The construction of the TV-14 structures has effectively reduced water level variability in the northern part of the project area. This reduction in variability combined with the construction of the TV-21 project has reduced the land loss rate in the project area since construction. However, erosion continues unabated on unprotected shoreline reaches. Little remains of the separation between Lake Sand and West Cote Blanche Bay as breaks have formed in the landbridge on the eastern shore of Lake Sand. Without this separation, the project will no longer be effective at reducing variability and without future action will exacerbate future land loss. Therefore, continued upkeep of the project features as well as additional shoreline protection are critical to the long term stability of the project area land mass.

VI. Literature Cited

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APPENDIX A
(Inspection Photographs)

Photo No. 1, Closure No. 1

Photo No. 2, Closure No. 2

Photo No. 3, Closure No. 3

Photo No. 4, Closure No. 4

Photo No. 5, Closure No. 5, Southern End

Photo No. 6, Closure No. 5, Northern End

Photo No. 7, Closure No. 6

Photo No. 8, Closure No. 6, Southern End

Photo No. 9, Closure No. 7

Photo No. 10, Closure No. 8

Photo No. 11, Closure No. 9

APPENDIX B
(Three Year Budget Projection)

MARSH ISLAND/ TV-14 / PPL 6

Three-Year Operations & Maintenance Budgets 07/01/2019 - 06/30/2022

Project Manager	O & M Manager	Federal Sponsor	Prepared By
Dion Broussard, P.E.	*Dion Broussard, P.E.*	*COE*	*Dion Broussard, P.E.*

	2019/2020 (-18)	2020/2021 (-19)	2021/2022 (-20)
Maintenance Inspection	$ -	$ -	$ -
Structure Operation			
State Administration	$ 12,432.00	$ 14,367.00	$ 16,420.00
Federal Administration	$ -		$ -
Maintenance/Rehabilitation			

14/15 Description:

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

15/16 Description :

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

16/17 Description:

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

	2019/2020 (-18)	2020/2021 (-19)	2021/2022 (-20)
Total O&M Budgets	**$ 12,432.00**	**$ 14,367.00**	**$ 16,420.00**

O &M Budget (3 yr Total)	**$ 43,219.00**
Unexpended O & M Budget	**$ 200,000.00**
Remaining O & M Budget (Projected)	**$ 156,781.00**

APPENDIX C
(Field Inspection Notes)

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name:TV-14 Marsh Island Hydrologic Restoration — Date of Inspection: May 16, 2017 Time: 11:00 AM

Structure No. 1 — Inspector(s): Dion Broussard, Darrell Pontiff, Mark Mouledous (CPRA)
Tyson Crouch (LDWF)
Structure Description: Rock Plug — Scott Wandell (USACE)

Type of Inspection: Annual — Water Level Inside:_____ Outside: _____
Weather Conditions: Clear and Warm

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	N/A				
Stop Logs	N/A				
Hardware	N/A				
Timber Piles	N/A				
Timber Wales	N/A				
Galv. Pile Caps	N/A				
Cables	N/A				
Signage /Supports	N/A				
Rip Rap (fill)	Good			1	The site is in good condition.
Earthen Embankment	N/A				

What are the conditions of the existing levees?	
Are there any noticeable breaches?	
Settlement of rock plugs and rock weirs?	
Position of stoplogs at the time of the inspection?	
Are there any signs of vandalism?	

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name:TV-14 Marsh Island Hydrologic Restoration

Date of Inspection: May 16, 2017 Time: 12:15 PM

Structure No. 2

Inspector(s): Dion Broussard, Darrell Pontiff, Mark Mouledous (CPRA)
Tyson Crouch (LDWF)
Scott Wandell (USACE)

Structure Description: Rock Plug

Type of Inspection: Annual

Water Level Inside:_____ Outside: _____

Weather Conditions: Clear and Warm

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	N/A				
Stop Logs	N/A				
Hardware	N/A				
Timber Piles	N/A				
Timber Wales	N/A				
Galv. Pile Caps	N/A				
Cables	N/A				
Signage /Supports	N/A				
Rip Rap (fill)	Good			2	The site is in good condition.
Earthen Embankment	N/A				

What are the conditions of the existing levees?	
Are there any noticeable breaches?	
Settlement of rock plugs and rock weirs?	
Position of stoplogs at the time of the inspection?	
Are there any signs of vandalism?	

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: TV-14 Marsh Island Hydrologic Restoration

Date of Inspection: May 16, 2017 Time: 12:15 PM

Structure No. 3

Inspector(s): Dion Broussard, Darrell Pontiff, Mark Mouledous (CPRA)
Tyson Crouch (LDWF)
Scott Wandell (USACE)

Structure Description: Rock Plug

Type of Inspection: Annual

Water Level Inside:_____ Outside: _____

Weather Conditions: Clear and Warm

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	N/A				
Stop Logs	N/A				
Hardware	N/A				
Timber Piles	N/A				
Timber Wales	N/A				
Galv. Pile Caps	N/A				
Cables	N/A				
Signage /Supports	N/A				
Rip Rap (fill)	Good			3	This site is in good condition.
Earthen Embankment	N/A				

What are the conditions of the existing levees?	
Are there any noticeable breaches?	
Settlement of rock plugs and rock weirs?	
Position of stoplogs at the time of the inspection?	
Are there any signs of vandalism?	

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name:TV-14 Marsh Island Hydrologic Restoration — Date of Inspection: May 16, 2017 Time: 12:15 PM

Structure No. 4 — Inspector(s): Dion Broussard, Darrell Pontiff, Mark Mouledous (CPRA)
Tyson Crouch (LDWF)
Structure Description: Rock Plug — Scott Wandell (USACE)

Type of Inspection: Annual — Water Level Inside:_____ Outside: _____
Weather Conditions: Clear and Warm

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	N/A				
Stop Logs	N/A				
Hardware	N/A				
Timber Piles	N/A				
Timber Wales	N/A				
Galv. Pile Caps	N/A				
Cables	N/A				
Signage /Supports	N/A				
Rip Rap (fill)	Good			4	This site is in good condition.
Earthen Embankment	N/A				

What are the conditions of the existing levees?	
Are there any noticeable breaches?	
Settlement of rock plugs and rock weirs?	
Position of stoplogs at the time of the inspection?	
Are there any signs of vandalism?	

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name:TV-14 Marsh Island Hydrologic Restoration — Date of Inspection: June 19, 2014 Time: 11:15 AM

Structure No. 5 — Inspector(s): Darrell Pontiff, Dion Broussard, Mark Mouledous (CPRA)
Tyson Crouch, Cassidy Lejeune (LDWF)
(USACE) Not present

Structure Description: Steel Sheet Pile with Rip Rap

Type of Inspection: Annual — Water Level Inside:_____ Outside: _____
Weather Conditions: Clear and Warm

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
				5	Good
Steel Bulkhead / Caps	Good				
Steel Grating	N/A				
Stop Logs	N/A				
Hardware	N/A				
Timber Piles	N/A				
Timber Wales	N/A				
Galv. Pile Caps	N/A				
Cables	N/A				
Signage /Supports	N/A				
Rip Rap (fill)	Good			5 & 6	Water migrating around structure on both ends.
Earthen Embankment	N/A				

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name:TV-14 Marsh Island Hydrologic Restoration

Date of Inspection: May 16, 2017 Time: 12:00 PM

Structure No. 6

Inspector(s): Dion Broussard, Darrell Pontiff, Mark Mouledous (CPRA)
Tyson Crouch (LDWF)
Scott Wandell (USACE)

Structure Description: Rock Plug

Type of Inspection: Annual

Water Level Inside:_____ Outside: _____

Weather Conditions: Clear and Warm

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	N/A				
Stop Logs	N/A				
Hardware	N/A				
Timber Piles	N/A				
Timber Wales	N/A				
Galv. Pile Caps	N/A				
Cables	N/A				
Signage /Supports	N/A				
Rock Dike	Good			7 & 8	Water migrating around southern end of structure.
Earthen Embankment	N/A				

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name:TV-14 Marsh Island Hydrologic Restoration

Date of Inspection: May 16, 2017 Time: 11:45 AM

Structure No. 7

Inspector(s): Dion Broussard, Darrell Pontiff, Mark Mouledous (CPRA)
Tyson Crouch (LDWF)
Scott Wandell (USACE)

Structure Description: Rock Dike

Type of Inspection: Annual

Water Level Inside:_____ Outside: _____

Weather Conditions: Clear and Warm

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	N/A				
Stop Logs	N/A				
Hardware	N/A				
Timber Piles	N/A				
Timber Wales	N/A				
Galv. Pile Caps	N/A				
Cables	N/A				
Signage /Supports	N/A				
Rock Dike	Good			9	The site is in good condition.
Earthen Embankment	N/A				

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name:TV-14 Marsh Island Hydrologic Restoration — Date of Inspection: May 16, 2017 Time: 11:45 AM

Structure No. 8 — Inspector(s): Dion Broussard, Darrell Pontiff, Mark Mouledous (CPRA)
Tyson Crouch (LDWF)
Structure Description: Rock Plug — Scott Wandell (USACE)

Type of Inspection: Annual — Water Level Inside:_____ Outside: _____
Weather Conditions: Clear and Warm

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	N/A				
Stop Logs	N/A				
Hardware	N/A				
Timber Piles	N/A				
Timber Wales	N/A				
Galv. Pile Caps	N/A				
Cables	N/A				
Signage /Supports	N/A				
Rock Plug	Good			10	Breach on southern end of closure was repaired in conjunction with TV-21 maintenance event. Some settlement of canal plug.
Earthen Embankment	N/A				

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: TV-14 Marsh Island Hydrologic Restoration

Date of Inspection: May 16, 2017 Time: 11:00 AM

Structure No. 9

Inspector(s): Dion Broussard, Darrell Pontiff, Mark Mouledous (CPRA)
Tyson Crouch (LDWF)
Scott Wandell (USACE)

Structure Description: Rock Plug

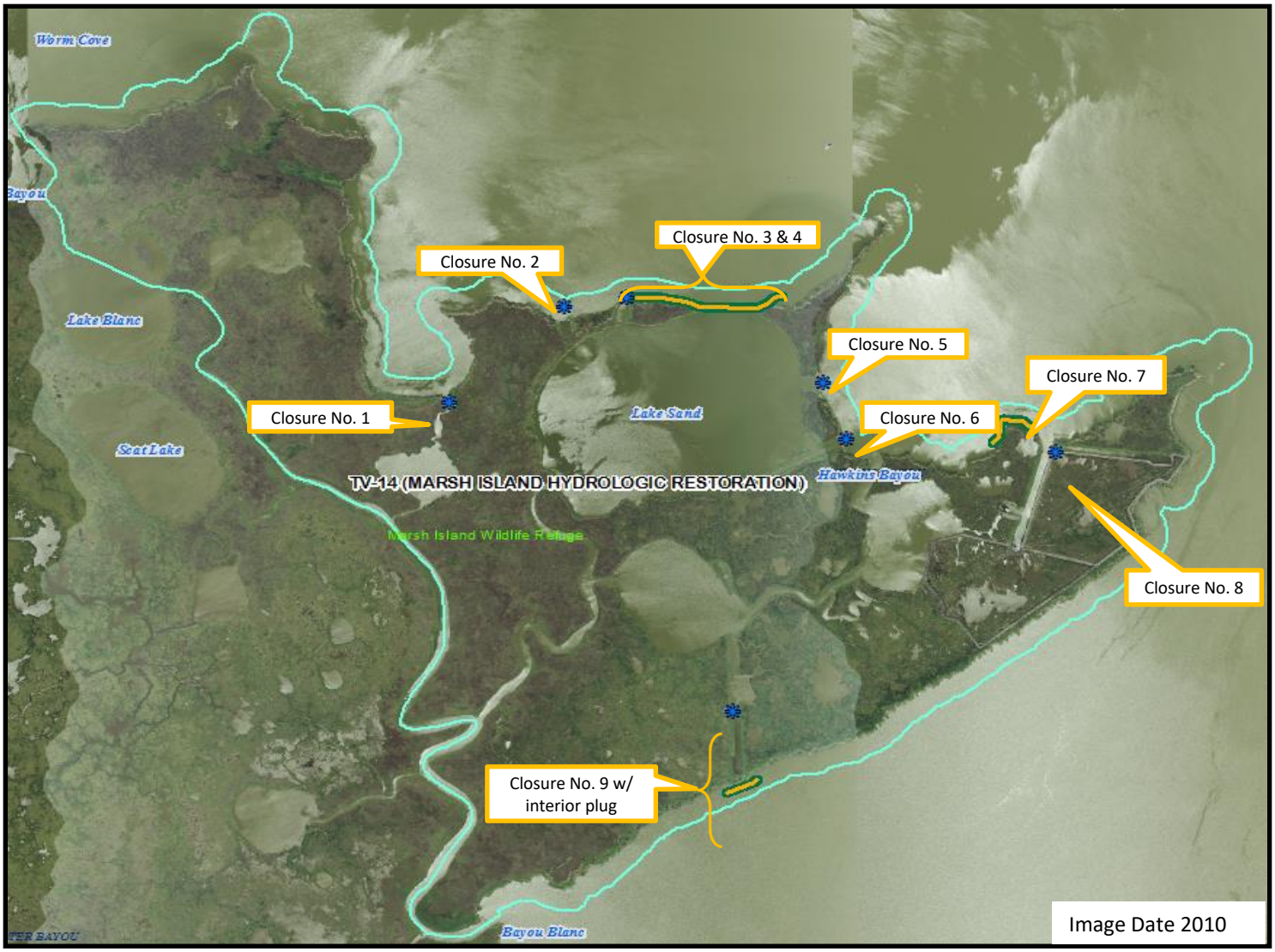
Type of Inspection: Annual

Water Level Inside:_____ Outside: _____

Weather Conditions: Clear and Warm

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	N/A				
Stop Logs	N/A				
Hardware	N/A				
Timber Piles	N/A				
Timber Wales	N/A				
Galv. Pile Caps	N/A				
Cables	N/A				
Signage /Supports	N/A				
Rock Dike	Fair			11	Dike is settling in some areas. Breach is closed and shoreline looks good since the TV-21 project.
Earthen Embankment	N/A				

What are the conditions of the existing levees?
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism?



TV-14 Marsh Island Hydrologic Restoration

Project Completion Date December 2001