State of Louisiana

Coastal Protection and Restoration Authority (CPRA)

2014 Operations, Maintenance, and Monitoring Report

for

Boston Canal/Vermilion Bay Shoreline Stabilization Project (TV-09)

State Project Number TV-09
Priority Project List 2

June 2014
Vermilion Parish

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Suggested Citation:

Wood, B. and Guidry, M. 2014. *2014 Operations, Maintenance, and Monitoring Report for Boston Canal/Vermilion Bay Shoreline Stabilization (TV-09),* Coastal Protection and Restoration Authority of Louisiana, Lafayette, Louisiana 40pp and Appendices.

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For
Boston Canal/Vermilion Shoreline Stabilization (TV-09)

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Preface

The 2014 OM&M Report format combines the Operations and Maintenance annual project inspection information with the Monitoring data and analyses for the project. This report includes monitoring data collected through December 2013 and annual Maintenance Inspections through June 2014.

The 2014 report is the 4th report in a series of OM&M reports. For additional information on lessons learned, recommendations and project effectiveness please refer to the 2004, 2005, and 2009 Operations, Maintenance, and Monitoring Reports, annual O&M inspection reports (2005-2013), progress reports (four early monitoring reports, 1995-1999), and comprehensive monitoring reports (2000 and 2005) on the CPRA web site (http://lacoast.gov/new/Projects/Info.aspx?num=TV-09).

I. Introduction

The Boston Canal/Vermilion Bay Shoreline Stabilization project (TV-09) is sponsored by the Natural Resources Conservation Service and was on the CWPPRA Priority Project List 2. TV-09 is located in the Teche-Vermilion Basin, approximately 15 miles southeast of the city of Abbeville, Louisiana on the north shore of Vermilion Bay in Vermilion Parish. Wave induced shoreline erosion is a considerable cause of land loss in the TV-09 project area and much of coastal Louisiana (Kindinger et al. 2013). The 13 miles of vegetative plantings and approximately 1,405 linear feet of foreshore rock dike at the confluence of Vermilion Bay and Boston canal are project features designed to provide protection to ecologically important interior marshes (Figure 1). The project area consists of approximately 193 acres (78.1 ha) of intermediate to brackish marsh and open water. The project boundaries extend from Mud Point on the western end to Oaks Canal on the eastern end. The northern boundary is interior marsh and the southern boundary is the waters of Vermilion Bay. *Spartina patens* (saltmeadow cordgrass), *Sagittaria lancifolia* (bull tongue), and *Schoenoplectus americanus* (Chairmaker's bulrush) together make up a majority of the back shore marsh platform vegetation. *Phragmites australis* (common reed), *Spartina alterniflora* (smooth cordgrass), and to a lesser extent *Spartina cynosuroides* (big cordgrass) make up the shoreline which typically has an elevation gradient from subtidal to supratidal averaging two to three feet above the interior marsh platform at its apex. The interior open water areas contain minimal submerged and floating aquatics which are confined to narrow bands along the pond edges due to the tidal influence.

Several historic estimates of shoreline erosion in and around the project area have been developed by external sources to better understand the temporal nature of land loss. These historic rates also allow for general comparisons to the project specific rates measured in TV-09 project area monitoring. The shoreline retreat from 1948 to 1972 for Vermilion Bay (Mud Point to Lake Cleodis) as determined by the Louisiana Department of Transportation and Development was -0.8 m/yr (-2.6 ft/yr) (Adams et al. 1978). Shoreline change in Vermilion Bay near the vicinity of Four Mile Canal calculated by USGS in 2003 was -0.9 m/yr (-2.9

ft/yr) (USGS 2003). The Barrier Island Comprehensive Monitoring Program (Martinez et al 2009a; Martinez et al 2009b) short term shoreline change rates for 1996 through 2005 indicates a loss of -0.7 m/yr (-2.3 ft/yr) along the shoreline of the Boston Canal/Vermilion bay in the Vermilion Beach reach (Figure 3). The easternmost part of the shoreline east of Boston Canal near the Avery Island reach had an estimated erosion rate of -2.3 m/yr (-7.6 ft/yr). The 2004-2005 BICM near term rates greatly overstate the actual amount of shoreline progradation and retreat in the project area and coastwide, but the general trend of the western project area remaining stable and the eastern project area retreating is reasonable. However the longer term BICM measurements for the Vermilion beach shoreline reach are more in keeping with other external data sets (Table 1). To address these historic shoreline erosion rates and protect back marsh habitat and infrastructure a combination of foreshore vegetative plantings and rock dikes were constructed and completed in 1995. The foreshore rock dikes where confined to the confluence of Boston Canal and Vermilion Bay at approximately 0.3 miles with the remaining 13 miles consisting of a double or triple hedgerow of *Spartina alterniflora* plantings on five foot centers.

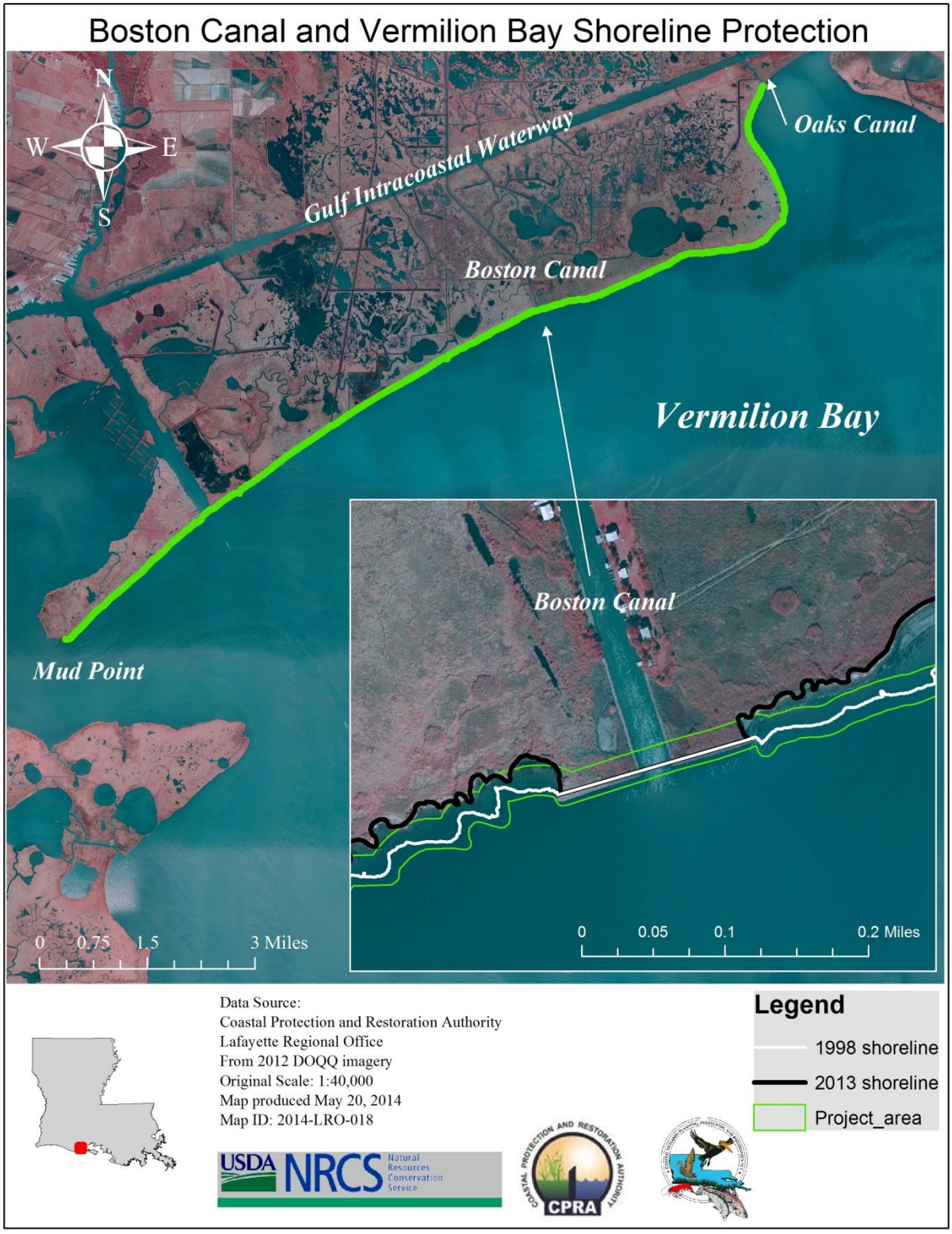


Figure 1. Boston Canal/Vermilion Bay Shoreline Stabilization (TV-09) project area with the 1998 and 2013 shorelines.

Table 1. Current and historic shoreline change rates in and around the TV-09 project area.

Time Frame	Years	Source	Change Rate (ft/y)	Change Rate (m/y)	Notes
1800's-2005	~200	BICM	-5.5	-1.6	Historical map and aerial measurement
1920-2005	~85	BICM	-5.8	-1.7	Long term aerial imagery measurement
1948-1972	24	DOTD	-2.6	-0.8	Long term aerial imagery measurement
1995-1998	3	DNR	-5.2	-1.6	Short term DGPS measurement
1996-2005	9	BICM	-2.3	-0.7	Short term aerial imagery measurement
2002-2003	1	USGS	-2.9	-0.9	Near term aerial imagery measurement
1998-2013	15	CPRA	-3.6	-1.1	Short term DGPS measurement

These project features were designed to stabilize the Boston Canal and Vermilion Bay shorelines to prevent further regression of the shoreline into the adjacent marshes. Vegetation was planted along approximately 13.25 mi (21.3 km) of the Vermilion Bay north shoreline bounded on the west by Mud Point and on the east by Oaks Canal. The transplants, 34,090 trade-gallon pots of *Spartina alterniflora* (smooth cordgrass), were planted parallel to the shoreline on five-foot centers in two rows west of Boston Canal and in three rows east of Boston Canal. Planting was completed in September 1995. The planting area was divided into four land types, based on the preexisting topography of the shoreline (Figure 2). Where the different land types where recognized as potentially affecting the percent cover and overall survivorship of the transplants.

The rock dikes were constructed foreshore of and parallel to the banks of Boston Canal, extending into Vermilion Bay and then turning 90^{o} to re-establish the bay shoreline. The structures are designed to prevent the edges of the banks at the mouth of the Boston Canal from widening into the adjacent marshes (Figure 4). Sediment fences were installed behind each rock dike to trap sediments during times of overwash. The majority of the water area behind the rock dike was unvegetated and relatively deep at the time of construction. It was assumed that these areas would vegetate slowly over the life of the project.

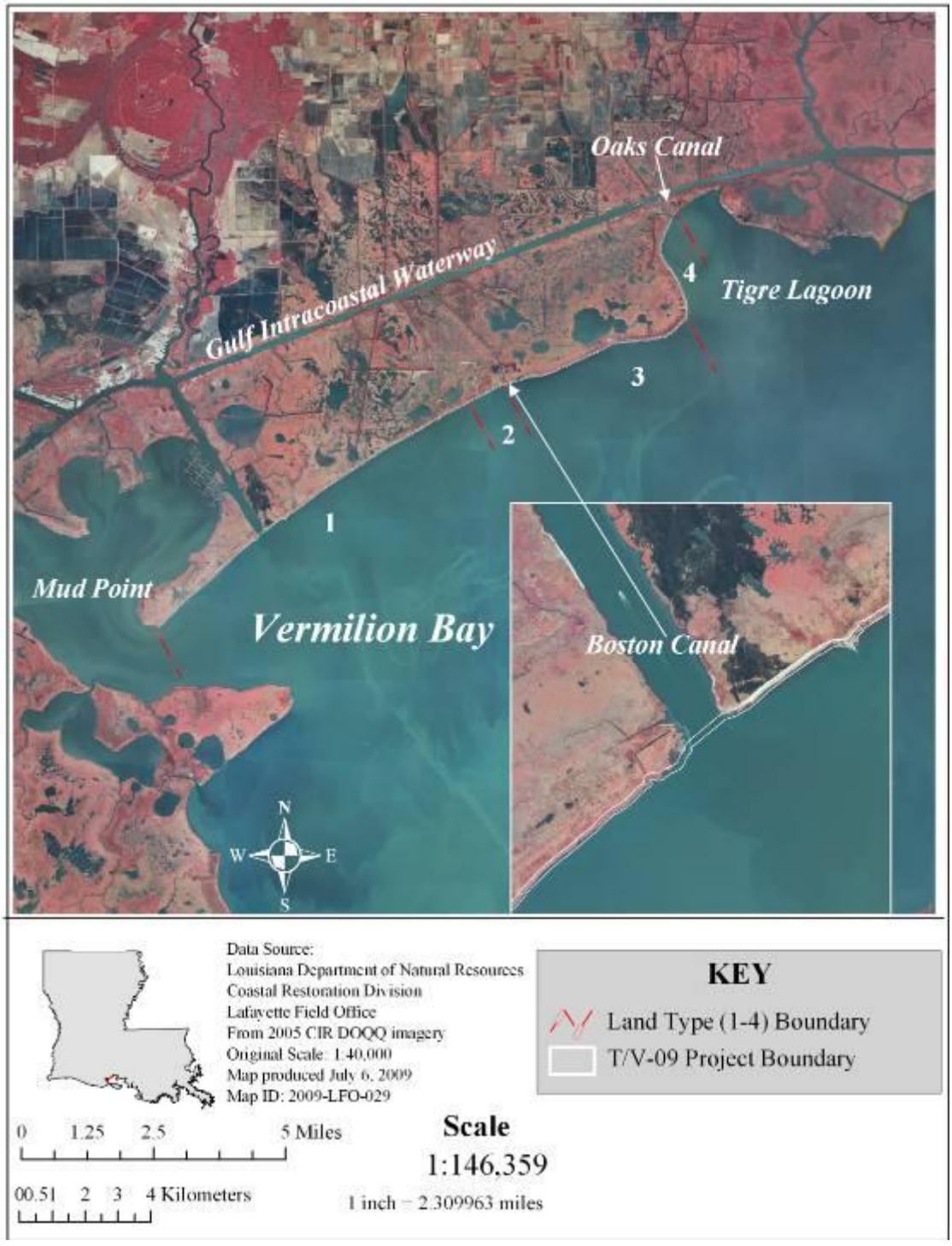
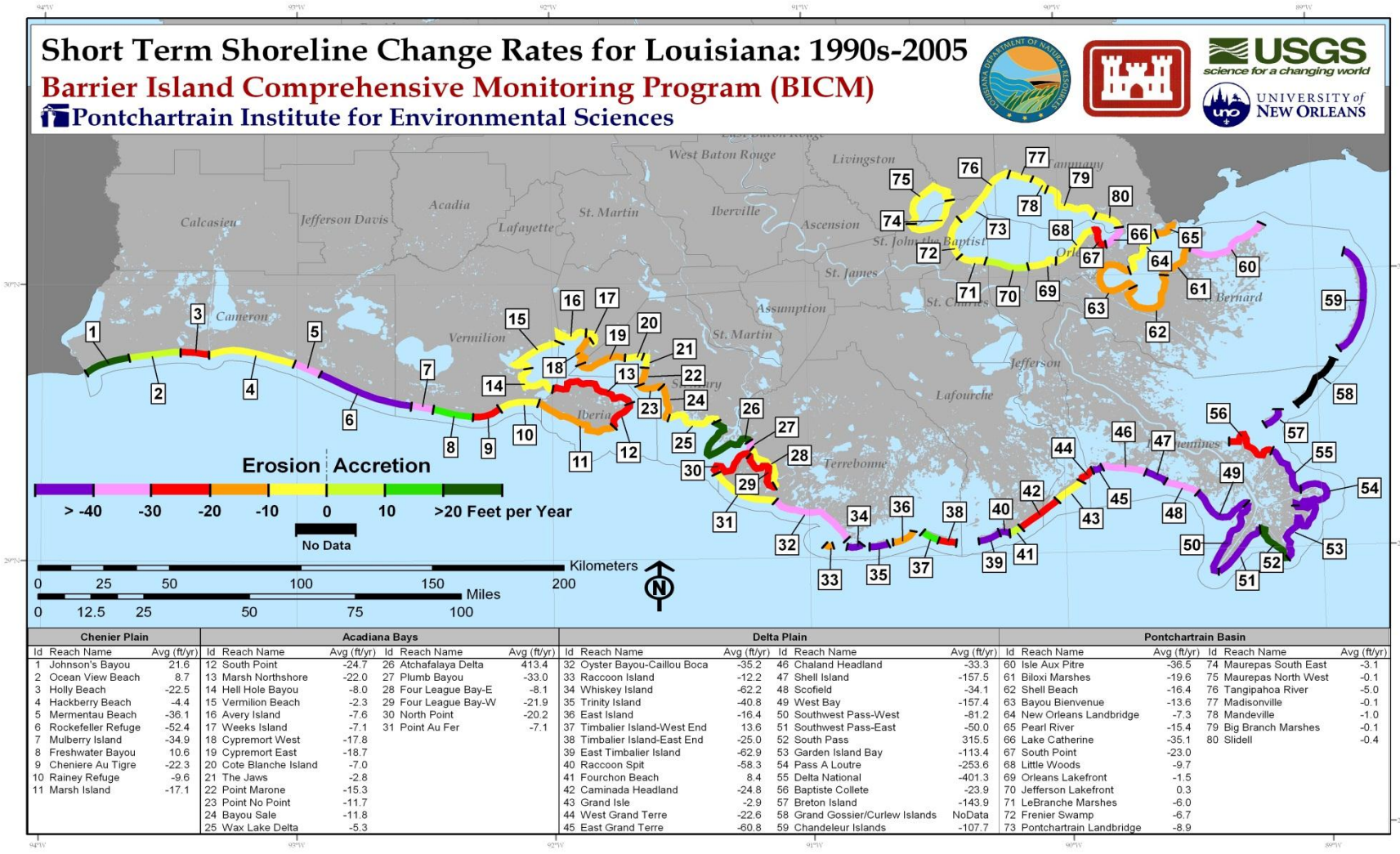


Figure 2. Boston Canal/Vermilion Bay Shoreline Stabilization (TV-09) project area and planting land type boundaries.



Chenier Plain			Acadiana Bays					
Id	Reach Name	Avg (ft/yr)	Id	Reach Name	Avg (ft/yr)	Id	Reach Name	Avg (ft/yr)
1	Johnson's Bayou	21.6	12	South Point	-24.7	26	Atchafalaya Delta	413.4
2	Ocean View Beach	8.7	13	Marsh Northshore	-22.0	27	Plumb Bayou	-33.0
3	Holly Beach	-22.5	14	Hell Hole Bayou	-8.0	28	Four League Bay-E	-8.1
4	Hackberry Beach	-4.4	15	Vermilion Beach	-2.3	29	Four League Bay-W	-21.9
5	Mermentau Beach	-36.1	16	Avery Island	-7.6	30	North Point	-20.2
6	Rockefeller Refuge	-52.4	17	Weeks Island	-7.1	31	Point Au Fer	-7.1
7	Mulberry Island	-34.9	18	Cypremort West	-17.8			
8	Freshwater Bayou	10.6	19	Cypremort East	-18.7			
9	Cheniere Au Tigre	-22.3	20	Cote Blanche Island	-7.0			
10	Rainey Refuge	-9.6	21	The Jaws	-2.8			
11	Marsh Island	-17.1	22	Point Marone	-15.3			
			23	Point No Point	-11.7			
			24	Bayou Sale	-11.8			
			25	Wax Lake Delta	-5.3			

Delta Plain						Pontchartrain Basin					
Id	Reach Name	Avg (ft/yr)	Id	Reach Name	Avg (ft/yr)	Id	Reach Name	Avg (ft/yr)	Id	Reach Name	Avg (ft/yr)
32	Oyster Bayou-Caillou Boca	-35.2	46	Chaland Headland	-33.3	60	Isle Aux Pitre	-36.5	74	Maurepas South East	-3.1
33	Raccoon Island	-12.2	47	Shell Island	-157.5	61	Biloxi Marshes	-19.6	75	Maurepas North West	-0.1
34	Whiskey Island	-62.2	48	Scofield	-34.1	62	Shell Beach	-16.4	76	Tangipahoa River	-5.0
35	Trinity Island	-40.8	49	West Bay	-157.4	63	Bayou Bienvenue	-13.6	77	Madisonville	-0.1
36	East Island	-16.4	50	Southwest Pass-West	-81.2	64	New Orleans Landbridge	-7.3	78	Mandeville	-1.0
37	Timbalier Island-West End	13.6	51	Southwest Pass-East	-50.0	65	Pearl River	-15.4	79	Big Branch Marshes	-0.1
38	Timbalier Island-East End	-25.0	52	South Pass	315.5	66	Lake Catherine	-35.1	80	Slidell	-0.4
39	East Timbalier Island	-62.9	53	Garden Island Bay	-113.4	67	South Point	-23.0			
40	Raccoon Spit	-58.3	54	Pass A Loutre	-253.6	68	Little Woods	-9.7			
41	Fourchon Beach	8.4	55	Delta National	-401.3	69	Orleans Lakefront	-1.5			
42	Caminada Headland	-24.8	56	Baptiste Collete	-23.9	70	Jefferson Lakefront	0.3			
43	Grand Isle	-2.9	57	Breton Island	-143.9	71	LeBranche Marshes	-6.0			
44	West Grand Terre	-22.6	58	Grand Gossier/Curlew Islands	NoData	72	Frenier Swamp	-6.7			
45	East Grand Terre	-60.8	59	Chandeleur Islands	-107.7	73	Pontchartrain Landbridge	-8.9			

Figure 3. Barrier Island Comprehensive Monitoring Program (BICM) short term shoreline change rates. Boston Canal/Vermilion Shoreline Stabilization project is located in the Acadiana Bays area in reach 15 Vermilion Beach and near reach 16 Avery Island.

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the annual inspection of the Boston Canal/Vermilion Bay Shore Restoration Project (TV-09) 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, if any, which were completed since project feature construction 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 B.

An inspection of the Boston Canal/Vermilion Bay Shore Restoration Project (TV-09) was held on June 18, 2014 under sunny skies and warm temperatures. In attendance were, Stan Aucoin, Dion Broussard and Bernard Wood of CPRA. NRCS was represented by Brandon Samson, Loland Broussard and Dale Garber. Parties met at the Maxie Pierce Landing off Hwy 333 in Intracoastal City. The annual inspection began at approximately 12:00 p.m.

The field inspection included a complete visual inspection of all constructed features. Staff gauge readings were used, when available, to determine approximate elevations of water, and rock structures. Photographs were taken at each project feature (see Appendix A) and Field Inspection notes were completed in the field to record measurements and deficiencies (see Appendix C).

b. Inspection Results

Rock Dikes

The rock dikes are in excellent condition. The Vermilion Bay shoreline erosion to the west and east of the rock dike tie-ins continue at average annual rates but have not worsened. Sediment accretion behind the rock dikes continues and approximately 90% of the open water area between the dikes and existing shoreline have filled-in and become emergent marsh. It was noted during previous inspections that a small gap left on the western tie-in during the original construction has increased in size and substantially separated from the existing shoreline. The eastern tie-in has also moderately separated from the existing shoreline due to ongoing shoreline recession. NRCS and CPRA agree that a maintenance event be performed to extend the rock dike on both the western and eastern sides of Boston Canal prior to the end of life of this project in October 2015. The west and east day markers installed as part of the TV-09 project are missing; however, the pilings remain. Additional day/night markers have been installed by others. (Photos: Appendix A, Photos 1 - 5)

Sediment Fencing

The sediment fencing was removed in 2002 as stated in Section II.d above. Vegetation has established between the rock dikes and previously existing shoreline. (Photos: Appendix A, Photos 1 - 6)

Smooth Cordgrass plantings

The shoreline plantings were not inspected on this trip. The vegetation in the area adjacent to the mouth of the Boston Canal, including the vegetation behind the rock dikes, is in good condition. (Photos: Appendix A, Photo 2-6)

c. Maintenance Recommendations

i. Immediate/ Emergency Repairs

- Survey the western and eastern sides of Boston Canal to design a rock dike extension (765 linear feet total) to tie into the existing marsh shorelines.
- Prepare a funding request for the Fall CWPPRA Technical Committee meeting.

ii. Programmatic/ Routine Repairs

Extend the rock foreshore dike on both the western and eastern sides of Boston Canal prior to the end of life of this project in October 2015.

d. Maintenance History

General Maintenance: Below is a summary of completed maintenance projects and operation tasks performed since October 1995, the construction completion date of the Boston Canal/Vermilion Bay Shore Protection Project.

Maintenance Project – Loland Broussard: This maintenance event included the modification of the sediment trapping fences constructed behind the rock dikes by Loland Broussard of NRCS in concurrence with LDNR and at no cost to CWPPRA on March 7, 2002. Modification of the fences involved cutting the geotextile panels from the top of the fence down to approx. 6" below the mud line (~ 30") and removing the panel. The 4x4 wooden posts were not disturbed and left intact. The reinforcement wire behind each panel was severely deteriorated and virtually non-existent. The southernmost fences were preventing sediment from filling the entire area behind the dikes. Since the fences have been removed, sediment has been more evenly distributed. Vegetation cover continues to expand over the accreted sediment behind the dikes.

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 Structural Operation Plan is required.

IV. Monitoring Activity

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-09 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 sites located in the project area as it is a bay shoreline but CRMS coastwide land water flight data was used to support project specific data.

a. Monitoring Goals

The objectives for the Boston Canal/Vermilion Bay Shoreline Stabilization project are:

1. Protect approximately 193 ac (78.1 ha) of wetlands between Mud Point and Oaks Canal from physical erosion from Vermilion Bay through shoreline stabilization.

2. Stabilize 13.25 mi (21.3 km) of the Vermilion Bay shoreline and prevent further regression of the Boston Canal banks.

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

1. Decrease the rate of shoreline erosion at the intersection of the Boston Canal and Vermilion Bay by armoring the corners of the canal with foreshore rock dikes.

2. Decrease the rate of shoreline erosion and maintain the integrity of approximately 193 ac (78.1 ha) of shoreline and interior marsh on the northern edge of Vermilion Bay by establishing an intertidal *Spartina alterniflora* hedgerow along the shoreline.

b. Monitoring Elements

Aerial Photography:

To document vegetated and non-vegetated areas, near vertical color-infrared aerial photography (1:24,000 scale with ground controls) were obtained in 1994 (pre-construction) and post construction in 1997. The original photographs were checked for flight accuracy, color correctness, and clarity and were subsequently archived. Aerial photographs were

scanned, mosaicked, and georectified by USGS/NWRC personnel according to standard operating procedures (Steyer et al. 1995, revised 2000).

Vegetation:

The condition of the vegetation plantings were documented using an accepted methodology similar to Mendelssohn and Hester (1988), Coastal Vegetation Project, Timbalier Island. Percent survival and percent cover were monitored in 1 m^2 plots marked by the installation of 4x4 wooden posts. Percent survival of planted vegetation was determined in plots that originally contained 16 live stems. Three percent of plantings were randomly sampled among the four land types that represent the variable topography of the shoreline. Land type 1 was a straight mineral shoreline with a gradual slope. The shoreline of land type 2 was deeply scalloped, consisting of cutbanks and gently sloped inlets with high organic content. Land type 3 was a gently scalloped shoreline with a mineral soil. Land type 4 was gently scalloped with a mineral soil, but is recognized as a different land type due to its north-south orientation (LADNR 2004). These data were collected at 6, 12 and 36 months post-construction, in 1995, 1996, and 1999 respectively. Herbivore damage was recorded if observed.

Shoreline Change:

To document shoreline movement continuous differential GPS was established at the mean high water line along the original shoreline adjacent to vegetative plantings in the project area. The reference shoreline site located east of Avery Canal was subsequently found to have been planted by the landowner prior to the project plantings. The vegetative plantings effectively made the reference shoreline similar to the project shoreline and therefore not a valid reference. Only project area shoreline data are presented here. The shoreline was mapped in post-construction years 1998, 2001, 2004, 2008, and 2013.

c. Monitoring Results and Discussion

Aerial Photography:

The 1994 to 1997 Land/Water analysis including the project area shows some land gain in the project area but also contains areas that were in the interior and not part of the project area and unrelated to project features (Figure 4). However there were gains in the areas behind the rock dikes and among the plantings on the bay shoreline. This pattern of shoreline progradation demonstrates the effective establishment of an intertidal *Spartina alterniflora* hedgerow (Figure 5). Though as of the 2013 shoreline survey, the project area has lost an average of one meter of land per year from 1998-2013 and this trend is likely to continue through the end of project life in 2015. The -1.0 m/y shoreline erosion rate is accelerating, the 2008-2013 period showed an average shoreline change of -2.0 m/y (Table 2). There were multiple storm events prior to and during this time period that likely impacted the planted hedgerows coverage and density contributing to this accelerated rate. A conservative estimate of the average shoreline loss of -1.0 m/y would equate to 20 meters along the 13 miles of planted coastline by 2015. This would yield a substantial acreage loss in terms of the project area. This shoreline erosion rate generates a land loss estimate of approximately 100 acres along the edge of Vermilion Bay from 1998 to 2013. This 100 acre loss represents approximately 50% of the project area. Based on regional scale analysis of satellite imagery (Thematic Mapper, 30 m^2 resolution) starting in 1985 (Figure 6) the percent land change from

1985 through 2015 shows a decline from >85% land to approximately 50% land by 2015 based on simple linear regression (Couvillion et al. 2011). This is a coarse estimate for a small project area yet it is in relative agreement with the shoreline change data showing overall land loss in the project area approaching 50% by the end of project life. Over a longer historical time frame Barras via the CRMS spatial viewer details a 34% loss in the TV-09 project area from 1956-2008 (Barras et al. 2009) and an 8.5% loss in the TV basin as a whole over the same period (McGinnis et al. 2011). As this project almost completely consists of bay shoreline habitat the higher local land loss is reasonable compared to the TV basin as a whole.

Vegetation:

Spartina alterniflora trade gallons were planted along approximately 13 miles of Vermilion Bay shoreline in double or triple hedgerows to stabilize the shoreline and prevent land loss from wave and wake generated erosion. These plantings took place in 1995 and were monitored for percent coverage and survival six months later in the same year and then again in one year later in 1996 and three years post planting in 1999. By the 1999 monitoring effort the individual plants were indistinguishable from one another and monitoring was ceased due to the high survivorship and percent cover of *Spartina alterniflora* along much of the project shoreline. The project shoreline was divided into four land types based on geomorphic and topography characteristics (Figure 2). Land type 1 is a straight mineral shoreline with a gradual slope with relatively homogeneous erosion rates. Land type 2 is distinct based on the deeply scalloped cutbanks and gently sloped inlets with high organic content. Land type 3 is a gently scalloped shoreline with a mineral soil. Land type 4 is also gently scalloped with mineral soil, but is recognized as a different land type due to its north-south orientation (LADNR 2004). The entire project shoreline was vegetated prior to planting, areas with extensive *Phragmites australis* were noted and examined in closer detail to document the effect of this species on the success of the *Spartina alterniflora*. Overall the land types produced similar results for the percent survival of *Spartina alterniflora*. Although land type 1 had a lower percent survival than the other land types (Figure 7). This is more likely an effect from the preexisting vegetation in this region of the project shoreline being non conducive to the plantings and out competing the new vegetation. Land type was also not a major factor in the percent cover of *Spartina alterniflora* over the three years of vegetation monitoring, although land type 2 did appear more robust during each sampling period. Time post planting was a more important factor as the planting became strongly established one year after planting and after three years post planting was indistinguishable from the pre project vegetation (Figure 8 and Figure 11). Planting in or near existing stands of *Phragmites australis* heavily reduced the survivorship and thus the percent cover of the project plantings. In dense stands of *Phragmites* the *Spartina* planting percent survivorship was reduced by over half in the first six months and by 80% over the three years studied (Figure 9). The logical extension of this failure to survive is the lack of cover and the lack of expansion in the high density *Phragmites* locations over the study period (Figure 10). Medium density Phragmites stands had much lower cover after six months and one year but by year three were preforming almost as well as the low density sites.

During the 2004 shoreline mapping the vegetation along some of the shoreline was photographed and most appeared to be in good condition. Plantings were observed during the 2008 and 2013 shoreline mapping efforts. As of the 2013 shoreline mapping very little

Spartina alterniflora was present west of Four Mile Cut to the end of the project area which is approximately 2.5 miles of relatively stable shoreline with few remaining plantings. The remaining 10.5 miles of the project shoreline contains approximately 50% of the original hedgerow plantings. Of the 50% remaining hedgerows some have retreated to cut banks or disassociated from the existing marsh providing little erosion protection from Vermilion Bay (Figure 12). Some segments of the plantings remain intact and are providing an intertidal vegetation hedgerow that is rolling landward as its associated shoreline retreats. These remaining intact shoreline planting hedgerows are mostly along the north south oriented shoreline of land type 4 (Figure 13). The overall quality of the vegetative planting component of this project is in poor condition and has provided little shoreline erosion reduction over the life of the project when compared to historic rates.

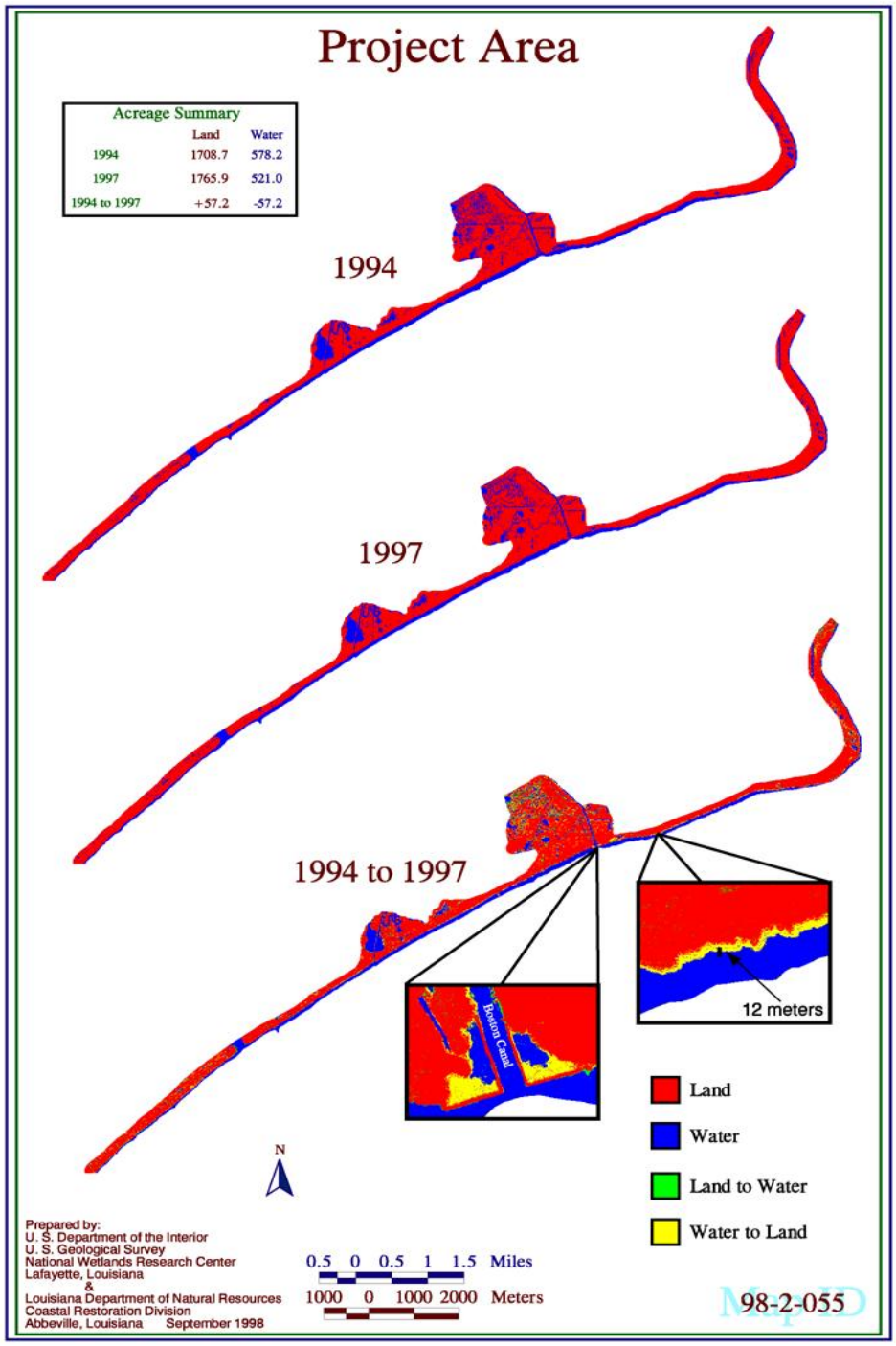


Figure 4. Land water analysis including the Boston Canal Shoreline Stabilization (TV-09) project, highlighting the land gain behind the rock dike and the hedgerow along the shoreline from 1994 through 1997.

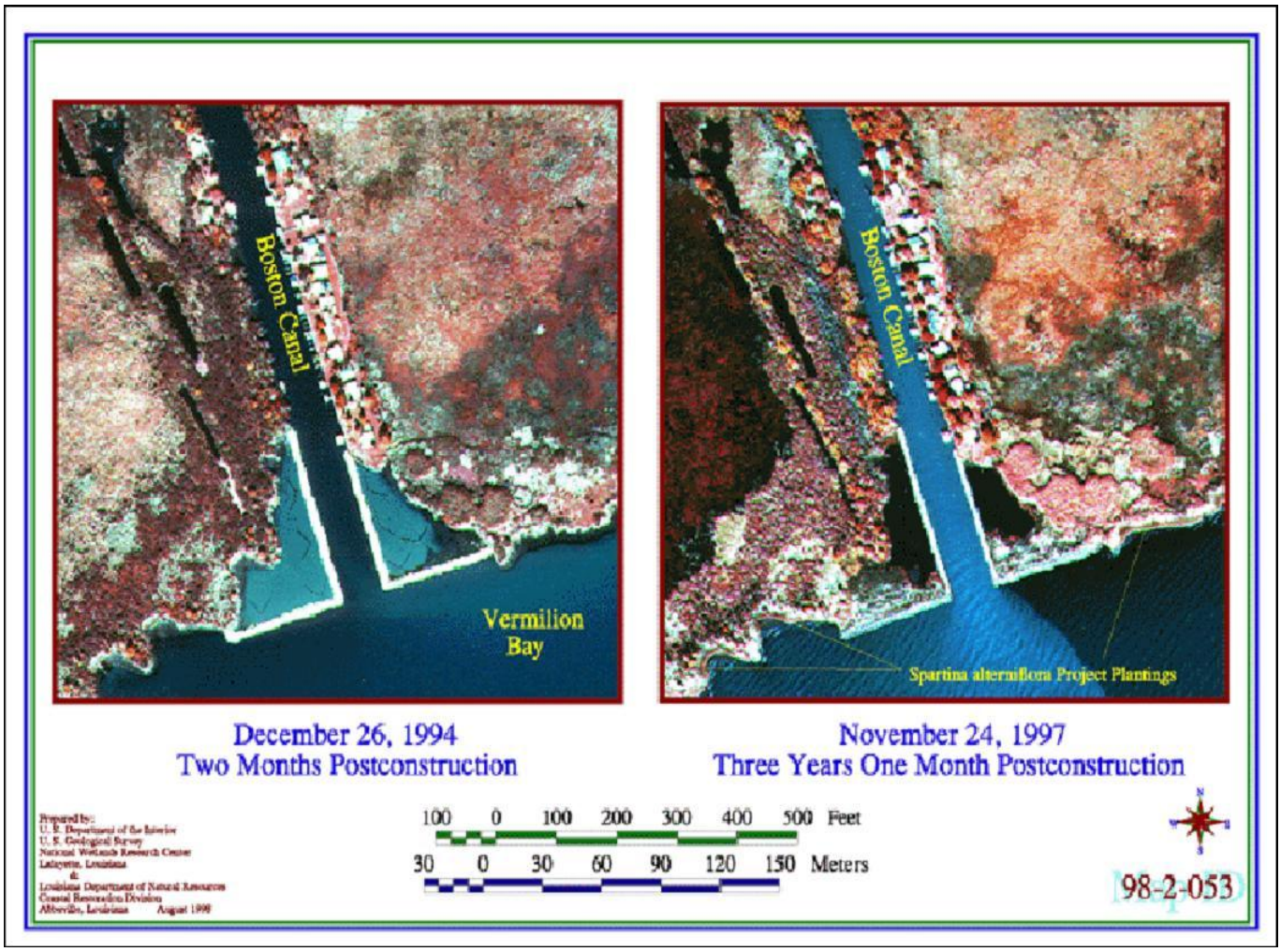


Figure 5. Aerial photography comparison of Boston Canal Shoreline Stabilization (TV-09) project at two month post construction in 1994 and three years post construction in 1997.

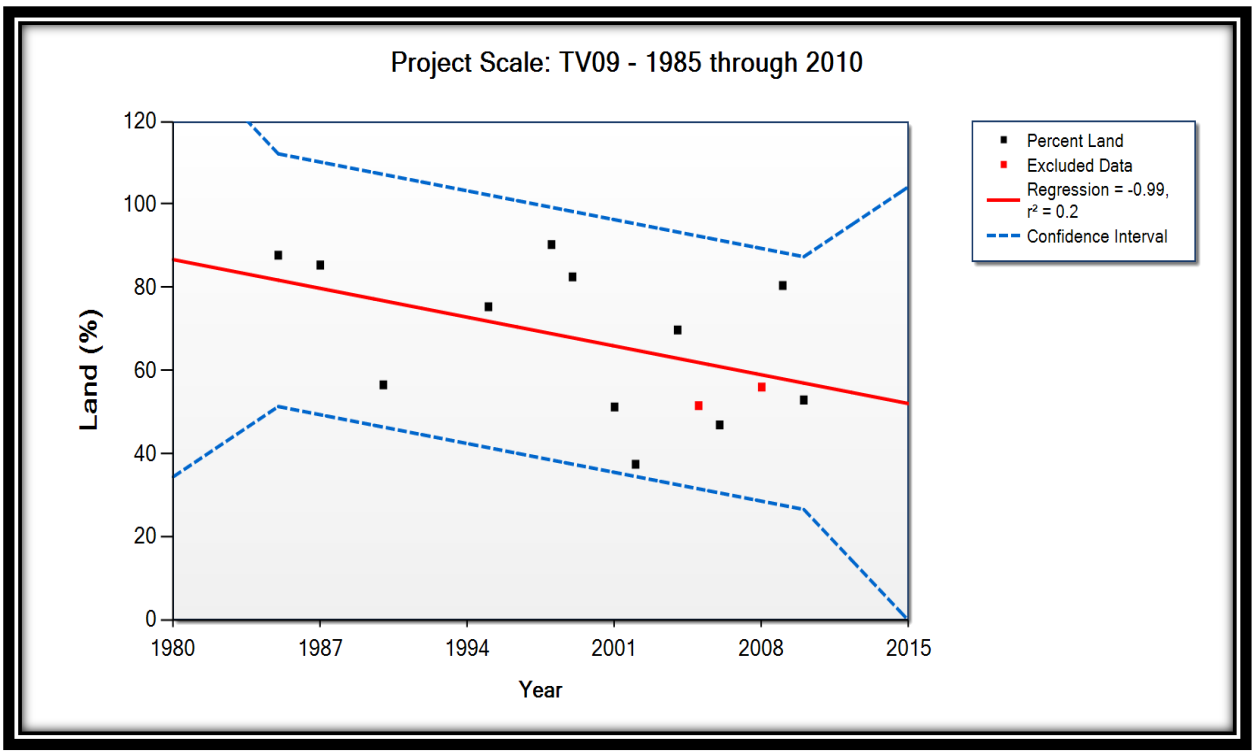


Figure 6. Land water analysis for Boston Canal Shoreline Stabilization (TV-09) project from 1980-2015, showing the land change trend for the project area of -1%/yr or -2 ac/yr.

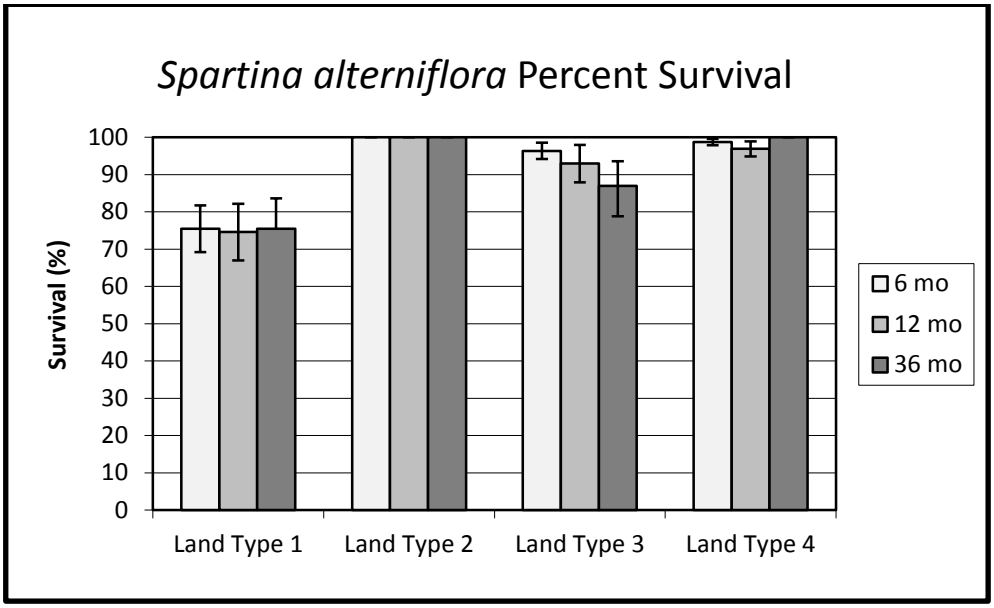


Figure 7. Average percent survival of *Spartina alterniflora* plantings in land types 1-4 observed at 6, 12, and 36 months post planting in 1995, 1996, and 1999 at TV-09 (means ± SE).

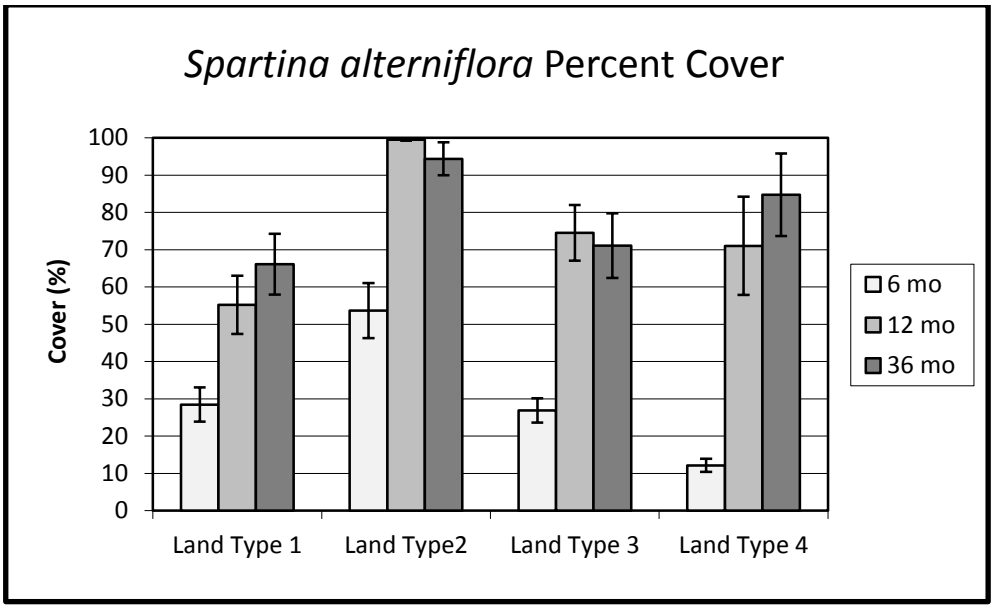


Figure 8. Average percent cover of *Spartina alterniflora* plantings in land types 1-4 observed at 6, 12, and 36 months post planting in 1995, 1996, and 1999 at TV-09 (means ± SE).

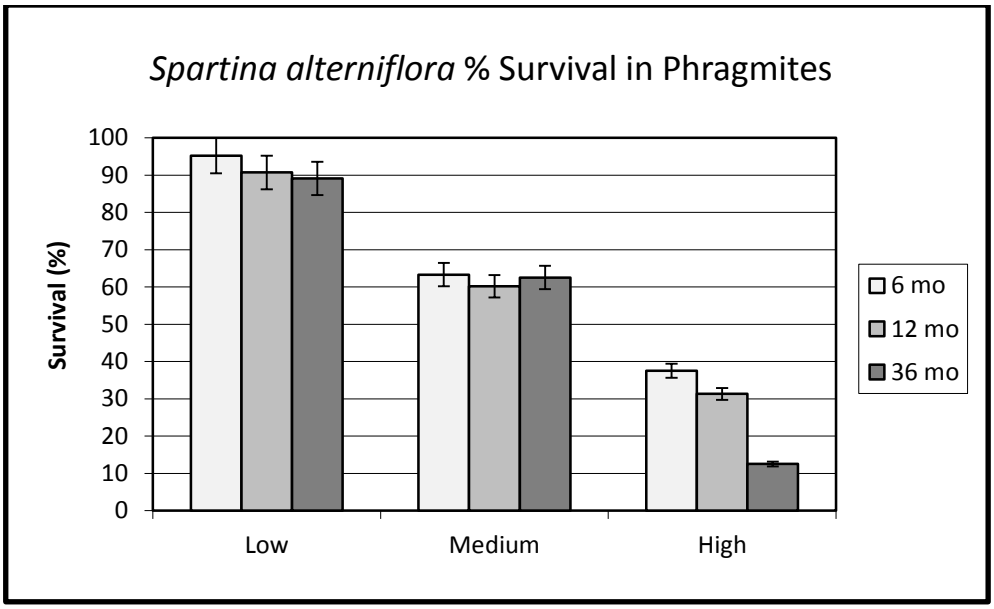


Figure 9. Average percent survival of *Spartina alterniflora* plantings in low, medium, and high levels of *Phragmites australis* coverage at 6, 12, and 36 months post planting in 1995, 1996, and 1999 at TV-09 (means ± SE).

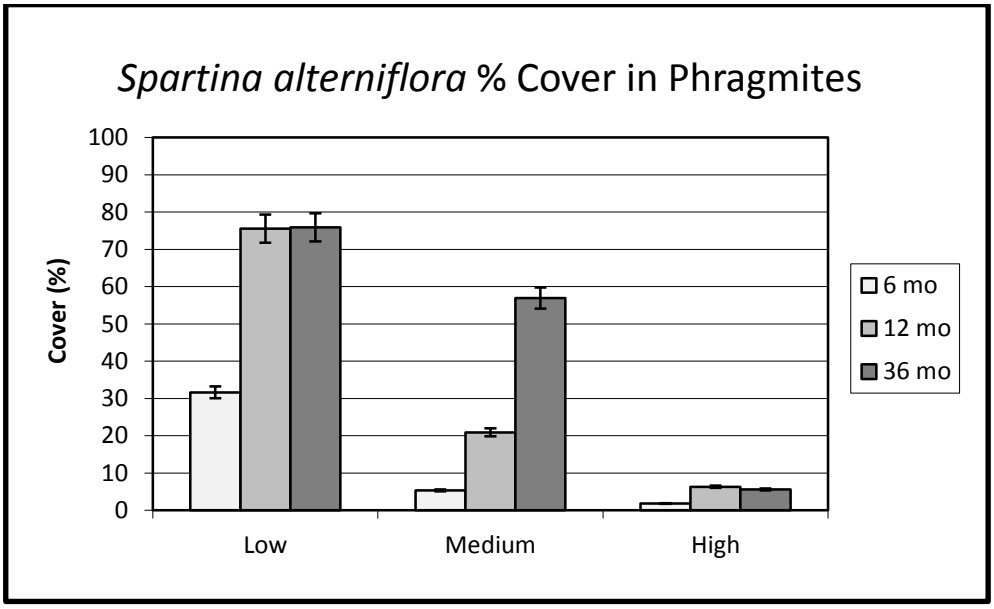


Figure 10. Average percent cover of *Spartina alterniflora* plantings in low, medium, and high levels of *Phragmites australis* coverage at 6, 12, and 36 months post planting in 1995, 1996, and 1999 at TV-09 (means ± SE).

Figure 11. *Spartina alterniflora* plantings during vegetation monitoring in 1995 (6 months post-planting), 1996 (one year post-planting), and 1999 (three years post-planting) respectively.

Figure 12. During the DGPS shoreline survey this broken and detached portion of the Spartina alterniflora hedgerow in the center of the project shoreline was noted.

Figure 13. During the DGPS shoreline survey this very intact portion of the planting area on the north south oriented shoreline was noted.

Shoreline Change:

The project shoreline was mapped in 1998, 2001, 2004, 2008, and 2013. Over the 1998 to 2013 time frame the shoreline has retreated at -1.1 m/yr (-3.6 ft/y, Table 2) which is similar to the published pre project area rates in table 1 (Figure 14). A comparison of DGPS mapping of the 13.25 mile project shoreline from 1998 to 2001 indicates a progradational shoreline with an average gain of +0.5 m/yr (+1.6 ft/yr) (Figure 15). The vegetative plantings were installed in 1995 and considered full established by 1998. A comparison of the 2001 and 2004 shorelines show a high rate of shoreline loss likely due to the effects of Hurricane Lili in 2002 of -1.4 m/yr (-4.6 ft/yr) (Figure 16). In general the center of the project shoreline near Boston Canal has retreated at the highest rate as it is the most exposed section of the project to the prevailing southerly winds and is contiguous to the open waters of Vermilion Bay that stretch for over ten miles and extend into West Cote Blanche Bay. Erosion slowed from 2004-2008 even as it was adversely affected by multiple hurricanes over the same time frame. The average loss from this period was -1.0 m/yr (-3.3 ft/yr) (Figure 17). After the 2004-2008 survey period large areas of the project shoreline were devoid of the planted foreshore *Spartina alterniflora* hedgerow and the erosion rates subsequently increased over the next survey period. The 2008 to 2013 time period indicated average losses of -2.0 m/yr (-6.6 ft/yr) and loss near Boston Canal was prominent (Figure 18). During the 2013 mapping effort it was evident that nearly 50% of the project area contained no intertidal *Spartina alterniflora* and in some locations where it was present either cut banks or separations from the main shoreline was taking place further limiting the protective potential of this project feature (Figure 12). However there were still large areas of *Spartina alterniflora* in the intertidal zone between the existing marsh and Vermilion Bay along the project shoreline where losses are taking place (Figure 13). This is likely due to the Spartina hedgerow rolling backward in step with the existing marsh as the wave energy of the bay causes continued shoreline erosion. The rock dike at the confluence of Boston Canal and the Vermilion Bay shoreline has been extremely successful and maintenance free. The open water area behind the rock dike has build-up sediment and continues to vegetate over the previously exposed mud flats (Figures 19-20). Even though the plantings generally survived, their function to reduce the rate of shoreline erosion is not applicable; competition, herbivory, regular wave action, storms, and debris can cause the loss of large sections of plantings annually during the project life.

Table 2. Net shoreline position change between DGPS measurements in the TV-09 project area.

Time Frame	Years	Source	Change Rate (ft/y)	Change Rate (m/y)	Notes
1998-2001	3	TV-09	+1.6	+0.5	Plants fully established
2001-2004	3	TV-09	-4.6	-1.4	Hurricane Lili
2004-2008	4	TV-09	-3.3	-1.0	Hurricane Rita and Ike
2008-2013	5	TV-09	-6.6	-2.0	~ 50% plantings gone
1998-2013	15	TV-09	-3.6	-1.1	Near project lifetime rate

The initial monitoring results from 1998-2001 showed a progradation of +0.5 m/y (+1.6 ft/y) occurring along the project shoreline and net gain in acreage was likely achieved. Over the next two shoreline change measurement intervals hurricanes became a dominant force in reshaping coastal Louisiana. Hurricane Lili struck the Louisiana coast east of Vermilion Bay in 2002 followed by Hurricanes Rita in 2005 and Ike in 2008, all of which produced storm surge that caused extensive damage both locally and afar. It is certain that the wave energy from these storms produced and exacerbated some of the shoreline erosion and resulting acreage losses in the following data collection periods. Other moderate losses have occurred from *Eichhornia crassipes* (water hyacinth) mats and other wrack material thrown onshore from bay waters via wave action that smothered established vegetation. The now established *Spartina alterniflora* community has persisted in some areas, but along some sections of the shoreline where consistent loss has occurred, the hedgerow moves along with the shoreline edge to maintain occupation of its niche in the intertidal zone. This explains why there are still hedgerows existing well behind the remaining original monitoring posts.

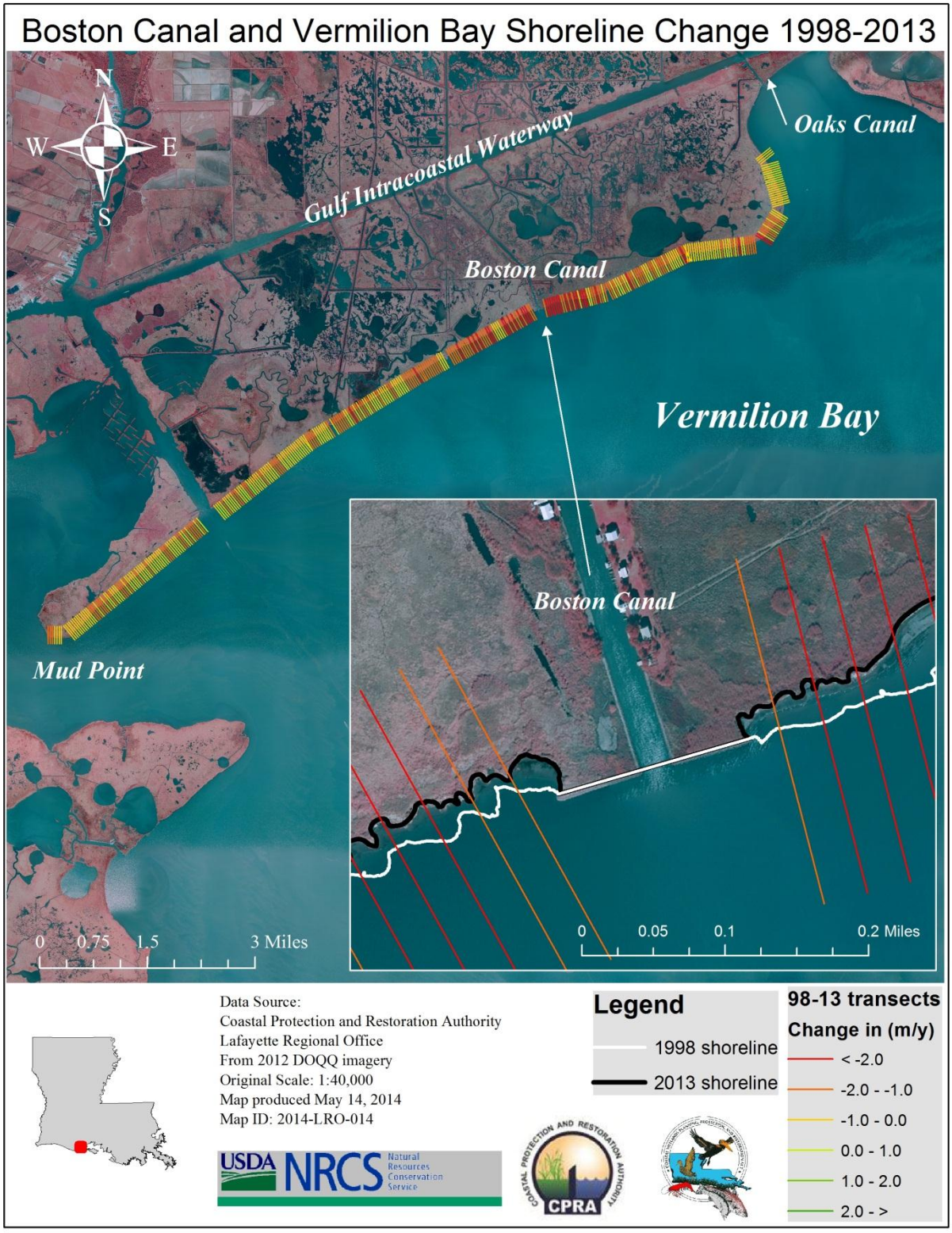


Figure 14. Overall shoreline position change for the TV-09 project using 1998 and 2012 differential global positioning system mapping data.

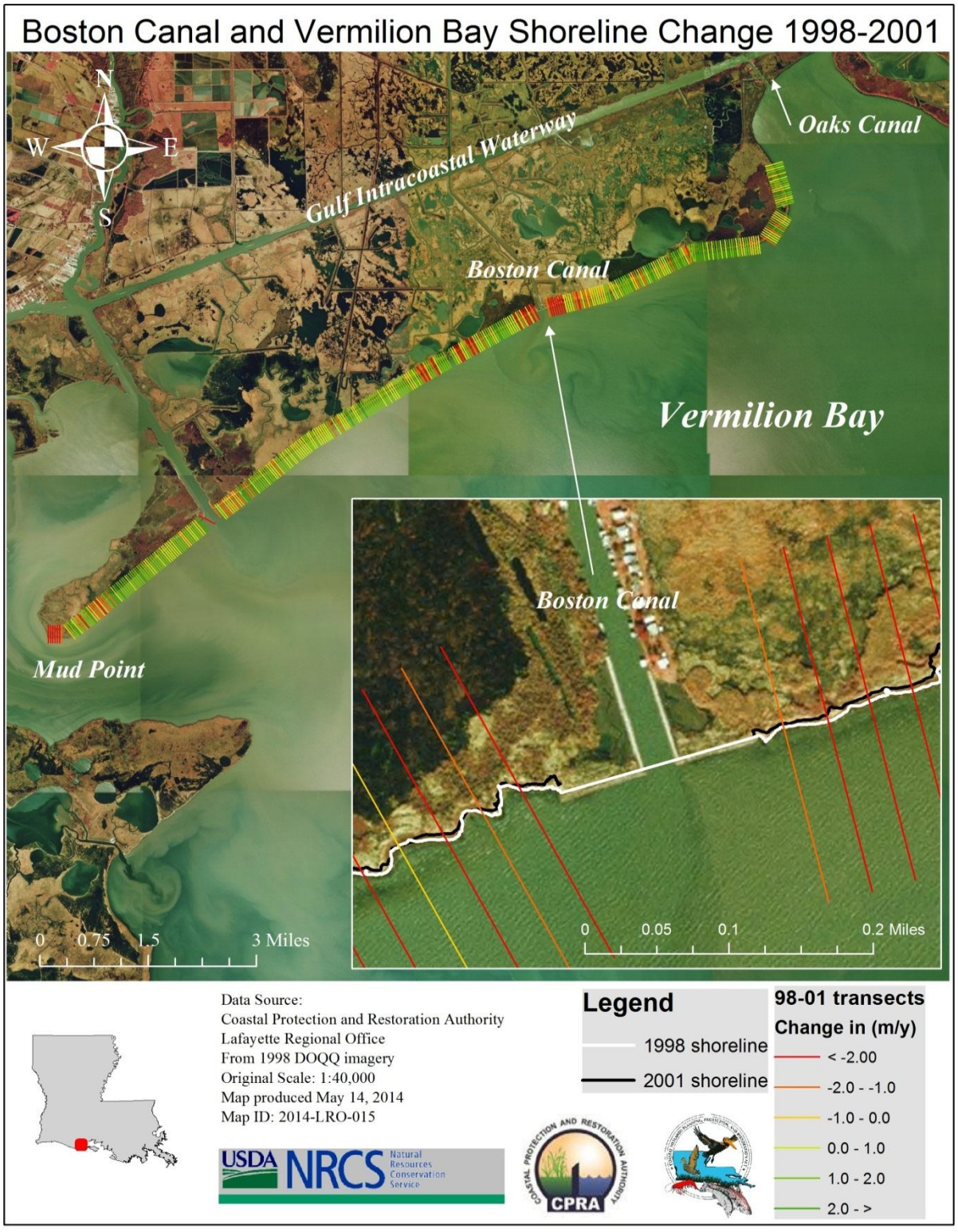


Figure 15. Shoreline position change for the TV-09 project using 1998 and 2001 differential global positioning system mapping data.

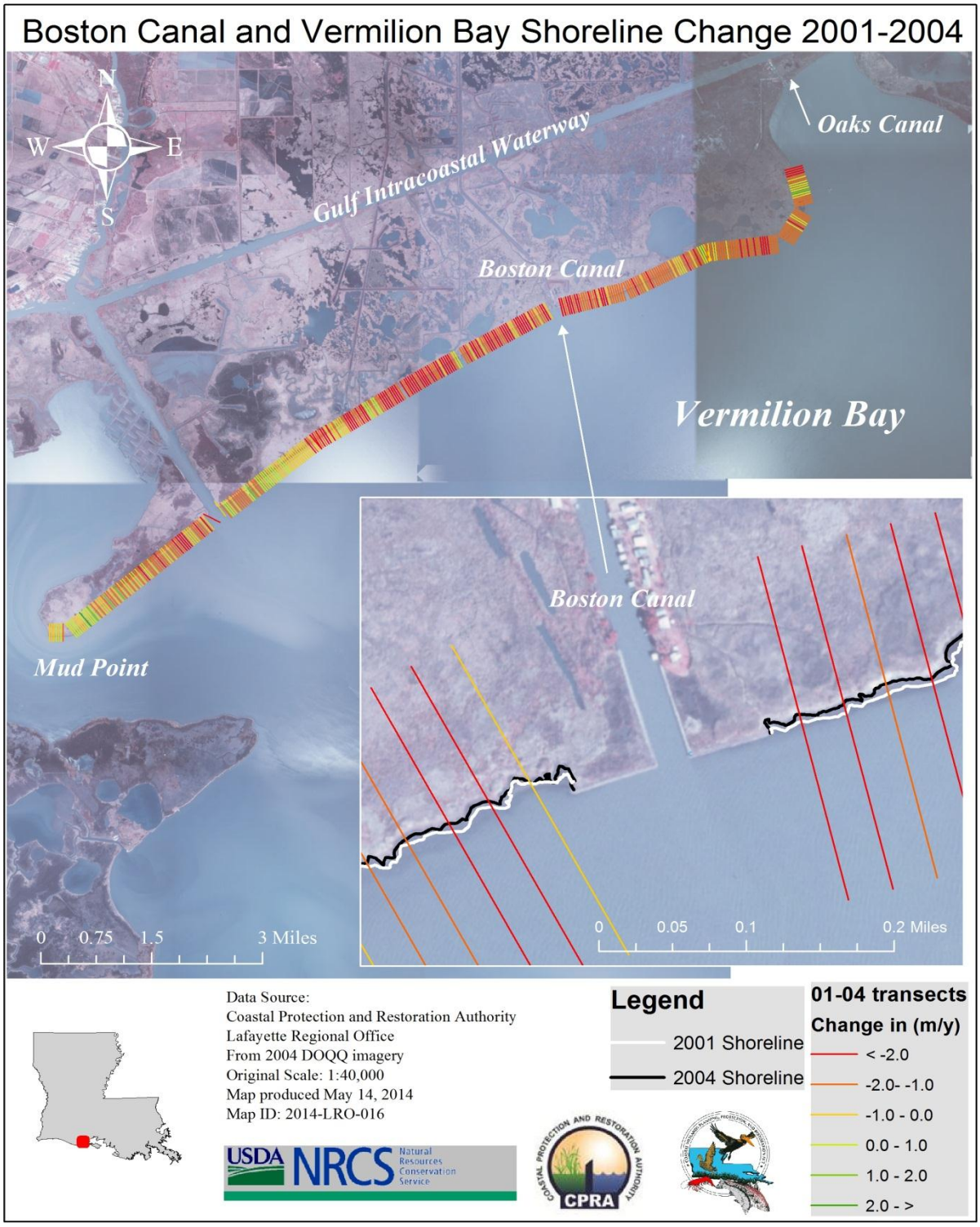


Figure 16. Shoreline position change for the TV-09 project using 2001 and 2004 differential global positioning system mapping data.

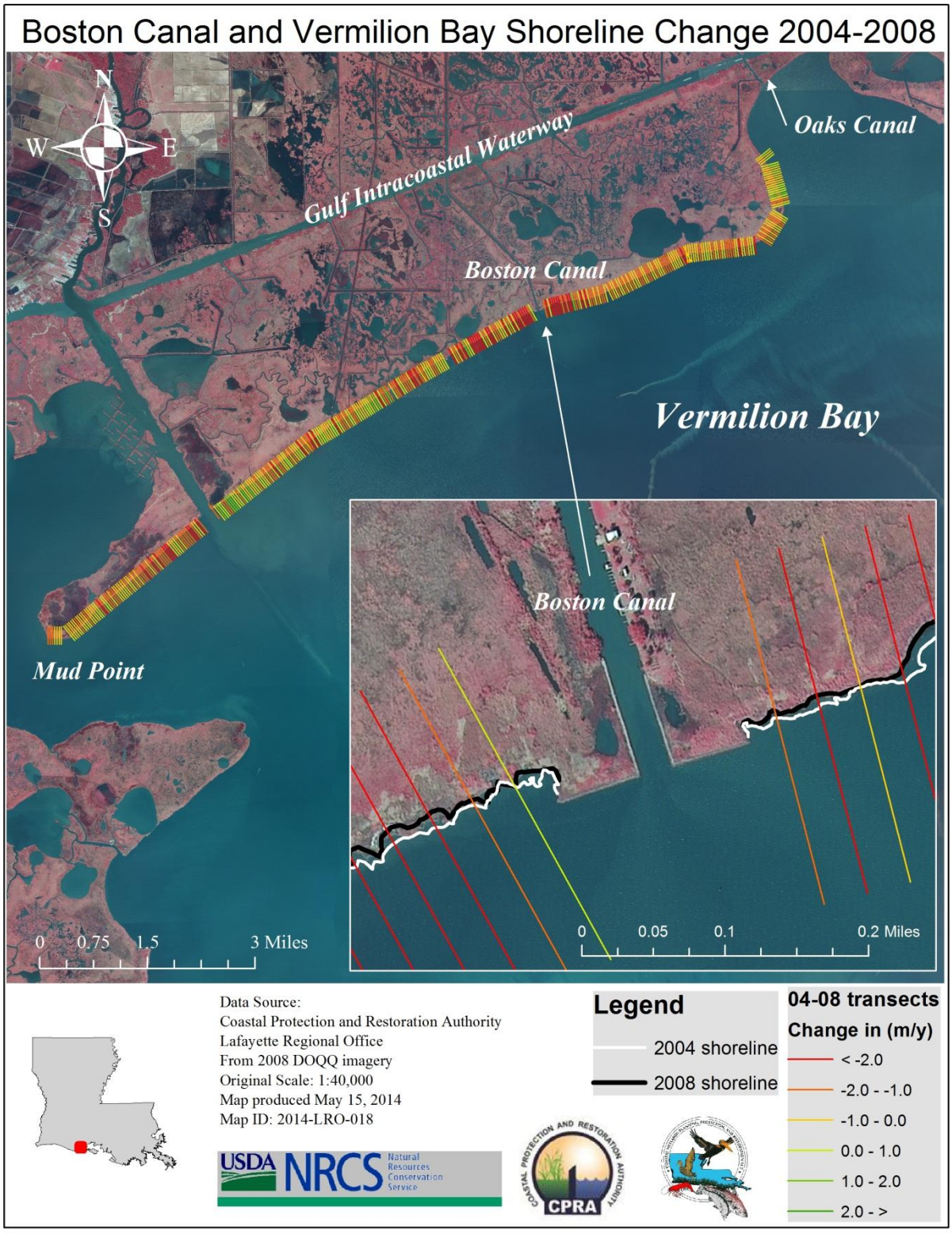


Figure 17. Overall shoreline position change for the TV-09 project using 2004 and 2008 differential global positioning system mapping data.

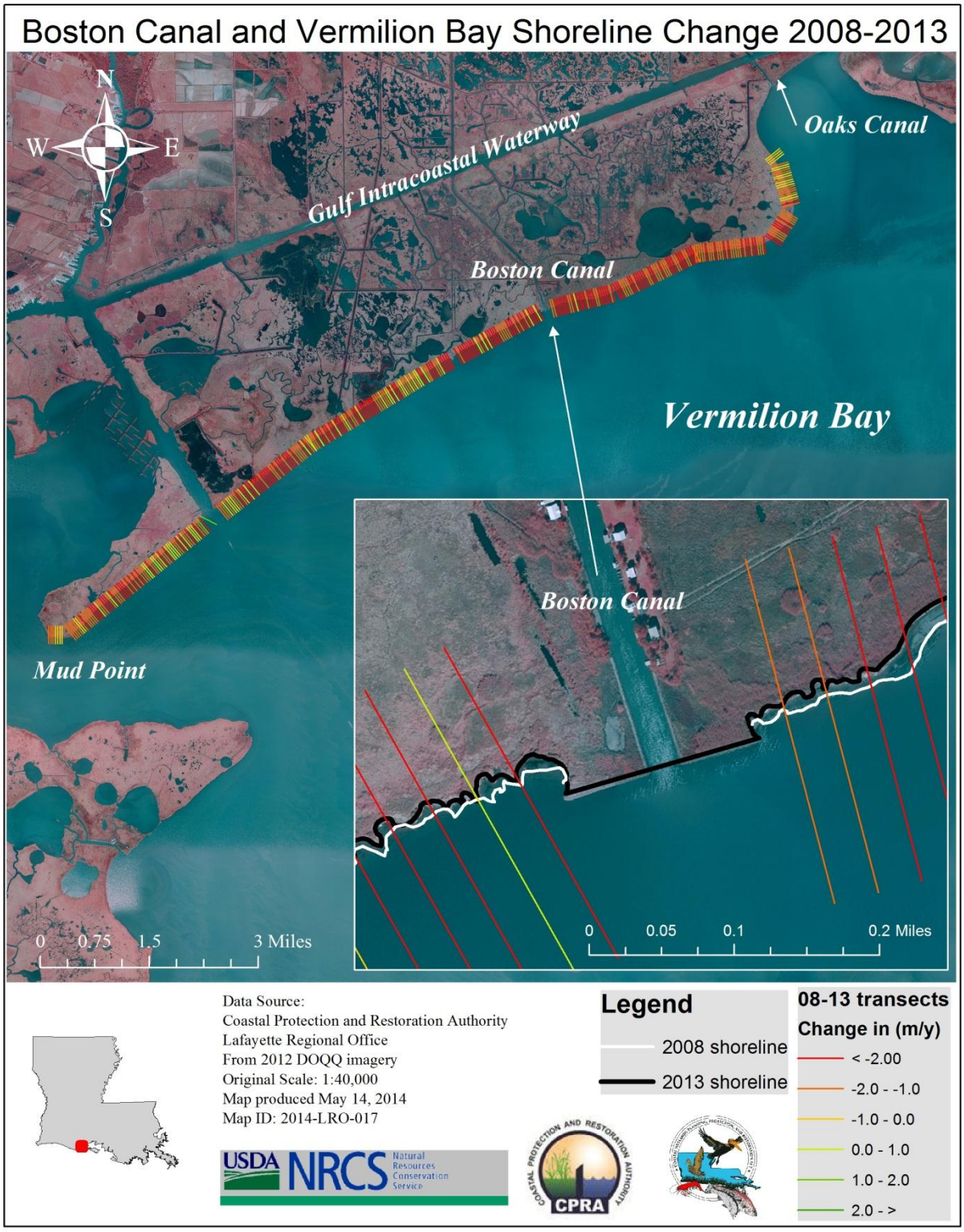


Figure 18. Shoreline position change for the TV-09 project using 2008 and 2013 differential global positioning system mapping data.

Figure 19. Boston Canal/Vermilion Bay Shoreline Stabilization (TV-09) rock dike and sediment fences at the mouth of Boston Canal (January 2001).

Figure 20. Boston Canal/Vermilion Bay Shoreline Stabilization Project behind the eastern rock dike November 9, 2004.

V. Conclusions

a. Project Effectiveness

The project area is experiencing continued and accelerating erosion along the Vermilion Bay shoreline despite the successful establishment of *Spartina alterniflora* plantings. The portion of the project vegetation plantings still in place are retreating inland in step with the shoreline, or on cutbanks, or disassociated from the shoreline. The current erosion rate of -2 m/yr is expected to continue into the future as the project shoreline continues to erode in the absences of a hard structure. Although the plantings of *Spartina alterniflora* did become well established and were indistinguishable from each other along the shoreline, the plantings did not protect exposed bay or lake shorelines from the wave energy these habitats typically encounter including tropical storm and hurricane forces. The rock dike at the confluence of Boston Canal and the Vermilion Bay shoreline has been extremely successful and completely maintenance free. The open water area behind the rock dike has build-up sediment and continues to vegetate over the previously exposed mud flats.

b. Recommended Improvements

The vegetative planting method of shoreline protection on any currently eroding high energy location is likely not to be successful for the lifetime of the project without successive replanting maintenance events. Hard structures are required to protect high energy erosive shorelines and planting behind these structures is not necessary.

c. Lessons Learned

Vegetative planting along high energy south facing shorelines requires additional structural protection in order to successfully prevent erosion. These plantings also require planned and funded maintenance events to replant vegetation as dictated by monitoring results. Planting *Spartina alterniflora* in dense to moderate stands of *Phragmites australis* should be avoided.

Sediment fences inhibited even distribution of sediment behind the rock breakwaters. After the geocloth-covered wire on the sediment fencing was removed by NRCS personnel it allowed the sediment to be more evenly distributed into the open water areas behind the rock dike. The use of sediment fences is not necessary behind rock breakwaters.

d. End of Project Life

The foreshore rock dike at the confluence of Vermilion Bay and Boston Canal has been highly successful at eliminating shoreline erosion while revegetating formally open water areas behind the structure. This feature should, under normal environmental conditions including hurricanes, continue to protect the ecological and human infrastructure behind this project feature. The foreshore rock dike has needed little to no maintenance over the 20 year project life and this trend is expected to continue into the foreseeable future. Removal of this feature would immediately expose vulnerable marsh habitat to erosive forces. In addition, the NRCS is considering a maintenance event that would extend the rock dike on both the western and

eastern sides of Boston Canal prior to the end of project life. This maintenance event would assist in bolstering the rock dike long after the project's twenty year life. This would further extend shoreline protection benefits into the future and prevent the adjacent eroding shoreline from degrading accreted areas behind the structure. A potential funding request for the rock dike maintenance event is forthcoming.

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APPENDIX A
(Inspection Photographs)

Photo No. 1, View of Boston Canal Looking South into Canal

Photo No. 2, Rock Dike along the Bay Shore Looking West, Vegetation behind Rock

Photo No. 3, View of East Rock Dike, Vegetation, and Signs

Photo No. 4, Proposed East Tie In at Shoreline

Photo No. 5, Proposed West Tie In at Shoreline

Photo No. 6 Vegetation Behind Rock Dike, West Side

Appendix B
(Three Year Budget Projection)

BOSTON CANAL/ TV-09 / PPL 2

Three-Year Operations & Maintenance Budgets 07/01/2014 - 06/30/2017

Project Manager	O & M Manager	Federal Sponsor	Prepared By
Pat Landry	*Mel Guidry*	*NRCS*	*Mel Guidry*

	2014/2015 (-19)	2015/2016 (-20)	2016/2017 (-21)
Maintenance Inspection	$ 6,651.00	$ 6,851.00	
Nav. Aid Inspection	$ 5,000.00		
State Administration		$ 10,000.00	$ -
Federal Administration		$ 10,000.00	$ -
Maintenance/Rehabilitation			

13/14 Description: E&D for rock dike extensions

E&D	$ 85,000.00	(Incl. $25,000 for geo-tech)
Construction		
Construction Oversight		
Sub Total - Maint. And Rehab.	$ 85,000.00	

14/15 Description: Construction of rock dike extensions

E&D	$ -	
Construction	$ 597,600.00	(Incl. 25% Cont.)
Construction Oversight	$ 25,000.00	
Sub Total - Maint. And Rehab.	$ 622,600.00	

14/15 Description:

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

	2014/2015 (-19)	2015/2016 (-20)	2016/2017 (-21)
Total O&M Budgets	**$ 96,651.00**	**$ 649,451.00**	**$ -**

O &M Budget (3 yr Total)	**$ 746,102.00**
Unexpended O & M Budget	**$ 116,633.00**
Remaining O & M Budget (Projected)	**$ (629,469.00)**

OPERATION AND MAINTENANCE BUDGET WORKSHEET

BOSTON CANAL SP / PROJECT NO. TV-09 / PPL NO. 2 / 2014/2015

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$6,651.00	**$6,651.00**
Nav Aid Inspection	LUMP	1	$5,000.00	**$5,000.00**
Engineering and Design	LUMP	1	$40,000.00	**$40,000.00**
Operations Contract	LUMP	0	$0.00	**$0.00**
Construction Oversight	LUMP	0	$0.00	**$0.00**

ADMINISTRATION

CPRA Admin.	LUMP	0	$0.00	$0.00
FEDERAL SPONSOR Admin.	LUMP	0	$0.00	$0.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$0.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:					
Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Marsh Elevation / Topography	LUMP	1	$20,000.00	$20,000.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$20,000.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:					
Borings	EACH	2	$12,500.00	$25,000.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$25,000.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION: Construct 756 LF of rock dike extension either side of Boston Canal.

Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
Rock Dike	0	0.0	0	$0.00	$0.00
Bank Paving	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
Navigation Aid		EACH	0	$0.00	$0.00
Signage		EACH	0	$0.00	$0.00
General Excavation / Fill		CU YD	0	$0.00	$0.00
Dredging		LUMP	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)		LF	0	$0.00	$0.00
Timber Piles (each or lump sum)		EACH	0	$0.00	$0.00
Timber Members (each or lump sum)			0	$0.00	$0.00
Hardware		LUMP	0	$0.00	$0.00
Materials		LUMP	0	$0.00	$0.00
Mob / Demob		LUMP	0	$0.00	$0.00
Contingency (25%)		LUMP	0	$0.00	$0.00
General Structure Maintenance		LUMP	0	$0.00	$0.00
Vegetative Plantings		LUMP	0	$0.00	$0.00
Whalers		LF	0	$0.00	$0.00
OTHER				$0.00	$0.00
				TOTAL CONSTRUCTION COSTS:	**$0.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$96,651.00**

OPERATION AND MAINTENANCE BUDGET WORKSHEET

BOSTON CANAL SP / PROJECT NO. TV-09 / PPL NO. 2 / 2015/2016

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$6,851.00	**$6,851.00**
Nav Aid Inspection	LUMP	0	$0.00	**$0.00**
Engineering and Design	LUMP	0	$0.00	**$0.00**
Operations Contract	LUMP	0	$0.00	**$0.00**
Construction Oversight	LUMP	1	$25,000.00	**$25,000.00**

ADMINISTRATION

CPRA Admin.	LUMP	1	$10,000.00	$10,000.00
FEDERAL SPONSOR Admin.	LUMP	1	$10,000.00	$10,000.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$20,000.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:					
Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:					
Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION: Construct 756 LF of rock dike extension either side of Boston Canal.

Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
Rock Dike	756	5.5	4,208	$85.00	$357,680.00
Bank Paving	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	2,550	$8.00	$20,400.00
Navigation Aid		EACH	0	$0.00	$0.00
Signage		EACH	0	$0.00	$0.00
General Excavation / Fill		CU YD	0	$0.00	$0.00
Dredging		LUMP	1	$50,000.00	$50,000.00
Sheet Piles (Lin Ft or Sq Yds)		LF	0	$0.00	$0.00
Timber Piles (each or lump sum)		EACH	0	$0.00	$0.00
Timber Members (each or lump sum)			0	$0.00	$0.00
Hardware		LUMP	0	$0.00	$0.00
Materials		LUMP	0	$0.00	$0.00
Mob / Demob		LUMP	1	$50,000.00	$50,000.00
Contingency (25%)		LUMP	1	$119,520.00	$119,520.00
General Structure Maintenance		LUMP	0	$0.00	$0.00
Vegetative Plantings		LUMP	0	$0.00	$0.00
Whalers		LF	0	$0.00	$0.00
OTHER				$0.00	$0.00
				TOTAL CONSTRUCTION COSTS:	**$597,600.00**

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$649,451.00**

Appendix C
(Field Inspection Notes)

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name:	Boston Canal/Vermilion Bay Bank Protection (TV-09)	Date of Inspection: June 18, 2014	Time: 12:00 p.m.
Structure No.		Inspector(s): Stan Aucoin, Dion Broussard, Bernard Wood (CPRA) Dale Garber, Brandon Samson, Loland Broussard (NRCS)	
Structure Description:	Rock Dike		
		Water Level Inside:_____ Outside:	
Type of Inspection:	Annual	Weather Conditions: sunny and warm temperatures	

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	Good			2,3,4	Day mark signs are missing. Only piling is present on east and west dike. New day and night markers installed by others.
Rock Dike	Excellent			1,2,3,4,5	Rock Dike is in excellent condition. The separation between the SW and SE tie-ins and existing shoreline continues to enlarge.
Vegetative Plantings	Good			6	Vegetation behind rock in good condition, Vegetation along bayshore was not inspected on this trip.

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?