State of Louisiana

Coastal Protection and Restoration Authority of Louisiana

2021 Operations, Maintenance, and Monitoring Report

for

Coastwide Vegetative Planting Project (LA-0039)

State Project Number LA-0039
Priority Project List 20

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Operations, Maintenance, and Monitoring Report

Coastwide Vegetative Planting Project (LA-0039)

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Preface

The Coastwide Vegetative Planting Project (LA-0039) is funded through the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) on the 20th Priority Project List and was authorized by Section 303(a) of Title III Public Law 101-646, enacted on November 29, 1990, as amended. The United States Department of Agriculture's National Resources Conservation Service (NRCS) serves as the federal sponsor of LA-0039, in partnership with the Coastal Protection and Restoration Authority (CPRA) as the state sponsor. This 2021 Operations, Maintenance, and Monitoring (OM&M) Report addresses 21 LA-0039 plantings that have been completed as of December 2018. The 2021 report is the 2nd report in a series of reports. Reports and other information for this project are accessible through CPRA's Coastal Information Management System (CIMS) website at *http://cims.coastal.louisiana.gov*.

I. Introduction

The LA-0039 project provides an annual mechanism for nominating, screening, and selecting restoration planting sites, as well as for formulating site-specific designs. The project includes herbaceous and woody plantings that are implemented coast wide to create/protect emergent vegetation and maintain landscape features in coastal areas. The LA-0039 project is intended to facilitate a consistent and responsive planting effort in coastal Louisiana that is flexible enough to routinely plant on a large scale and be able to rapidly respond to specific areas of need following storms or other damaging events. Unique to LA-0039 within the context of CWPPRA projects, new sites are added annually; therefore, several project components occur simultaneously (site selection, planning, construction, and monitoring). Following installation, the planting sites are monitored to assess survivorship and the overall condition of the plantings and planting site. Lessons learned from the monitoring help to inform subsequent site selection and planning.

II. Site Selection, Planning, and Design Review (Phase II - O&M)

Each year, the LA-0039 project team, consisting of NRCS and CPRA personnel, and a CWPPRA advisory panel select planting sites. Around 15 sites are nominated each year; the project team and advisory panel screen and score nominated sites using five criteria with weighted values: Probability of Success (30 points), Landrights/Logistical Access (25 Points), Urgency (20 Points), Landscape Value (15 Points), and Relation to Existing CWPPRA Projects (10 Points). Around six of the nominated sites are selected for further evaluation each year. After field visits, the project team preliminarily selects sites for the project year and develops planting concepts for the advisory panel to review. Three to six of the nominees are chosen as planting sites each year.

Following final site selection, NRCS starts permitting and land rights processes, conducts necessary surveys, and develops planting designs which are reviewed by the project team. The plans are then distributed to the LA-0039 project team and CWPPRA advisory panel for review and final approval. When approved, NRCS develops final plans, specifications, and cost estimates for contract bid packages; timing is dependent on targeted season of planting. The contracts are then advertised to IDIQ contactors and awarded for construction.

Planting sites were planned to be selected for the first 10 years of the project life. Over the first ten years of the project, 38 planting sites were selected, 28 sites were planted, and seven sites were canceled due to land owner issues or unsuitable planting conditions. The typical time from site selection to planting is one and half to two years within LA-0039 which is much shorter than the time from project selection to construction for a typical CWPPRA project. Following planting, sites are distributed among the CPRA regional offices for monitoring (Table II-1; Fig. II-1). The following chapters detail 21 sites planted through 2018 (Appendix A).

Table II-1. Coastwide Planting Project (LA-0039) selected planting sites and status

Project Year	Site Name	Parish	Regional Office	Status	Planting Date	Plants
1	South Lake DeCade	Terrebonne	TRO	Planted	Fall 2012	33,330
2011	Cameron Creole	Cameron	LRO	Planted	Spring 2013	49,340
	Marsh Island	Iberia	LRO	Planted	Spring 2013	9,116
2	West Little Lake	Lafourche	TRO	Planted	Fall 2014	10,570
2012	DeCade Area	Terrebonne	TRO	Planted	Fall 2016	10,674
	The Prairie	St. John	NORO	Planted	Spring 2014	13,565
3	The Jaws	St. Mary	LRO	Planted	Fall 2014	10,650
2013	Little Vermilion Bay	Vermilion	LRO	Planted	Fall 2014	25,900
	Willow Lake	Cameron	LRO	Planted	Fall 2014	17,961
	Mud Lake	Cameron	LRO	Canceled	Too Deep	
4	Green Island Bayou	Vermilion	LRO	Planted	Fall 2015	31,840
2014	Point Aux Chenes	Terrebonne	TRO	Planted	Fall 2015	3,874
	Rockefeller Unit 4	Cameron	LRO	Planted	Spring 2015	11,350
	Northwest Little Lake	Lafourche	TRO	Canceled	Land Rights	
5	Rockefeller Terraces	Cameron	LRO	Planted	Spring 2016	57,900
2015	South Bayou DeCade	Terrebonne	TRO	Shortened	Spring 2017	1,700
	East Grand Terre	Plaquemines	TRO	Planted	Summer 2017	67,145
6	West Little Lake #2	Lafourche	TRO	Planted	Spring 2017	15,360
2016	Gentilly Unit	Orleans	NORO	Planted	Spring 2017	26,700
	Sabine Unit 1 Overflow	Cameron	LRO	Planted	Fall 2017	30,260
	The Jaws #2	St. Mary	LRO	Planted	Fall 2017	4,425
	Willow Lake #2	Cameron	LRO	Planted	Spring 2018	9,450
	Belle Isle Lake	Vermilion	LRO	Planted	Spring 2018	10,951
	Decade Vicinity	Terrebonne	TRO	Planted	Spring 2018	16,590
7	Big Branch Marsh	St. Tammany	NORO	Planted	Fall 2018	13,388
2017	Little Vermilion Bay #2	Vermilion	LRO	Planted	Fall 2018	15,567
	Joyce WMA	Tangipahoa	NORO	Planted	Winter 2019	9,270
	Bayou Perot	Jefferson	TRO	Planted	Fall 2019	9,288
7A	Miss R. Delta Trial	Plaquemines	NORO	Planted	Fall 2018	2,069
8	Joe Madere Marsh	Orleans	NORO	Planted	Spring 2019	11,611
2018	Black Lake West	Cameron	LRO	On Hold	Land Rights	~12,500

	MRGO/Shell Beach W	St. Bernard	NORO	Planted	Summer 2021	21,000
9	Bay Denesse	Plaquemines	NORO	Planning	Summer 2022	~12,500
2019	Joyce WMA #2	Tangipahoa	NORO	Canceled	Landowner no	
	Manchac WMA	St. John	NORO	Canceled	longer interested	
10	Big Branch Marsh #2	St. Tammany	NORO	Planted	Spring 2021	17,455
2020	Little Vermilion Bay #3	Vermilion	LRO	Planning	Summer 2022	~12,500
	Near Tigre Lagoon	Iberia	LRO	Planning	Summer 2022	~10,000
				Planted	Total	568,299
				Planned	Total	~47,500

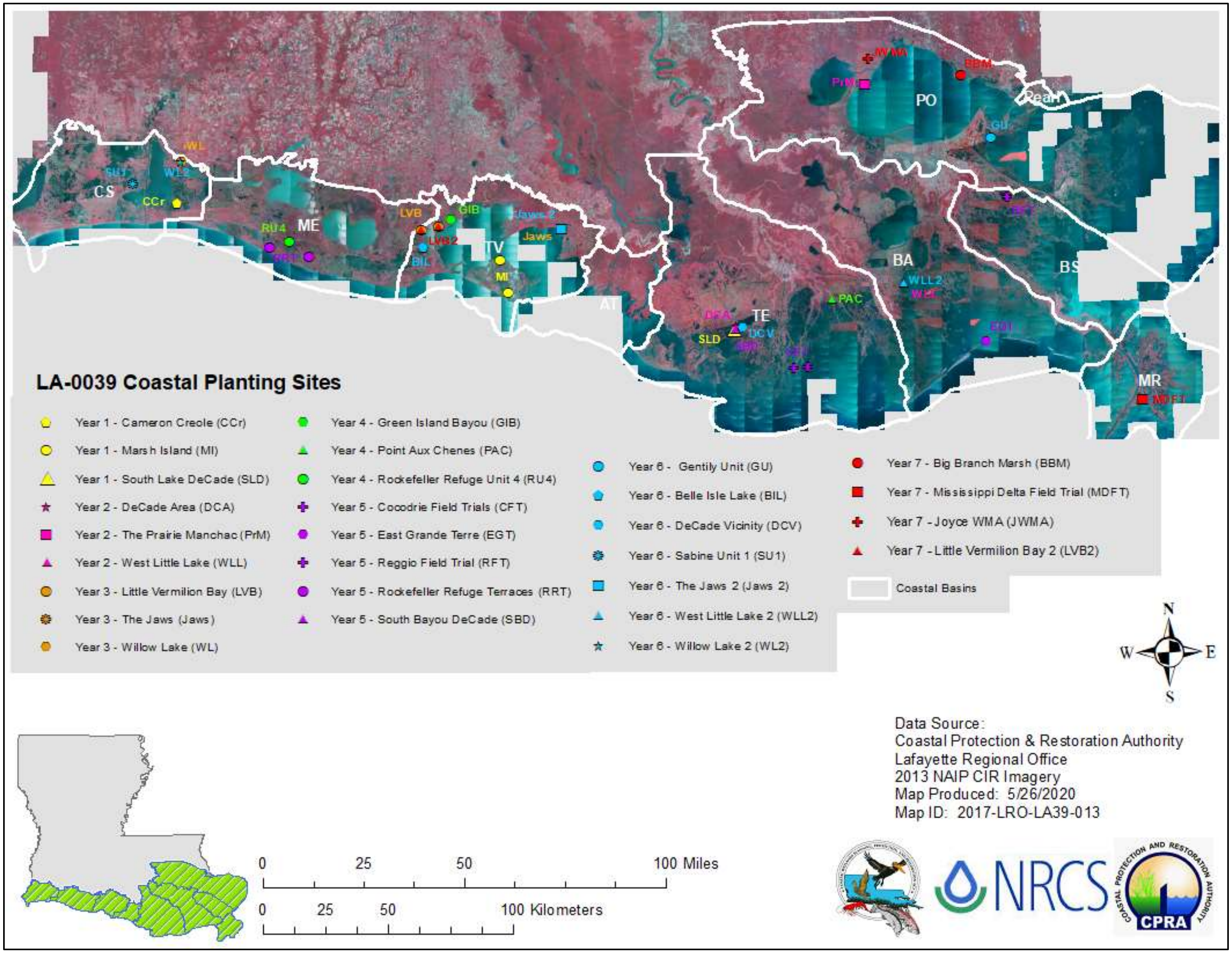

Figure II-1. LA-0039 Coastwide Vegetative Planting Project sites across coastal Louisiana from 2012 through 2018.

III. Year 1 – South Lake DeCade

Prepared by Elaine Lear – CPRA Thibodaux Regional Office
Margaret Luent and Tommy McGinnis – CPRA Lafayette Regional Office
Data collected by CPRA Thibodaux Regional Office

A. Site and Planting Description

South Lake DeCade (SLD), a Year 1 planting site, is in Terrebonne Parish southwest of Lake DeCade just south of Bayou DeCade (Fig. III-1) in the Terrebonne basin (Fig. II-1). Based on marsh categorization since 1949, the marsh along Bayou DeCade switched from brackish (1949-1988) to intermediate (1988-2013). The planting site, which experienced steady land loss since 1932, has a recent (1985-2010) land change rate of -0.85% per year which is a high loss rate (Couvillion et al. 2011; CPRA 2017). The planting site is within the CWPPRA project boundaries of TE-44 North Lake Mechant Landbridge Restoration, which protects the area from gulf tidal conditions to the south, and TE-34 Penchant Natural Resources Basin Plan Increment 1, which delivers freshwater and sediments from the north (CPRA 2017). The site is divided into three (3) planting areas (Fig. III-1). The final construction inspection of the South Lake DeCade planting was on October 29, 2012.

Area 1 consists of interior area plantings in a fragmented marsh intended to reconnect and stabilize patches of existing marsh. The interior of Area 1 was planted with plugs of *Spartina alterniflora* Vermilion (smooth cordgrass) in rows of plants spaced five feet apart with plants on five feet alternating centers with five feet spacing between rows. Perimeter segments were planted with a single row of trade-gallon sized smooth cordgrass planted on 10 ft centers. A small area within open water was planted with trade-gallon sized smooth cordgrass in north to south oriented rows spaced five feet apart with plants on five ft alternating centers.

Area 2 is oriented parallel to the shoreline south of Bayou DeCade and intended to establish vegetative cover in open water to disrupt wind fetch which may protect existing marsh shoreline. Area 2 consists of two double rows of trade-gallon sized *Schoenoplectus californicus* (California bulrush) positioned approximately 60 ft and 120 ft from the marsh shoreline. The double rows have 20’ spacing between the rows, with plants on five ft alternating centers.

Area 3 is denoted as auxiliary and was planted with extra trade-gallon sized *Schoenoplectus californicus* (California bulrush). The Area 3 plantings were designed to reinforce the shoreline along the tidal channel. Rows were spaced five feet apart with plants on five ft alternating centers.

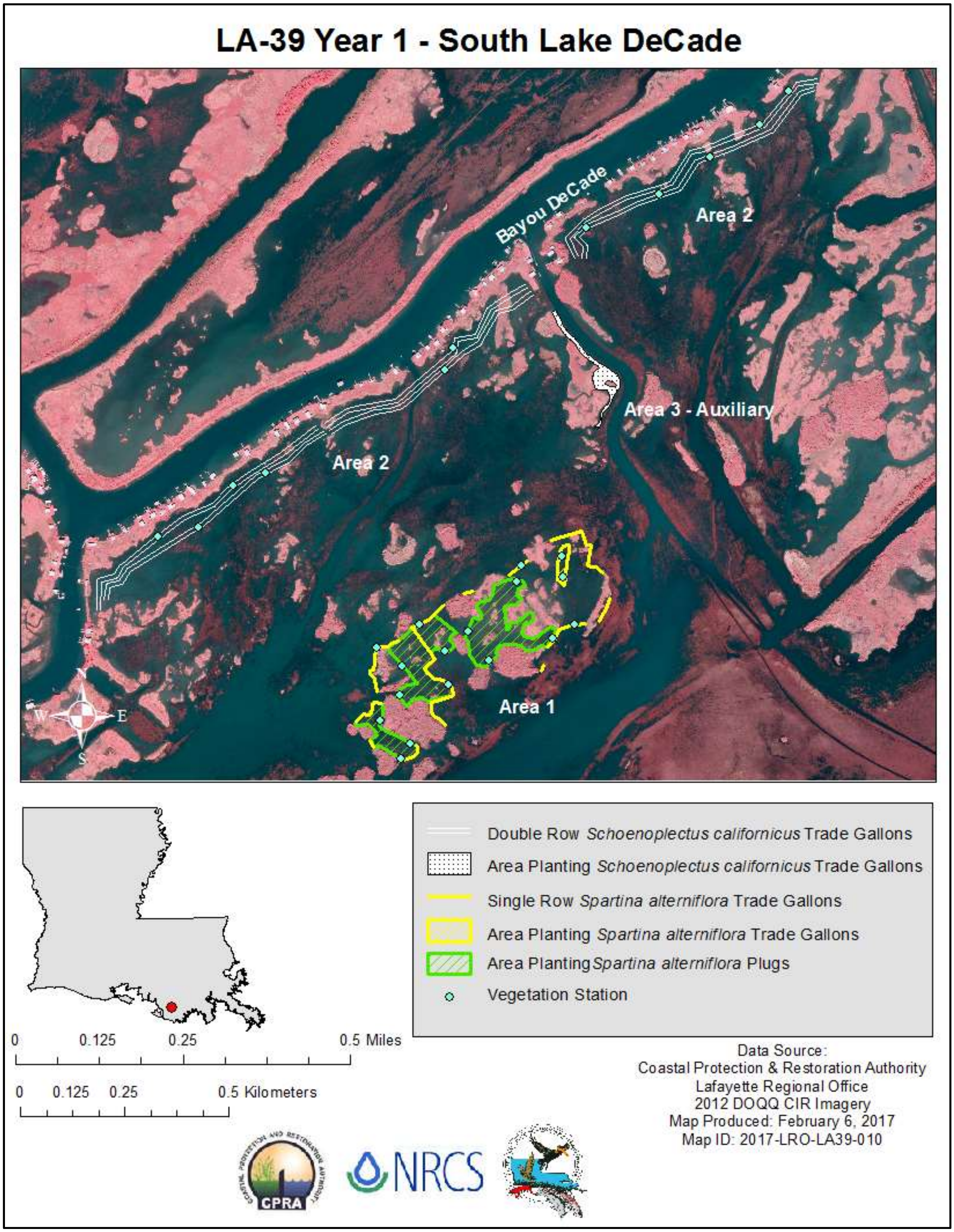

Figure III-1. LA-0039 Year 1 Site – South Lake DeCade site map shows plantings areas and types. The vegetative monitoring stations are also displayed.

B. Monitoring Activity

1. Monitoring Goals

The Year 1 South Lake DeCade plantings were designed to reinforce submerged and broken marsh platforms (interior area and perimeter plantings), to protect existing marsh, and to vegetate open water (double row plantings).

The goals of the South Lake DeCade plantings are:

- Area 1 broken marsh plantings of *Spartina alterniflora* Vermilion plugs will survive and expand between patches of existing marsh.
- Area 1 broken marsh perimeter plantings of trade-gallon sized *Spartina alterniflora* Vermilion will survive and expand to reinforce the submerged and broken marsh platform.
- Area 2 double row plantings will survive and expand to establish vegetation in open areas and break wind fetch.
- Area 3 plantings will survive and revegetate a degrading marsh platform.

2. Monitoring Elements

The monitoring elements include procedures to assess planting survival and effects on the planting site for the two main types of project plantings, interior area coverage and shoreline protection. Planting survival and vegetative cover were monitored at vegetation stations in November 2012, October 2013, and October 2015; and general planting conditions on a planting area scale was assessed in May 2018. Hydrologic data from nearby CRMS0398 was used to explain hydrologic influences such as flooding and salinity.

<u>**Vegetation Assessment**</u>

To assess the plantings and their effect on the planting areas, 29 vegetation stations were established to monitor planting survival and emergent vegetation cover. Data collection for planting survival and vegetative cover was conducted one week, one year, three years, and five and a half years after plant installation. Percent survival was calculated from 10 plants at each vegetation station; plants were characterized as live (any green vegetation) or dead/absent. Vegetative cover data includes cover of emergent vegetation (%), cover of species present (%), vegetative stand height (ft), and height of dominant species (ft) within a 4 m^2 plot (Folse et al. 2014). Flooding depth, surface water salinity, and temperature were collected at all sampling stations during each sampling event. Conditions occurring outside of the stations and segments including additional species were also noted along with photo documentation.

Area 1 (Fragmented Marsh Planting) has 18 vegetation stations to monitor planting survival and vegetative cover. Nine stations are within the plug-sized smooth cordgrass plantings. The trade-gallon sized smooth cordgrass planting have seven stations along the perimeter segments and two stations are within the open-water area planting.

Area 2 (Double Row California Bulrush Plantings) has 11 stations divided between the two double rows of California bulrush; five stations are in the double row 60 ft from the shoreline, and six stations are in double row 120 ft from the shoreline.

Area 3 (Auxiliary California Bulrush Plantings) does not have any vegetation stations. Progression of the plantings will be qualitatively described with Google Earth imagery.

Planting Failure/Success Causation

Hydrologic data from CRMS0398, located 1.5 miles north of the planting site, was used to describe area water-level trends and salinity. The water level data will be compared to planting elevations (ft, NAVD88, Geoid 12A) to describe flood conditions. Photographic documentation will also be used to describe processes of planting success and failure.

3. Monitoring Results and Discussion

a. Vegetation

The ocular estimates of the planting areas captured the general performance of the plantings (Table III-2). Healthy stands of intermediate submerged aquatic vegetation (*Ceratophyllum demersum, Myriophyllum spicatum, and Vallisneria americana*) were present during planting and throughout the monitoring period in all areas. Most of the smooth cordgrass plantings, plug and trade gallon sized, in Area 1 were gone by one year after planting (Fig. III-2 A and C) and were completely absent by three years after planting (Fig. III-2 B and D). Naturally occurring *Phragmites australis* (Roseau cane) has expanded from the existing marsh patches (Fig. III-2 C) and onto floating vegetation mats (Fig. III-2 D & E).

Area 2 double row plantings of California bulrush had survived and expanded by the first year after planting at both the 60' and 120' from the shoreline with the exception of plantings near the opening of Bayou DeCade (Table III-1), continued to do so through early 2015, but by late 2019 had declined to remnants of the 120' double rows (Fig. III-3). By three years after planting (October 2015), much of the California bulrush was destroyed by floating mats of giant Salvinia and water hyacinth, and large stands of *P. australis* were engulfing many of those rows nearest to the bayou (Figs. III-3 - 5). Auxiliary Area 3 plantingsof California bulrush had survived and expanded with minor losses through early 2015 (Fig. III-6).

Table III-1. Overall % Survival of LA-0039 Year 1 South Lake DeCade plantings were ocularly estimated over time while conducting monitoring field trips.

		% Overall Survival			
Area	Planting Type	Nov 2012	Oct 2013	Oct 2015	May 2018
Area 1	Fragmented Marsh Openings	100	<5	0	0
	Perimeter Segments	100	<5	0	0
	Open Water	100	0	0	0
Area 2	Double Row – 60 ft from marsh	100	70	20	<1
	Double Row – 120 ft from marsh	100	70	20	<5
Area 3	Channel Reinforcement	100	90	80*	5*

* Estimated

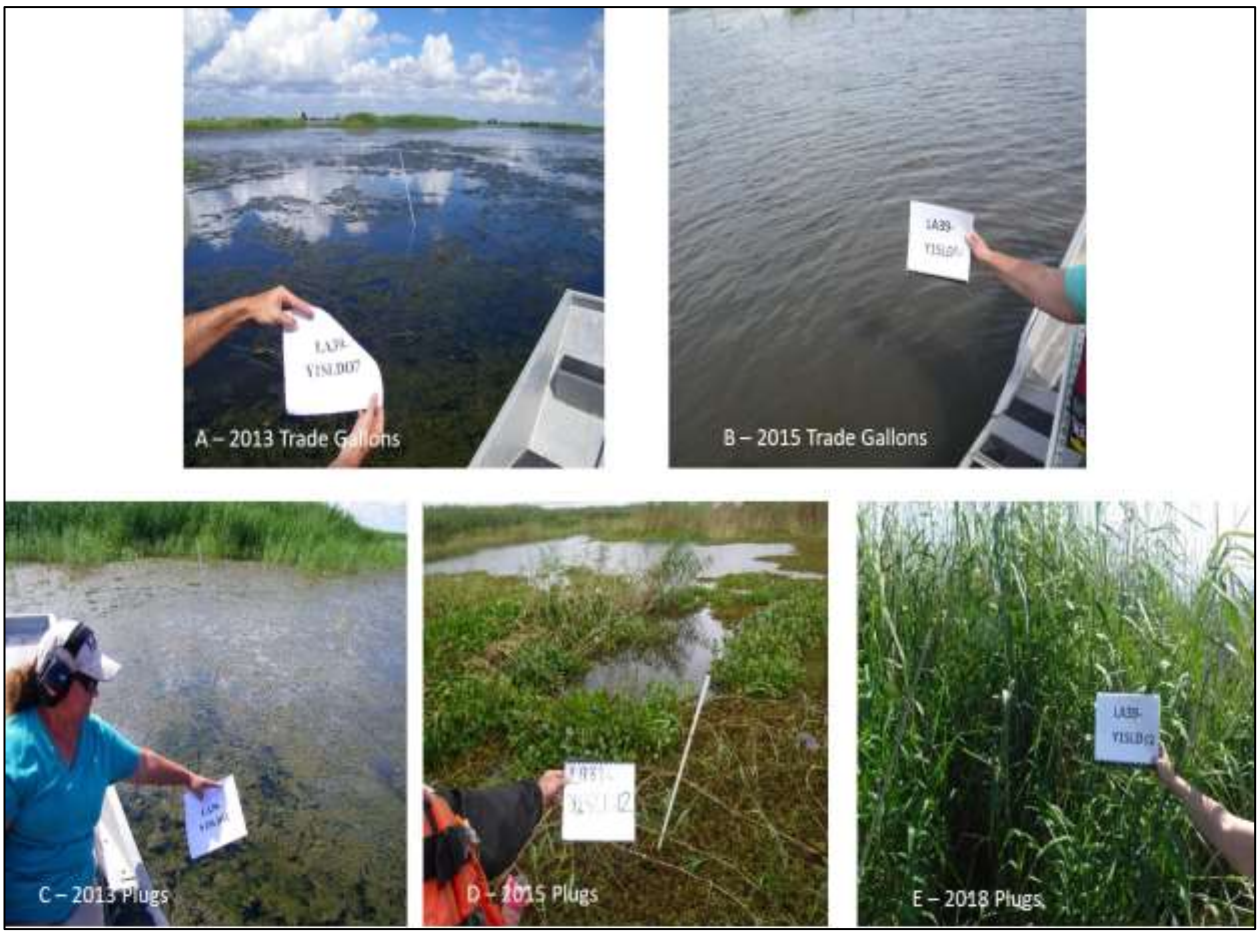

Figure III-2. Pictures of LA-0039 Year 1 South Lake DeCade Area 1 *Spartina alterniflora* Vermilion (smooth cordgrass) plantings were taken during October 2013 and 2015 monitoring trips. Top row of photos are depicting the trade-gallon sized plant plantings from 2013 (A) and 2015 (B). The bottom row of photos depicts the plug sized plantings from 2013 (C) and 2015 (D). Note algae on submerged aquatic vegetation in A and C. Also note advancement of Roseau cane from marsh edge in C (2013), onto floating vegetation in D (2015), and a solid stand in E (2018).

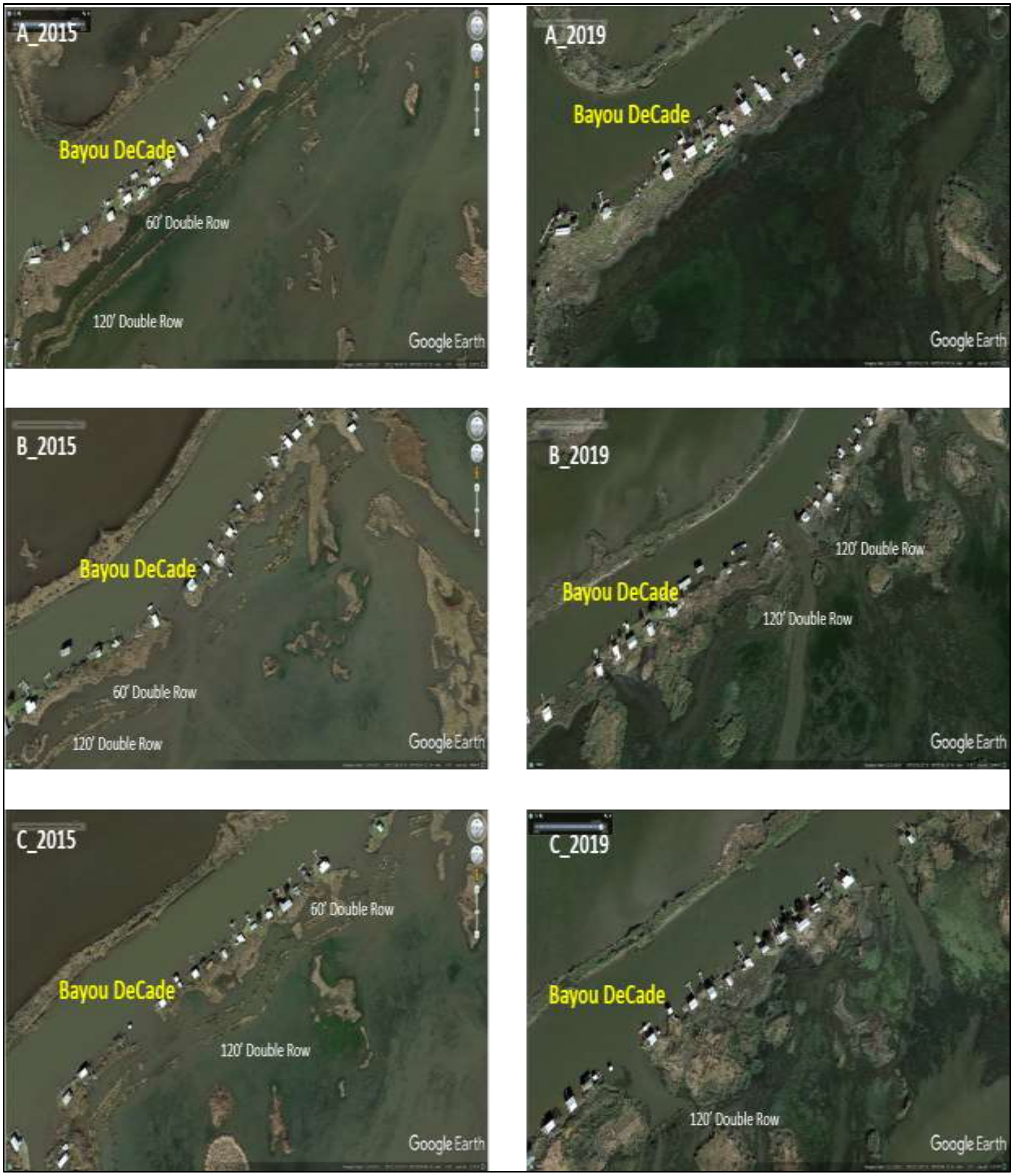

Figure III-3. Aerial imagery dated January 24, 2015 and December 11, 2019 of LA-0039 Year 1 South Lake DeCade Area 2 – Google Earth images showing Double Row Plantings of *S. californicus*. Frames A-C are oriented from southwest to northeast along Bayou DeCade. The two sets of double row plantings had good survival and expansion in 2015, but by 2019 most of the 60' rows were missing or engulfed by expanding *Phragmites australis* stands and water hyacinth mats. Remnants of the 120' double rows remained in 2019.

Figure III-4. Expansive mats of floating vegetation impacted the Area 2 by pushing over and covering Califonia bullwhips (A). Sparse and damaged plants, if any, typically remain when the mats dissipate (B). Pictures were taken during the Oct 2015 monitoring.

Figure III-5: Photo taken during the October 2018 data collection trip indicates the loss of the initial plantings installed in Area 2. The plantings in the background of the photograph are newly installed LA-0039 Year 6 DeCade Vicinity plantings.

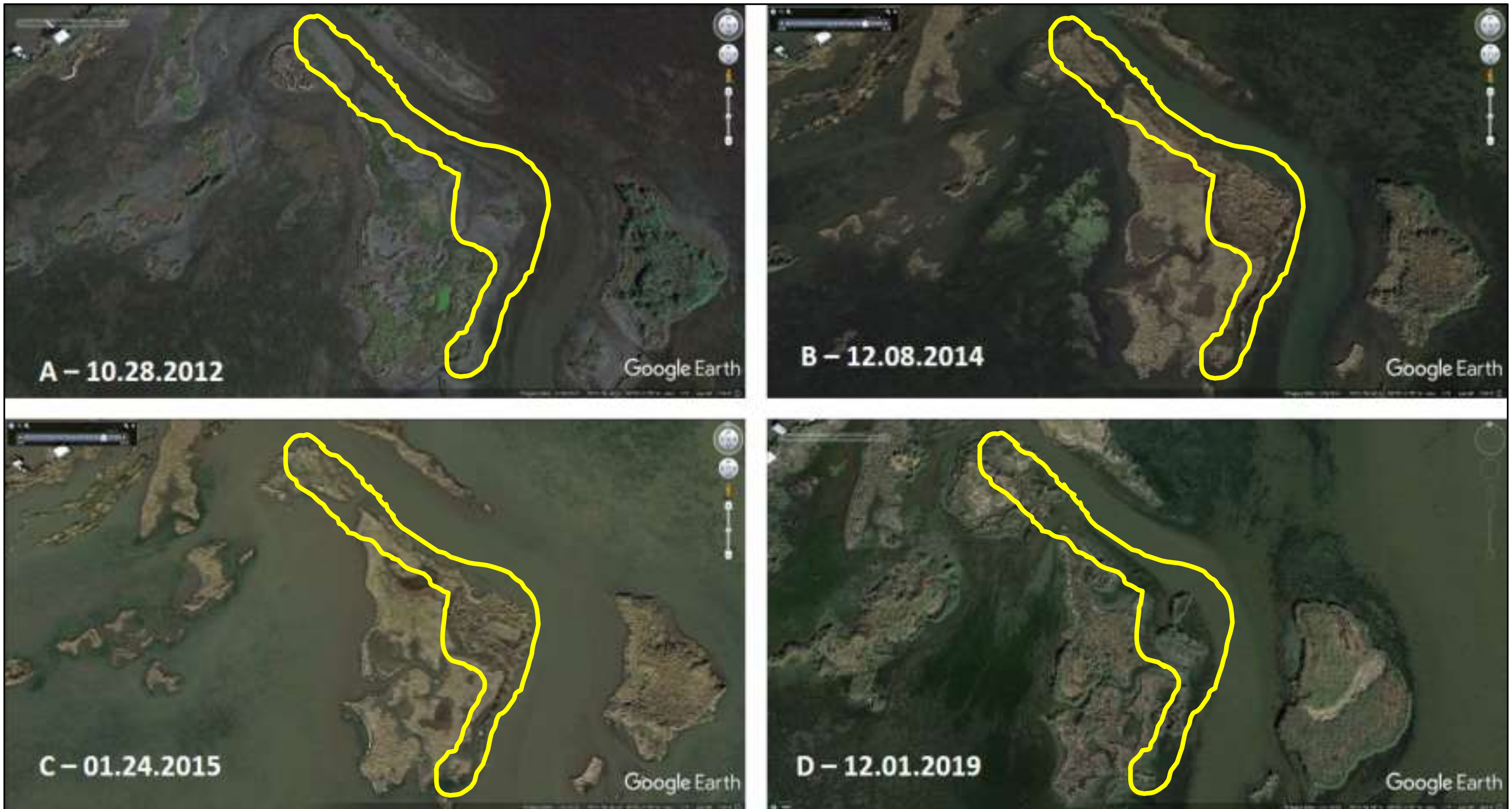

Figure III-6: A time series of LA-39 Year 1 South Lake DeCade Area 3 – Auxilary Plantings of *S. Californicus* from Google Earth displays changes since planting along and at the bend of the tidal channel running south of Bayou DeCade. Image A indicates pre-installment time frame while images B, C, and D indicate 2 years, 3 years, and 7 years post-installment time frames respectively. Plantings expanded and survived through 2015, however by 2019 the auxilary area shoreline eroded back leaving few survivors.

Vegetation station data collected over three years captured the station scale performance of the plantings. Percent survival was 0% at all Area 1 vegetation stations by one year after planting, and vegetation stations were not established in the Area 3 Auxiliary; therefore, station level analyses were only conducted for the Area 2 double rows of California bulrush, and stations from the 60 ft and 120 ft marsh double rows were combined because of performance similarities. Percent survival decreased about 30% by one year after planting and continued to decrease by another 50% to about 20% survial by three years after planting (Table III-1) because of rafting by floating vegetation (Fig. III-4). Percent cover of emergent vegetation at least doubled a year after planting (Fig. III-7A) as surviving plants expanded despite some loss caused by floating vegetation (Fig III-7). By three years after planting, emergent vegetative cover at stations showed no additional expansion driven by impacts from floating vegetation. Stem height of remaining plantings at least doubled by a year after planting and had decreased by about 1.5 ft three years after planting (Fig. III-7B). Stem heights ranged from three to nine feet depending on impacts from floating vegetation mats ranging from high to low, respectively (Fig. III-4).

In 2018 0% of the plantings remained on the station scale. As a result, no cover or height data was available. On an area scale outside of the stations, there *were* sparse survivors in Area 2 where segments of rows or single clumps remained (Table III-2, Figure III-8 and Google earth images Figure III-3).

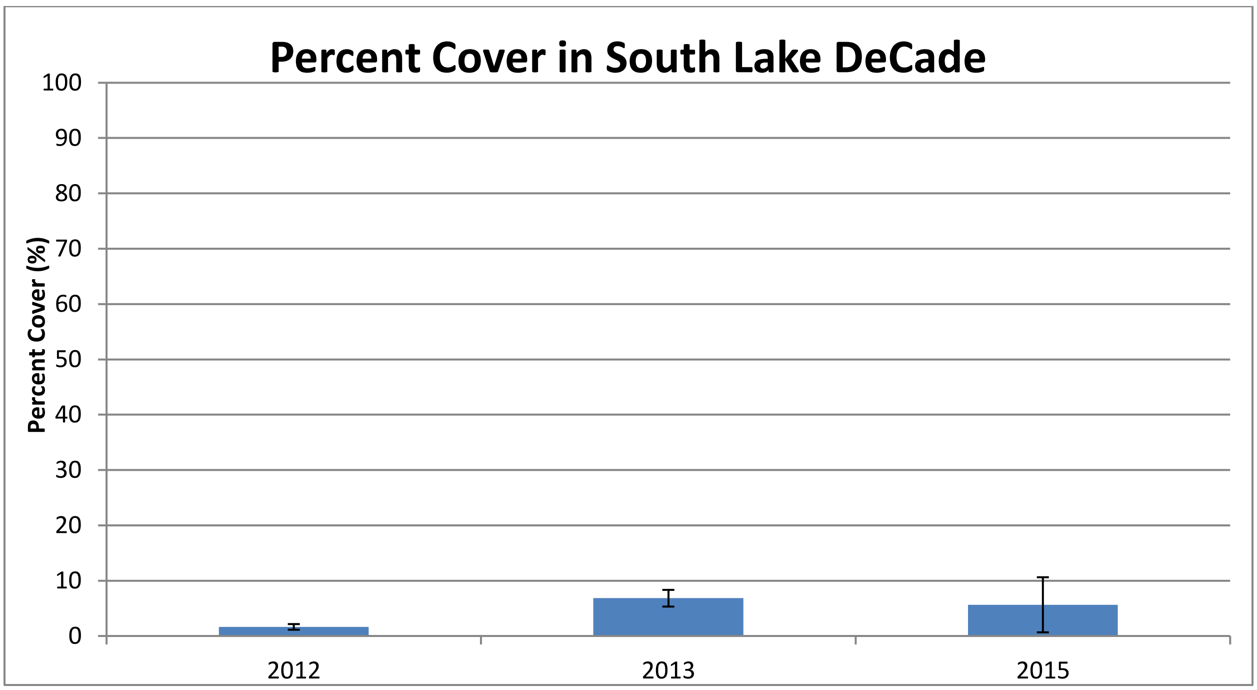

Figure III-7A. Percent cover was collected from vegetation stations in Area 2 Double Row plantings of *Shoenoplectus californicus* in the LA-0039 Year 2 South Lake DeCade site. In 2018 none of the *S. californicus* survived inside of the data collection stations, therefore no cover data was available.

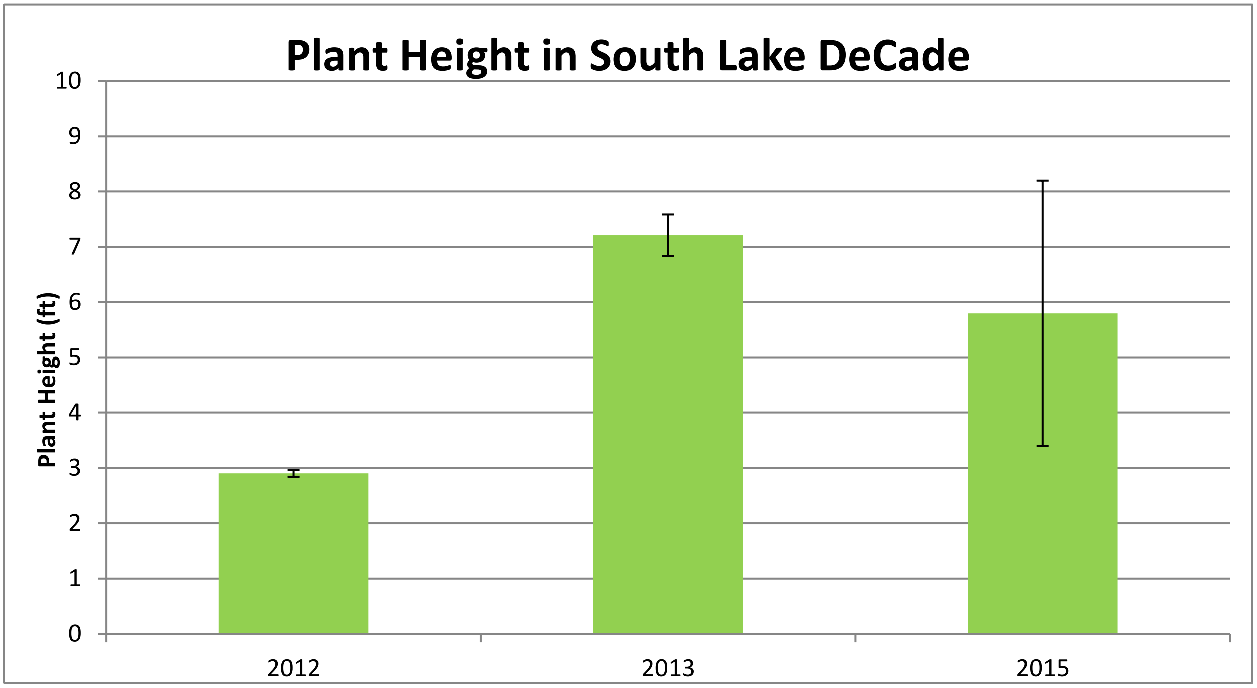

Figure III-7B. Plant height was collected from vegetation stations in Area 2 Double Row plantings of *Shoenoplectus californicus* in the LA-0039 Year 2 South Lake DeCade site. In 2018 none of the *S. californicus* survived inside of the data collection stations, therefore no height data was available for analysis.

Figure III-8. Pictures of LA-0039 Year 1 South Lake DeCade Area 2 - Double Row *Shoenoplectus californicus* (California bulrush) plantings were taken during 1 (A), 3 (B), and 5.5 (C) years after planting. Losses from the rafting of floating aquatic vegetation began prior to the 2013 sampling (A) and expanded by the 2015 sampling (B). The dead stems in B are from seasonal senescence.

b. Planting Failure Causation

Water depths were typically greater than the optimum range of 1 - 18 inches for smooth cordgrass 'Vermilion' strain establishment (Fine and Thomassie. 2000); and, the plants were constantly flooded (Fig. III-9) which causes anaerobic soil conditions that can be toxic to plant roots. Isolated plants, as planted along rows with five feet spacing between plants, are especially vulnerable to anaerobic soil conditions. Submerged and floating aquatic vegetation (SAV and FAV) rafting over the plants is another significant contributor to planting failure (Fig. III-2). Water salinity averaged around 2 ppt which is within the tolerance range of smooth cordgrass 'Vermilion' strain (8–30 ppt) and should not have been a stress factor (Fine and Thomassie. 2000). The California bulrush plantings were not stressed by the water levels or salinity. Sometime between January 2015 (Fig. III-3) and field sampling in October 2015 established stands of California bulrush were smothered out by large mats of floating invasive species, giant Salvinia and water hyacinth (Fig. III-4).

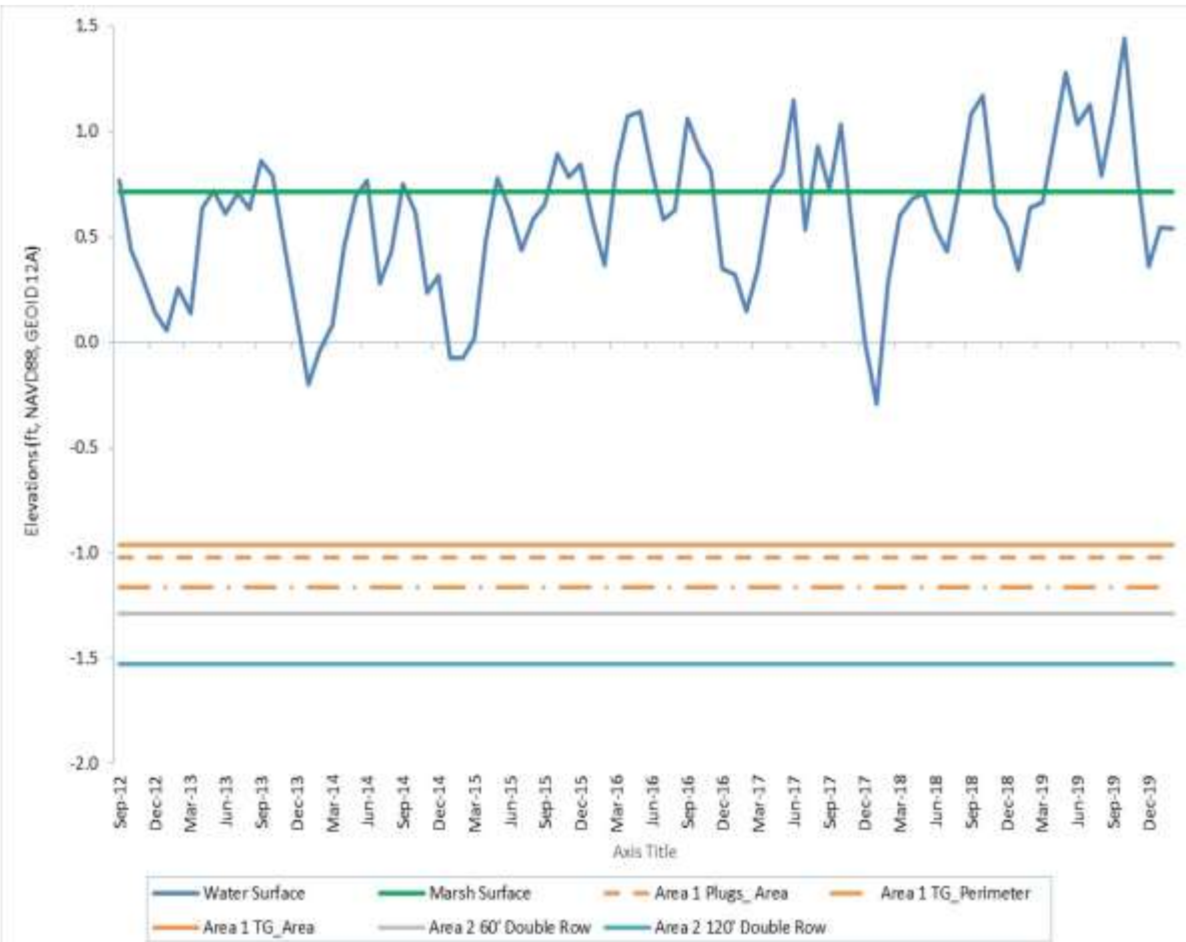

Figure III-9. Monthly averages of water-level elevations from CRMS0398-H01 are plotted relative to average planting elevations measured throughout the South Lake DeCade plantings. The Area 1 plantings were different sized (smaller plugs and larger trade gallons = TG) *Spartina alterniflora* Vermilion (smooth cordgrass), and the Area 2 plantings were TG sized *Schoenoplectus califonicus* (California bulrush). Note increased inundation during the growing seasons and the elevation of the adjacent marsh surface relative to water and planting elevations.

C. Conclusions

The Year 1 South Lake DeCade plantings had very limited success. The smooth cordgrass plantings sharply declined within the first year after planting and were completely gone by three years after planting. California bulrush plantings had successfully established and expanded over the first 2+ years; however, most of the plantings were physically destroyed and smothered by floating vegetation mats by the three-year sampling event in October 2015. Area 3 plantings adjacent to a tidal channel continued to thrive and expand by 2015, but by December 2019 had declined and succumbed to the combined effects of shoreline erosion and periods of higher water levels at longer inundation times.

1. Project Effectiveness

As per the project goals:

- Area 1 broken marsh plantings of *Spartina alterniflora* Vermilion (smooth cordgrass) plugs did not survive and expand between patches of existing marsh.
- Area 1 broken marsh perimeter plantings of trade-gallon sized smooth cordgrass did not survive and expand to reinforce the submerged and broken marsh platform.
- Area 2 double row plantings of *Schoenoplectus californicus* (California bulrush) survived and expanded to vegetate open areas; however, they were severely impacted by rafts of floating vegetation.
- Area 3 plantings of California bulrush survived and expanded to revegetate a degrading marsh platform along a tidal channel by 2015, but succumbed to shoreline erosion and the generally higher water levels which occurred thereafter.

2. Recommended Improvements

Plant mature stalks of *Phragmites australis* which is expanding in the area where smooth cordgrass was attempted.

3. Lessons Learned

The Year 1 South Lake DeCade planted smooth cordgrass and California bulrush on chronically flooded, former marsh platforms, and California bulrush performed much better. Planting of smooth coedgrass in such areas should be avoided. Planting smooth cordgrass could be useful to compliment other restoration/conservation measures that increase elevations such as marsh creation, sediment nourishment, or terracing.

Large, nearly three year old, stands of California bulrush were pushed over and smothered by floating vegetation composed mainly of giant Salvinia and water hyacinth. The occurrence of large mats of floating vegetation in recent years are attributable to recent mild winter temperatures and a decrease in nuisance floating vegetation control by the Louisiana Department of Wildlife and Fisheries along with moderate to heavy rainfall. Planning for additional resources to be implemented for floating invasive species control may need to be considered. Alternative plants that are more flexible, such as giant cutgrass (Zizaniopsis miliaceae), should be considered.

IV. Year 1 – Cameron Creole

Prepared by Tommy McGinnis – CPRA Lafayette Regional Office

A. Site and Planting Description

Cameron Creole, a Year 1 planting site, is in Cameron Parish within the USFWS Cameron Prairie National Wildlife Refuge just west of the South Prong of Grand Bayou. The refuge is hydrologically managed. The marsh in the refuge was severely damaged during Hurricanes Rita in 2005 and Ike in 2008 and has since degraded. The site is divided into four (4) areas planted with trade-gallon sized *Spartina alterniflora* Vermilion (smooth cordgrass) in a variety of planting strategies intended to stabilize existing marsh and re-establish vegetation in shallow open water areas (Fig. IV-1). The final construction inspection of the Cameron Creole planting was on June 13, 2013.

The **Northwest Area (NWA)** consists of marsh platform (~23 acres of broken marsh and mudflats) and bankline plantings (~3500 lf) along Lambert Bayou. The marsh platform plantings were planted in parallel rows 15 ft apart with plants on alternating five ft centers; the rows are on a submerging marsh platform and are roughly perpendicular to Lambert Bayou. The bankline plantings along Lambert Bayou consist of double rows spaced three ft apart with plants planted on alternating five ft centers.

The **Central Area (CA)** has five interior plantings in shallow open water and five perimeter plantings. The interior plantings consist of parallel rows 15 ft apart with plants on alternating five ft centers covering ~ 12 acres of open water. The perimeter plantings are a single row with plants planted on three ft centers around existing marsh platforms and cover ~8050 linear feet of perimeter.

The **Northeast Area (NEA)** has two techniques of interior plantings differing by row grouping and orientation to the South Prong of Grand Bayou. Triple rows are within open water and run perpendicular to South Prong; they consist of 31 sets of three rows five ft apart with plants on alternating five ft centers. The area planting that parallels the South Prong is adjacent to existing marsh in six rows planted five ft apart with plants on alternating five ft centers.

The **Southeast Area (SEA)** is an area planting parallel to the South Prong and adjacent to existing marsh just south of the NEA. SEA covers ~10 acres with parallel rows planted five ft apart with plants on alternating five ft centers.

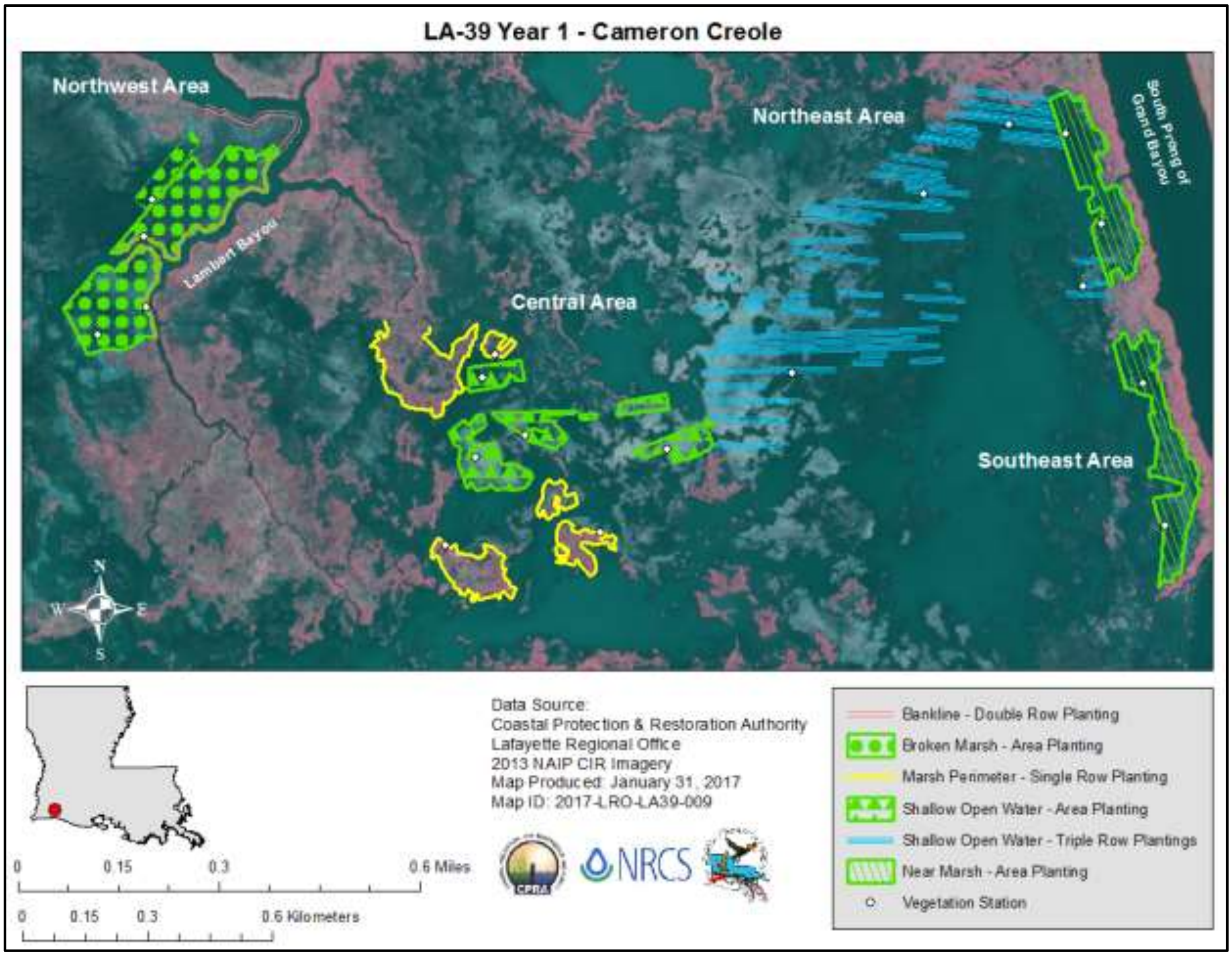

Figure IV-1. LA-0039 Year 1 Site – Cameron Creole site map shows plantings areas and types, the vegetative monitoring stations are also displayed.

B. Monitoring Activity

1. Monitoring Goals

The Year 1 Cameron Creole plantings were designed to stabilize existing marsh vegetation (bankline and perimeter plantings) and establish vegetation on large expansive mudflats and submerged marsh platforms (broken marsh interior plantings, interior, triple row, and area plantings).

The goals of the Cameron Creole plantings are:

- NWA interior plantings will survive and expand on the broken and submerging marsh platform.
- NWA bankline plantings will survive and expand to stabilize the Lambert Bayou bank.
- CA perimeter plantings will survive and expand to stabilize stands of existing marsh vegetation.
- CA interior plantings will survive and expand to form and reconnect existing stands of marsh vegetation on mudflats and submerged marsh platforms.
- NEA triple-row interior plantings will survive and expand to form bands of marsh vegetation on mudflats and submerged marsh platforms.
- NEA and SEA area plantings will survive and expand to widen vegetation along Grand Bayou onto submerged marsh platforms.
- Determine if triple row (NEA) or interior (CA) plantings are more effective at establishing marsh vegetation on mudflats and submerged marsh platforms.

2. Monitoring Elements

The monitoring elements include procedures to assess planting survival and effects on the planting area for the two main types of project plantings, existing marsh stabilization and interior area coverage. Vegetation stations are intended to monitor planting survival and vegetative cover representative of the variety of planting strategies over time (Table IV-1). Hydrologic data from nearby CRMS sites are used to explain hydrologic influences such as flooding and salinity.

Table IV-1. Sampling scheduled for LA-0039 Year 1 site, Cameron Creole.

Sampling Type	T_0 2013	T_1 2013	T_2 2014	T_3 2016	T_4 2018	T_5 2023
Planting Survival	June 13	June 25	June 24	June 23	June	Spring
Percent Cover		June 25	June 24	June 23	June	Spring

Vegetation Assessment

To assess planting status, an ocular estimate of % survival and plant condition was conducted at the station level for each area and planting type while visually inspecting the entire site during sampling visits. Planting survival and % vegetative cover data was collected at the vegetation station level; 19 stations were established to represent the areas and planting types. Percent survival was calculated from a set number of plants at each vegetation station; plants were characterized as live or dead/absent. PVC poles were placed on both ends of the plants monitored for survival. Vegetative condition was assessed by measuring % cover of species present, vegetative stand height, and height of dominant species at 4 m^2 vegetation plots at the vegetation stations (Folse et al. 2014). Flooding depth, surface water salinity and temperature, and porewater salinity and temperature were also collected at all sampling stations during each sampling event. Conditions occurring outside of the stations and segments including additional species, marsh interspersion, and site-specific points of interest were noted along with photographic documentation.

NWA – Broken Marsh Platform: Two vegetation stations were established with a PVC pole marking the SW corner along planting rows which are generally oriented west to east. The percent vegetative cover plot is a 2 × 2 m (4 m^2) plot incorporating the row, and 10 survival plants extend east along the planting row from the PVC pole.

NWA – Bankline: Two vegetation stations are oriented along the bankline double row with a PVC pole marking the beginning of the station. The percent cover plot is 4 m long × 1 m wide (4 m^2) incorporating both rows and the 10 survival plants are divided evenly between the two rows (5 plants per row).

CA - Mudflat/Shallow Openwater Grid: Four vegetation stations were established in planting grids with a PVC pole marking the SW corner along a planting row. Percent vegetative cover is determined in a 2 × 2 m (4 m^2) plot, and 10 survival plants extend east from the PVC pole divided evenly between two rows (five plants per row).

CA – Existing Marsh Perimeter: Three vegetation stations are oriented along the bankline row extending clockwise around the patch of existing marsh with a PVC pole marking the beginning of the station. The percent cover plot is 4 m long × 1 m wide (4 m^2) encompassing the single row and 10 survival plants extend in a clockwise direction.

NEA – Mudflat/Shallow Openwater Triple Row: Four vegetation stations were established among the triple row plantings marked with a PVC pole in the southwest corner along the southern most row. The percent vegetative cover is determined in a 2 × 2 m (4 m^2) plot along the southern row of plants. Fifteen survival plants are divided evenly among the three rows (five plants per row) and extend east from the PVC pole.

NEA/SEA – Mudflat/Shallow Openwater, Near-Marsh Grid: Four vegetation stations, two within the NEA and two within the SEA, were established along the north to south oriented rows with a PVC pole marking the NW corner. The percent vegetative cover is determined in 2 × 2 m (4 m^2) plot, and 10 survival plants extend in a row from the PVC pole.

Planting Failure/Success Causation

If significant loss of plants occurs, suspected causes (soil conditions, hydrologic conditions, planting removal) will be investigated. Hydrologic data from CRMS0645-H01, located just northeast of the planting site in the South Prong of Grand Bayou, will be used to describe area water-level trends and salinity. The water level data will be compared to planting elevations (ft, NAVD88, Geoid 12A) to describe flood conditions.

3. Monitoring Results and Discussion

a. Vegetation Assessment

The ocular estimates of overall planting areas captured the overall performance of the plantings. The maximum planting depth was lowered from -0.25 ft NAVD88 to -0.5 ft NAVD88 during installation because of limited planting areas higher than -0.25 ft NAVD88. Boundaries and number of plantings in the NWA broken marsh platform and CA mudflat/open water grids were modified during planting because of algae rafting on submerged aquatic vegetation (SAV, mainly *Ruppia maritima*) was immersing new plantings. A few weeks after planting, the plants looked healthy aside from some herbivory and rafting from algae and SAV. Survival a year following planting had decreased by > 90 % in all areas, and surviving plants were not expanding. Three years after planting, surviving plants were only found in patches of the NWA among previously existing plants at higher elevations, a 400 ft stretch at the northern end of NWA bankline (30% survival in that stretch), and some individual plants in the northern section of the NEA open water near marsh grid that have not expanded. (Table IV-2). The previously existing marsh in the Cameron Creole site is mainly composed of *Spartina patens* and *S. alterniflora*. Marsh vegetation has degraded in the NWA since construction, especially along the bankline of Lambert Bayou which is barely discernible. The existing marsh in the other areas has looked healthy but is eroding along the edges over the three years since planting. *Ruppia maritima* was abundant throughout the site since planting.

Table IV-2. Overall % Survival of LA-0039 Year 1 Cameron Creole plantings was ocularly estimated over time while conducting the final inspection and monitoring field trips.

		% Overall Survival			
Area	Planting Type	T_0 Jun 13, 2013	T_1 Jun 25, 2013	T_2 Jun 24, 2014	T_3 Jun 23, 2016
Northwest	Marsh Platform	100	82.5	5	1.75
	Bankline	100	92.5	5	2.5
Central	Mudflat/Open Water Grids	100	90	0.5	0
	Marsh Perimeter	100	98	6.67	0
Northeast	Open Water Triple Rows	100	88.75	0	0
	Open Water Near Marsh Grid	100	90	0.5	<1
Southeast	Open Water Near Marsh Grid	100	90	1	0

Plantings were assumed to have 100 percent survival, occupy a percentage of a 4 m^2 vegetation station based on number of plants in the cover plot, and to have 30 inch stem heights upon planting in June 2013 as per planting specifications. Vegetation station data collected over three years captured the performance of the plantings. Station level percent survival was similar to overall percent survival from the ocular estimates. Percent vegetative cover a couple of weeks following the final planting inspection was similar to assumed coverage during planting for most planting combinations. Percent vegetation cover was, or was nearing, 0 percent for all combinations by 1 year following planting except for the CA perimeter plantings which also included previously existing marsh vegetation. By three years following planting, stations along the CA perimeter were 0% as the existing marsh had eroded back 3-6 feet from the original planting alignment (Fig. IV-2A and B). Note the changes in the area pictures from June 2013 and later (Figs. IV3-9).

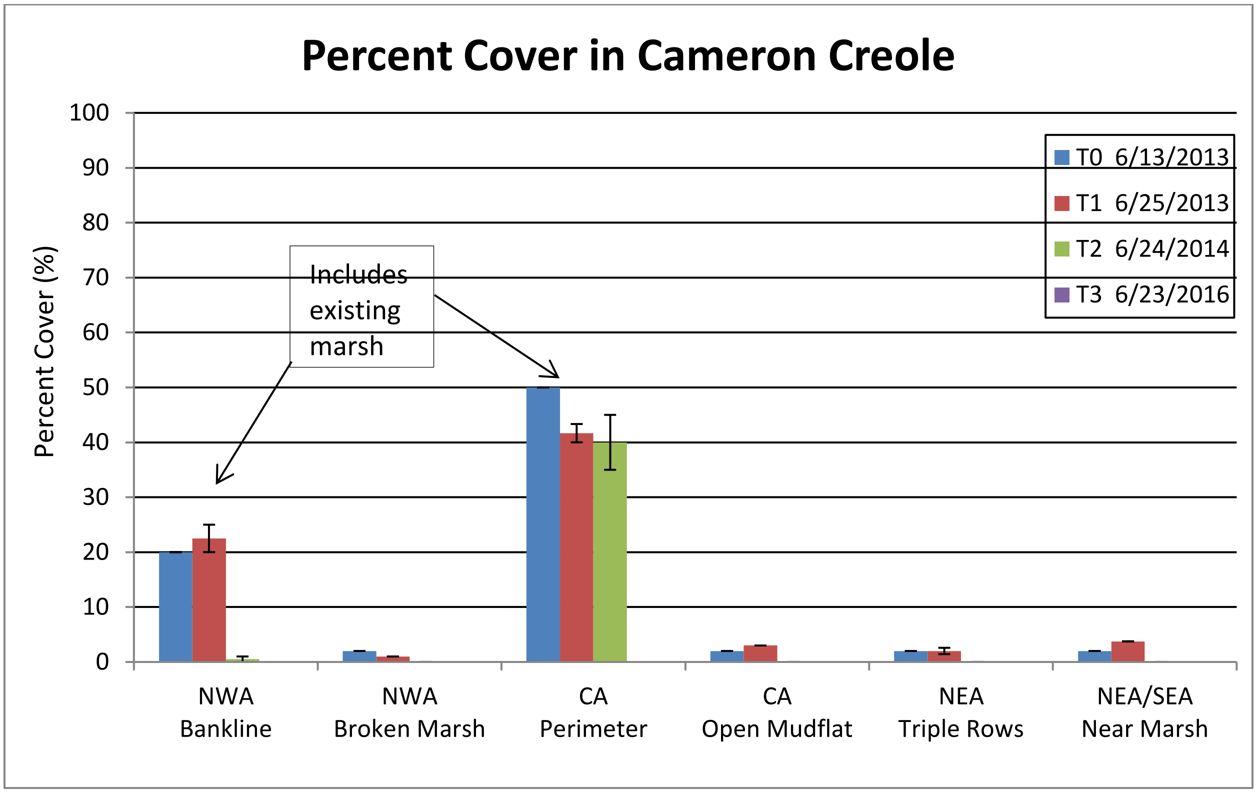

Figure IV-2A. Station scale percent cover was collected from different area and planting type groups within LA-0039 Year 1 Cameron Creole over three years.

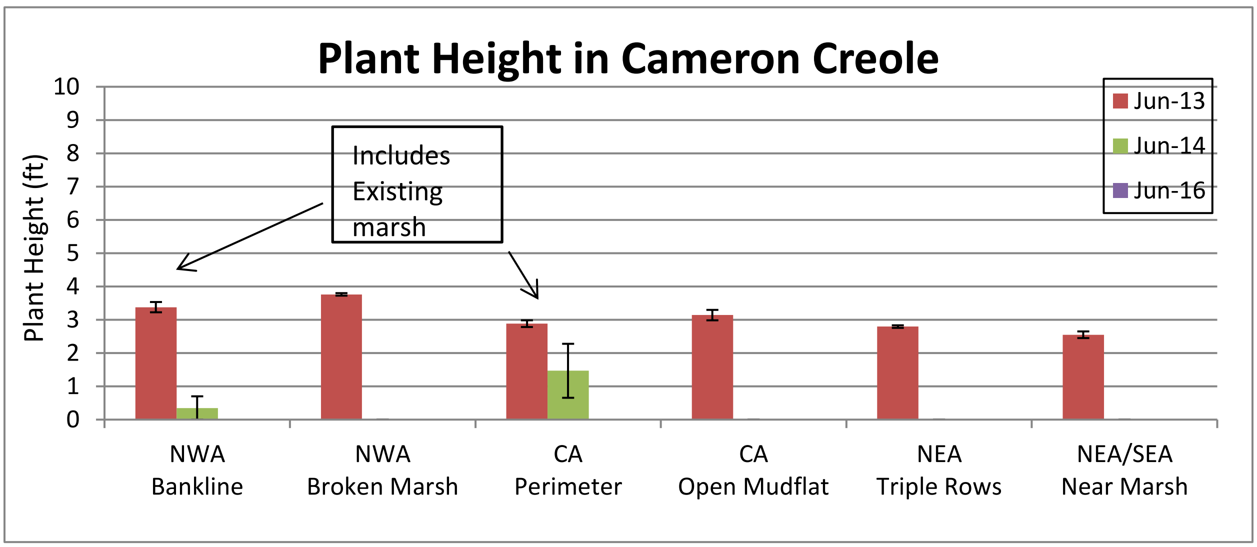

Figure IV-2B. Station scale plant height was collected from different area and planting type groups within LA-0039 Year 1 Cameron Creole over three years.

Figure IV- 3. A double row of *Spartina alterniflora* Vermilion was planted to stabilize the Lambert Bayou shoreline in the Northwest Area of the LA-0039 Year 1 Cameron Creole site in June 2013 (A). Most of the plantings were absent a year later in June 2014 (B).

Figure IV- 4. *Spartina alterniflora* Vermilion was planted on a broken marsh platform in the Northwest Area of the LA-0039 Year 1 Cameron Creole site in June 2013 (A). Most of the plantings were absent a year later in June 2014 (B).

Fig 1V- 5. *Spartina alterniflora* 'Vermilion' strain was planted around patches of existing marsh in the Central Area of the LA-39 Year 1 Cameron Creole site in June 2013 (A). Most of the plantings were absent a year later in June 2014 (B). The marsh edge eroded 3-9 ft by June 2016 (C); the poles represent the original planting position.

Figure IV- 6. *Spartina alterniflora* Vermilion was planted in shallow open water/former mudflats between patches of marsh in the Central Area of the LA-0039 Year 1 Cameron Creole site in June 2013 (A). Note algae rafts on SAV in A. All of the plantings were absent a year later in June 2014 (B); SAV was still present although algae were reduced. G# represents different planting grids.

Figure IV- 7. Triple rows of *Spartina alterniflora* Vermilion was planted in shallow open water/former mudflats in the Northeast Area of the LA-0039 Year 1 Cameron Creole site in June 2013 (A). Note some algae rafts on SAV in A. All of the plantings and most pedestals of marsh vegetation were absent a year later in June 2014 (B); SAV was still present although algae were reduced. Paired numbers and "Aux" represent sets of triple rows.

Figure IV- 8. Rows of *Spartina alterniflora* Vermilion were planted in shallow open water/former mudflats near marsh in parallel to the South Prong of Grand Bayou in the Northeast Area (A). Most of the plantings were absent and most pedestals of marsh vegetation were collapsing a year later in June 2014 (B). Note 6'4" Bernard Wood (CPRA) for scale (A). SAV was present in both years.

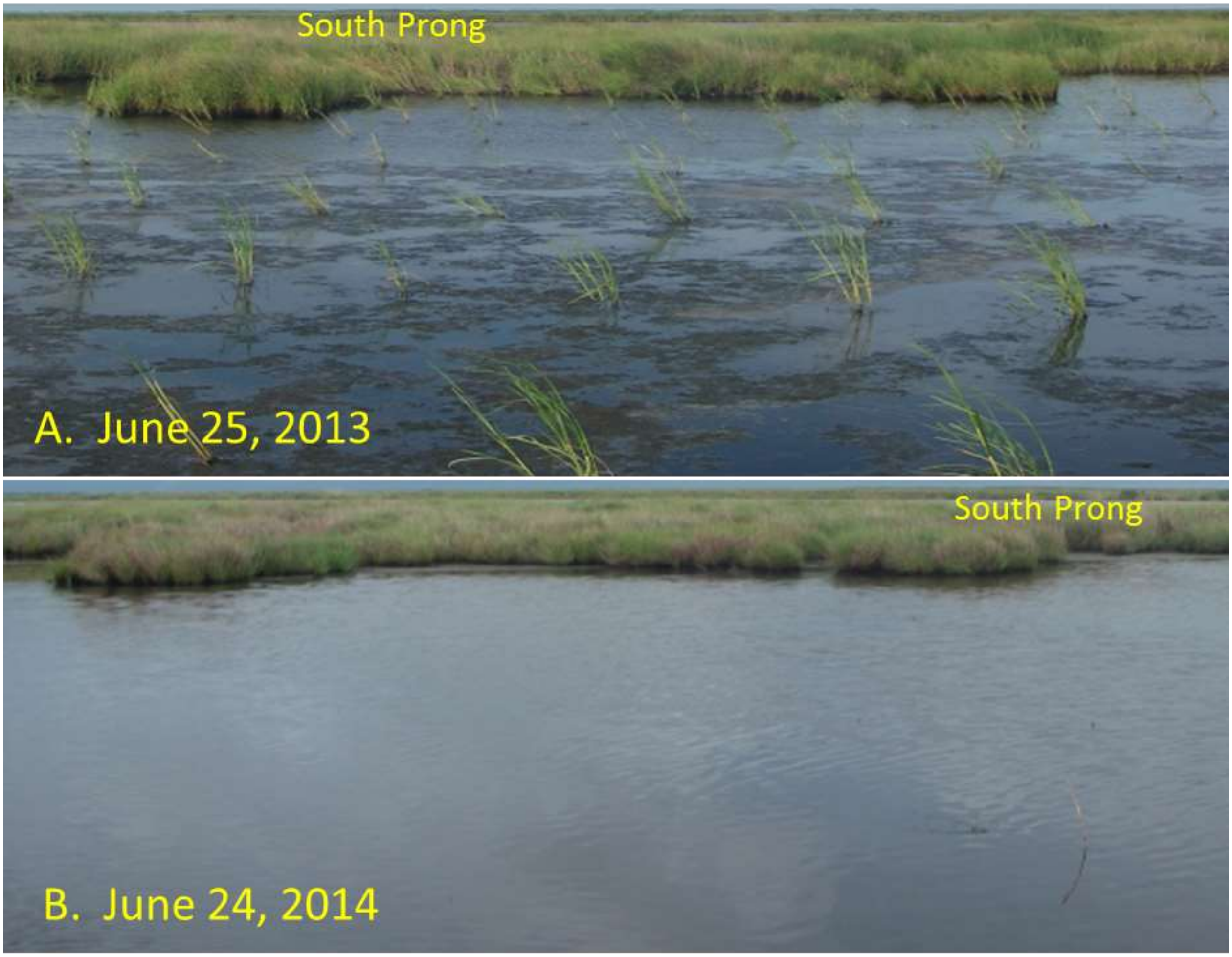

Figure IV- 9. Rows of *Spartina alterniflora* Vermilion were planted in shallow open water/former mudflats near marsh in parallel to the South Prong of Grand Bayou in the Northeast Area (A). Note some algae rafts on SAV in A. Most of the plantings were absent a year later in June 2014 (B); SAV was still present although algae were reduced.

b. Planting Failure/Success Causation

Failure of the Cameron Creole plantings was caused by chronic flooding of mostly stagnant water (Fig. IV-10). Chronic flooding causes anaerobic soil conditions that can be toxic to plant roots. Isolated plants, planted along rows with five ft spacing between plants, are especially vulnerable to anaerobic soil conditions. Of the existing marsh, higher elevation vegetation within larger patches was healthy throughout the monitoring period whereas isolated pedestals of vegetation and plantings diminished (Fig. IV-11). Rafting by algae and SAV physically damaging the plants is another contributor to planting failure; however, algal rafting was not as widespread throughout the site as the planting failure. Water salinity averaged 7.9 ± 5.2 ppt within a range of 0.4 – 22.5 ppt which is within the tolerance range of smooth cordgrass (Vermilion) and should not have been a stress factor (Fine and Thomassie 2000).

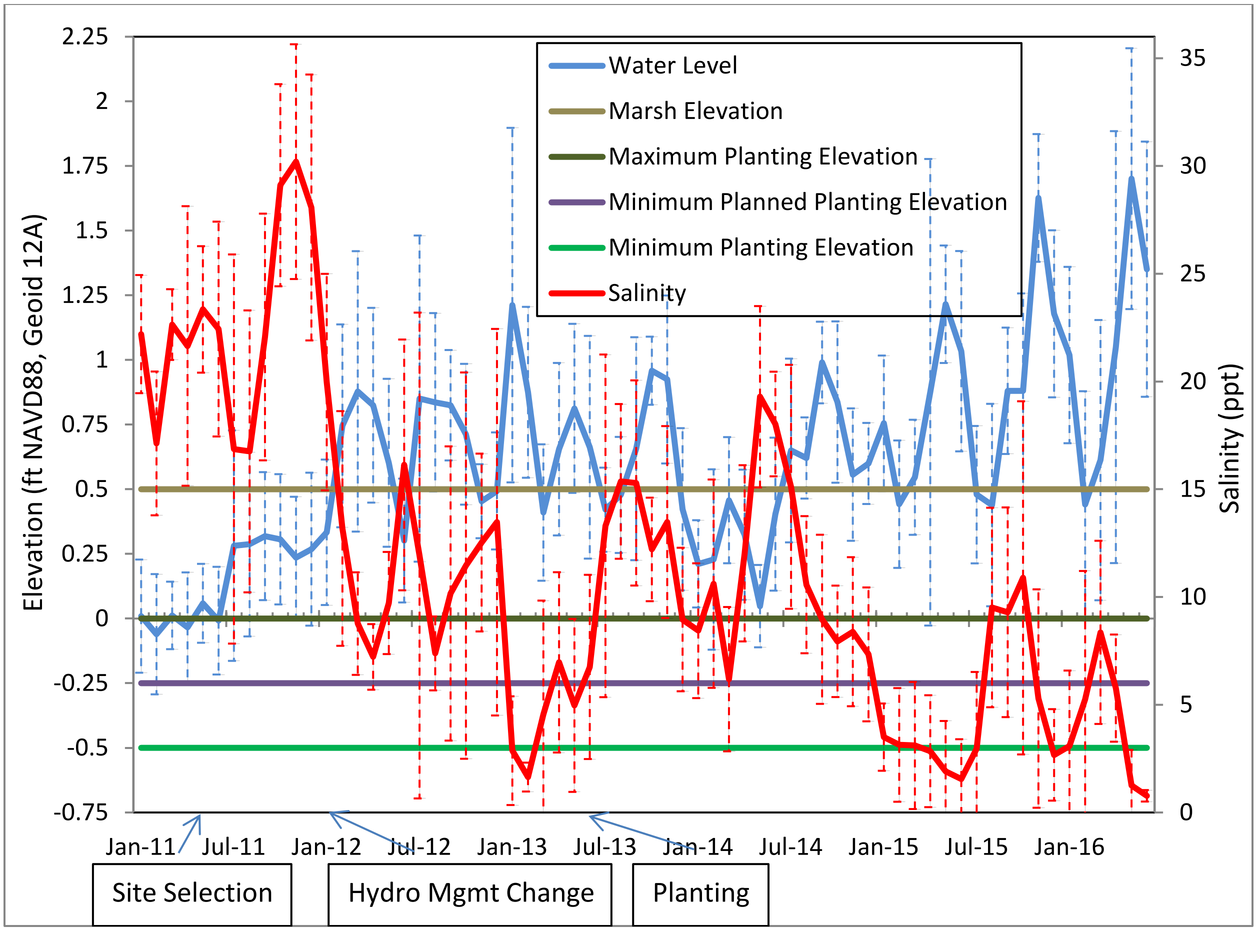

Figure IV-10. Monthly averages of water-level elevations and salinity from CRMS0645-H01 are plotted relative to average plant elevations for the Cameron Creole plantings. The Maximum Planting elevations were typical for the plantings within and around the broken marsh (Northwest Area and Central Area Perimeters) while the Minimum Planting elevations were typical for all other planting areas. Major events were noted along the x-axis.

Figure IV-11. Higher elevation vegetation in larger patches fared better than lower elevation vegetation such as the individual plantings and pre-existing pedestalled vegetation.

Climatic and watershed management conditions changed from site selection in May 2011 to the time of planting and monitoring (June 2013-2016), water levels were lower and salinities were higher in 2011 than in 2012-2016 (Fig. IV-10). In 2011, the Cameron Creole area was in a drought that lasted into early 2012 and did not return through 2016 (NOAA 2011-2016). Coincidentally, the Cameron Creole watershed resumed hydrologic management to maintain lower salinity on January 1, 2012 which also increased water levels. Areas that were mudflats with sprouting smooth cordgrass during initial site selection in May 2011 (Fig. IV-12) converted to open water supporting vigorous submerged aquatic vegetation by the time of planting in June 2013 (Figs. IV4-8). Minimum planting elevations were lowered from -0.25 ft NAVD 88 to -0.5 ft NAVD 88, which was still within the reported tolerance of Vermilion smooth cordgrass (Fine and Thomassie. 2000), to accommodate the lowering of elevation at the site.

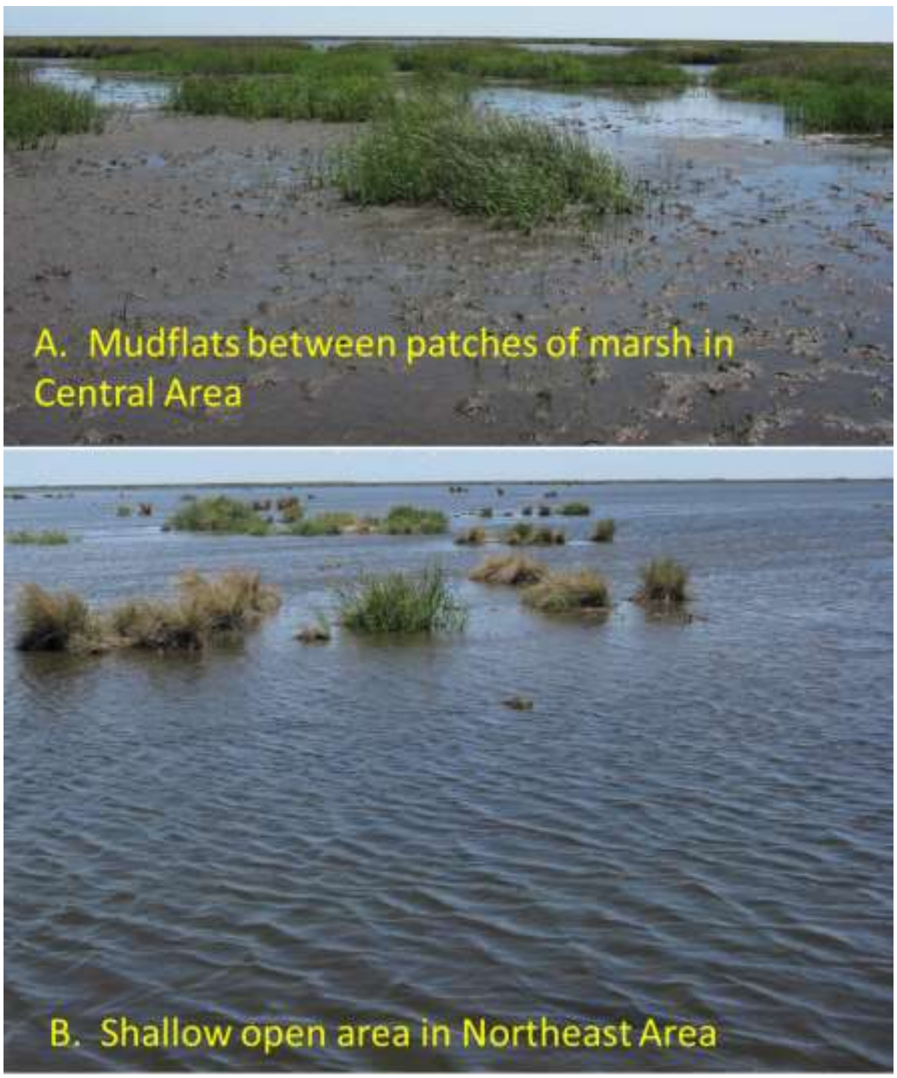

Figure IV-12. The LA-0039 Year 1 Cameron Creole site was initially visited on May 4, 2011; water levels were ~0.16 ft NAVD88 which was about 0.5 ft below average marsh elevation at that time. (A) Note sprouting *Spartina alterniflora* on mudflats. (B) Water was 2-4 inches deep throughout open areas, and no SAV was established.

C. Conclusions

The Year 1 Cameron Creole plantings were not successful. Marshes within the Cameron Creole watershed have degraded since Hurricanes Rita and Ike, and the planting site has been chronically flooded since 2012. While this has allowed for a dramatic increase in the SAV population it correspondingly flooded the newly planted area with water further lowering the soils redox potential (Eh).

1. Project Effectiveness

As per the project goals:

- NWA interior plantings did not survive and expand on the broken and submerging marsh platform.
- NWA bankline plantings did not survive and expand to stabilize the Lambert Bayou bank.
- CA perimeter plantings did not survive and expand to stabilize stands of existing marsh vegetation.
- CA interior plantings did not survive and expand to form and reconnect existing stands of marsh vegetation on mudflats from submerged marsh platforms.
- NEA triple-row interior plantings did not survive and expand to form bands of marsh vegetation on mudflats from submerged marsh platforms.
- NEA and SEA area plantings did not survive and expand to widen vegetation along Grand Bayou onto submerged marsh platforms.
- Neither triple row (NEA) nor interior (CA) plantings were effective at establishing marsh vegetation on mudflats from submerged marsh platforms.

2. Recommended Improvements

Avoid planting smooth cordgrass in chronically flooded areas with little water movement.

3. Lessons Learned

The Year 1 Cameron Creole planting attempted to establish smooth cordgrass in degraded coastal marsh conditions, permanently flooded shallow open ponds/open water areas with unconsolidated organic soils, for which vegetative plantings as a stand-alone technique may not provide a solution. Planting in such areas could be used to compliment other restoration/conservation measures to increase elevations such as marsh creation, sediment nourishment, or terracing.

Planting conditions worsened considerably over the two years from the site selection trip in May 2011 to planting in June 2013 as the area switched from promising mudflats with sprouting vegetation to chronically flooded water bottoms with firmly established SAV. After conducting elevation surveys, original plans were altered to select the more conducive areas remaining. Planners could have further reduced the planting effort to test sections.

V. Year 1 – Marsh Island

Prepared by Tommy McGinnis – CPRA Lafayette Regional Office

A. Site and Planting Description

Marsh Island, a Year 1 planting site, is in Iberia Parish between Vermilion Bay and the Gulf of Mexico; it is a wildlife and game refuge managed by the Louisiana Department of Wildlife and Fisheries. The Marsh Island plantings are comprised of two planting areas, the northern shoreline of Marsh Island (Northern Shore Plantings, NSP) and interior marsh blown out by previous hurricanes along West Branch Oyster Bayou in the southeastern part of the island (Oyster Bayou Plantings, OBP). The Year 1 Marsh Island plantings were designed as trials because wave conditions along the northern shoreline are harsh for plant survival and a previous attempt to plant the Oyster Bayou areas had failed.

North Shore Plantings (NSP)

The NSP are short segments located along a 6.5 mile stretch of shoreline centrally located along the northern shoreline of Marsh Island (Fig. V-1a). The northern shoreline receives direct waves from Vermilion Bay which resulted in a mean erosion rate of 14 ft/yr from the 2004 to 2012 ranging from 0-81 ft/y depending on location (Byrnes et al. In Press). The NSP consists of three strategies: open shoreline protection, shoreline enhancement behind foreshore-rock dikes, and pond area coverage near the shoreline:

The **open shoreline** plantings are short segments in 6 reaches of the northern shoreline (Fig. V-1a). Trade-gallon sized *Spartina alterniflora* Vermilion (smooth cordgrass) was planted in a row of plants on 5 ft centers as close as possible to the existing marsh no deeper than 0.0 ft NAVD88, and every other plant was anchored with a metal reinforcement rod. The Bayou Platte East reach had a wider submerged platform resulting in room for an additional row staggered 5 feet from the near-shore row resulting in 2.5 ft centers between rows. In total, 1,389 plants were planted on 6,335 linear feet (1.2 miles) of shoreline which was 18 % of the available shoreline.

The **protected shoreline** plantings behind the foreshore rock dikes are located along opposing banks of the mouth of Bird Island Bayou (Fig. V-1a). Double rows of trade-gallon sized *Schoenoplectus californicus* (California bulrush) were planted 20 ft apart with plants spaced on alternating 5 ft centers. The center line of the double rows were positioned parallel to and 10-40 feet from the existing shoreline no deeper than -1.0 ft NAVD88, and alternating plants within each row were anchored. 5,830 linear feet of double rows consisting of 1,166 plants covered 2,915 linear feet of shoreline.

The **pond area** plantings are located south of the Bayou Michael East segments in a small pond vulnerable to the influence and flooding of Vermilion Bay (Fig. V-1a). Smooth cordgrass trade gallons were planted in parallel rows with plants on 7 ft alternating centers 10 ft apart no deeper than -0.25 ft NAVD88. The rows were oriented west to east.

Oyster Bayou Plantings (OBP)

The OBP are located in open water, hurricane blowout areas north and south of West Branch Oyster Bayou which runs southeast from Oyster Lake (Fig. V-1b). The plantings consist of 13, single test rows with plants on 5 ft centers; the rows consist of different species and/or plant sizes. Planting elevation limits were -0.5 ft NAVD88 for smooth cordgrass trade gallons, -0.25 ft NAVD88 for smooth cordgrass plugs, and no limit established for *Juncus roemerianus* (black needlerush). Rows 1-10 are oriented west to east across the blown out areas, and rows 11-13 are oriented perpendicular to hydrologic connections with Oyster Bayou.

***Spartina alterniflora* Vermilion (smooth cordgrass) trade-gallons** were planted in a deeper section of row 2 (segment 2B). 196 plants covered 980 linear feet.

***Spartina alterniflora* Vermilion (smooth cordgrass) trade-gallons and vegetative plugs** were planted in alternating fashion in 11 rows. 1725 plants covered 9695 linear feet.

Smooth cordgrass trade-gallons, smooth cordgrass vegetative plugs, and *Juncus roemerianus* (black needlerush) trade gallons were planted in alternating fashion in two rows. 524 plants covered 3100 linear feet.

An **auxiliary planting** with extra smooth cordgrass trade gallons (141 plants), smooth cordgrass plugs (140 plants), and black needlerush trade gallons (33) was planted in the northern blown out section.

Figure V-1a. LA-0039 Year 1 Site – Marsh Island North Shore plantings site map showing location of plantings and vegetative monitoring stations. Metal anchors were used to secure every other plant in all reaches except Bayou Michael Pond.

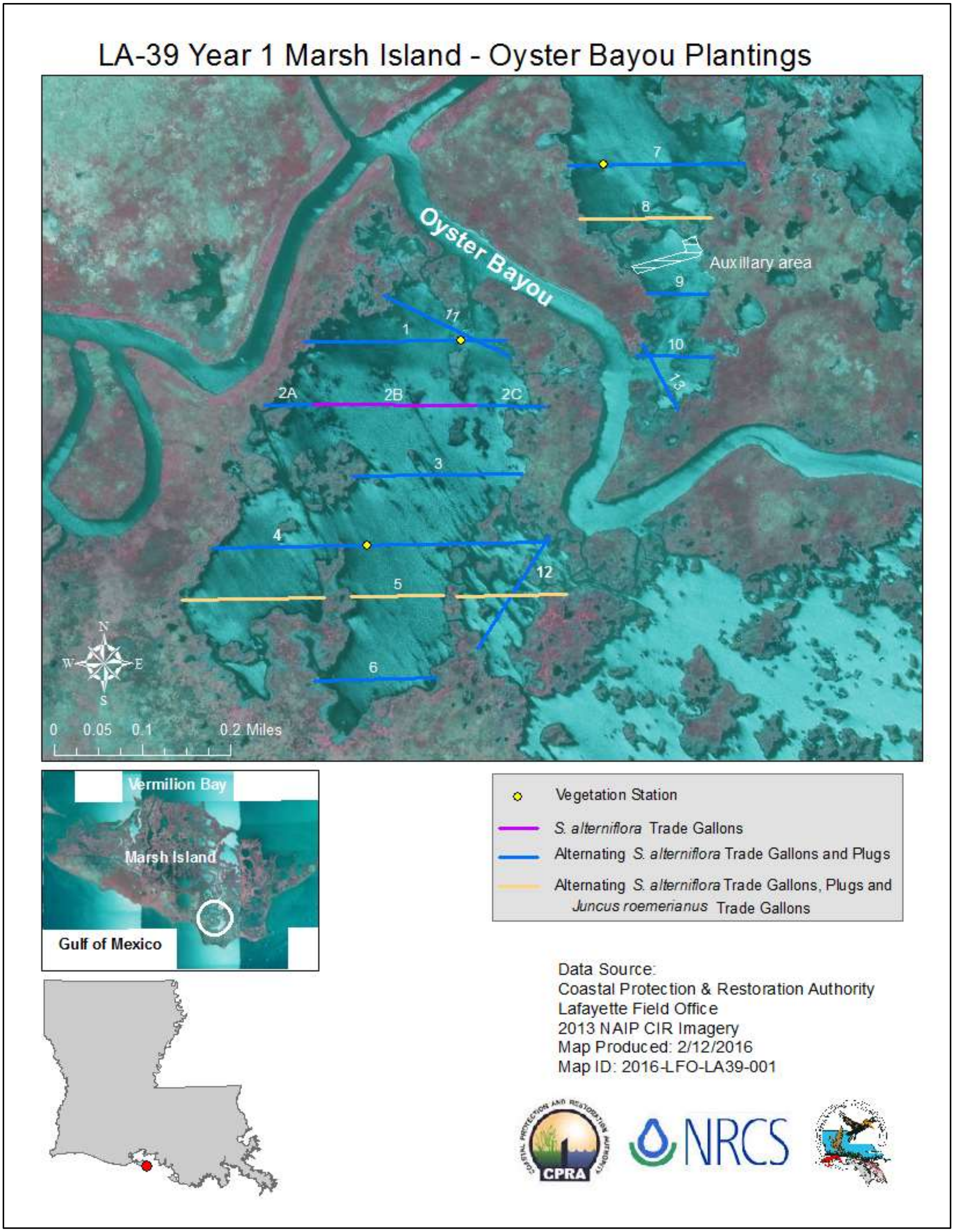

Figure V-1b. LA-0039 Year 1 Site – Marsh Island Oyster Bayou Plantings site map showing location of plantings and vegetative monitoring stations.

B. Monitoring Activity

1. Monitoring Goals

The Year 1 Marsh Island plantings were designed as trials because conditions along the northern shoreline are harsh for plant survival and a previous attempt to plant the Oyster Bayou areas failed.

The goals of the Marsh Island plantings are to determine if:

- Plantings along the northern, open shoreline along a large bay are feasible.
- Anchoring plants help to secure plantings in open shoreline conditions.
- Plantings behind a foreshore dike at a lower elevation along a large bay are feasible.
- Plantings in lower elevation areas of former marsh blown out by storms are feasible.
- Plant size or species affects planting survival in lower elevation areas of former marsh blown out by storms.

2. Monitoring Elements

The monitoring elements include procedures to assess planting survival and effects on the planting area for the two main types of project plantings, shoreline protection and interior area coverage. Vegetation stations were intended to monitor planting survival and vegetative cover representative of the variety of planting strategies within the NSP (open/protected shorelines, single/double row plantings, anchored/nonanchored plants) and OBP (plant species, plant sizes, and depths) areas over time. However, locations with surviving plants were targeted for sampling stations because planting survival was extremely low (<5% in the NSP and 0% in OSP) at the initial monitoring (T_1) trip on June 3, 2013, seven weeks following the planting inspection (T_0). Because of the trial nature and anticipated harsh conditions of the Marsh Island plantings, the monitoring schedule was compressed to allow for higher frequency sampling of planting survival within the first two years (Table V-1). Sampling was suspended after the second monitoring trip (T_2) on December 18, 2013 because planting survival was 0% with the exception of 1 surviving plant in the Bayou Michael Pond.

Table V-1. Sampling scheduled for LA-0039 Year 1 site, Marsh Island. Sampling was discontinued because survival was 0% in Dec 2013.

Sampling Type	T_0 2013	T_1 2013	T_2 2013	T_3 2014	T_4 2014	T_5 2015	T_6 2018
Planting Survival	April	June	Dec	Spring	Fall	Spring	Spring
Percent Cover		June	Dec	Spring	Fall	Spring	Spring
Mapping		June					Spring

<u>**Vegetation Assessment**</u>

To assess planting status an ocular estimate of survival and plant condition was conducted for each reach, segment, and/or row. Planting survival and vegetative cover data was also collected at the vegetation station level; stations were established among remaining live plants. Percent survival was calculated from a set number of plants at each vegetation station; plants were characterized as live or dead/absent. PVC poles were placed on both ends of the plants monitored for survival. Vegetative condition was assessed by measuring % cover of species present, vegetative stand height, and height of dominant species at 4 m^2 vegetation plots at the vegetation stations (Folse et al. 2014). Flooding depth, surface water salinity and temperature, and porewater salinity and temperature was also collected at all sampling stations during each sampling event. Conditions occurring outside of the stations and segments including additional species, marsh interspersion, and site-specific points of interest were noted along with photographic documentation.

NSP - Open Shoreline: Six stations were established among the shoreline reaches, targeting live plantings. Percent survival of 10 plants per station and % cover data were recorded at each station. At each station, 5 anchored and 5 unanchored plants were monitored for presence (live or dead)/absence in order to compare the effectiveness of anchoring plants in a high wave-energy environment. Monitoring was suspended after Dec 2013 field trip as survival reached 0%.

NSP - Protected Shoreline: Initially, four stations were to be divided among the California bulrush plantings along the two banks at the mouth of Bird Island Bayou. At each station, 5 anchored and 5 unanchored plants were to be monitored to compare the effectiveness of anchoring plants in a low wave-energy environment. The intent of planting double rows spaced 20' apart is that the rows would eventually grow together to strengthen wind-fetch disruption; therefore, the space between the rows was planned to be measured at each station. However, no plantings survived behind the rock dike; therefore, no sampling stations were established. The area was re-evaluated during the Dec 2013 field trip, and no plantings were found.

NSP - Pond Coverage: Low planting survival was observed during the June 2013 monitoring; therefore, two stations targeting the two areas along the shallow bank with live planting were established. Sampling was suspended following the Dec 2013 field trip although one plant remained.

OBP – Hurricane Blowout Areas: Initially, ten percent survival and cover stations were to be dispersed among combinations of species, planting sizes, and planting elevations throughout the two areas to assess differential survival and cover among the combinations. The four stations among the different-sized smooth cordgrass plantings and black needle rush plantings (rows 5 and 8) were to consist of 15 plants per station rather than 10 for monitoring survival to account for 3 planting types. Although some dead stems were present, no live stems in were found in either area during the June 2013 monitoring; therefore, one station was established in each area. The OBP was re-evaluated during the Dec 2013 fieldtrip; no stems, live or dead, were found. Three soil cores were collected (two in the southern area and one in the northern area) to observe soil physical conditions.

Planting Failure/Success Causation

Hydrologic data from CRMS0520-H01 for the NSP and CRMS0499-H01 for the OBP was used to describe area water-level trends and salinity. The water level data was tied to water depths collected within the planting areas to convert water depth (ft) to planting elevations (ft, NAVD88 Geoid 12A) and calculate flood parameters (levels, duration, and frequency).

3. Monitoring Results and Discussion

a. Vegetation Assessment

The ocular estimates of overall planting areas captured the large scale poor performance of the plantings, as the cautious approach to planting in known harsh environments was validated. Survival two months following planting was sparse in the NSP and non-existent in the OBP. The low survival in the NSP was variable among segments during the June 2013 sampling. Survival was 0% across all areas by the December 2013 sampling, eight months after planting in April 2013 (Table V-2).

Table V-2. Overall % Survival of LA-0039 Year 1 Marsh Island plantings over time. Open Shoreline and Pond Area plantings in Northern Shoreline plantings (NSP) were *Spartina alterniflora* Vermilion (smooth cordgrass) trade gallons, and the Protected Shoreline was *Schoenoplectus californicus* (California bulrush) trade gallons. The Oyster Bayou plantings were trade gallon sized and plugs of Vermilion smooth cordgrass and trade gallon sized *Juncus roemerianus* (black needlerush).

		% Overall Survival		
Plantings	Types	T_0 Apr 2013	T_1 Jun 2013	T_2 Dec 2013
NSP	Open Shoreline	100	15	0
	Bayou Michael East	100	1	0
	Bayou Platte West	100	10	0
	Bayou Platte East - Single	100	5	0
	Bayou Platte East - Double	100	10	0
	Joe Aucoin Bayou West	100	30	0
	Joe Aucoin Bayou East	100	15	0
	Protected Shoreline	100	0	0
	Pond Area	100	1	~0 (1 stem)
OBP	Smooth Cordgrass Trade Gallons	100	0	0
	Smooth Cordgrass Plugs	100	0	0
	Black Needlerush Trade Gallons	100	0	0

Surviving plantings during the first sampling in June 2013 in North Shore open shoreline and pond area were targeted for vegetation station locations to quantify changes in plant survival, percent cover, and stem heights over time (Figs. V-2A and B). Plantings were assumed to have 100 percent initial survival, occupy ~5% of a 4 m^2 vegetation station, and to average 27 inch stem heights upon planting in April 2013 as per planting specifications. Percent survival sharply declined by the first sampling in June 2013 and continued to decline towards 0% by the December 2013 sampling. Vegetative cover initially shrank to ~ 1 percent by two months after planting and also continued to decline towards 0% at eight months after planting. Surviving plants did not grow after planting as stem heights decreased by 77% along the open shoreline and 55% in the pond area. Surviving plants were impacted by herbivory and wave damage (Fig. V-3). By the December 2013 sampling, the northern shoreline had eroded 10-20 feet (Fig V-4), and there was only a single surviving stem, located in the pond area (Fig. V-5).

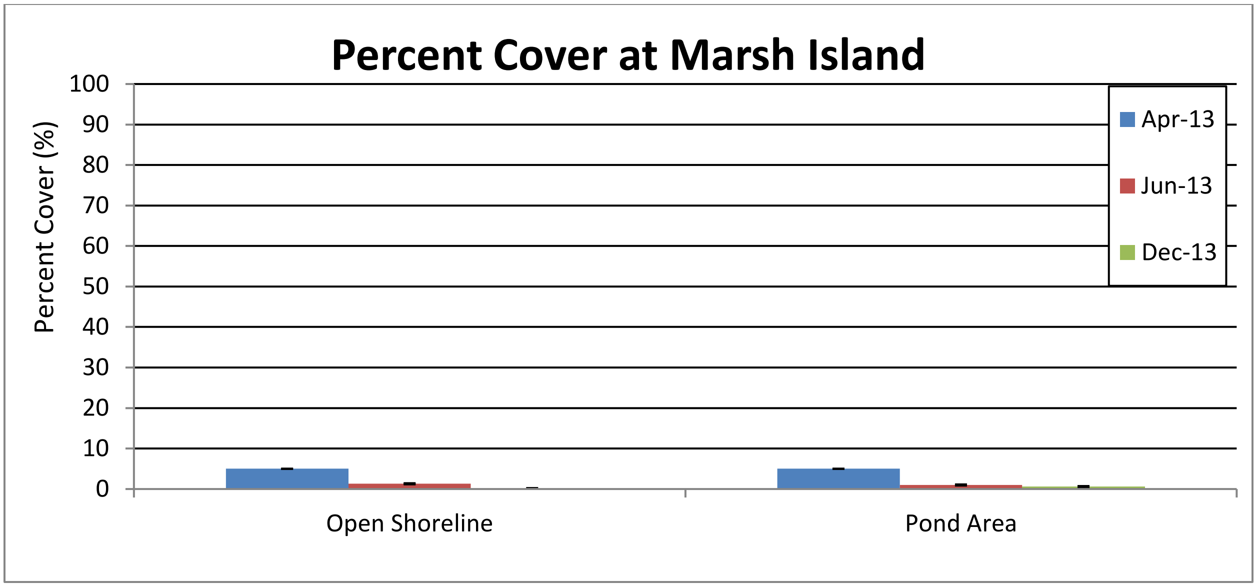

Figure V-2A. Percent cover collected from April – December 2013 at Marsh Island Northern Shoreline Plantings.

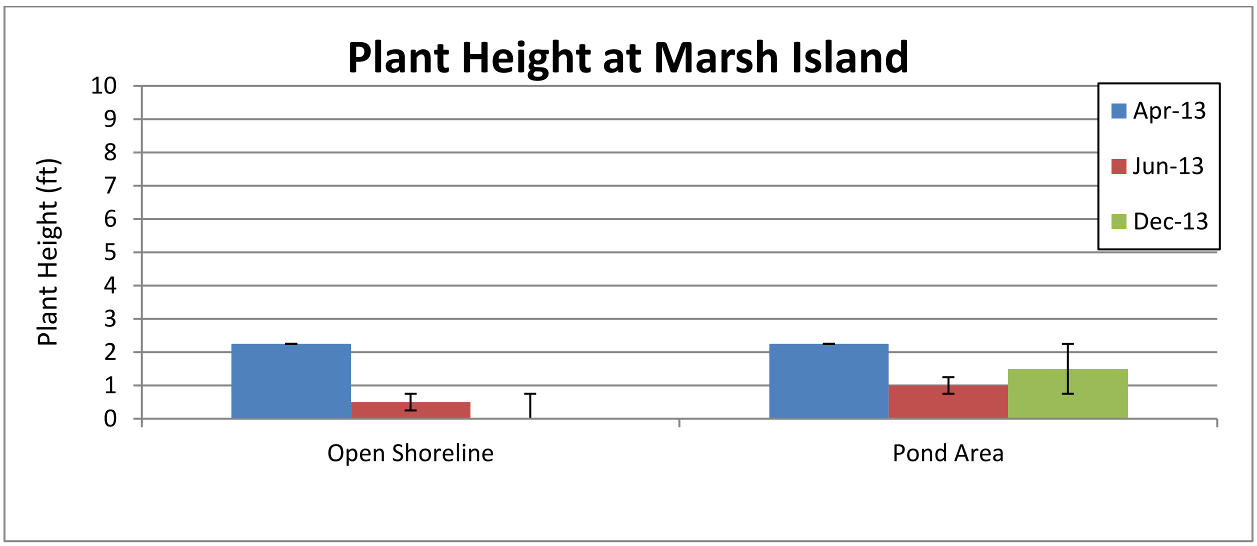

Figure V-2B. Plant stem heights collected from April – December 2013 at Marsh Island Northern Shoreline Plantings.

Figure V-3. The Northern Shoreline on 06/03/2013 during typical water levels. Note the taller, interior marsh vegetation in the background, the reduced vegetation height in the nearshore marsh platform impacted by herbivory (note taller vegetation in the crab cage), and the unvegetated shoreline eroded by surf conditions with a surviving plant to the bottom right side.

Figure V-4. The Northern Shoreline had low water levels on 12/18/2013. Empty anchors along the brown line indicate the planting alignment. The shoreline eroded back about 15-20 ft in the 8 months since the plantings installation.

Figure V-5. The loan surviving plant was in Bayou Michael Pond area planting along the northern shoreline of Marsh Island; it was photographed on 12/18/2013 during very low water levels.

Anchoring plants with metal rods did not help to secure plantings in the high wave-energy environment of the open shoreline. The percentage of plants found (live or dead) did not significantly differ between plants with or without anchors during the June or December 2013 sample dates (Figs. V-6 and 7). The percentage of plant present significantly decreased from June to December 2013.

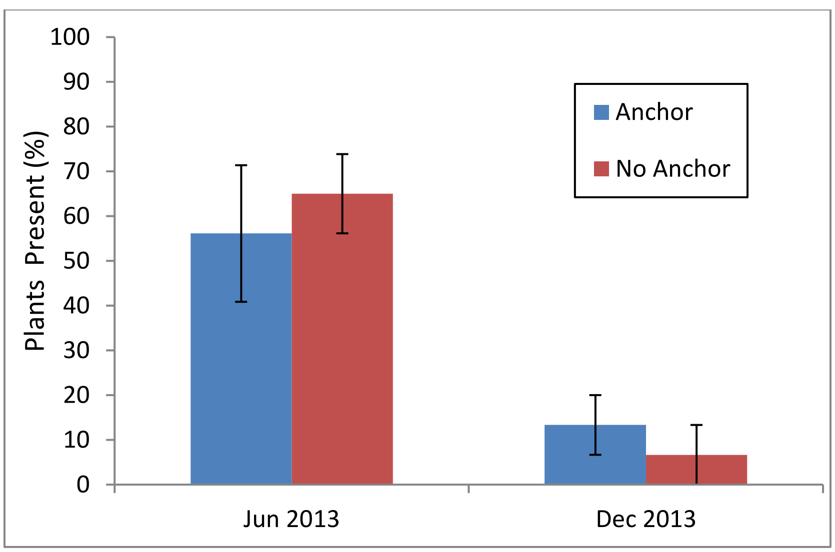

Figure V-6. The presence (live or dead) of plants was recorded at vegetation stations along the Northern Shoreline plantings two and eight months after installation in April 2013. Half of the plants were secured with anchors.

Figure V-7. Two surviving plants along a typical Northern Shoreline planting alignment were photographed on 06/03/2013 during typical water levels and calm wave conditions. Surviving plants were impacted by wave action. Note the anchored plant on the left and the non-anchored plant on the right. Two plants, one non-anchored and one anchored (anchor is missing), are absent between the surviving plants based on the planting specifications.

b. Planting Failure Causation

The low survival of Open Shoreline plantings was caused by constant wave energy and, secondarily, herbivory. A large storm passage following the planting effort and regular high water levels relative to planting depth resulted in poor survival in the Bayou Michael Pond area (Fig. V-8). Water salinity averaged 4.7 ± 3.1 ppt with a range of 0.3-11.3 ppt; this was not a contributing factor for the failure of smooth cordgrass which is a salt tolerant plant.

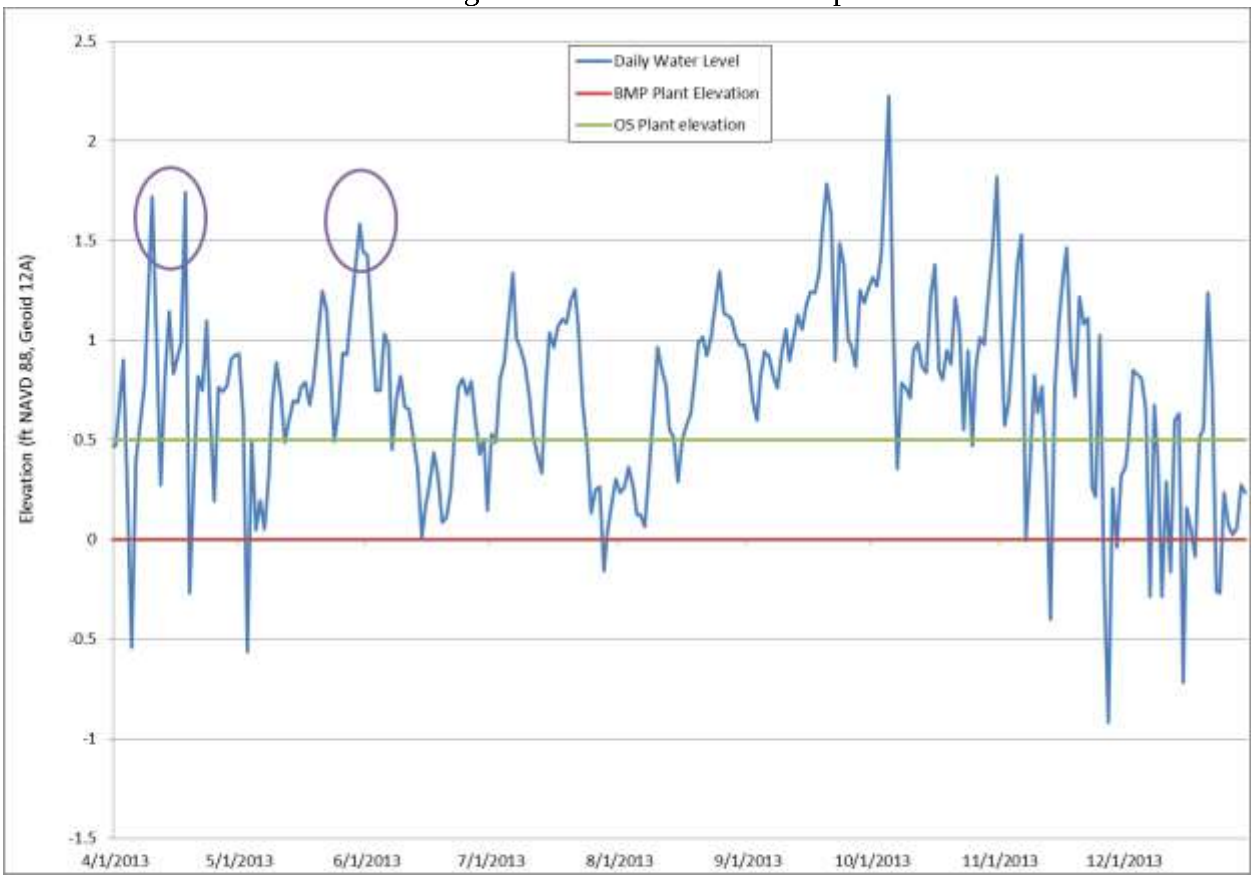

Figure V-8. Water level elevations were plotted relative to plant elevations for the Bayou Michael Pond (BMP) and Open Shoreline (OS) plantings from time of planting to the end of 2013. Note the high water levels resulting from storm passage just after planting and prior to the June 2013 field trip (purple ovals).

The Protected Shoreline plantings along the mouth of Bird Island Bayou were uprooted and removed soon after planting following a large storm system passage accompanied by high water levels within 2 weeks after the plants were installed. Marsh Island Wildlife Refuge employees observed the bulrush plantings being washed away from behind the foreshore rock dike into Bird Island Bayou. Water overtopped the foreshore dike and a strong current formed between the shoreline and dike as the high water levels receded (Fig V-9). Water salinity may have stressed the lower salt tolerant California bulrush plantings if they had survived as salinity was often > 8 ppt from August through December.

Figure V-9. California bulrush was planted in two double rows behind the foreshore rock dike protecting the shoreline along the mouth of Bird Island Bayou. Pictures were taken from both sides of rocks on the southern end of the west bank. **A** - note the watermark on the higher rocks during typical water levels; this indicates that the dike is overtopped during high water events. **B** - note the small opening between the dike and shoreline where water exists as water levels recede into Bird Island Bayou; also note the Louisiana Department of Wildlife and Fisheries Refuge camp.

Failure of the Oyster Bayou plantings was caused by flooding that persisted as a result of low planting elevations located in the hurricane blowout ponds (Fig. V-1b). The plantings were chronically inundated by water with flood depths averaging 1.35 ft for the first two months after plant (Fig. V-10). Flooding would have been a constant struggle as flooding averaged 1.35 ft throughout the growing season (Figs. V-10 and 11). Chronic flooding causes anaerobic soil conditions that can be toxic to plant roots. Isolated plants, planted along the single rows with five ft spacing between plants, are especially vulnerable to anaerobic soil conditions. Water salinity averaged 4.9 ± 2.1 ppt within a range of 0.9 - 9.3 ppt and was not a stress factor as it was within the tolerance of smooth cordgrass and black needlerush.

Figure V-10. Water level elevations were plotted relative to average plant elevations for the Oyster Bayou (OB) plantings from planting to the end of 2013.

Figure V-11. The Oyster Bayou planting area was photographed on 12/18/2013 during very low water level; however, the area was still inundated with a couple inches of water. Note the potential remnant of a planting in the circle.

C. Conclusions

Marsh Island Year 1 planting was largely experimental because of the harsh conditions along the shore of a large water body such as Vermilion Bay and expanding marsh pond conditions along Oyster Bayou. Shoreline plantings were limited to less than 7% of the northern shoreline of Marsh Island, and interior pond plantings along Oyster Bayou were limited to 13 transects in two ponds. Project sponsors should continue to be cautious and use limited plant numbers to determine if sufficient plant survival is attainable in such conditions before planning more expanded plantings. A large storm system just after plant installation is a potential confounding factor; if the plants had time to become more firmly rooted then performance may have differed, especially for the bulrush planted along the protected mouth of Bird Island Bayou.

1. Project Effectiveness

As per the project goals:

- Plantings along the northern, open shoreline along a large bay were unsuccessful. Survivorship of plantings was initially low 7 weeks (<5 – 30 % survival) after planting and decreased to 0% by 34 weeks after planting.
- Anchoring plants did not help to secure plantings in open shoreline conditions. There was no difference in plants present between the plants originally anchored and not anchored.
- Plantings along the mouth of a bayou protected by a foreshore dike along a large bay were unsuccessful. No plantings (live or dead) were found during field trips 7 and 34 weeks after planting.
- Plantings in open water areas of former marsh blown out by storms were unsuccessful. No live plantings were found during field trips 7 and 34 weeks after planting.
- There was no difference in planting survival between smooth cordgrass and black needle rush nor between different sizes of smooth cordgrass. All plantings in the Oyster Bayou areas were dead or absent 7 and 34 weeks after planting.

2. Recommended Improvements

Regardless of the period selected for plant installation, it is recommended that project sponsors incorporate flexibility in planting dates to provide some opportunity to avoid planting during excessive high water events.

3. Lessons Learned

The Marsh Island Year 1 planting illustrates two types of degraded coastal marsh conditions for which vegetative plantings, as a stand-alone technique, may not provide a solution:

1) Eroding shorelines of large, high energy water bodies.
2) Permanently flooded, shallow open-water areas with unconsolidated organic soils.

Planting in such areas could be used to compliment other restoration/conservation measures.

VI. Year 2 – West Little Lake

Prepared by Elaine Lear - Thibodaux Regional Office and Bernard Wood, Tommy McGinnis, Margaret Luent – CPRA Lafayette Regional Office

Data collected by the CPRA Thibodaux Regional Office

A. Site and Planting Description

West Little Lake (WLL), a Year 2 planting site, is in Lafourche Parish on a peninsula of marsh that projects out from the west bank of Little Lake, with Bay L'Ours to the south (Fig. VI-1). The surrounding marsh is intermediate vegetation.

The West Little Lake site is divided into six (6) areas and has four (4) planting strategies (shoreline plantings, hedge rows, double rows, and area plantings in smaller ponds) (Fig. VI-1). A combination of *Schoenoplectus californicus* (California bulrush) (9,670 plants) and *Spartina alterniflora* Vermilion (smooth cordgrass) (900 plants) trade-gallon sized plants were planted.

Shoreline plantings are smooth cordgrass and California bulrush rows located along the Little Lake (north) side of the peninsula (Site 1). Smooth cordgrass was planted as close as possible to the existing marsh edge on 5 ft centers no lower than +0.25 ft NAVD88; California bulrush was planted 1 ft – 3 ft from the existing marsh edge on 5 ft alternating centers from the smooth cordgrass no lower than -0.75 ft NAVD88.

Hedge row plantings of California bulrush were installed in hedges of 5 rows parallel to the shoreline. Rows within a hedge were spaced 5 ft apart with plants on 5 ft alternating centers for a total hedge width of 20 ft no deeper than -0.75 ft NAVD88. Hedges are located in **coves** along the peninsula open to Little Lake (Site 2 and 3) and in a large pond (Site 4).

Double row plantings are 8 double rows of California bulrush in a larger pond almost bisecting the peninsula (Site 4). Within each double row, rows are spaced 5 ft apart with plants on 5 ft alternating centers no deeper than -1.0 ft NAVD88.

Pond area plantings are California bulrush planted in smaller ponds in parallel rows 5 ft apart with plants on 5 ft alternating centers over the entire pond no deeper than -1.0 ft NAVD88 (Sites 5 and 6). A similar auxiliary area was planted in the south end of Site 4.

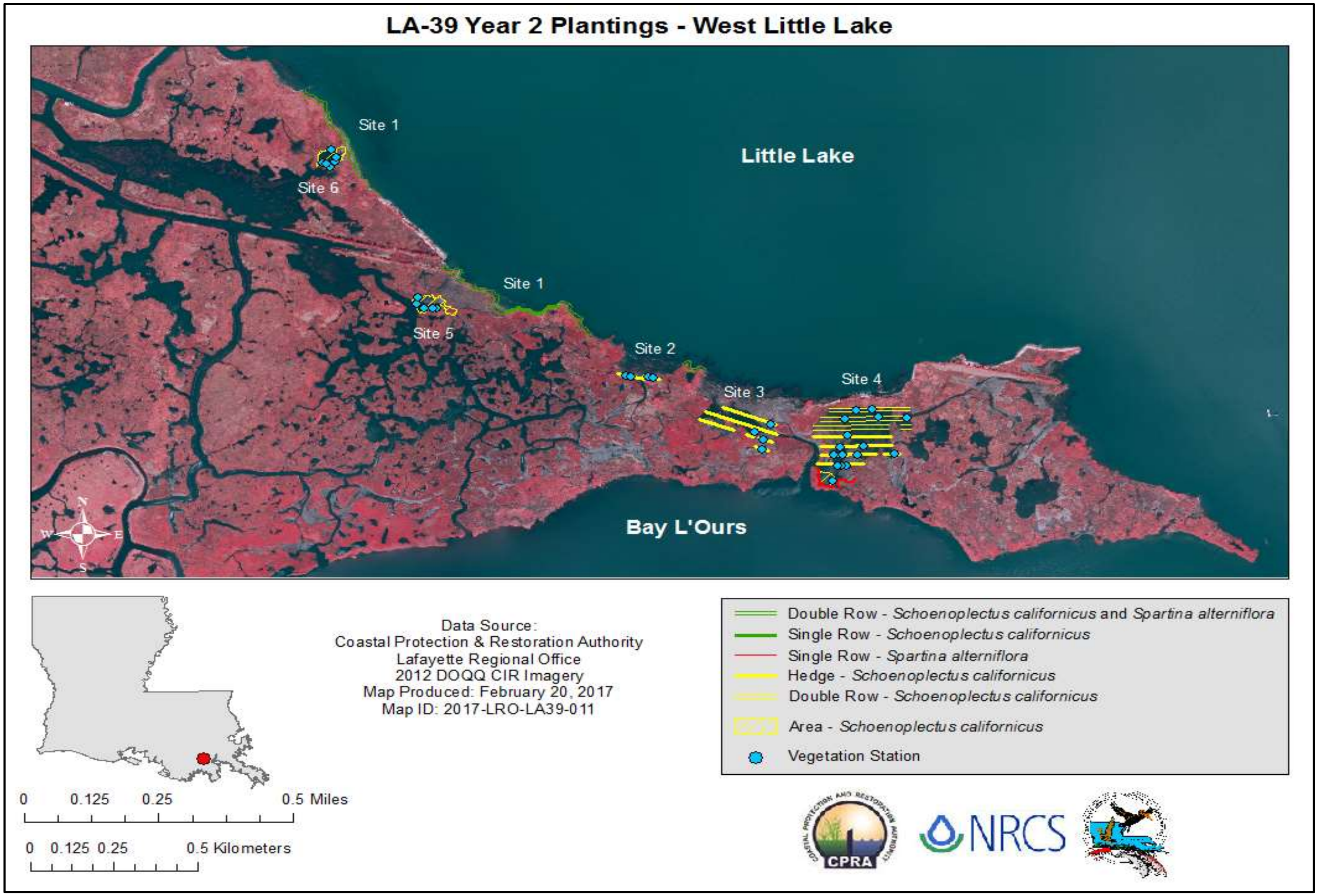

Figure VI-1. LA-0039 Year 2 Site – West Little Lake site map shows plantings areas, planting types, and vegetative monitoring stations.

B. Monitoring Activity

1. Monitoring Goals and Objectives

The goals of the West Little Lake plantings are:

- Shoreline plantings of smooth cordgrass and California bulrush will survive and expand to reinforce shorelines.
- Cove hedge row plantings of California bulrush will survive and expand within the coves along Little Lake shoreline.
- Double row plantings of California bulrush will survive and expand within the pond.
- Area plantings of California bulrush will survive and expand within the small ponds.

2. Monitoring Elements

The monitoring elements include procedures to assess planting survival and effects on the planting area for the project plantings. The final planting inspection of October 15, 2014 is considered the beginning of the monitoring period with survival assumed to be 100%. Planting survival and vegetative cover representative of the variety of planting strategies were monitored over time after installation: one month - November 2014, one year - October 2015, and three years in September 2017; only area plantings were observed in 2017 because of accessibility issues. Hydrologic data from nearby CRMS sites are used to explain hydrologic influences such as flooding. Monitoring for LA-0039 Year 2 West Little Lake terminated in September 2017 because an additional planting event, LA-0039 Year 6 West Little Lake #2, was installed in overlapping areas in May 2017.

<u>**Vegetation Assessment**</u>

To assess planting status, an ocular estimate of % survival and plant condition was conducted for each area and planting type while visually inspecting the site during sampling visits. Planting survival and vegetative growth data was also collected at the vegetation station level in 2014 and 2015; 35 stations were established to represent the areas and planting types. Percent survival was calculated from 10 plants at each vegetation station; plants were characterized as live (any green vegetation) or dead/absent. The 10 plants were divided evenly among two rows of plantings (5 plants per row). Vegetative cover data includes percent (%) vegetative cover of emergent vegetation, % cover of species present, vegetative stand height, and height of dominant species within a 4-m^2 plot (Folse et al. 2014). Conditions occurring outside of the vegetation stations including additional emergent species, floating and submerged vegetation, marsh interspersion, and site-specific points of interest were noted along with photographic documentation.

Shoreline Plantings have no vegetation stations. Shoreline plantings were destroyed or covered by wrack before the first monitoring visit (approximately 6 weeks after planting).

Cove Hedge Row Plantings had eight (8) vegetation stations (Site 4).

Pond Hedge Row Plantings had 10 vegetation stations (Site 2 and 3).

Pond Double Row Plantings had six (6) vegetation stations (Site 4).

Pond Area Plantings had 12 vegetation stations (Site 5 and 6). The stations are located along the perimeters of the plantings so that plants are not damaged via access. Therefore, the results may be biased by conditions along the perimeter. These stations were inaccessible in 2017.

<u>Hydrology</u>

Surface and porewater salinity (ppt), specific conductivity (*u*S/cm), and temperature (°C) are measured at each vegetation station during each survey. Porewater is collected from a depth of 20 cm beneath the sediment surface. The depth of water at each station is also measured during sampling. Salinity and water level data recorded hourly from CRMS4218, located approximately 3 miles northeast of the site, were utilized to document salinity variation and approximate the elevation for the planted vegetation in NAVD 88 GEOID 12A.

3. Monitoring Results and Discussion

a. Vegetation

The ocular estimates of the planting area captured the overall performance of the plantings. All planting sites at this project area have reacted similarly over time, with the exception of the shoreline plantings. The shoreline plantings were destroyed or covered with wrack by the first monitoring visit in November 2014 resulting in a total loss; no vegetation stations were established. The remaining planting regimes (area plantings, cove hedges, pond hedges and double row) declined in percent survival (Table VI-1); however, surviving plants increased in both percent vegetative cover and stem heights (Figs. VI-2 and 3). Most of the decrease in survival was due to disturbance by floating aquatic vegetation (water hyacinth and/or giant Salvinia).

Only 10 of the original 35 $4m^2$ plots were monitored in 2017 due to avoidance of newly installed plantings for West Little Lake #2, time constraints, high winds, and the predominance of dry conditions in thick *Sphenoclea zeylandica* stands making navigation and accessibility difficult (Figure IV-4). The ten plots quantitavely monitored were inside of area plantings. The remainder of the planting types were examined qualitatively and photographed. Mean herbaceous cover inside the $4m^2$ stations averaged 79% with mean herbaceous height at 7 feet.

Table VI-1. Overall % Survival of LA-0039 Year 2 West Little Lake plantings were ocularly estimated over time while conducting the final inspection and monitoring field trips.

		% Overall Survival			
Location	Planting Type	Oct 2014	Nov 2014	Oct 2015	Sept 2017*
Shoreline	Single Row	100	0	0	0
	Double Row	100	0	0	0
Cove	Hedge Row	100	100	50	50
Pond	Double Row	100	100	66	70-80
	Hedge Row	100	100	57	60-70
	Area	100	100	67	70-80

*2017 survival was coarsely estimated because plants were often inaccessible without damaging subsequent plantings and/or expanded into solid stands surrounded by thick, dry stands of vegetation and inaccessible by airboat.

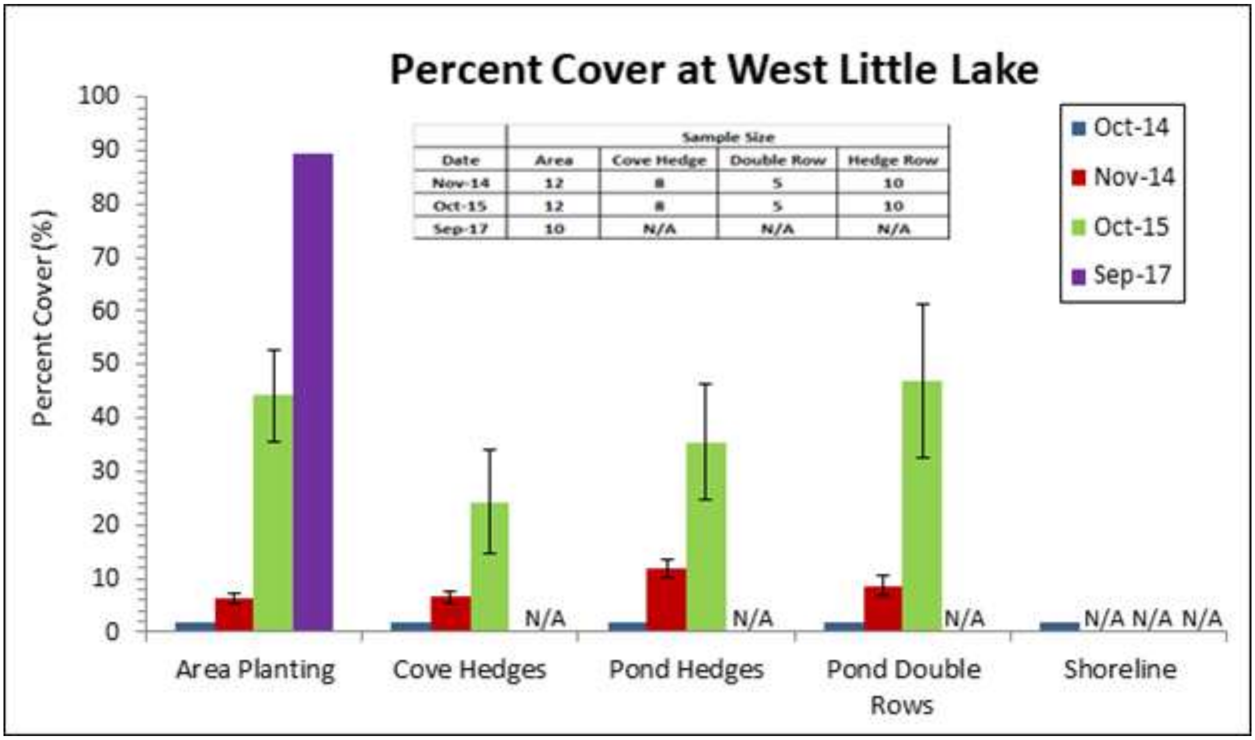

Figure VI-2. Percent cover measured from vegetation stations at LA-0039 Year 2 West Little Lake from November 2014 through September 2017. October 2014 cover is based upon as-built newly planted observations.

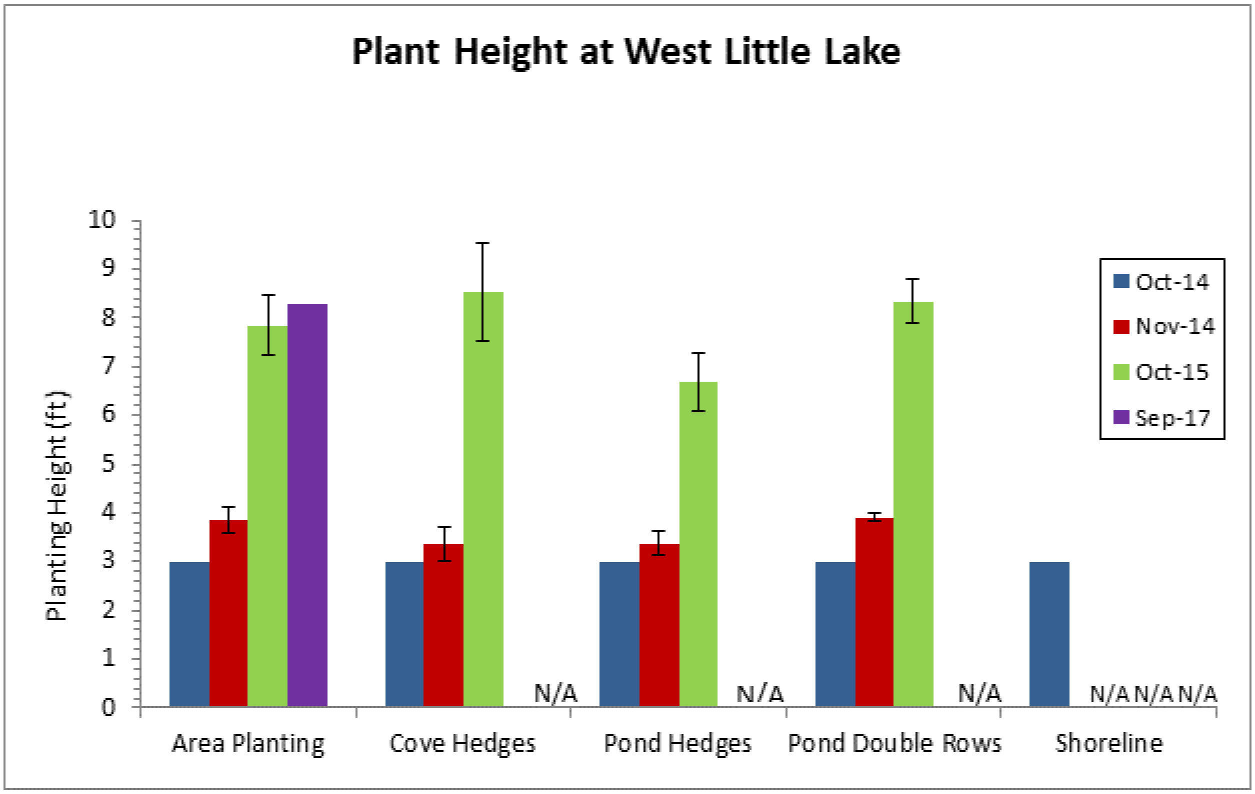

Figure VI-3. Stem heights collected from vegetation stations at LA-0039 Year 2 West Little Lake from November 2014 – October 2015. October 2014 cover is based upon as-built newly planted observations.

Shoreline Plantings

The shoreline plantings were destroyed or covered with wrack by the first monitoring visit (November 2014) resulting in a total loss of those plantings. No further data was collected.

Archival wind data from the National Oceanic and Atmospheric Administration's (NOAA) Center for Operational Oceanographic Products and Services (CO-OPS) database, indicates that several fronts pushed through this portion of coastal Louisiana between the time the plantings were installed in mid-October 2014 and the first data collection effort on November 10, 2014 (Fig. VI-4). Winds were predominately from the NNE and reached over 11 m/s (25 mi/hr) on several occasions. There were also several wind shifts from the SSE with equally strong winds. During this time, thick mats of floating aquatics toppled the newly planted vegetation and created conditions which did not allow the vegetation to become established. At the time of the first data collection effort, the shoreline sites 1 and 2 were devoid of plantings.

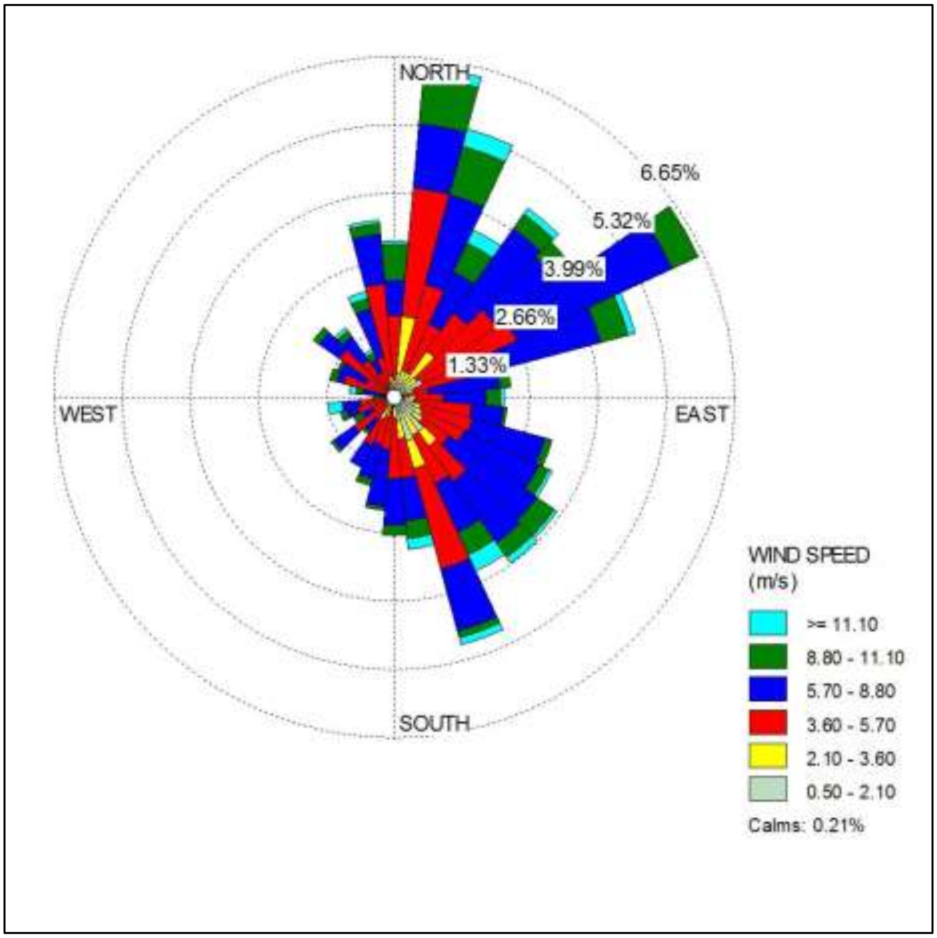

Figure VI-4. Wind rose data from NOAA's nearest CO-OPS station in Grand Isle, Louisiana. Wind history is from October 1, 2014 through November 30, 2014. The concentric rings are percentage classes which indicate the portion of time the winds occurred. The colored wedges indicate strength and direction of the winds.

<u>Cove Hedge Row Plantings</u>
During the first monitoring trip in November 2014, the plantings looked really healthy and were expanding; by the October 2015, remaining plantings looked healthy with continued growth (Fig. VI-5). At the vegetation station level, survival decreased by 50% (Table VI-1), while vegetative cover and stem height increased by 18% and 5.0 ft, respectively (Figs. VI-2 and 3). Qualitative observations from September 2017 indicate survivors remain healthy and stands appear to have expanded to merge with surrounding vegetation.

Figure VI-5. Example photographs of expansion of Cove Hedge Row plantings at the station level from November 2014 (A) to October2015 (B), along a hedge row in October 2015 (C), and over a larger expanded bird's-eye view in September 2017 (D).

Pond Hedge Row Plantings

During the first monitoring trip in November 2014, the plantings looked really healthy and were expanding; by the October 2015, remaining plantings looked healthy with continued growth (Fig. VI-6). At the vegetation station level, survival decreased by 40% (Table VI-1), while vegetative cover and stem height increased by 24% and 3.3 ft, respectively (Figs. VI-2 and 3). Qualitative observations from September 2017 indicate survivors have expanded to form solid hedge rows. Expansion of these pond hedge rows was much more noticeable than the cove plantings.

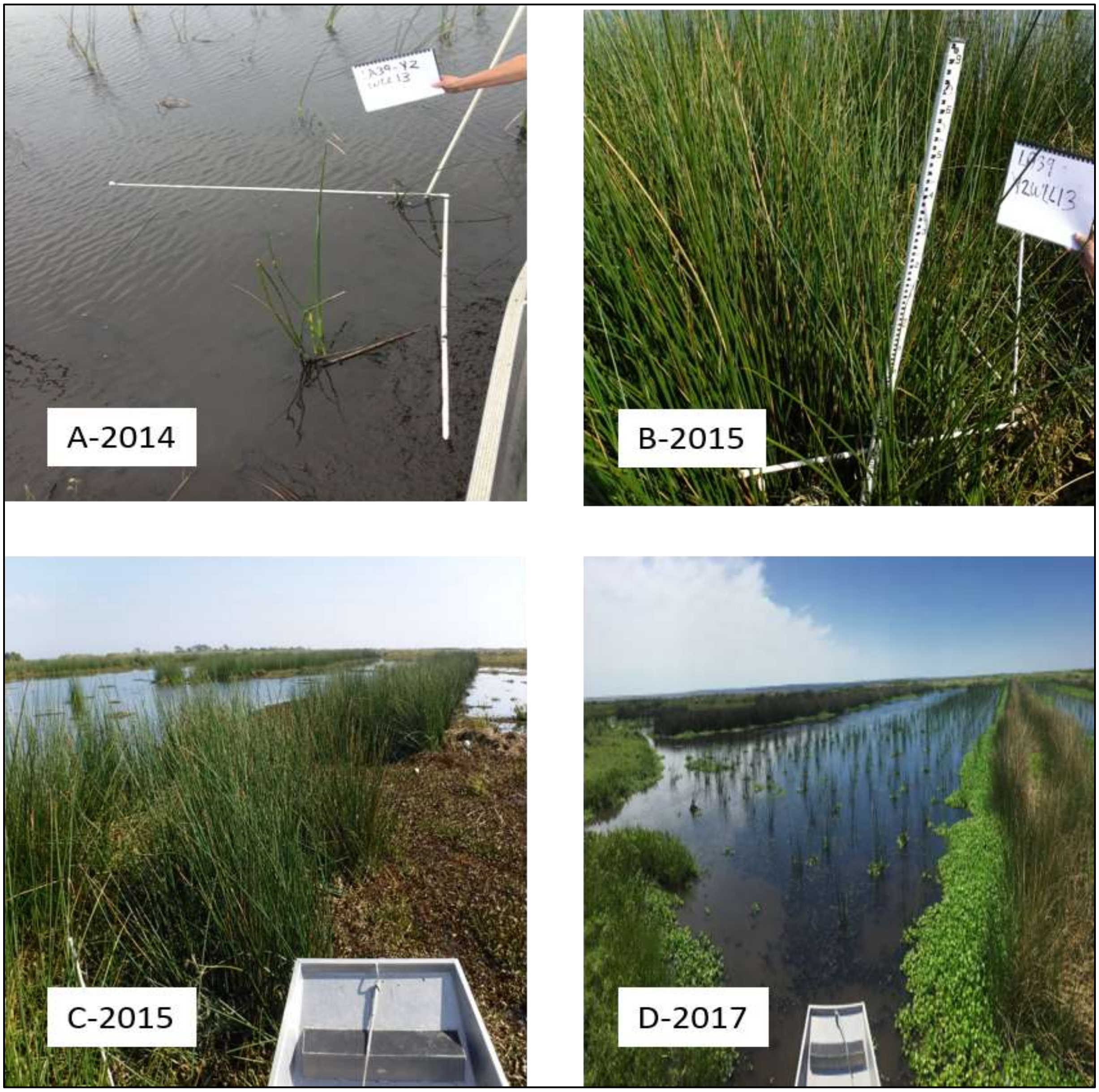

Figure VI-6. Example photographs of expansion of Pond Hedge Row plantings at the station level from November 2014 (A) to October 2015 (B), along a hedge row in October 2015 (C), and over a larger expanded bird's eye view in September 2017 with more recent year 6 WLL#2 plantings between them (D).

Pond Double Row Plantings

During the first monitoring trip in November 2014, the plantings looked really healthy and were expanding; by the October 2015, remaining plantings looked healthy with continued growth (Fig. VI-7). At the vegetation station level, survival decreased by 30% (Table VI-1), while vegetative cover and stem height increased by 38% and 4.4 ft, respectively (Figs. VI-2 and 3). Qualitative observations from September 2017 indicate survivors have expanded to form solid rows. As with the pond double hedge rows, expansion of these pond double rows was much more noticeable than the cove plantings.

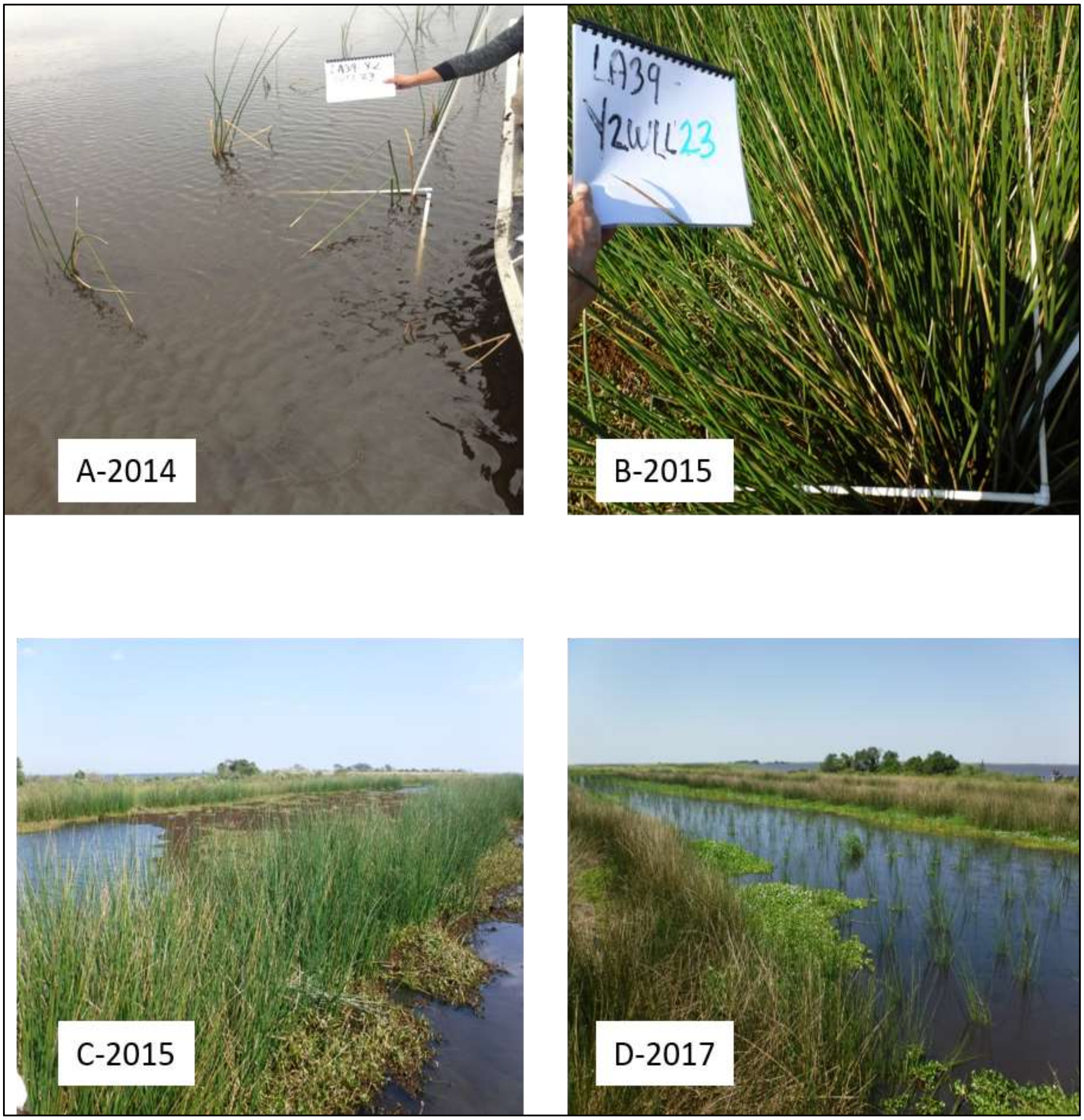

Figure VI-7. Example photographs of expansion of Pond Double Row plantings at the station level from November 2014 (A) to October 2015 (B), along double rows in October 2015 (C), and over a larger expanded bird's eye view in September 2017 with more recent LA-0039 Year 6 WLL#2 plantings between them (D).

Pond Area Plantings

During the first monitoring trip in November 2014, the plantings looked really healthy and were expanding; by the October 2015, remaining plantings looked healthy with continued growth (Fig. VI-8). At the vegetation station level, survival decreased by 20% (Table VI-1), while vegetative cover and stem height increased by 38% and 4.0 ft, respectively (Figs. VI-2 and 3). The location of the stations along the perimeter of the area plantings underestimated survival and vegetative growth, as most of the interior space was occupied by large (10+ ft) California bulrush. Qualitative observations from the pond area plantings in 2017 indicate that survivors are still robust and continue to expand their reach inside of the ponds along with other plant species.

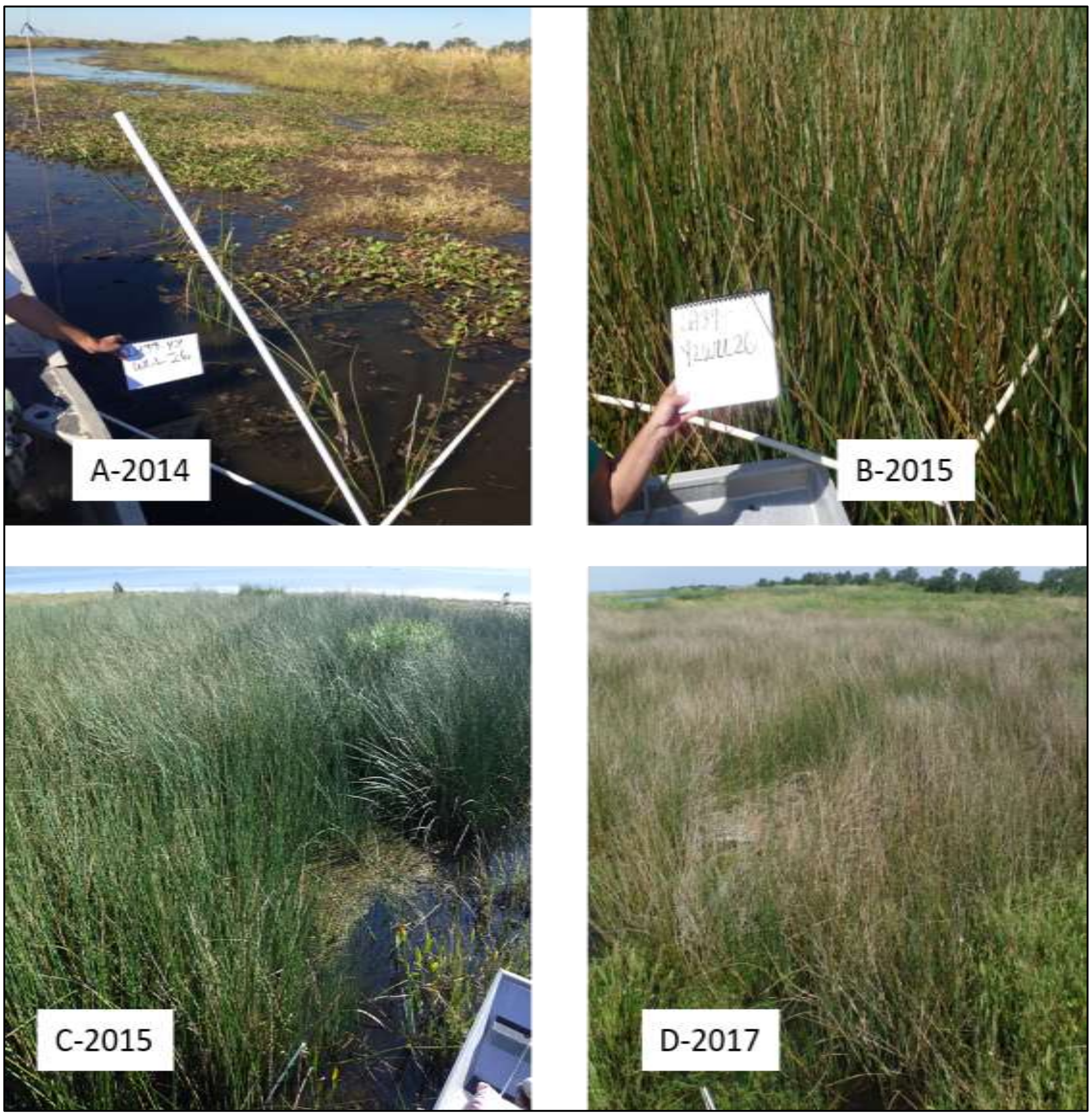

Figure VI-8. Example photographs of expansion of Pond Area plantings at the station level from November 2014 (A) to October 2015 (B), and over a larger expanded bird's eye view in October 2015 (C) and September 2017 (D).

b. Hydrology

Hydrologic data were obtained from CRMS4218 along the north shore of Little Lake. Daily averages were graphed over the formative first year of the planting (September 2014 – December 2015), and monthly averages were graphed for the entire monitoring period (September 2014 – December 2017).

From September 2014 through the end of 2015, mean daily salinity at CRMS4218 was 1.9 ppt ± 0.1 SE (Fig. VI-9). *Schoenoplectus californicus* grows best in salinities between 0 – 6 ppt and can tolerate brief spikes of higher salinity (Materne and Fine 2000). The higher salinity event that occurred during the latter half of October through the beginning of November 2015, where salinities were briefly over 18 ppt, was well over the reported tolerance levels for this species. The effects of the salinity pulse appeared to be minimal as it was short lived. Mean porewater salinity measured at CRMS4218 between 2014 and 2015 never reached above 3.0 ppt, within the favorable range for *S. californicus*. The porewater salinity values are an average of porewater salinity collected at 10 cm and 30 cm depth at CRMS4218.

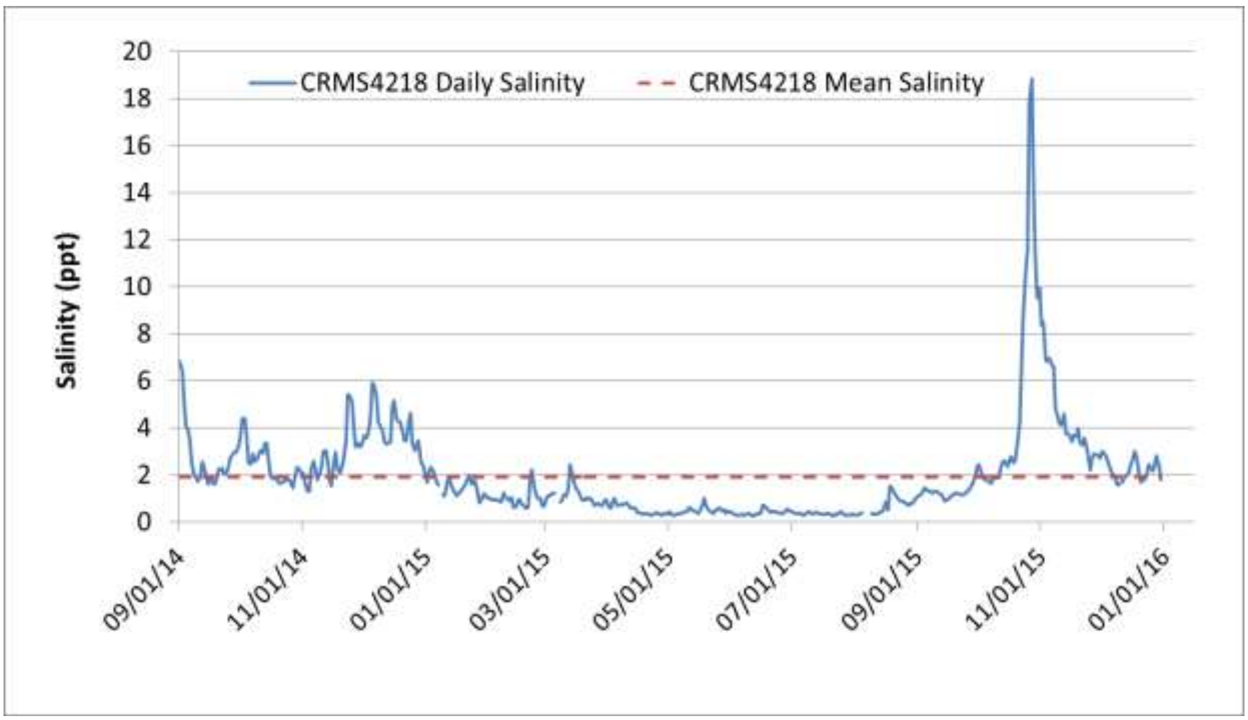

Figure VI-9. Daily and mean salinity measured at CRMS4218 near the project area.

The mean water elevation during 2014 and 2015 at CRMS4218 was +0.52 ft ± 0.02 SE (NAVD88, GEOID 12A) and ranged from a high of +2.6 ft to a low of -0.4 ft (Fig. VI-10). The same event that resulted in an increase of salinity also contributed to the increase in water elevation that occurred mid-October through November.

The plantings elevation was estimated by subtracting the water depth measured at each vegetation station during the survey, from the water elevation recorded at the corresponding time at CRMS4218. The estimated planting area elevation was calculated by averaging the elevation of all plants sampled within a planting area. The optimum water depth for establishment of *S. californicus* is reported as between 1 to 2 feet (Materne and Fine 2000). The estimated mean depth of inundation for the plants is within this range for the cove and pond plantings at 1.6 and 1.4 feet respectively.

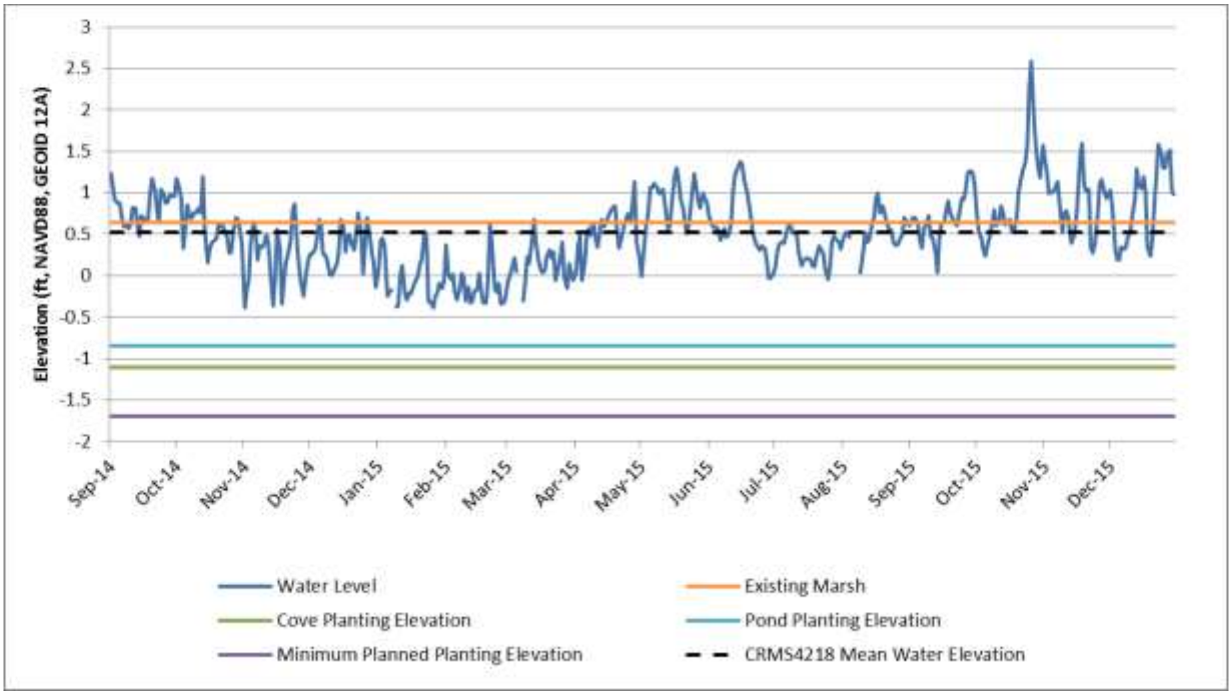

Figure VI-10. Mean daily and mean overall water elevation at CRMS4218, shown with the estimated elevation of the Cove and Pond planting area in West Little Lake.

Within the context of the entire monitoring period (September 2014 – December 2017, Fig. VI-11), average surface water salinity on a monthly basis decreased by 0.63 ppt to 1.29 ppt ± 0.22 SE for 2016 – 2017. The high points in monthly salinity in April and May 2017 resulted from a high salinity event on April 29 - May 02 when salinity peaked at 12.5 ppt. From 2016 – 2017, porewater salinity hovered around 2 ppt which was similar to 2014-2015. Both salinity parameters provided good growing conditions for *S. californicus*. In contrast to surface water salinity, average monthly water elevations increased 0.23 ft in 2016-2017 resulting in deeper inundation but not duration. The increased inundation depth remained less than 2 ft deep which is tolerated by mature *S. californicus.*

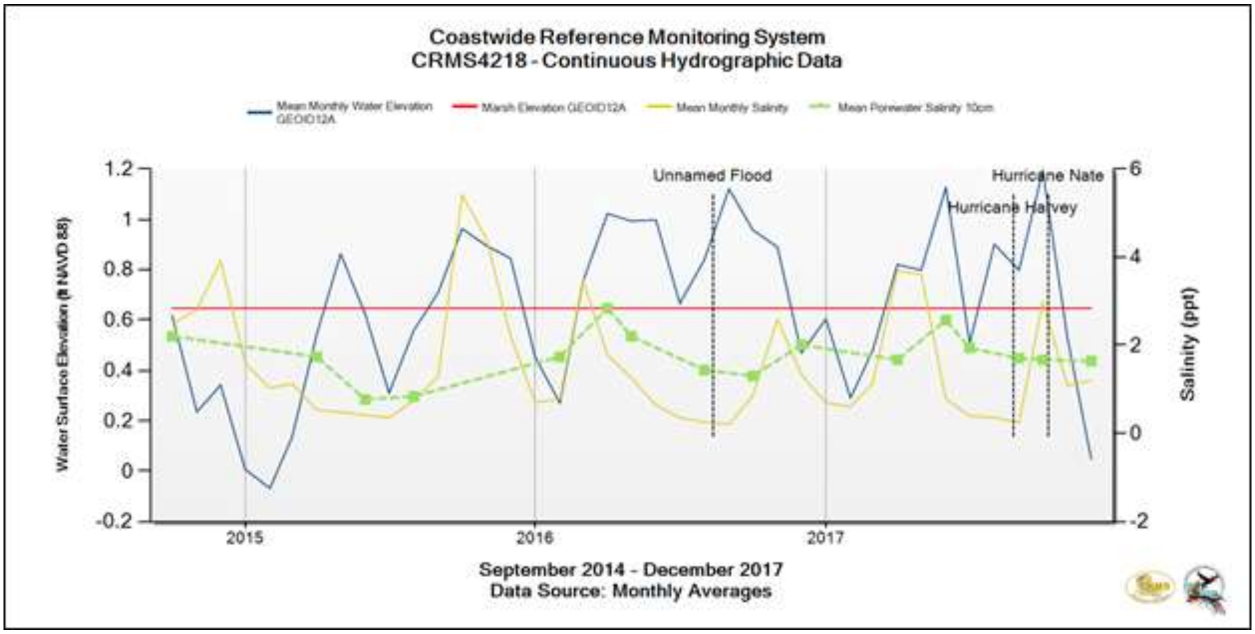

Figure VI-11. Monthly hydrologic data (salinity and water elevation) during the LA-0039 Year 2 West Little Lake monitoring period (September 2014 – December 2017). Graph obtained from Coastwide Reference Monitoring System (CRMS)-*Wetlands*, 2021; Data retrieved from Coastal Information Management System (CIMS) database. http://cims.coastal.louisiana.gov. Accessed 20 January 2021.

c. Planting Failure/Success Causation

The shoreline plantings were destroyed by waves or covered with wrack within a month of installation; plantings along large water bodies are exposed to rough surf conditions and rafting by vegetation and/or debris. Most of the decrease in survival in other planting types was caused by floating aquatic vegetation (water hyacinth and giant Salvinia); the force from the floating aquatic mats being pushed by water is strong enough to topple well established California bulrush (Figs. VI-12 and 13).

Hydrologic conditions were condusive for S. californicus growth and expansion as surface water salinity was < 6 ppt (porewater salinity did not exceed 3 ppt) and inundation depth was between 1 - 2 ft (Materne and Fine 2000). Also, the plantings were typically in protected conditions such as small marsh ponds and shallow coves.

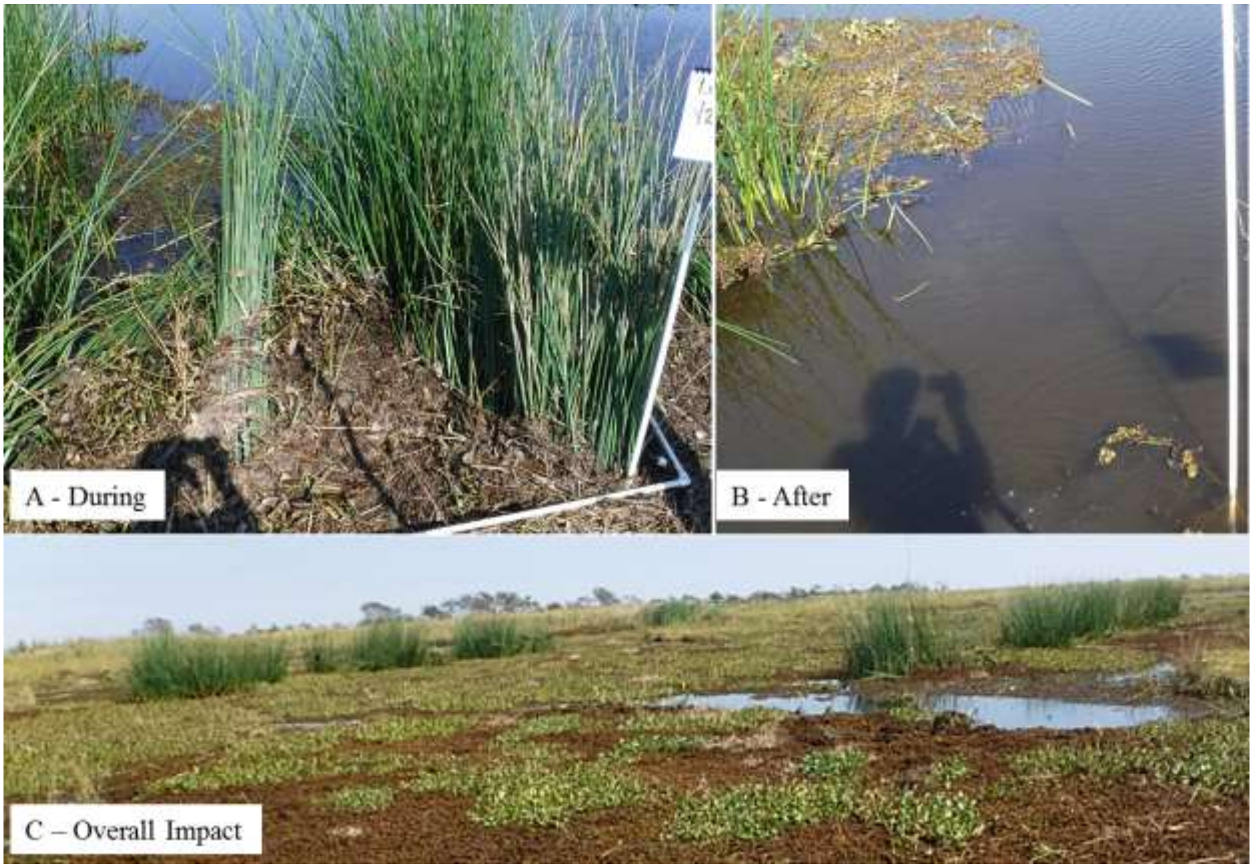

Figure VI-12. Progression of floating vegetation impacts on double row plantings.

Figure VI-13. Progression of floating vegetation impacts on pond area plantings.

C. Conclusions

The Year 2 West Little Lake plantings are successful except for the shoreline plantings. Overall, all other planting types survived and expanded even though percent survival decreased. Decreases in survival were caused by damage from floating vegetation rather than physiological stress from poor planting conditions.

1. Project Effectiveness

As per the project goals:

- Shoreline plantings of smooth cordgrass and California bulrush did not survive to reinforce shorelines.
- Cove hedge row plantings of California bulrush did survive and expand within the coves along Little Lake shoreline.
- Double row plantings of California bulrush did survive and expand within the pond.
- Area plantings of California bulrush did survive and expand within the small ponds.

2. Recommended Improvements

Planting along exposed shoreline on a large water body with high wave energy coupled with large floating mats of vegetation should be avoided unless some other form of protection is provided.

Monitoring of inaccessible plantings and stations would benefit from drone observations.

3. Lessons Learned

Plantings along the exposed shoreline of a large water body is not advisable a stand-alone strategy. Planting in such areas could be used to compliment other restoration/conservation measures such as planting behind a shoreline protection measure.

Large stands of California bulrush were pushed over and smothered by floating vegetation composed mainly of giant Salvinia and water hyacinth. The occurrence of large mats of floating vegetation in recent years is attributable to recent mild winter temperatures. Planning for additional resources to be implemented for floating invasive species control or alternative plant types that are more resistant to floating vegetation may need to be considered.

Many of the planting stations and sites became inaccessible by airboat without damaging the plantings because of in-filling of areas by plants in protected areas or installation of new plants around the older plants. Observations of these inaccessible plantings aided by drones would help to improve monitoring.

VII. Year 2 - The Prairie

Prepared by Danielle Richardi – CPRA New Orleans Regional Office and Maggie Daigle – CPRA Lafayette Regional Office
Data collected by CPRA New Orleans Regional Office

A. Site and Planting Description

The Prairie refers to a shallow pond that comprises approximately 500 acres in St. John the Baptist Parish along the northwest rim of Lake Pontchartrain (Fig. VII-1). The planted project area encompasses slightly greater than 16 acres of The Prairie, which is located within the Manchac Wildlife Management Area (WVA) and is managed by the Louisiana Department of Wildlife and Fisheries (LDWF).

Several restoration projects have targeted shoreline protection of the eroding, narrow strip of land that separates The Prairie and the surrounding fresh/intermediate marsh from Lake Pontchartrain. Turtle Cove Shoreline Protection (PO-0010) is a state-funded project that was completed in 1994. The project consisted of a 1,642 ft rock-filled gabion breakwater constructed in Lake Pontchartrain, approximately 300 ft from the shoreline along the far northeastern reach of the Prairie. Monitoring was only conducted for three years post-construction, but results indicated that the project was successful in reducing wave energy along the shoreline and in trapping sediment behind the gabion (O'Neil and Snedden, 1999).

The following year, the U.S. Army Corps of Engineers (USACE) constructed the Manchac Wildlife Management Area (MWMA) mitigation project, which consisted of segmented rock breakwaters with marsh creation between the breakwaters and the shoreline (USACE, 2014). This project did not produce the anticipated results, prompting a revised construction plan that filled in the gaps between the breakwaters and added dredged sediment to the marsh creation area. This Modified MWMA Mitigation Project was completed in September 2013, but additional changes were still deemed necessary by the USACE to reach the goals of the project. The current project, Lake Pontchartrain and Vicinity Mitigation MWMA Marsh Creation (state project number PO-0146) dredged sediment from the lake to raise the marsh platform to an approximate as-built elevation of + 2.5 ft NAVD 88 (Geoid 03), constructed, and repaired earthen dikes and rock dikes. The project was completed the summer of 2016 and should provide much-needed shoreline protection for the narrow stretch of land between the lake and the Prairie.

The Prairie Project Features

Plantings were conducted in four areas following three planting designs: area planting, double row planting and single row shoreline enhancement planting (Fig. VII-1). A total of 13,168 trade gallon *Schoenoplectus californicus* (California bulrush) and 567 trade gallon *Spartina alterniflora* Vermilion (smooth cordgrass) were planted in The Prairie between March 11−15, 2014. *Schoenoplectus californicus* was used for the interior plantings, while *S. alterniflora* was used for the edge shoreline plantings. Maximum planting depth was specified as no lower than - 0.75 ft NAVD88 (GEOID12A) for *S. californicus*, and no lower than - 0.25 ft NAVD88 (GEOID12A) for *S. alterniflora*.

Area 1

1A: *Schoenoplectus californicus* was planted in parallel rows 5 feet apart, with plants on 5-foot alternating centers. The planting row alignment was parallel to the shoreline and followed an area planting design.

1B: *Schoenoplectus californicus* was planted in four double rows perpendicular to the shoreline. The two rows within each double row were planted approximately 20 feet apart. Plants within each row were planted on 5-foot alternating centers.

1C: *Spartina alterniflora* Vermilion was planted on 5-foot centers in one row following the alignment of the existing marsh edge as a shoreline enhancement.

Area 2

2A: *Schoenoplectus californicus* was planted in parallel rows 5 feet apart, with plants on 5-foot alternating centers. The planting row alignment was parallel to the shoreline and followed an area planting design.

2B: *Spartina alterniflora* Vermilion was planted on five-foot centers in one row following the alignment of the existing marsh edge as a shoreline enhancement.

Area 3:

3A: *Schoenoplectus californicus* was planted in 10 double rows that were arranged in a delta-splay formation. The two rows within each double row were planted approximately 20 feet apart. Plants within each row were planted on 5-foot alternating centers.

Auxiliary Planting Area:

An area within The Prairie adjacent to the southwestern boundary of Area 3 was designated for the placement of surplus plants. *Schoenoplectus californicus* was planted in parallel rows 5 feet apart with plants on 5-foot alternating centers, following an area planting design.

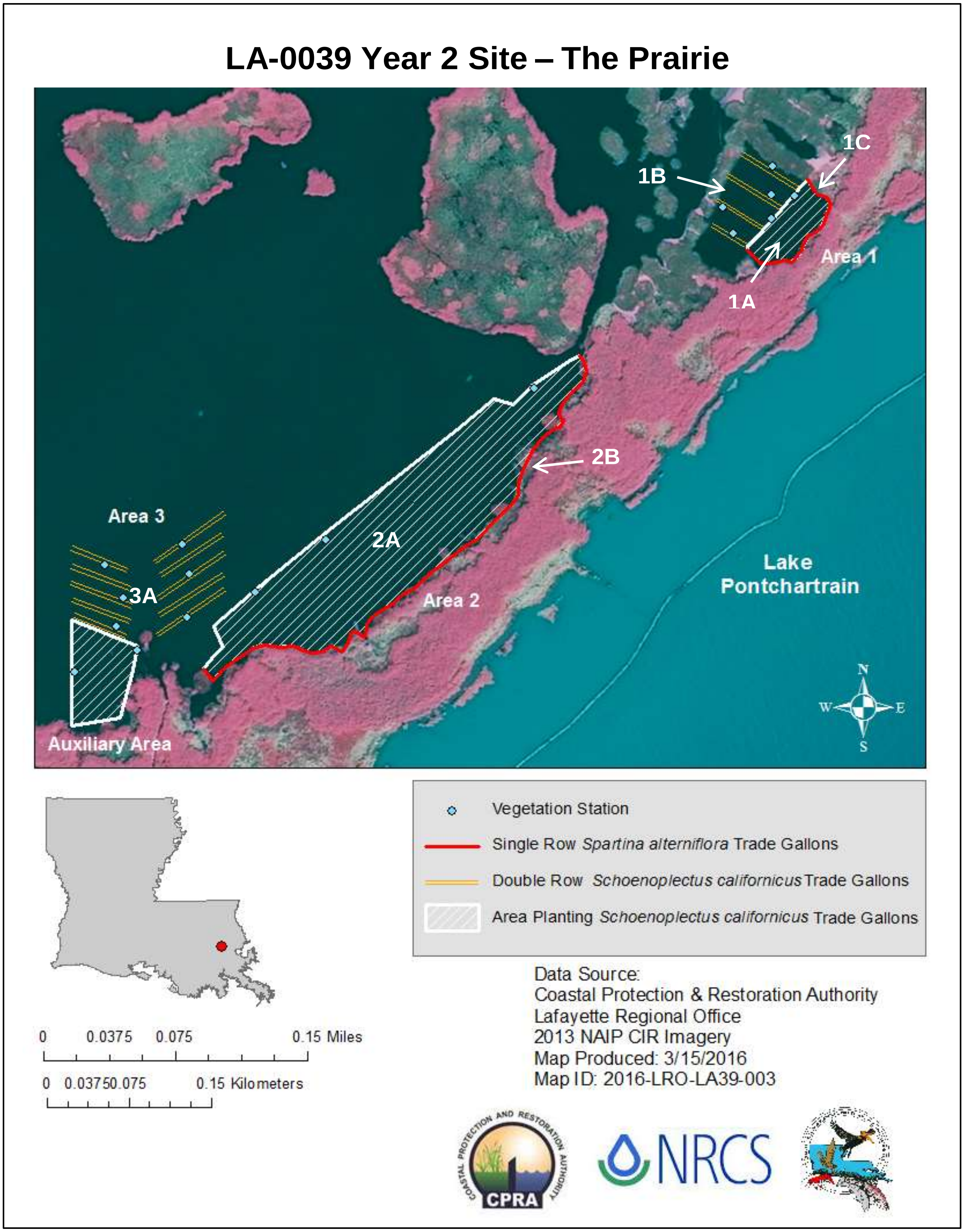

Figure VII-1. Map of LA-0039 Year 2 Site – The Prairie, showing the location of planting areas and vegetation monitoring stations.

B. Monitoring Activity

1. Monitoring Goals and Objectives

The goal of interior area plantings is to establish emergent vegetation in areas devoid of vegetation and/or in areas with damaged or degraded vegetation. The goal of shoreline plantings is primarily to reduce shoreline erosion. The CWPPRA Environmental Work Group predicts shoreline loss reduction and land loss rate reduction of at least 50% for plantings assuming successful colonization and expansion of planted vegetation (NRCS 2010).

The objectives for the Prairie planting are as follows:

- Area plantings of *S. californicus* in open water areas will survive and expand.
- Area plantings of *S. californicus* will widen the land bridge in Areas 1 and 2.
- Double row plantings of *S. californicus* in open water areas will survive and expand.
- Shoreline plantings of *S. alterniflora* will survive and expand in Areas 1 and 2.

2. Monitoring Elements

Planting survival and growth were assessed for the planting areas the site scale and at vegetation station scales for five years. The baseline planting survival was the date of the planting inspection, March 17, 2014. The initial vegetation survey was conducted May 20, 2014, year 1 survey was conducted June 2, 2015, and a year 3 survey was conducted June 2, 2017. Planting survival and coverage was estimated at site scale five years after planting on May 15, 2019 as many of the vegetation stations were not accessible without damaging vegetation because of the tremendous growth and expansion of the plantings.

Vegetation Assessment

Seventeen vegetation stations were established to assess planting survival and vegetative growth (Fig. VII-1). Due to the 5-foot spacing of the *S. californicus* rows in the area plantings (1A, 2A and Auxiliary), the interior of the planted areas was not accessible without damaging plants. Therefore, monitoring stations were established along the perimeter of these planting areas. The *S. alterniflora* shoreline plantings (1C and 2B) were even less accessible between the area plantings and the existing shoreline. A general assessment of survival of the shoreline plantings was conducted from the boat when possible and was supplemented with Goggle Earth aerial photography.

The assessment of planting survival was based on monitoring 10 plants at each station; plants are characterized as live or dead/absent. The survival monitoring plants, 10 plants along a single row or five (5) plants along two neighboring parallel rows, were marked with PVC poles at the start and at the end. The survival monitoring plants extended beyond the 4 m^2 quadrant that was used for vegetative growth monitoring but were considered part of the same monitoring station. Vegetative growth was determined by measuring total percent vegetative cover, species composition, percent cover of each species, dominant species height, and vegetative layer height at 4 m^2 stations following CRMS methodology (Folse et al. 2014). An ocular assessment of the overall survival and condition of adjacent area and double row plantings were also noted. In addition to planting survival and vegetative growth, the distance between each row of the double rows was measured to determine if *S. californicus* is expanding and closing the gap between the double rows.

Hydrology

Surface and porewater salinity (ppt), specific conductivity (*u*S/cm), and temperature (°C) were measured at each vegetation station during each survey. Porewater is collected from a depth of 20 cm beneath the sediment surface. The depth of water at each station was also measured during sampling. Salinity and water level data recorded hourly from CRMS0030, located approximately 4 miles north-northeast of the site, were utilized to document salinity variation and approximate the flooding depth and duration for the planted vegetation. Porewater data are collected at CRMS0030 when the site is visited for servicing and during the annual vegetation surveys. Porewater salinity data from CRMS0030 were used to approximate conditions in the Prairie. A detailed analysis was conducted for the first two years after installation (2014 and 2015) while the plantings were becoming established.

3. Monitoring Results and Discussion

a. Vegetation

Planting survival of *Schoenoplectus californicus* was 100% at each of the 17 vegetation stations for the 2014 initial vegetation survey. By the 2015 survey, *S. californicus* had vegetated prolifically along and between the planted rows, and individual plants were indistinguishable within the stations. Survival at all stations is assumed to be 100% or nearly 100% (Figs VII-2–7). This level of survival was representative of all of the area and double row plantings. This trend was evident at the 2017 sampling as well. All plantings have survived and expanded.

Figure VII-2. Double row planting area 3A of LA-0039 Year 2 The Prairie was photographed during the May 2014 vegetation survey.

Figure VII-3. Double row planting area 3A of LA-0039 Year 2 The Prairie, photographed during the June 2015 vegetation survey.

Figure VII-4. Double row planting area 3A of LA-0039 Year 2 The Prairie was photographed during the May 2019 vegetation assessment.

Figure VII-5. Area planting 2A of LA-0039 Year 2 The Prairie was photographed during the May 2014 vegetation survey.

Figure VII-6. Area planting 2A of LA-0039 Year 2 The Prairie was photographed during the June 2015 vegetation survey. The SW marker pole for the survival plantings for station P08 Visible in the photograph was accessible in May 2014. Note the laid over *S. californicus* stems.

Figure VII-7. Area planting 2A of LA-0039 Year 2 The Prairie was photographed during the spring 2019 vegetation assessment.

The positive growth response of *S. californicus* between the 2014 and 2017 surveys indicates that this species is well suited for the environmental conditions that exist in the shallower areas of The Prairie (Figs. VII-8 and 9). Over the first year after planting, a general trend of increasing cover for planting areas from the northeast to the southwest was apparent from the vegetation stations (Fig. VII-8). There are several possible explanations for the lower cover in Area 1, including a greater presence of *Salvinia molesta* (kariba weed) and a lower planting elevation, both of which are discussed later, and being a more enclosed location than the other planting areas (Fig. VII-1). As a result, the plants may have experienced less hydrologic exchange and possibly inferior water quality as compared to the other planting areas. Also, the vegetation was live but laid over in 2015, especially in Areas 2 and 3 (Fig. VII-6), which contributed to the large increases in vegetative cover from 2014 and apparent difference of percent cover in 2017. By three years after planting in 2017, covers may appear lower than the previous survey due to the dense mat of veg that was formed from the laid down stems, especially in Area 3; although the standing stems resulted in a lower percent cover, the extent of *S. californicus* increased. By 2019, the double rows in 3A completely grew together and have merge where 3A meets 2A. For the 2014 survey, 100% of the cover was attributed to *S. californicus*, with no other species colonizing the stations within the short 2.5 months between the planting and the survey. In 2015, the species composition was again comprised nearly entirely of *S. californicus* with *Alternanthera philoxeroides* (alligator weed) being the only other rooted species recorded at the stations (0.8% mean cover); other vegetation was observed, but they were rooted in the floating mats of giant Salvinia. Limited colonization by other plant species continued to May 2017 as the occasional alligator weed or *Typha sp* was observed. During the 2019 vegetation sampling, an increase in other species present was observed including *Typha sp.*, *Phragmites australis*, *Ludwigia sp.* and *Zizaniopsis miliacea*.

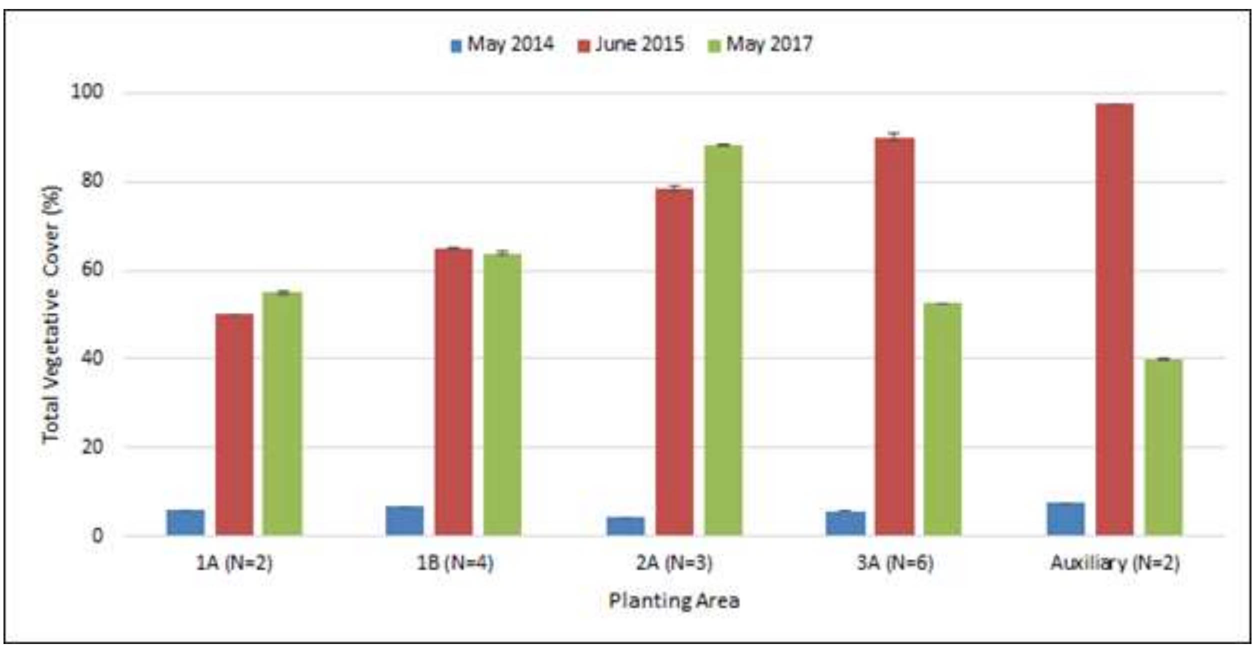

Figure VII-8. Mean total cover (± SE) of vegetation at stations in each planting area of LA-0039 Year 2 The Prairie as measured during the 2014, 2015 and 2017 vegetation surveys. Area and Double Row refer to the type of planting. N refers to the number of stations surveyed.

The mean height of *S. californicus* also increased at all stations among years (Fig. VII-7). Heights ranged from approximately 4-5 feet in 2014 to between 9-10 feet in 2017. The height of *S. californicus* at each station was measured by vertically elongating five randomly-selected stems within the 4 m^2 quadrant (Fig. VII-9).

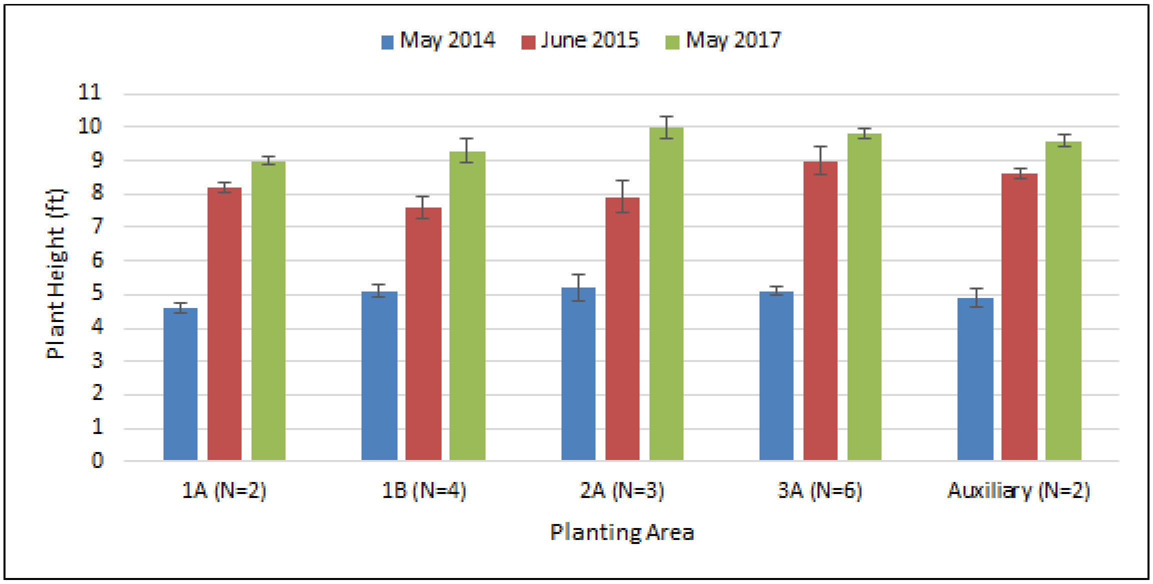

Figure VII-9. Mean height of *S. californicus* (± SE) at stations in each planting area LA-0039 Year 2 The Prairie as measured during the 2014, 2015 and 2017 vegetation surveys. *Area* and *Double Row* refer to the type of planting. *N* refers to the number of stations surveyed.

Figure VII-10. Ten-foot tall *S. californicus* photographed in double row planting Area 3A LA-0039 Year 2 The Prairie.

Double rows were planted with approximately 20 feet between each row in two areas (1B and 3A). The double rows were intended to converge as the plants proliferate. *Schoenoplectus californicus* spreads primarily through rhizomes and under appropriate conditions can expand its coverage 8–10 feet within one growing season (Materne and Fine 2000). This rate of expansion could result in each double row merging into one row within one to two growing seasons in ideal conditions. In planting Area 1B, the mean distance between rows as measured at vegetation stations declined from 20 ft in May 2014 to 4 ft by June 2015 (N=4 for both years). In planting area 3A, the mean distance between rows declined from 19 ft in May 2014 (N = 3) to 5 ft by June 2015 (N = 4). At this rate of expansion, the double rows were expected to unite into a single row by the 2017 survey, which did indeed happen (Figs. VII – 11 and 12). Spaces between double rows completely filled with new vegetation, which has allowed for the sediment around the plantings to become more solidified. This expansion continued through 2019 as sets of double rows have expanded to each other in Areas 1 and 3 and double rows from Area 3 have converged with the Auxillary plantings and Area 2 (Figs. VII – 12-14).

One row of *Spartina alterniflora* Vermilion (1C and 2B) was planted along the shoreline, directly behind planting Areas 1A and 2A (Fig. VII-1). While a quantitative assessment of the species was not possible without destroying other plants, it was visible from the boat and was noted as being alive in both planting areas in 2014. By 2015, the dense growth and increased height of *S. californicus* in the 1A and 2A planting areas prohibited any on-the-ground detection of the species; however, aerial imagery has provided some additional information. The 1C planting of *S. alterniflora* is Visible in Google earth aerial imagery taken October 31, 2014, but it is no longer discernible in the latest Google earth imagery taken April 4, 2016 (Fig. VII-9). A section of the *S. alterniflora* 2B planting also appears Visible in the 2014 Google earth imagery, but it too is no longer discernible in 2016 (Fig. VII-10). The ideal salinity and water depth for the *S. alterniflora* 'Vermilion' cultivar are 8−30 ppt and 1−18 inches, respectively (Fine and Thomassie 2000). While the water depth is within the range exhibited in The Prairie, the salinity is not; mean daily salinity in the area was approximately 1 ppt in following establishment in 2014 and 2015 and did not exceed 3.5 ppt on any day (see Hydrology section). *Spartina alterniflora* Vermilion can grow in freshwater environments without competitors; however, its growth has been shown to be greatly hindered when it is planted in association with freshwater-adapted species (Crain et al. 2004).

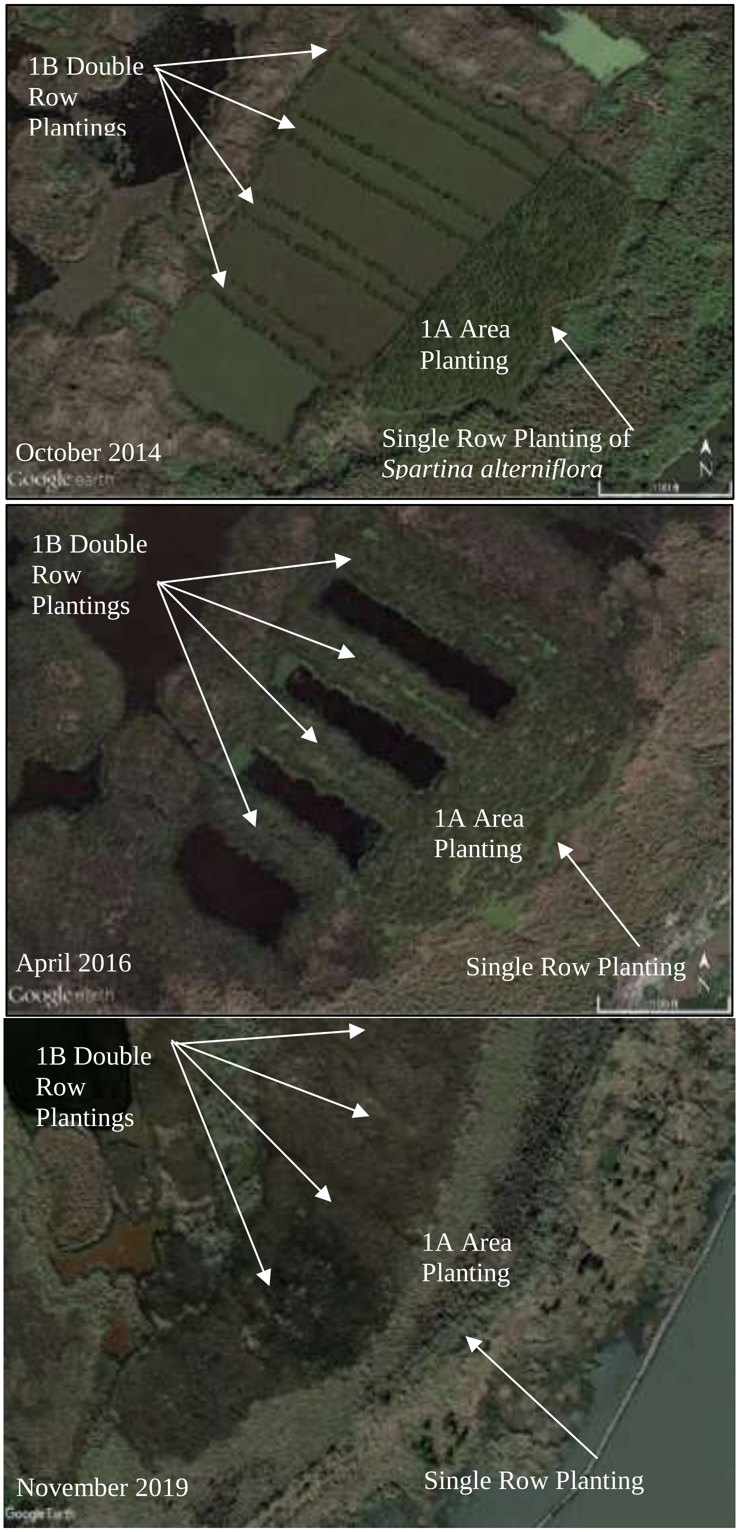

Figure VII-11. Google earth imagery taken October 2014, April 2016, and November 2019 of planting Area 1 LA-0039 Year 2 The Prairie. The 1B double rows of *S. californicus* have largely grown together as well as the 1A area plantings. The single row of *Spartina alterniflora* planted along southeast 1A Area was not discernible by 2016.

Figure VII-12. Google earth imagery taken October 2014, April 2016 and November 2019 of planting areas 2, 3, and the Auxiliary planting areas of *Schoenoplecus califonicus* in LA-0039 Year 2 The Prairie. All plantings have flourished and grown together. The single row of *Spartina alterniflora* was not discernible by 2016.

Figure VII-13. New *S. californicus* stems are Visible growing between a double row during the 2015 vegetation survey in Area 1B LA-0039 Year 2 The Prairie. *Salvinia molesta* covers the surface of the water.

Figure VII-14. Approximately 5 ft remained between the double row of *S. californicus* during the 2015 vegetation survey in Area 3A LA-0039 Year 2 The Prairie. *Salvinia minima* covers the surface of the water.

Figure VII-15. Encroachment of double row *S. californicus* plantings in area 3A of LA-0039 Year 2 The Prairie. Note *Zizaniopsis miliacea* establishing between the double row plantings (white circle) and the floating aquatic vegetation, *Eichornia crassipes* (water hyacinth).

In addition to the expansion and growth of *S. californicus*, there has also been an increase in submerged and floating aquatic vegetation. While present in 2014 at several stations, submerged aquatic vegetation was more dense and diverse during the 2015 survey in areas that were not covered by *Salvinia molesta* (kariba weed), *Salvinia minima* (water spangles) (Figs. VII-13 and 14), or *Eichornia crassipes* (water hyacinth; Fig. VII-15). *Ceratophyllum demersum* (coon's tail), *Najas guadalupensis* (southern water nymph), and *Potamogeton pusillus* (small pondweed) were all prevalent in or bordering the 2A, 3A, and Auxiliary planting areas. Submerged aquatic vegetation was also dense in the shallow open water expanse of The Prairie. The expansion of the invasive aquatic plant *Salvinia molesta* is of concern in Louisiana and along much of the coastal United States. This species was not noted in planting areas during the 2014 survey; however, it blanketed much of the water's surface between the double rows in 2015. Salvinia weevils (*Cyrtobagous Salviniae*) were released in The Prairie in May and August 2015 and again in May 2016 as part of an ongoing effort by the Louisiana State University AgCenter and LDWF to combat the invasive species. The weevil has not established a locally-reproducing population and has not effectively controlled *S. molesta* in The Prairie to date. It was observed during the 2015 survey that the *S. molesta* mat was providing a floating substrate for the establishment of other species, including *Amaranthus australis* (southern amaranth), *Habenaria repens* (waterspider bog orchid) and *Symphyotrichum* sp. (aster). *Salvinia molesta* was particularly dense in Area 1, and may partially account for the lower vegetative cover for *S. californicus* in the area. The species is certainly reducing light penetration through the water and may be having a smothering effect on emerging vegetation. This species were still present during the 2017 and 2019 surveys, but not worse than what was noted in 2015.

b. Hydrology

Mean salinity recorded at the 17 vegetation stations during the May 20, 2014, survey was 1.18 ppt ± 0.01 SE, which corresponded closely with the mean hourly salinity of 1.01 ppt ± 0.02 SE recorded during the same time frame at CRMS0030. Mean salinity recorded during the June 2, 2015, survey was 0.48 ppt ± 0.02 SE, which again corresponded closely with the mean hourly salinity of 0.55 ± 0.00 SE recorded at CRMS0030 during the same time (Fig. VII-16). In 2014, porewater salinity was 3.3 ppt at the one successfully sampled station. In 2015, porewater salinity was sampled from 10 stations for a mean salinity of 0.9 ppt ± 0.1 SE.

For 2014 and 2015, mean daily salinity at CRMS0030 was 1.09 ppt ± 0.02 SE (Fig. VII-16). *Schoenoplectus californicus* grows best in salinities between 0 – 6 ppt and can tolerate brief spikes of higher salinity (Materne and Fine 2000). Even with the pulse of higher salinity that occurred the latter half of October 2015 (Fig. VII-16), mean daily salinity remained well within the tolerance levels for this species. The salinity pulse resulted from a period of sustained easterly winds that pushed more saline waters from Lake Pontchartrain into the marsh. Mean porewater salinity measured at CRMS0030 between 2014 and 2015 was 1.53 ppt ± 0.17 SE which was higher than the surface water salinity but still within a favorable range for *S. californicus*. The reported porewater salinity values are an average of porewater salinity collected at 10 cm and 30 cm depth, as is standard collection procedure at CRMS sites (Fig. VII-16).

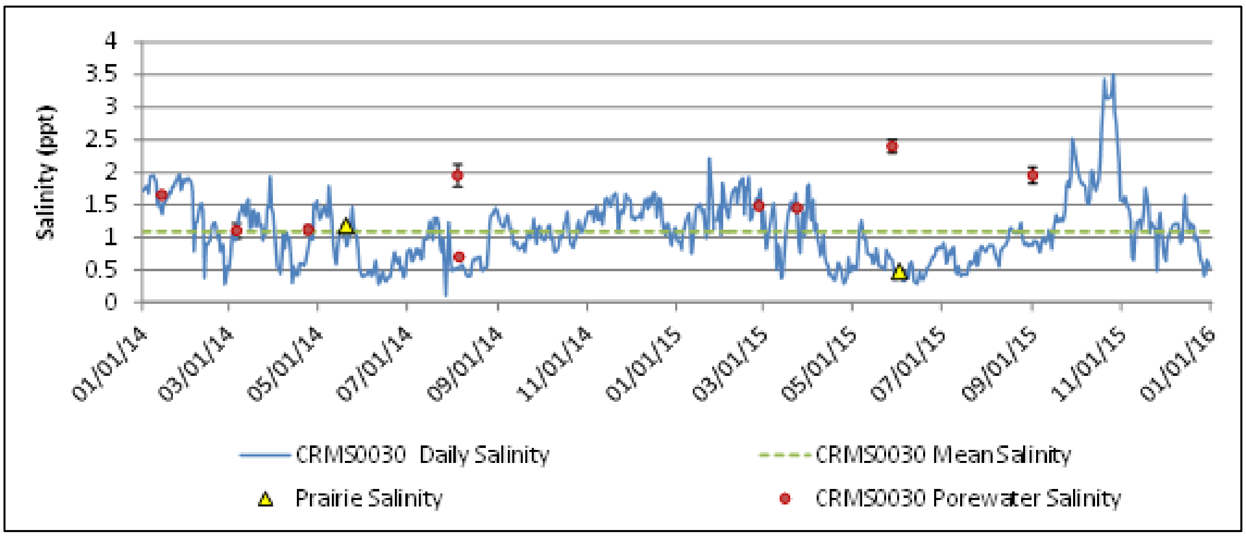

Figure VII-16. Mean salinity at vegetation stations in The Prairie during the 2014 and 2015 surveys graphed in relation to mean daily and mean overall salinity measured at CRMS0030 01/01/2014 – 12/31/2015. Porewater salinity (± SE) measured at CRMS0030 is also displayed.

For 2014 and 2015, mean daily water elevation (NAVD88, GEOID 12A) at CRMS0030 was +0.47 ft and ranged from a high of +3.44 ft to a low of -0.93 ft (Fig. VII-17). The same easterly winds that resulted in an increase of salinity at CRMS0030 also likely contributed to the increase in water elevation that occurred October 25–27, 2015. However, the 6.68 inches of rain that fell on October 25 (Louisiana Regional Airport in Gonzales, LA) may have also contributed to the increase in water level.

The plant elevation was estimated by subtracting the water depth measured at each vegetation station during the survey, from the water elevation recorded at the corresponding time at CRMS0030. The estimated planting area elevation was calculated by averaging the elevation of all plants within a planting area. Mean estimated planting area elevation ranged from a high of -0.4 ft in the Auxiliary planting area, to a low of - 0.9 ft in Areas 1A and 1B (Table VII-1). Using these elevations and the water elevation at CRMS0030, the depth and duration of flooding for 2014 and 2015 were calculated for the planting areas. The mean depth of flooding in the planting areas was + 1.2 ft, and ranged from a high of + 1.4 ft in Area 2A, to a low of + 0.9 ft in the Auxiliary area. On average, the plants were flooded 98.1% of the time, with flooding ranging from a high of 99.7% in area 2A and a low of 94.0% in the Auxiliary area. The optimum water depth for establishment of *S. californicus* is reported as between 1 to 2 feet (Materne and Fine 2000). The estimated mean depth of inundation for the plants is within this range for all planting areas except the Auxiliary area, which had the greatest cover in 2015 and shows no negative impact from slightly less frequent and shallower flooding. Area 1 had the greatest depth and duration of flooding, and also had lower vegetative cover than the other planting areas. It seems unlikely that the greater flooding resulted in reduced growth, but it is a noted difference between planting areas.

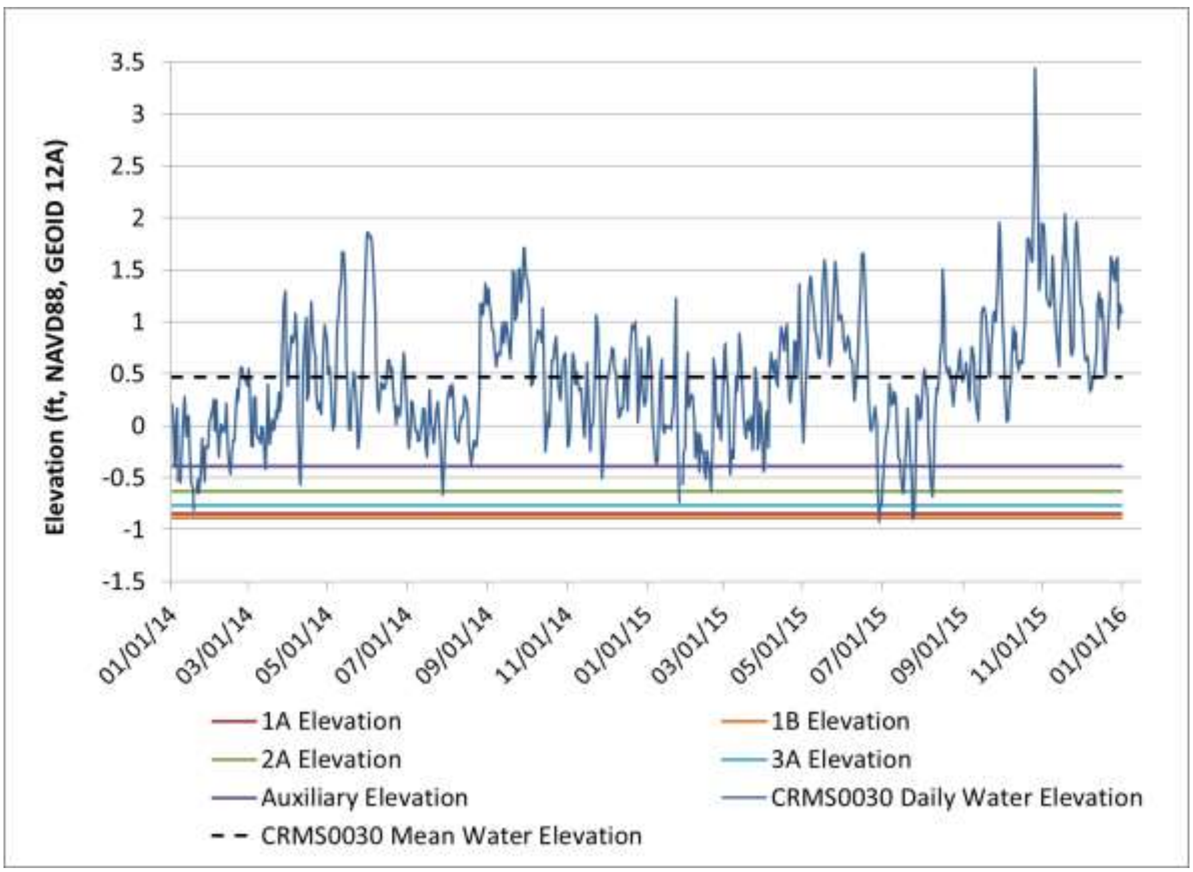

Figure VII-17. Mean daily and mean overall water elevation at CRMS0030 was graphed with the estimated elevation of each planting area to demonstrate inundation at LA-0039 Year 2 The Prairie.

Table VII-1. Depth and duration of flooding from January 1, 2014 to December 31, 2015, for each planting area within LA-0039 Year 2 The Prairie. Elevation is in ft NAVD88 GEOID 12A.

		Depth of flooding (ft)			Time Flooded (%)
The Prairie Planting Area	Planting Area Elevation (ft)	Mean	High	Low	
1A	-0.9	1.3	4.3	-0.1	99.6
1B	-0.9	1.4	4.3	0.0	99.7
2A	-0.6	1.1	4.1	-0.3	98.1
3A	-0.8	1.2	4.2	-0.2	99.3
Auxiliary	-0.4	0.9	3.8	-0.5	94.0
	Mean	1.2	4.1	-0.2	98.1

Water depth and salinity measurements taken during the 2019 monitoring survey indicate little change in these hydrologic parameters. On a monthly basis at CRMS0030, salinity seemed to have decreased since 2015, while water levels increased since the beginning of 2018 (Fig. VII-18). The proliferate expansion of the plantings show that hydrological conditions were conducive to planting success.

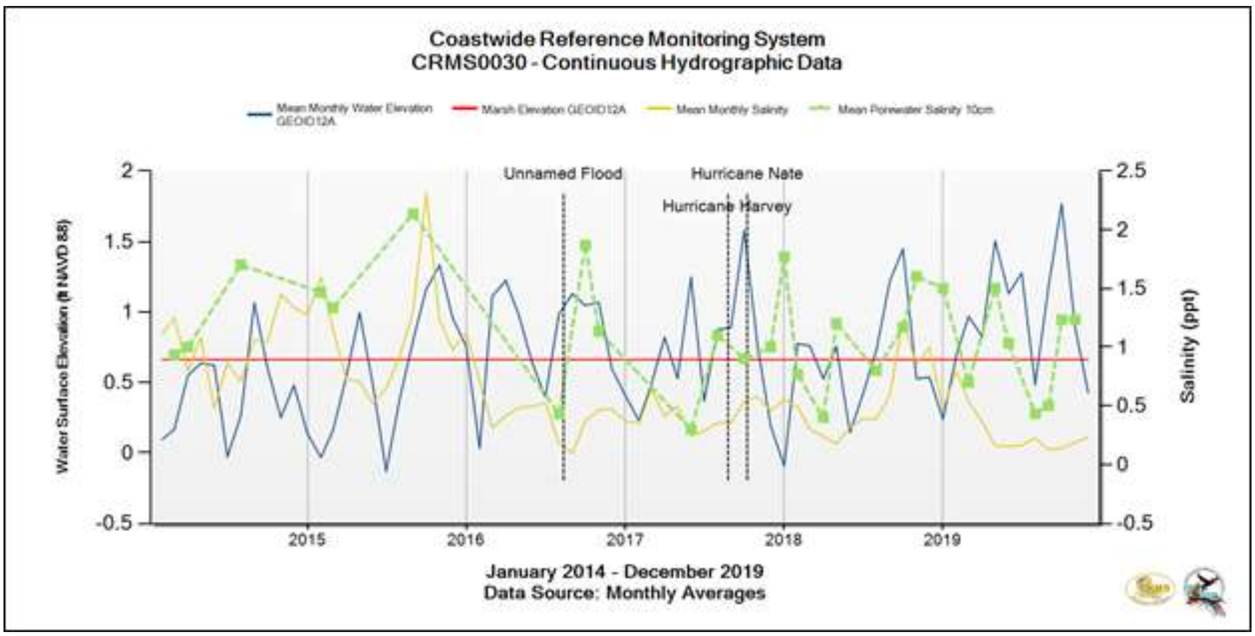

Figure VII-18. The continuous recorder at nearby CRMS0030 was used to approximate hydrologic conditions at LA-0039 Year 2 The Prairie. Water surface elevations and salinity are monthly means of data collected hourly. The porewater salinity is collected upon sonde servicing.

C. Conclusions

1. Project Effectiveness

The LA-0039 Year 2 − The Prairie planting of *Schoenoplectus californicus* has been successful.

- All area plantings of *S. californicus* survived and expanded.
- The area plantings of *S. californicus* widened the land bridge in Areas 1 and 2.
- The double row plantings of *S. californicus* in areas 1B and 3A survived and expanded.
- The shoreline plantings of *S. alterniflora* appear to have survived initially, but an on-the-ground assessment was difficult due to the location of the plantings. The plantings were no longer evident in the Google earth April 2016 imagery as *S. californicus* filled the area.

2. Recommended Improvements

In isolated and protected sites with favorable hydrologic conditions like the Prairie, planting costs could be reduced by increasing spacing between plants to reduce plant density.

Salvinia molesta was blanketing the surface of the water between the 1B double row plantings and was also covering the surface of the water in sections of the other double row and area plantings. The LDWF is attempting to control the species with the introduction of the Salvinia weevil, but the current assessment of this strategy indicates that the weevils are not establishing a viable reproducing population in The Prairie. It is recommended that invasive species control be considered where the spread of *S. molesta* or other invasive species is likely.

Shoreline enhancement plantings may be unnecessary in conjunction with adjacent area plantings if environmental conditions are similar in the planting areas and an expansion of the area planting is expected to occur.

Spartina alterniflora Vermilion does not appear to have thrived under the same conditions as *S. californicus*. The low salinity in the Prairie may have hindered its successful establishment. This species may perform better under higher salinity conditions and in association with species that will not have a greater competitive advantage.

3. Lessons Learned

Schoenoplectus californicus is a rapidly growing species that does well in shallow, continuously-flooded fresh to intermediate marsh habitats such as The Prairie. Based on survival and growth data collected to present, this species is recommended for future plantings in similar environments.

The planting of *Spartina alterniflora* Vermilion may not be advisable for fresh/intermediate marsh plantings, although conditions other than salinity could have affected the species success in the Prairie. Assessment of *S. alterniflora* has been difficult due to the location of the shoreline enhancement plantings; therefore, it is possible that some plants are still alive.

VIII. Year 3 – The Jaws

Prepared by Bernard Wood – CPRA - Lafayette Regional Office

A. Site and Planting Description

The Jaws, a Year 3 planting site for LA-0039, is located in St. Mary Parish, along the northeast shore of West Cote Blanche Bay in an area of confluence of several water bodies including the Charenton Canal, the Gulf Intercostal Waterway, West Cote Blanche Bay and several other smaller bayous collectively referred to as The Jaws. The approximate 100-acre project area is located within the northern portion of the Sediment Trapping at "The Jaws" (TV-0015) Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) project area, which is a set of delta splay terraces constructed in 2004 (CWPPRA Priority Project List 6).

This planting included 23 linear hedgerows of *Schoenoplectus californicus* (California bulrush) (Fig. VIII-1 a and b). A total of 10,185 trade gallon *Schoenoplectus californicus* were planted in The Jaws by September 16th, 2014, with the final construction inspection occurring on October 25, 2014. The project area is divided into two primary areas, which are subdivided based on the proximity to the existing TV-0015 terrace field. The areas that were planted are categorized as shallow open-water habitat with some sparse emergent marsh and submerged aquatic vegetation. The dominant emergent vegetation present in the project area pre plantings was *Zizaniopsis miliacea* (giant cutgrass) and to a lesser extent *Sagittaria platyphylla* (delta arrowhead), combined covering less than 10% of the project area. The plantings are designed to establish perennial emergent vegetation in areas devoid of vegetation and/or in areas with sparse annual vegetation in order to increase water bottom friction to trap sediments. Increasing vegetation in this sediment rich environment should increase water bottom elevation and colonization of other emergent species to the area.

<u>Northwest Plantings</u>

Schoenoplectus californicus was planted in 14 double rows angled towards the northern TV-0015 terrace to the west of the main "delta" channel (Fig. VIII-1a). The Northwest plantings are protected by terraces. Within each double row, rows were spaced fifteen feet (15′) apart with plants on five-foot (5′) alternating centers. These plants were installed at elevations ranging from -0.3 to -1.1 ft NAVD 88, GEOID 12A.

<u>Northeast Plantings</u>

Schoenoplectus californicus was planted in 9 double rows parallel to one another northeast of the TV-0015 terraces on a subaqueous sediment deposit east of the main "delta" channel and west of Bayou Mascot (Fig. VIII-1b). The Northeast plantings are not protected by terraces. Within each double row, rows were spaced fifteen feet (15′) apart with plants on five-foot (5′) alternating centers. These plants were installed at elevations ranging from -0.7 to -1.1 ft NAVD GEOID 12A.

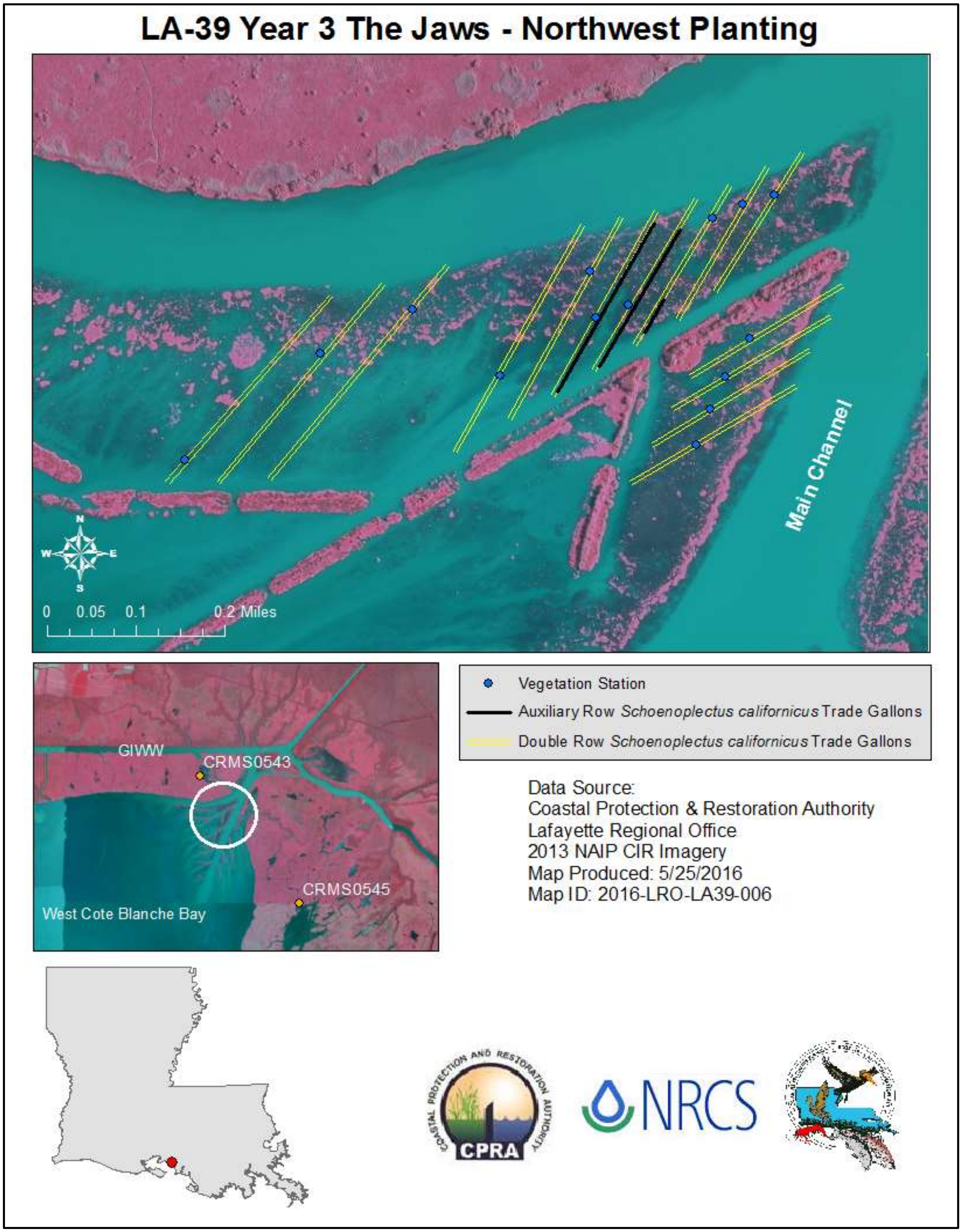

Figure VIII-1a. LA-0039 Year 3 Site – The Jaws Northwest Plantings site map showing location of plantings and vegetative monitoring stations.

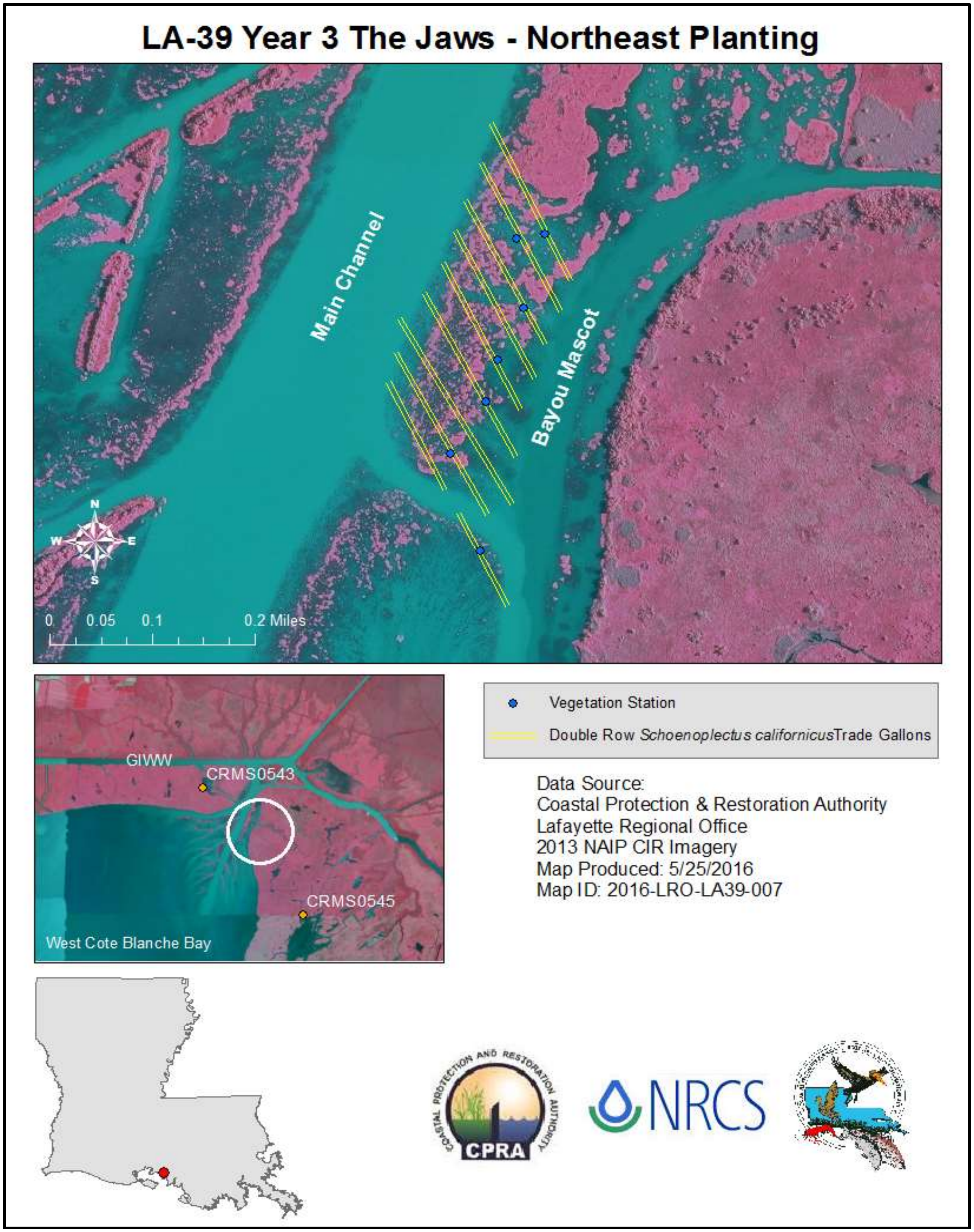

Figure VIII-1b. LA-0039 Year 3 Site – The Jaws Northeast Plantings site map showing location of plantings and vegetative monitoring stations.

B. Monitoring Activity

1. Monitoring Goals

Year 3 Site - The Jaws plantings were designed to create thick, robust hedgerows of *Schoenoplectus californicus* along pre-existing sediment flats both within and adjacent to the TV-0015 project terraces to enhance the sediment deposition and natural recruitment of emergent plant species.

The goals of The Jaws plantings are:

- Northwest double row plantings in the tidal flats in and around the TV-0015 terraces will survive and expand.
- Northeast double row plantings in the tidal flats east of the TV-0015 terraces will survive and expand.
- Survival of the planted *Schoenoplectus californicus* trade-gallons will exceed 50%.
- Recruit new emergent marsh species to the tidal flats in and around The Jaws.

2. Monitoring Elements

The monitoring elements include procedures to assess plant survival and effects on the planting area for the project plantings and the recruitment of any other emergent marsh vegetation to the area. Vegetation stations were intended to monitor planting survival and vegetative cover representative of the double row plantings within The Jaws project area over time. Plantings were monitored shortly after planting in November 2014, and one and three year after planting in September 2015 and 2017, respectively. No additional station monitoring is planned; however, overall condition will be checked during monitoring of a follow-up planting in the same area, LA-0039 Year 6 Site - The Jaws 2.

<u>Vegetation Assessment</u>

To assess planting status, an ocular estimate of survival (%) and plant condition was conducted for each double row. Planting survival and vegetative cover (%) data was also collected at the vegetation station level; 21 vegetation stations were established randomly along the double rows. Percent survival was calculated from 10 plants (5 plants per row) at each vegetation station; plants were characterized as live or dead/absent. PVC poles were placed on both ends of the plants monitored for survival. Vegetative condition was assessed by measuring percent cover of species present, vegetative stand height, and height of dominant species in a 4 m^2 plot at each vegetation station (Folse et al. 2014). Flooding depth, surface water salinity, temperature, and, when possible, porewater salinity and temperature were also collected at all sampling stations during each sampling event. Conditions occurring outside of the stations and segments including additional species, marsh interspersion, and site-specific points of interest were noted along with photo documentation.

<u>Northwest plantings:</u> Fourteen (14) stations were established along the double rows planted within the northern tidal flats surrounding the beginning of the TV-0015 terrace field.

Northeast plantings: Seven (7) stations were established along the double rows planted within the tidal flats east the main channel through the center of the TV-0015 terrace field.

Hydrology

Water level elevations from nearby CRMS sites (CRMS0543 and CRMS0545) were used to convert water depth (ft) at vegetation stations to estimated planting elevations (ft, NAVD88 GEOID 12A). The water elevations and estimated planting elevations were then used to create a water-level hydrograph depicting flood levels, duration, and frequency.

Planting Failure/Success Causation

Significant loss of plants in LA-0039 Year 3 - The Jaws were investigated by assessing hydrologic conditions and plant competition conditions.

3. Monitoring Results and Discussion

a. Vegetative Assessment

Plantings in the vegetation stations were performing exceptionally well, with survival rates over 90% as of the Sept 2015 sampling, before a substantial reduction by Sept 2017 (Table VIII-1); this pattern was similar to the overall condition of the plantings. The percent cover of the sample plots had increased from near 3% per sampling plot to 25-35% over a year (Figs. VIII-2, 3, and 4). This trajectory was expected to continue and as the plants became more established other emergent marsh species would likely recruit to the area; however, the data collected in September 2017 reveals this was not the case. The plantings have failed over the vast majority of the planting area and the naturally occurring marsh species *Zizaniopsis miliacea* (giant cutgrass) has continued to expand modestly, with the plantings reaching an apex of around 20 percent cover in fall of 2015, and becoming almost nonexistent by fall of 2017. The project area filled in with floating aquatic vegetation (FAV) in 2015 likely due to the resistance provided by the hedgerows of *Schoenoplectus californicus* stopping the rafts of *Eichhornia crassipes* (water hyacinth) from floating out into West Cote Blanche Bay (Fig. VIII-4). The mechanical and physiological damage induced from these rafts removed and smothered the large robust hedgerows of *Schoenoplectus californicus*, while leaving some of the *Zizaniopsis miliacea* alive and growing (Fig. VIII-5). Along with the floating aquatic vegetation, pioneer emergent marsh species started to appear, though many of these species appeared to be anchored in the floating vegetation and not rooted to the soil beneath (Figs. VIII-6 and 7). After the destruction of the double hedge rows both the floating mats and the pioneer emergent species broke up and floated out of the project area (Fig. VIII-8). Although the plantings initially expanded greatly in both locations, the NE area percent cover was greater than the NW area plantings. This was likely due to the NE area having a more robust existing marsh platform with a higher percentage of preexisting emergent marsh cover, while the NW area was planted in a more open water environment. Stem heights also increased dramatically from planting through September 2015, almost tripling in the NE area while almost doubling in the NW locations (Fig. VIII-9). The difference in planting heights between the two locations is likely due to the same mechanisms affecting percent cover, but the precipitous decline in Sept 2017 was felt equally in both locations height measurements as the lack of vegetation overall reduced average vegetation cover and height throughout the project area.

Table VIII-1. Survival of vegetation stations at LA-0039 Year 3 - The Jaws Northwest (NW) and Northeast (NE) tidal flat plantings of California bulrush trade gallons. Survival at vegetation stations were similar to the overall planting areas.

	% Overall Survival				
Areas	Number of Plants Sampled	Sept 2014	Nov 2014	Sept 2015	Sept 2017
NW	140	100	100	93	0
NE	70	100	100	94	20

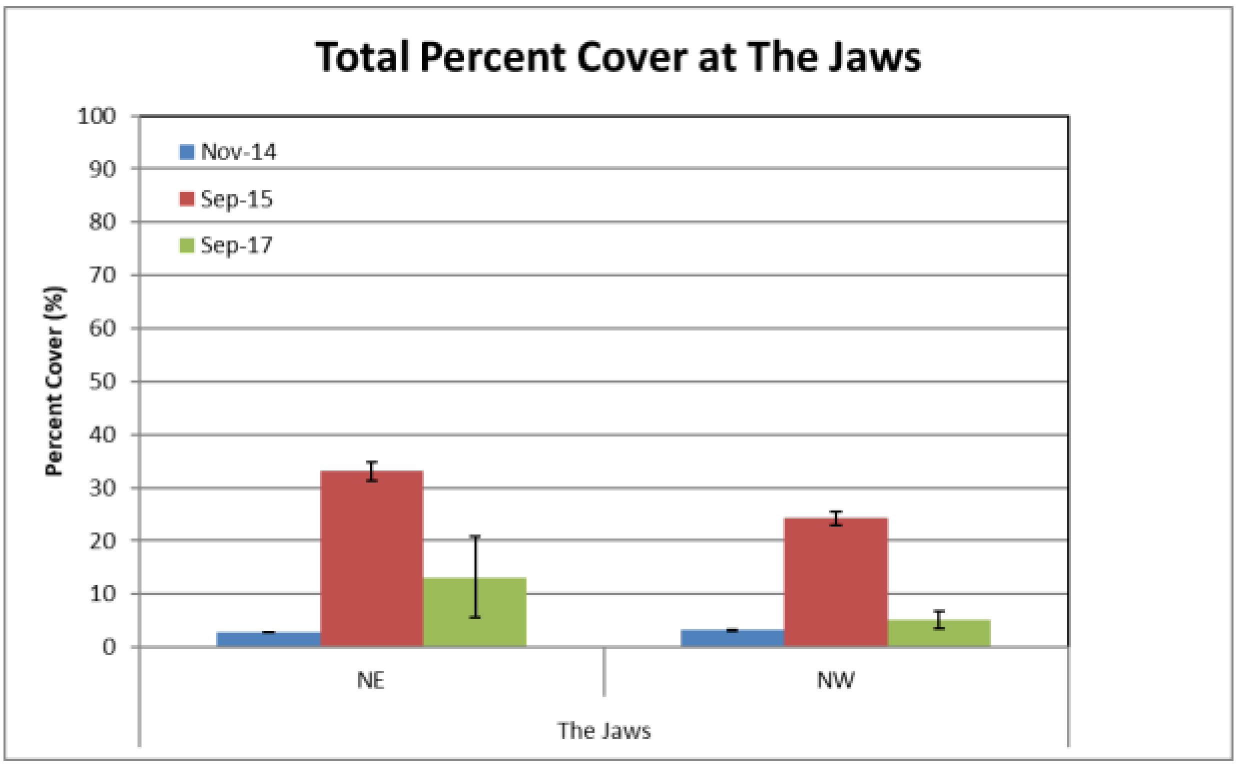

Figure VIII-2. The percent cover of emergent vegetation in the sample plots at LA-0039 Year 3 - The Jaws planting location over time; percent cover increased by an order of magnitude in one year, then decreassed drastically after water hyacinth rafts smothered the planted vegetation.

Figure VIII-3. Typical veiw of a double row planting at LA-0039 Year 3 - The Jaws in November 2014.

Figure VIII-4. Typical veiw of a double row plantings at LA-0039 Year 3 - The Jaws just prior to the September 2015 sampling. Note accumulation of *Eichhornia crassipes.*

Figure VIII-5. Typical veiw of a double row plantings at LA-0039 Year 3 - The Jaws during September 2017 sampling. Note the absense of *Schoenoplectus californicus* and presence of naturally occurring *Zianiopsis miliacea*.

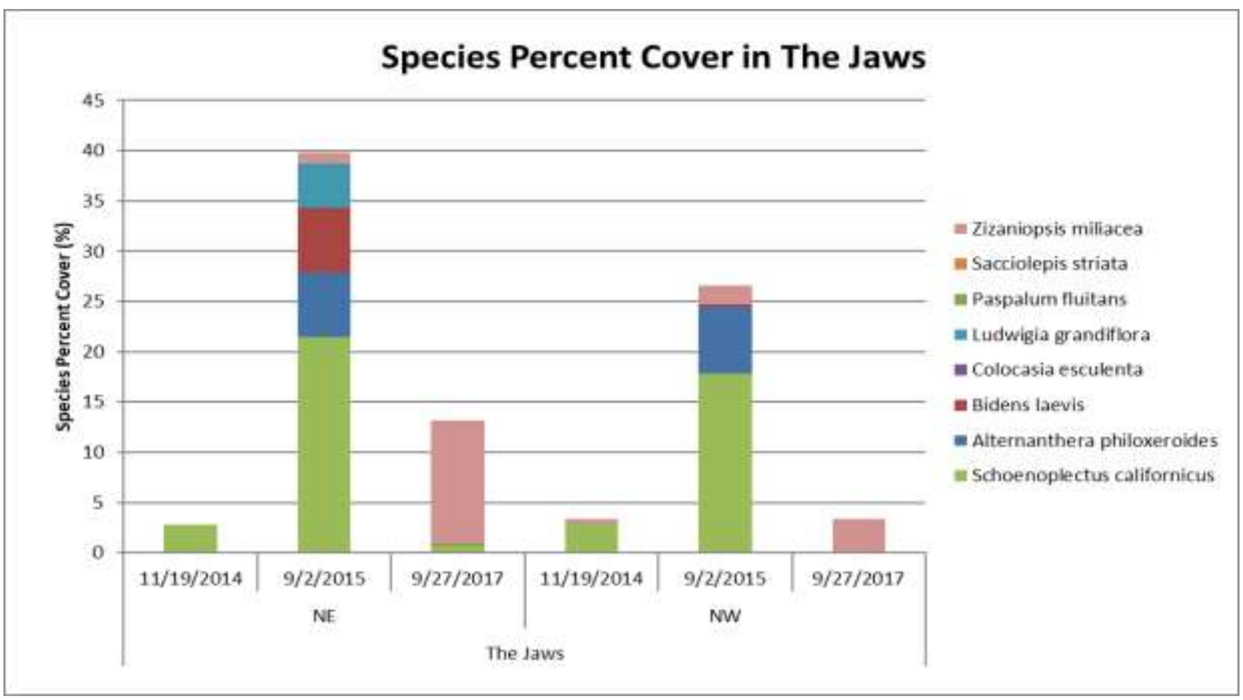

Figure VIII-6. The species specific percent cover of emergent vegetation in the planting transects at LA-0039 Year 3 - The Jaws over time as other emergent species began recruiting to the planting locations.

Figure VIII-7. Recruited species growing in and among the double row plantings during September 2015 sampling including *Alternanthera philoxeroides* and *Zizaniopsis miliacea*.

Figure VIII-8. Recruited species remaining after the double row plantings is gone in September 2017 consited of *Zizaniopsis miliacea* (giant cutgrass).

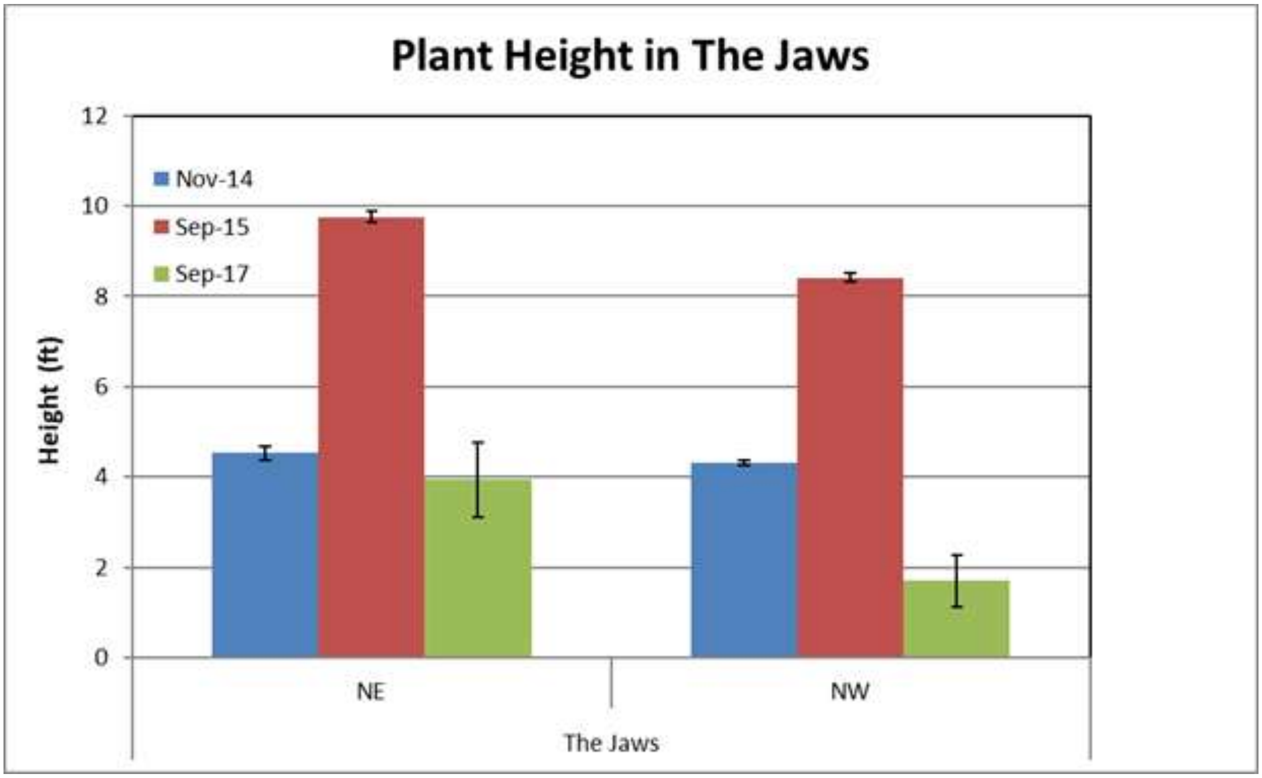

Figure VIII-9. The average height of emergent vegetation in the double row plantings at LA-0039 Year 3 - The Jaws planting location over time; average height more than doubled in one year, and then was reduced drastically by the almost complete removal of *Scheonoplectus californicus* (California bulrush).

b. Hydrology

The water levels in the planting area are generally quite deep, but as the plantings matured, sedimentation was expected to increase allowing for the addition of other species that thrive in deeper flood regimes to become established (Fig. VIII-10). The optimum water depth for establishment of *S. californicus* is reported as between 1 to 2 feet (Materne and Fine 2000). Water depth within this range was common in the project area during 2015 and 2016, but 2017 routinely exceeding the 2 foot depth threshold during the growing season adding to the stress the water hyacinth rafts had induced the previous fall and winter.

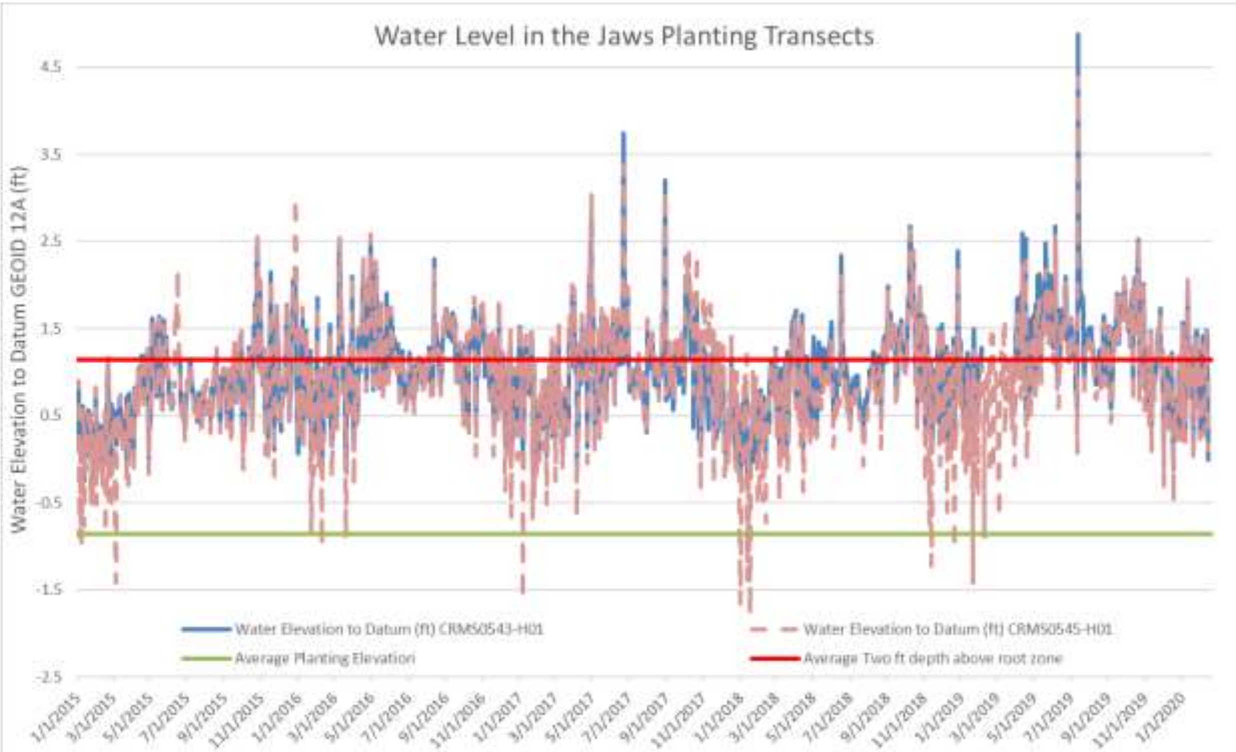

Figure VIII-10. Hydrograph of nearby CRMS sites displaying water levels and averaged planting depth for both the NW and NE planting areas for the LA-0039 Year 3 - The Jaws from 2015 through 2019.

c. Planting Failure/Success Causation

Significant loss of plants through the first year of the planting was only observed in the southern-most double row of the NW area, just west of the main canal through the project area. The channel-side row of this double row was unprotected by terraces or other plantings and suffered some mortality due to boat wake and wave energy causing rafting of *Eichhornia crassipes* (water hyacinth). The only other plant loss was isolated and random, possibly due to poor plant health at the time of planting or isolated poor environmental conditions.

The project area plantings looked very different in September 2017. Both percent survival and percent cover were extensively lower, along with all other metrics. The observed decline was thought to be due to extensive physical damage from rafts of water hyacinth, wave activity, elevated water level, and still senesced vegetation from the winter of 2016; the pattern of reduced survival and cover was continuous and obvious. These observations coincided with the apparent expansion of *Zizaniopsis miliacea* (giant cutgrass), *Sagittaria platyphylla* (delta arrowhead), and *Nelumbo lutea* (American lotus). The dominant submerged aquatic vegetation (SAV) species *Ceratophyllum demersum* (Coontail) and *Vallisneria americana* (American eelgrass) were intermixed with the naturally occurring and planted emergent marsh species. As of September 2017 only part of one of the original 23 planted transects planted with California bulrush was visually obvious, and it was diminished and not growing vigorously. Meanwhile, the slow expansion of *Zizaniopsis miliacea* continued which inspired the LA-0039 Years 6 - The Jaws #2 planting.

C. Conclusions

1. Project Effectiveness

As per the project goals through September 2017:

- Northwest and northeast double-row plantings in the tidal flats in and around the TV-15 terraces was initially successful, with survivorship of plantings near 95% and total vegetative cover increasing about 30% one year after planting; however, the physical barriers the double hedgerows designed to become sediment retention also held vast rafts of floating aquatic vegetation (FAV) mainly consisting of *Eichhornia crassipes* (water hyacinth). This ultimately led to the plantings failure three years after planting.
- Planting survival was near 100% through one year post planting; however, by the fall of third year post planting, the area was well below the 50% survival goal of the *Schoenoplectus californicus* (California bulrush) trade-gallons plantings.
- The recruitment of new emergent plants within the planting transects was successful though modest with many of those species anchored in the dense rafts of FAV trapped by the project hedgerows; as the plantings deteriorated under the weight of these rafts, many of the recruits floated out of the project area.

2. Recommended Improvements

The planting of *Zizaniopsis miliacea,* a naturally occurring species in the project areas' intertidal flats, which has survived multiple rafting events, may offer a better opportunity for long-term sediment trapping and species recruitment success than the more rigid California bulrush.

3. Lessons Learned

The linear hedgerow plantings offered enough support and reduced the energy of the system such that a dense growth of FAV mostly consisting of water hyacinth stayed in the project area. The rafts of SAV added to the reduction of flow and some interior openings in the floating vegetation were extremely clear and filled with various submerged aquatic vegetation (SAV) species. While SAV was seen in the area pre planting, the quantity and variety was more impressive post planting; also, to have pockets of high-light penetration in this muddy, sediment-rich environment was remarkable. This is further evidence that additional sediments were falling out of suspension as the three dimensional structure of the area increased via the plantings and recruitment.

Large stands of California bulrush were destroyed after becoming well established via physical damage by FAV rafts composed mainly of water hyacinth driven by wave action and currents. The occurrence of large mats of floating vegetation in recent years is attributable to recent mild winter temperatures and low salinity conditions. Planting *Zizaniopsis miliacea,* a more flexible species that may be able withstand floating invasive species, and *Schoenoplectus californicus* in a less linear alignments was later tried in the LA-0039 Year 6 - Jaws #2 planted in fall 2017.

IX. Year 3 – Little Vermilion Bay

Prepared by Bernard Wood – CPRA Lafayette Regional Office

A. Site and Planting Description

Little Vermilion Bay (LVB), a Year 3 planting site for the Coastwide Planting project (LA-0039), is located in two terrace fields in Vermilion Parish. Both areas are within Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) project areas designed to trap sediments at the confluences of multiple water bodies including the Vermilion River, the Gulf Intercostal Waterway (GIWW), Freshwater Bayou Canal (FBC), and Little Vermilion Bay. Both terrace projects have succeeded in creating mudflats between and around the constructed terraces. The eastern planting area is within the ~250 acre terrace field of the Four Mile Canal Terracing and Sediment Trapping project (TV-0018) located along the western shore of the Vermilion River Cutoff Canal (VRCC), also known as Four Mile Canal, (Thibodeaux and Aucoin 2008) (Fig. IX-1). The western planting area is interspersed within the western side of approximately 200 acres of the Little Vermilion Bay Sediment Trapping (TV-0012) project terraces between FBC and Little Vermilion Bay (LVB) (Wood and Aucoin 2016) (Fig. IX-2).

A combined total of 26,285 trade gallons of *Schoenoplectus californicus* (California bulrush) were planted in the east and west planting locations by September 25th, 2014, with the final construction inspection occurring on September 26th, 2014. These plantings included 14 double row and 4 area plantings of *Schoenoplectus californicus* in the east and west planting locations along with a few auxiliary rows. The areas that were planted are categorized as intertidal mudflat habitat and shallow open water. The double row plantings were designed to create thick, robust hedgerows and dense areas of *Schoenoplectus californicus* along preexisting sediment flats within both the TV-0012 and TV-0018 project terraces to enhance the sediment deposition and natural recruitment of volunteer species to the area. The dominant emergent vegetation present in the TV-0018 project area (East) pre plantings was *Typha domingensis* (southern cattail) and to a lesser extent *Sagittaria lancifolia* (bulltongue arrowhead), combined covering less than 10% of the project area. The dominant emergent vegetation present in the TV-0012 project area (West) pre plantings was *Schoenoplectus californicus* (California bulrush), *Spartina alterniflora* (smooth cordgrass) and to a lesser extent *Sagittaria lancifolia* (bulltongue arrowhead), combined covering less than 20% of the project area. The existing *Schoenoplectus californicus* and *Spartina alterniflora* vegetation in the western area were previously planted as part of the TV-0012 project construction along the terraces and as a small but ongoing effort by the Vermilion Soil and Water Conservation District office (SWCD).

The LVB plantings are designed to establish perennial emergent vegetation in areas devoid of vegetation and/or in areas with sparse annual vegetation in order to increase water bottom friction to trap sediments. Increasing vegetation in this sediment rich environment should increase water bottom elevation and the colonization of other emergent species to the area along with the survival and expansion of the *Schoenoplectus californicus*.

East Plantings

Nine (9) double rows of *Schoenoplectus californicus* were planted in parallel rows fifteen feet (15′) apart with plants on five-foot (5′) alternating centers. The nine double rows ran primarily north to south and diagonally across shallow open water within TV-0018 terrace cells. These plants were installed at elevations ranging from -0.3 ft to -1.6 ft, with an average elevation of -0.76 ft NAVD GEOID 12A. Excess plants were placed along two of the double rows for an East area total of 2,756 *Schoenoplectus californicus* trade-gallon sized plants (Fig. IX-1).

West Plantings

Schoenoplectus californicus was planted in five (5) double rows consisting of parallel rows fifteen feet (15′) apart with plants on five-foot (5′) alternating centers and in four (4) area plantings in parallel rows five feet (5′) apart with plants on five-foot (5′) alternating centers. The double row (1,474 plants) and area (22,054) planting alignments were parallel to the project terraces on the western side of the TV-0012 project areas. These plants were installed at elevations ranging from -0.2 ft to -1.6 ft with an average elevation of -0.68 ft NAVD GEOID 12A. Excess plants were placed along the northernmost double row for a West area total of 23,529 *Schoenoplectus californicus* trade-gallon sized plants (Fig. IX-2).

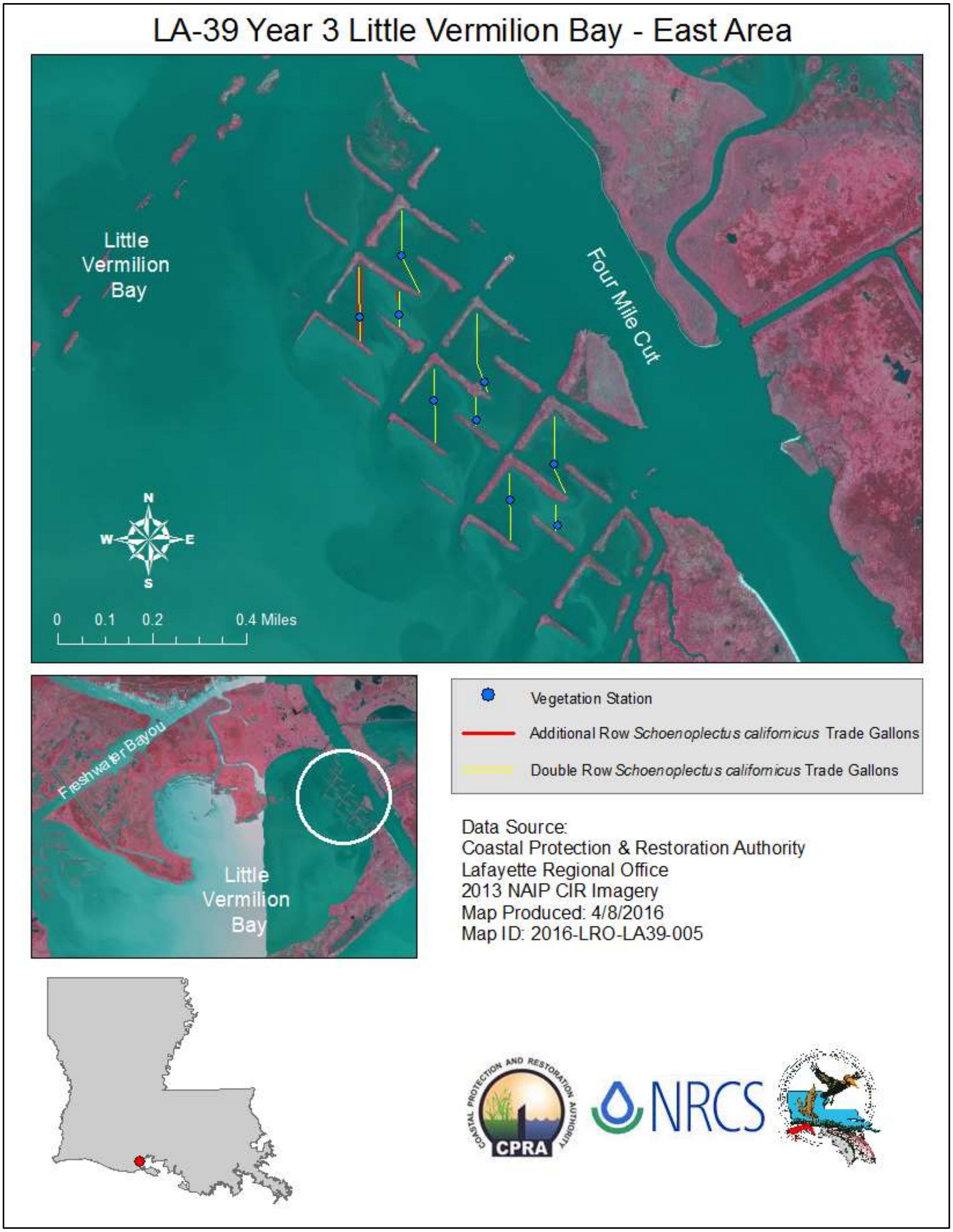

Figure IX-1. LA-0039 Year 3 Little Vermilion Bay East Plantings site map shows location of plantings between TV-0018 terraces and vegetative monitoring stations.

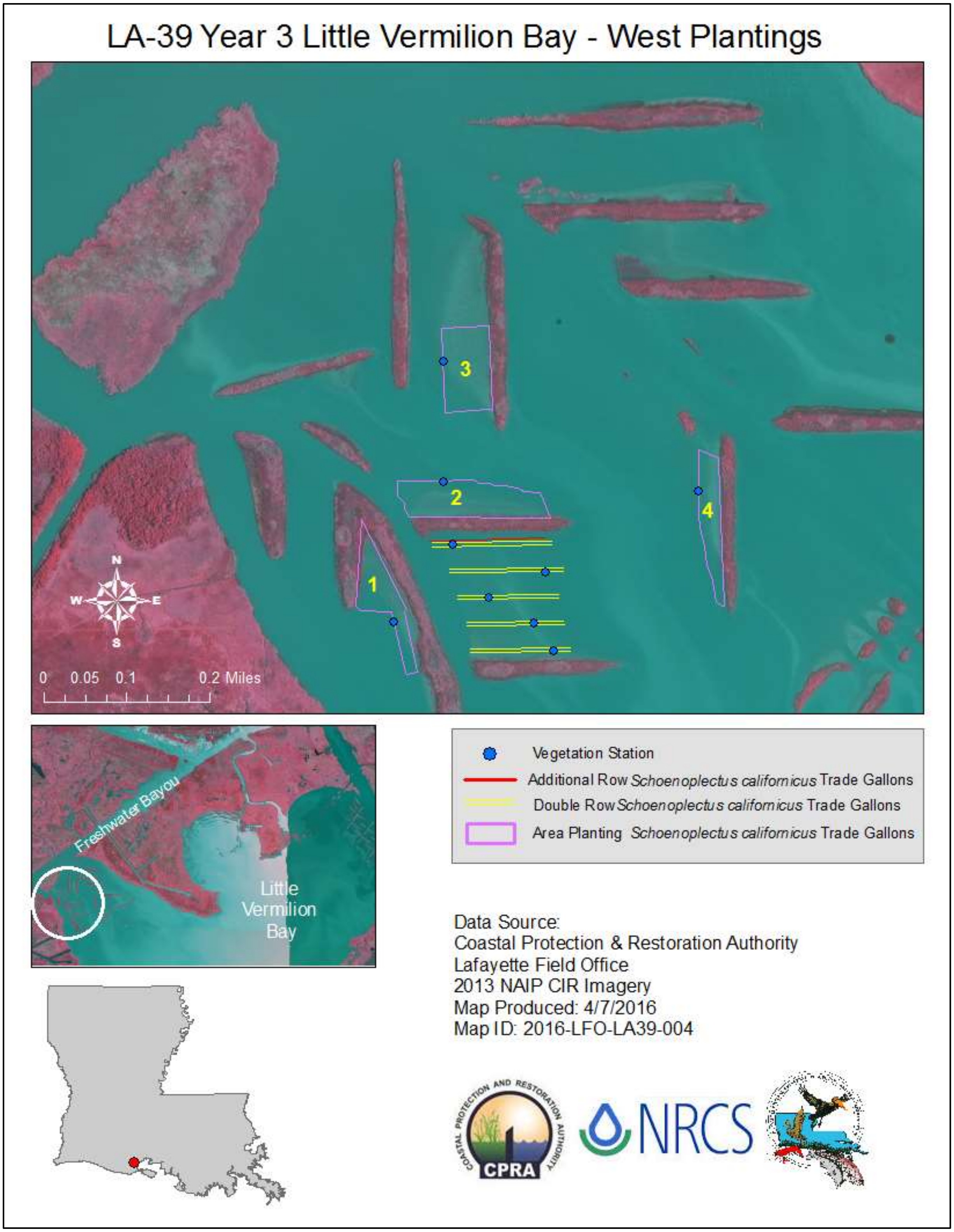

Figure IX-2. LA-0039 Year 3 Little Vermilion Bay Wast plantings site map shows location of plantings between TV-0012 terraces and vegetative monitoring stations.

B. Monitoring Activity

1. Monitoring Goals

The LA-0039 Year 3 LVB plantings were designed to create thick, robust hedgerows and dense areas of *Schoenoplectus californicus* along preexisting sediment flats within both the TV-0012 and TV-0018 project terraces to enhance the sediment deposition and natural recruitment of volunteer species to the area.

The goals of the LVB plantings are:

- East Double Row plantings exceed 50% survival and moderately expand between terraces.
- West Double Rows plantings exceed 50% survival and moderately expand between terraces.
- West Area plantings exceed 50% survival and moderately expand among the grid area plantings.
- Recruit new emergent marsh species to the tidal flats in and around TV-0012 and TV-0018 plantings.

2. Monitoring Elements

The monitoring elements include procedures to assess plant survival and effects on the planting area for the project plantings and the recruitment of any other emergent marsh vegetation to the area. Vegetation stations were intended to monitor planting survival and vegetative cover representative of the double row and area plantings within the LVB project area over time. Plantings were assumed to have 100% survival when planted in September 2014. Planting survival and vegetative cover were monitored two months (November 2014), one year (October 2015), three years (September 2017), and five years (November 2019) after planting.

<u>Vegetation Assessment</u>

To assess planting status, an ocular estimate of percent survival and plant condition was conducted for each reach, segment, and/or row. Planting survival and percent vegetative cover data was also collected at the vegetation station level; stations were established randomly among live plants. Percent survival was calculated from a set number of plants at each vegetation station; plants were characterized as live or dead/absent. PVC poles were placed on both ends of the plants monitored for survival. Percent cover of species present, vegetative stand height, and height of dominant species were measured in 4 m^2 vegetation stations (Folse et al. 2014). Flooding depth, surface water salinity and temperature, and when possible porewater salinity and temperature were also collected at all sampling stations during each sampling event. Conditions occurring outside of the stations and segments including additional species, marsh interspersion, and site-specific points of interest were noted along with photo documentation. One vegetation station was located in each double row and along the perimeter of each area planting in order to not damage plantings while monitoring.

East plantings: Nine (9) stations were established along the double rows planted within shallow open water and tidal mudflats surrounding the interior terraces of the TV-0018 terrace field. Percent survival of 10 plants per station, % cover data, and height were recorded at each station (Figure IX-1).

West plantings: Five (5) double row stations and 4 area stations were established along the double rows and area plantings within shallow open water and tidal mudflats surrounding the interior terraces of the TV-0012 terrace field. Percent survival of 10 plants per station, % cover data, and height were recorded at each station (Figure IX-2).

Hydrology

Water-level elevations from the nearby site CRMS2041, located between the West and East areas were used to convert water depth (ft) at vegetation stations to estimated planting elevations (ft, NAVD88 Geoid 12A). The water elevations and estimated planting elevations were then used to create a water-level hydrograph depicting flood levels, duration, and frequency.

3. Monitoring Results and Discussion

a. Vegetative Assessment

Overall, double-row and area plantings in the LA-0039 LVB West planting location have performed exceptionally well, with survival rates of 100% before plants grew together, spread, and became indistinguishable from one another (Table IX-1). The LA-0039 LVB East planting location initially performed well below its counterpart due to herbivory (Fig. IX-3), with a survival rate of 66.7% by one year after planting (Table IX-1). However, percent cover of the East vegetation stations still increased from near 3% per sampling plot to just over 50% over the course of five years (Fig. IX-4). Stem heights also increased dramatically from initial planting through November 2019, nearing 8 ft in the East and 7 ft in the West locations (Fig. IX-5). The differences in planting heights between the two locations are minimal, but percent cover and height at a few stations was zero for these variables when no vegetation remained. This effect is noticeable in the error bars of the East showing a lack of consistent heights during the last three sampling efforts. Vegetation cover in the West increased dramatically from near 3% in 2014 to just over 70% during 2019 (Fig. IX-4 and 6-11). Some of the double row plantings were actually experiencing significant intraspecific competition at the end of one growing season (Fig. IX-10). These trajectories have been consistent, and as the plants become established, other emergent marsh species have recruited to the area (Figs. IX-8 and 12). The project area remained mostly a *Schoenoplectus californicus* monoculture in 2019 but other species are gaining a foothold in the project area, notably *Phragmites australis, Zizaniopsis miliacea,* and *Alternanthera philoxeroides*. The water level in the planting area is generally relatively deep and variable but as the plantings mature, sedimentation and accretion due to friction and below ground organic production have increased allowing for the addition of other species that thrive in intermediate salinity regimes and previously deeper waters are becoming established (Fig. IX-11).

Table IX-1. Overall survival of LA-0039 Year 3 Little Vermilion Bay East and West plantings of California bulrush trade gallons. ND is Not Determined because plantings grew together to become indistinguishable or other species recruited.

	Number of Plants	Survival (%)				
Areas	Sampled	Sept 2014	Nov 2014	Oct 2015	Sept 2017	Nov 2019
East	90	100	98	67	ND	ND
West	90	100	100	100	ND	ND

Figure IX-3. Veiw of minor herbivory damage of *Schoenoplectus californifus* in the LA-0039 Year 3 Little Vermilion Bay East double rows in October 2015 and November 2019 (the standing brown stems are scenesed).

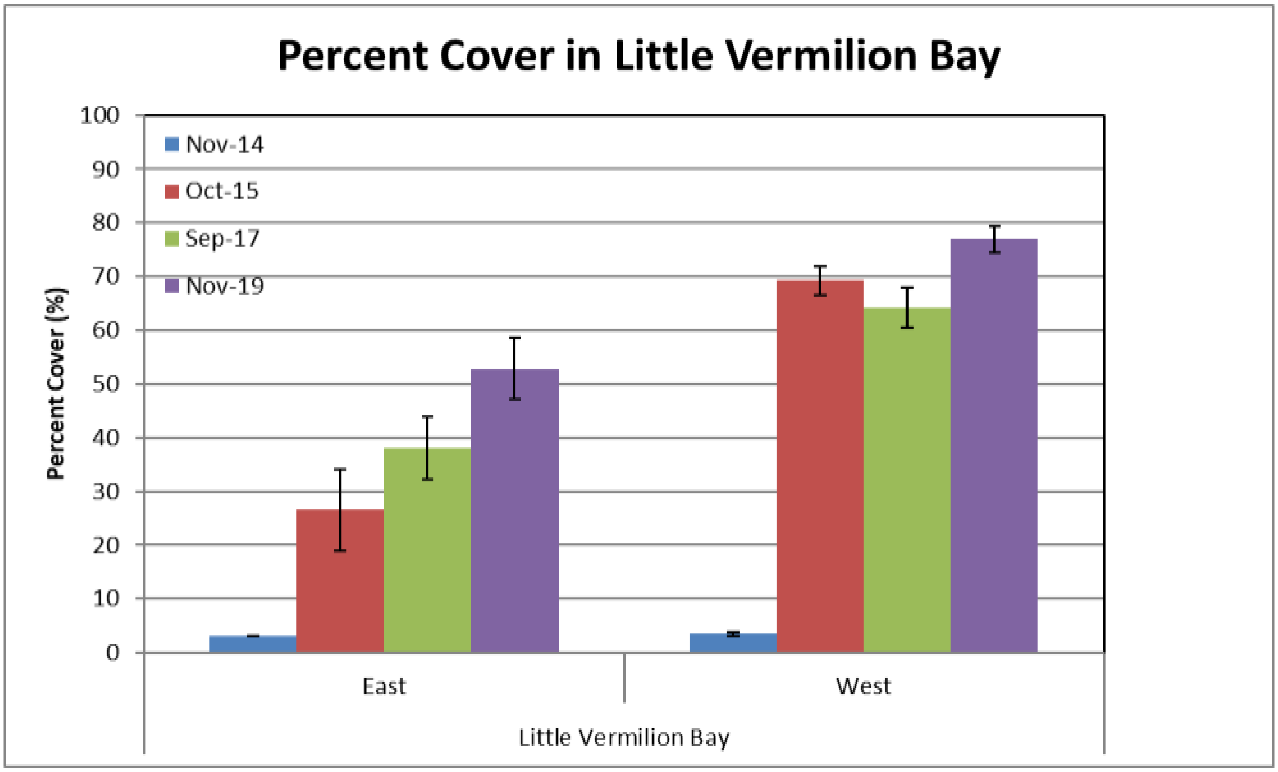

Figure IX-4. The percent cover of emergent vegetation in the planting transects at LA-0039 Year 3 Little Vermilion Bay over time, percent cover increased by an order of magnitude in one year.

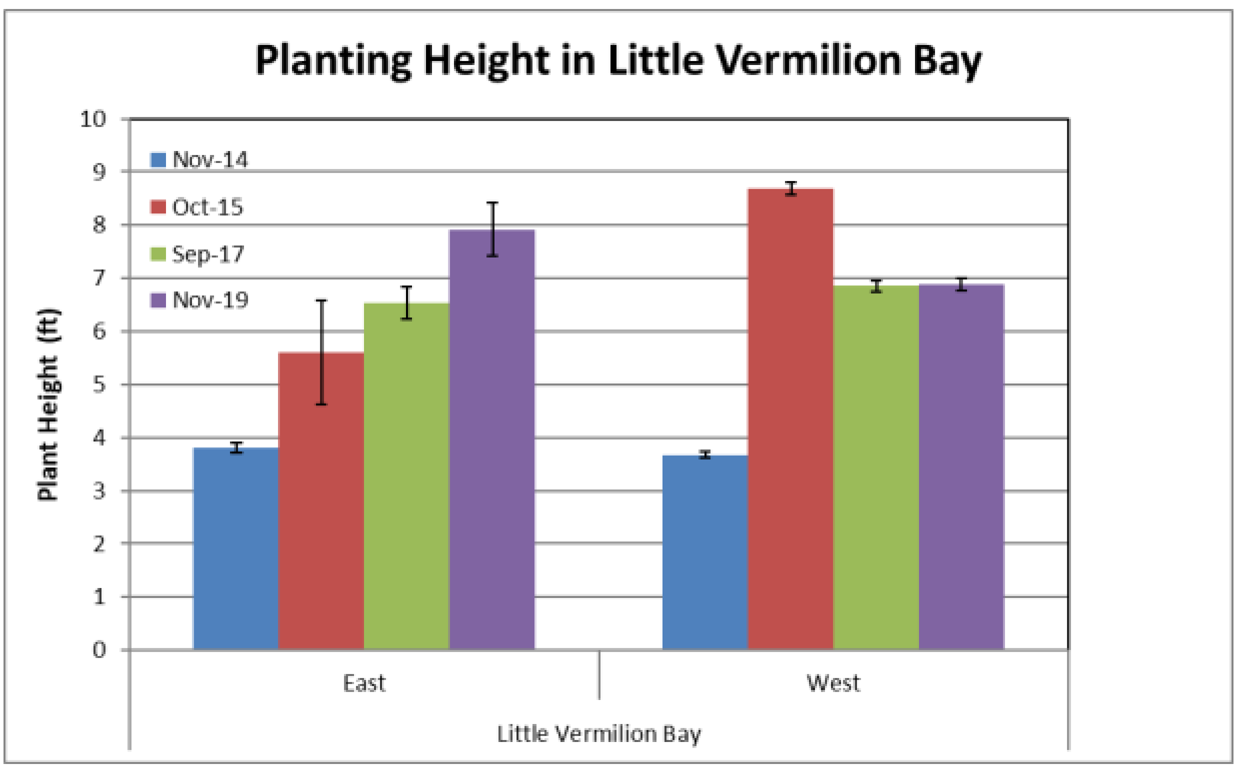

Figure IX-5. The average height of emergent vegetation in the double row and area plantings at LA-0039 Year 3 Little Vermilion Bay over time; average height more than doubled in one year.

Figure IX-6. Typical veiw of a LA-0039 Year 3 Little Vermilion Bay West area planting at low tide during November 2014.

Figure IX-7. Typical veiw of a vegetation station in a LA-0039 Year 3 Little Vermilion Bay West area planting in October 2015.

Figure IX-8. Typical veiw of a vegetation station in a LA-0039 Year 3 Little Vermilion Bay West area planting in Sept 2017, additional species now clearly visible.

Figure IX-9. Note wrack deposition and surviving plants after Hurricane Barry in a LA-0039 Year 3 Little Vermilion Bay West area planting in November 2019.

Figure IX-10. The growth over the first year after planting (Novemeber 2014 - October2015) of a typical double row in the LA-0039 Year 3 Little Vermilion Bay West plantings.

Figure IX-11. The growth from September 2017 (upper) – November 2019 (lower) of a typical double row in the LA-0039 Year 3 Little Vermilion Bay West; hedgerows now resemble earthen terraces, gaining both horizontally and vertically.

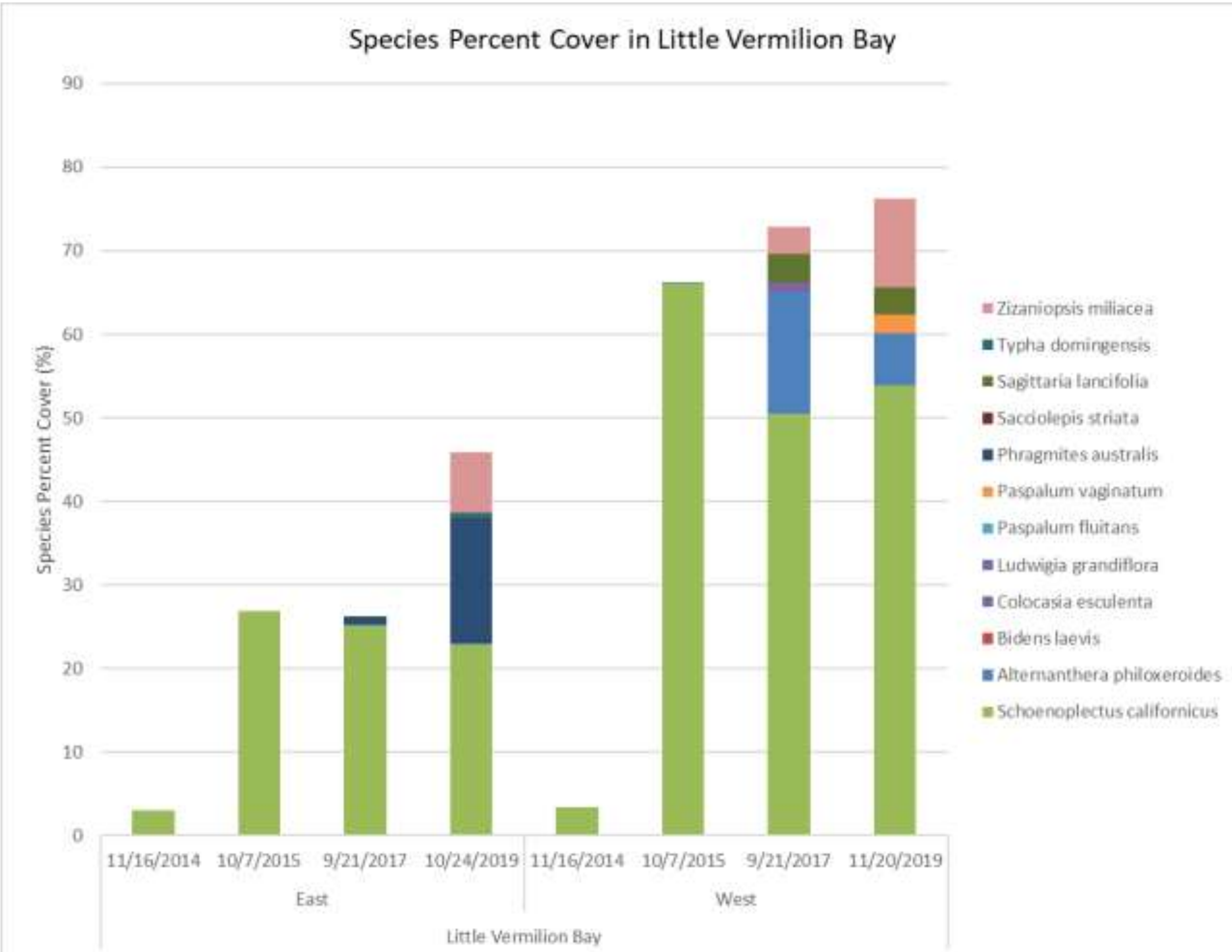

Figure IX-12. The change in species assemblage from November 2014 – 2019 in LA-0039 Year 3 Little Vermilion Bay; the original monocultures have transitioned into a more diverse assemblage of marsh species.

Hydrology

The water level in the planting area is generally deep but variable due to tidal action (Fig. IX-13). As the plantings have matured, sedimentation and organic deposition have increased, allowing for the addition of other species that thrive in deeper flood regimes to become established (Figs. IX-8, 11, and 12). The optimum water depth for establishment of *S. californicus* is reported as between 1 to 2 feet (Materne and Fine 2000). Water depth within this range was the standard in the project area from 2014-2019 only routinely exceeding the 2 foot depth threshold during tropical storms which can potentially also add sediment to the plantings. However, during the 2016 and 2019 growing season, there have been significant periods where water levels have exceeded the root zone by well over the two foot threshold due to upland rainfall. The historic flooding of August 2016 brought nutrients and sediment to the area through nonpoint source runoff from upland agricultural activities. The elevations of some of the double row planting have increased significantly to the point of being visually obvious especially in the West plantings (Figure XI-11).

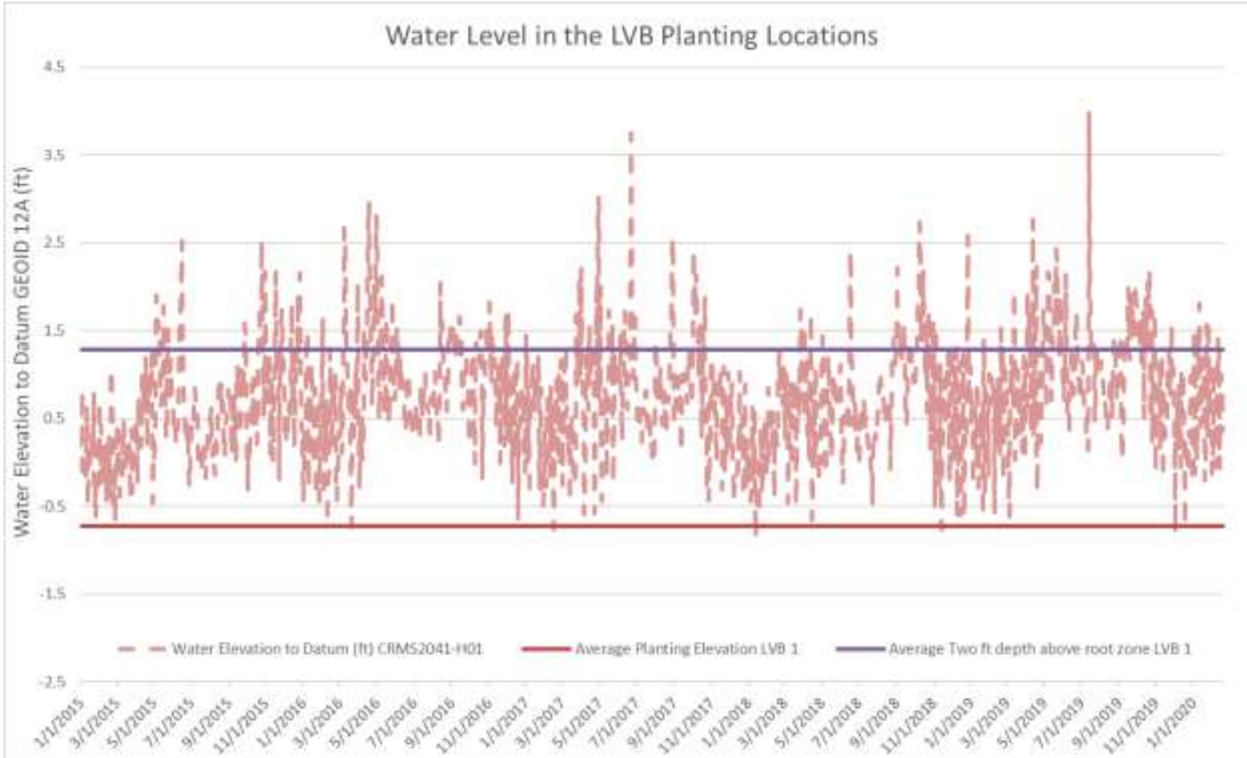

Figure IX-13. Hydrograph of nearby CRMS2041 displaying water levels in LA-0039 Year 3 Little Vermilion Bay during 2015 through 2019.

b. Planting Failure/Success Causation

Herbivory was responsible for nearly all plant mortality in the planting area. There was a significant loss of plants in the LVB East planting's southern double rows; the loss of plants gradually increased further south in the planting area, nearing complete loss at the last double row. These double rows suffered some mortality due to herbivory believed to be caused by *Ondatra zibethicus* (muskrats). Detached stems, tracks, and scat in and among the damaged plantings were observed during the October 2015 vegetation survey (Fig. IX-14). On the nearby TV-0018 project terraces, nests and at least one individual was observed. Google Earth imagery 5/6/2016 show a complete loss of the 8th and 9th double rows (southeastern set) in the eastern LVB planting area and a notable reduction of the 7th while all others appear intact and healthy (Fig. IX-15). Other than this location, the only plant loss was isolated and random, either due to poor plant health at the time of planting or isolated poor environmental conditions. However, with the flood of August 2016 and Hurricane Barry in 2019, it is reasonable to expect some loss of plants in the LVB area as it is just off the main Vermilion River Cutoff Canal. This flooding may however provide the area with upland sediments, increasing soil elevation and enhance natural recruitment in the area, especially in proximity to the project plantings (Fig. IX-16). The LVB West plantings showed some significant impacts from Hurricane Barry wrack (Fig. IX-9) but the elevation gain already present make a full recovery likely, including expanded species diversity as the dominant vegetation was disturbed in some locations.

Figure IX-14. Upper frame - Active herbivory damage to the planted double rows in LA-0039 Year 3 Little Vermilion Bay East during the October 2015 sampling. The double row had extended to the terrace to the north in the background prior to herbivory. Lower frame - Herbivore tracks in and among the planted double rows in the LA-0039 Year 3 Little Vermilion Bay East.

Figure IX-15. Google Earth imagery of LA-0039 Year 3 Little Vermilion Bay East plantings taken on 5/6/2016. The northeastern and middle sets of double rows expanded, whereas, the southeastern set of double rows were mostly removed by herbivory.

Figure IX-16. Google Earth imagery of the taken on 4/14/2018 shows the robust LA-0039 Year 3 - Little Vermilion Bay West plantings three and half years after installation.

C. Conclusions

1. Project Effectiveness

As per the project goals:

- Double row plantings in the shallow open water and tidal mudflats in LVB East have been successful, with total combined survivorship of plantings ~67% and total vegetative cover increasing from 3% to near 50% 5 years after planting.

- Double row plantings in the shallow open water and tidal mudflats in LVB West have been extremely successful, with survivorship of plantings at 100% and percent cover increasing from 3% to ~80% 5 years after planting.

- Area plantings in the shallow open water and tidal mudflats in LVB West have been extremely successful, with survivorship of plantings at 100% and percent cover increasing from 3% to ~80% 5 years after planting.

- The recruitment of new emergent plants to the area began in 2017 and has accelerated through 2019 as water-bottom/ground surface elevations increase within the plantings.

2. Recommended Improvements

The area and double row plantings were experiencing significant intraspecific competition at the end of one year; wider spaced plantings could grow for a longer period of time before resource limitations decrease growth while increasing the overall project foot print. The density of plantings in the project area in both the area and double row planting could be reduced in future plantings to reduce costs or increase the overall coverage.

Based on the success of the LA-0039 Year 3 Little Vermilion Bay (LVB) plantings, another round of plantings, LA-0039 Year 7- LVB #2 were installed in fall 2018 with more spacing between plants (less density of plants).

3. Lessons Learned

This project area has the potential for fast growth and high survival rates among transplanted trade gallons of *Schoenoplectus californicus*; however, herbivory especially in the east planting location did originally jeopardize the impressive results elsewhere in the project area. One possible solution would be to coordinate with Louisiana Department of Wildlife and Fisheries to survey the area pre planting and possibly direct local trappers to the project area.

X. Year 3 – Willow Lake

Prepared by Tommy McGinnis – CPRA Lafayette Regional Office

A. Site and Planting Description

Willow Lake, a Year 3 planting site, is in north-central Cameron Parish east of Calcasieu Lake and north of the Gulf Intracoastal Waterway (GIWW) (Figure II-1). Saltwater intrusion from Calcasieu Lake to the general area is minimized by the Calcasieu Lock on the GIWW which is part of the Mermentau Basin Project managed and operated by the Corps of Engineers to maintain fresh to intermediate salinity conditions. Willow Lake is within the CS-11b project boundaries; it is separated from the GIWW by a rock dike, and there was a failed attempt at erecting terraces along the northern shoreline of the lake attributed to poor soil structure for terrace construction.

The planting site is in the broken marsh north and northwest of Willow Lake. The site is divided into three (3) areas (West, South, and East) and four (4) planting strategies (double rows parallel to shoreline of open ponds, double rows across open ponds, area plantings, and deeper water test sections) (Fig. X-1). All plants were trade gallons of *Shoenoplectus californicus* (California bulrush, 17,367 plants) except for the deeper-water test plots which also included two (2) trade gallon California bulrush (297 plants) and two (2) trade gallon *Phragmites australis* (Roseau cane, 297 plants). Planting occurred in two phases; the California bulrush plantings were completed by October 26, 2014, and the Roseau cane plantings were completed by May 11, 2015. The final inspection of the Willow Lake planting was on May 11, 2015.

Double Row Plantings parallel to perimeters and across open-water areas were planted in all three areas with the intent to establish vegetation in shallow open-water areas, break wind fetch distance, and stabilize existing marsh. Rows of California bulrush trade gallons were planted fifteen feet (15′) apart with plants on five-foot (5′) alternating centers no lower than -1.9 ft NAVD88, GEOID 12A.

Area plantings in small open-water areas were planted as auxiliary areas in the South and East areas to establish vegetation in areas susceptible to breaching by Willow Lake. Trade gallon California bulrush was installed in parallel rows five feet (5′) apart with plants on five-foot (5′) alternating centers no lower than -1.9 ft NAVD88, GEOID 12A.

Deeper water test plots were planted in the middle of larger ponds of the West (8 test plots) and East (1 test plot) areas with the intent to test plant survival and growth in deeper water. Nine (9) alternating rows of trade-gallon California bulrush, two-gallon California bulrush, and two-gallon Roseau cane with rows 10 feet apart and plants on five-foot (5′) alternating centers. Each row contained 11 plants. No depth limit was specified, but the pond bottoms are typically not lower than -2.5 ft NAVD88, GEOID 12A.

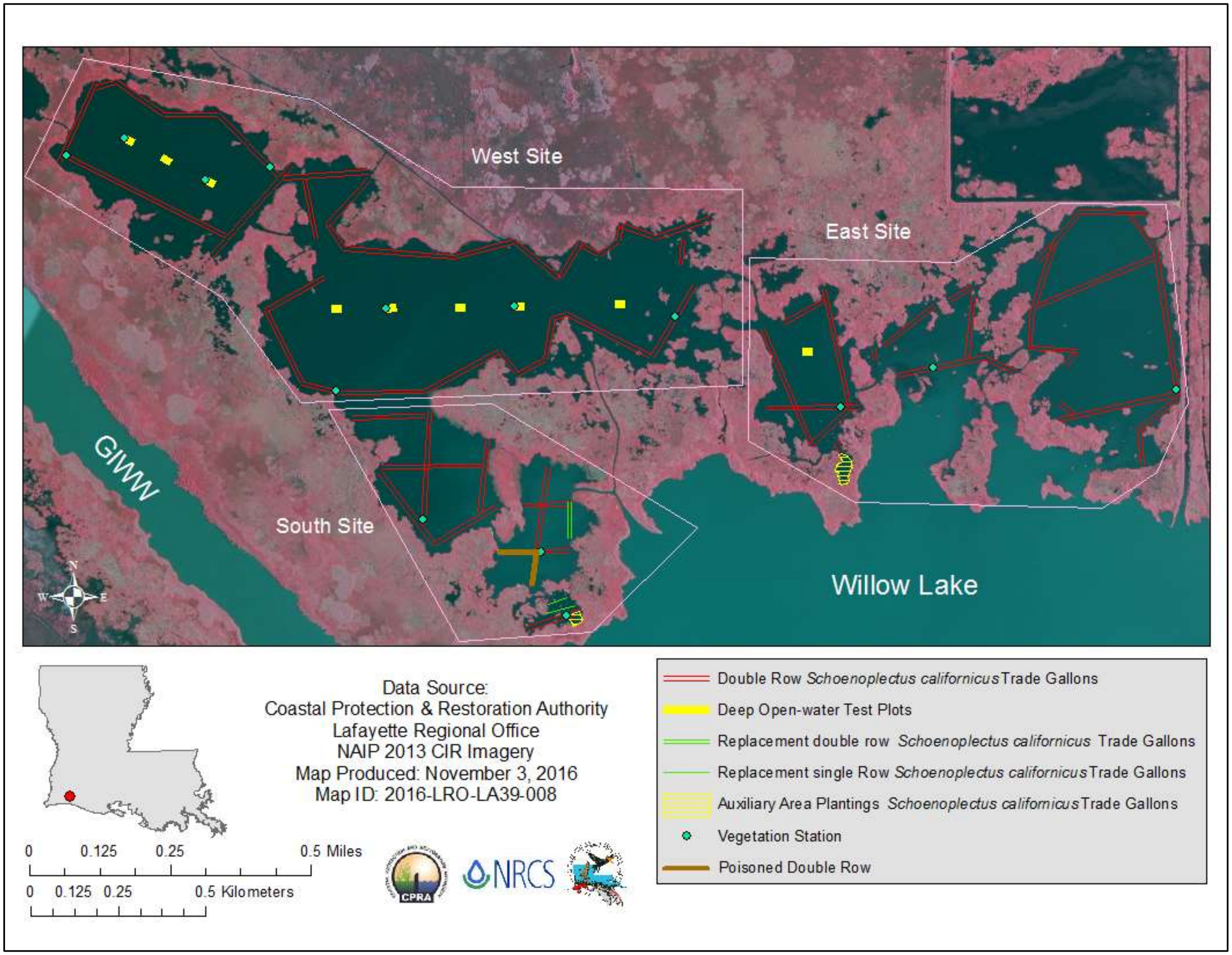

Figure X-1. LA-3009 Year 3 Site – Willow Lake site map shows plantings locations and types. The vegetative monitoring stations and post planting modifications are also displayed.

B. Monitoring Activity

1. Monitoring Goals

The goals of the Willow Lake plantings are:

- Double row plantings of California bulrush along open-water perimeters will survive and expand to reinforce shorelines.
- Double row plantings of California bulrush bisecting open-water areas will survive and expand to act as hydrologic baffles.
- Deep water test plots will test the survival and growth for different sizes of California bulrush (one and two gallon sized).
- Deep water test plots will test the survival and growth for two gallon sized Roseau cane.
- Area plantings of California bulrush will survive and expand to increase vegetation in areas susceptible to breaching by Willow Lake.

2. Monitoring Elements

The monitoring elements include procedures to assess planting survival and effects on the planting area for the various types of project plantings. Vegetation stations are intended to monitor planting survival and vegetative cover representative of the variety of planting strategies and areas over time. The plantings were assumed to have 100 % survival at the time of planting which was in October 2014 for the California bulrush and May 2015 for the Roseau cane. All plantings were monitored in July 2015, May 2016, October 2017, and May 2019. Hydrologic data from nearby CRMS sites are used to explain hydrologic influences such as flooding.

Vegetation Assessment

To assess planting status, an ocular estimate of survival and plant condition was conducted for each area and planting type while visually inspecting the site during sampling visits. Planting survival and vegetative growth data was also collected at the vegetation station level; 14 stations were established to represent the areas and planting types. Vegetation stations were different for the double row and deeper water test plots. Flooding depth, surface water salinity and temperature, and porewater salinity and temperature were also collected at all sampling stations during each sampling event. Conditions occurring outside of the vegetation stations including additional emergent species, floating and submerged vegetation, marsh interspersion, and site-specific points of interest were noted along with photographic documentation.

Double Row Plantings have ten (10) vegetation stations to monitor planting survival and vegetative cover. The West Area has four (4) stations; the South Area has three (3) stations; and, the East Area has three (3) stations. Percent survival was calculated from 10 plants (five plants per row) at each vegetation station; plants were characterized as live or dead/absent. PVC poles were placed on both ends of the plants monitored for survival. Vegetative growth was assessed by measuring percent (%) cover of species present, vegetative stand height, and height of dominant species at 4-m^2 vegetation plots at the vegetation stations (Folse et al. 2014).

Area plantings in small open-water areas in the South and East Areas had ocular assessments only. A vegetation station was located adjacent to the area planting in the South Area.

Deeper Test Plots have four (4) stations to monitor planting survival and vegetative growth. All four test plots used for monitoring are in the West Area. Percent survival was determined for each of the three (3) plant types (one trade-gallon sized California bulrush, two trade-gallon sized bulrush, and two gallon sized Roseau cane) over the entire test plot, each plant type had 33 plants per test plot. Stem heights (ft) and plant diameters (ft) were measured from a subset of 6 plants for each plant type. Plant diameters were converted to area assuming radial growth:

$$Plant\ Area = \pi r^2,$$

and percent planting cover for each plant type over the whole test plot was calculated by:

$$Percent\ Planting\ Cover = \left(\frac{\text{Plant Area (ft}^2) \times \text{\# of Live Plants}}{\text{Test Plot Area (ft}^2)}\right) \times 100,$$

where # of live plants is 0-33 plants from planting survival, and Test Plot Area is 4800 ft^2.

Plantings were assumed to have 100 percent survival upon planting. As per planting specifications, one trade-gallon sized (1 TG) California bulrush were assumed to average 42 inch (36-48”) stem heights; two trade-gallon sized (2 TG) California bulrush and Roseau cane were assumed to average 56 inch (40-72”) stem heights. Plant areas were assumed to be 0.22 ft^2 for 1 TG plants and 0.44 ft^2 for 2 TG plants when planted.

3. Monitoring Results and Discussion

a. Vegetation Assessment

Double Row and Area Plantings

The ocular estimates of planting areas captured the overall performance of the plantings (Table X-1). Throughout the Willow Lake planting areas, the open water areas had expansive growths of a fresh to intermediate mix of submerged aquatic vegetation (*Cabomba caroliniana*, *Vallisneria americana*, *Myriophyllum spicatum*, *Nelumbo lutea*) and abundant floating vegetation (*Salvinia molesta*, *Eichhornia crassipes*) that formed mats in many areas; the surrounding intermediate marsh vegetation appeared healthy. During the first monitoring trip on July 25, 2015, about 9 months following planting, the plantings looked really healthy and were expanding; survival was estimated between 85-95 % survival, and many of the California bulrush had expanded between the double rows (Fig. X-2A). Most of the missing plants were likely damaged by large patches of giant Salvinia (Fig X-2B). Two transects of double rows of California bulrush were poisoned in the South area by a hunting lessee (Fig. X-3A and B), but the same number of plants were planted by the lessee in other locations within the South area later that year (Figs. X-1 and 3C).

By the second monitoring trip on May 26, 2016, remaining plantings looked healthy with continued growth; we estimated ~ 75% survival, overall (Table X-1). Curiously, although survival remained high, California bulrush in the western pond of the South area were notably smaller than other plantings (Fig. X-4). The East area had the most robust plants of all areas (Fig. X-5). Decreases in overall plant survival were typically caused by physical damage from rafting by floating vegetation mats (Fig. X-2C and 6A). The large patches of giant Salvinia and water hyacinth added other species such as alligator weed (*Altanthera philoxoides*) and Cuban sedge (*Oxycaryum cubense*) to form more robust floating mats (Fig. X-6B). Larger swaths of plantings were damaged along the northern perimeters of the West and East areas where the plantings were closer to the existing marsh (Fig. X-7). The more protected Auxiliary area plantings appear to be expanding (Fig. X-8) which will help these areas if Willow Lake breaches into these ponds.

Survival of the double-row plantings continued to decline substantially, decreasing by ~50% in all areas by October 2017 (three years after planting) and approaching 0% by May 2019 (four and half years after planting) (Table X-1). Pressure from floating mats of vegetation and high water levels on the plantings continued while surviving plants are in sparse patches of shortened, physically battered looking plants (Figs. X-2D and 4D). The best remaining plantings were in the more protected South Auxiliary Area planting (Fig. X-8B).

Table X-1. Overall survival of LA-0039 Year 3 Willow Lake California bulrush plantings was ocularly estimated over time while conducting the final inspection and monitoring field trips.

		Overall Survival (%)				
Area	Planting Type	Oct 2014	Jul 2015	May 2016	Oct 2017	May 2019
West	Double Row	100	93	60	10	<1
South	Double Row	100	95	83	33	2
	Area - Auxiliary	100	90	50	75	20
East	Double Row	100	93	80	25	3
	Area - Auxiliary	100	95	80	ND	0

ND = Not Determined

Figure X-2. Double row plantings in the LA-0039 Year 3 Willow Lake - West area were expanding nine months after planting (A), and gaps in the plantings were probably caused by floating mats of giant Salvinia (B). A year later, standing plantings had grown, but gaps increased as floating vegetation mats expanded to include water hyacinth (C). By three years after planting, planting survival was sparse and remaining plants were physically battered (D).

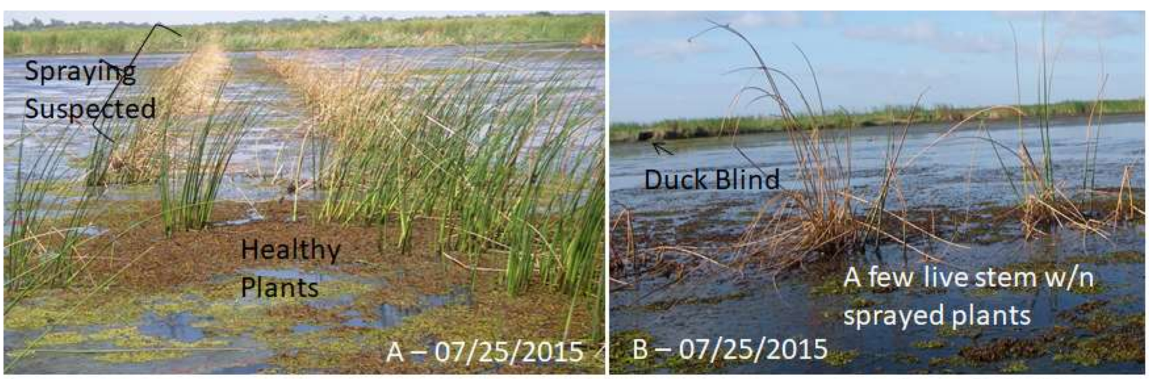

Figure X-3. Two sections of double row plantings in the eastern pond of the LA-39 Year 3 Willow Lake - South area were poisoned by a lessee for duck hunting (A and B) soon after planting. The plants were subsequently replaced by the lessee in other parts of the pond to help secure against breaching from Willow Lake (C). See site map for locations (Fig. X-1).

Figure X-4. The LA-0039 Year 3 Willow Lake - South area. The foreground is between rows of a south to north double row with west to east double rows in the background. Plants expanded towards the middle despite not being as big as in other areas about nine months after planting. Although still healthy looking, plantings did not expand over the next year (B and C) nor by three years after planting (D); note the larger flowering plants in (C) which are typical of plants in other areas. Water levels were about 1 foot lower in A and D than in B and C.

Figure X-5. The planting in the East area of the LA-39 Year 3 Willow Lake site were the most robust. Plants were growing across the double rows nine months after planting (A). The double rows were almost indistinguishable and the stems were 10+ feet tall by about a year and half after planting (B). Broad, complex mats of floating vegetation felled much of the plantings (white oval) by three years after planting, but surviving stems (yellow oval) were still robust (C).

Figure X-6. Large floating vegetation mats lead to planting loss even among the more robust plantings in the LA-39 Year 3 Willow Lake - East area. Floating mats consisted of water hyacinth (A) and combinations of water hyacinth, giant Salvinia, and otherwise emergent vegetation (B).

Figure X-7. Damage from floating vegetation mats was noted to be more severe where the plantings were closer to the existing marsh within the LA-0039 Year 3 Willow Lake site, especially along the northern portion of the West and East areas, over the first year and a half after planting. Damage spread throughout the site four and a half years after planting by May 2019 with most of the surviving plants being away from the shoreline.

Figure X-8. LA-0039 Year 3 Willlow Lake Auxiliary plants were used for area plantings to help vegetate areas at risk of breaching from Willow Lake are pictured in July 2015 (A) and October 2017 (B, yellow oval) along with newer replacement plants to compensated for poisoned plantings (white oval).

Vegetation station data suggests California bulrush double row plantings performed well over the first year and a half after planting but declined thereafter (Figs. X-9A and B). Plantings were assumed to have 100 percent survival, occupy a 2 % of a 4 m^2 vegetation station, and to have 42 inch average (36-48") stem heights when planted in October 2014 as per planting specifications. The plantings expanded by a year and half (May 2016) after installation throughout all areas; however, they decreased to practically non-existent at the vegetation stations by four and half years after planting (Fig. X-9A). The West plantings had the least expansion by May 2016, and average stem height of remaining plants began to decrease after peaking at 8.3 ft in May 2016 (Figs. X-2 and 9B). The South area had persistent survival through May 2016 which lead to moderate vegetation cover, but the stems were typically shorter than in other areas. The high variability and higher cover in the Oct 2017 South area was from the station adjacent to the Auxillary area planting which had 80 % cover whereas the other two stations had 3 % vegetative cover (Fig. X-1). The East area had the most robust double row plantings by a year and half after planting; the high variability in vegetation cover in May 2016 was from one station that had 0 % cover whereas the other two had ~75% (Fig. 9-A). Surviving stems in the East area remained ranged from 7 to 11 feet tall until all were absent by May 2019 (Fig. X-9B).

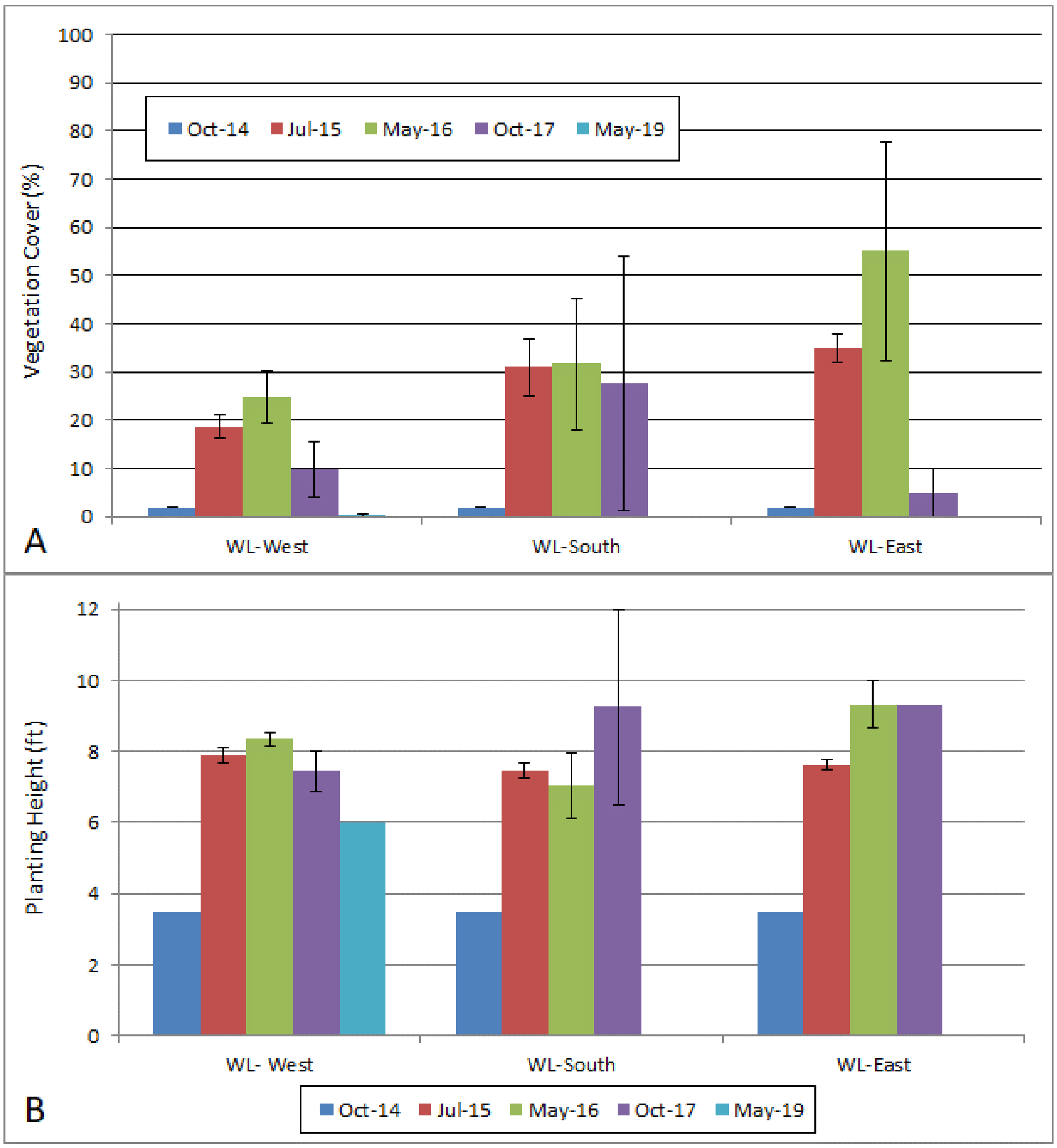

Figure X-9. Percent vegetation cover (A) and height of remaining plants (B) were collected at vegetation stations in the different areas of double-row *Schoenoplectus californicus* plantings in LA-0039 Year 3 Willow Lake over four and half years after planting. *S. californicus* was assumed to cover < 0.4 % when planted in October 2014.

Deeper Test Plots

Vegetation station data collected at four of the nine test plots captured performance over three years after planting for California bulrush and the first year for Roseau cane; all California bulrush plantings had died by the October 2019 monitoring except at one test section, and all Roseau cane had died by the May 2017 monitoring. Both 1 and 2 TG California bulrush plantings had high survival and good expansion by a year and half after planting in May 2016 (Table X-2; Figs. X-10 B and 11), and their maximum stem height of ~8 ft was reached in their first growing season (Fig. X-10B). The larger, 2 TG California bulrush had greater and more consistent survival and expansion than the smaller, 1 TG which had more variable survival and expansion (Table X-2). The 1 TG California bulrush has handled the deeper conditions, but the larger, 2 TG California bulrush may be more resistant to damage from floating vegetation mats (Fig. X-11). Roseau cane survival was highly variable and poor overall, and its growth did not progress following initial modest growth (Fig. X-10A and B). The new Roseau cane stems were very spindly and laid on top of the water where they were easily covered and displaced by surrounding SAV, algae, and floating vegetation (Fig. X-12).

Table X-2. Overall survival of LA-0039 Year 3 Willow Lake deeper test plots were estimated over time while conducting the final inspection and monitoring field trips. Survival in May 2019 was from survival in only two of nine test plots. Roseau cane was planted in May 2015.

		Overall Survival (%)					
Area	Planting Type	Oct 2014	May 2015	Jul 2015	May 2016	Oct 2017	May 2019
Deeper Test Plots	One Gallon Bulrush	100	90	86	84	47	2
	Two Gallon Bulrush	100	97	96	95	50	1
	Two Gallon Roseau Cane	NP	100	81	29	0	0

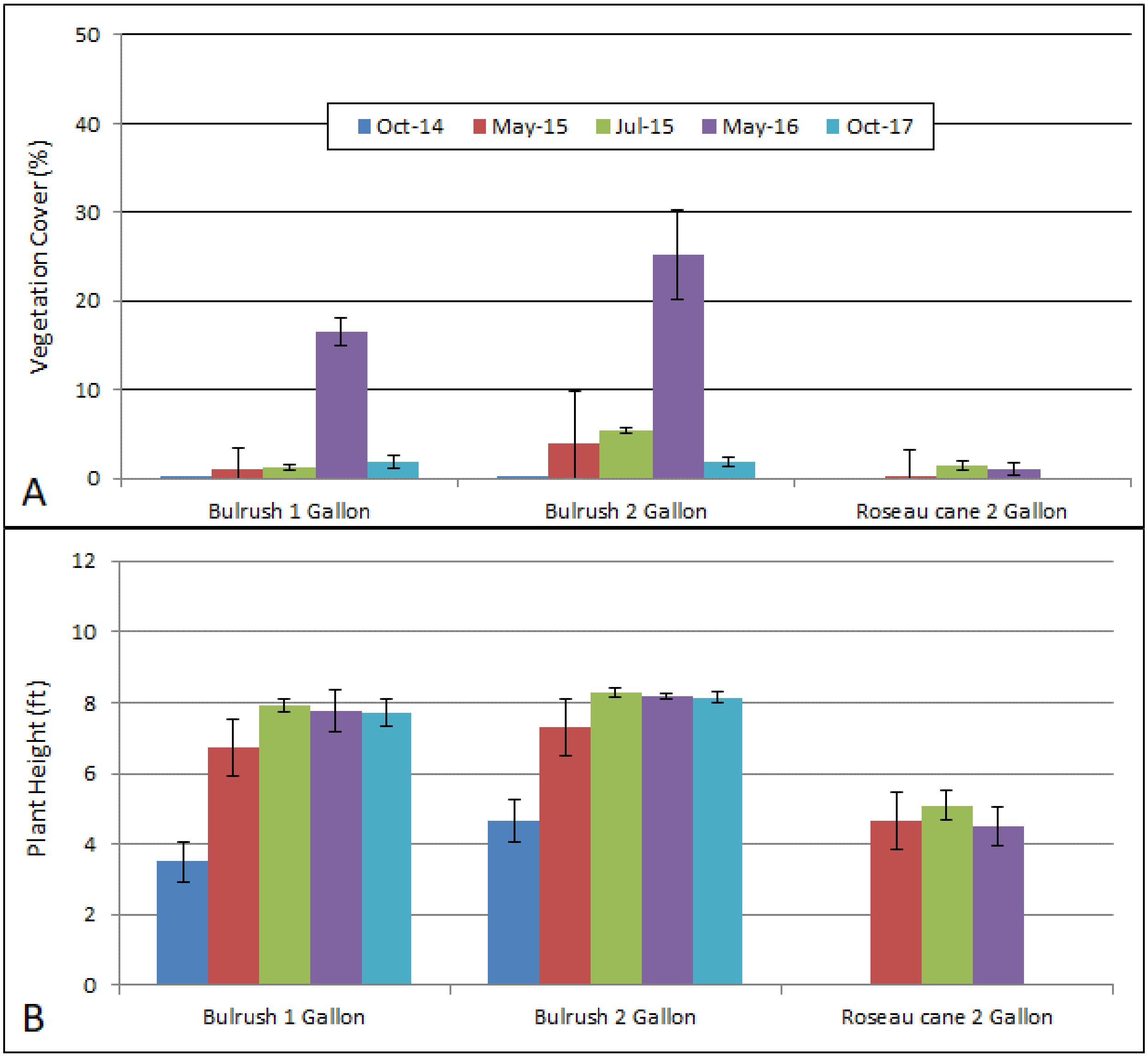

Figure X-10. Vegetation cover (A) and height of remaining plants (B) was determined from one and two gallon *Schoenoplectus californicus* (California bulrush) and 2 gallon *Phragmites australis* (Roseau cane) planted in the deep test plots in LA-0039 Year 3 Willow Lake. *S. californicus* was assumed to cover < 0.4 % when planted in October 2014; note that y-axis for vegetation cover only goes to 50 %. Roseau cane was not planted until April 2015 and did not survive by October 2017.

Figure X-11. The deeper test plots from LA-0039 Year 3 Willow Lake were observed on 07/25/2015 (A) and 05/26/2016 (B). The test plots consisted of rows of 1 and 2 Trade Gallon sized (1 and 2 TG) *Schoenoplectus californicus* (SCCA, California bulrush) and 2 TG *Phragmites australis* (PHAU, Roseau cane). The submerged aquatic vegetation is *Cabomba caroliniana* in all years. Note the absence of visible PHAU in 2016 (B, see Fig. X-12). Note the rafts of floating aquatic vegetation and dead water lotus stems in 2017. Water was about one foot deeper in 2016 than 2015 and 2017.

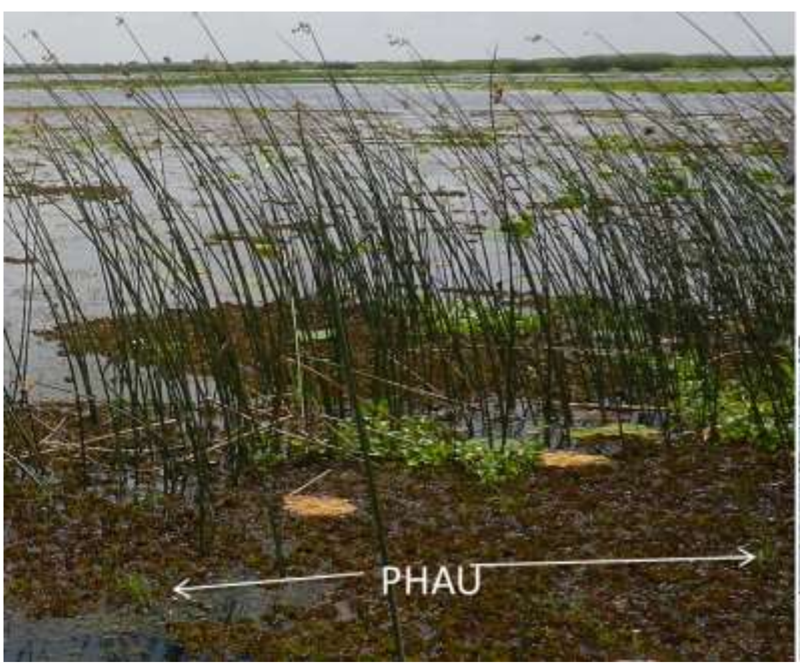

Figure X-12. Growth of *Phragmites australis* (PHAU, Roseau cane) from two trade-gallon sized containers was limited by competition from submerged and floating aquatic vegetation. California bullwhip was also susceptible to floating vegetation during higher water.

b. Hydrology

Hydrologic data for the Willow Lake planting sites was obtained from CRMS0691-H01 which is about 5 miles southeast of the plantings. The mean water elevation over the monitoring period from October 2014 through May 2016 at CRMS0691 was +0.895 ft ± 0.411 (NAVD88, GEOID 12A) and ranged from a high of +2.29 ft after Hurricane Harvey in September 2017 to a low of -0.08 ft during the 2018 spring drought (Fig. X-13). The planting elevations were estimated by subtracting the average water depth measured at each vegetation station during the survey from the water elevation recorded at the corresponding monitoring date at CRMS0691; planting elevations were then compared to water levels to determine water depth of the planting surfaces over time. Water depth averaged 2.52 ± 0.411 ft at double row stations and 2.82 ± 0.411 ft at deeper test sections over the monitoring period.

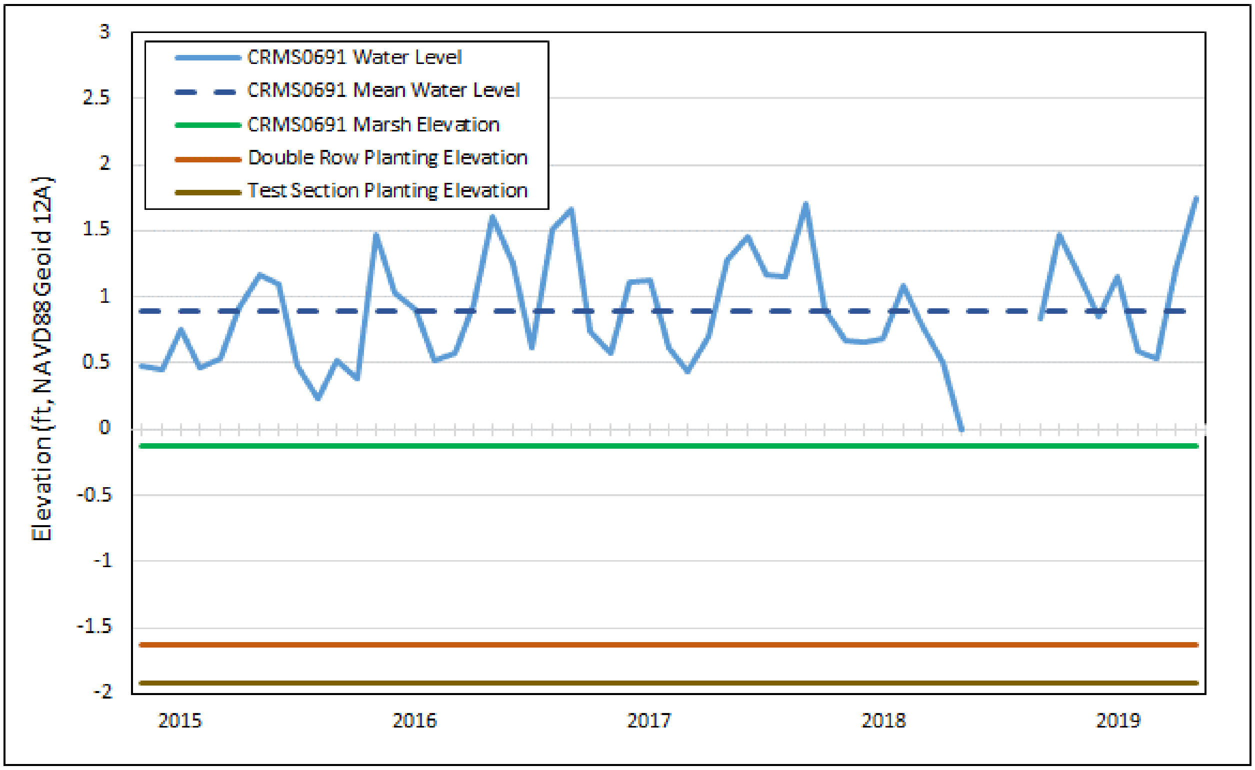

Figure X-13. Water levels from CRMS0691 are compared to planting elevations of LA-0039 Year 3 Willow Lake double rows and deeper test sections.

c. Planting Failure/Success Causation

The recommended water depth for establishment of *S. californicus* is reported as between 1 to 2 feet (Materne and Fine 2000), and water depth averaged .52 and .82 ± 0.41 ft deeper than the upper limit over the monitoring period at the double rows and test sections, respectively. This amount of chronic flooding is physiologically stressful to *S. californicus*, especially to next generation plants trying to sprout from the original plantings.

The double-row shoreline plantings were severely hampered due to rafting by FAV and SAV, with the exception of the poisoned double rows of plants.

In combination, the high flood depths allows floating vegetation mats to impact the thinner and weaker parts higher on the stems.

C. Conclusions

The Year 3 Willow Lake plantings were had mixed success three years after plant but were mostly gone by five years after planting. Despite initial California bulrush survival and expansion of double row plantings through the first year, sustained loses from a combination of high water levels and rafting by floating and submerged aquatic vegetation (F and SAV) decimated the plantings by four and half years after installation. Deeper test plots eventually failed after mixed results initially. Through three years after planting, both one (1) and two (2) trade-gallon sized California bulrush plantings survived and expanded while two (2) trade-gallon sized Roseau cane experienced low survival and growth after the initial half year.

1. Project Effectiveness

As per the project goals:

- Double row plantings of bulrush along open-water perimeters did not survive and expand to reinforce shorelines by five years after planting.
- Double row plantings of bulrush bisecting open-water areas did not survive and expanded to act as hydrologic baffles by five years after planting.
- Both one and two trade-gallon sized California bulrush in the deeper water test plots failed to survive and expand over the five year monitoring period although they initially survived and expanded.
- The two trade-gallon sized Roseau cane in the deeper water test plots failed to survive and expand.
- Area plantings of bulrush have survived and expanded to increase vegetation in areas susceptible to breaching by Willow Lake.

2. Recommended Improvements

Consider testing cut stalks of larger, adult Roseau cane for deeper water applications rather than new, wispy growth sprouting from two (2) trade-gallon sized containers. This suggestion is from observations of duck binds brushed with large stems that establish.

3. Lessons Learned

Large areas of California bulrush were pushed over and smothered by floating aquatic vegetation (FAV) composed mainly of giant Salvinia and water hyacinth in deep waters for plantings. The occurrence of large mats of floating vegetation is attributable to recent mild winter temperatures. Planning for floating invasive species control may need to be considered.

Lack of sustained survival in the deeper test plots suggest that this technique should not be applied to large open-water settings in areas with robust SAV and FAV assemblies.

XI. Year 4 – Green Island Bayou

Prepared by Tommy McGinnis – CPRA Lafayette Regional Office

A. Site Description

Green Island Bayou, a Year 4 planting site, is in eastern Vermilion Parish between the Gulf Intracoastal Waterway (GIWW) and Vermilion Bay. The site is intermediate marsh within a passively managed hydrologic area that has been subdivided by petroleum exploration canals. The main intent of the planting effort is to stabilize existing marsh along large open-water areas that have expanded from initial marsh loss that occurred from 1932-1956 and 1956-1973.

The Green Island Bayou site (GIB) is divided into five (5) areas (West, Southwest, East, Central, and North) and has three (3) planting strategies (shoreline plantings, double rows, and area plantings in smaller ponds) (Fig. XI-1). All strategies were planted with trade gallons of *Shoenoplectus californicus* (California bulrush, 31,840 plants) no lower than -0.6 ft, NAVD88 (Geoid 99), or -1.6 ft NAVD88 (Geoid 12A). The final inspection of the GIB planting was on September 11, 2015.

Area plantings in small open-water areas were planted in the North, West, and Southwest areas to establish vegetation in smaller open-water areas along larger open-water bodies. California bulrush was planted in parallel rows five (5) ft apart with plants on five-foot (5) alternating centers.

Shoreline Plantings of a single row were planted in the West and East areas to reinforce the shoreline of large open-water bodies. California bulrush was planted every three (3) ft as close as possible to the marsh edge. An additional row of auxiliary plants was added three (3) ft from some single row segments.

Double Row Plantings parallel to perimeters were planted in the North, Central, and East areas with the intent to stabilize existing marsh shoreline and establish vegetation in shallow open water areas. Rows of California bulrush were planted fifteen (15) ft apart with plants on five (5) ft alternating centers. **Double Row Plantings across open-water areas** were also installed in the North area to establish vegetation in shallow open-water areas.

B. Monitoring Activity

1. Monitoring Goals

The goals of the California bulrush plantings in GIB are:

- Area plantings will survive and expand to increase vegetation in smaller open-water area adjacent to larger open-water areas.
- Shoreline Plantings will survive and expand to reinforce the shoreline of open-water bodies.
- Double row plantings will survive and expand to stabilize existing marsh shorelines and establish vegetation in shallow open water areas.

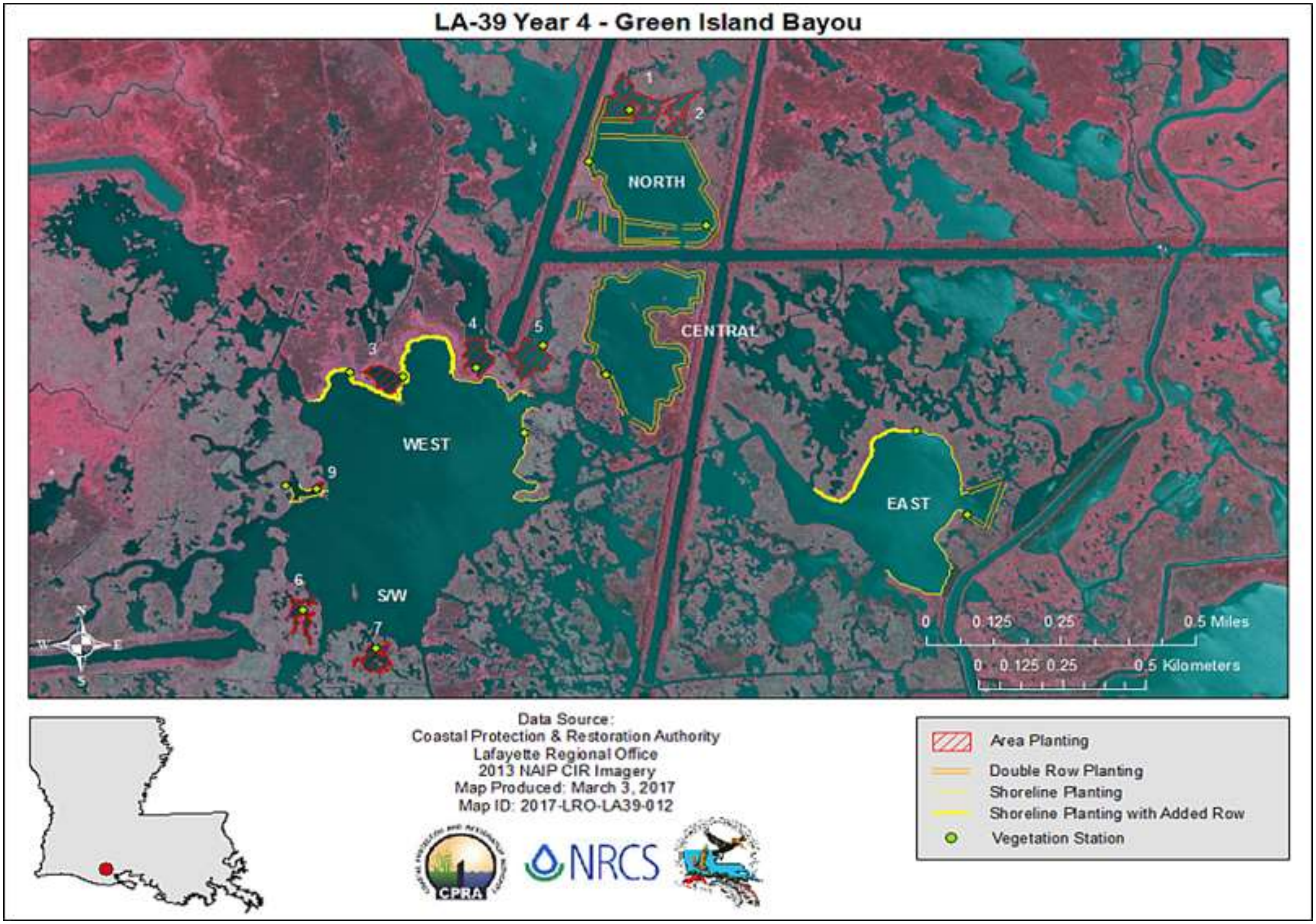

Figure XI-1. LA-0039 Year 4 Green Island Bayou site map shows plantings areas and types. The vegetative monitoring stations are also displayed.

2. Monitoring Elements

The monitoring elements include procedures to assess planting survival and effects on the planting site for the three main types of project plantings, existing marsh edge stabilization in single and double rows and interior area coverage. An ocular assessment of all area and planting type combinations was conducted during each site visit. Vegetation stations were established to monitor planting survival and vegetative cover representative of the variety of planting strategies over time. Hydrologic data from a nearby CRMS site, CRMS1650, is used to explain hydrologic influences such as flooding and salinity. The final planting inspection of September 11, 2015 is considered the beginning of the monitoring period; 100% survival is assumed for this date. Monitoring trips were conducted within two months after planting on October 28, 2015, one year after planting on October 18, 2016, and three years after planting on October 10, 2018. The five-year post-planting monitoring trip scheduled for fall 2020 was canceled due to an active hurricane season (Hurricane Laura – 08/29/2020; Hurricane Delta – 10/9/2020) and COVID-19 precautions; however, October 12, 2020 aerial imagery from Google Earth is used to provide a qualitative description of the plantings from 3 days after Hurricane Delta. A final monitoring field trip was conducted on May 26, 2021 to assess general survival and condition of the plantings 5 ½ years after planting.

Vegetation Assessment

To assess planting status, an ocular estimate of survival and plant condition was conducted for each area and planting type while visually inspecting the site during sampling visits. Planting survival and percent vegetative growth data was also collected at the vegetation station level; 15 stations were established with a PVC pole marking the start of the station. Percent survival was calculated from ten (10) plants at each vegetation station; plants were characterized as live or dead/absent. Vegetative growth was assessed by measuring percent cover of species present, vegetative stand height, and height of dominant species at 4 m^2 vegetation plots at the vegetation stations (Folse et al. 2014). Flooding depth, surface water salinity and temperature, and porewater salinity and temperature were also collected at all sampling stations during each sampling event. Conditions occurring outside of the stations and segments including additional species, marsh interspersion, and site-specific points of interest were noted along with photographic documentation.

Area plantings in small open-water areas had seven (7) vegetation stations distributed throughout the West (4 stations), Southwest (2 stations), and North (1 station) areas. The 10 survival plants extend along two rows (5 plants per row), and the vegetative growth plot is 2 × 2 m (4 m^2) and incorporates two rows.

Shoreline Plantings had four (4) stations distributed among the West (3 stations) and East (1 station) areas; three (3) stations are within single rows and one (1) station has an additional row. For the single row stations, the 10 survival plants extend along the shoreline while the vegetative growth plot is 4 m long × 1 m wide (4 m^2) incorporating the single row along the shoreline and the existing marsh equally. For the station with the additional row, the 10 survival plants are divided between the two rows (5 plants per row) while the vegetative growth plot is 4 m long × 1 m wide (4 m^2) incorporating both rows along the shoreline and a smaller portion of the existing marsh.

Double Row Plantings had four (4) stations distributed among the North (2 stations), Central (1 station), and East (1 station) areas; three stations, one in each area, are in a double row along water body perimeters, and one North station is within a double row across the open-water body. The 10 survival plants extend along the two rows (5 plants per row), and the vegetative growth plot is 2 × 2 m (4 m^2) that incorporates one row.

<u>Planting Loss/Success Causation</u>

Hydrologic data from CRMS1650-H01, located just northeast of the GIB, will be used to describe area water-level trends and salinity that may adversely affect the plantings. Other factors contributing to planting loss will also be discussed.

3. Monitoring Results and Discussion

a. Vegetation Assessment

The ocular estimates of planting areas and types capture the overall performance of the plantings (Table X1-1). During the October 2015 monitoring trip, which was about six weeks after planting, the northern Vermilion Bay area was experiencing a sustained, high water/salinity event (Fig. XI-8), and low salt-tolerant plant species in the existing marsh and previously existing California bulrush plantings were visibly stressed. Plantings in firmer water bottoms to the north (North Area and northern area plantings of West Area) had good survival (Table XI-1) and growth from plantings (new and longer stems). Plantings in the southern half of the site (shorelines and southern ponds in West area, Southwest area, and East area; see Fig. XI-1) with unconsolidated water bottoms had low survival (Table XI-2), and little to no new growth was observed in surviving plants. By the October 2016 monitoring trip, the general vicinity had freshened to average salinities, and the existing marsh and previously existing California bulrush appeared healthy. Typically, planting areas continued to perform as they started; plantings in the northern areas continued to have a high percentage of survival and expand while the more southern areas and shorelines did not rebound from the initial low performance and continued to diminish (Table XI-1). By October 2018, northern plantings continued to perform the best with the highest survival. All other planting areas had similar survival numbers as the 2016 sampling (Table X1-1). This trend continued through spring 2021, even after the hurricanes of 2020, except for the Southwest pond area planting which had pockets of vigorous California bulrush and the North area planting which had thinned out.

Table XI-1. Overall survival of LA-0039 Year 4 Green Island Bayou plantings was estimated over time while conducting the final inspection[a] (assume 100% survival) and monitoring field trips.

Area	Planting Type	Subset	Overall Survival (%) [a]Sept 11, 2015	Oct 28, 2015	Oct 18, 2016	Oct 10, 2018	Oct 12, 2020
North	Area	Pond 1	100	95	100	95	70
		Pond 2	100	85	95	80	70
	Double Row	Perimeter	100	80	50	80	70
		Across	100	70	60	75	70
West	Area - Northern	Pond 3	100	70	35	40	30
		Pond 4	100	60	45	40	50
		Pond 5	100	90	90	90	80
	Area - Southern	Pond 9	100	20	0	0	0
	Shoreline	Northern	100	40	5	10	5
		Eastern	100	55	<1	<1	0
		Southwestern	100	40	8	5	0.25
Southwest	Area - Southern	Pond 6	100	45	<10	15	20
		Pond 7	100	30	<5	<2	12.5
Central	Double Row	Perimeter	100	50	30	40	40
East	Shoreline	Northern	100	30	0.5	0	0
		Southern	100	20	0	0	0
	Double Row		100	90	40	<5	0

Upon installation in September 2015, plantings were assumed to have 100 percent survival, occupy a percentage of a 4 m^2 vegetation station based on plant spacing, and have 42 inch (3.5 ft) stem heights as per planting specifications. Vegetation station data collected through three years after installation captured planting survival and growth (percent cover and stem heights). Stations were grouped by planting types, and the Area plantings were sub-divided into Northern (1 North and 3 West stations) and Southern (1 West and 2 Southwest stations) halves of the GIB based on performance similarities.

<u>Area Plantings – Northern</u>

The Area Plantings in the northern half of the GIB (Ponds 1-5) had the greatest survival and most robust growth of all the groupings (Table XI-1 and Fig. XI-2A and B). After the initial loss of 30 percent over the first two months post planting, the northern Area Plantings only loss 10 percent more over the next year. By one year after planting, vegetative cover increased by ~33 % and stem heights grew by ~5.5 ft. Percent cover increased slightly, around 3% in 2018 while heights remained steady, as well as survival. In order to avoid damaging the plantings while accessing the stations, vegetation stations were located along the perimeter of Area plantings resulting in underestimates for three of the four stations. Values and error bars in the graphs are representative of the variability among the Area Plantings in the Northern ponds (Fig. XI-3 and 4).

Area Plantings – Southern

The Area Plantings in the southern half of the GIB (Ponds 6-9) starkly contrasted the northern half (Fig. XI-2 through 5). At the vegetation stations, more than half of the plants were lost over the first two months and the rest of the plants (47%) were lost over the next year. Remaining plants were sparse and ~ 6 feet tall (Fig. XI-5). Most plants were gone in 2018. The southern ponds had the most unconsolidated soil of all planting types. In 2021, surprisingly, the Southwest (S/W) ponds had pockets of vigorous *S. californicus* (Pond 6 along the perimeters; Pond 7 in the middle) although most of the ponds were void of plantings.

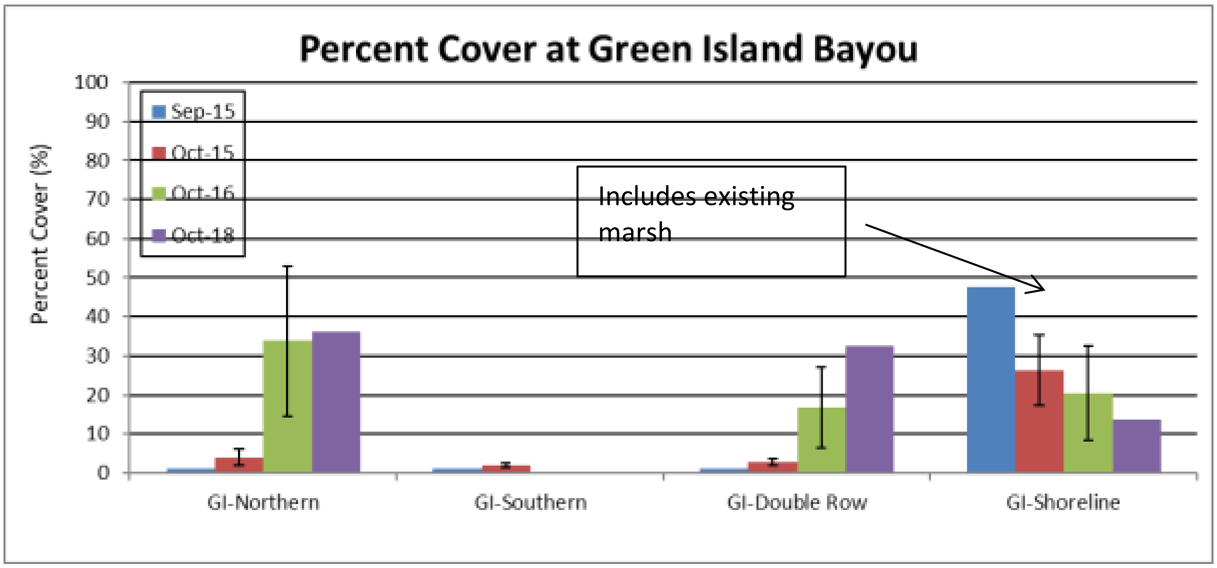

Figure XI-2A. Percent cover was determined at 15 vegetation stations throughout the different planting strategies of *Shoenoplectus californicus* in the LA-0039 Year 4 Green Island Bayou site.

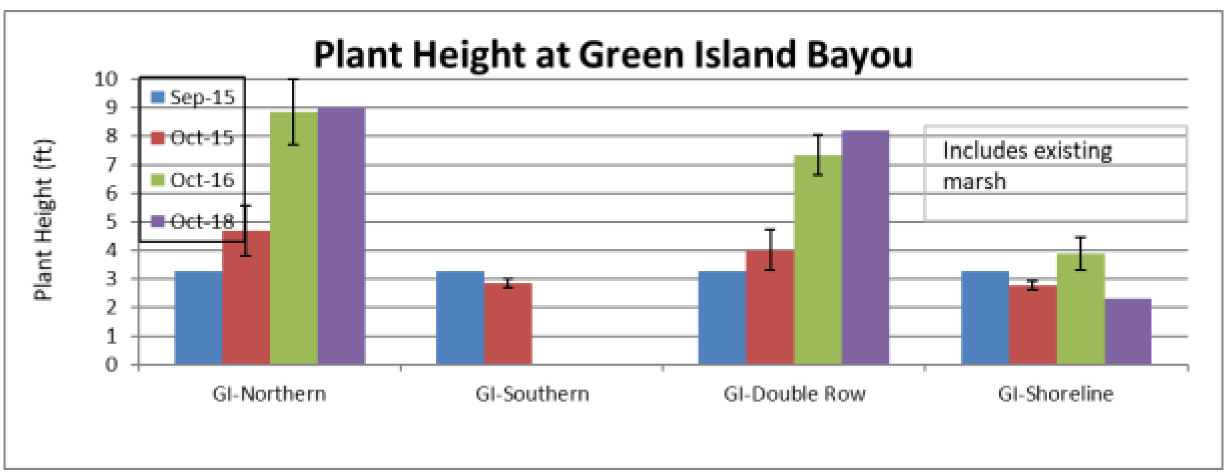

Figure XI-2B. Plant height was determined at 15 vegetation stations throughout the different planting strategies of *Shoenoplectus californicus* in the LA-0039 Year 4 Green Island Bayou site.

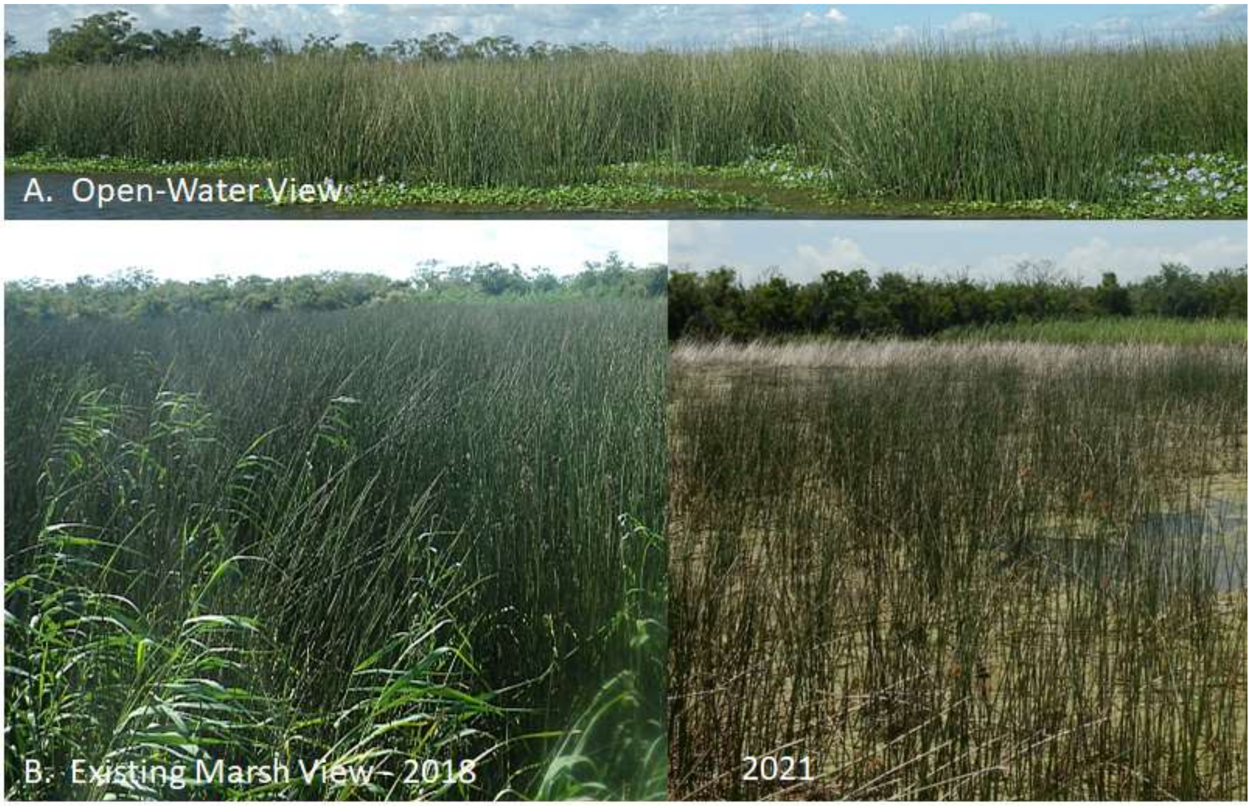

Figure XI-3. Plantings in the North area (Ponds 1 and 2) experienced the best survival and growth (12+ ft stems) of the Green Island Bayou plantings since planting in 2015. Marsh vegetation (Roseau cane and cattails) are creeping into the area planting (B). Water depth is the same as the other plantings, but the water bottom is firmer here; the soil contains a clay/silt mix in the top 5 inches, then a silt/organic mix down to a clay lens at about 12 inches, then peat below. By 2021, the plantings have thinned as resources were utilized, but plant density was still high.

Figure XI-4. Area Plantings – The northern half of the West area experienced varying degrees of success. (A) Pond 3 had the least survival and growth (stems 6-7 ft tall) which was limited to the middle of the pond while survival and stature of plant decreases towards the edges. (B) Pond 4 also had a similar pattern as Pond 3 but with greater survivorship and growth (stems 7-8 ft tall). (C) Pond 5 had excellent survivorship and growth (stems 8-10 ft tall); individual plantings are indistinguishable with a small gap along the pond edge. Coincidentally, the water bottom was noticeably firmer from Pond 3 to Pond 5. These conditions persisted by May 2021.

Figure XI-5. The southern portions of the west and southwest areas had very low success. Survival was limited to the middle of Southwest Area Ponds 6 (A) and 7 (B). In 2018, surviving plants were dark green but had not grown much; individual plants were ~6ft tall and highly distinguishable. Survival was sparser in Pond 7, possible because of the high occurrence of giant Salvina. By 2020, pockets of vigorous California bulrush was present. (C) Pond 9 had no survival since 2016.

Double Row Plantings

The double row plantings were moderately successful and highly variable (Figs. XI-2A, B, and 6). After an initial loss of 35 percent over the first two months after planting, the double row plantings only loss another 15 percent over the next year. By one year after planting, vegetative cover increased by ~16 % and stem heights grew by ~3.3 ft. By October 2018, percent cover had almost doubled and stem heights increased slightly, less than a foot. The North Area had greater survival and growth; the Central area was intermediate; and, the East Area has the least survival and growth (Table XI-1; Fig. XI-6). This trend continued as of the most recent sampling in October 2018.

Figure XI-6. Double rows were planted in the North, Central, and East areas. (A) The North had 40-70% survival; plants are growing well (8-10 ft stems) and expanding. (B) The Central had highly variable survival (0-70%) among reaches; plants are growing well (stems ~8 ft) and expanding. The marshside row is performing better than the pondside row. (C) The East had ~40% survival but not much growth (stems 5-6 ft tall) or expansion of surviving plants.

Shoreline Plantings

The shoreline plantings were not successful (Fig. XI-2 and 7). Surviving plants were targeted for vegetation station locations. After a sharp initial loss of 57 percent of survival over the first two months after planting, the shoreline plantings lost another 37 percent over the next year. By one year after planting, vegetative cover, which also includes existing marsh along the shoreline, decreased by ~27% and stem heights grew a modest 0.6 ft. Vegetative cover continued its downward trend in 2018, decreasing another ~7% while stem heights also decreased another 1.5 ft.

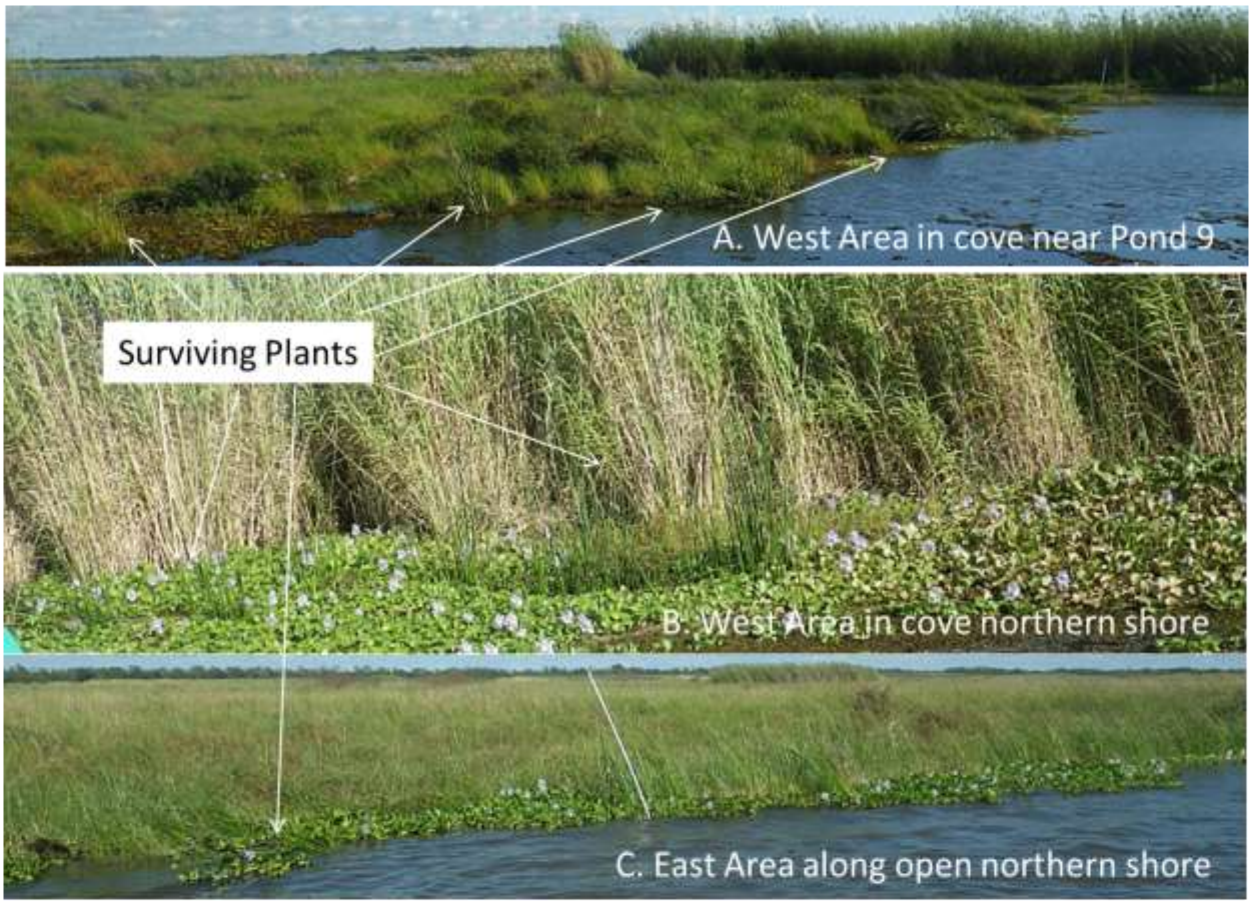

Figure X1-7. The Shoreline Planting pictures taken on October 16, 2016 targeted remaining plants. (A) The southwestern shoreline plantings of the West Area were in a cove off of the main open-water body; survival was sparse, but this stretch of shoreline plantings had the highest survival of all the shoreline plantings. (B) Much of the northern and western shorelines of the West site survivors were limited to protected areas and stems were only 3-4 ft tall. (C) Shoreline plantings north and south of the double row cover had <1% survival. Isolated, surviving plants in the NW corner were very small (~3 ft).

b. Planting Failure/Success Causation

Low survivorship was prompted by a sustained, high salinity event that occurred during the critical time of plant installation and establishment (Fig. XI-8). From late July to early November 2015, water salinities were typically greater than five (5) parts per thousand (ppt) which is the upper-limit salinity for newly planted California bulrush (Fine and Thomassie. 2000). Water salinity reached a maximum of 13 ppt during this event. Such a high and sustained salinity event is anomalous for this area.

Curiously, not all plantings were affected by the salinity. Salinity and planting depths were typically uniform throughout the Green Island Bayou site during monitoring trips, and the CRMS1650 station is northeast of the site, closest to the North area. Water bottom soils were more unconsolidated in the area plantings in the south (Ponds 6, 7, and 9) where survival was lowest while water bottom soils were more firm in the area plantings to the north (Ponds 1-5) where survival was greater. The firmer soils are less porous and may provide more protection against salt intrusion from the above water column; firmer soils also hold plants in place better during high water/wind events.

Plantings along the shoreline of the larger water bodies were also exposed to higher wave energy than the other planting types. Survival was higher among shoreline plantings where the shoreline was more protected, such as in coves.

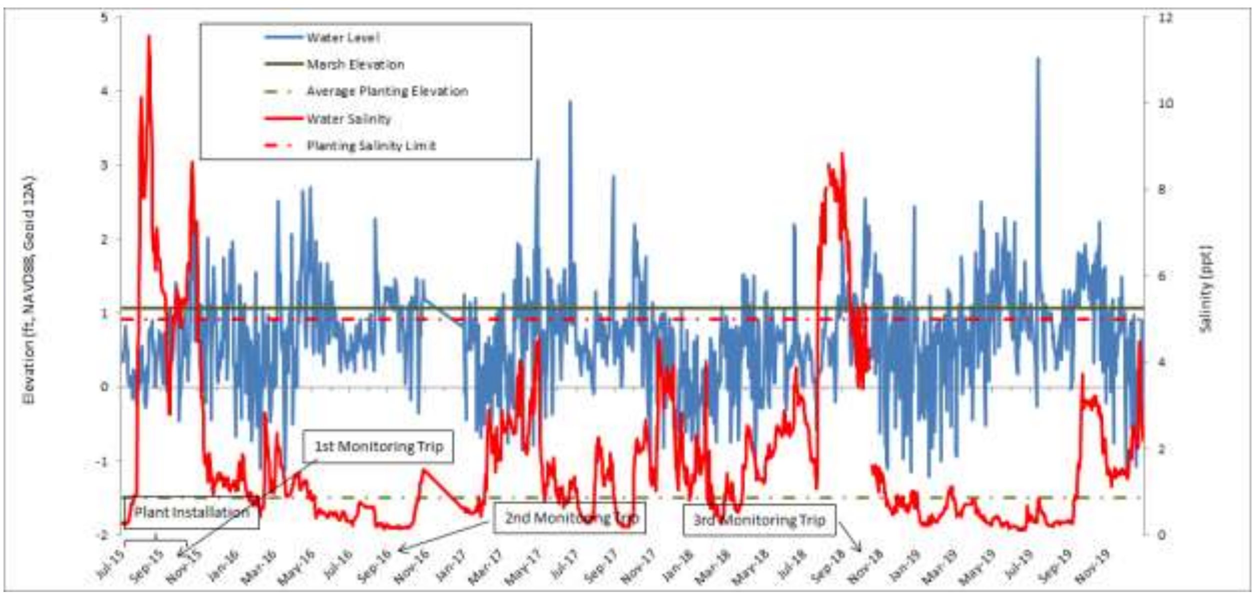

Figure XI-8. Daily averages of water-level elevation (left y-axis) and salinity (right y-axis) from CRMS1650-H01 are plotted relative to average planting elevation (left y-axis) and upper-limit salinity (right y-axis) at LA-0039 Year 4 Green Island Bayou.

C. Conclusions

The Green Island Bayou plantings have had mixed success to this point in their post-planting monitoring. The Area plantings to the north have performed far better than those to the south. Overall the double row plantings have had above average success and the shoreline plantings failed to thrive. The California bulrush area plantings in the north and along sections of the double rows survived and expanded despite some initial loses from unusually high salinity at the time of plant installation. The north-south proximity of the plantings which reflected some variation in soil conditions seemed to be a consistent predictor of success or failure, possibly due to soil porosity and high salinity surface water conditions at the time of planting.

1. Project Effectiveness

As per the project goals:

- Northern Area Plantings have survived and expanded to increase vegetation in smaller open-water area adjacent to larger open-water areas, but Southern Area Plantings have not.
- Shoreline plantings did not survive and expand to reinforce the shoreline of open-water bodies.
- Double row plantings have survived and expanded.

2. Recommended Improvements

Regardless of the period selected for plant installation, it is recommended that project sponsors incorporate flexibility in planting dates to provide some opportunity to avoid planting during high salinity events.

3. Lessons Learned

A provision in the planting specifications like the one for high water levels should be added for high salinity conditions relative to the species being planted. Once established, stands of California bulrush can withstand pulses of higher salinity waters in the project area without substantial long-term negative effects. This area shows that, after establishment, the plantings are far more resilient to salinity variation above the area average and future plantings in the area will likely be successful.

Expansion of the successful planting area and others like it in the vicinity should be considered for future plantings. Re-planting of highly exposed shorelines is not recommended.

XII. Year 4 – Pointe-aux-Chenes

Prepared by Elaine Lear – CPRA Thibodaux Regional Office

A. Site and Planting Description

Pointe-aux-Chenes (PAC), a Year 4 planting site for the Coastwide Planting project (LA-0039), is located in Terrebonne Parish in the Pointe-aux-Chenes Wildlife Management Area (PAC WMA) on the north side of Sonat Road and south of Louisiana Highway 665 (Figure XII-1). The PAC WMA is hydrologically isolated from surrounding areas; management practices are mainly directed towards water control through the use of variable crested weirs and levees.

Project Features

The plantings consisted of 3,874 trade-gallon sized California bullwhip (*Schoenoplectus californicus*) planted in 22 double rows (Figure XII-1). The rows were spaced fifteen feet apart with plants installed on five foot alternating centers. Nineteen of the double rows were planted parallel to shorelines or within broken marsh. Planting elevation was typically -1.1 to -0.25 feet NAVD88, not to exceed -2.25 feet NAVD88 (Geoid 12A). Installation was completed by October 5, 2015.

B. Monitoring Activity

1. Monitoring Goals and Objectives

The purpose of the PAC planting was to increase vegetative coverage in the shallow ponds in order to reduce wind fetch-generated waves which enlarge the open water areas

- The objective of the double row plantings is for the California bulrush to survive and expand within the pond.

2. Monitoring Elements

The monitoring elements include procedures to assess planting survival and effects on the planting area for the various types of project plantings. Vegetation stations are intended to monitor planting survival and vegetative cover representative of the variety of planting strategies and areas over time. The plantings were assumed to have 100 % survival at the time of planting in fall 2015. All plantings were monitored one year after planting in November 2016 and three years after planting in May 2019. Hydrologic data from nearby CRMS sites are used to explain hydrologic influences such as flooding.

a. Vegetation Assessment

During each monitoring trip, each double row will be inspected to estimate overall survival and qualitative condition over time. Twenty-two sampling stations were established to assess planting survival and vegetative cover (Figure XII-1). At each station, 10 plants, 5 per row will be counted as live, dead, or absent to calculate percent survival. Monitoring of vegetative cover within a 4 m^2

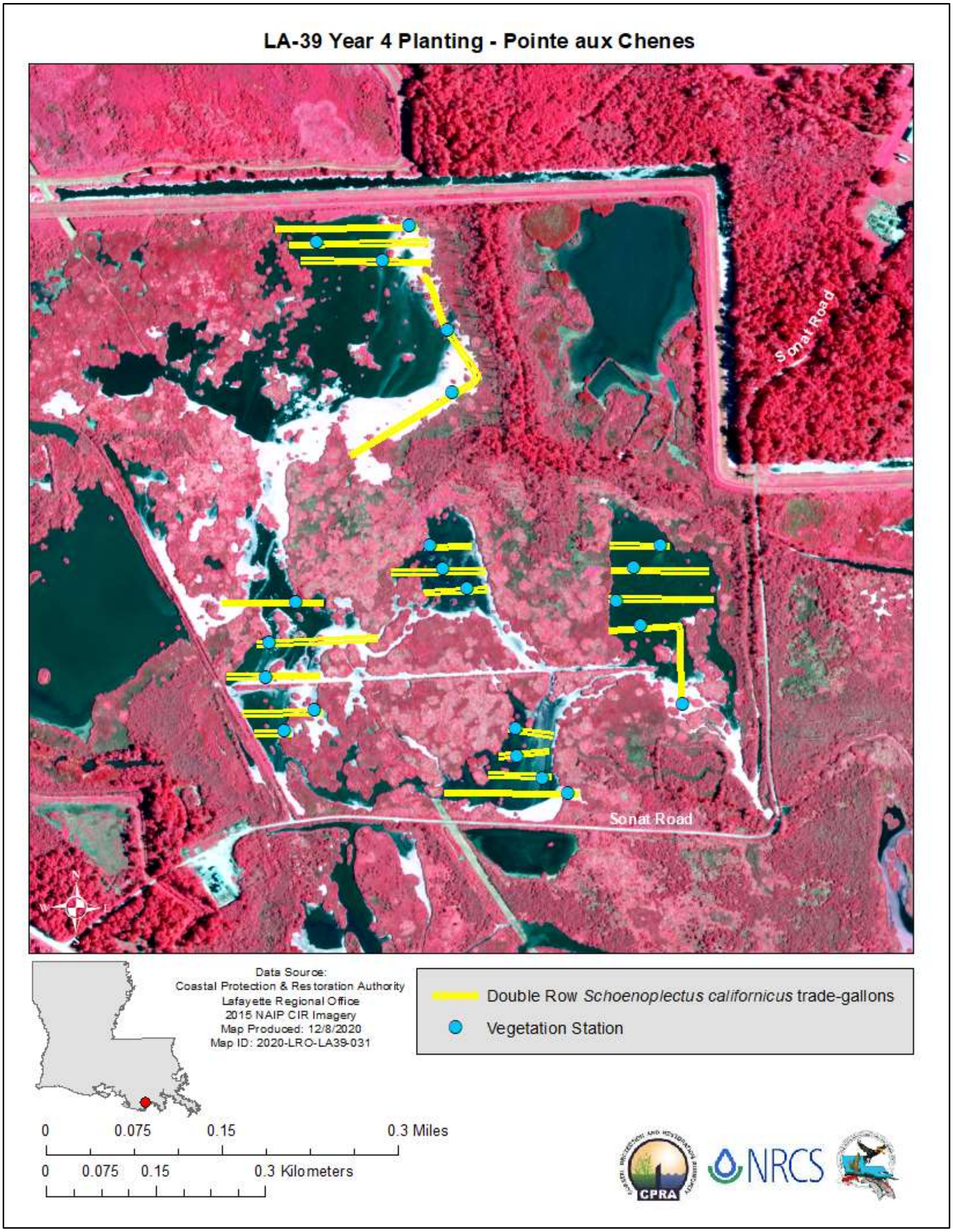

Figure XII-1. LA-0039 Year 4 - Pointe-aux-Chenes (PAC) plantings location with vegetation stations.

vegetation stations will include percent vegetative cover, percent cover of species present, vegetative stand height, and height of dominant species (Folse et. al. 2014). Average surface water depth will be taken at each station. All plant species located within 5 m of the stations will be recorded. Photographs will document the plantings and surroundings.

b. Hydrology

The nearest CRMS sites, CRMS400-H01 and CRMS0416-H01, are approximately 1.3 miles north and 1.9 miles east away, respectively, and hydrologically disconnected from the PAC plantings. The CRMS sites will be used to describe region water-level trends. Planting depth collected during the fall 2016 sampling trip is used to describe planting depth relative to regional water levels. Discrete surface-water measurements collected at all vegetation stations during fall 2016 are used to describe conditions faced by the plantings. Generalized water salinity conditions are also inferred by floating vegetation.

3. Monitoring Results and Discussion

a. Vegetation Assessment

In the three years post-planting, survival of *S. californicus* has been successful (Table XII-1), and the vegetation cover and height has increased (Figure XII-2). Qualitative field observations indicate that by August 2018 (about three years after planting) the planted double rows expanded enough to create almost continuous stands. Not all rows were continuous, having some breaks in expansion, but visual inspection indicated that with time some of these gaps could potentially fill in. The largest gaps occurred in the southwestern portion of the project within the first year after planting (fall 2015 -2016). This area is where Sonat Road intersects with a small access road on the southwestern perimeter of the project and a small pipeline canal reaches its terminus. The field crew has observed boaters navigating from the canal and through the planted rows in order to access points north into more open water. The southwestern plants remaining in 2016 had expanded by August 2018 (Figures XII-2 and 3). Greater expansion, cover, and survival in the remainder of the project's areas (central, southeastern, eastern, and northern) was more obvious by 2018. Photographs provide some perspective on the overall health and success of the planted areas (Figures XII-2 through 5).

Table XII-1. Percent survival from vegetation stations of planted *S. californicus* at LA-0039 Year 4 Pointe-aux-Chenes planting.

Year	Southwest	North	Central	Southeast	South
2016	42.5	76	80	87.5	77.5
2018	*Successful	*Successful	*Successful	*Successful	*Successful
*Notes: % survival for 2018 was indeterminate at each station due to expansion of plants into one continuous stand where individuals were no longer distinguishable. Two stations could not be accessed in 2018 therefore, only the twenty stations with data for both years were used to calculate means.					

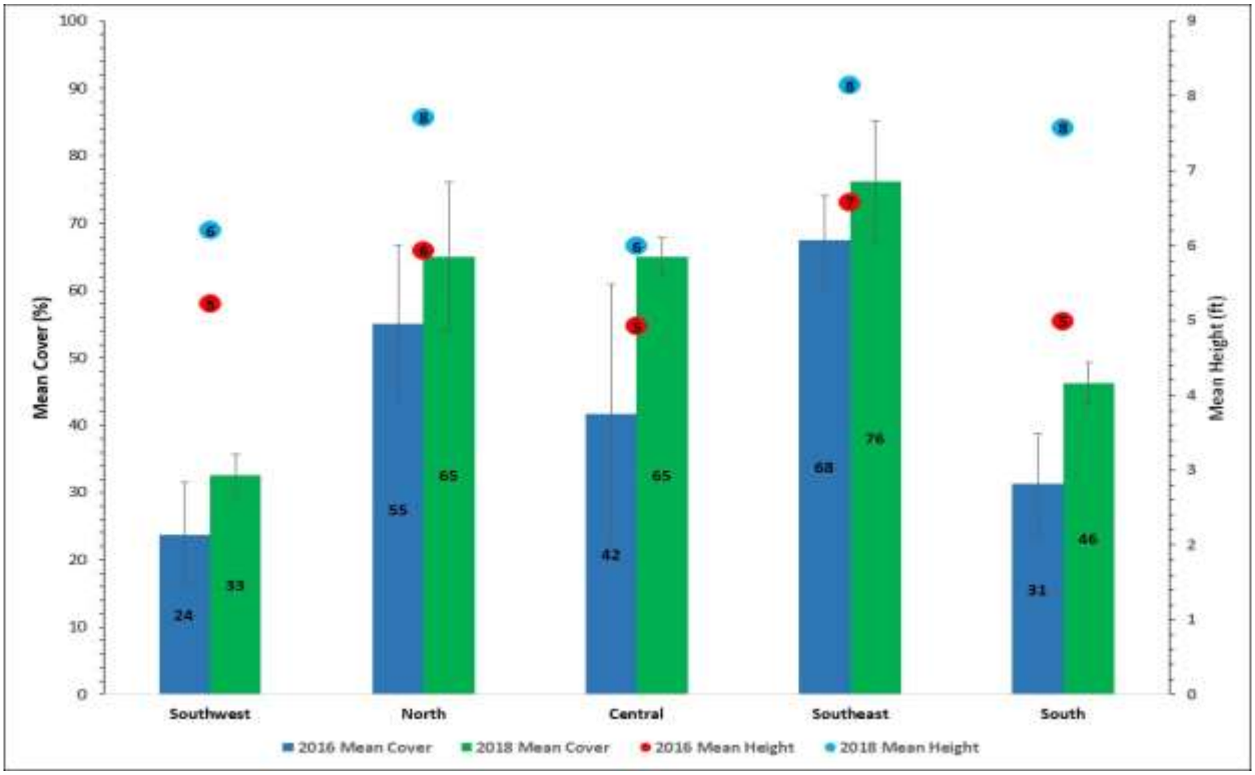

Figure XII-2: LA-0039 Year 4 Pointe-aux-Chenes plantings cover (bars, left y-axis) and height (dots, right y-axis) from each area one (November 2016) and three (August 2018) years after planting.

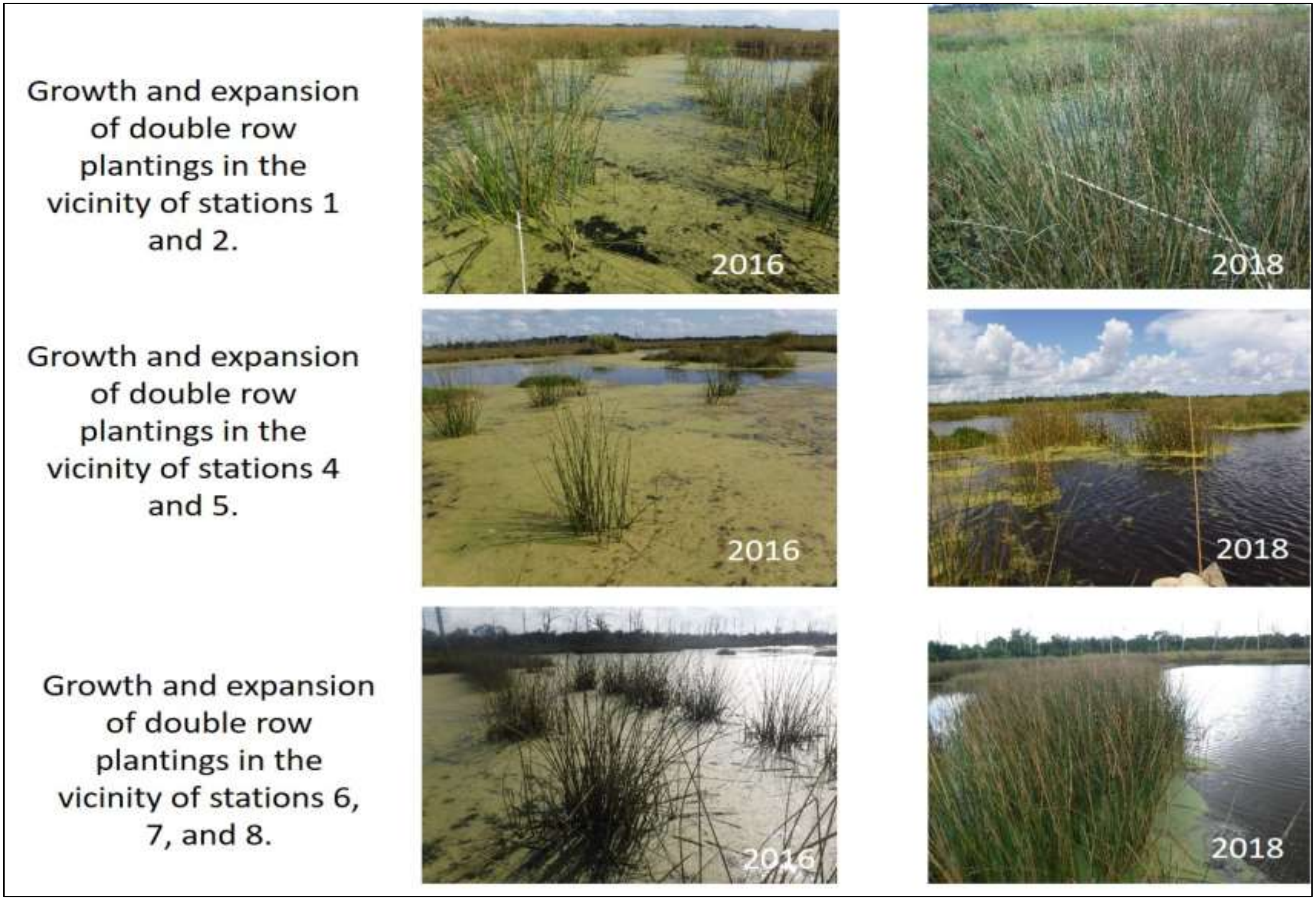

Figure XII-3: Comparative photographs of plantings in the southwestern (Stations 1-5) and northern (Stations 6-10) portions of LA00-39 Year 4 Pointe-aux-Chenes plantings from one (November 2016) and three (August 2018) years after planting.

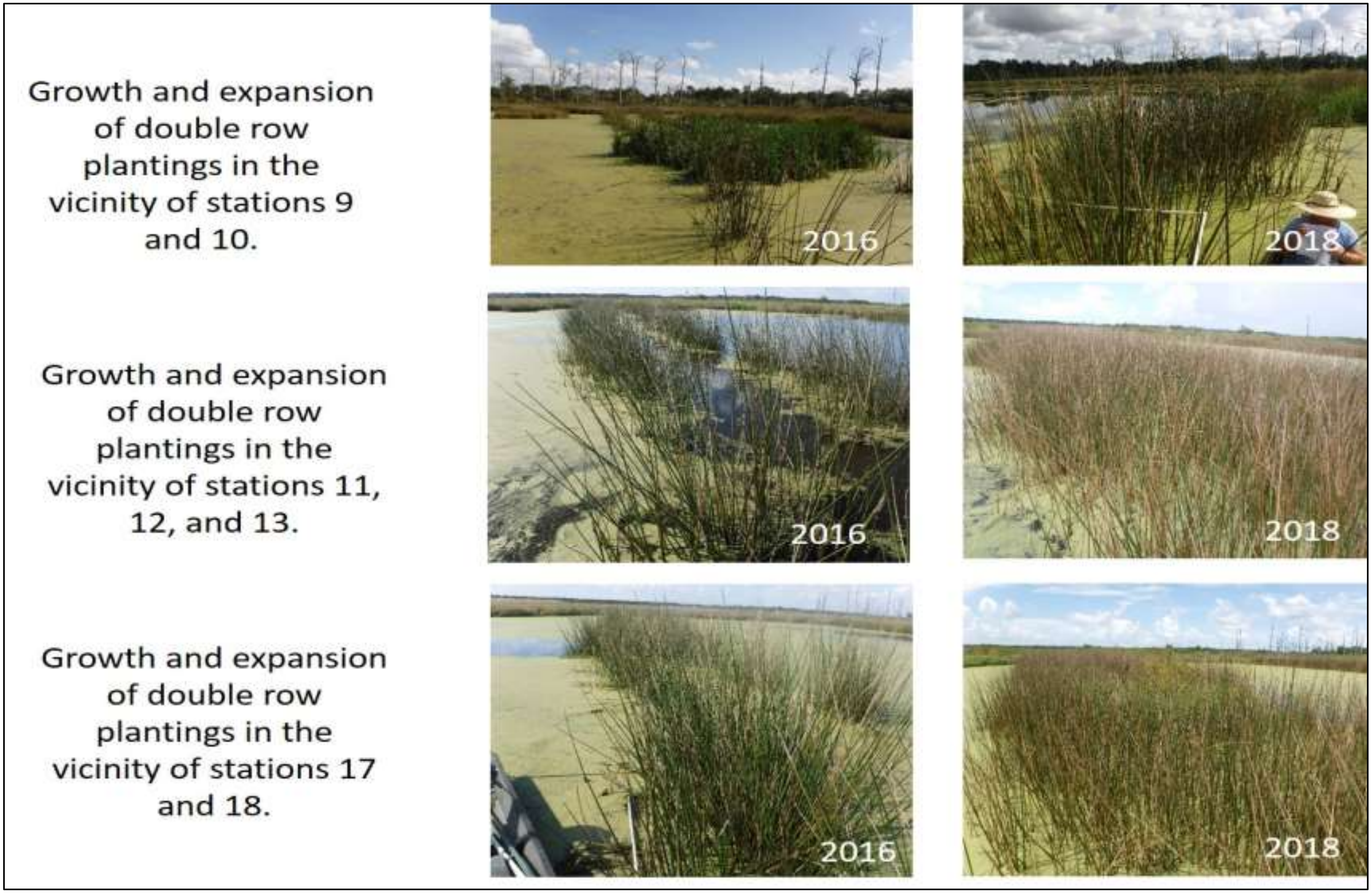

Figure XII-4: Comparative photographs of plantings in the northern (Stations 6-10), central (Stations 11-13), and southeastern (Stations 14-18) portions of LA00-39 Year 4 Pointe-aux-Chenes plantings from one (November 2016) and three (August 2018) years after planting.

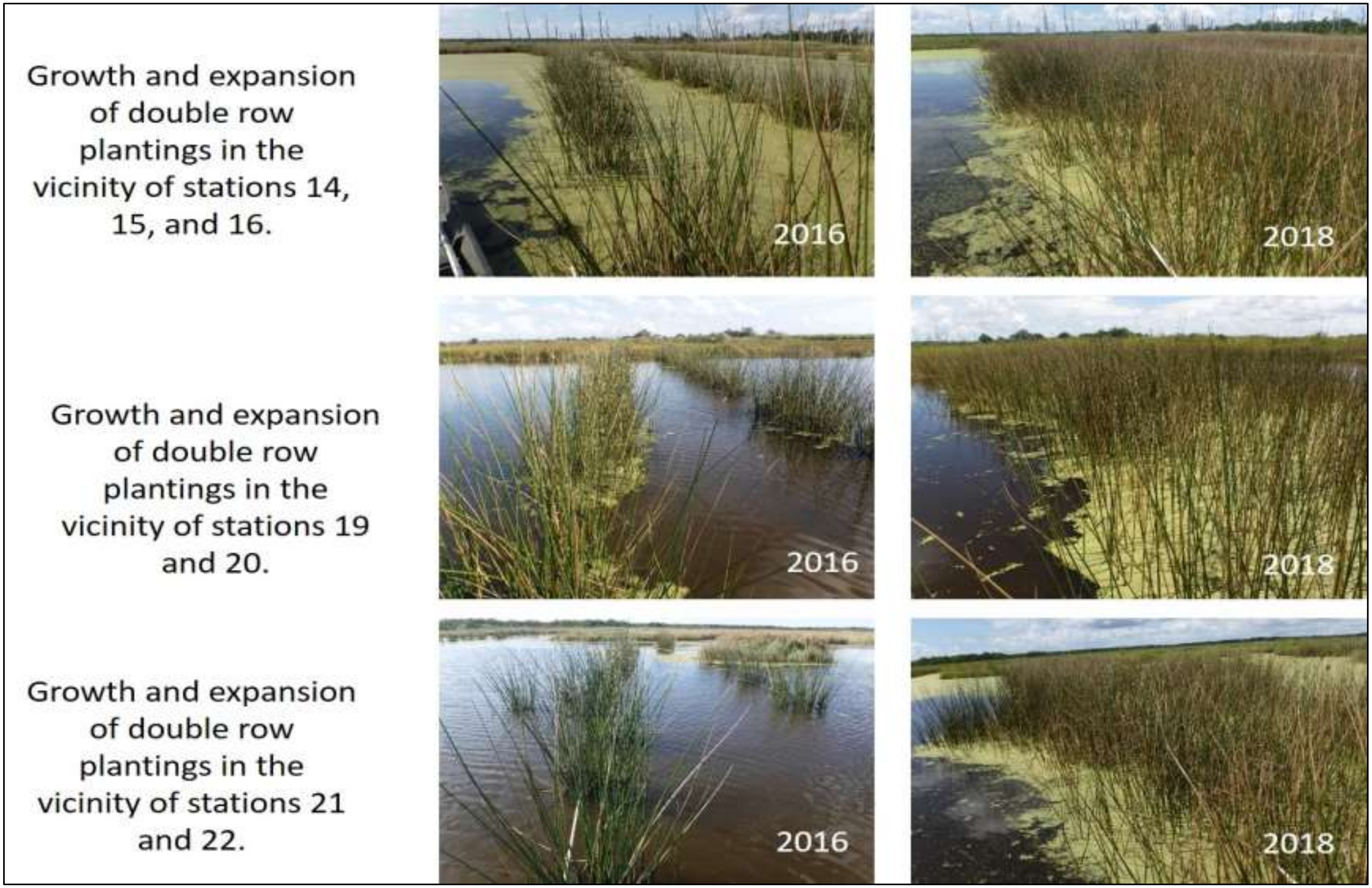

Figure XII-5: Comparative photographs of plantings in the southeastern (Stations 14-18) and southern (Stations 19-22) portions of LA00-39 Year 4 Pointe-aux-Chenes plantings from one (November 2016) and three (August 2018) years after planting.

b. Hydrologic Assessment

As noted earlier, the two CRMS sites nearest to the PAC plantings are not hydrologically connected to the project. The hydrologic data provides a regional perspective in terms of water level and salinity over a five-year time frame (2015-2019) which overlaps the project life. Water levels (Figure XII-6) averaged about 0.4 ft NAVD88, Geoid 12A, and salinity averaged 4.4 ppt. Discrete water depths at PAC vegetation stations averaged ~1.0 ft in November 2016 and 1.2 ft in August 2018. Relative to the water elevations at the CRMS sites, plantings were installed at a mean depth of 0.034 ft NAVD88 throughout the project area with a maximum depth of -0.87 ft NAVD88 and a minimum depth of 0.43 ft NAVD88. The plantings were typically flooded less than 1 foot and rarely flooded more than 2 feet. Fluctuations in water levels and salinity tended to track similarly between the two CRMS stations (Figure XII-6). The lowest water elevations occurred in the coldest months of the year (November through January) when they dipped below the mean planting elevation. Discrete surface water salinities at PAC vegetation stations averaged ~1.4 ppt in November 2016. Salinity at the PAC vegetation stations and the CRMS sites are well within the tolerance threshold of 8 ppt for *S. californicus*.

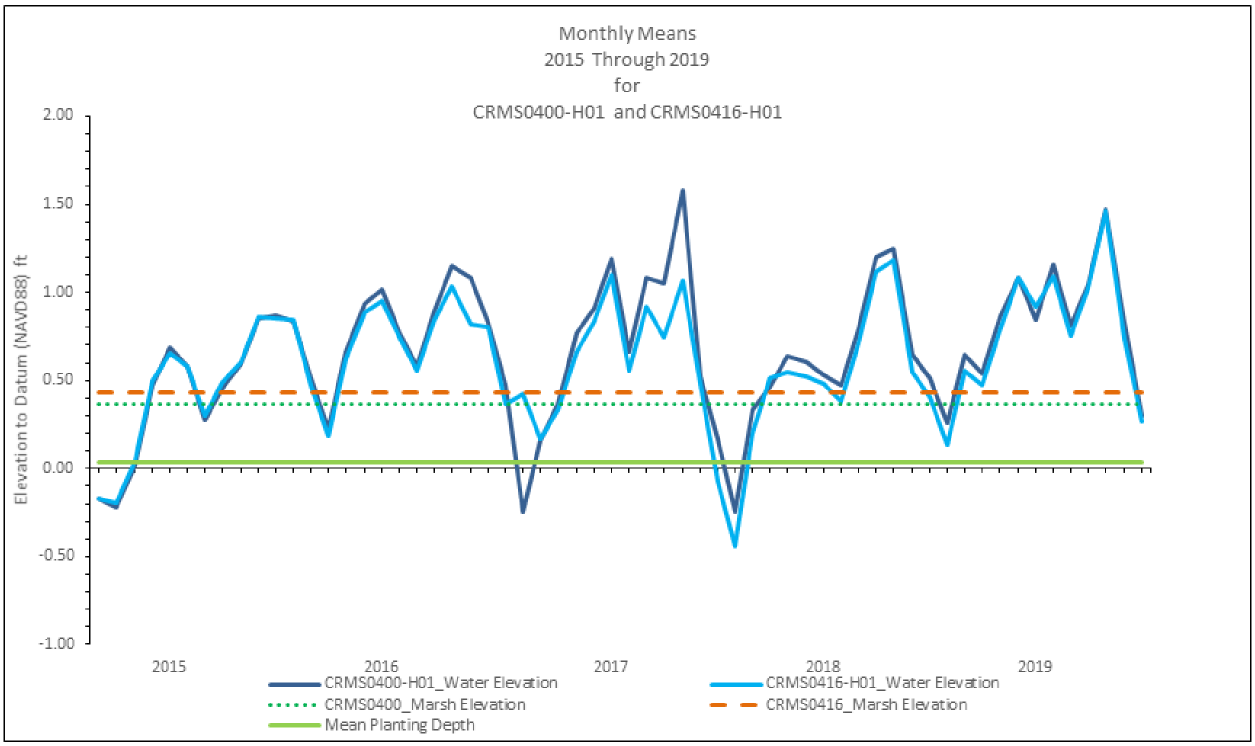

Figure XII-6. Hydrograph indicating planting depth with relation to monthly mean water elevations, salinities, and marsh elevations, at the CRMS-*wetlands* hydro stations nearest to year 4 PAC plantings project area. Years presented are 2015 through 2019. All elevations are in NAVD88, ft, Geoid12a.

c. Planting Failure/Success Causation

No definitive reason could be found to account for the lower survival and expansion of the Southwest plantings (Stations 1 - 5) due to the similarity in water elevations, planting depths, and salinity to the rest of the project area. The possibility exists that repetitive boat traffic in the southwest corner of the project created gaps in these double rows.

The most abundant floating aquatic vegetation (FAV) in the project area was common duckweed (*Lemna minor*) which indicates sustained low surface-water salinity at all planting locations (Figures XII-3 - 5). There was no presence of water hyacinth (*Eichhornia crassipes*) or *Salvinia* sp. The absence of these two latter species reduced damaging effects of large mats of (FAV) covering the plantings and burying them in the aftermath of high-water events.

C. Conclusions

1. Project Effectiveness

The LA-0039 Year 4 PAC vegetative plantings have been successful toward increasing vegetative coverage in the shallow ponds. Where no vegetation existed before, the plants have expanded into largely continuous hedge rows which reduce wind fetch.

- The double row plantings of California bulrush survived and expanded within the ponds.

2. Recommended Improvements

No recommended improvements are suggested at this time.

3. Lessons Learned

Early losses of plantings mainly occurred in the southwestern area where boat traffic was greatest. Consideration should be given to boat traffic when planning planting locations through engagement with local landowners and/or managers.

The PAC plantings have benefitted from a lack of heavy floating aquatic vegetation damage. Water hyacinth and giant Salvinia controls should be considered during planning and after installation.

XIII. Year 4 – Rockefeller Unit 4

Prepared by Mark Mouledous – CPRA Lafayette Regional Office

A. Site and Planting Description

Rockefeller State Wildlife Refuge is located in Vermilion and Cameron Parishes between the Gulf of Mexico and LA Hwy 82. The LA-0039 Year 4 – Rockefeller Unit 4 plantings were planted within the northwestern portion of the Refuge's Unit 4 in southeast Cameron Parish, which is managed by the Louisiana Department of Wildlife and Fisheries as a large, multi-use area to provide controlled access to estuarine organisms in an intermediate to brackish marsh environment (Fig. XIIII-1). The plantings were designed to establish perennial emergent vegetation in areas devoid of vegetation and/or in areas with sparse annual vegetation.

The areas that were planted are categorized as shallow open-water habitats with some very sparse emergent, intermediate marsh. Twenty-two double rows of trade-gallon sized *Schoenoplectus californicus* (California bulrush) were planted (Figure XIII-1). Each double row consisted of parallel rows fifteen feet (15 ft) apart with plants on five foot (5 ft) alternating centers. The double row alignment was designed to bisect some of the open water areas and create wave breaks. A total of 11,350 plants were planted from April 20 – April 24, 2015.

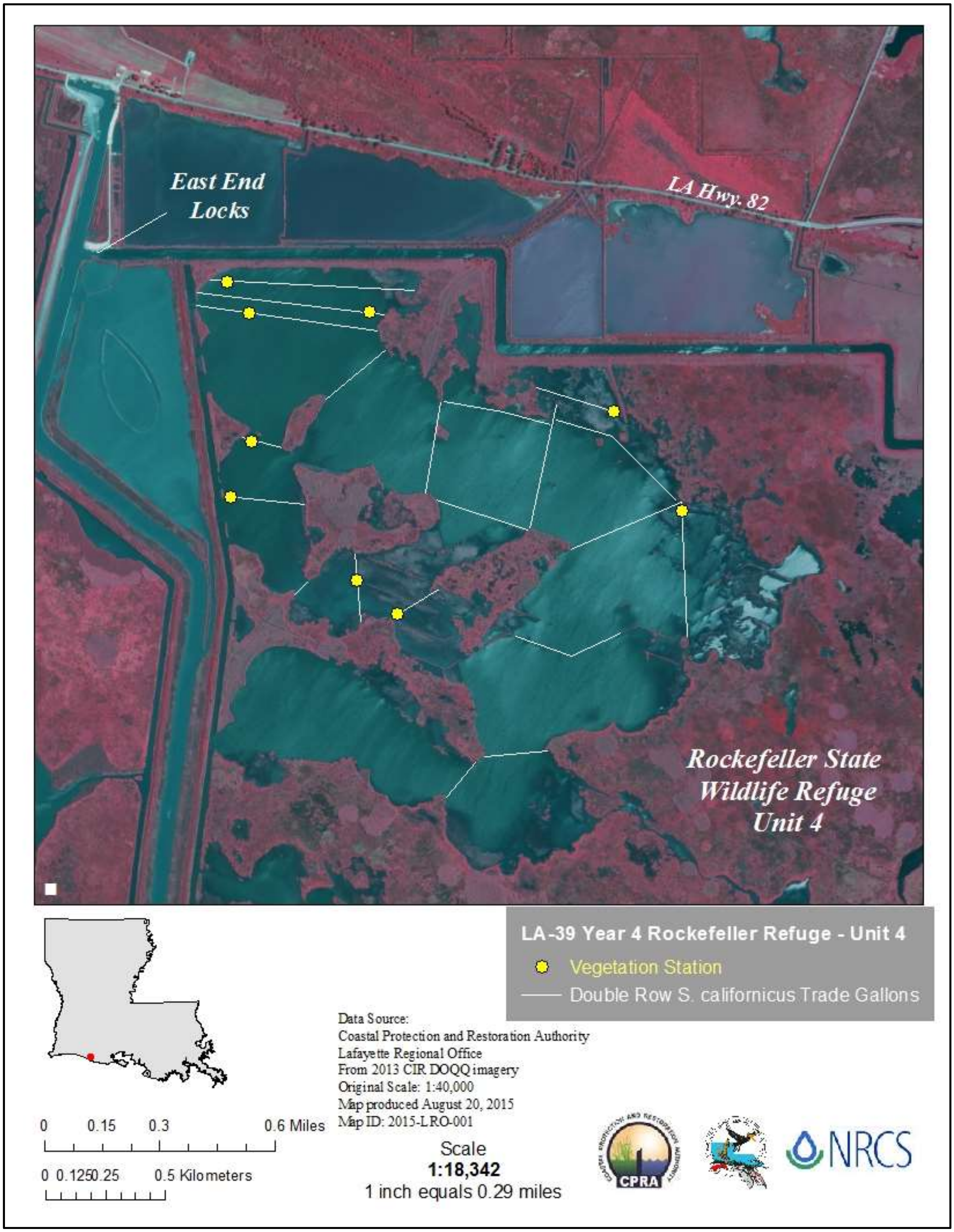

Figure XIII-1. LA-0039 Year 4 Site – Rockefeller Unit 4 Plantings site map showing location of plantings and vegetative monitoring stations.

B. Monitoring Activity

1. Monitoring Goals

The Year 4 Rockefeller Unit 4 plantings were designed to create thick hedgerows of *Schoenoplectus californicus* within open water areas to protect project area shorelines and decrease wind driven wave fetch.

The goals of the Rockefeller Unit 4 plantings are:

- Double row plantings of *Schoenoplectus californicus* in close proximity to pond shorelines will achieve at least 50% survival and expand cover.
- Double row plantings of *Schoenoplectus californicus* across open-water areas will achieve at least 50% survival and expand cover.

2. Monitoring Elements

The monitoring elements include procedures to assess plant survival, effects on the planting area, and the recruitment of any other emergent marsh vegetation to the area. Vegetation stations were intended to monitor planting survival and vegetative cover throughout the Rockefeller Unit 4 planting area over time. Sampling stations were limited to locations with surviving plants because planting survival was low (25%) during the initial monitoring trip on August 6, 2015, three and a half months following the planting inspection. Monitoring continued in August 2016 and was suspended after the three-year post planting monitoring trip on May 8, 2018 due to low planting survival.

Vegetation Assessment

To assess planting status, an ocular estimate of survival and plant condition was conducted for each double row. Planting survival and vegetative cover data was also collected at the vegetation station level. Vegetation stations were limited to locations with remaining live plants; therefore nine (9) stations were established along the double row plantings. Percent survival was calculated from a set of 10 plants at each vegetation station; plants were characterized as live or dead/absent. PVC poles were placed on both ends of the plants monitored for survival over time. Percent cover of the species present and planting heights were measured in 4 m^2 vegetation stations (Folse et al. 2018). Surface water depth, salinity, and temperature were also collected at all sampling stations during each sampling event. Conditions occurring outside of the stations and segments including additional species, marsh interspersion, and site-specific points of interest were noted along with photo documentation. At the time of the planting inspection (April 24, 2015), planting survival was assumed to be 100% overall; vegetation station level % planting survival, % cover, and stem heights were assumed to be 100%, 3%, and 91 cm (36 inches), respectively.

Planting Failure/Success Causation

Hydrologic data from CRMS0581-H01, located within the southeastern area of Unit 4, a temporary staff gauge installed during construction by NRCS staff, and Louisiana Department of Wildlife and Fisheries staff records were used to convert water depth (ft) to estimated planting elevations (ft, NAVD88 Geoid12a) to describe area water-level trends during and after plant installation. The water-level data were tied to water depths collected within the planting areas to estimate flood depths in the project area.

3. Monitoring Results and Discussion

a. Vegetation Assessment

Overall, percent survival of the plantings was low at around 25% four months after planting during the August 2015 sampling (Table XIII-1). Lowest survival occurred along rows planted in large open water areas. In these areas, plant survival was limited to the ends of rows near the shoreline, and even these plants appeared somewhat sparse and stressed (Fig. XIII-2). Orientation of the rows did not seem to matter as much as the size of the pond area. Moderate survival was observed in areas that were planted near terraces or within broken marsh sections that provided the plantings with protection from wind and wave action. In these areas, percent survival as high as 85% was observed.

In August 2016, percent survival dropped even further to 16%, but the remaining plantings looked healthy and were forming clumps and even spreading some in the northeastern protected area (Fig. XIII-3). This trend continued into 2018 as overall percent survival dropped to 10% with the remaining surviving plantings clustered at the ends of the rows near the shoreline. The few individual plantings that had survived in the middle of deeper open water areas were no longer present (Fig. XIII-4). As on previous surveys, the plantings in protected broken marsh areas showed much higher survival rates (Fig. XIII-5). The remaining plantings look healthy for the most part, with some stress evident in a few locations on the outer edges. The percent cover of the vegetation stations increased from 3% per sampling plot to near 17% over the course of one year, then remained the same through 2018 (Fig. XIII-7). Average stem height nearly doubled as well from 4.2 ft in 2015 to ~8 ft in 2016, but decreased by 2018 to 5.8 ft, indicating perhaps a nutrient drain by the plantings in the initial years (Fig. XIII-8).

Table XIII-1. Overall Survival of LA-0039 Year 4 Rockefeller Refuge plantings were estimated over time while conducting monitoring field trips.

	Overall Survival (%)			
Planting Type	Apr 2015	Aug 2015	Aug 2016	May 2018
Double Row plantings	100	27	16	10

Figure XIII-2. View of surviving *Schoenoplectus californicus* plantings on end of row across northern open water area in August 2015 in LA-0039 Year 4 - Rockefeller Unit 4.

Figure XIII-3. View of healthy *Schoenoplectus californicus* forming clumps in the protected, northeast double row in August 2016 in LA-0039 Year 4 - Rockefeller Unit 4.

Figure XIII-4. A few plantings survived in open water areas into 2016 (A), but had disappeared by 2018 (B) in LA-0039 Year 4 - Rockefeller Unit 4.

Figure XIII-5. View of healthy *S. californicus* clump in the protected, southern portion of the LA-0039 Year 4 - Rockefeller Unit 4 in May 2018.

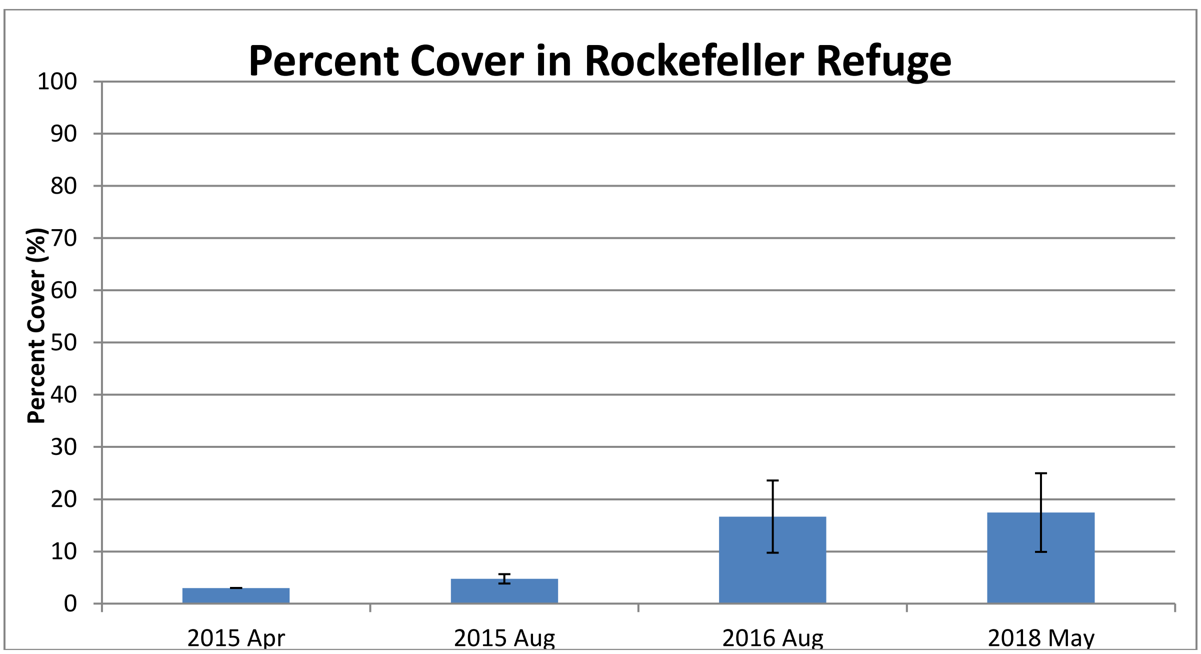

Figure XIII-7. Percent cover collected from vegetation stations at LA-0039 Year 4 - Rockefeller Unit 4 from April 2015 – August 2016. Error bars represent standard error.

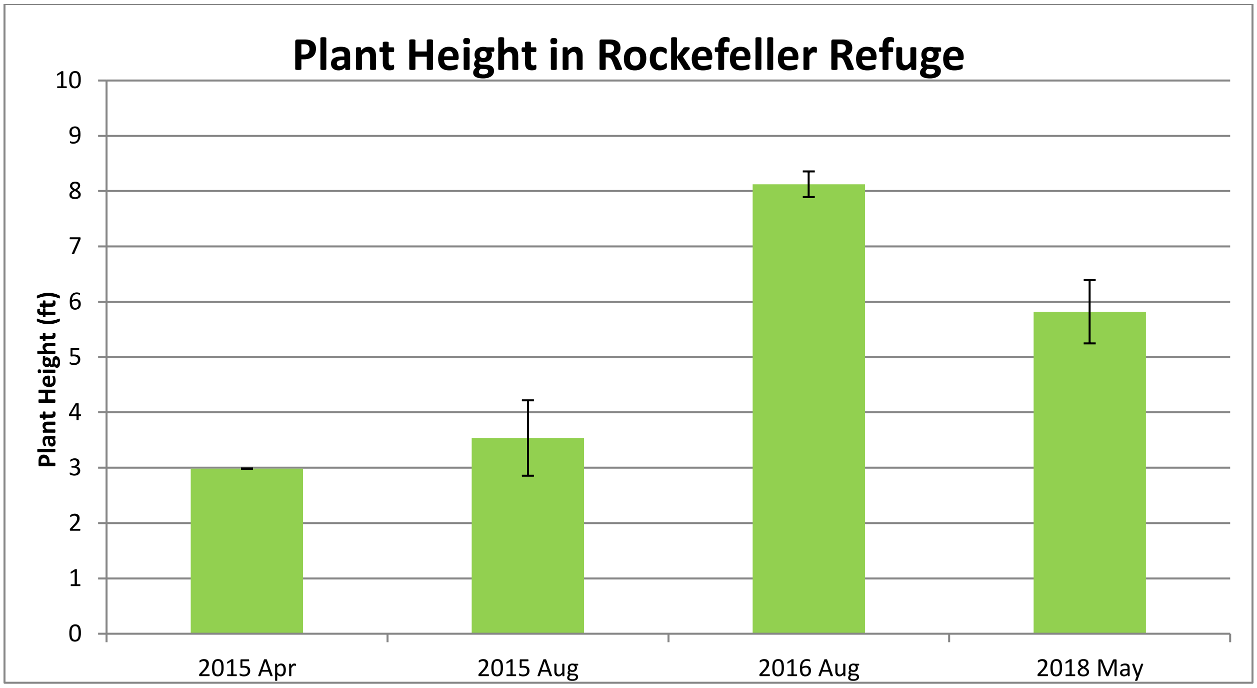

Figure XIII-8. Plant heights collected from vegetation stations at LA-0039 Year 4 - Rockefeller Unit 4 from April 2015 – August 2016. Error bars represent standard error.

b. Planting Failure/Success Causation

The low survival of plantings was likely caused by high water/flooded conditions and wave energy, contributing to uprooting of plants in those areas that had minimal protection from the elements and were not well established. Water levels following construction were fairly consistent, around 0 ft NAVD88, until mid-June when a heavy rain caused water levels to rise by over a half a foot within Unit 4 (Fig. XIII-9). Water levels during this period exceeded the maximum water elevation of 0.43 ft NAVD88 (Geoid12a) established for the planting period within the plans and specs by the NRCS Contracting Officer. Given that the average height of the plants at installation was 36", there would have been about 1.5 ft of stem above the water line at planting and less than a foot for June 14-19. Granted, this was not during the planting period; however, the plantings were still becoming established and had not firmly rooted themselves to the substrate. In addition, rafts of algae were observed in many of these areas growing along and on the remaining plantings, adding further stress to the young plantings (Fig. XIII-10). High water events in 2016 and 2018 further exposed the few remaining unprotected plantings to wave energy. Depth of water did not seem to be a factor on plant survival as water depths were fairly consistent throughout the project area and planting success did not seem to vary from the shallower areas to the deeper areas. Salinities did not affect survival, either, as average salinities during the 2015 and 2016 surveys were 3.5 ppt and 2.5 ppt, respectively. However, on the 2018 survey, barnacles were noted on the PVC vegetation plot poles indicating higher salinities may have entered the project area at some point, potentially contributing to the stress observed on some of the plantings on that survey. Consistency of pond bottoms varied from firm to soft but also did not appear to contribute to planting success as much as protection from the elements.

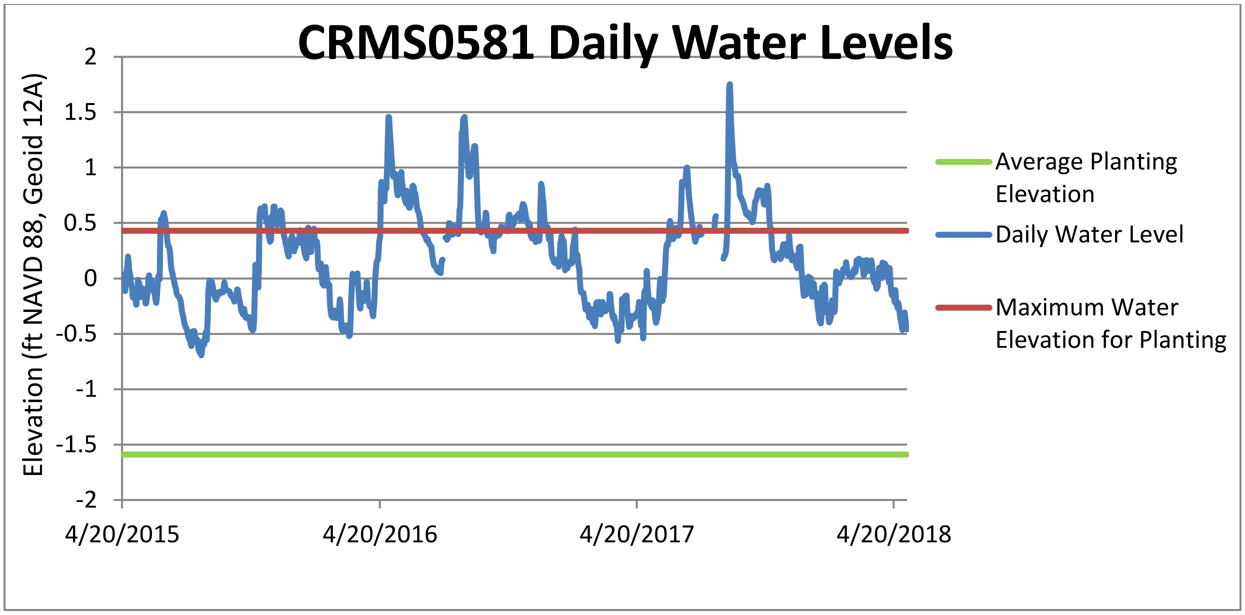

Figure XIII-9. Hydrograph of nearby CRMS0581 displaying daily water levels throughout the monitoring period in the LA-0039 Year 4 - Rockefeller Unit 4.

Figure XIII-10. Example of algal rafts collecting on a stressed *S. californicus* planting in August 2015 in LA-0039 Year 4 -Rockefeller Unit 4.

C. Conclusions

1. Project Effectiveness

As per the project goals:

- Double row plantings in close proximity to pond shorelines were not successful in forming hedges to protect shorelines. Planting survival was low (25%) three and a half months after planting, decreasing to 10% three years after planting.
- Double row plantings across open-water areas were not successful in forming hedges to disrupt fetch. Plantings did not survive within the large open-water areas of the project.

2. Recommended Improvements

Consideration could be given to increasing the size and density of plantings if planting in large wind-fetch areas are repeated.

3. Lessons Learned

Fetch across the large open water areas was too great for survival of newly installed plants, especially during elevated water levels that occurred within the 8 weeks following the planting effort. Although storm systems are unpredictable, if the plants would have had time to become more firmly rooted, performance would likely have improved.

XIV. Year 5 – Rockefeller Terraces

Prepared by Mark Mouledous – CPRA Lafayette Regional Office

A. Site and Planting Description

Rockefeller Terraces, a Year 5 planting site for the Coastwide Planting project (LA-0039), is located in Cameron Parish. Three separate areas of the Rockefeller State Wildlife Refuge were planted along previously constructed terraces. The Price Lake site is located on the western side of the refuge along the southeast bend of Price Lake Road and is in a brackish environment (Figure XIV-1). The Little Constance and Superior Canal sites are located southwest of Superior Canal in the central portion of the refuge and are in intermediate environments (Figure XIV-2).

The areas that were planted are categorized as shallow open-water habitat, with some very sparse emergent marsh. Approximately 12,150 trade gallons of *Schoenoplectus californicus* (California bulrush), 13,450 vegetative plugs of *Spartina alterniflora* 'Vermilion' (Vermilion smooth cordgrass), and 32,400 small pots of *Paspalum vaginatum* Brazoria Germplasm (Brazoria Germplasm seashore paspalum) were planted in three areas on Rockefeller Refuge between May 17 – June 8, 2016. Plantings were conducted following the guidelines listed below.

Price Lake Site

Spartina alterniflora was planted at elevation 1.2 ft relative to a gage set by Louisiana Department of Wildlife and Fisheries (LDWF), in a single row along the slope of each terrace on three-foot (3') centers (13,450 plants).

Paspalum vaginatum was planted on the crest of each terrace on paired rows five-feet (5') apart on three-foot (3') centers and parallel to the terrace centerline (13,000 plants).

Little Constance Site

Schoenoplectus californicus was planted at elevation 0.5' to 1.0' relative to the gage set by LDWF, in a single row along the slope of each terrace on five-foot (5') centers (5,800 plants).

Paspalum vaginatum was planted on the crest of each terrace on paired rows five-feet (5') apart on three-foot (3') centers and parallel to the terrace centerline (9,350 plants).

Superior Canal Site

Schoenoplectus californicus was planted at elevation 0.5' to 1.0' relative to the gage set by LDWF, in a single row along the slope of each terrace on five-foot (5') centers (6,350 plants).

Paspalum vaginatum was planted on the crest of each terrace on paired rows five-feet (5') apart on three-foot (3') centers and parallel to the terrace centerline (10,050 plants).

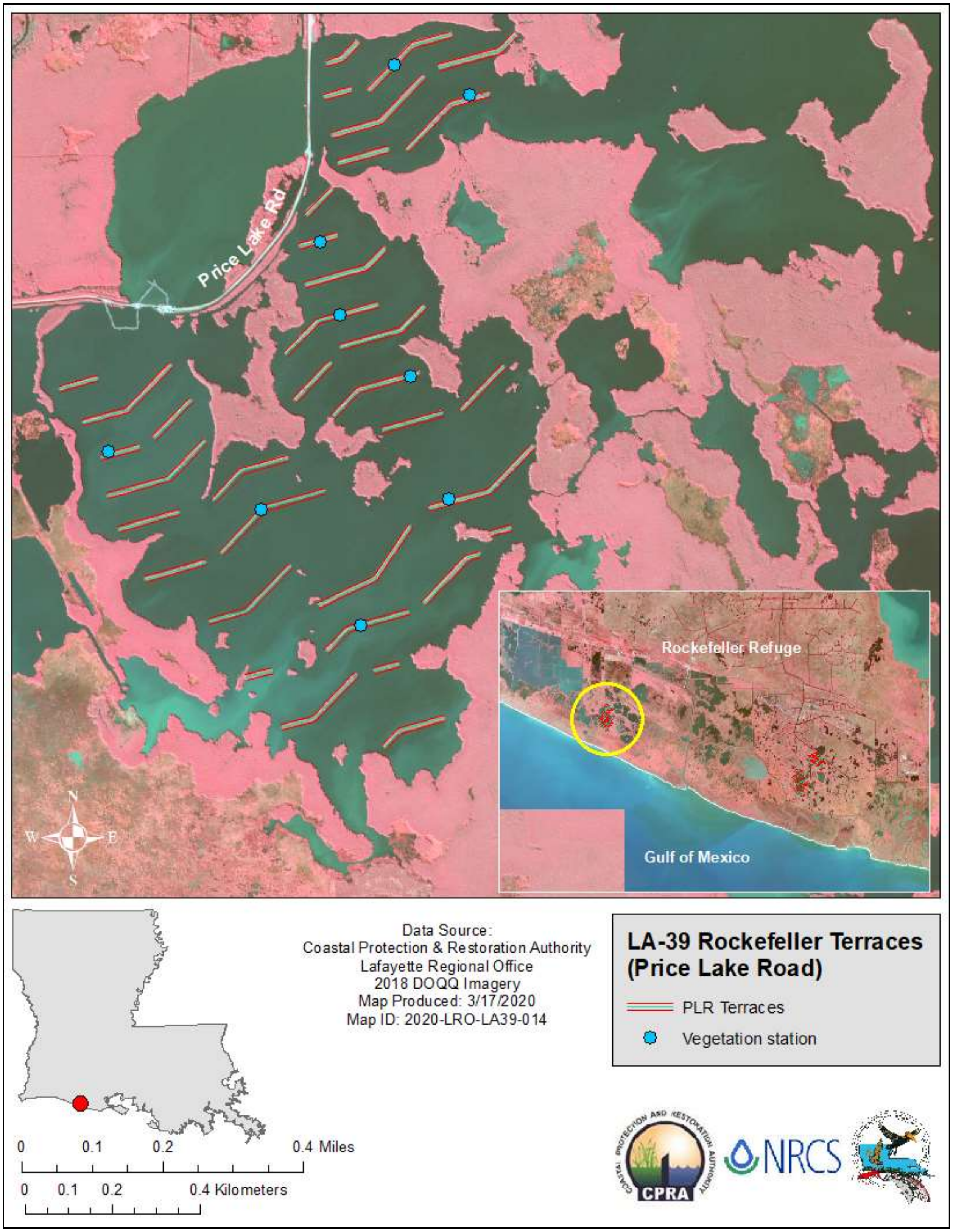

Figure XIV-1. LA-0039 Year 5 Site Rockefeller Terraces - Price Lake Road site map showing location of plantings and vegetative monitoring stations.

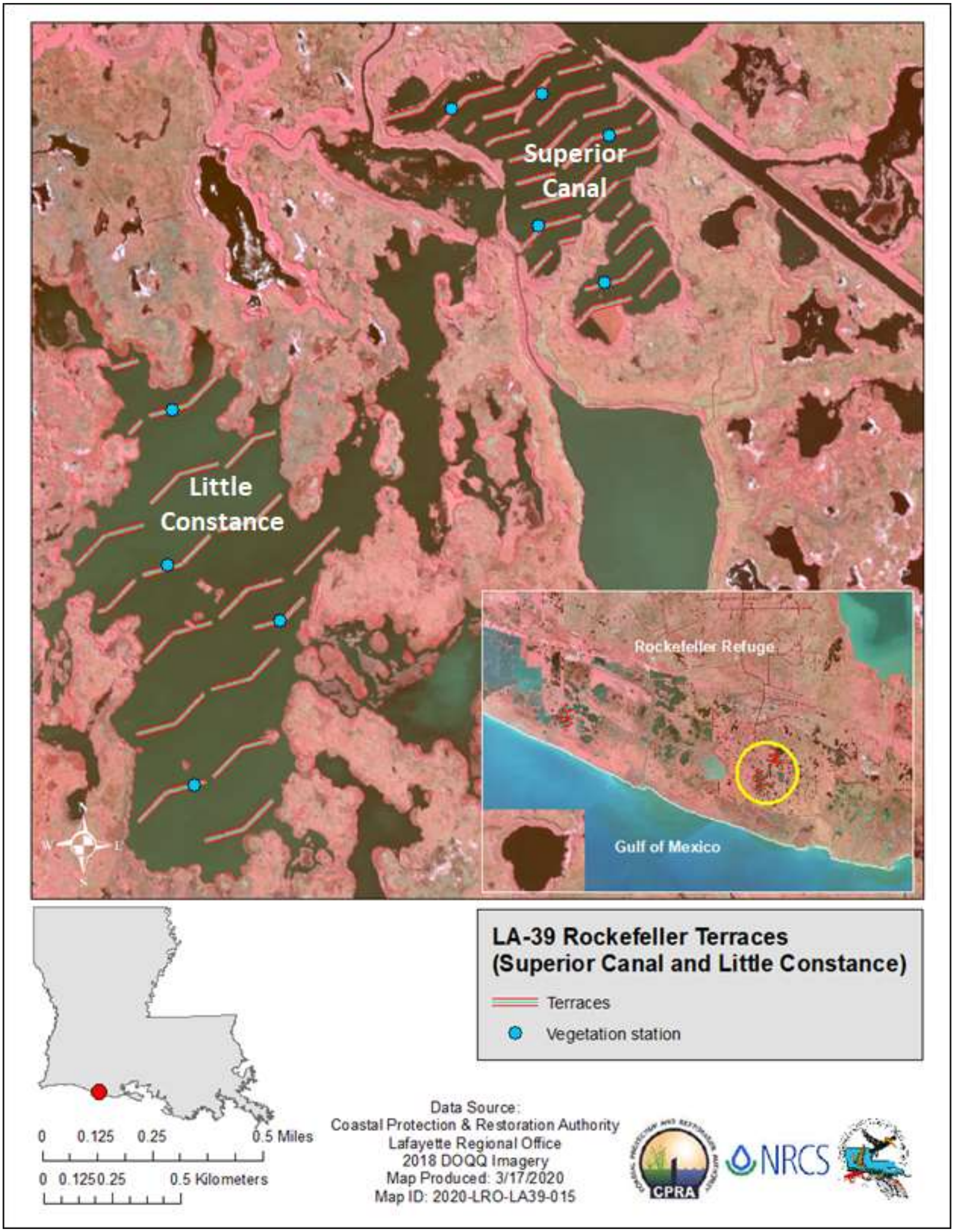

Figure XIV-2. LA-0039 Year 5 Site Rockefeller Terraces - Superior Canal and Little Constance sites map showing location of plantings and vegetative monitoring stations.

B. Monitoring Activity

1. Monitoring Goals

The LA-0039 Year 5 Rockefeller Terraces plantings were designed to establish perennial emergent vegetation on slopes and crowns of pre-constructed terraces devoid of vegetation to protect against erosion.

The goals of the Rockefeller Terraces plantings are:

- 75% survival of the *Spartina alterniflora* 'Vermilion' plantings at the Price Lake Site 45 days after installation.
- Planted vegetation will survive and expand vegetation on the toes and crowns of terraces recently constructed by the Louisiana Department of Wildlife and Fisheries.

2. Monitoring Elements

The monitoring elements include procedures to assess plant survival, effects on the planting area, and the recruitment of any other emergent marsh vegetation to the area. Planting survival was assumed to be 100% at the time of planting June 2014. Post planting survival and vegetative cover were monitored throughout the Rockefeller Terraces plantings at the end of the first growing season in November 2016 and at three (3) years in May 2019. A general assessment of planting health following the hurricane season of 2020 will be conducted in spring or fall 2021.

Vegetation Assessment

To assess planting status, an ocular estimate of percent survival and plant condition was conducted for each area and the plantings on the terraces while visually inspecting the site during sampling visits. Planting survival and vegetative growth data was also collected at the vegetation station level; 18 stations were established to represent the areas and planting types (Figures XIV-1 and 2). Nine (9) stations were established in the brackish Price Lake terraces, three on the crowns and six (6) on the slopes. Nine (9) stations were established in the intermediate Superior Canal/Little Constance terraces; five (5) stations were established in the Superior Canal terraces, two on the crowns and three (3) on the slopes, and four (4) stations were established in the Little Constance terraces, one (1) on a crowns and three (3) on the slopes.

Percent survival was calculated from a set of 10 plants at each vegetation station; plants were characterized as live or dead/absent. A PVC pole was placed at one end of the plants monitored for survival over time and notes taken on the plot orientation. Percent cover of the species present and planting heights were measured in 4 m^2 vegetation stations (Folse et al. 2018). Flooding depth, surface water salinity and temperature, and porewater salinity and temperature were also collected at all sampling stations during each sampling event. Conditions occurring outside of the vegetation stations including additional emergent species, floating and submerged vegetation, marsh interspersion, and site-specific points of interest were noted along with photographic documentation.

Planting Failure/Success Causation

Hydrologic data from CRMS0615-H01, located just southeast of the Price Lake planting site, and CRMS0608-H01, located northeast of the Superior Canal and Little Constance sites, were used to describe area water-level and salinity trends. The water-level data were compared to planting elevations (ft, NAVD88 Geoid 12A) to describe flood conditions.

3. Monitoring Results and Discussion

a. Vegetation Assessment

Overall, the Rockefeller Terraces plantings have performed exceptionally well, with a survival rate of 90% for the species planted on the terrace slopes at all three sites, as of the most recent sampling (Table XIV-1). The *Paspalum vaginatum* plantings had very high survival and coverage through November 2016, but as of the most recent sampling, showed stress in some areas, potentially indicating an extended period of high water levels. In many areas, the plantings on the crowns were outcompeted and replaced by other species, such as *Phragmites australis*. Because of this, percent cover of the *P. vaginatum* plantings dropped considerably from November 2016 to May 2019 (Figure XIV-3).

Price Lake Plantings

The *S. alterniflora* plantings have performed well over the 3 years since planting. Survival was near 90% six months after installation and has remained high through 2019 (Table XIV-1). The plantings are growing vigorously, and have expanded coverage substantially since being planted (Figure XIV-3). The average height of the plantings decreased slightly since the first survey, but is still averaging around 4.5 ft tall (Figures XIV-4 and 5)

Superior Canal Plantings

The survival estimate of the *S. californicus* plantings was low on the initial survey, at around 35% (Table XIV-1). By 2019, though, the plantings had expanded and filled in the gaps created by the missing plants, making it appear that the survival rate increased since the first survey. This is reflected in the percent cover data as well where a 70% increase occurred between surveys (Figure XIV-3). Height of the California bulrush plantings increased significantly as well between surveys, from 6.5 ft in 2016 to near 9 ft in 2019 (Figures XIV-4 and 6)

Little Constance Plantings

Survival of the *S. californicus* plantings within the Little Constance area has been solid since installation (Table XIV-1). As in the Superior Canal area, the increase in percent cover between the two surveys was significant in this area as well (Figure XIV-3). Plant height did not change as drastically, but still averaged ~1 ft growth in three years (Figures XIV-4 and 7).

Therefore, the goal to establish and expand vegetation on the terraces has been met. The slope plantings have expanded. Even though the *P. vaginatum* plantings on the crown showed signs of stress after three years, they initially expanded and worked to stabilize the terraces until other species could become established and have functioned to prevent erosion of the terraces.

Table XIV-1. Overall % Survival of LA-0039 Year 5 Rockefeller Terraces plantings were estimated over time while conducting monitoring field trips. "Survival" indicates amount of planting footprint occupied by planted species relative to age of planting and initial spacing. Survival was assumed to be 100 % at the time of planting in June 2016.

		Overall Survival (%)		
Area	Species Planted	June 2016	November 2016	May 2019
Price Lake Road	*Spartina alterniflora*	100	89	90
	Paspalum vaginatum	100	100	65
Superior Canal	*Schoenoplectus californicus*	100	35	90
	Paspalum vaginatum	100	100	85
Little Constance	*Schoenoplectus californicus*	100	98	90
	Paspalum vaginatum	100	100	20

For the Price Lake terraces, a modification of the contract resulted in the contractor providing a guarantee of 75% survival of the *S. alterniflora* plugs at 45 days after installation due to the contractor's use of plants that were transplanted from substrate prior to the time frame called for in the original contract specifications. In lieu of a complete count, approximately 11% of the plugs were observed to determine percent survival at approximately 45 days after installation in July 2016, which was a more extensive count than the survival estimate at the vegetative monitoring stations. This first sampling near the end of July 2016 resulted in an estimate of approximately 84% survival, fulfilling the contract obligations and meeting the monitoring goal of 75% survival. The sampling was again repeated in November 2016 and resulted in a determination of 78% survival at the end of the growing season after planting.

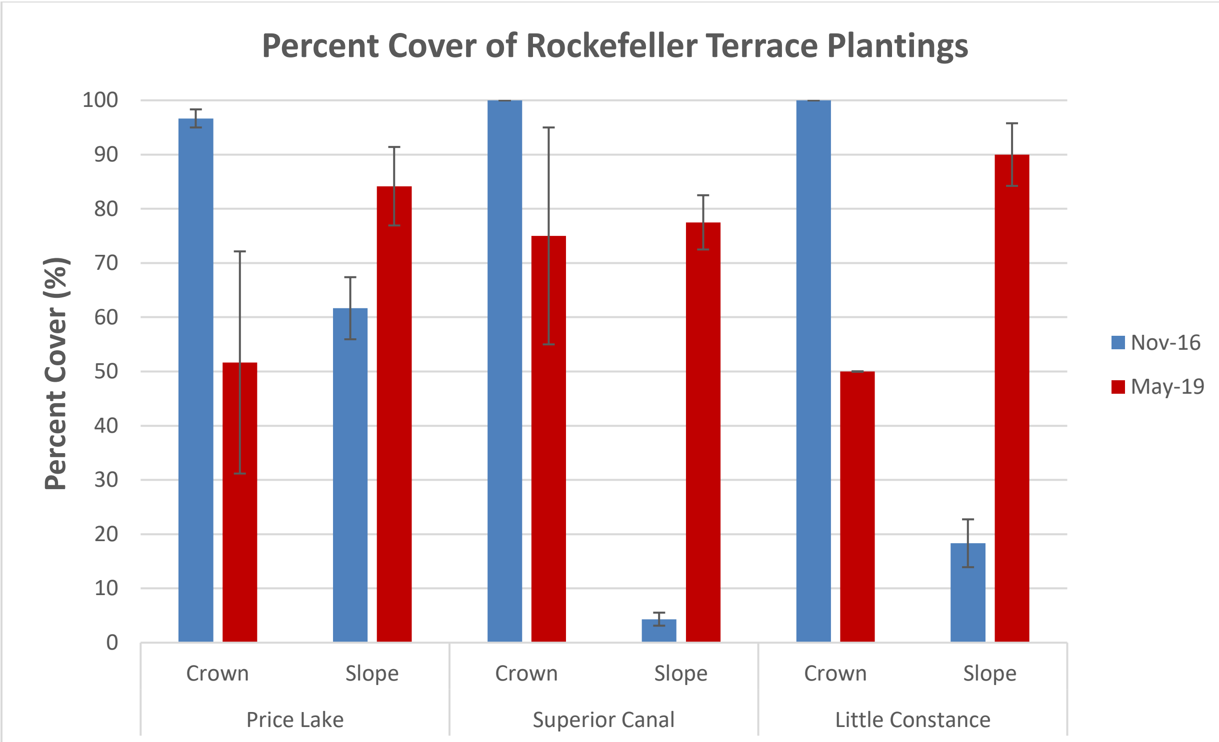

Figure XIV-3. Percent cover collected from vegetation stations at the three sites in the LA-0039 Year 5 Rockefeller Terrace plantings in November 2016 and May 2019 by planting type. *Paspalum vaginatum* was planted on all crowns; *Spartina alterniflora* was planted on the Slope in Price Lake; and, *Schoenoplectus californicus* was planted on the Slopes in Superior Canal and Little Constance. Bars are means with standard error bars.

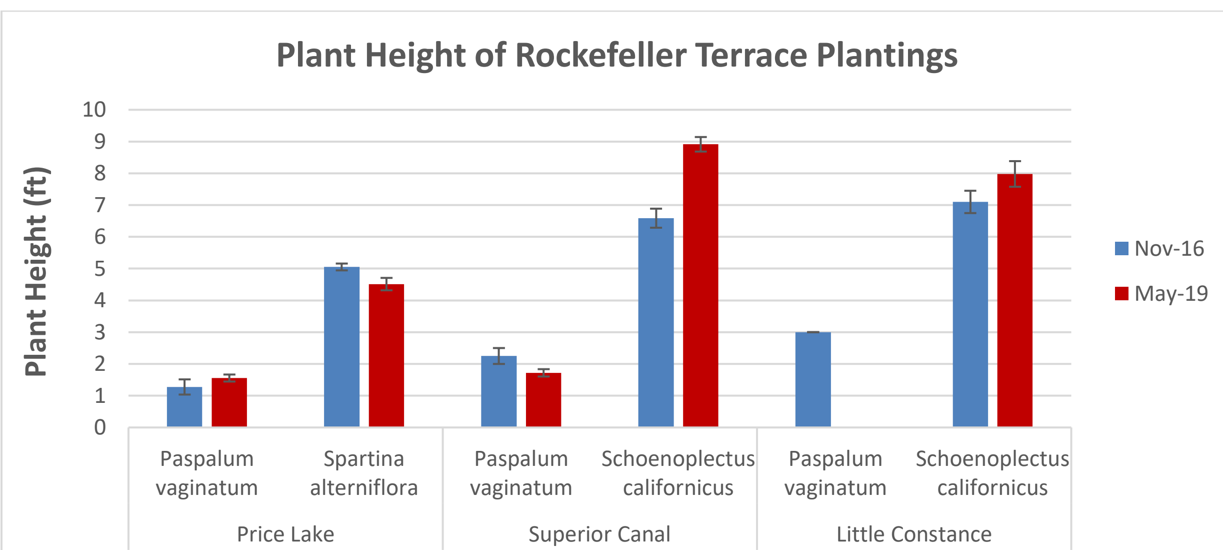

Figure XIV-4. Plant Heights collected from vegetation stations at the three sites in the LA-0039 Year 5 Rockefeller Terrace plantings in November 2016 and May 2019 by planting type. *Paspalum vaginatum* was planted on all crowns; *Spartina alterniflora* was planted on the Slope in Price Lake; and, *Schoenoplectus californicus* was planted on the Slopes in Superior Canal and Little Constance. Bars are means with standard error bars.

Figure XIV-5. Photos of LA-0039 Year 5 Rockefeller Terrace Price Lake plantings immediately following plant installation in June 2016 (A), at the end of one growing season in November 2016 (B), and a vegetation plot in May 2019 (C). Note the increase in cover of the *Spartina alterniflora* on the slope as well as the colonization of outside species with the *Paspalum vaginatum* on the crown.

Figure XIV-6. Photos of LA-0039 Year 5 Rockefeller Terrace Superior Canal plantings following plant installation in June 2016 (A), at the end of one growing season in November 2016 (B), and a vegetation plot in May 2019 (C) demonstrating the growth of the *Schoenoplectus californicus* recovery growth and during that time.

Figure XIV-7. Photos of LA-0039 Year 5 Rockefeller Terrace Little Constance plantigs following plant installation in June 2016 (A), a vegetative sampling plot in November 2016 (B), and the same plot in May 2019 (C) illustrating stressed *Paspalum vaginatum* plantings as well as expansion of *Schoenoplectus californicus* plantings.

b. Planting Failure/Success Causation

Hydrologic data for the Rockefeller Terrace plantings was obtained from CRMS0615, in the Price Lake Area, and CRMS0608, in the Superior Canal and Little Constance areas, from June 2016 through May 2019 along with estimated planting elevations (Figures XIV-8 and 9). No loss of *P. vaginatum* occurred through the November 2016 sampling and the plantings were in excellent condition in all three areas. By the 2019 sampling, though, the *P. vaginatum* plantings appeared stressed in many locations at all three areas, potentially from overtopping of the terraces on multiple occasions in 2017 and 2018.

Hydrologic conditions have been ideal for the *Spartina alterniflora* plantings. Water depths within the Price Lake area were typically within the optimum range of 1 – 18 inches for smooth cordgrass ‘Vermilion’ strain establishment (Fine and Thomassie 2000), only exceeding this range briefly during two events in 2017. Salinities were also within the tolerance range of 0.4 – 22.5 ppt for the plantings for the entire record (Fine and Thomassie 2000) (Figure XIV-8).

The optimum water depth for establishment of *S. californicus* is reported as between 1 to 2 feet (Materne and Fine 2000). Water levels within the Superior Canal and Little Constance areas exceeded this range during the flood of 2016 for a prolonged period, likely leading to the poor survival of the plantings in the Superior Canal area during the first vegetative sampling. Water levels rarely, and only briefly, exceeded this range since that event, allowing the plantings to recover and expand in the Superior Canal and Little Constance areas. Mean salinities for these areas were below 2 ppt and even though they have briefly spiked to above 5 ppt on multiple occasions, have not bothered the plantings (Figure XIV-9).

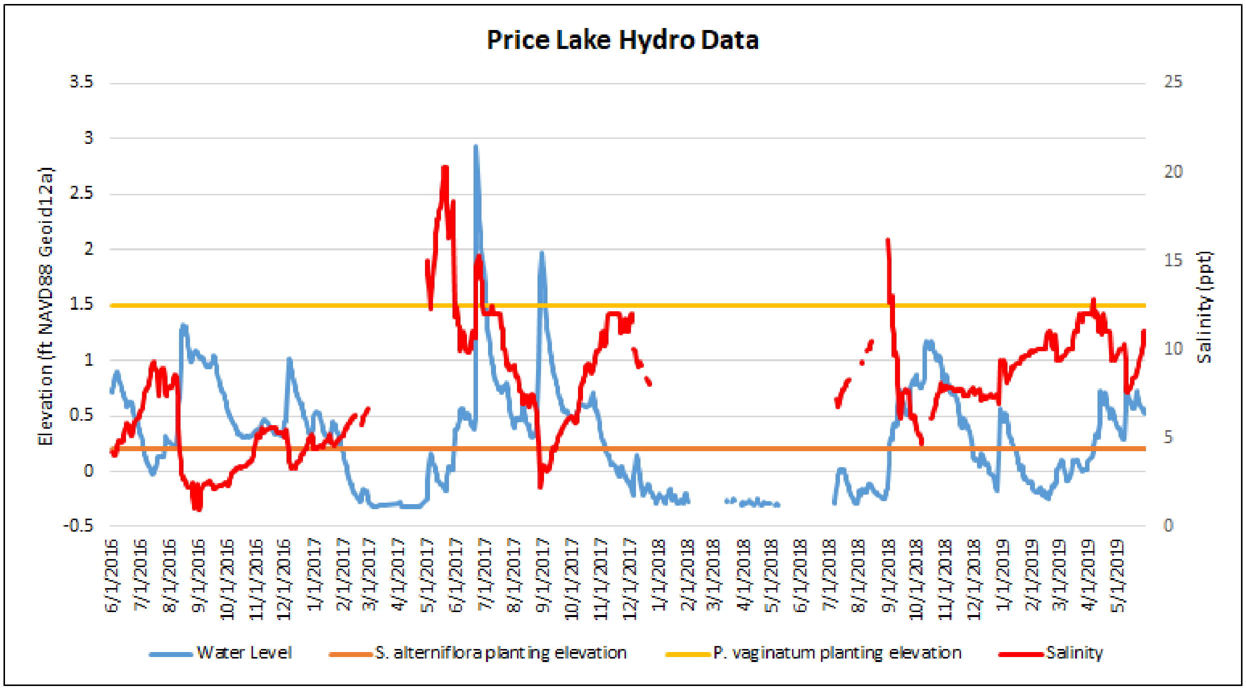

Figure XIV-8. Mean daily water elevation and salinity at CRMS0615 in the LA-0039 Year 5 Rockefeller Terrace Price Lake Area, graphed with the estimated planting elevations of *Spartina alterniflora* on the slope and *Paspalum vaginatum* on the crest of the terraces.

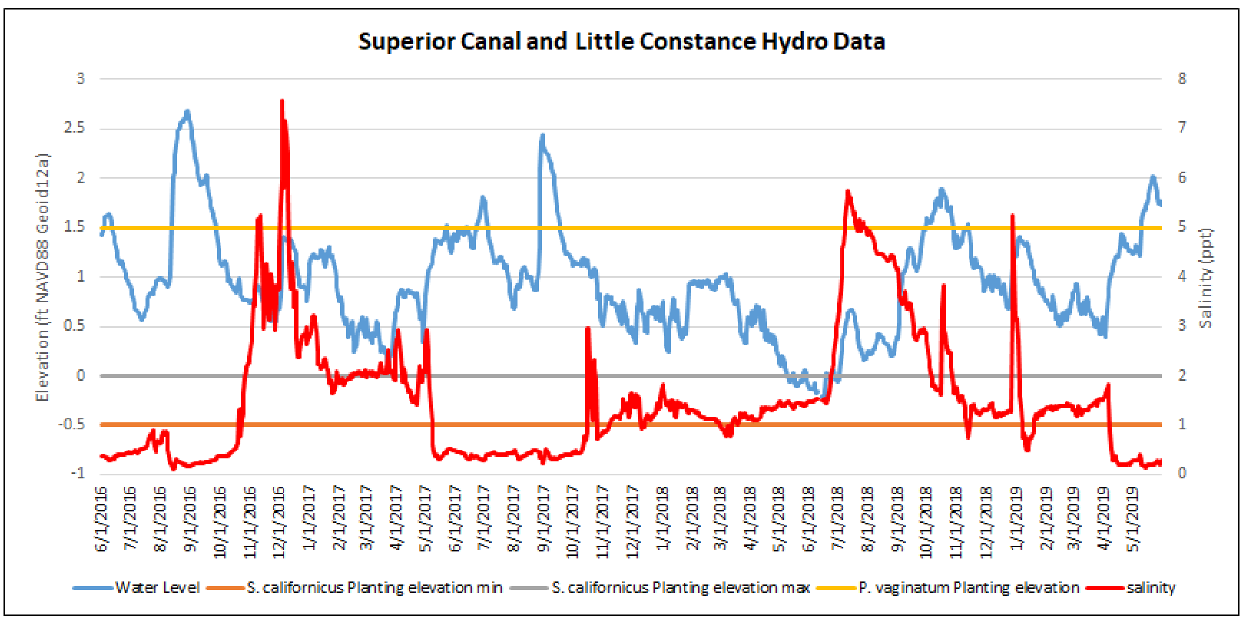

Figure XIV-9. Mean daily water elevation and salinity at CRMS0608 in the LA-0039 Year 5 Rockefeller Terrace Superior Canal and Little Constance areas, graphed with the estimated minimum and maximum planting elevations of *Schoenoplectus californicus* on the slope and *Paspalum vaginatum* on the crest of the terraces.

C. Conclusions

The LA-0039 Year 5 Rockefeller Terrace plantings overall has been successful through its first three years. Plantings have survived and expanded on terraces that were previously devoid of vegetation. The crown plantings showed a decrease in cover due to flooding stress, but should recover, absent further flooding events, and are starting to be replaced by outside species.

1. Project Effectiveness

As per the project goals:

- The *Spartina alterniflora* 'Vermilion' plantings at the Price Lake Site did achieve 75% survival 45 days after installation.
- The vegetation has survived and expanded on the toes and crowns of terraces constructed by the Louisiana Department of Wildlife and Fisheries and is preventing erosion of the terraces.

2. Recommended Improvements

There are no recommended improvements.

3. Lessons Learned

The *Paspalum vaginatum* plantings quickly expanded to cover the crowns of the terraces and, even though this species is vulnerable to flooding stress, functioned to stabilize the terraces until other species could colonize. This species should be considered in future terrace plantings.

XV. Year 5 - East Grand Terre

Prepared by Elaine Lear – CPRA Thibodaux Regional Office

A. Site and Planting Description

The LA-0039 Year 5 East Grand Terre (EGT) planting is located on a small barrier island in southwest Plaquemines Parish Louisiana between Pass Abel to the west and Quatre Bayou Pass to the east (Figure XV-1). East Grand Terre is part of the Barataria/Plaquemines barrier island complex, one of the most rapidly disappearing areas in coastal Louisiana. Once one large barrier island, it was bisected in the mid 1800's due to the effects of tropical storms, subsidence, and the lack of sand replenishment (Penland and Suter 1988). In an effort to restore the vanishing barrier island, the East/West Grand Terre Islands (BA-30) Restoration project was completed in 2010. CPRA, in partnership with NOAA fisheries, through the CWPPRA program, engineered, designed, permitted, and constructed 165 acres of beach and 450 acres of marsh (CPRA 2011). Actual shoreline construction occurred between mid-December 2009 and Late June 2010. The effort restored 2.8 miles of shoreline. In the interim, the island was impacted in April 2010 by the British Petroleum Deepwater Horizon Oil Spill however, efforts were made to minimize beach oiling during construction by Weeks Marine and British Petroleum; Weeks Marine by pumping water through the dredge pipeline to clear it ahead of placement, and British Petroleum by the deployment of crews for oil removal and cleanup. The EGT planting was installed and inspected in July 2017 in several areas along the shoreline.

Project Features

An estimated 58,450 four-inch container *Panicum amarum* (bitter panicum) plants were installed along the beach, foredune, and dune platform on seven (7) foot centers in staggered rows ten (10) feet apart. The number of rows installed were dependent upon the expanse of the areas and the site conditions.

An estimated 8,695 *Spartina alterniflora* (smooth cordgrass) plugs were installed on three (3) foot centers in staggered rows. These were installed in two small areas behind the dunes. The number of rows installed were dependent upon the expanse of the areas and the site conditions.

Unfortunately, an as-built drawing was not performed; the site map is based on planning efforts (Figure XV-1). Both species were planted in the approximate locations indicated in the planning map, though when CPRA field crews canvassed the planting during as-built inspections in July 2017, the planted areas were slightly different. The project plans noted that installation locations shown in Figure XV-1 were approximate and could vary due to site conditions and/or construction variables.

Figure XV-1. LA-0039 Year 5 East Grand Terre Island features from planning efforts.

B. Monitoring Activity

1. Monitoring Goals and Objectives

The goals of the EGT plantings are:

- Plantings of bitter panicum will survive and expand to reinforce shoreline integrity in order to increase island longevity.
- Plantings of smooth cordgrass will survive and expand to reinforce shoreline integrity in order to increase island longevity.

2. Monitoring Elements

Vegetation Assessment

The EGT planting is logistically difficult and demanding. Performing the typical suite of LA-0039 monitoring requires a specialized boat to traverse Barataria Bay and transport a four wheeler and take two days per event. Therefore, only area-scale assessments were performed in each of the 10 area polygons identified and mapped during the 2017 field trip (Figure XV-2); typical vegetation stations were not established. Data collection to assess survival and growth via plant height of the planted species occurred near the end of the first growing season after planting on October 17, 2017 and one year after planting on July 27, 2018. Qualitative observations were made inside of the area polygons and photographs were taken to document the success and health of the planted features over time. The third year post-construction sampling trip scheduled for 2020 was postpone until fall 2021.

Figure XV-2. Map of LA-0039 Year 5 Site – East Grand Terre shows the planting types and areas where vegetation monitoring data was collected.

The EGT plantings were installed on beach dunes or isolated ponds; therefore, hydrologic assessments were not conducted from nearby CRMS sites as is typical for LA-0039 monitoring.

3. Monitoring Results and Discussion

Estimated percent survival of the planted species did not change between 2017 and 2018 in the bitter Panicum (PAAM) area plantings; however, surviving plants did increase overall in height (Table XV-1). Surviving plants grew and expanded into clumps of vegetation, but not to the extent that solid unbroken rows of vegetation formed. The ideal zone for bitter panicum to thrive was noticeable. The most robust and expansive plant growth for this planted species occurred on the higher portion of the dune platform above the high tide mark. The dynamic environment along the immediate shoreline where erosion occured or where overwash from powerful storms occurred accounted for the loss of some plant rows. Rows installed closest to the Gulf bore the brunt of these impacts.

Very little, if any, smooth cordgrass (SPAL) survived (Table XV-1). The swale areas behind the dune platform where swaths of *S. alterniflora* were planted were lower in relief and did not have the benefit of tidal exchange. Ponding occurred which resulted in the formation of large alga mats. This was followed by dry periods where the ponded water evaporated resulting in the formation of salt pans. These areas only supported salt tolerant species such as *Salicornia bigelovii* and *Suaeda linearis*.

Table XV-1. Estimated percent survival and plant height in areas planted with bitter panicum (*Panicum amarum*, PAAM) and smooth cordgrass (*Spartina alterniflora*, SPAL) over time at LA-0039 Year 5 East Grand Terre planting.

	Estimated Survival (%)		Average Height (ft)	
Area	Oct 2017	Jul 2018	Oct 2017	Jul 2018
1 - PAAM	25	0	--	--
2 - PAAM	25	25	2.5	3.5
3 - PAAM	30	30	3.5	3.5
4 - PAAM	15	15	2	2.7
5 - PAAM	20	20	2	2.1
6 - SPAL	55	3	1.5	2.5
7 - SPAL	0	0	--	--
8 - SPAL	0	0	--	--
9 - PAAM	0	3	--	0.82
10 - PAAM	10	10	0.98	2.7

Qualitative Observations and Photographs by Area

Area 1 – Bitter Panicum (PAAM)
In 2017 all plants were either dead, absent, or dying. About one-quarter of the plants had live green tissue on the base of the plants but no green leaves. A decision was made to consider these dead, given the environmental conditions, and wait to see if they would grow out by the 2018 assessment. In 2018 all of the planted species within this area were dead. The fringes of the planted area consisted mainly of *Distichlis spicata* in both data collection years. (Photos in Figure XV-3).

Area 2 – Bitter Panicum (PAAM)
In 2017 the field crew observed five planted rows in this area polygon. About a quarter or the plants appeared very weak and spindly, but alive. There was no tiller expansion from the original plants. In 2018 the crew observed noticeable tiller formation and plant growth compared to previous year's assessment. Though survival of the planted species remained the same, the cover increased due to robust growth of the plants. The Gulfside rows above high tide had much healthier and more robust plants than rows further back nearer to the back marsh. Additional species observed in this area were *Spartina patens, Amaranthus greggii, Batis maritima*, and *Sesuvium portulacastrum*. (Photos in Figure XV-3).

Area 3 – Bitter Panicum (PAAM)
In 2017 the field crew observed five planted rows in this area polygon. Plants in the first two (2) rows (gulfside) were healthier and more robust than the three remaining rows which were sparse in number and size. Cover of natural vegetation was very sparse in this area. In 2018 natural plant recruitment was very strong in this area as vegetative cover was about 40%. Additional species in the area included *Vigna luteola* and *S. patens*. (Photos in Figure XV-3).

Area 4 – Bitter Panicum (PAAM)
In 2017 the field crew observed twelve planted rows in this area polygon. The gulfside rows above the high water mark were healthier. A large portion of the polygon had an area overwashed by a recent storm. This was basically denuded with the few surviving plants laid over by wave action from the storm. Natural recruitment of vegetation was very low and sparse overall. In 2018 lateral spread in planted species was markedly improvement. Planted survivors were larger, healthier, and formed tillers to form expanded clumps. Also, natural recruitment of non-planted species greatly increased. Total vegetative cover was about 20%. (Photos in Figure XV-4).

Area 5 – Bitter Panicum (PAAM)
In 2017 ten planted rows were observed in this area polygon; however, they were on five-foot row spacings instead of the typical ten. Plants were on seven foot centers and the rows were staggered. As the field crew moved from east to west they observed areas of recent storm overwash alternating with higher, drier patches. A large amount of oyster shell mixed with the sand. Natural recruitment of non-planted species was sparse. In 2018 the ten rows were still present. The planted species expanded in size and were more robust but not as robust as those in areas 3 and 4; total vegetative cover was about 20%. (Photos in Figure XV-4).

Area 6 – Smooth cordgrass (SPAL)
This polygon covers a small breach/pond, which at the time of the 2017 data collection was flooded due to the incoming tide. *Spartina alterniflora* (smooth cordgrass) was planted in multiple rows with 3 ft × 3 ft spacings. Planted rows stretched from the tidal zone to the back of the ponded area. The east side of the pond was deeper and had no plantings. The west side of the pond was planted. Plants were not healthy but alive. In 2018 the field crew found that the breach/tidal pond had filled in with sand and attained substantial elevation equivalent to surrounding beach front. Note: Water levels were not overtopping the breach fill during high tide when observations were made. Planted survivors were on the western edge of the old breach, and the survivors were healthy and more robust than in the previous year. (Photos in Figure XV-4).

Area 7 – Smooth cordgrass (SPAL)
In 2017 the area inside of this polygon had no live plants and was algae encrusted. ATV tracks remained from planting operations. Plans indicate that this area should have contained planted *S. alterniflora*. The area had not changed by 2018 remaining as an algae-encrusted salt pan with dead stalks of the planted species. Vegetation on the periphery of the salt flat was *Salicornia bigelovii* and *S. patens*. (Photos in Figure XV-5)

Area 8 – Smooth cordgrass (SPAL)
In 2017 the area inside of this polygon was an algae-encrusted salt flat much like areas 1 and 7. No planted *S. alterniflora* survived. Field crew could smell hydrogen sulfide gas associated with anaerobic conditions. The area had not changed by 2018 remaining an algae-encrusted salt pan with dead stalks of the planted species. Vegetation on the periphery of the salt flat was *S. bigelovii* and *Suaeda linearis*. (Photos in Figure XV-5)

Area 9 – Bitter Panicum (PAAM)
No planted survivors were observed in October 2017. It appears the recent storms washed over the LA-0039 plantings and wiped them out. There were dead stalks in places where the plantings were originally installed. Adjacent to the 2017 plantings, farther back from the existing beachfront, and at an elevation above the high tide mark, there was an extensive stretch of older established plantings which Cindy Steyer (NRCS, pers comm.) stated were not part of the LA-0039 plantings effort. The plants in the eastern half of this previously planted area were more robust and taller than the occasional spindly survivors as one moved west toward the spit. Average stem height on the east half was 3 feet, while the west end plants averaged around 1.8 feet approaching the lower elevation sand spit. By 2018 some of the plants produced latent tillers, resulting in 3% survival at the LA-0039 EGT planting. The nearest species were *S. bigelovii* and *S. linearis*. (Photos in Figure XV-5)

Area 10 – Bitter Panicum (PAAM)
Crew found three planted rows in 2017; the remaining plants were very spindly. Some were in the tidal zone at the water's edge on the bay side and were frequently inundated. This area was otherwise bare of natural vegetation except for the perimeter of the polygon. A stand of *Avicennia germinans* divided the northern perimeter of the polygon from the rest of the planted area, and the south side of the polygon was a cove/canal with *Spartina patens* growing on its bankline. A small cut separated the western perimeter of the polygon from the beach to the west. Tides were high and water was flowing in through this cut. In 2018 surviving plants were noticeably larger than previous year and covered about 20% of the area (Table XV-1). These plants were not as large as those on the eastern half of the island, but were well-established with healthy tiller formation. Perimeter vegetation was also more robust and healthier than 2017. Additional species inside the polygon were: *Amaranthus greggii*, *S. patens*, *Heliotropium curassavicum*, *Schizyochrium maritima*, *V. luteola*, and *Solidago sempervirens*. (Photos in Figure XV-6)

Figure XV-3. Bitter Panicum plantings (Areas 1, 2, and 3) at the LA-0039 Year 5 EGT in 2017 and 2018.

Figure XV-4. Bitter Panicum (Areas 4 and 5) and smooth cordgrass (Area 6) plantings at the LA-0039 Year 5 EGT in 2017 and 2018.

Figure XV-5. Smooth cordgrass (Areas 7 and 8) and bitter Panicum (Area 9) plantings at the LA-0039 Year 5 EGT in 2017 and 2018.

Area 10

Figure XV-6. Bitter Panicum plantings (Area 9) at the LA-0039 Year 5 EGT in 2017 and 2018.

C. Conclusions

1. Project Effectiveness

- The goal to expand and increase planted bitter panicum (*Panicum amarum*) to vegetate the East Grand Terre beach/dune complex in order to reinforce shoreline integrity and island longevity has been moderately successful. Survival of bitter Panicum one year after planting (0-30 %) was not successful; however, surviving plants did expand with healthy tiller formation.

- The goal to expand and increase planted smooth cordgrass (*Spartina alteniflora*) to vegetate the EGT shoreline in order to reinforce shoreline integrity and island longevity has not been successful.

2. Recommended Improvements

There is no recommendation to replant EGT. Bitter Panicum should be planted above the high tide zone on the beach/dune complex.

3. Lessons Learned

Within the beach/dune complex, bitter panicum plantings were more successful above the high tide zone (supratidal) but failed below the high tide zone (intertidal), especially when open to the Gulf of Mexico waves.

In future planting efforts on barrier islands, plantings should not include the installation of smooth cordgrass in the swale areas behind the dune platforms where highly saline water from storm inundation or water from rainfall forms ponded areas for extended periods of time with no drainage. Algae mats form followed by the formation of salt flats once evaporation occurs. The cycle of ponding with no tidal exchange, followed by evaporation and long dry periods creates a hypersaline environment which is not conducive to smooth cordgrass survival, expansion, or colonization.

XVI. Year 6 – West Little Lake #2

Prepared by Elaine Lear – CPRA Thibodaux Regional Office

A. Site and Planting Description

West Little Lake #2 (WLL#2), a year 6 planting site, is in Lafourche Parish on a peninsula of marsh that projects out from the west bank of Little Lake, with Bay L'Ours to the south (Figure XVI-1). The Bayou L'Ours subdelta has experienced a reduction in freshwater and sediment supply since the construction of a dam at the confluence of the Mississippi River at Bayou Lafourche in 1904 and the channelization of the river with artificial levees (Sasser and Evers 1995). The location of this planting is surrounded by a mixture of highly organic freshwater and intermediate marsh, slowly subsiding ridges, and the rapidly eroding mineral lake rim (Gagliano and Wicker 1989; Sasser and Evers 1995). This planting is an extension of the older LA-0039 Year 2 - West Little Lake (WLL) planting due to success of interior pond planting. The WLL#2 planting was installed and inspected in May 2017.

Project Features

The West Little Lake #2 site has two planting configurations.

Double row plantings of California bulrush (*Schoenoplectus californicu*s) were installed parallel to the shoreline at two sites. Trade-gallon size plants were installed on 5 ft alternating centers on paired rows 10 ft apart no deeper than -1.0 ft NAVD88. The double rows are located in open areas of broken marsh just along the northern shoreline of the peninsula and open to Little Lake but set back from the shoreline on a old marsh platform (Sites A and B).

Pond area plantings of California bulrush (*S. californicu*s) were planted in shallow ponds and surrounding broken marsh. Trade-gallon size plants were installed to the extent possible in each area pond on 7 ft alternating centers on parallel rows 7 ft apart no deeper than -1.5 ft NAVD88 (Sites 1-13 and Auxiliary Sites 1 and 2).

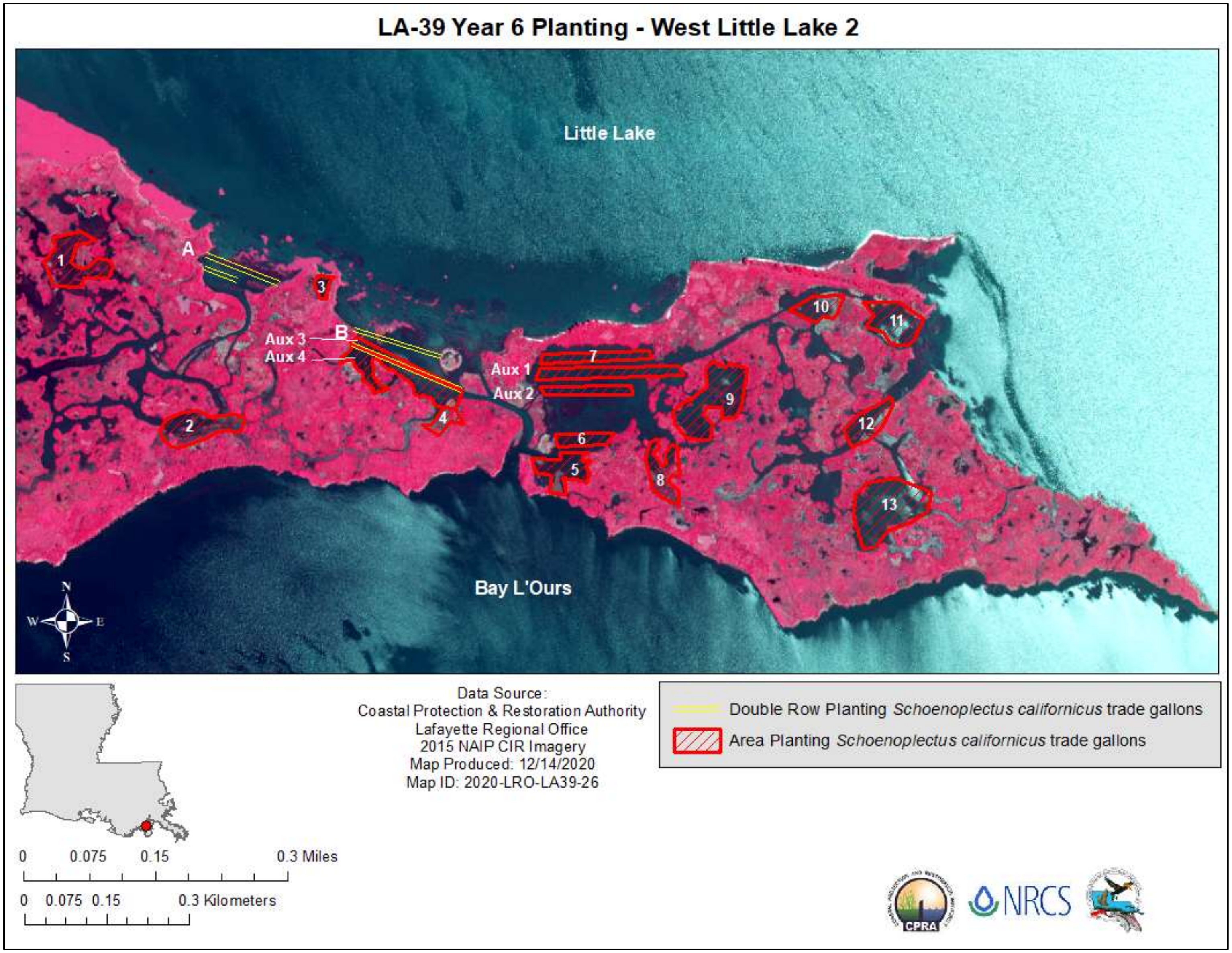

Figure XVI-1. LA-0039 Year 6 Site West Little Lake #2 site of Double Row (A and B) and Area (1-13 and four Auxillaries) plantings.

B. Monitoring Activity

1. Monitoring Goals and Objectives

The goals of the LA-0039 Year 6 - West Little Lake #2 (WLL #2) plantings are:

- Double row plantings of *S. californicus* will survive and expand into the surrounding broken marsh to protect the shoreline.

- Pond area plantings of *S. californicus* will survive and expand within the shallow ponds.

2. Monitoring Elements

<u>Vegetation Assessment</u>

In order to assess survival and expansion in all areas, qualitative observations were made for each area pond and each double row site. Photographs were taken to document the success and health of the planted features over time. Vegetation stations were not established due to budget, time, and access constraints in October 2017; however, to try to quantify planting success the field crew collected overall percent cover of the planted species in each pond area in October 2018. Cover was not documented for the double rows due to time constraints but photographs were taken. Percent survival could not be estimated due to the expansion of the original plants into dense stands by 2018. Monitoring trips have been canceled because of access issues to the site, logistical issues at the site, and apparent continued trajectories from to March 2019 aerial imagery on Google Earth.

<u>Hydrology</u>

Hydrologic data from CRMS6303-H01, located 3.9 miles southwest of the WLL #2 plantings, will be used to describe area water-level trends and salinity. The water-level data from CRMS6303-H01 will be compared to specified planting elevations to describe flood conditions. Salinity means will be used to determine whether they were within an acceptable range for the planted species. Photographic documentation will also be used to describe processes of planting success and failure.

3. Monitoring Results and Discussion

a. Vegetation Assessment

Pond Areas:

In September 2017, qualitative observations and photographs were made to determine planting health and success. In October 2018, ocular estimates of percent vegetation cover and mean plant height of the planted *S. californicus* were documented for each of the thirteen pond area polygons (Figure XVI-2). Overall mean percent cover of the plantings was 76% in 2018 while mean plant height was 9.8 ft. The highest mean cover and height occurred in Pond Area #7 in the largest pond in the center of the site, while the lowest occurred in Pond Area #1 in the western-most pond. For the most part, mean heights were lowest in pond areas with lower cover values, but not in every instance. Photographs from 2017 and 2018 indicating typical planting success and health are found in Figure XVI-3.

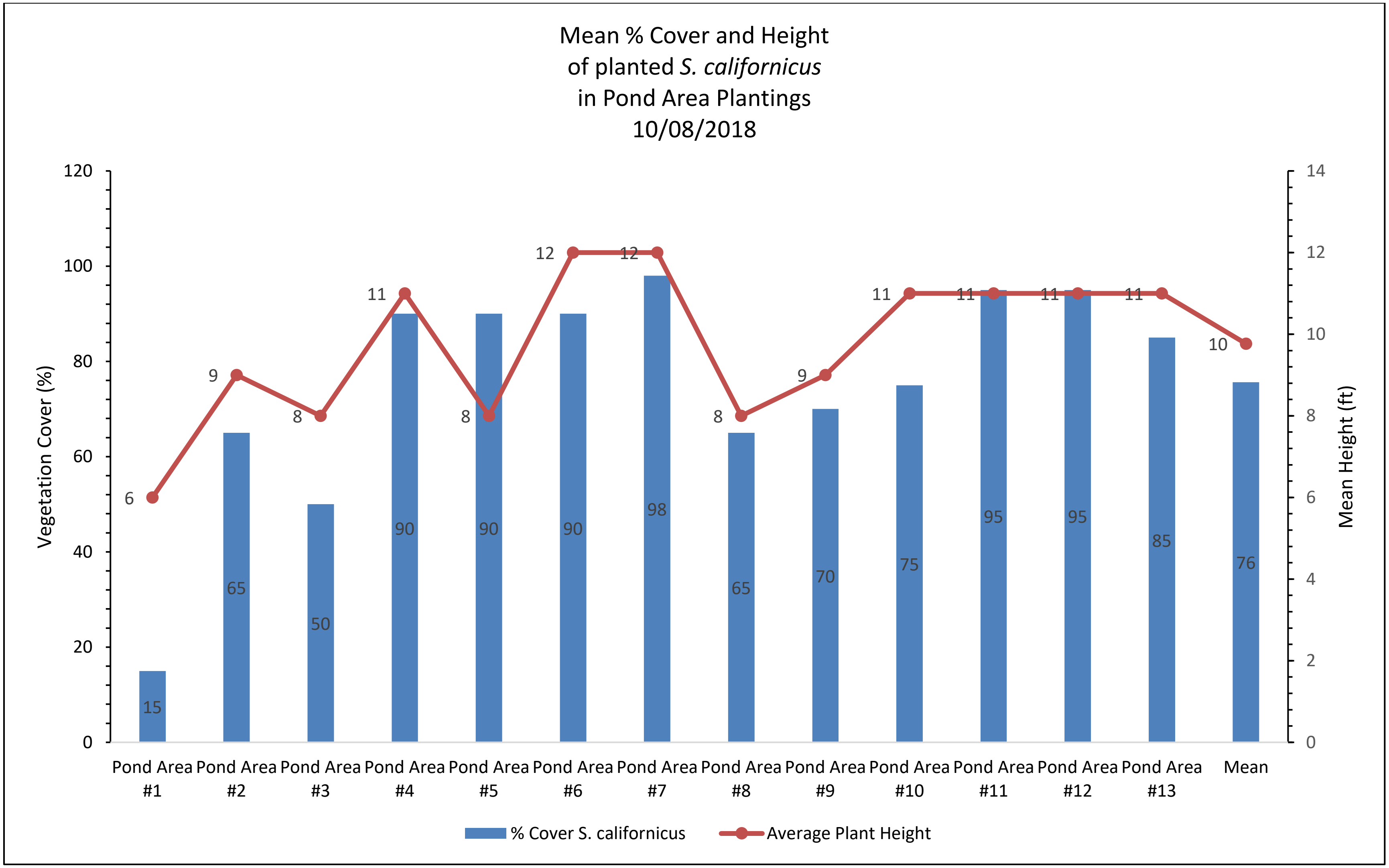

Figure XVI-2. Percent cover and mean height of *S. californicus* at each LA-0039 Year 6 West Little Lake #2 pond area planting one year post-planting (10/08/2018).

Figure XVI-3. LA-0039 Year 6 West Little Lake #2 photographs of a variety planting survival, health, and success within selected ponds throughout the planted area a growing season (Sep 2017) and a year and a half (Oct 2018) after planting in May 2017.

Pond Area 1:
The planted species did not expand well. This pond area had the lowest cover out of the thirteen ponds. It is the farthest to the west, inside of a broken, intermediate marsh surrounded by thick stands of *Typha* sp. (cattails), *Phragmites australis* (Roseau cane), *Sagittaria lancifolia* (bulltongue), and *Schoenoplectus americanus* (three-square bulrush). This area is continuously inundated. There is a heavy presence of submerged aquatic vegetation (SAV) and floating aquatic vegetation (FAV) throughout. Thick mats of *Ceratophyllum demersum* (coontail), *Nuphar lutea* (Yellow water lily), *Eichhornia crassipes* (water hyacinth), *Salvinia molesta* (giant Salvinia) were observed throughout this pond. The frequent flooding and heavy SAV/FAV presence may have contributed to the lack of expansion of the planted species. Though plants observed in 2017 were healthy and robust from the onset, by 2018 they were spindly and short in comparison which is a sign of physical and competitive stress. See Figure XVI-3.

Pond Area 2:
The plantings were already expanding laterally and in height in 2017, and by 2018 had merged with the surrounding, thickly-vegetated marshes. Cover of the planted species was estimated at 65%, and overall vegetation cover in this pond was around 95%. In 2017 surrounding marsh species included *T. latifolia*, *Zizaniopsis miliacea* (giant cutgrass), *S. lancifolia*, *Ludwigia sp*. (primrose), and a heavy presence of *Sphenoclea zeylanica* (chickenspike). There was a moderate presence of the FAV *E. crassipes*. By 2018 surrounding marsh species included *T. latifolia*, *Polygonum punctatum* (smartweed), *Ludwigia* sp., and expanding stands of *P. australis* with no presence of the *S. zeylanica* that was so ubiquitous throughout the area in 2017. *S. zeylanica* is an invasive indicator of higher elevation or low-water conditions.

Pond Area 3:
In 2017, the plants were healthy. The pond area was inundated and subject high wave energy from Little Lake (Figure XVI-1). There was a heavy FAV presence (*E. crasssipes*) but water levels were not high enough to raft over the plants at that time. Surrounding marsh species were *S. americanus*, *T. latifolia*, *Spartina alterniflora* (smooth cordgrass), and *P. aust*ralis. By 2018 the planted species expanded laterally and in height with an approximate cover of 50%. Plantings nearest to the shoreline were stressed. The species mix in the surrounding marsh was unchanged from the 2017.

Pond Area 4:
This area pond was surrounded by a large expanse of broken emergent marsh in 2017. Species mix was mainly *T. latifolia*, *S. latifolia*, and *S. americanus*. There was a heavy presence of FAV (*E. crassipes*) in the open water areas. It is important to note that heavy stands of *S. zeylanica* were found throughout this pond area in the higher elevations of the emergent marsh. Planted species were robust and healthy. In 2018 the species mix was the same. There were heavy mats of FAV including heavy presence of *Salvinia molesta* and *E. crassipes*. Stands of *Z. miliacea* were also expanding into the pond area. The plantings expanded tremendously in height and width to make dense stands.

Pond Area 5:
This pond area was very similar in species mix, cover, and FAV presence as Pond Area 4. As in 2017, the *S. zeylanica* was very dense in this area, but by 2018 it was not present due to the wetter

conditions. All emergent marsh vegetation was very thick in 2018, but planted species mixed in well with it. Planted species cover was not as heavy on the west side of this pond area as on the eastern end. There were open water areas throughout where the planted species was not as successful due to possible inundation associated with a small natural trenasse which winds through from the south and then east-west where it forks.

Pond Area 6:
The pond area in 2017 was surrounded by broken marsh heavily vegetated with *S. lancifolia* and *T. latifolia*. Open-water areas had a heavy presence of FAV (*E. crassipes*). By 2018 the planted species expanded into large stands. The LA-0039 Year 2 WLL plantings skirted the perimeter of the 2017 plantings and were visible as very dense hedge rows.

Pond Area 7:
The 2017 plantings were healthy and beginning to expand with few missing plants. The Year 2 WLL planting survivors formed dense hedge rows between these newer WLL#2 plantings. There was heavy presence of FAV (*E. crassipes*) in 2017. By 2018 the plantings were successful and robust. The cover was excellent and plants had highest average heights of all the pond areas. FAV was present but not as thick as in 2017, and mainly consisted of *Salvinia minima* (water spangles), *S. molesta*, and *Oxycaryum cubense* (Cuban sedge). Auxiliary pond areas 1 and 2 were very similar in species mix and cover success. See Figure XVI-3.

Pond Area 8:
Plantings in this area were surrounded by expanses of broken emergent marsh with a mix of *S. americanus* and *S. alterniflora*. Open water areas had FAV (*E. crassipes*). Planted species were healthy and beginning to expand. There were some dense stands of *S. zeylanica* with *Baccharis halimifolia* bush in the higher portions of emergent marsh periphery. By 2018 the plantings expanded successfully throughout the pond area, though there were some open areas remaining. Species mix of surrounding emergent marshes remained the same, but with none of the *S. zeylanica* stands due to wetter conditions.

Pond Area 9:
This pond area had very similar conditions and species mix as pond area 8 in 2017 and 2018. Plantings were successful and expanding. Overall cover was not as good as pond area 8, but still quite good (70%). Open water areas tend to have large presence of FAV (*E. crassipes, S. molesta*).

Pond Area 10:
This pond area experienced robust expansion of the plantings in 2017. There was both FAV (*E. crassipes*) and SAV (*Nuphar lutea*) present, but mainly on the perimeter of the pond area. Emergent marsh species mix was *S. alterniflora*, *S. americanus*, *S. lancifola*, and *T. latifolia*. The 2018 species mix of emergent marsh species remained the same. Estimated cover of the planted species indicated plantings success (75%). FAV was mainly *S. minima*. *T. latifolia* and *P. australis* stands were expanding into the northeast and southeast portions of the pond area.

Pond Area 11:
Plantings in 2017 were healthy and beginning to expand in size. The portions adjacent to the lake shoreline (Figure XVI-1) were experiencing some wave action and there were mats of *E. crassipes*.

The species mix of the surrounding broken marsh was mainly *S. lancifolia*, *S. americanus,* and some *S. alterniflora*. In 2018 the plantings successfully expanded (> 90% cover), and despite the heavy wind generated wave action, those plantings on the lake perimeter were still upright, even with heavy FAV presence.

Pond Area 12:
In 2017 and 2018 the conditions and species mix were very similar to pond area 11. Though the northeast end of the pond area did not have direct exposure to the lake, inundation was similar to pond area 11. By 2018, survival was very successful (over 90% cover) and thick, dense stands of the planted species were evident throughout the entirety of pond area 12. See Figure XVI-3.

Pond Area 13:
Individual plants were not as robust as in the other pond areas, but plantings were beginning to expand in 2017. There were some missing plants which did account for future gaps in the pond area in 2018 though cover was very successful by then (85%). The species mix of the surrounding emergent marsh was *T. latifolia*, *S. lancifolia*, and *S. americanus*, with *B. halimifolia* on higher elevations. FAV mats were present in both years as well as SAV in the open water gaps.

Planting survival and coverage in Pond Area plantings from October 2018 persisted and potentially expanded into March 2019 (Figures VXI-4).

Figure XVI-4. Aerial imagery at LA-0039 Year 6 West Little Lake #2 from Google Earth Pro© from March 20, 2019 showing expansion in western (A) and eastern (B) Pond Area plantings.

Double Rows

Only qualitative field observations and photographs were recorded for the double row plantings A and B (Figure XVI-1 and 5). The most current Google Earth Pro© imagery from March 20, 2019 is also used in this report to indicate the extent and location of the surviving plants. In 2018 photographs were not taken due to the time constraints and high winds making it impossible to approach the area safely in the airboat. Water depths were not documented in either year for the same reasons.

In 2017 the plants in both areas were healthy, expanding slightly in size, and still upright despite the wave action from the lake. There were large mats of *E. crassipes* stacked up on the periphery of the plantings from the lake side, but no rafting occurred to the extent that it would bend the plants over and cover them. Wave energy was dampened somewhat by the shallow former marsh platform extending between plantings and open lake. Dense presence of SAV included *N. lutea* and *C. demersum*. In 2018 the plants in both areas expanded substantially both laterally and in height. There were gaps in the planting rows, but survival was good. Wind driven waves and continuous inundation of the planting rows did not appear to have a negative impact on their expansion. FAV and SAV remained dense. The installation of the plants in the shallows adjacent to the shoreline has helped to protect them to some extent by dampening the wave energy. The Google Earth Pro© imagery from March 2019 indicates that there are some gaps in the rows, but survival was good (Figure XVI-5).

Figure XVI-5. Typical double row planting at LA-0039 Year 6 West Little Lake #2 photographed in September 2017 (upper). Google Earth Pro© imagery from March 2019 indicating location and expansion of double rows along the Little Lake shoreline (lower).

b. Hydrology

All of the plantings inside of the pond areas at WLL#2 were flooded during most monitoring period. During the winter months when water levels and tides were at their lowest some of the plantings were on exposed mudflats for short periods of time. The deepest plantings in 2018 were located in pond areas 7, 8, 9, 12, and 13 on the central/eastern side of the spit and were continuously flooded. The remaining pond areas in the central/western side had the shallowest plantings in 2018. It is important to note that all of the plantings fell within the acceptable range of *S. californicus* survival for planting depth between 1 to 2 feet (Materne and Fine 2000) and relative inundation was not an indicator of any failures.

Mean water elevation to datum during the monitoring period (May 2017 – March 2019) along the southern shore of Little Lake 3.1 miles south of WLL #2 at CRMS6303-H01 was 0.49 ft NAVD88, with a minimum of -1.37 ft NAVD88 and a maximum of 2.51 ft NAVD88. Mean salinity was 2.66 ppt, with a minimum of 0.34 ppt and a maximum of 11.14 ppt. *Schoenoplectus californicus* is best suited for salinity < 5.0 ppt and can tolerate short periods of higher salinity. During the planting observation period, salinity was typically < 5.0 ppt (75^{th} quartile = 3.61 ppt), and higher salinities were the result of short-term events (Figure XVI-6). Neither inundation nor salinity was an indicator of sustained planting stress or failure.

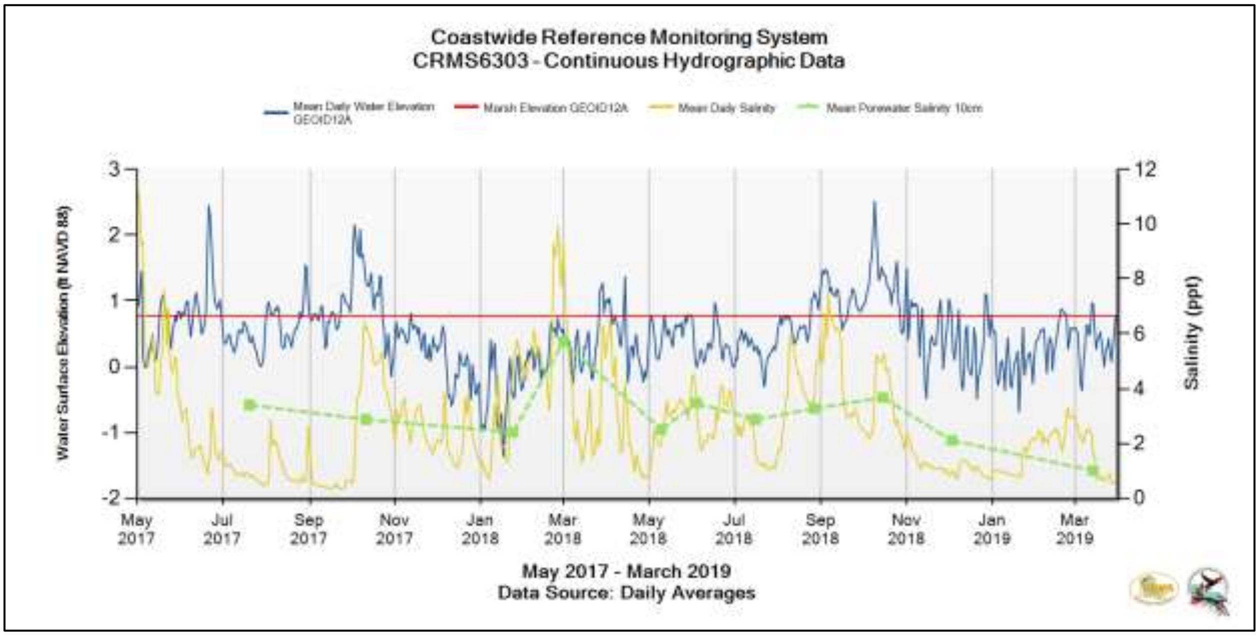

Figure XVI-6. Water surface elevation and salinity from May 2017 – March 2019 collected at CRMS6303 demonstrates regional hydrologic conditions. Graphic from Coastwide Reference Monitoring System (CRMS)-Wetlands retrieved from Coastal Information Management System (CIMS) database. http:/cims.coastal.louisiana.gov ; accessed 28 January 2021.

C. Conclusions

The LA-0039 Year 6 WLL#2 planting has been a success thus far. Despite continuous inundation, the plantings were at the proper depth and spacing and the salinity range was ideal for *S. californicus*. The location of the shallow ponds inside of broken marsh afforded enough protection from the effects of wind and waves so that the plants could become robust enough to survive. Previous planting efforts from LA-0039 Year 2 WLL resulted in initially surviving plants forming solid hedge rows which in turn provided protection to the WLL#2 plantings in the more open water areas (ex. large central pond with pond areas 5-7) where they formed healthy stands. Additionally, placement of double row plantings some distance inside of the cove-like shoreline segments in the shallows allowed plants to expand and survive despite the high-energy waves from Little Lake.

1. Project Effectiveness

As per the project goals:

- The goal for the planted species *S. californicus* to survive and expand into surrounding on the old marsh platform utilizing double row plantings along the shoreline of Little Lake has been successful.
- The goal for the planted species *S. californicus* in small shallow ponds to survive and expand in small shallow ponds has been successful.

2. Recommended Improvements

For future double row planting efforts in cove-like shallow shoreline segments, the adjustment of plant spacing to five foot centers is suggested. This may contribute to fewer gaps in the double rows. Also, installing the plant rows some distance inside the cove appears to afford more protection from the lake effects.

Based on the successes of small pond plantings in LA-0039 Year 2 WWL, WWL #2 planners increased plant spacing from 5 ft between plants and 5 ft between rows to 7 ft for both, which reduce plant density and costs. Similarly, with the success of WWL #2, planners could further consider increasing plant spacing to reduce costs in similar settings (i.e. protected plantings with favorable depth and salinities).

3. Lessons Learned

Site selection for this planting effort contributed to its success. The Little Lake shoreline double row plantings were installed far enough into the cove-like areas where the water bottom shallowed out in front of the eroding shoreline. This placement allowed for some dampening of high-energy waves before they inundated the planted rows. Though there were gaps in the rows where some plants did not survive, survivors were robust enough to withstand rafting of FAV. Contributing to the pond area plantings success were the ideal planting depths and salinity range for species survival, as well as the protection from wind and waves the surrounding interior marshes provided to the plants.

XVII. <u>Year 6 – Gentilly Unit</u>

Prepared by Danielle Richardi, CPRA New Orleans Regional Office
Margaret Luent and Tommy McGinnis, CPRA Lafayette Regional Office

A. Site and Planting Description

The Year 6 Gentilly Unit planting site is located in eastern Orleans Parish, Louisiana, in the Pontchartrain Basin. This shallow, open-water planting area is located within the Gentilly Unit (Unit 6) of the Bayou Sauvage National Wildlife Refuge (NWR), which is managed by the U.S. Fish and Wildlife Service (USFWS) (Figure XVII-1). This hydrologic management unit is within the project boundary of the Bayou Sauvage NWR Hydrologic Restoration, Phase 1 project (PO-0016), which was constructed in 1996 and is funded through the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA), with the USFWS as the federal sponsor. The PO-0016 project installed two pump stations and a weir to manage water levels in the hydrologically-impounded project area to promote the reestablishment of emergent marsh vegetation and maintain black willow habitat for the benefit of wading bird rookeries.

A total of ~27,208 *Schoenoplectus californicus* Louisiana ecotype (California bulrush) trade gallons (TG) were planted in the Gentilly Unit between 05/05/2017 and 05/22/2017 in both double-row and area planting designs (Figure XVII-1). The site is divided into an eastern and western planting area delineated by the contours of the remnant Bayou Gentilly.

West Planting Area

<u>West Double-Row Plantings:</u> *Schoenoplectus californicus* (~14,018 TGs) was planted in double rows from 1,079 to 10,899 linear feet and totaling 34,131 linear feet (Figure XVII-1). The two rows within each double row were planted 15 feet apart, with plants along each row planted on five-foot alternating centers. An additional 1,586 linear-foot single row was planted in the west planting area to make use of surplus plants. The west planting area is located in the far southern section of the Gentilly Unit, and the rows generally run parallel to the southern shoreline adjacent to the Lake Pontchartrain Hurricane Protection Levee along the Gulf Intracoastal Waterway.

East Planting Area

<u>East Double-Row Plantings:</u> *Schoenoplectus californicus* (~8,790 TGs) was planted in double rows ranging in length from 596 to 8,003 linear feet and totaling 21,439 linear feet (Figure XVII-1). The two rows within each double row were planted 15 feet apart, with plants along each row planted on five-foot alternating centers. An additional 947 linear-foot single row was planted in the east planting area to make use of surplus plants. The east planting area is located in the far eastern side of the Gentilly Unit, and the rows run both parallel and perpendicular to the eastern shoreline adjacent to the Lake Pontchartrain Hurricane Protection Levee.

<u>East Area Plantings:</u> *Schoenoplectus californicus* was planted in parallel rows seven feet apart on seven-foot alternating centers. The four area plantings range from 0.7 to 1.6 acres and are interspersed among the east double-row plantings (Figure XVII-1). A total of ~4,400 TG plants were installed in the area plantings: ~1,430 in Area 1, ~630 in Area 2, ~1,340 in Area 3, and ~1,000 in Area 4.

Figure XVII-1. LA-0039 Year 6 Gentilly Unit site map showing east and west plantings and vegetation monitoring stations.

B. Monitoring Activity

1. Monitoring Goals

The Year 6 Gentilly Unit planting was designed with the expectation that the successful establishment and expansion of *S. californicus* will reduce wind fetch and revegetate an open water habitat that was previously dominated by emergent marsh.

While the overall goals of the plantings are shared between the two planting designs, the specified intent of each design is as follows:

- Double-row planting transects will grow together and expand to reduce wind fetch.
- Area plantings will expand to revegetate the marsh platform.

2. Monitoring Elements

Monitoring is required to assess the planting success over time and determine if additional planting is recommended. Quantitative assessment of plant survival, vegetative cover and height, along with a more qualitative ocular assessment of the plantings as a whole, is conducted to assess the general condition of the plantings and effects on the planting site. Water depth and surface and porewater salinity are also measured during surveys.

Monitoring of LA-0039 plantings typically follows a 0.5, 1, 3, and 5-year schedule, with plantings assumed to have 100% survival immediately following planting (As-built, Year 0). The timing of monitoring can be adjusted to allow for sampling at the end of the growing season, as it was for this planting. The Gentilly Unit was planted in May 2017, initially monitored on October 23, 2017, and again monitored on October 26, 2018. The next monitoring event is scheduled for late summer/early fall 2021, with a final, more qualitative assessment of survivorship scheduled for 2023.

<u>Vegetation Assessment</u>

Eighteen sampling stations were established to monitor vegetative growth and planting survival. Total percent vegetative cover, species composition, percent cover of each species, dominant species height, and additional vegetation parameters are assessed at permanent 2 m x 2 m monitoring stations (Folse et al. 2020). Each station is also photographed during sampling events. Assessment of planting survival is based on a monitoring transect that starts at each 2 m x 2 m station and continues along the aligning planted transect for a length of 10 plants. General assessments of planting areas, including additional species present, marsh interspersion, and site-specific points of interest are also noted, as applicable.

<u>Vegetation Station Establishment</u>

1. West Double-Row Planting: Eight stations were established to monitor the west double-row plantings in locations that represent varying distances from the shoreline and water depth (Figure XVII-1). The distance between each row of the double rows is measured during sampling to document the anticipated decrease in distance between rows.

2. East Double-Row Planting: Six stations were established to monitor the east double-row plantings in locations that represent varying distances from the shoreline and water depth (Figure XVII-1). The distance between each row of the double rows is measured during sampling to document the anticipated decrease in distance between rows.

3. East Area Plantings: Four stations were established, one station in each of the four area plantings (Figure XVII-1).

Hydrologic Assessment

Typically, hydrologic data from nearby Coastwide Reference Monitoring System (CRMS) stations are used to approximate flooding parameters and salinity within the planted area to see if they fall within acceptable ranges to promote plant survival and growth. However, the Gentilly Unit planting is located in an impounded, hydrologically-managed area without a CRMS station. Both CRMS3650 and CRMS4107 are located within one mile of the Gentilly Unit planting area. CRMS3650 is located in hydrologically-disconnected marsh just east of the planting area and is not representative of hydrologic conditions for the Gentilly Unit planting. CRMS4107 is located in an adjacent USFWS hydrologically-managed unit of Bayou Sauvage NWR (Joe Madere Marsh, Unit 5) and while not perfectly representative of conditions in the Gentilly Unit, it should provide a closer estimate of salinity and water level in the planting area. Data from both of these CRMS stations will be presented for reference. Discrete surface and porewater salinity (measured at ~20 cm below the soil surface) and water depth data collected in the Gentilly Unit during the vegetation surveys will also be presented.

3. Monitoring Results and Discussion

a. Vegetative Assessment

Survivorship

Planting survival of *S. californicus* was 100% along each of the eighteen 10-plant survivorship transects monitored during the October 2017 survey. By the October 2018 survey, the species had vegetated prolifically along and between the planted rows and individual plants were indistinguishable. Demonstrating this expansion, the mean distance between each row of the double-row plantings decreased from 10.7 ft ± 0.6 SE in 2017, to nearly 0 ft in 2018, with only one transect still having a consistent measurable distance between rows. Survival in 2018 was assumed to be 100% or nearly 100% for the monitoring transects, but since individual plants could not be discerned, this assessment is no longer feasible for this project (Figure XVII-2). Survivorship of the overall Gentilly Unit planting in 2018 was estimated to be > 90%, with widespread vigorous growth occasionally punctuated by small gaps along the rows (Figure XVII-2).

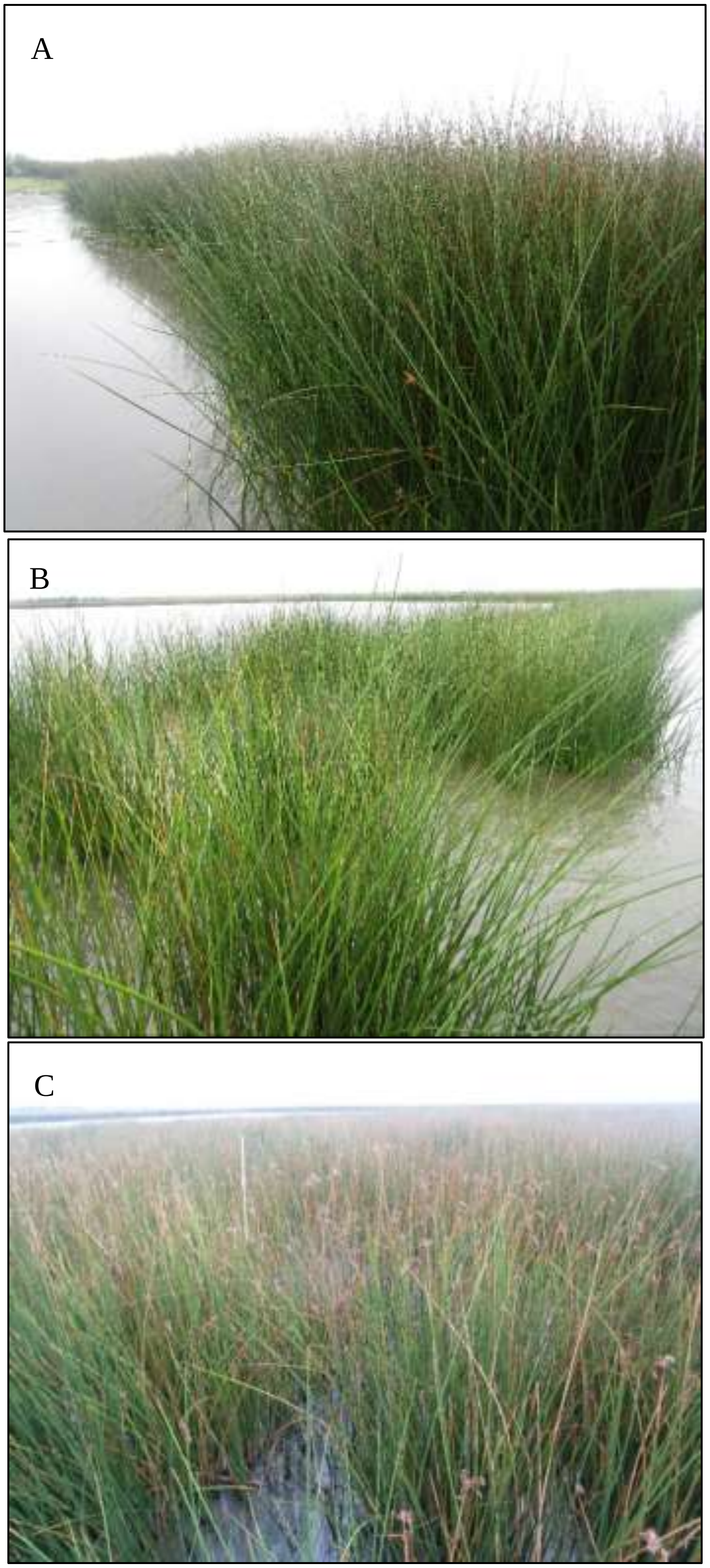

Figure XVII-2. Representative photographs of *S. californicus* taken during the 2018 survey. (A) double-row (DR) continuous growth, (B) DR interrupted growth, (C) area planting with merging rows.

Vegetative Cover

Total mean percent vegetative cover at the 18 monitoring stations more than tripled between the 2017 and 2018 surveys, increasing from 18% to 56% cover (Figures XVII-3, 4). Individual percent cover at stations ranged from 5% to 55% in 2017, and from 25% to 90% in 2018. Due to the lack of significant vegetative cover from other species, all covers reported represent both total percent cover at the stations, as well as percent cover of *S. californicus*. Other species that were reported either in or just outside of the monitoring station quadrats included *Amaranthus australis, Bacopa* sp.*, Cyperus odoratus, Cyperus* sp.*, Echinochloa* sp.*, Erechtites hieraciifolius, Mikania scandens, Leptochloa fusca, Morus rubra* (seedling)*, Pluchea odorata*, and *Triadica sebifera* (seedling, pulled).

Differences in percent cover between planting areas were examined to see if any relationship between planting locations and conditions could be discerned. Mean total percent vegetative cover was not significantly different between the east and west double-row planting areas and area plantings in 2017 or in 2018 (Figure XVII-4). However, a possible negative relationship between vegetative cover and water depth existed in 2017, with cover increasing as water depth declined (Figure XVII-5) ($p < 0.0001$, $r^2 = 0.7211$, $F_{(1,17)} = 41.36$). A further investigation of the station locations with the highest vegetative cover and lowest water depth showed that they were located along the planted surveyed transects that are closest to the eastern and southern shoreline of the Gentilly Unit (Figures XVII-1, 5). This relationship was not noted for the 2018 survey, likely due to low water levels that the USFWS had maintained in the Unit for an extended period of time, with water level being recorded below the level of the marsh at 45% of stations during the survey (Figure XVII-5) ($p < 0.9714$, $r^2 = 8.2614E\text{-}05$, $F_{(1,17)} = 0.0013$).

Plant Height

Mean height of *S. californicus* at the 18 monitoring stations increased from 6.0 ft in 2017 to 7.7 ft in 2018 (Figure XVII-6). At the individual stations, mean height of the species ranged from 4.9 ft to 6.7 ft in 2017, and from 5.7 ft to 9.6 ft in 2018. Mean height was not significantly different between the east and west double-row planting areas and area plantings in 2017 or in 2018 and there was no apparent relationship between water depth and height in 2017 or 2018 (Figure XVII-7).

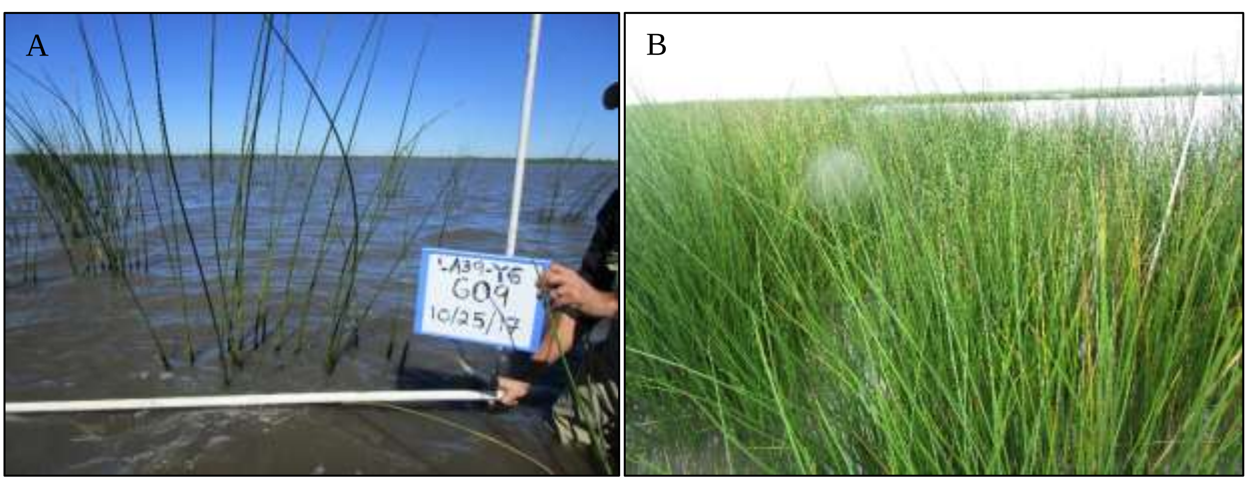

Figure XVII-3. Example of increasing vegetative growth between the 2017 (A) and 2018 (B) surveys, as seen at double-row planting station G09. This station was located in the deepest water of all the monitoring stations.

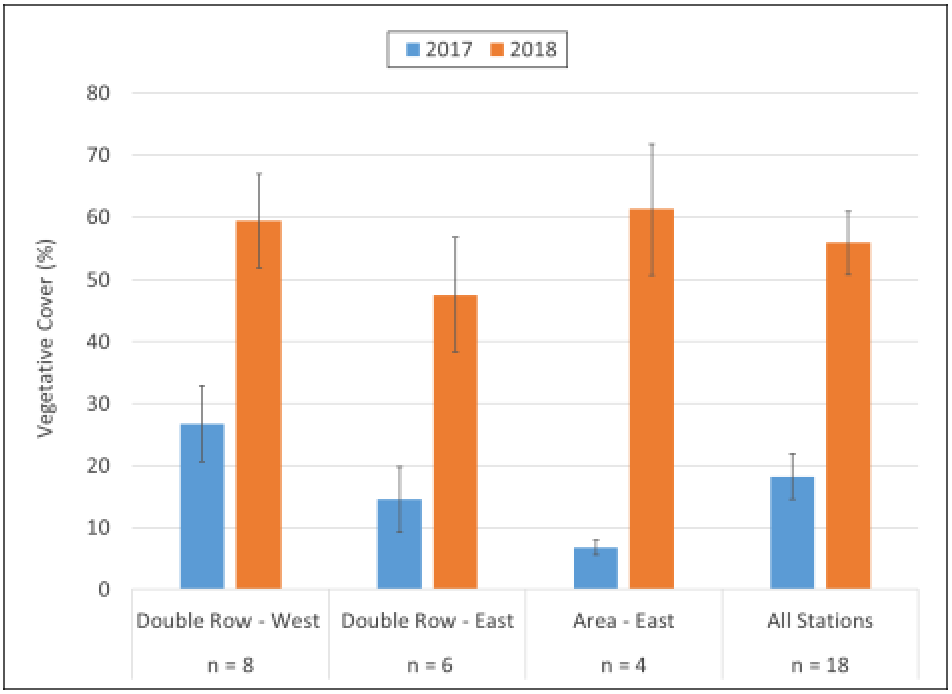

Figure XVII-4. Mean total vegetative cover (%) ± SE of *S. californicus*, as measured during the 2017 and 2018 vegetation surveys. Double Row and Area refer to the planting design.

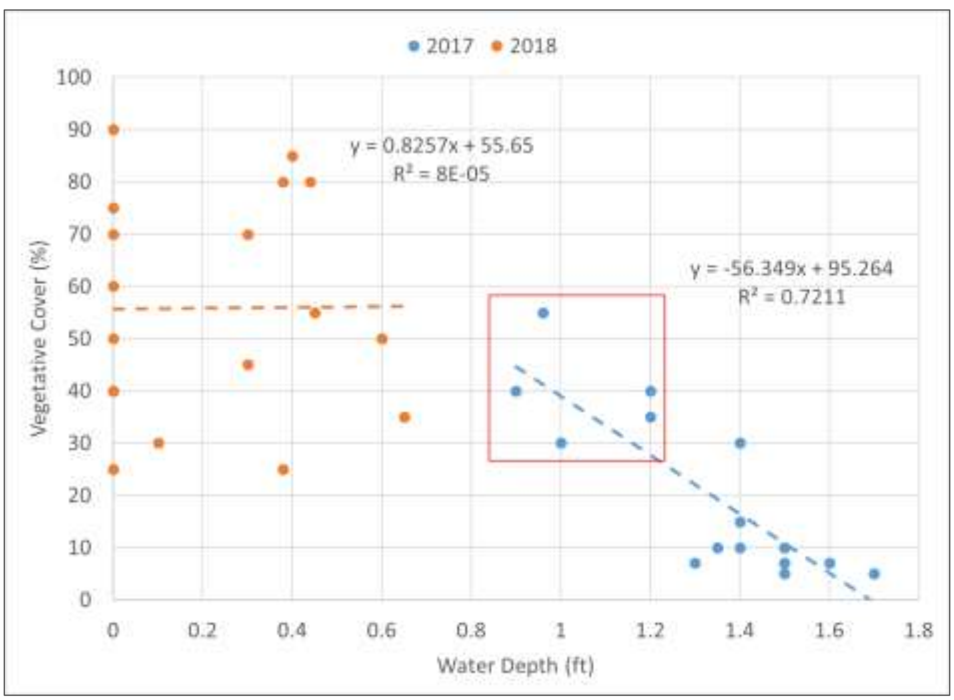

Figure XVII-5. Regression analysis of water depth and total % vegetative cover at each monitoring station as measured during the 2017 and 2018 vegetation surveys. The stations enclosed by the red square indicate stations that are located along the surveyed transects closest to the eastern and southern border of Unit 6.

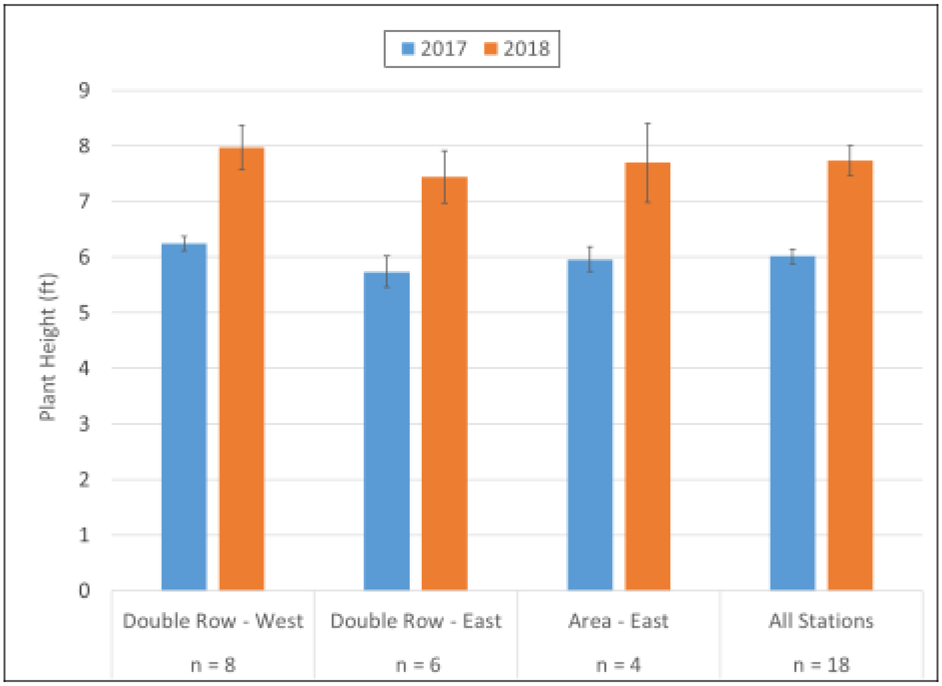

Figure XVII-6. Mean height of *S. californicus* ± SE, as measured during the 2017 and 2018 vegetation surveys. Double Row and Area refer to the planting design.

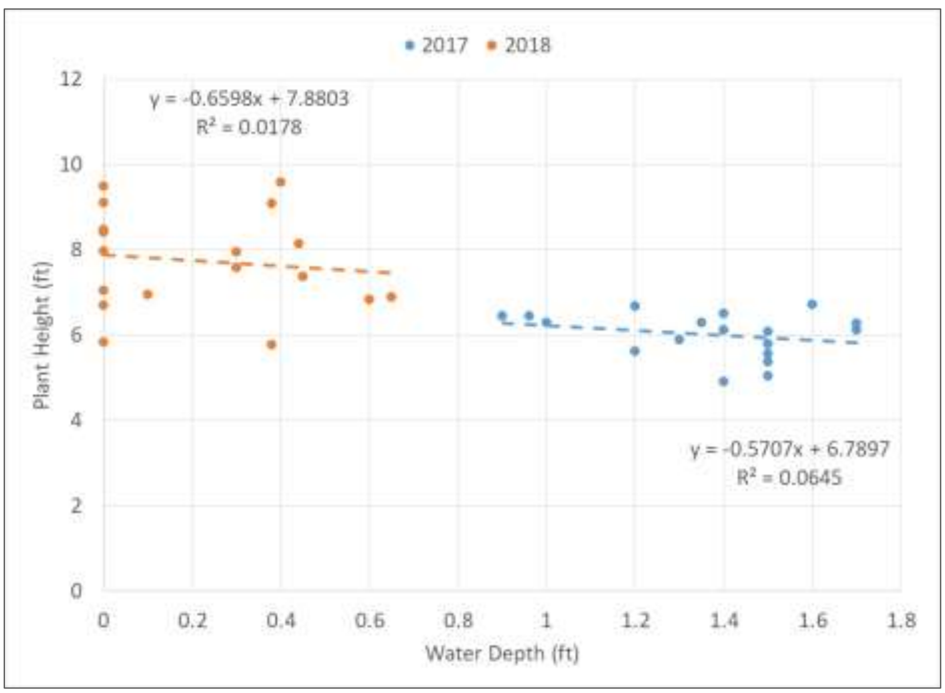

Figure XVII-7. Regression analysis of water depth and plant height at each monitoring station as measured during the 2017 and 2018 vegetation surveys.

b. Hydrologic Assessment

Discrete measurements of surface and porewater salinity and water depth were recorded at monitoring stations during the 2017 and 2018 vegetation surveys. Mean surface water salinity was 0.8 ppt ± 0.0 SE (n = 18) in 2017 and 1.8 ppt ± 0.1 SE (n = 12) in 2018, with the highest reading of 2.2 ppt in 2018. Mean porewater salinity was 3.0 ppt ± 0.2 SE (n = 17) in 2017 and 3.4 ppt ± 0.4 SE (n = 4) in 2018 (Figure XVII-7). The highest porewater salinity was 4.6 ppt in 2017. The ideal salinity range for *S. californicus* is 0–6 ppt (Materne and Fine 2000), and the limited salinity data collected for this planting site are well within this range.

Figure XVII-8 shows the mean surface water and porewater salinity readings taken in the Gentilly Unit, plotted along with continuous mean daily surface water and discrete porewater salinity readings for CRMS4017 (managed, impounded) in Joe Madere Unit 5 and CRMS3650 (unimpounded). The mean discrete surface water salinity for the Gentilly Unit is similar to the mean daily surface water salinity reading for CRMS4107 during both surveys (2017: Gentilly Unit = 0.8 ppt, CRMS4107 = 0.7 ppt; 2018: Gentilly Unit = 1.8 ppt, CRMS4107 = 2.0 ppt). Mean daily surface water salinity for CRMS4017 between 01/01/2017 and 12/31/2018 was 1.4 ppt ± 0.03 SE, and mean porewater salinity during the same time was 2.0 ppt ± 0.3 SE. Since both hydrologic units are impounded and water from the Gentilly Unit is pumped into Joe Madere Marsh Unit 5 when water levels need to be lowered, it is reasonable that surface water salinity for CRMS4107 can serve as a general proxy for surface water salinity in the Gentilly Unit planting area. Salinity at CRMS3650 is considerably higher than at CRMS4017 or in the Gentilly Unit and demonstrates a greater estuarine tidal salinity influence, whereas the impounded areas remain fresher and are more influenced by rainfall.

Mean water depth at monitoring stations during the 2017 vegetation survey was 1.4 ft ± 0.06 SE (n = 18) and in 2018 was 0.22 ft ± 0.06 SE (n = 18). Optimum water depth for *S. californicus* is between 0.1 to 2.0 feet (Materne and Fine 2000); therefore, the transects were established and plants installed in higher elevation areas where water depth was expected to remain ≤ 2.0 ft (i.e., near the shoreline and away from the center of the Gentilly Unit). In 2017, water depth at all stations was measured within the acceptable range; however, in 2018, water depth was recorded below the surface of the marsh at eight stations due to a scheduled draw-down. While lower water levels have fostered increased marsh expansion in the planting area, the effects on *S. californicus* of longer-term drainage and possible drying and oxidation of the marsh surface at higher elevations should be monitored.

Figure XVII-9 shows the mean daily water elevation for CRMS4017 (managed, impounded) in Joe Madere Unit 5 and CRMS3650 (unimpounded). Unit 5 was maintained at a lower elevation than the surrounding hydrologically-connected marsh and is not subjected to the tidally-induced variability in water level as at CRMS3650. The mean marsh elevation at CRMS4107 is also plotted, demonstrating that water level was below the marsh for most of the time in 2017 and 2018. Again, while continuous water elevation is not monitored in the Gentilly Unit, it can be expected to be considerably closer to the water elevation for CRMS4107 than for CRMS3650.

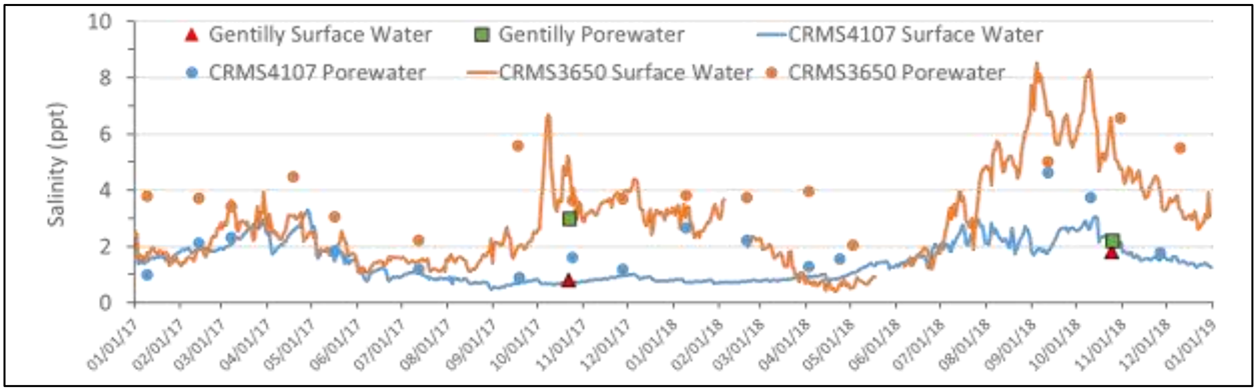

Figure XVII-8. Continuous mean daily surface water and discrete porewater salinity for CRMS3650 and CRMS4107 between 01/01/2017 and 12/31/2018. Mean surface water and porewater salinity collected on 10/23/2017 and 10/26/2018 in the Gentilly Unit plantings are plotted for comparison.

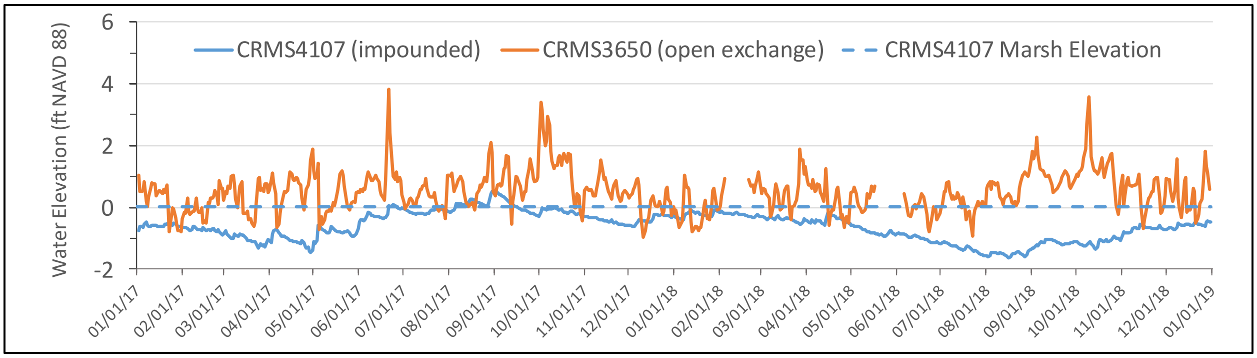

Figure XVII-9. Continuous mean daily water elevation (Geoid 12A) for CRMS3650 and CRMS4107 between 01/01/2017 and 12/31/2018. The dashed line represents the mean marsh elevation at CRMS4107.

c. Planting Failure/Success Causation

The planting of *S. californicus* in the Gentilly Unit has proven successful since installation in May 2017, with double-row and area plantings flourishing in both percent cover and height. Vegetative growth was initially most pronounced along transects closest to the project perimeter, likely due to higher elevation and subsequent reduced depth, duration and frequency of flooding; however, by 2018, these differences were no longer apparent. Google Earth aerial imagery taken three months after the 2017 survey and again approximately two years later shows considerable expansion of the plantings and supports the field observations made during the 2017 and 2018 surveys (Figures XVII-10, 11).

Hydrologic management of water levels in the Gentilly Unit since the planting has likely influenced planting success and natural marsh revegetation in the area. The water level in the Gentilly Unit was partially drawn down in September 2017 to replace a water control structure and culvert and was again lowered in March 2019 in anticipation of needed repairs to the Maxent South Levee. The USFWS has maintained the Gentilly Unit at a drawn-down level since March 2019, while awaiting completion of repairs to this levee. Water from the Gentilly Unit is lowered by pumping it into the neighboring Joe Madere Unit 5 to the immediate north. The lower water level has likely facilitated vegetative growth, with natural emergent marsh replacing shallow open water habitat near the project perimeter and merging with the neighboring planted rows (Figure XVII-12). Of particular interest during the 2018 survey was the establishment of *Salix nigra* (black willow) seedlings and saplings in the western planting area in this newly-vegetated marsh. While establishment of *S. nigra* was not a goal of the Gentilly planting, maintaining black willow habitat for the benefit of wading bird rookeries is a goal of the PO-0016 project.

Figure XVII-10. Google Earth imagery of the LA-0039 Year 6 Gentilly Unit – West. In the 2018 imagery, the transects closer to the shoreline appear more robust. In the 2020 imagery, all transects appear densely vegetated, and natural marsh has expanded inwards from the perimeter of the Gentilly Unit, merging with the more southern planted transects.

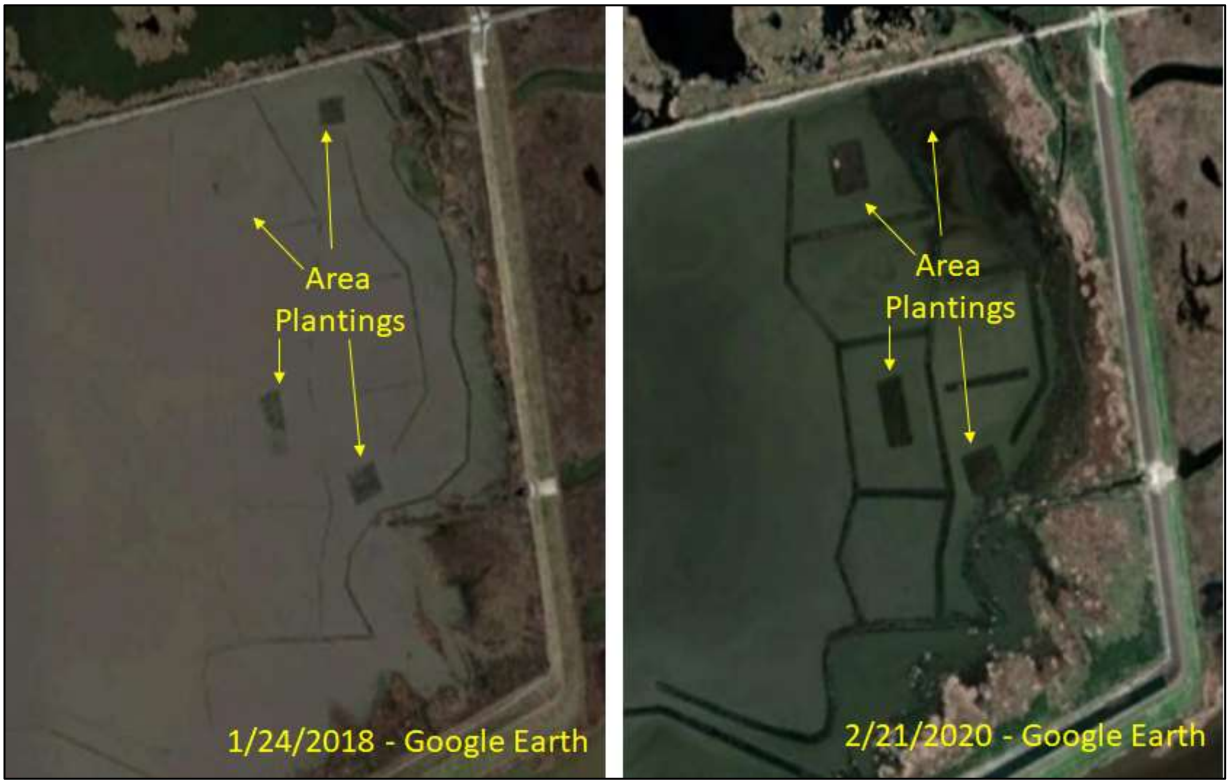

Figure XVII-11. Google Earth imagery of the LA-0039 Year 6 Gentilly Unit – East. In the 2018 imagery, the double-row transects and area plantings closer to the shoreline appear more robust. In the 2020 imagery, all double-row transects and planting areas appear densely vegetated and natural marsh has expanded inwards from the perimeter of the Gentilly Unit.

Figure XVII-12. Natural marsh habitat expansion between planted *S. californicus* transects, as photographed during the October 26, 2018 vegetation survey.

C. Conclusions

1. Project Effectiveness

Vegetation monitoring of the LA-0039 Year 6 – Gentilly Unit conducted in 2017 and 2018 indicates that the planting of *Schoenoplectus californicus* has been a success. Individual plants can no longer be discerned, as expansion of the plants has resulted in largely continuous double rows and area plantings. Visual analysis of Google Earth imagery from 2018 and 2020 further supports this conclusion. Assessment of the specific project goals are as follows:

- The double-row planting transects have grown together and expanded. While wind fetch has not been measured, the vigorous growth of the plantings should serve to reduce wind fetch in the Gentilly Unit.
- Area plantings have expanded and are successfully revegetating the marsh platform.

In addition, areas that were shallow open water in 2017 had transitioned to natural marsh along the perimeter of the Gentilly Unit by the 2018 survey. This marsh expansion was aided by partial drawdowns of water levels in the Gentilly Unit that have facilitated revegetation of the marsh platform at higher elevation along the Gentilly Unit shoreline.

2. Recommended Improvements

Plantings of other species that have been noted to naturally occur in or near the Gentilly Unit could have been conducted at higher elevations around the perimeter of the planting area to increase species diversity.

3. Lessons Learned

Plantings in protected hydrologic units with the potential for partial drawdowns can promote the success of vegetative plantings; however, water levels and the health of the marsh should be monitored to prevent excessive drying. While the expansion of *S. californicus* may be slower in deeper water, survival can still be high if depth remains below 2.0 feet and other conditions are amenable to growth.

XVIII. Year 6 – Sabine Unit 1 Overflow

Prepared by Margaret Luent and Tommy McGinnis – CPRA Lafayette Regional Office

A. Site and Planting Description

Sabine Unit 1 (SU1) Overflow, a LA-0039 Year 6 planting site, is in Cameron Parish within Sabine National Wildlife Refuge Unit 1A located just north of West Cove and west Highway 27 near Hog Island Gully Canal within the Calcasieu-Sabine Basin. The surrounding marsh is classified as brackish vegetation. The SU1 area is a designated disposal area for the Corps of Engineer's Beneficial Use of Dredge Material (BUDMAT) Program.

The SU1 Overflow area resulted from two marsh creation units (390 acres total; 220 in the northern unit and 170 acres in the southern unit) located in the northeast corner of SU1. The western containment dikes were built lower than typical containment dikes to allow for overflow into the adjacent open water to the west of the marsh creation areas and not overtop the SU1 boundary levees to the north and east. Filling of the marsh creation areas and resultant overflow area was completed on May 30, 2015. The LA-0039 plantings were installed on these overflow areas (Figure XVIII-1).

The SU1 Overflow plantings are comprised of two planting strategies, an area planting and a single row planting. *Spartina alterniflora* Vermilion (smooth cordgrass) plugs were planted in both the the single row (1,450) and area (28,810) plantings for a total of 30,260 plants. Installation was completed in late September 2017.

Single Row Plantings of smooth cordgrass were installed parallel to the containment dike of the northern marsh creation unit on 3 ft centers no lower than +0.6 ft NAVD88.

Area Plantings consist of parallel rows of smooth cordgrass west of the southern marsh creation unit planted 7 ft apart and on 7 ft alternating centers no lower than +0.6 ft NAVD88.

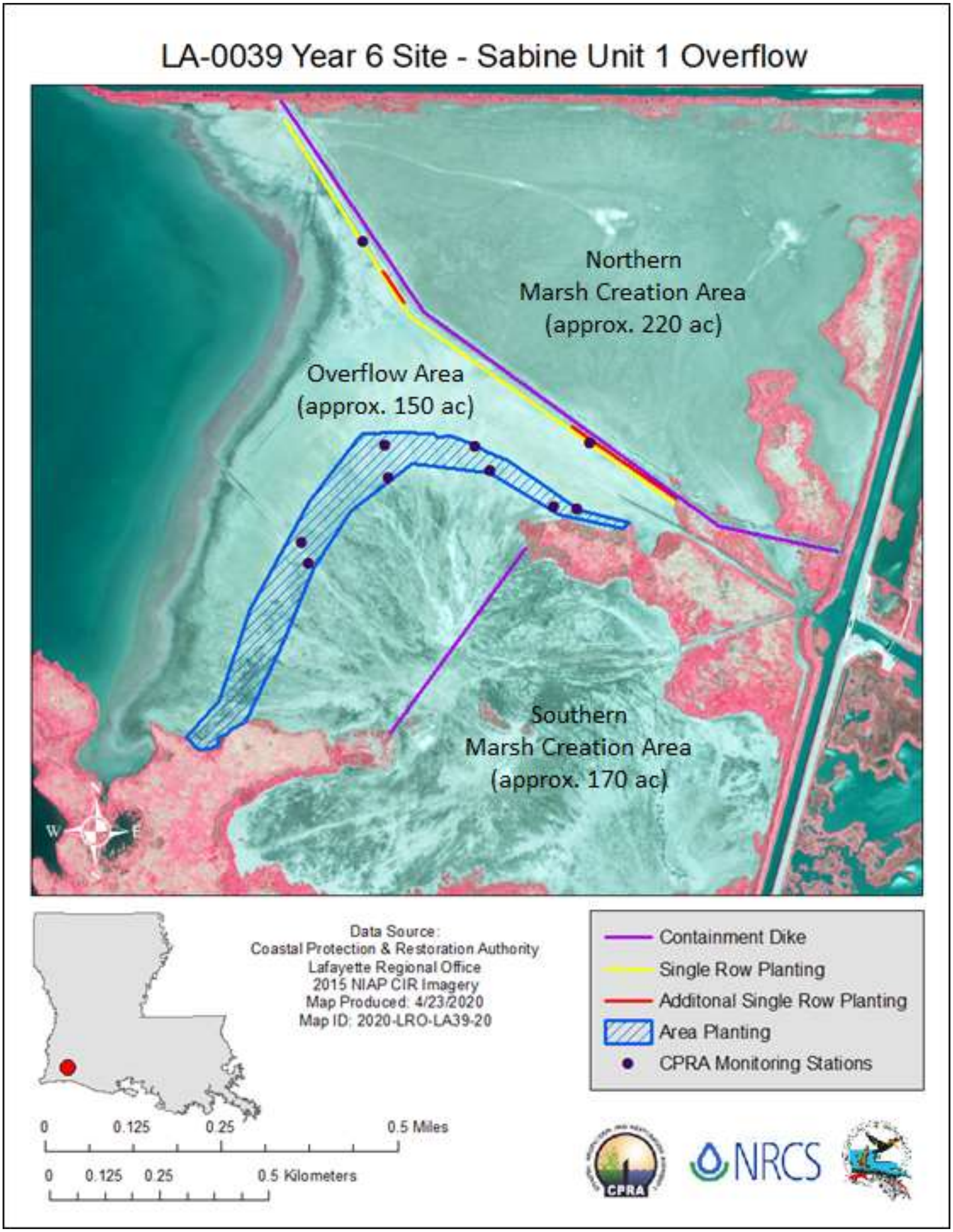

Figure XVIII-1. LA-0039 Year 6 Site – Sabine Unit 1 Overflow site map showing planting areas, planting strategies and vegetative monitoring stations.

B. Monitoring Activity

1. Monitoring Goals

The goals of the Sabine Unit 1 Overflow plantings are:

- Area plantings of smooth cordgrass will survive and expand.
- Single Row plantings of smooth cordgrass will survive and expand.

2. Monitoring Elements

The monitoring elements include procedures to assess planting survival and effects on the planting area for the project plantings. Vegetation stations are intended to monitor planting survival and vegetative cover representative of the planting strategies over time. Planting survival was assumed to be 100% at the end of planting on September 27, 2017. LA-0039 Year 6 SU1 Overflow was monitored near the end of the following spring in June 2018 and one year after planting in October 2018. No additional monitoring is planned because of the initial planting failure

Vegetation Assessment

To assess planting status an ocular estimate of % survival and plant condition was conducted for each area and planting type while visually inspecting the site during sampling visits. Planting survival and vegetative growth data was also collected at the vegetation station level. Ten (10) vegetation stations were established to represent the areas and planting types. Percent survival was calculated from 10 plants at each vegetation station; plants were characterized as live (any green vegetation) or dead/absent. Vegetative cover data was not collected because of lack of planting survival by the first monitoring trip. Conditions occurring outside of the vegetation stations and site-specific points of interest were noted along with photographic documentation.

Planting Failure/Success Causation

Hydrologic data from nearby CRMS sites are used to explain hydrologic influences such as flooding and salinity. A description of inundation of the CS Basin following Hurricane Harvey was used to explain planting stress and mortality. Surface water salinity was measured during the field trips.

3. Monitoring Results and Discussion

a. Vegetation Assessment

The ocular estimates of the planting areas captured the overall performance of the plantings (Table XVIII-1). The smooth cordgrass plantings in both strategies did not survive. Most of the plantings were gone by the 6 month monitoring visit; while a few single-row plantings survived, none remained from the area plantings. No planted smooth cordgrass as found one year after planting. However, naturally occurring smooth cordgrass from existing marsh stands in the area have grown and expanded. From June to October 2018, percent cover of the naturally occurring vegetation increased in the North single row planting from 2.5 to 20% and in the South area planting from 20 to 44 % in the South-Inner area planting and from 18 to 40%. Stem heights of these plants also increased.

Table XVIII-1. Overall % Survival of LA-0039 Year 6 Sabine Unit 1 Overflow plantings were ocularly estimated over time at the end of plant installation and during monitoring field trips.

		% Overall Survival		
Area	Planting Type	September 2017	June 2018	October 2018
North	Single Row	100	<5	<5
South	Area	100	<1	0

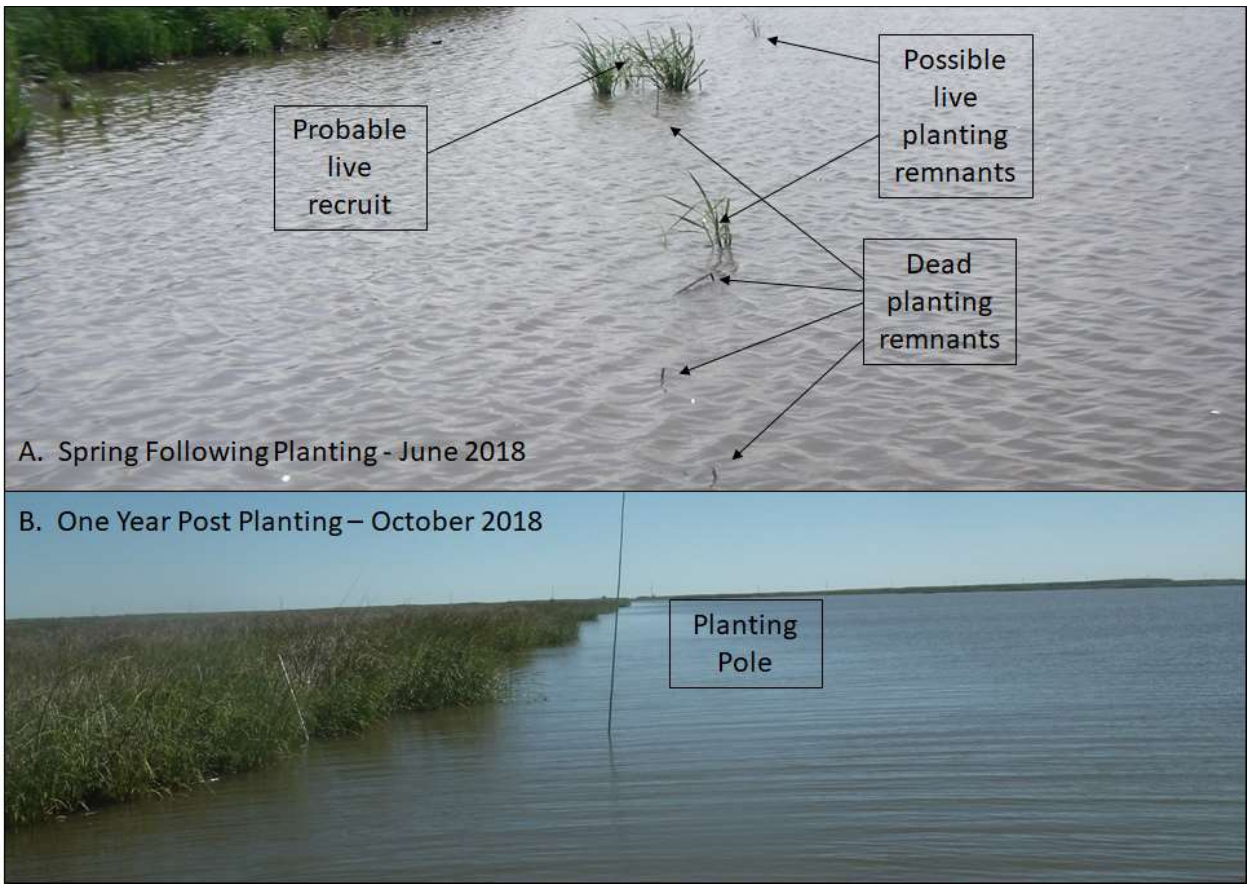

Figure XVIII-2. Smooth cordgrass (*Spartina alterniflora*) plantings in the North Single-Row plantings of the LA-0039 Year 6 Sabine Unit 1 Overflow the following spring in June 2018 (B), and one year post planting in October 2018 (C).

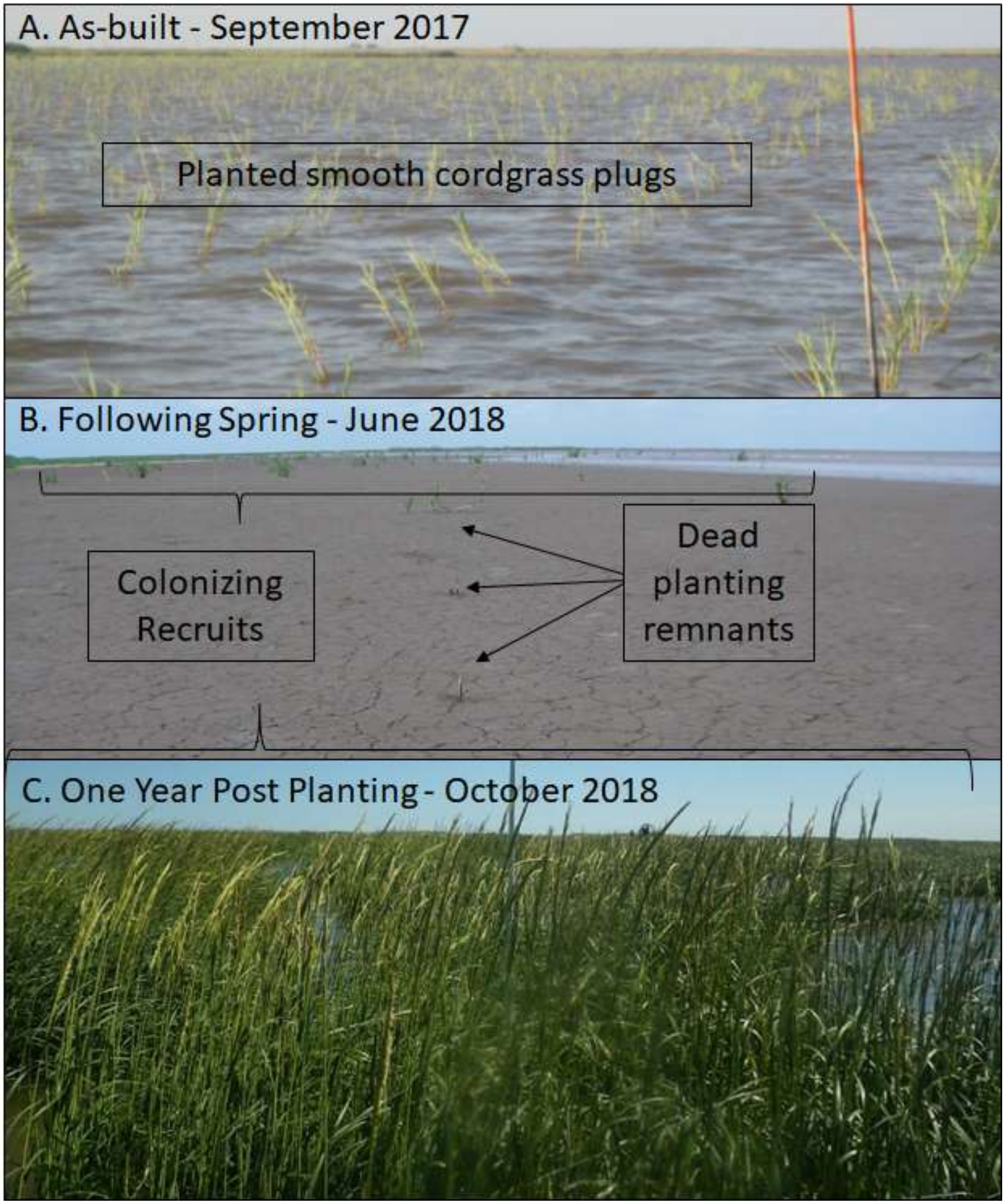

Figure XVIII-3. Smooth cordgrass (*Spartina alterniflora*) plantings in the South Area plantings of the LA-0039 Year 6 Sabine Unit 1 Overflow after installation in September 2018 (A), the following spring in June 2018 (B), and one year post planting in October 2018 (C).

b. Planting Failure Causation

Prolonged flooded conditions at the time of installation and for the next few months are believed to be responsible for the planting failure. Plantings were installed in late September 2017, not long after Hurricane Harvey and the subsequent release of rain water released from Toledo Bend devastated the SW Texas/SW Louisiana Gulf Coast in late August 2017. Water levels recorded at nearby CRMS sites to Sabine Unit 1A (see Sabine East line in Figure XVIII-4) flooded the marsh by at least 0.5 ft until November 2017, and those flood waters did not completely recede until May 2018, a total of 7.25 months (McGinnis et al. 2019). Although the water depths were appropriate for planting *Spartina alterniflora* (optimum range is 1 – 18 inches) in mid to late September, the sustained flooding probably resulted in mortality of the newly-planted, plug-sized plants. Possible causes of mortality was sustained stress from low REDOX potential during the flooding and/or an acid sulfate event after the area drained and pH dropped between May 2018 and the first monitoring trip in June 2018. The flood waters from Hurricane Harvey were the result of rainwater relief of Toledo Bend rather than storm surge; therefore, surface water salinity did not exceed 5 ppt until May 2018. Surface water salinity did not exceed 14 ppt during the monitoring trips. Salinity is not suspected to have stressed the smooth cordgrass plantings.

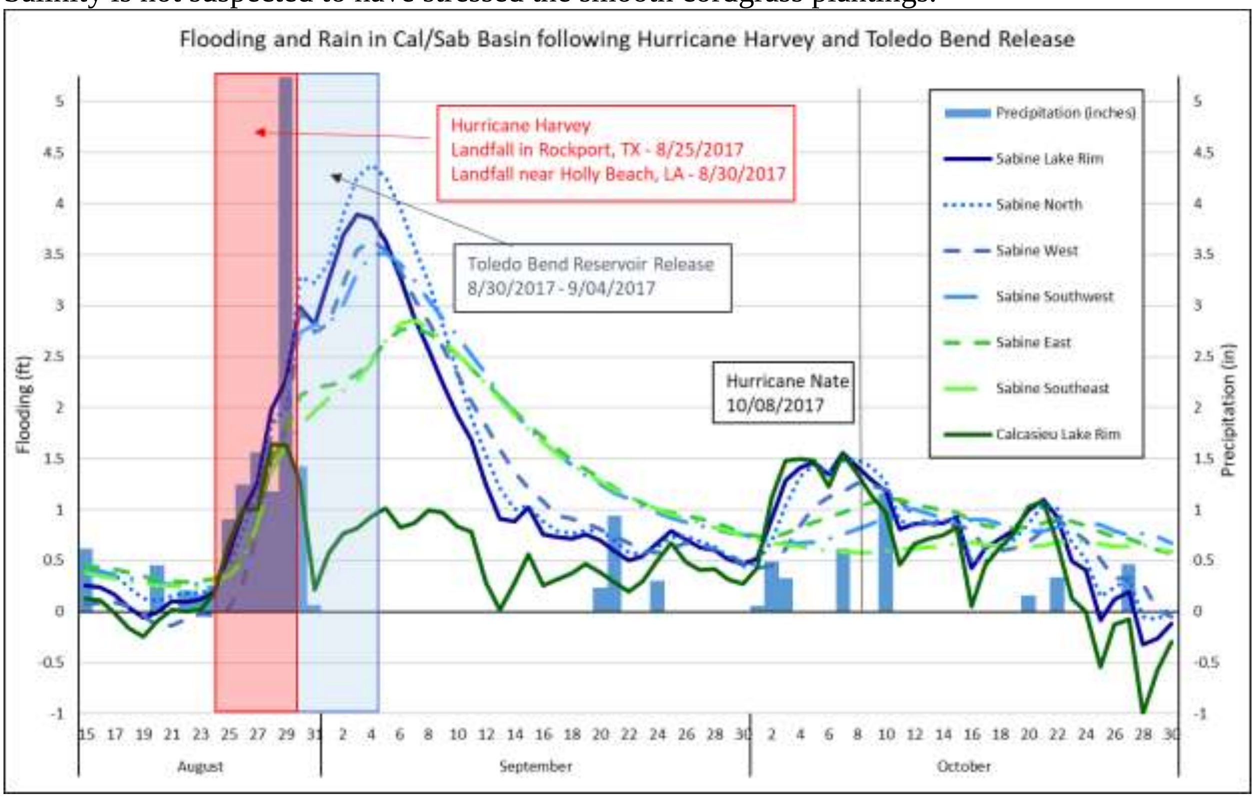

Figure XVIII -4. The lines represent CRMS sites from different areas throughout the Calcasieu-Sabine Basin, and LA-0039 Year 6 Sabine Unit 1 Overflow is in Sabine East (dashed green line) and was planted in the latter half of September 2017. After the initial peak from Hurricane Harvey, the region's marsh was flooded by at least 0.5 ft of water until November 20, 2017 (2.5 months) and flood waters did not recede to marsh elevation until May 2018 (7.25 months). Figure from McGinnis et al. 2019.

C. Conclusions

The Year 6 Sabine Unit 1 Overflow plantings were not successful. The smooth cordgrass plantings sharply declined within the first 6 months of planting and were completely gone within the first year. Naturally occurring smooth cordgrass from nearby marsh areas have grown and expanded into the planting areas.

1. Project Effectiveness

As per the project goals:

- Area plantings of smooth cordgrass did not survive and expand.
- Single row plantings of smooth cordgrass did not survive and expand.

2. Recommended Improvements

Future plantings are not recommended for this area since natural colonization has occurred. Larger plant sizes should be considered in future planting of areas that are typically inundated.

3. Lessons Learned

The Year 6 Sabine Unit 1 Overflow planted smooth cordgrass in an area that had been inundated with flood waters from Hurricane Harvey. Avoid planting *Spartina alterniflora* (smooth cordgrass) after a severe storm event until water levels return to normal levels. Flood duration of this extent is difficult to predict.

XIX. Year 6 – The Jaws 2

Prepared by Bernard Wood – CPRA Lafayette Regional Office

A. Site and Planting Description

The Jaws 2, a Year 6 planting site for LA-0039, is located in St. Mary Parish, along the northeast shore of West Cote Blanche Bay in an area of confluence of several water bodies including the Charenton Canal, the Gulf Intracoastal Waterway, West Cote Blanche Bay, and several other smaller bayous collectively referred to as The Jaws. The approximately 150-acre project area is located between terraces within the northern portion of the Sediment Trapping at "The Jaws" (TV-0015) Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) project area, which is a set of delta splay terraces. There are four planting zones including two species, *Schoenoplectus californicus* (California bulrush) and *Zizaniopsis miliacea* (giant cutgrass), in five different spatial orientations (Fig. XIX-1a through e). Among the different locations and species, the plantings' spatial orientation are one of the following: 3–plant clusters, 6–plant clusters, 9–plant clusters, 16–plant clusters, and a single row of *Z. miliacea*. These strategic alignments were in response to the monitoring observations from LA-0039 Year 3 The Jaws that showed an initial period of vigorous growth followed by mechanical damage of linear double rows of *S. californicus* via rafts of floating aquatic vegetation (FAV), mainly *Eichhornia crassipes* (water hyacinth). The surviving vegetation was mainly circular clumps of *S. californicus* and natural occurring *Z. miliacea* (see Chapter VIII LA-0039 Year 3 The Jaws).

A total of 951 trade gallons of *S. californicus* and 3474 trade gallons of *Z. miliacea* were planted in The Jaws 2 by October 20, 2017, with the final construction inspection occurring in November 2017 (Table XIX-1). The project plantings occurred in four zones subdivided based on the proximity to the existing TV-0015 terrace field. These zones were expected to behave similarly and will likely be treated as one unit to analyze the differences among species and planting spatial orientations. The zones are shallow open-water and tidal flat habitats with minimal emergent marsh and some submerged aquatic vegetation. The dominant emergent vegetation present in the project area pre plantings, *Z. miliacea* and, to a lesser extent, *S. californicus*, covered less than 20% of the project area. The plantings are designed to establish perennial emergent vegetation in areas devoid of vegetation and/or in areas with sparse annual vegetation, in order to increase water bottom friction to trap sediments. Increasing vegetation in this sediment rich environment should increase water bottom elevation and colonization of other emergent species to the area.

Plantings Orientation

Both *Z. miliacea and S. californicus* were planted in linear 3–plant clusters, 6–plant clusters, and 9–plant clusters 25 feet apart and in randomly-located 16-plant clusters; all orientations were nested in four zones around the northern TV-0015 terraces on either side of the main "delta" channel. *Z. miliacea* was also planted in single rows on five foot centers (Fig. XIX-1a, Table XIX-1). This was not done with *S. californicus* as the previous LA-0039 Year 3 The Jaws planting had shown it to be ineffective in this orientation for long-term stability.

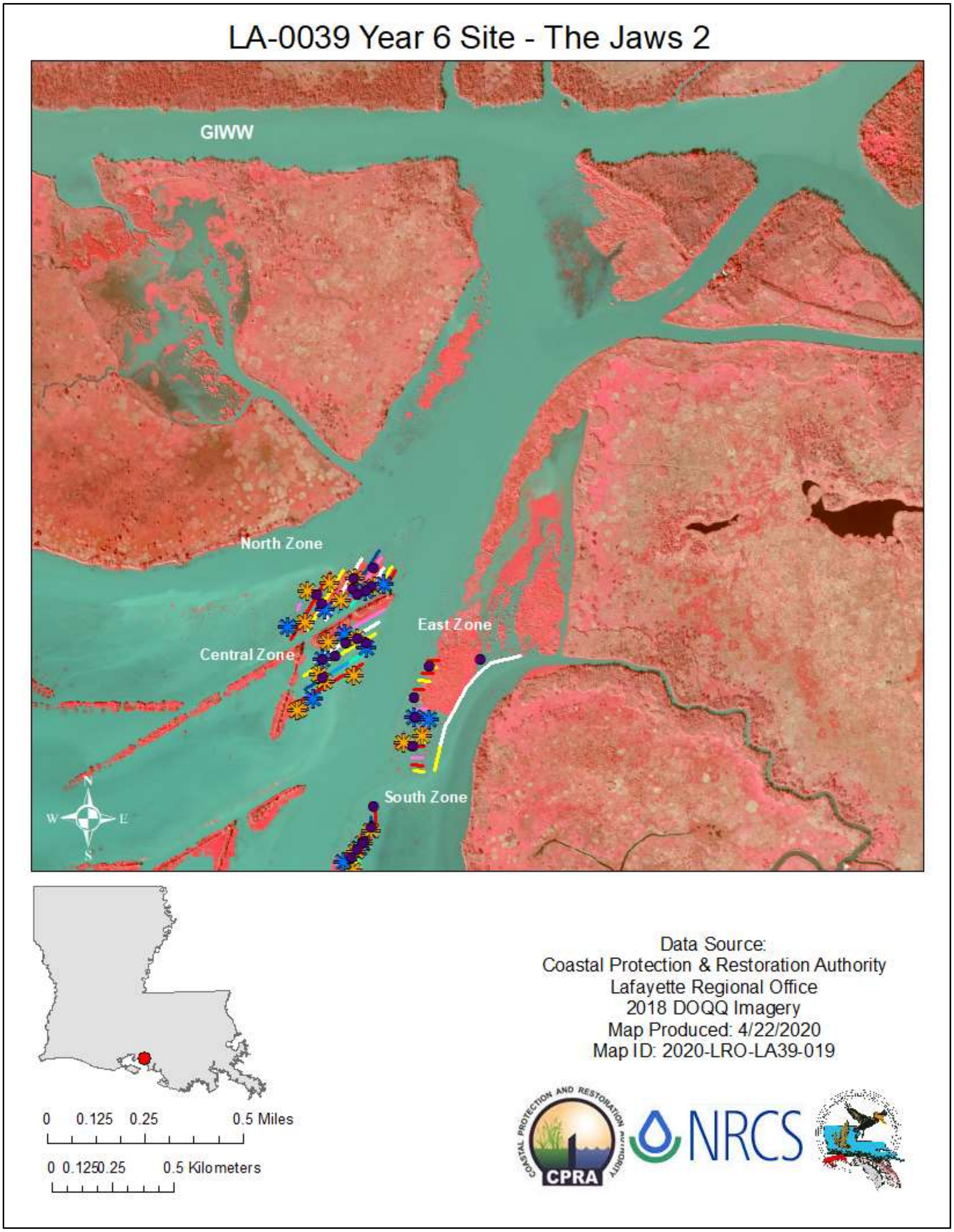

Figure XIX-1a. LA-0039 Year 6 The Jaws 2 overall planting site map showing the location of plantings, which vary by species and spatial orientation. See Fig. XIX-1 b-e for details of each zone.

Table XIX-1. Planting quantities by species, location, and orientations in LA-0039 Year 6 The Jaws 2.

Species		***S. californicus***	***Z. miliacea***
Zone	**Site Description**	**trade gallons**	**trade gallons**
North	Single Row 5’ centers	0	101
North	3–plant clusters, 25 feet apart’	51	174
North	6–plant clusters, 25 feet apart’	102	318
North	9–plant clusters, 25 feet apart’	153	450
North	16 –plant clusters, miscellaneous locations	64	96
	North Subtotal	**370**	**1139**
Central	Single Row 5’ centers	0	100
Central	3–plant clusters, 25 feet apart’	45	126
Central	6–plant clusters, 25 feet apart’	84	252
Central	9–plant clusters, 25 feet apart’	126	378
Central	16–plant clusters, miscellaneous locations	64	96
	Central Subtotal	**319**	**952**
East	Single Row 5’ centers	0	61
East	3–plant clusters, 25 feet apart’	0	210
East	6–plant clusters, 25 feet apart’	0	270
East	9–plant clusters, 25 feet apart’	0	279
East	16–plant clusters, miscellaneous locations	32	32
	East Subtotal	**32**	**852**
South	Single Row 5’ centers	0	41
South	3–plant clusters, 25 feet apart’	33	0
South	6–plant clusters, 25 feet apart’	66	120
South	9–plant clusters, 25 feet apart’	99	306
South	16–plant clusters, miscellaneous locations	32	64
	South Subtotal	**230**	**531**
	Totals	**951**	**3474**

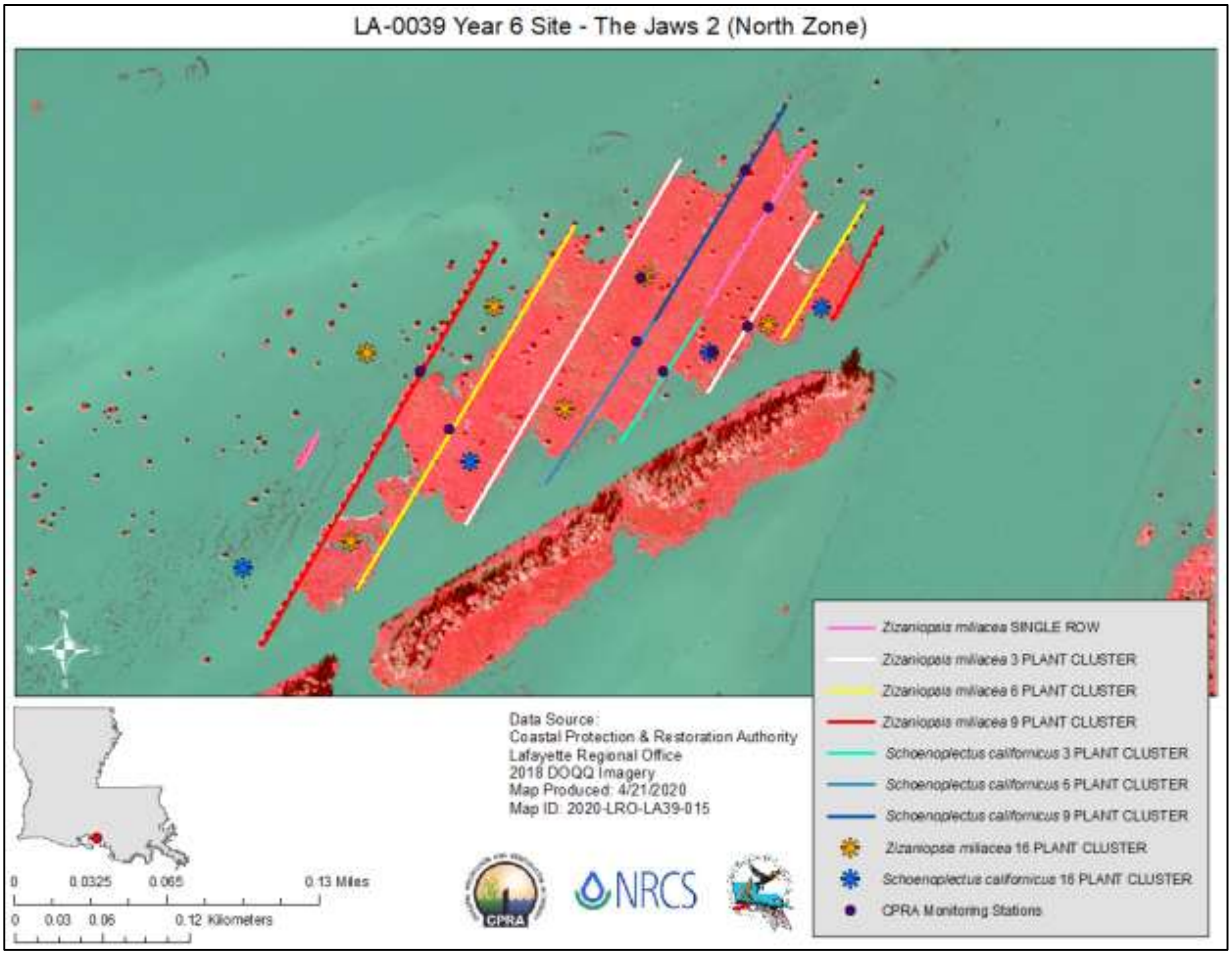

Figure XIX-1b. LA-0039 Year 6 The Jaws 2 North planting zone map showing location of plantings, species, orientation, and vegetative monitoring stations.

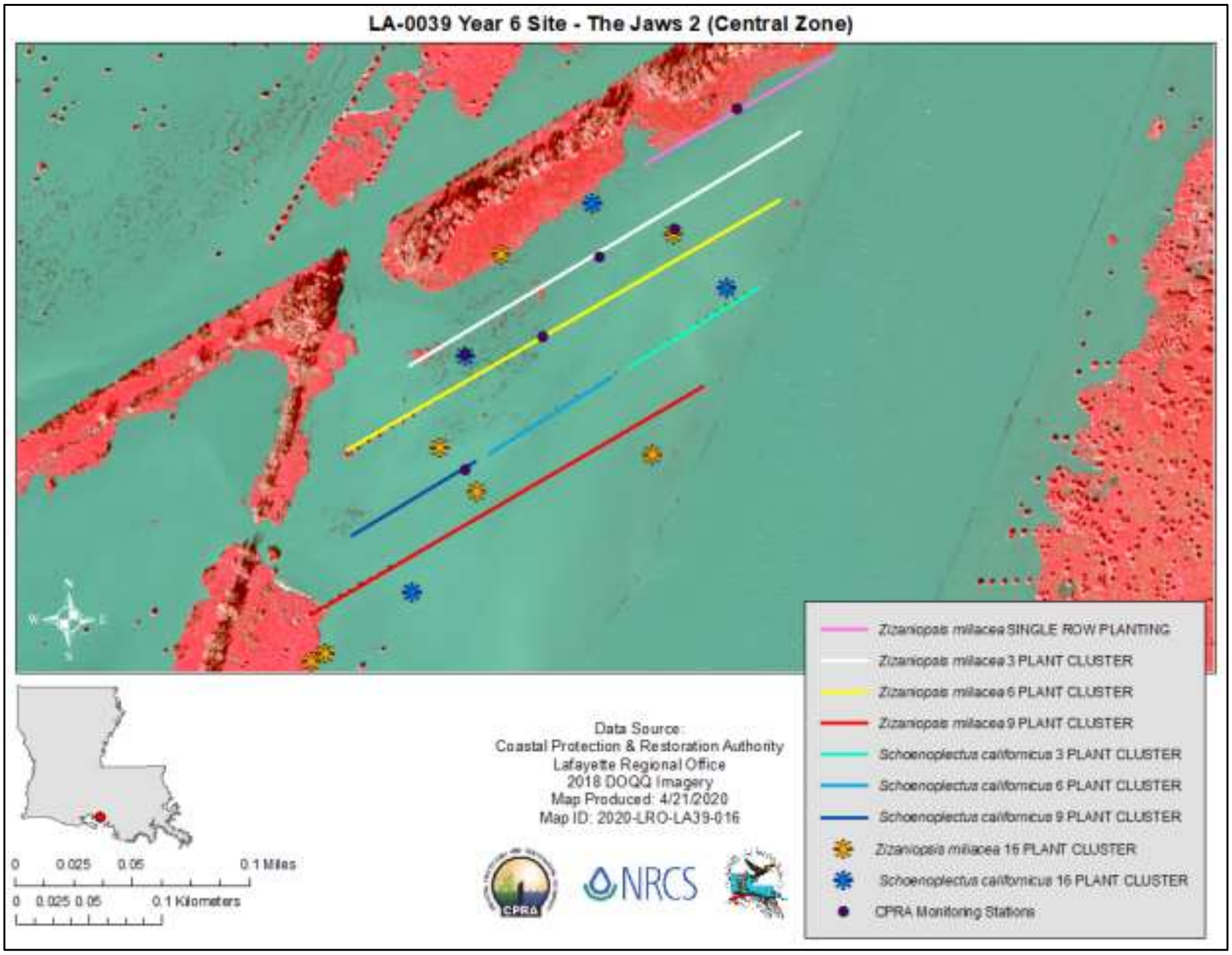

Figure XIX-1c. LA-0039 Year 6 The Jaws 2 Central planting zone map showing location of plantings, species, orientation, and vegetative monitoring stations.

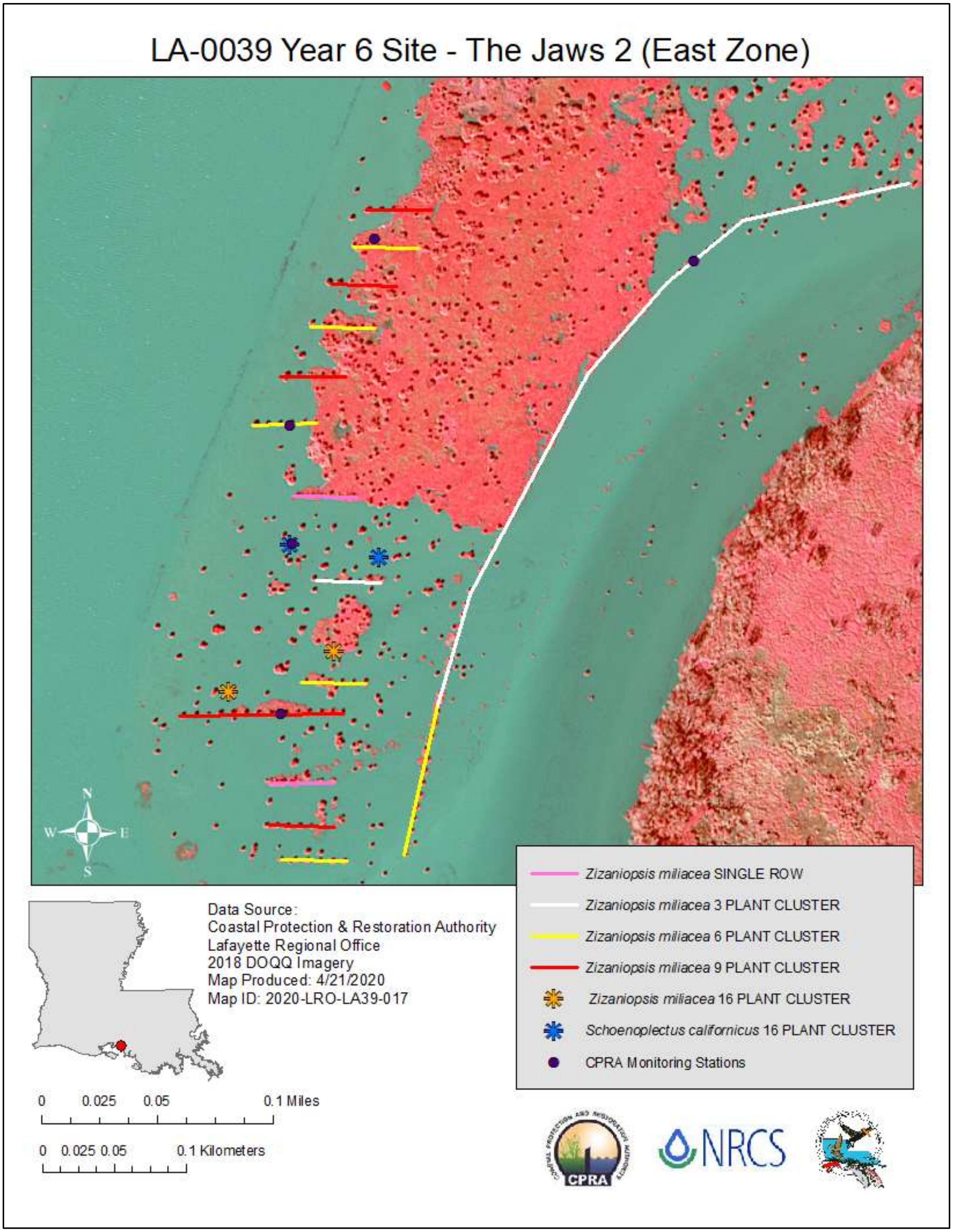

Figure XIX-1d. LA-0039 Year 6 The Jaws 2 East planting zone map showing location of plantings, species, orientation, and vegetative monitoring stations.

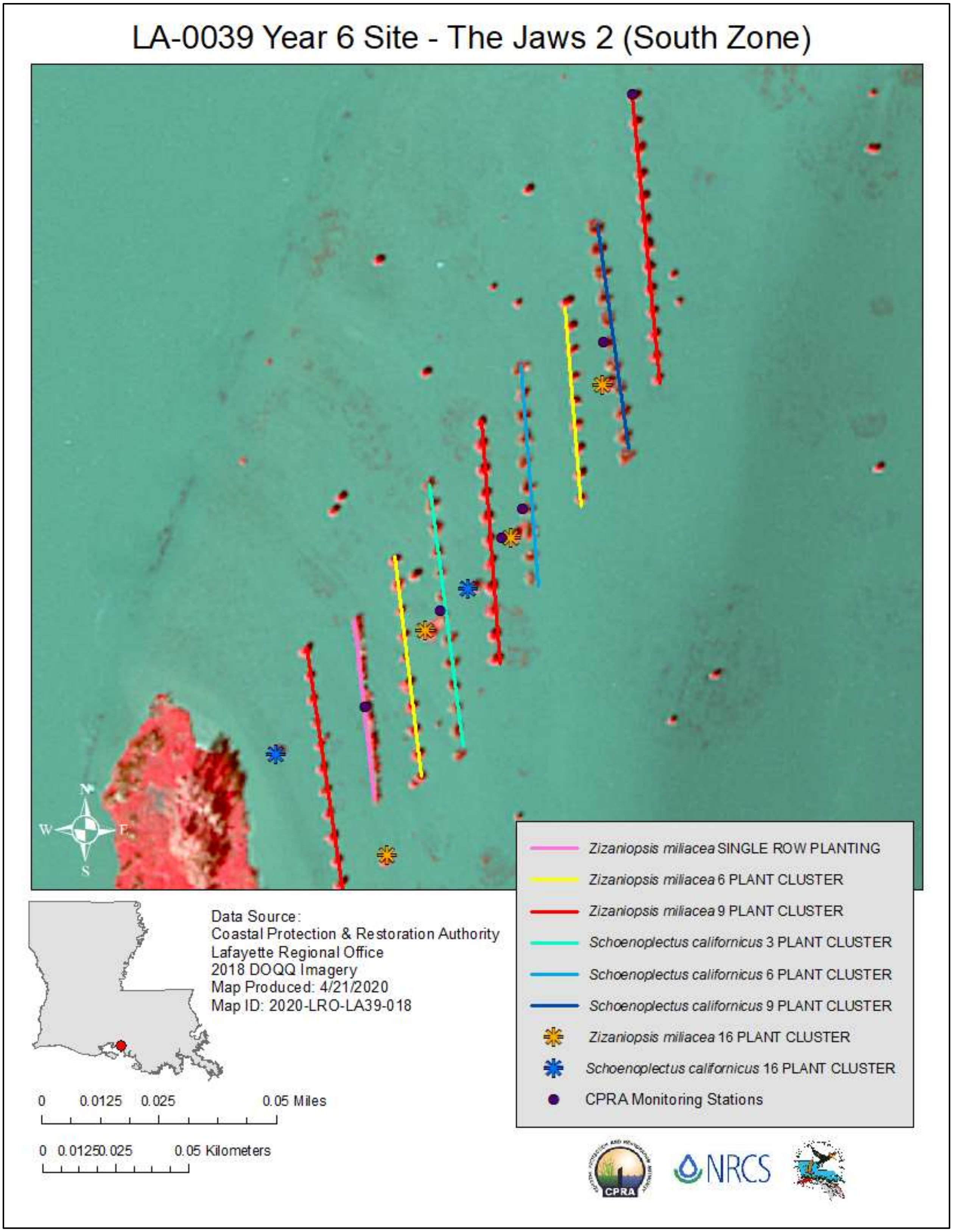

Figure XIX-1e. LA-0039 Year 6 The Jaws 2 South planting zone map showing location of plantings, species, orientation, and vegetative monitoring stations.

B. Monitoring Activity

1. Monitoring Goals

LA-0039 Year 6 The Jaws 2 plantings were designed to establish *Z.miliacea* and *S. californicus* colonies within pre-existing tidal flats, both within and adjacent to the TV-0015 project terraces, to enhance the sediment deposition and natural recruitment of volunteer species, while being less susceptible to rafting from FAV (mainly *E. crassipes*).

The goals of LA-0039 Year 6 The Jaws 2 plantings are:

- The survival and expansion of planted *Schoenoplectus californicus* and *Zizaniopsis miliacea* trade-gallons.
- Determine if the clustered planting orientation is resistant to rafts of FAV over the course of several growing seasons.
- Examine the difference between planted *Schoenoplectus californicus* and *Zizaniopsis miliacea* trade-gallons.

2. Monitoring Elements

The monitoring elements include procedures to assess plant survival and effects on the planting area for the project plantings and the recruitment of any other emergent marsh vegetation to the area. Vegetation stations were intended to monitor planting survival and vegetative cover representative of the various plantings within The Jaws project area over time. The plantings were assumed to have 100 % survival when planted by October 20, 2017. The plantings were monitored about seven (7) months (May 2018) and a year (October 2018) after planting. The three year monitoring was postponed to spring 2021 because of the heavy tropical storm season of 2020 and COVID-19.

<u>Vegetation Assessment</u>

To assess planting status, an ocular estimate of survival and plant condition was conducted for each zone by species by cluster arrangement. Planting survival and vegetative cover data was also collected at the vegetation station level; 25 vegetation stations were established randomly among the different species by planting orientations to repetitively sample all possible configurations. Percent survival was calculated from 10 plants (5 plants per row) at each vegetation station; plants were characterized as live or dead/absent. PVC poles were placed on both ends of the plants monitored for survival. Vegetative condition was assessed by measuring percent cover of species present, vegetative stand height, and height of dominant species in a 4 m^2 plot at each vegetation station (Folse et al. 2014). Flooding depth, surface water salinity, temperature were also collected at all sampling stations during each sampling event. Conditions occurring outside of the stations and segments including additional species, marsh interspersion, and site-specific points of interest were noted along with photo documentation.

North plantings: Nine (9) stations were established randomly among the different species by planting orientations to repetitively sample all possible configurations in the project area.

Central plantings: Six (6) stations were established randomly among the different species by planting orientations to repetitively sample all possible configurations in the project area.

East plantings: Five (5) stations were established randomly among the different species by planting orientations to repetitively sample all possible configurations in the project area.

South plantings: Six (6) stations were established randomly among the different species by planting orientations to repetitively sample all possible configurations in the project area.

Hydrology

Water level elevations from nearby CRMS0545 was used to convert water depth (ft) at vegetation stations to estimated planting elevations (ft, NAVD88 GEOID 12A). The water elevations and estimated planting elevations were then used to create a water-level hydrograph depicting flood levels, duration, and frequency.

Planting Failure/Success Causation

If significant loss of plants in LA-0039 Year 6 The Jaws 2 planting area occurs, suspected causes (soil conditions, hydrologic conditions, planting removal) will be investigated.

3. Monitoring Results and Discussion

a. Vegetative Assessment

Overall the plantings in the vegetation stations at LA-0039 Year 6 The Jaws 2 location have performed well, during the May 2018 sampling effort, percent survival of the original planted individuals was calculated as 94.7% survival. Six months later during the October 2018 sampling event percent vegetation cover at vegetation stations showed substantial expansion to over 70% total cover (Figure XIX-2). The percent total cover of the planting areas has increased by nearly 50% across both species and planting regime, with the stark exception of the Central zone. The Central zone had a nearly one half reduction in total cover from 13.5% in spring to 6.6% in fall 2018. This was somewhat unexpected as zone was not anticipated to be a key factor in this planting regime. However, this area also sustained early damage in LA-0039 Year 3 The Jaws, which was eventually a total loss due in large part to winter *E. crassipes* rafting (Figs. XIX-3 and 4) (see Chapter VIII LA-0039 Year 3 The Jaws).

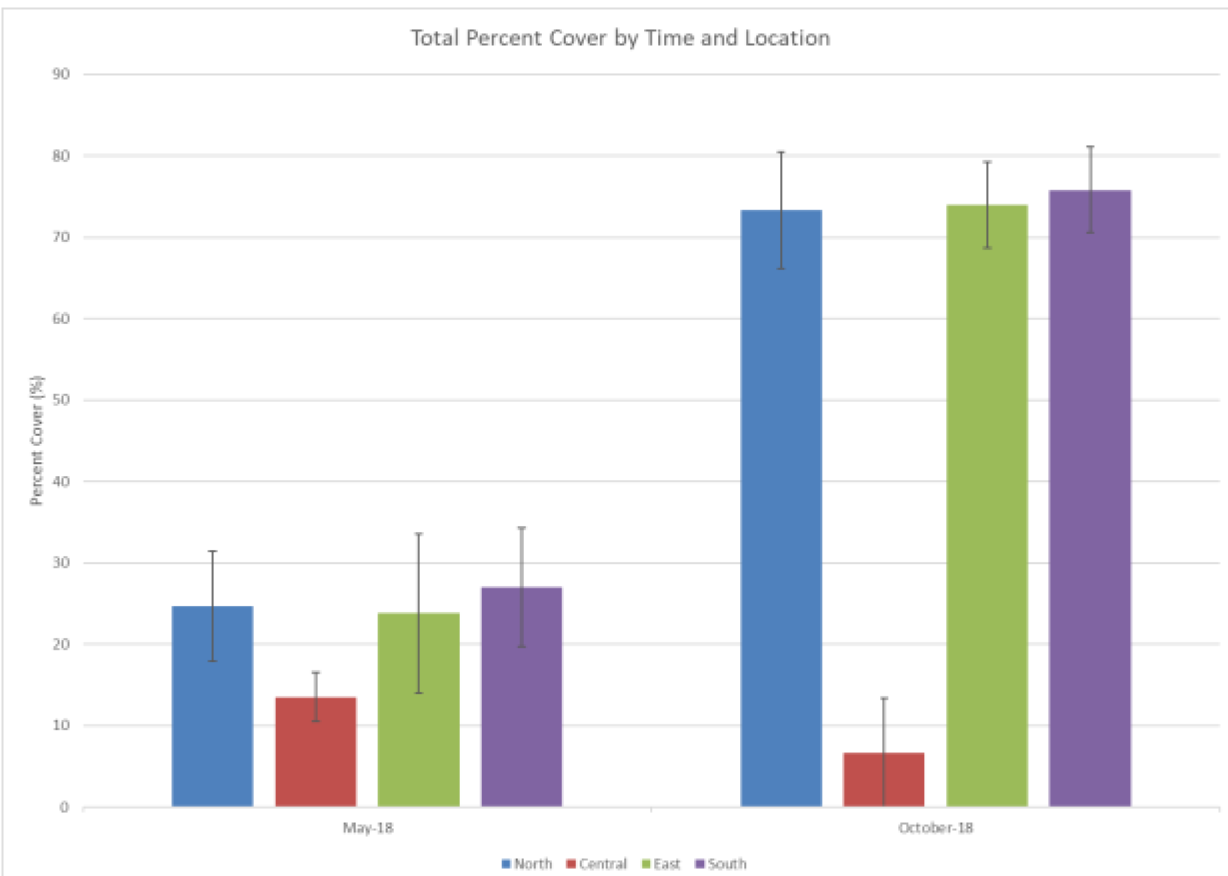

Figure XIX-2. The percent cover of emergent vegetation in the sample plots at LA-0039 Year 6 The Jaws 2 planting zones over time; percent cover increased drastically in one growing season, except in the Central area, where *E. crassipes* rafts smothered the planted vegetation. Plantings were installed in October 2017.

Figure XIX-3. *Schoenoplectus californicus* plantings (yellow circle) in LA-0039 Year 6 The Jaws 2 Central zone were already severely affected by rafting from *E. crassipes* rafts by October 2018.

Figure XIX-4. View of cluster plantings at LA-0039 Year 6 The Jaws 2 Central zone in October 2018; *Z. miliacea* is in the center, and *S. californicus* are off to the left and right in the distance. This was representative of some zones which were completely covered with *E. crassipes* among other floating aquatics.

Overall, both *Z. miliacea* and *S. californicus* trade gallons have successfully survived and expanded in their new environment with significant increases in total percent cover across area and planting arrangement (Fig. XIX-5). *S. californicus* was initially quicker to expand and thrive under fairly high spring water-level conditions averaging 36.3% total cover while *Z. miliacea* was closer to 12% (Figs. XIX-5 and 6). This trend reversed course over the 2018 growing season, at the end of which *Z. miliacea* average cover across all conditions was 60.6% with *S. californicus* slightly trailing at 55.5% (Figs. XIX-5 and 7).

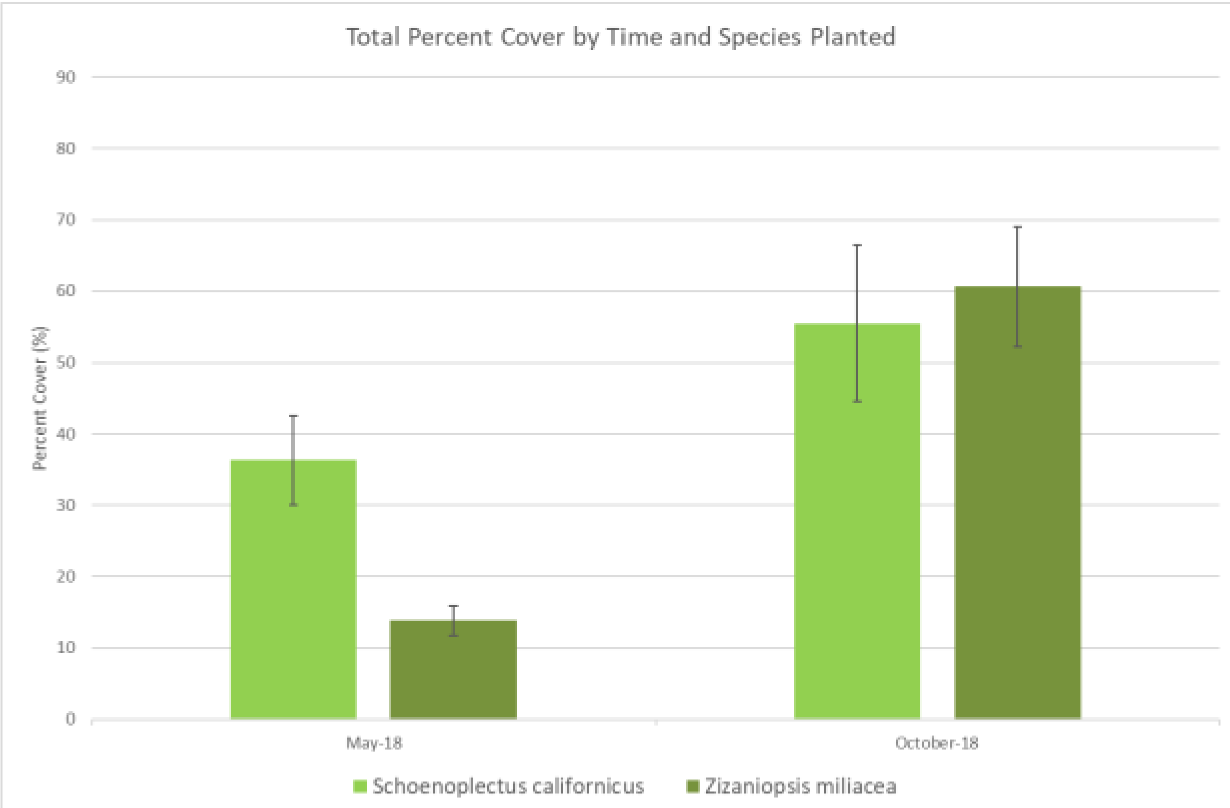

Figure XIX-5. The percent cover of emergent vegetation in the sample plots at LA-0039 Year 6 The Jaws 2 by species over time. Plantings were installed in October 2017.

Figure XIX-6. Typical view of nine plant cluster plantings at LA-0039 Year 6 The Jaws 2 North zone in May 2018 (planted in Oct 2017); *Z. miliacea* is on the left and is notably shorter than *S. californicus* under high water conditions.

Figure XIX-7. Typical view of nine plant cluster plantings at LA-0039 Year 6 The Jaws 2 North in Oct 2018 (planted Oct 2017). *Z. miliacea* is on the left and is similar in stature to *S. californicus;* both have experienced substantial growth over the 2018 growing season.

The planting arrangement strategy of single plants all the way through 16 plant clusters had a noticeable effect on total percent cover in spring 2018, seven months after planting. Single plants covered only 4% of the 4 m^2 sampling plot, and nine and sixteen plant clusters had 32% and 31% cover, respectively (Fig. XIX-8). Three plant and six plant clusters were intermediate with 15.2% and 18.6% total cover, respectively, across species and areas. This generally tiered percent cover ranging up from single plants through the largest clusters homogenized by the end of the first growing season in October 2018 with no noticeable relationship between amount of plants in the cluster and vegetation cover. The lowest cover average of 49% was the three plant arrangement, and nine plant clusters cover averaged 71.6%. The error range of these averages is overlapping, likely indicating not much in the way of significant differences. Visually, single, three, and six plant clusters looked similar but smaller than nine and 16 plant clusters, which in some instances seemed to dwarf the others (Fig. XIX-9). The sampling method for percent cover uses two by two meter square stations which may be too small to incorporate growth of the highest cluster plantings to show a differential in the short term. The goal is to create plantings that can survive, thrive, and sustain themselves against rafting *E. crassipes* over multiple growing seasons which will require more time to be determined.

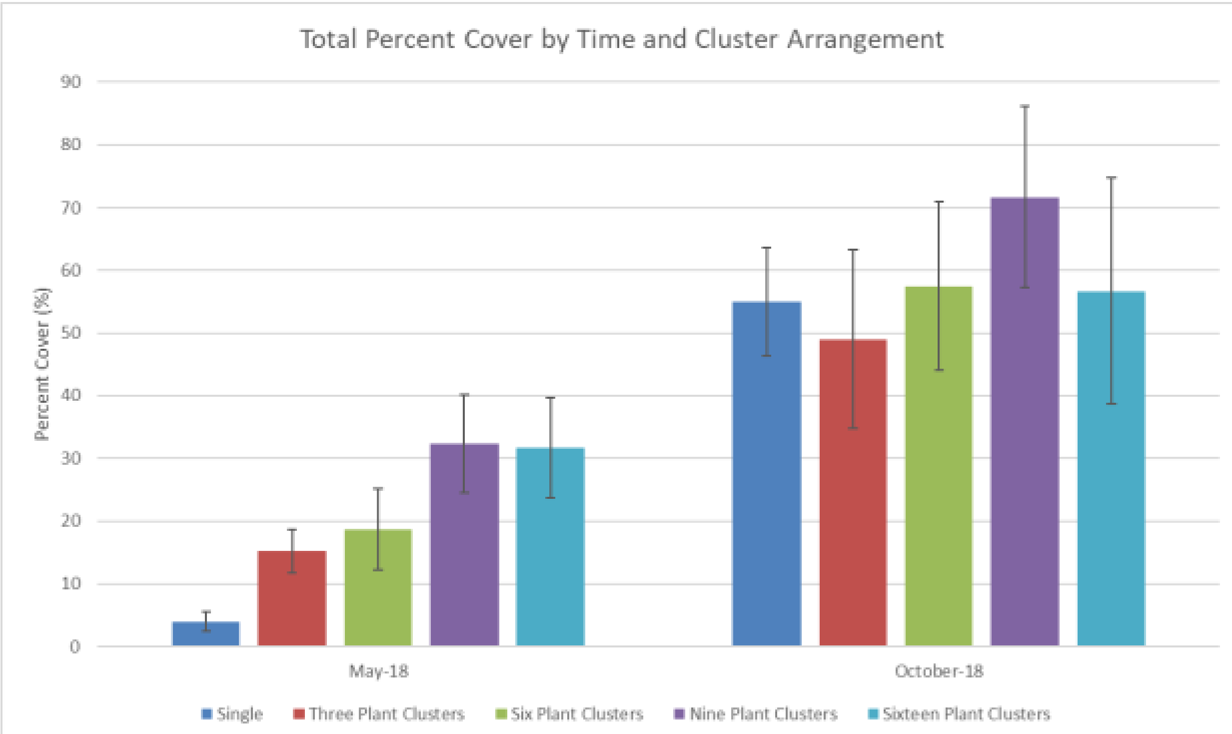

Figure XIX-8. The percent cover of emergent vegetation in the sample plots at LA-0039 Year 6 The Jaws 2 by cluster arrangement over time (planted in Oct 2017). Percent cover started staggered by cluster size but then homogenized through time as rapid growth of smaller clusters filled in the 2 m ×2 m sampling area similarly to larger clusters.

Figure XIX-9. In some LA-0039 Year 6 The Jaws 2 locations (East Zone pictured), *Zianiopsis miliacea* 16-plant clumps were growing out away from the monitoring station and becoming contiguous with naturally occurring stands of the same species by October 2018. They could start to build elevation and recruit emergent vegetation if the plants can withstand the *Eichornia. crassipes* rafts during the winter months.

b. Hydrology

The water levels in the planting area are generally quite deep, but, as the plantings mature sedimentation is expected to increase, allowing for the addition of other species that thrive in deeper flood regimes to become established along with continued expansion of plantings. The optimum water depth for establishment of *S. californicus* is reported as between 1 to 2 feet (Materne and Fine 2000), while *Z. miliacea* shows consistent colony expansion at water depths between 1 to 2 feet, with some slowing of growth as water depths increase (Fox and Haller 2000). Water depths on the higher end of this range are common in the project area but also routinely exceed the 2 foot depth threshold during the growing season (Fig. XIX-10), potentially adding stress to the specimens.

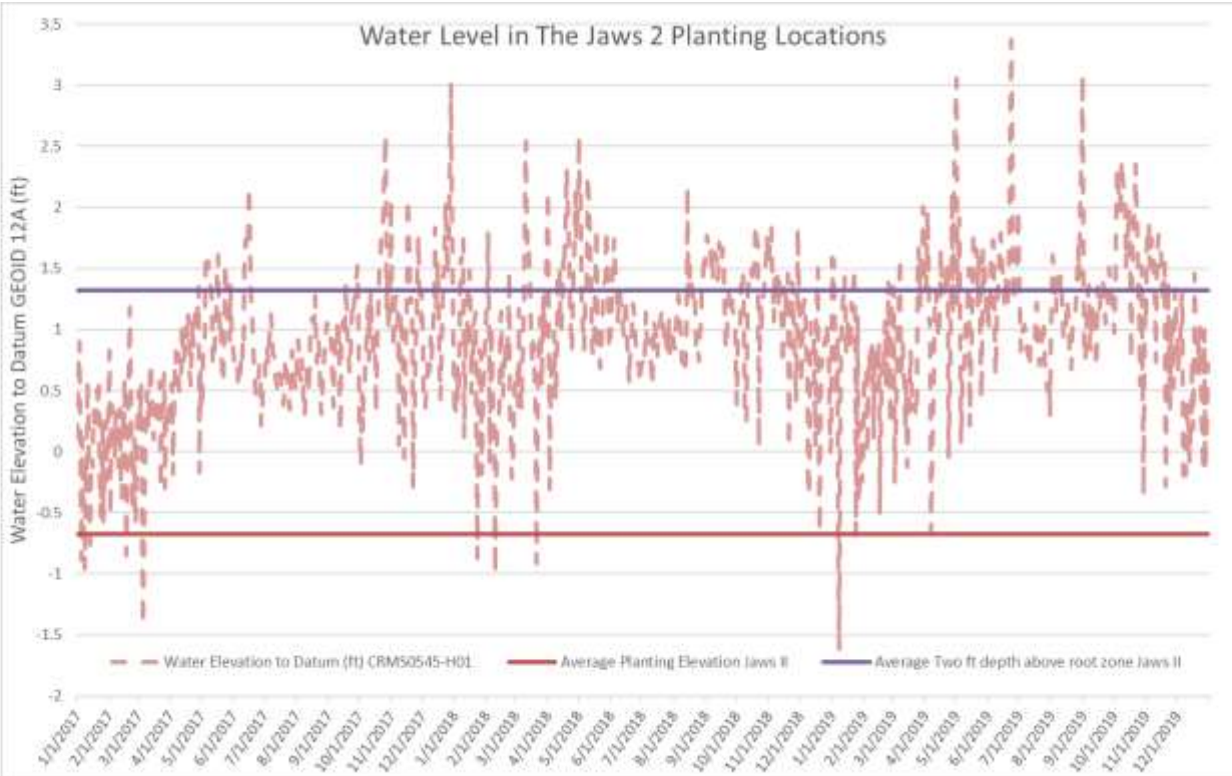

Figure XIX-10. Hydrograph of nearby CRMS site displaying water level and averaged planting depth for the LA-0039 Year 6 The Jaws 2 planting areas, which were all similar, from 2017 through 2019.

c. Planting Failure/Success Causation

There was no significant loss of plants in three of the four planting areas through the first year after planting. The glaring exception being the Central area; this area of systemic plant failure is just west of the main canal through the project area. The channel side is unprotected by terraces or other vegetation and the area suffered significant mortality due to rafting of *E. crassipes*, possibly exacerbated by boat wake and wave energy. The only other plant loss was isolated and random, possibly due to poor plant health at the time of planting or isolated poor substrate conditions.

The project area plantings looked notably changed three years after planting as of the November 2020 imagery available through Google Earth (Fig. XIX-11-14) and a brief field visit in April 2021. The imagery shows that the large rafts of *E. crassipes* have been swept clean as multiple hurricanes have impacted the area since the last monitoring event in fall 2018. Beginning with Hurricane Barry in 2019 and followed by Laura and Delta in 2020, the planting area has suffered three significant storm surges and extensive damage in and around the plantings. Based on field observations, the Northern area seems to have maintained the majority of the *Z. miliacea* plantings while losing most of the *S. californicus.* The Central area looks to now be a complete loss of both species after already showing poor results through 2018. Both the East and South areas look to be in reasonably good condition given the environmental obstacles of the last two growing seasons. In the South planting area the *S. californicus* plantings appear intact, the only area where this was obvious from the field observations in April 2021. These observations will be assessed during the next monitoring trip in fall 2021 which was unfortunately delayed by an active hurricane season and COVID-19.

Figure XIX-11. Google Earth imagry for the LA-0039 Year 6 The Jaws 2 on 11-16-2020 North zone.

Figure XIX-12. Google Earth imagry for the LA-0039 Year 6 The Jaws 2 on 11-16-2020 Central zone.

Figure XIX-13. Google Earth imagry for the LA-0039 Year 6 The Jaws 2 on 11-16-2020 East zone.

Figure XIX-14. Google Earth imagry for the LA-0039 Year 6 The Jaws 2 on 11-16-2020 South zone.

C. Conclusions

1. Project Effectiveness

As per the project goals through October 2018:

- Plantings in the tidal flats in and around the TV-0015 terraces has been successful in three of the four planting areas, with total vegetative cover across species increasing to ~70% 1.5 years after planting in those areas. However, vast rafts of *E. crassipes* still remain a problem along with hurricane damage.
- Based on the near complete failure of the Central area it appears that species and planting orientation are not sufficient factors to resist the immense weight and damage caused by *E. crassipes*, especially in exposed locations, as there was neither an obvious cluster nor species difference in total cover.
- There was no substantial difference between *S. californicus and Z. miliacea* as of the fall 2018 sampling, but it is expected that as winter conditions dislodge rafts of *E. crassipes*, a distinct difference between the two will emerge in the following growing seasons.

2. Recommended Improvements

The planting orientation of clustered groups of plants along a transect still resembles and functions as a hedgerow after one growing season, allowing *E. crassipes* to encapsulate both sides. If *Z. miliacea* proves to be resilient to this through multiple growing seasons, an area planting in a protected location should be considered.

If *Z. miliacea* can sustain multiple seasons of *E. crassipes* and hurricanes damage while still expanding, then multiple area plantings in the most protected locations could be successful. This would facilitate support both from the plants around one another as well as the TV-0015 terraces, in such locations as the two enclosed V-shaped terrace formations. This could also be tried across species. It is yet to be determined if the more isolated and randomly placed 16 plant clusters thrive through multiple growing seasons and, if so, an area planting following this methodology could be warranted.

3. Lessons Learned

The Jaws has abundant sediment with generally low salinity, but it is also a high energy environment which makes the long-term survival of planted individuals difficult to predict. The hurricane surges and subsequent damage during the 2019 and 2020 growing season have only added to this exertion; however, late fall Google Earth imagery of November 2020 and brief field visit in April 2021 suggests that multiple planted species, areas, and planting orientations have survived these events, and there is potential for continued growth and expansion in the area.

XX. Year 6 – Willow Lake 2

Prepared by Tommy McGinnis and Margaret Daigle – CPRA Lafayette Regional Office

A. Site and Planting Description

Willow Lake 2 (WL2), a Year 6 planting site, is in north-central Cameron Parish east of Calcasieu Lake and north of the Gulf Intracoastal Waterway (GIWW). Salt water intrusion from Calcasieu Lake to the general area is minimized by the Calcasieu Lock on the GIWW which is part of the Mermentau Basin Project managed and operated by the Corps of Engineers. Willow Lake is within the Sweet Lake/Willow Lake Hydrologic Restoration (CS-11b) project boundaries; it is separated from the GIWW by a rock dike, and had a failed attempt at erecting terraces along the northern shoreline of the lake attributed to poor soil structure for terrace construction (Miller and Guidry 2011).

The planting site is located in broken marsh ponds north of Willow Lake. The site has two (2) planting strategies, hedgerows across narrow strips of open water and area plantings within small ponds (Fig. XX-1). Both strategies were planted with trade gallons of *Shoenoplectus californicus* (California bullwhip, 9,450 plants). Plantings and final inspection were completed in May 2018.

Area plantings in small open-water areas of California bullwhips were planted in parallel rows seven feet (7 ft) apart on seven-foot (7 ft) alternating centers no deeper than -1.8 ft NAVD 88. Area plantings are in both the West and East sides of Willow Lake 2. Most area plantings are rectangular along the perimeters of open-water area except for a couple of blocks in the middle of the West side and a cove intended to fortify a land bridge in the southwest corner of the East side.

Hedge Row Plantings across narrow strips of open water were planted with the intent to stabilize existing marsh and establish vegetation in shallow open water areas. Plants were installed in groups of five (5) parallel rows of California bullwhip trade gallons planted five feet (5 ft) apart on five-foot (5 ft) alternating centers no deeper than -1.8 ft NAVD88. All Hedge Row plantings in the East side in coves open to Willow Lake.

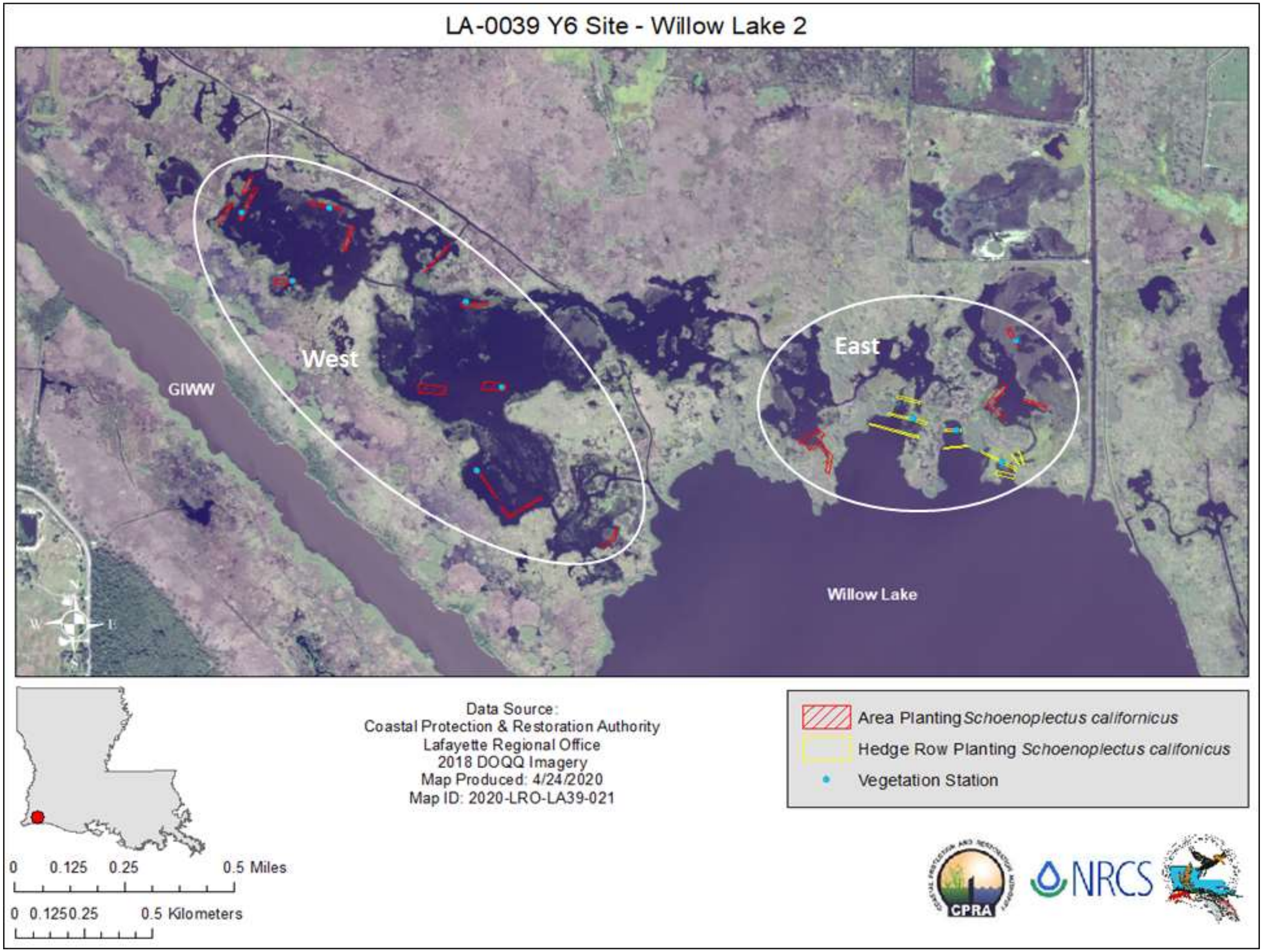

Figure XX-1. LA-0039 Year 6 Site – Willow Lake 2 site maps displays planting types and vegetation monitoring stations.

B. Monitoring Activity

1. Monitoring Goals

The goals of the LA-0039 Year 6 Willow Lake 2 plantings are:

- Hedgerow plantings of bullwhip across narrow strips of open water will survive and expand.
- Area plantings of bullwhip will survive and expand to increase vegetation in small open water ponds.

2. Monitoring Elements

The monitoring elements include procedures to assess planting survivorship and effects on the planting area for the two main types of project plantings, existing marsh stabilization and interior area coverage. Vegetation stations are intended to monitor planting survival and vegetative cover representative of the variety of planting strategies over time. Hydrologic data from nearby CRMS sites are used to explain hydrologic influences such as flooding. The final planting inspection of May 2018 is considered the beginning of the monitoring period. Monitoring trips were conducted near the end of the first growing season (October 31, 2018), one year (May 15, 2019), and three years (July 28, 2021) after planting. Willow Lake was close to both the Hurricane Laura and Delta storm tracks that passed in 2020.

Vegetation Assessment

To assess overall planting status, an ocular estimate of survival and plant condition was conducted for each side and planting type during sampling visits. Planting survival and vegetative growth data was also collected at the vegetation station level across planting types; 10 stations targeted representative plantings at the time of establishment in October 2018. Percent survival was calculated from 10 plants (five plants per row) at each vegetation station; plants were characterized as live or dead/absent. PVC poles were placed on both ends of the plants monitored for survival. Vegetative growth was assessed by measuring percent (%) cover of species present, vegetative stand height, and height of dominant species at 4 m^2 vegetation plots at the vegetation stations (Folse et al. 2012). Flooding depth, surface water salinity and temperature, and porewater salinity and temperature were also collected at all sampling stations during each sampling event. Conditions occurring outside of the vegetation stations including additional emergent species, floating and submerged vegetation, marsh interspersion, and site-specific points of interest were noted along with photographic documentation.

Area plantings in small open-water areas have seven (7) vegetation stations to monitor planting survival and vegetative cover.

Hedge Row plantings have three (3) vegetation stations to monitor planting survival and vegetative cover.

3. Monitoring Results and Discussion

a. Vegetation Assessment

Area and Hedge Row Plantings

The ocular estimates of planting areas captured the overall performance of the plantings. Percent survival sharply decreases over the first growing season, stabilized by one year after planting, and declined to <1% by three years after installation (Table XX-1).

Table XX-1. Overall % Survival of *Shoenoplectus californicus* (California bulrush) plantings was ocularly estimated over time while conducting the final inspection and monitoring field trips at LA-0039 Year 6 - Willow Lake 2.

	Estimated Survival (%)			
Planting Type	May 2018	Oct 30, 2018	May 15, 2019	July 28, 2021
Area - Overall	100	38.5	38	<1
West – North	100	60	65	1.5
West – Middle	100	70	60	0
West - Blocks	100	25	35	4
West - South	100	15	15	0
East - Southwest	100	1	0	0
East - East	100	60	55	0.5
Hedge Row	100	55	50	<1

By October 2018, the end of the growing season after planting, most of the area plantings were inundated with SAV and rafts of FAV (Figure XX-2). Remaining plants were still viable but not expanding or thriving as hoped. Within the Area plantings, survival decreased from north to south in each side for unknown reasons other than by water stacking during Northern frontal passages resulting in increased rafting damage by aquatic vegetation. Herbivory was also noticeable in the eastern-most area plantings. Survival was quite variable (10 - 70 %) within the Hedge Row plantings, as plantings were thin where exposed to winds and wave and more robust where protected by Roseau cane islands and adjacent to the marsh. By one year after planting in May 2019, the individual plants were dark green with big seed heads; however, they did not appear to have grown or expand (Figures XX-2 and 3). Less floating aquatic vegetation may account for the slight increases in some of the area plantings in May 2019. By a little more than three years after planting in July 2021, very few plants remained in any location. Remaining planting were mostly green and about 5-6 feet tall, whereas California bulrush in the surrounding marsh were 10–12 feet tall. Surviving plants were often in clusters with a couple of individual stems, but the spatial distribution of the plant clusters did not follow any discernable features.

Figure XX-2. Photo comparison of a typical Area Planting at LA-0039 Year 6 Willow Lake 2 five to six months (A), one year (B), and three years after installation. Note the heavy rafting by floating aquatics in October 2018 (A).

Figure XX-3. Photo comparison of a typical Hedgerow Planting at LA-0039 Year 6 Willow Lake 2. Note the heavy rafting by floating aquatics in October 2018.

Vegetation station locations targeted remaining vegetation representative of planting types when established in October 2018, a growing season after planting. At the vegetation station scale, survival was similar in both planting strategies in 2018 and decreased more in the Area plantings by 2019 (Figure XX-4A). Vegetative cover in the Area plantings caught up with Hedge Row plantings by a year after planting (May 2019) after starting with less coverage; however, coverage only averaged around 20 % in both planting types (Figure XX-4B). Heights were of the plants at the vegetation stations increased about a foot in both planting types (Figures XX-4C).

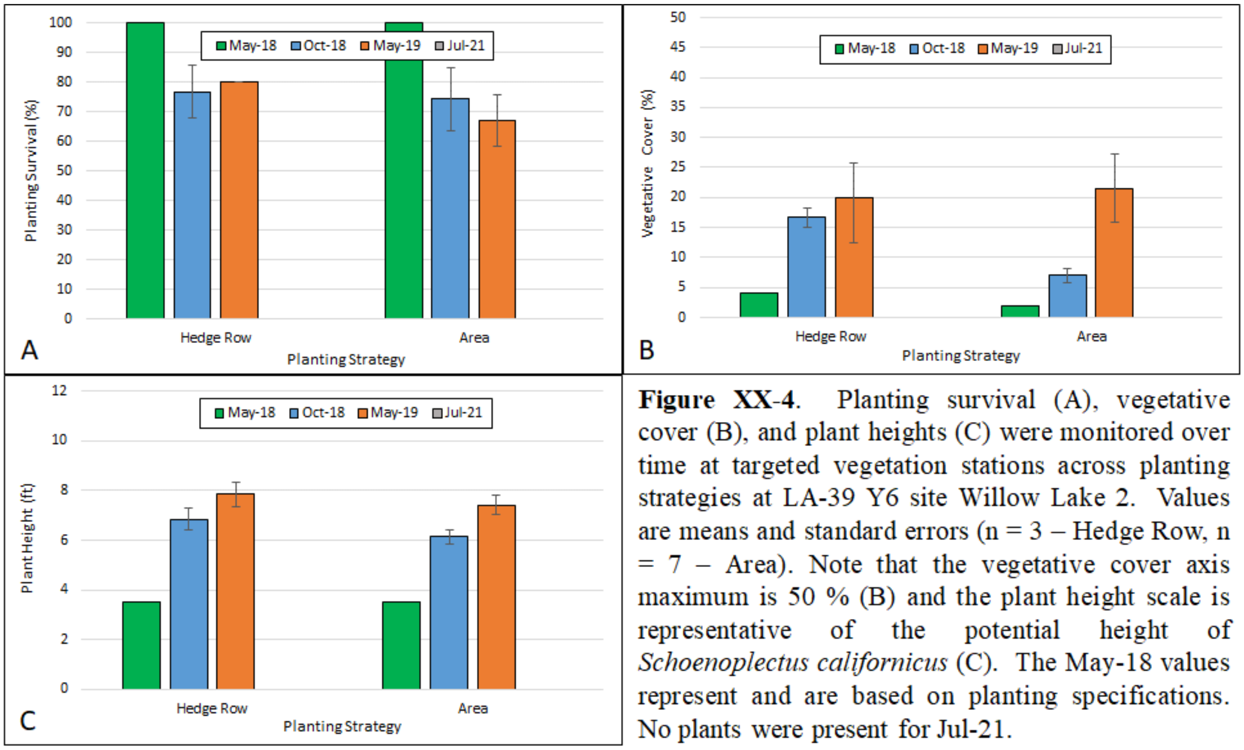

Figure XX-4. Planting survival (A), vegetative cover (B), and plant heights (C) were monitored over time at targeted vegetation stations across planting strategies at LA-39 Y6 site Willow Lake 2. Values are means and standard errors (n = 3 – Hedge Row, n = 7 – Area). Note that the vegetative cover axis maximum is 50 % (B) and the plant height scale is representative of the potential height of *Schoenoplectus californicus* (C). The May-18 values represent and are based on planting specifications. No plants were present for Jul-21.

b. Planting Failure/Success Causation

A combination of factors contributed to the lack of planting expansion in LA-0039 Year 6 Willow Lake 2. The water bottoms in the Willow Lake area are highly organic, unconsolidated, weak soils, as evidenced by the failed terraces at CS-11b (Miller and Guidry 2011), and provide a weak foundation for plantings. Sustained high water levels detailed in LA-0039 Year 3 Willow Lake (see Chapter X.B.3.b. Hydrology and c. Planting Failure/Success Causation) from COE management of the area for agricultural irrigation purposes provides stressful water-level conditions for new plants; the plantings are typically in at least 2.5 – 3.0 ft of water. As a point of reference, during the May 2019 monitoring trip, naturally occuring *S. californicus* coming out from the marsh stopped at ~1.2 ft deep and some cutgrass (*Zizaniopsis miliaceae*) stopped at 2 ft deep, whereas planted vegetation averaged 3.5 ft deep. In addition, high densities of floating and submerged aquatic vegetation created rafts of vegetation (Figure XX-2 and 3) that physically battered the plantings soon after planting. Also, mammalian (typically muskrat or nutria) herbivory was noted in the eastern-most area plantings during Oct 2018 monitoring trip (Figure XX-5).

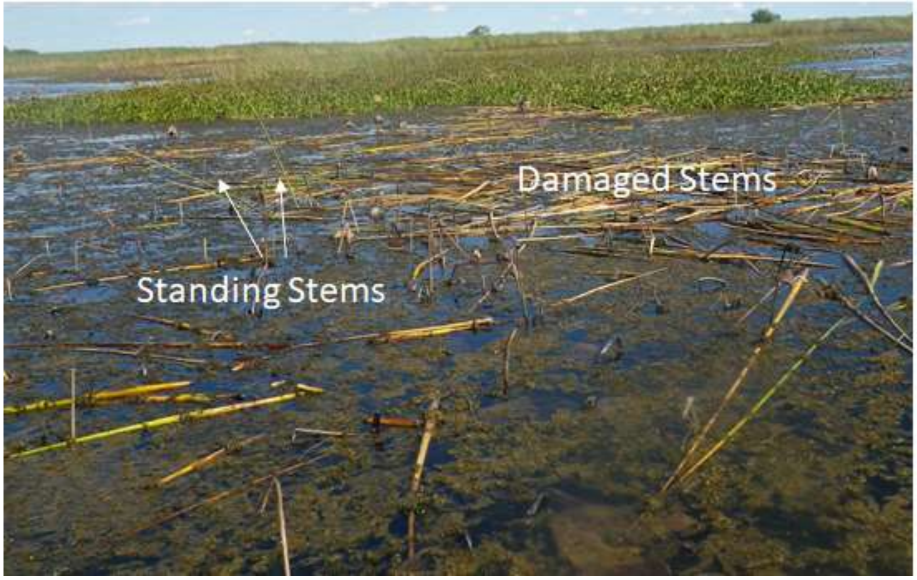

Figure XX-5. Herbivory (typically muskrat or nutria) damage of *Schoenoplectus californicus* (California bulrush) plantings in the East Area site of LA-0039 Year 6 Willow Lake 2 was photogaphed in October 2018, about eight months after planting. Also note the submerged and floating aquatic vegetation which forms rafts that also damaged the plantings.

More marsh around LA-0039 Year 6 Willow Lake 2 was converted to open water and opened up to Willow Lake after Hurricanes Laura and Delta in 2020. No plantings were observable in the post hurricanes aerial imagery from September 2020, and breaches from Willow Lake formed in vulnerable areas where a couple of area plantings were installed (Figure XX-6). The already weakened plantings were susceptible to removal by the hurricanes. This observation was confirmed during the three-year post construction monitoring in July 2021; however, whether or not the plantings had survived by the 2020 hurricane season is unknown.

Figure XX-6. Aerial imagery from Google Earth shows that more of the marsh around LA-0039 Year 6 Willow Lake 2 was converted to open water and opened up to Willow Lake following the 2020 Hurricane season (see Figure XX-1 for comparison to 2018). The imagery is dated as 09/28/2020.

C. Conclusions

Overall, the plantings at LA-0039 Year 6 Willow Lake 2 had lost about half of the plantings within 7 months after planting. The plants that did survive did not robustly expand as hoped by a year after planting. Rafts of aquatic vegetation and chronically high water conditions provide difficult growing conditions. Most plantings were absent by three years after construction after continued poor growing conditions and the hurricane season of 2020.

1. Project Effectiveness

As per the project goals:

- Area plantings of bullwhip in small open water ponds did not survive and expand to increase vegetation.
- Hedge Row plantings across narrow strips of open water did not survive and expand.

2. Recommended Improvements

Continued planting is not recommended for this site because of the unfavorable water level, aggressive aquatic vegetation, and weak water-bottom substrate conditions.

If planting is considered in the Willow Lake area, consider planting *Zizaniopsis miliaceae*, which may be more tolerant of aquatic vegetation rafting.

3. Lessons Learned

Large stands of California bulrush were pushed over and smothered by floating vegetation. The occurrence of large mats of floating vegetation is attributable to recent mild winter temperatures. Planning for additional resources to be implemented for floating invasive species control may need to be considered in future plantings.

XXI. Year 6 – Belle Isle Lake

Prepared by Mark Mouledous – CPRA Lafayette Regional Office

A. Site and Planting Description

Belle Isle Lake, a Year 6 planting site for the Coastwide Planting project (LA-0039) is located in Vermilion Parish. The project area is located within Belle Isle Lake, southwest of Little Vermilion Bay, within the Audubon Society's property. Belle Isle Lake was bisected west to east by navigation channel, and cell terraces were constructed to trap the resulting sediment flow. The objective of the plantings is establishing perennial emergent vegetation in open-water areas devoid of vegetation and/or in areas with sparse annual vegetation between terraces and re-establish relict terraces. The secondary objective is shoreline protection along the rim of Belle Isle Lake.

The areas that were planted are categorized as shallow open-water habitat, with some very sparse emergent vegetation and cell terraces. Approximately 2.27 acres of area plantings and 10,390 linear feet of row plantings were planted within the project area. The plantings were designed to create wave breaks in the open-water areas. Approximately 1,100 vegetative plugs of *Spartina alterniflora* 'Vermilion' (Vermilion smooth cordgrass), and 9,360 trade gallons of *Schoenoplectus californicus* (California bulrush), were planted in the Belle Isle Lake project area. The majority of plantings were installed in June 2018, except for three five row groups and three additional single rows that were installed in September 2018, due to the contractor running short of plants. Plantings were conducted following the guidelines listed below:

Spartina alterniflora was planted as open-water area plantings in parallel rows seven feet (7') apart planted on seven-foot (7') alternating centers. The specific area plantings were designed to occupy some of the open water areas within the northeastern portion of Belle Isle Lake in various depths (Figure XXI-1).

Schoenoplectus californicus was planted in groups of five rows five feet (5') apart on five-foot (5') alternating centers. The planting row alignments were either designed to bisect some of the open water areas within terrace cells or were planted parallel to the shoreline around Belle Isle Lake (Figure XXI-1).

Schoenoplectus californicus was planted in paired rows three feet (3′) apart on five-foot (5′) alternating centers. The planting row alignment was designed to revegate relict terraces that had eroded in the northern portion of Belle Isle Lake (Figure XXI-1).

Excess *Schoenoplectus californicus* were planted in single rows parallel to and five feet (5') from some of the five row plantings on five-foot (5') alternating centers (Figure XXI-1).

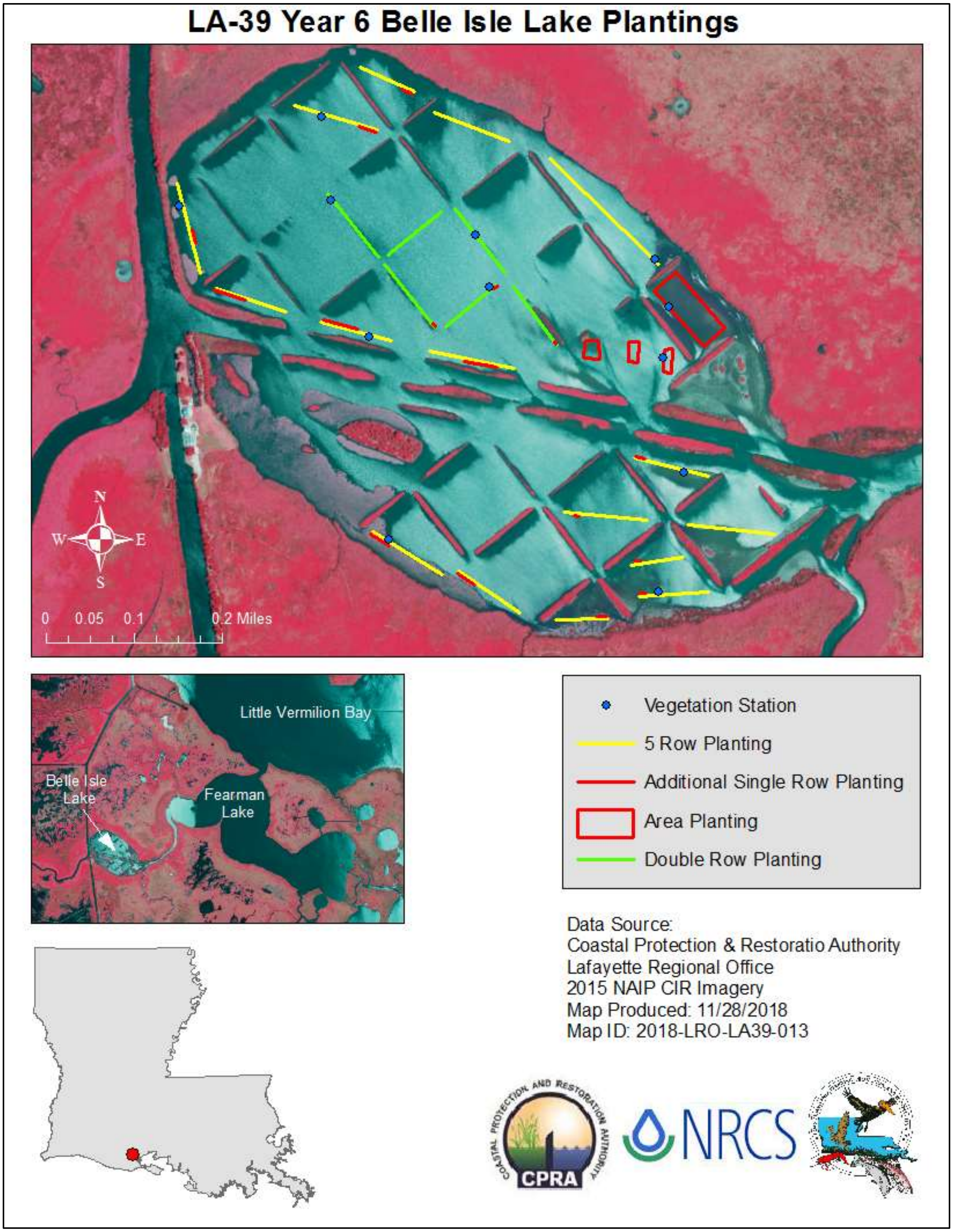

Figure XXI-1. LA-0039 Year 6 Site – Belle Isle Lake Plantings site map showing location of plantings and vegetative monitoring stations. All row plantings consist of *Schoenoplectus californicus*, and area plantings consist of *Spartina alterniflora*.

B. Monitoring Activity

1. Monitoring Goals

The goals of the Belle Isle Lake plantings are:

- Area plantings of *Spartina alterniflora* will exceed 50% survival and expand on mudflats between terraces.
- Terrace plantings of *Schoenoplectus californicus* will exceed 50% survival and maintain the terrace footprint.
- Five row plantings of *Schoenoplectus californicus* within terrace cells will exceed 50% survival and expand on mudflats between terraces.

2. Monitoring Elements

The monitoring elements include procedures to assess plant survival, effects on the planting area, and the recruitment of any other emergent marsh vegetation to the area. Vegetation stations were intended to monitor planting survival and vegetative cover throughout the LA-0039 Year 6 Belle Isle Lake planting area over time. Plantings were assumed to have 100 % survival when planted. Vegetation monitoring occurred near the end of the first growing season in October 04, 2018 and one-year after planting on June 12, 2019. Three-year post-planting monitoring is scheduled for June 2021.

Vegetation Assessment

To assess planting status, an ocular estimate of survival and plant condition was conducted for each area and planting type while visually inspecting the site during sampling visits. Planting survival and percent vegetative growth data were also collected at the vegetation station level; 12 stations were established with a PVC pole marking the start of the station (Figure XXI-1). Percent survival was calculated from ten (10) plants at each vegetation station; plants were characterized as live or dead/absent. Vegetative growth was assessed by measuring percent cover of species present, vegetative stand height, and height of dominant species at 4 m^2 vegetation plots at the vegetation stations (Folse et al. 2014). Flooding depth and surface water salinity were also collected at all sampling stations during each sampling event. Conditions occurring outside of the stations and segments including additional species, marsh interspersion, and site-specific points of interest were noted along with photographic documentation.

Area Planting: A vegetation was established within two (2) of the *Spartina alterniflora* area plantings to assess different planting depths.

Double-Row Terrace Planting: A vegetation station was established at three (3) of the *Schoenoplectus californicus* double rows along relict terraces.

Five-Row Hedge Planting: A vegetation station was established along seven (7) of the *Schoenoplectus californicus* five-row hedges.

Planting Failure/Success Causation

Hydrologic data from CRMS0535-H01, located southeast of Belle Isle Lake, is used to describe area water-level and salinity trends. The water level data will be tied to water depths collected within the planting areas to convert water depth (ft) to planting elevations (ft, NAVD88 Geoid 12A) to estimate innundation in the project area.

3. Monitoring Results and Discussion

a. Vegetation Assessment

The ocular estimates of the planting area captured the overall performance of the plantings. The plantings in the vegetation stations at the Belle Isle Lake LA-0039 planting locations have performed exceptionally well, with survival rates over 75% as of June 2019 (Table XXI-1). The three planting types have reacted similarly over time, with depth being the biggest influence on performance.

Area Plantings
The *Spartina alterniflora* area plantings overall have performed well but individually have performed differently based on depth of planting. Near the end of the first growing season, the plantings at all four areas had 100% survival, though a gradient in plant size was noted, with larger plants in shallower areas (Table XXI-1, Figure XXI-5a). The plantings in Area 4 were the most robust of the area plantings and this coincided with the shallowest depths (Figures XX-5c and XX-5d). By the one-year post planting in June 2019, though cover and height of the vegetation had increased on average, the deeper areas had decreased to 50% survival and were stressed (Figures XX-3 and 4). Plantings were healthy and expanding at bottom elevations about 0.25 ft (NAVD 88) but thinned out where it was deeper (Figure XXI-5b).

Double Row Plantings
The *Schoenoplectus californicus* double-row plantings overall have performed well but individually have performed differently based on depth of planting. Near the end of the first growing season, the plantings had 87% survival, with a gradient in plant size noted, with larger plants and higher survival in shallower areas (Table XXI-1, Figure XXI-6a). By the one-year post planting in June 2019, overall survival had decreased to 77%, but the remaining plantings had increased in cover and height, again with larger plants in shallower areas (Figures XXI-3, 4, and 6b).

Five Row Plantings
The *Schoenoplectus californicus* five-row plantings overall have performed exceptionally well but individually have performed differently based on depth and to a lesser extent, firmness of the soil. Near the end of the first growing season, the plantings had near 100% survival (Table XXI-1). The plantings in the southern portion of the planting area were taller and more robust, which coincided with shallower depths and firmer soils than the northern side (Figure XXI-7b). The lowest survival and smallest/thinnest plants were growing in the open water of the northwestern project area (Figure XXI-7a). Water levels were deepest here and pond bottoms were soft. By the one-year post planting in June 2019, overall survival had decreased only slightly to 92%, and the remaining

plantings had increased in cover and height; on many of the rows, the plantings had grown together and individual plantings were indistinguishable (Figures XXI-3, 4, and 7c).

Table XXI-1. Overall Percent Survival of LA-0039 Year 6 Belle Isle Lake plantings were estimated over time.

	Overall Survival (%)		
Planting Type	June/Sept 2018*	Oct 2018	June 2019
Area plantings	100	100	80
Double Row Terrace plantings	100	86.67	76.67
Five Row Hedge plantings	100	96.67	91.67

*Area, Double Hedgerow, and all but 3 groups of Five Row were planted in June 2018. The remainder of plantings were planted in September 2018.

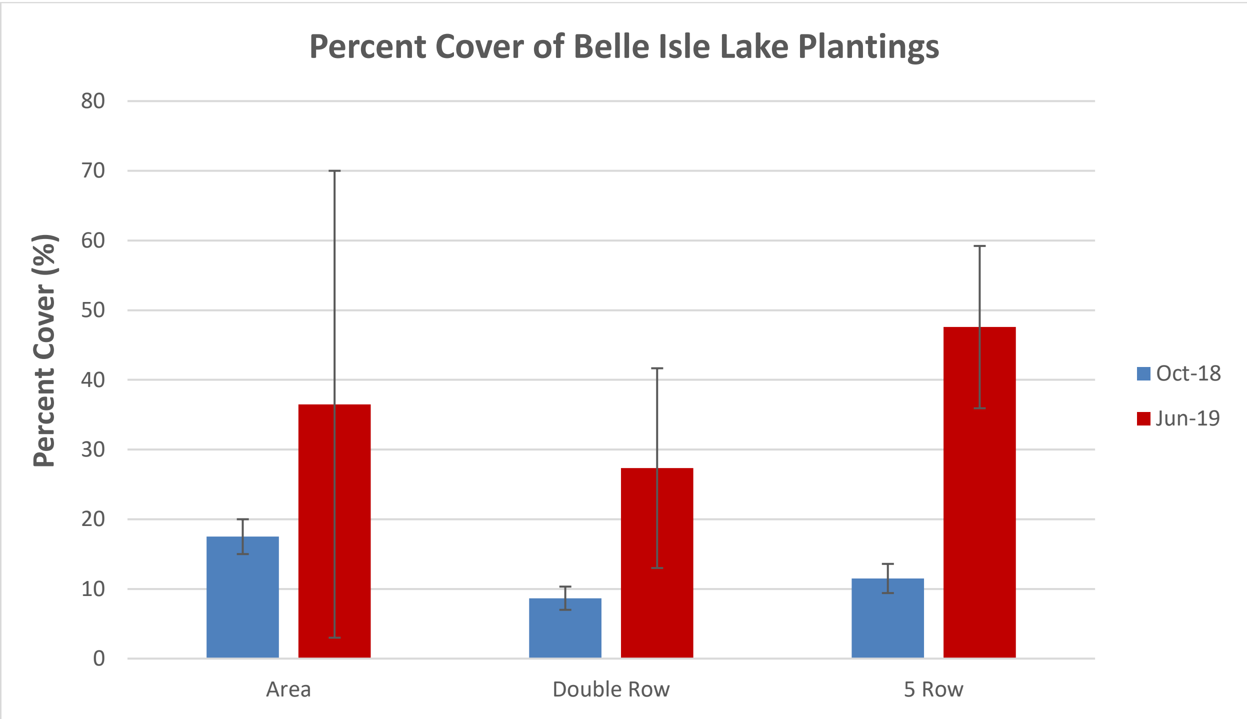

Figure XXI-3. Percent cover collected from vegetation stations at LA-0039 Year 6 Belle Isle Lake October 2018 and June 2019 by planting type. Error bars represent standard error.

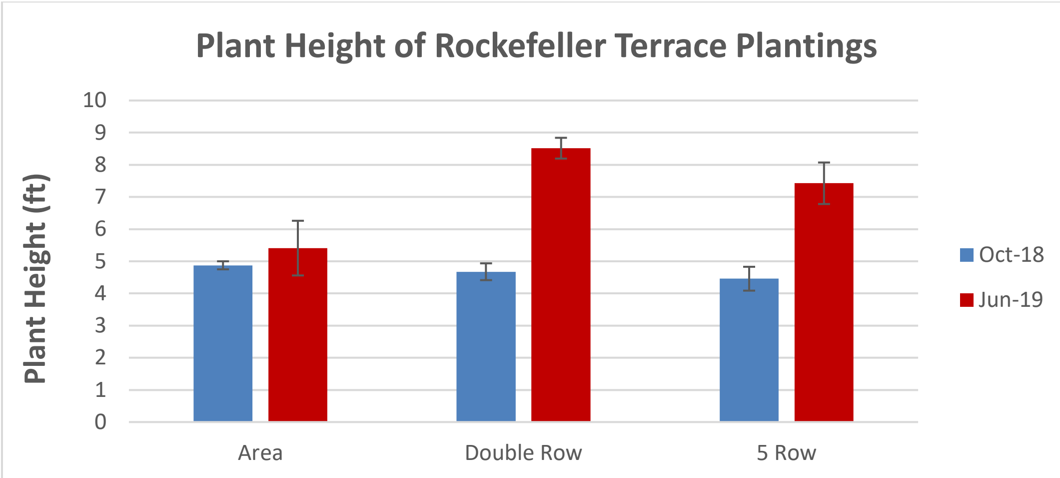

Figure XXI-4. Plant Heights collected from vegetation stations at LA-0039 Year 6 Belle Isle Lake October 2018 and June 2019 by planting type. Error bars represent standard error.

Figure XXI-5. Photos of *Spartina alterniflora* Areas 1 and 2 plantings in 2018 (A), Area 3 plantings in 2019 (B), Area 4 plantings in 2018 (C) and 2019 (D) at LA-0039 Year 6 Belle Isle Lake.

Figure XXI-6. Photos of *Schoenoplectus californicus* Double Row plantings in 2018 (A) and 2019 (B) at LA-0039 Year 6 Belle Isle Lake.

Figure XXI-7. Photos of *S. californicus* Five Row Plantings in 2018 at northwestern corner of project area (A), southern part of project area in 2018 (B), and southern part of project area in 2019 (C) at LA-0039 Year 6 Belle Isle Lake.

b. Planting Failure/Success Causation

Hydrologic data for the Belle Isle Lake plantings was obtained from CRMS0535 from June 2018 through June 2019 (Figure XXI-8). The optimum range for smooth cordgrass 'Vermilion' strain establishment is 1-18 inches (Fine and Thomassie 2000). This threshold was exceeded for the deeper plantings on multiple occasions and even though many survived, they didn't thrive as well as the plantings in the shallower locations (Figure XXI-9). As mentioned in the vegetation assessment section, 0.25 ft NAVD 88 and shallower appeared to be the optimum planting elevation as the plants started to thin out below this elevation. Salinities were within the tolerance range of 0.4 – 22.5 ppt for the entire period of record (Fine and Thomassie 2000).

Optimal water depth for establishment of *S. californicus* is 1 to 2 feet (Materne and Fine 2000). The deeper plantings on the double rows and five rows were often above this threshold, with a mean inundation of 2.15 ft, while the shallower plantings rarely exceeded it (mean inundation 0.85 ft). This was reflected in the monitoring data that showed much more vigorous growth in the shallower areas of the project (Figure XXI-9). Mean salinities for the area were below 4 ppt and even though they briefly spiked to over 10 ppt in August 2018, did not affect the plantings.

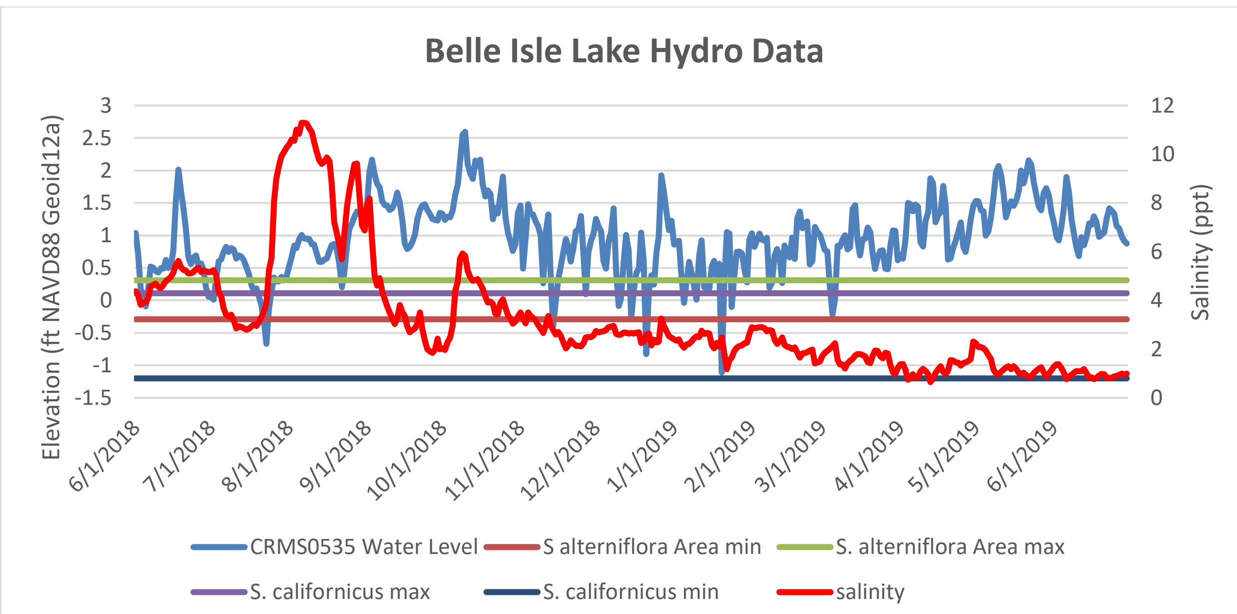

Figure XXI-8. Mean daily water elevation and salinity at CRMS0535 graphed with the estimated minimum and maximum planting elevations of the *Spartina alterniflora* area plantings and the *Schoenoplectus californicus* row plantings at LA-0039 Year 6 Belle Isle Lake.

Figure XXI-9. Aerial imagery taken almost two (2) years after planting of LA-0039 Year 6 Belle Isle Lake shows the robust row (*Schoenoplectus californicus*) and area (*Spartina alterniflora*) plantings in shallower water and less robust, stressed plantings in deeper water. See site map for planting layouts (Figure XXI-1).

C. Conclusions

The LA-0039 Year 6 Belle Isle Lake plantings has been successful through its first two years. Overall, the three planting types have survived and expanded. Decreases in survival occurred in deeper planting locations. At ideal depths, the plantings have flourished.

1. Project Effectiveness

As per the project goals:

- Area plantings of *Spartina alterniflora* have exceeded 50% survival and expanded on mudflats between terraces.
- Terrace plantings of *Schoenoplectus californicus* have exceeded 50% survival and have maintained the terrace footprint.
- Five row plantings of *Schoenoplectus californicus* have exceeded 50% survival and have expanded on mudflats between terraces.

2. Recommended Improvements

The Belle Isle Lake area would be a good candidate for future plantings of both species, but effort should be concentrated on the shallower elevations that had the most success.

3. Lessons Learned

Conditions within the Belle Isle Lake area are ideal for *Spartina alterniflora* and *Schoenoplectus californicus* establishment given the daily tidal movement, salinity range, protection from wind fetch, and replenishing sediment supply. However, selecting the correct planting elevation, even within 0.5 ft, makes a huge difference in whether the plants simply survive or thrive and expand.

XXII. Year 6 DeCade Vicinity: (Years 2, 5, and 6 Sites – DeCade Area, South Bayou DeCade, DeCade Vicinity, DeCade Area Vicinity Field Trials)

Prepared by Elaine Lear– CPRA Thibodaux Regional Office

A. Site and Planting Description

The LA-0039 Year 6 DeCade Vicinity plantings coalesces plantings from planning Years 2, 5, and 6. The plantings sites are in Terrebonne Parish west of Lake DeCade and around Bayou DeCade; some of the plantings overlap the earlier Year 1 South Lake DeCade plantings. The site is in intermediate marsh (1988-2013) and has experienced a high rate of land change rate of -0.85% per year (1985-2010) (Couvillion et al. 2011; CPRA 2017). The planting site is within the CWPPRA project boundaries of TE-44 North Lake Mechant Landbridge Restoration, which protects the area from gulf tidal conditions to the south, and TE-34 Penchant Natural Resources Basin Plan Increment 1, which delivers freshwater and sediments from the north (CPRA 2017). Years 2, 5, and 6 sites will be presented concurrently because planting efforts spatially and temporally overlap (Figure XXII-1). Years 2 and 5 plantings were installed and inspected in fall 2016. The Year 6 planting was installed and inspected in spring 2018.

Section 1 – Year 2: These consist of nine (9) **deepwater** plantings with alternating rows of two-gallon-sized *Phragmites australis* and *Schoenoplectus californicus* spaced 10 ft apart planted on 10 ft alternating centers on each row. Each test section had 6 rows with 11 plants per row. In addition, four (4) **area polygons** of *P. australis* trade gallons were planted in staggered rows spaced 10 ft apart with plants on 10 ft centers.

Section 2 – Years 2 and 6: A mix of single-row (Year 2), double-row (Year 6), and triple-row (Year 6) plantings of *S. californicus* trade gallons were installed to protect the southern shoreline of an open-water/formerly marsh area along north of the northern shore of DeCade Bayou. The rows were planted on five-foot centers starting adjacent to the existing marsh. Subsequent rows were spaced five feet apart with plants on alternating centers.

Section 3 – Years 5 and 6: Single- and double-row plantings of *S. californicus* trade gallons were installed in the same area south of Bayou DeCade as LA-0039 Year 1 South Lake DeCade. Single- and double-row plantings from Year 6 were installed to protect interior shoreline and fill in open areas south of Bayou DeCade. The single row was planted on three-foot centers adjacent to the existing marsh. Double rows were planted parallel to the shoreline on 5-foot centers with 15 or 20 feet spacing between rows. Further south, similar single- and double-row plantings were installed to provide stability to broken marsh platforms for Years 5 and 6 plantings.

Section 4 – Years 2 and 6: A mixture of interior shoreline plantings and an area planting of *S. californicus* trade gallons were installed to protect existing marsh behind the high-energy, western rim of Lake DeCade. The Year 2 area planting was installed in parallel rows four feet apart planted on five-foot alternating centers. Year 2 double rows had two-feet spacing between rows and planted on two-foot alternating centers. The Years 2 and 6 triple rows had five feet between rows planted on five-foot centers. All plantings started adjacent to the marsh existing along the lake rim. The Year 6 triple row replaced the northern-most Year 2 triple row.

Section 5 – Year 6: A small field trial of larger-sized (3 and 10 gallon) *S. californicus* plants in different alignments (grid and row) were installed in deepwater plots between broken marsh near the southwest shoreline of Lake DeCade. The four sections consisted of two, 10 × 10 ft grids planted on five-foot centers and two, 50 ft rows planted on 10-ft centers; each alignment was planted with either 3 or 10-gallon sized plants.

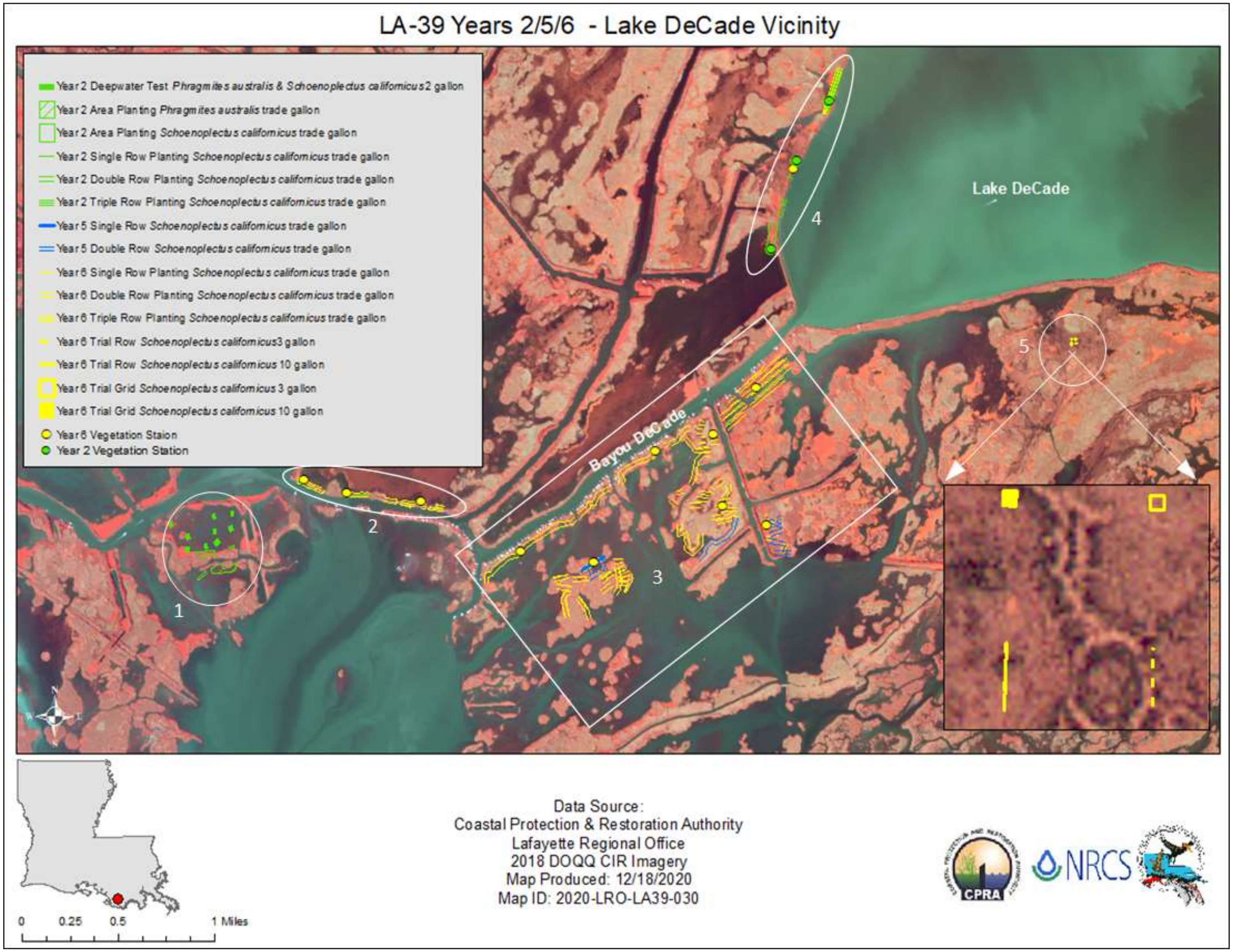

Figure XXII-1. LA-0039 Year 6 DeCade Vicinity plantings coalesced plans from Years 2 (green), 5 (blue), and 6 (yellow); the location of plantings and monitoring stations are displayed.

B. Monitoring Activity

1. Monitoring Goals and Objectives

The LA-0039 Year 6 DeCade Vicinity plantings were designed to reinforce submerged and broken marsh platforms (area and perimeter plantings), protect existing marsh (interior shoreline plantings), and vegetate open-water areas (deepwater, area, double row plantings, and field trials).

The goals of the plantings in the area of Lake DeCade and Bayou DeCade are:

Section 1: Year 2 deepwater plantings of two-gallon sized *P. australis* and *S. californicus* will survive and expand to vegetate deeper, open-water areas.

Section 1: Year 2 open-water area plantings of *P. australis* will survive and expand in shallower open-water areas to revegetate submerged marsh platforms.

Section 2: Interior near-shoreline segments planted with single, double, and triple rows of *S. californicus* from Years 2 and 6 will survive and expand to establish vegetation to widen and reinforce shoreline along the northern bank of Bayou DeCade..

Section 3: Single and double rows of *S. californicus* plantings (Years 5 and 6) will survive and expand to establish vegetation on submerged marsh platforms in open areas to reinforce shoreline broken marsh along the southern bank of Bayou DeCade.

Section 4: A mixture of interior shoreline plantings and an area planting of *S. californicus* (Years 2 and 6) will survive and expand to establish vegetation to protect existing marsh along the high-energy western rim of Lake DeCade.

Section 5: A small field trial will test the survival and growth of 3 and 10-gallon *S. californicus* plants (Year 6) in deepwater plots to vegetate open water areas between broken marsh south of the southwest shoreline of Lake DeCade.

2. Monitoring Elements

In order to assess survival and expansion in all areas, a limited number of vegetation stations were randomized within the time and budget constraints of the projects. Qualitative observations as well as photographs were utilized to describe and document the success of the various planting configurations over time. Although the plants were installed at different times (Years 2 in fall 2016, Year 5 in fall 2016 and spring 2018, and Year 6 in spring 2018), all LA-0039 Year 6 DeCade Vicinity plantings were monitored on the same schedule for logistical purposes. Monitoring was conducted in spring 2018 and fall 2019; future monitoring is scheduled for fall 2021.

<u>Vegetation Assessment</u>

To assess the plantings and their effect on the planting areas, planting survival (%) and emergent vegetation cover (%) was collected for years 2018 and 2019 where possible. Depending on the planting configuration, site-level planting survival estimates were based upon a baseline number of planted rows and the number of plants within those rows when initially installed, as-builts and initial site visits were used to determine baseline numbers. In addition to planting survival, vegetative cover was conducted one week, one year and either two or three years after plant installation. Station-level percent survival was calculated from 10 plants at each vegetation station; plants were characterized as live (any green vegetation) or dead/absent. Vegetative cover data includes cover of emergent vegetation (%), cover of species present (%), vegetative stand height (ft), and height of planted species (ft) within a 4 m^2 vegetation station (Folse et al. 2014). Flooding depth, surface water salinity, and temperature were collected at all sampling stations during each sampling event when time and budget constraints allowed. Conditions occurring outside of the stations and segments including additional species were also noted along with photo documentation.

Section 1: A. (Deep, open-water plantings) have an as-built baseline count of 33 *S. californicus* and 33 *P. australis* plants in alternating rows in each of the nine deepwater sections from which to calculate survival. Sections were also described qualitatively and photographed, particularly where survival could not be determined following subsequent expansion and/or loss of individual plants. Average water depths were taken in each section. **B. (Open-water plantings)** progression over time was documented mainly qualitatively through photographs due to time constraints.

Section 2: (**Interior bayou shoreline segments)** have three (3) randomized vegetation stations located inside the triple and double rows of *S. californicus*. Plantings were also documented qualitatively and through photographs.

Section 3: (Open water and broken marsh plantings) have seven (7) randomized vegetation stations located inside the single and double rows of *S. californicus*. This area was expansive and some years of plantings overlapped, so these plantings were also described qualitatively and photographed, particularly where survival could not be determined following subsequent expansion and/or loss of individual plants. Average water depths were taken throughout this area.

Section 4: (Interior lake shoreline segments and one area polygon planting) have three (3) randomized vegetation stations located inside the triple and double rows of *S. californicus* and also one station inside the area polygon. Some years of plantings overlapped, so these plantings were also described qualitatively and photographed, particularly where survival could not be determined following subsequent expansion and/or loss of individual plants. Average water depths were taken throughout this area.

Section 5: (Deep, open-water field trial) has survival data for one year post-planting. Each orientation (nine-plant grid or six-plant row) and plant-size (3 or 10 gallon) combination had one replicate. Plants were also documented photographically and average water depths were taken at each replicate.

<u>Planting Failure/Success Causation</u>

The water level data from CRMS0398-H01 was compared to discrete water depths taken on the date of vegetation data collection to describe flood conditions. Salinity means will be used to determine whether they were within an acceptable range for the planted species. Photographic documentation will also be used to describe processes of planting success and failure.

3. Monitoring Results and Discussion

a. Vegetative Assessment

Based on available vegetation station data, between the 2018 and 2019 data collection periods, the overall mean percent cover of the planted species *S. californicus* increased by almost 35%, from a mere 4.5% to 40%, while mean plant height almost doubled. Mean survival decreased by almost 30% (Figure XXII-2). Qualitative field observations from both years and the included photographs tend to support this overall trend where survival was not very high, but the plants that did survive were healthy and expanding in size and cover.

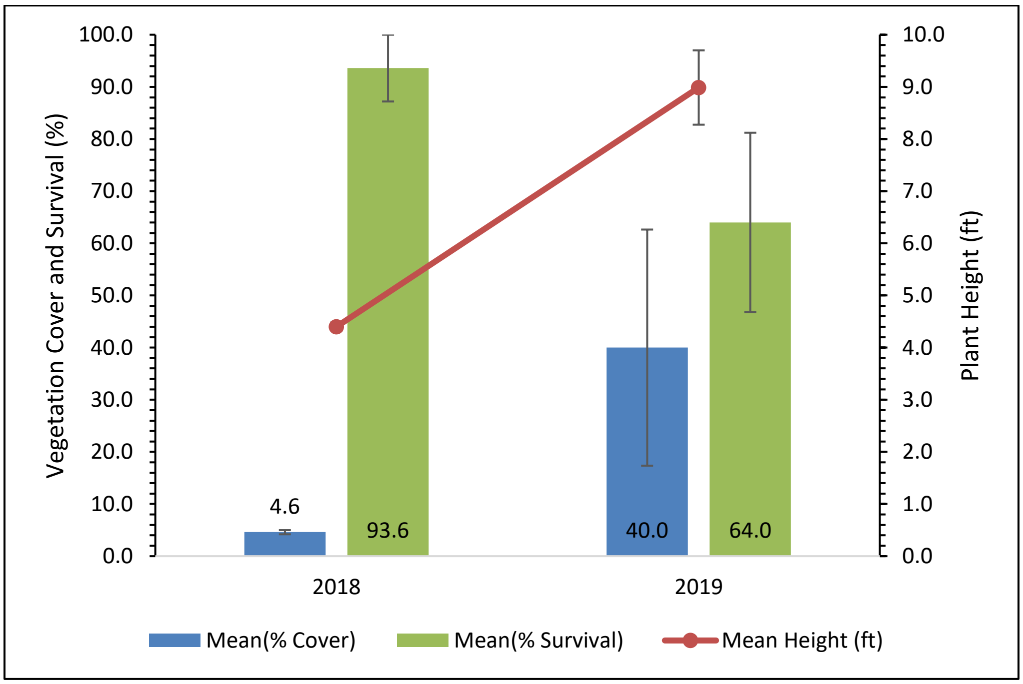

Figure XXII-2. Overall results for the LA-0039 Year 6 DeCade Vicinity plantings from vegetation stations. Means and standard errors were calculated for percent cover and Survival (columns, left y-axis) and planting height (line, right y-axis) using vegetation stations with available data for both years.

Plantings along the western rim of Lake DeCade where the shoreline breached and subsided did not fare as well as the interior shoreline plantings along Bayou DeCade where there was some protection from the effects of wind fetch and boat wakes.

Section 1: (Open Water Plantings in two configurations):

Deepwater Plantings:
Each of the nine deepwater test sections were planted with two-gallon sized plants. Plants were installed in rows 10 feet apart with alternating 10 foot centers. Rows alternated between *S. californicus* and *P. australis*. For survival data collection purposes a baseline number of 66 plants (six rows with eleven plants per row), 33 *S. californicus* and 33 *P. australis* plants were used per section (Table XXII-1).

Overall survival remained below 30% throughout the sections and water depths ranged from 2.15 to 3.2 feet. There were no surviving *P. australis* by 2019. Photos indicating typical survival in some of the deepwater test sections are shown in Figure XXII-3. It is important to note that floating aquatic vegetation (FAV) was moderately present during both years of data collection, while submersed aquatic vegetation (SAV) was largely present in 2018, but not as prevalent by 2019. Survival remained the same for 4 of the 9 sections and decreased slightly for 5 of the sections.

Table XXII-1. Estimated percent survival and water depth of planted species at each of the nine deepwater test sections in Section 1 of the LA-0039 Year 6 DeCade Vicinity.

Test Section	Average Water Depth (ft)		Estimated Overall Section Survival (%)		Estimated *Roseau* Survival (%)		Estimated *Bulwhip* Survival (%)	
	2018	2019	2018	2019	2018	2019	2018	2019
1	2.15	2.3	25.75	21.21	0	0	51.51	42.42
2	2.75	3.2	1.5	1.5	0	0	3.0	3.0
3	2.65	2.8	10.60	4.54	0	0	21.21	9.09
4	2.77	2.7	16.66	15.15	3.03	0	30.30	30.30
5	2.7	2.8	4.54	4.54	0	0	9.09	9.09
6	2.46	2.4	15.15	15.15	0	0	30.30	30.3
7	2.45	2.5	28.78	27.27	3.03	0	54.54	54.54
8	2.85	3.2	22.72	15.15	0	0	45.45	30.3
9	2.75	3	4.54	4.54	0	0	9.09	9.09

Note: Estimated overall Section survival is an average of both Roseau and Bulwhip survival.

Open-water Area Plantings:
Area plantings consisted of four large open-water polygons planted with trade gallon size *P. australis* as part of the Year 2 plantings. The plants were installed on parallel rows ten feet apart on ten foot alternating centers in fall 2016. Among the four areas, only three live plants were observed in spring 2018, and had expanded into low-growing clumps along the water surface in Area 3, in 2019 one healthy clump in Section 2-Auxillary, and one spindly plant in Polygon 3 were observed. Water depths ranged between 2.2 to 3.1 feet in 2018, with a similar range in 2019; the surviving plants were mid-depth (2.3-2.6 ft deep). SAV was thick in 2018 in most of the areas, but by 2019 its presence was not as noticeable. Sporadic mats of FAV were also noted by field crew in both years. Photos indicating typical survival in some of the area plantings are shown in Figure XXII-4.

Figure XXII-3: Selected deepwater test sections from LA-0039 Year 6 DeCade Vicinity showing typical survival and expansion of planted vegetation between 2018 and 2019 data collection periods.

Figure XXII-4: Photographs were taken in open-water areas in Section 1 where *P. australis* plantings were found in 2018 and 2019 data collection periods at LA-0039 Year 6 DeCade Vicinity plantings.

Section 2 (Interior near-shoreline segmentss north of Bayou DeCade Shoreline):
Seven segments consisting of a variety of layouts of trade gallon *S. californicus* were planted north of Bayou DeCade along the shoreline spoil bank. Five of the segments were triple-row plantings from Year 6 planted in spring 2018. Two of the segments were double-row plantings from Year 2 planted in fall 2016. One of the double-row Year 2 segments had an overlapping single row added in spring 2018 during the Year 6 plantings.

Three randomized vegetation stations were located along this stretch of the bayou among these mixed plantings; two stations were in the Year 6 triple rows, and one station was in the Years 2 and 6 combination triple row. Qualitative observations and photographs were taken to document the condition and success of the plantings. Figure XXII-5 shows vegetation station data means for the two years of data collection, 2018 and 2019. FAV was present in both years, but not as prevalent as in the south of Bayou DeCade.

Survival of the planted species was 76% in 2018. By 2019 the surviving plants expanded into indistinguishable rows to the extent that individual plants could not be differentiated. Mean percent cover of the plantings increased by 44% between 2018 and 2019, and the plants increased in mean height by approximately four feet (Figure XXII-5). Qualitative field observations in 2019 indicate that there were segments with gaps where plants should have been, and the rows nearest to the shoreline were more successful than those farther out from the shoreline edge. Photographs depict typical plant conditions and survival at the time of data collection for both years (Figure XXII-6).

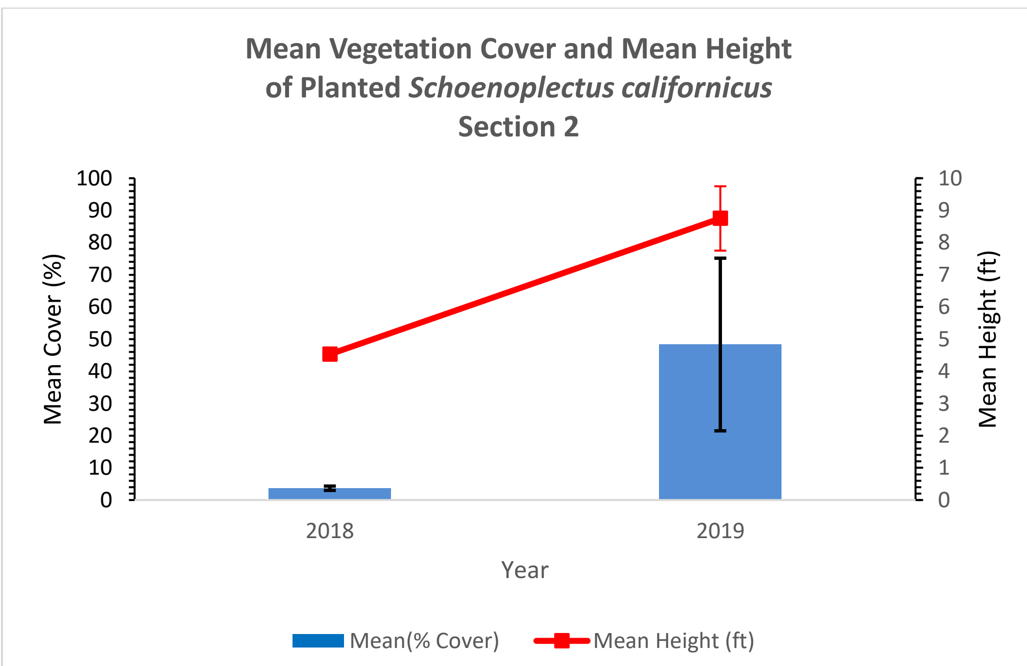

Figure XXII-5: Vegetation cover and plant heights at the Section 2 interior shoreline plantings north of Bayou DeCade at LA-0039 Year 6 DeCade Vicinity plantings. Values are means and standard errors from three vegetation stations.

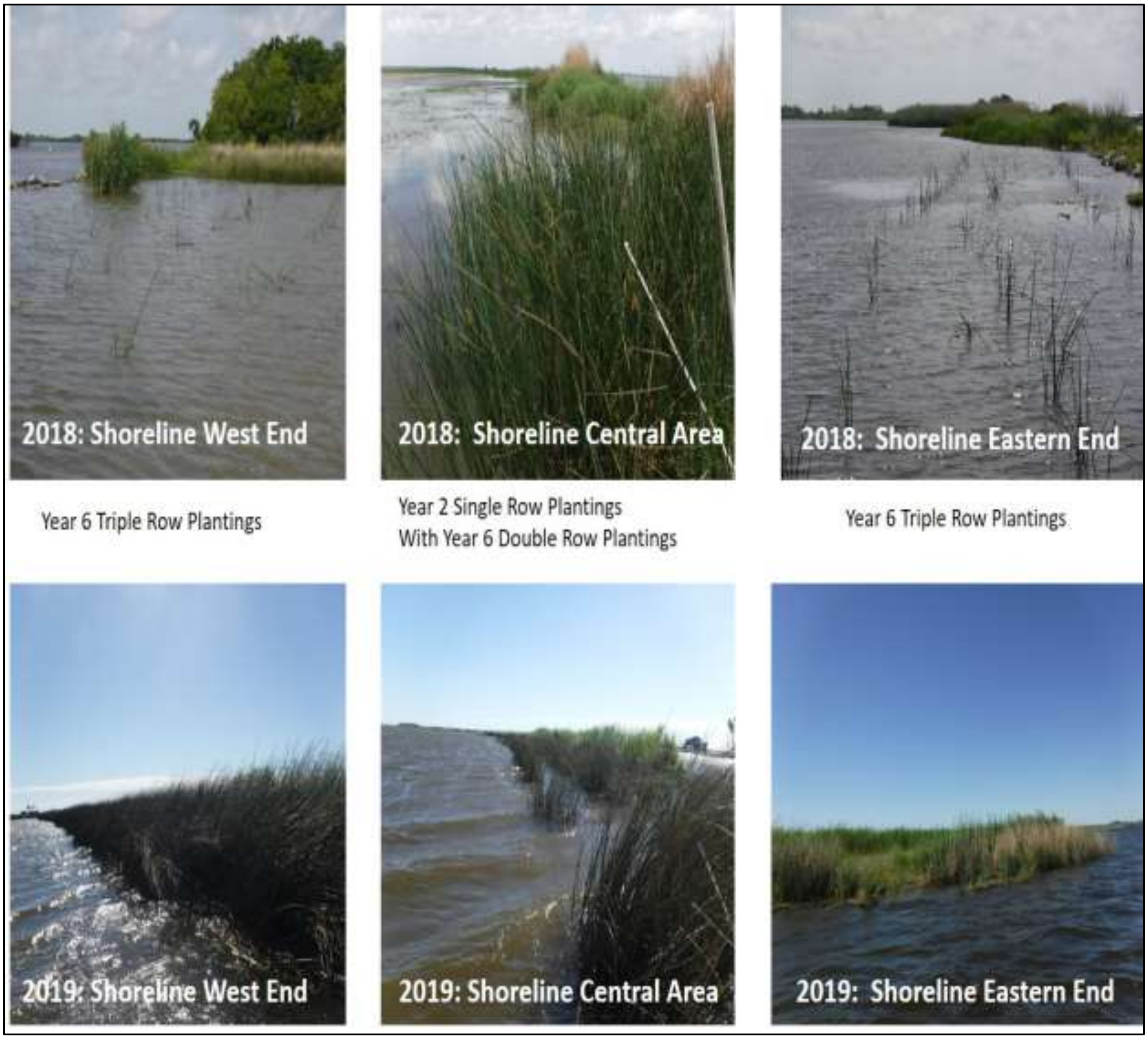

Figure XXII-6: Year 2 (installed fall 2016) and Year 6 (installed spring 2018) plantings were photographed in 2018 and 2019 at the Section 2 interior shoreline plantings north of Bayou DeCade at the LA-0039 Year 6 DeCade Vicinity plantings.

<u>Section 3 (Open-water shoreline and broken marsh plantings):</u>
The seven randomized vegetation stations in Section 3 were located among primarily double rows of *S. californicus* plantings for Year 6 (Figure XXII-1). The Section 3 expanse contains open water areas punctuated with broken marsh platform. The ten foot double rows were installed interior to and along the south shoreline of Bayou DeCade. The fifteen foot double rows were located among the broken marsh and open water areas. Two single rows were along the perimeter of a broken marsh island and along the interior southern shoreline of Bayou Decade in the western quadrant of Section 3.

At the seven stations, survival was 100% in 2018 and decreased by 2019 to 56%. Mean vegetation cover of the surviving *S. californicus* tripled from 6 to 18% between the 2018 and 2019 data collection periods. The remaining plantings more than doubled in mean height from four (4) to nine (9) feet (Figure XXII-7). Qualitative field observations and photographs (Figures XXII-8 and 9) were utilized to aid in determining the health and success of the plantings where no vegetation stations were established. Survival of the plantings outside of established stations appeared to be performing similarly to the stations. Though the surving plants expanded in width and height, no solid, continuous, dense hedgerows have formed. In this section, the substrate remains highly organic. Moderate FAV, mainly *Ceratophyllum demersum* (coontail) and *Valisneria americana* (tape grass) was observed throughout the entirety of Section 3. This section is expansive and punctuated by small marsh remnants dominated by *P. australis* and *Spartina alterniflora* (cordgrass) stands which are expanding in size each year.

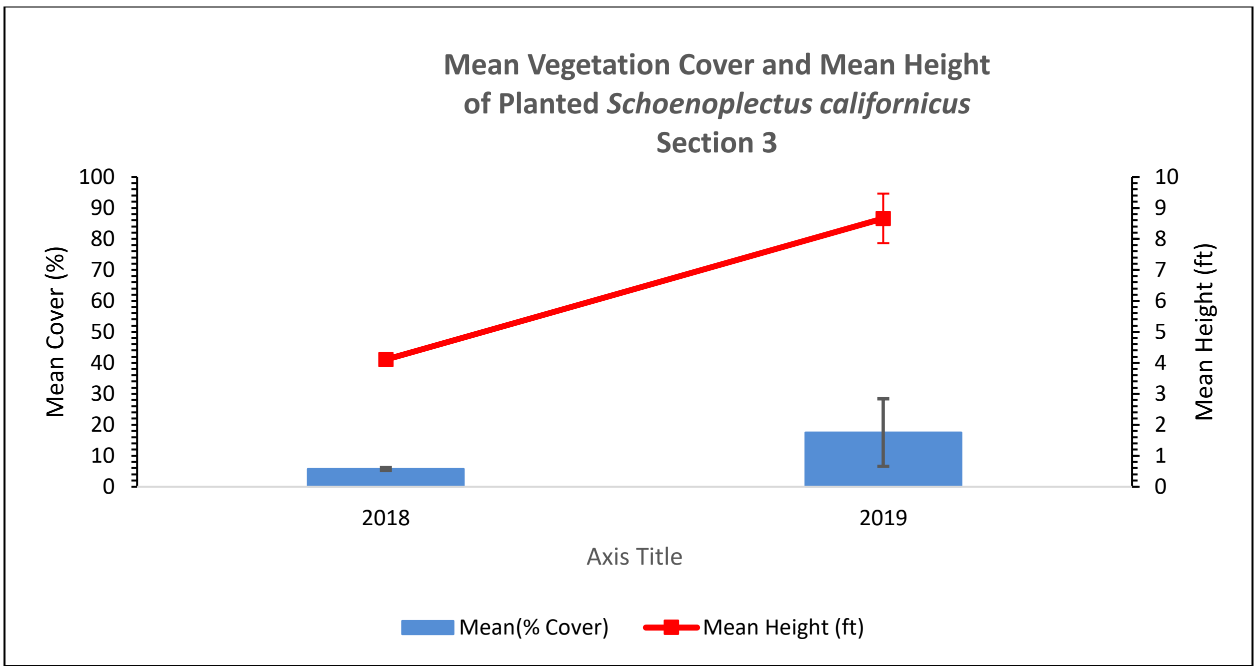

Figure XXII-7. Vegetation cover and plant heights at the Section 3 plantings in LA-0039 Year 6 DeCade Vicinity plantings. Values are means and standard errors from seven vegetation stations.

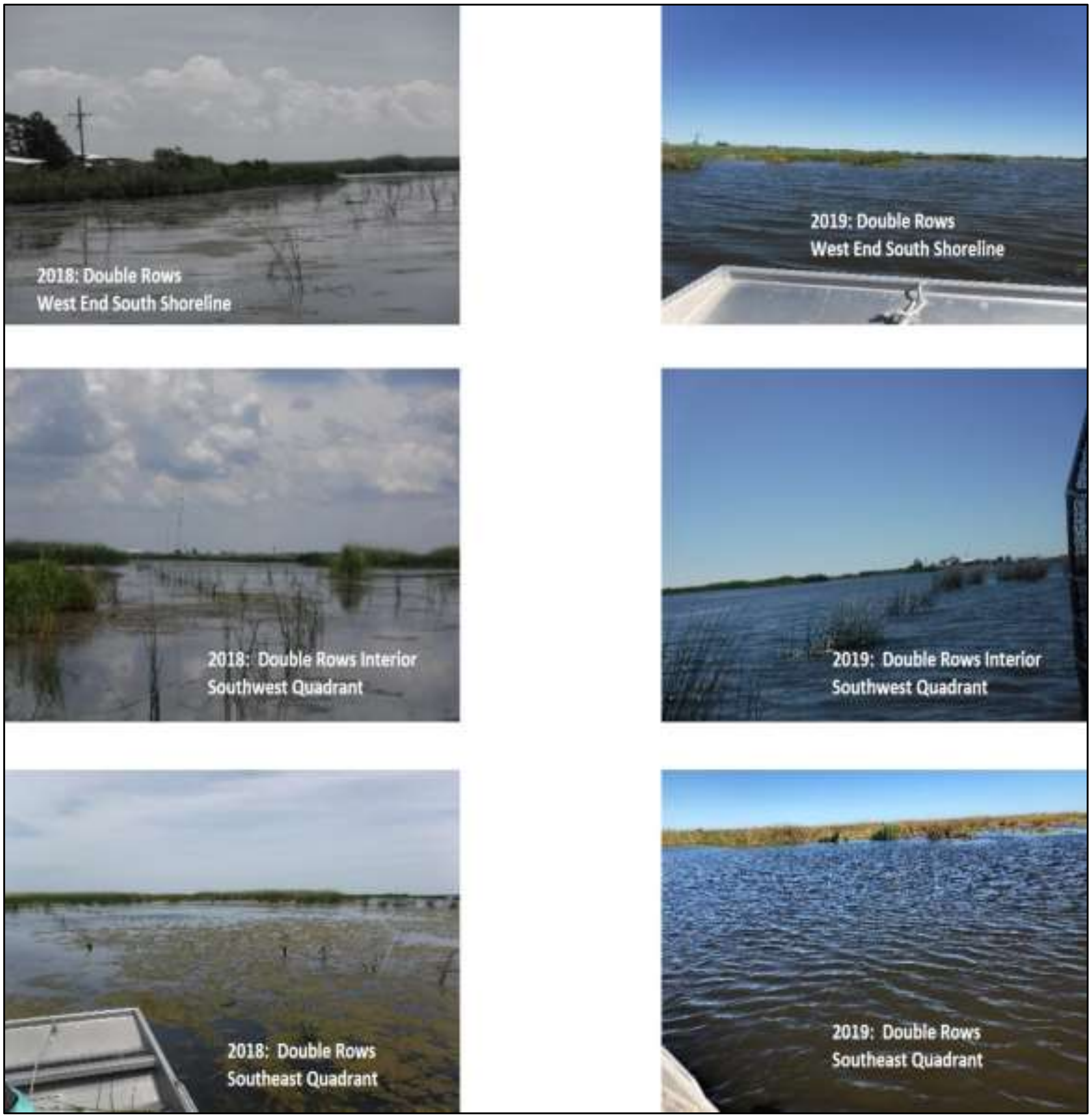

Figure XXII-8: Year 6 DeCade Vicinity open water and shoreline plantings south of Bayou DeCade (Section 3) for the 2018 and 2019 data collection periods.

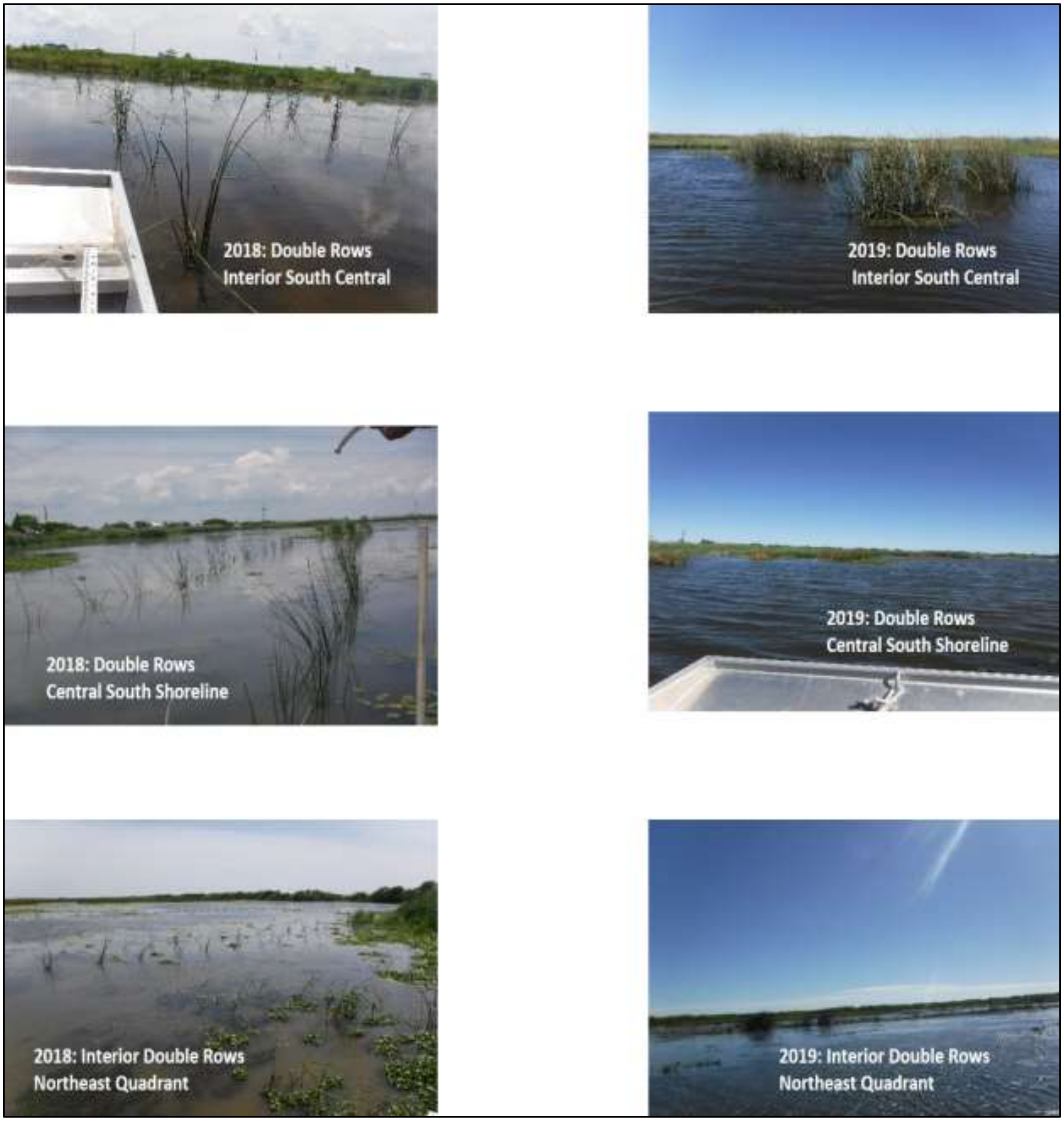

Figure XXII-9: Year 6 DeCade Vicinity open water and shoreline plantings south of Bayou DeCade (Section 3) for the 2018 and 2019 data collection periods.

Section 4 (Lake Rim Plantings):

Where plants expanded into clumps making it impossible to count live dead or absent for survival determinations, the field crew attempted to capture overall survival through qualitative field observations and photographs. Overall, the triple row plantings survival was estimated to be approximately 30% in 2018 and decreased to about 20% survival by 2019. Survival of the double row plantings remained around 15% between 2018 and 2019. The Year 2 polygon planting to the south decreased from about 60% to approximately 20% survival. The spoil bank that separated the plantings from Lake DeCade had eroded between monitoring trips, and the plantings were vulnerable to high wave energy.

Three randomized stations are located inside the overlapping triple rows from Years 2 and 6. These rows were installed just inside the spoil bank in open water along the lake rim. There is also one station inside the Year 2 area polygon to the south of the triple rows. No randomized vegetation stations were inside the Year 2 double row plantings (Figure XXII-1).

At the vegetation stations, vegetation cover and height decreased between the two data collection periods by 45% and two feet, respectively (Figure XXII-10). Vegetation stations only within the row plantings followed the same overall trend in both cover and height. The vegetation station in the area polygon plantings to the south had no surviving plants in 2019 therefore, no trend could be determined for height or cover statistically. However, qualitative observations inside the polygon did support the overall decline in cover and height of the survivors.

Large clumps of *Zianiopsis miliacea* were naturally recruiting into the area polygon to the south. The lake rim plantings experienced very high levels of FAV presence. Photos for the lake rim shoreline plantings are presented in Figure XXII-11.

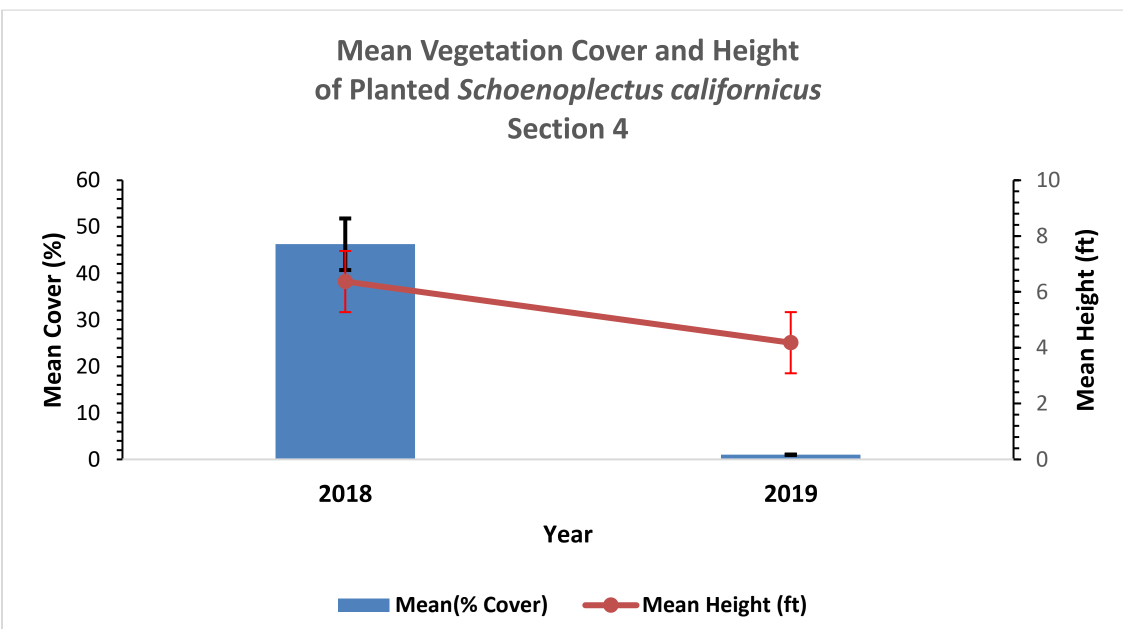

Figure XXII-10. Vegetation cover and plant heights at the Section 4 plantings in the LA-0039 Year 6 DeCade Vicinity plantings. Values are means and standard errors from four vegetation stations.

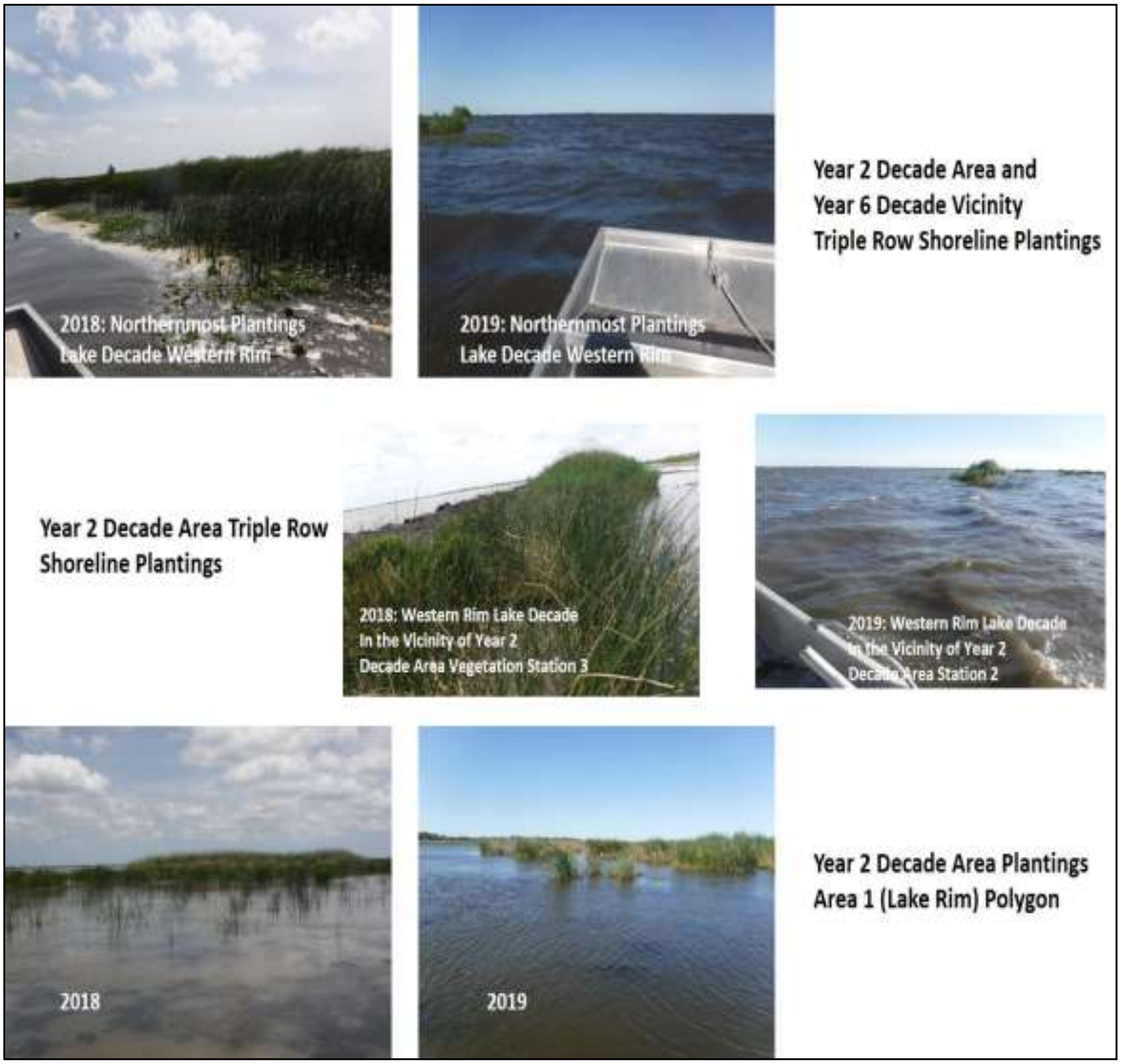

Figure XXII-11: Years 2 and 6 plantings along the Lake Decade western shoreline (Section 4) for the 2018 and 2019 data collection periods in the LA-0039 Year 6 DeCade Vicinity plantings.

Section 5 (Field Trial Plantings):

In May 2018, fifteen 3-gallon and fifteen 10-gallon *S. californicus* for trial in deep water (2.5+ ft) were installed in two configurations: 1) two, 10 × 5 ft three-row grids (one 3-gallon, one 10-gallon), and 2) two single-rows with plants on 10 ft centers (one 3-gallon, one 10-gallon). Survival and plant height data of the plantings were collected in October 2019.

Survival and average stem height was highest in the 3-gallon grid, while there were no survivors in the 10-gallon single row plot (Table XXII-2). 67% of the plants survived in the 10-gallon grid and the 3-gallon single row plots. Water levels were very similar across the board. Figures XXII-12 and 13 contain photos from 2018 (as-builts) and 2019 (1.5 years post planting). At this time, the 3 gallon-sized plants are out performing the 10-gallon sized plants, and the grid orientation is out performing the row.

Table XXII-2. Year 6 field trials consisted of different sized plants (3 and 10 gallon) installed in different planting types (3-Row Grid and Single Row) in deeper than typical water for a planting. Data collected on October 23, 2019, 1.5 years after planting, were planting counts to calculate survival and average stem height.

Size (Gallon)	Type	Water Depth (ft)	Planted	Live	Survival	Stem Height (ft)
10	Grid	3.4	9	6	67	6.6
3	Grid	3.4	9	7	78	8.1
10	Row	3.5	6	0	0	NA
3	Row	3.5	6	4	67	7.7

Figure XXII-12. Year 6 DeCade Vicinity 3-gallon field trial plantings for the data collection periods in 2018 and 2019.

Figure XXII-13. Year 6 DeCade Vicinity 10-gallon field trial plantings for the data collection periods in 2018 and 2019.

b. Hydrology

Utilizing the CRMS0398-H01 adjusted water level and salinity data, monthly means were calculated throughout a five year range and graphed alongside the average plantings elevations in the five areas throughout the LA-0039 Year 6 DeCade plantings (Figure XXII-14). All plants were installed in open water. The surrounding marshes were periodically flooded throughout the years, but the plantings were continuously flooded. The optimum water depth for *S. californicus* survival is 1.0 foot, with an acceptable range of 0.8 to 2.0 feet (Neill 2020). Pulses of inundation to 3.0 feet are tolerable for short periods of time. All of the plantings fell within the acceptable water depth range, with the exception of the field trial plantings in Area 5. Mean salinity at CRMS0398-H01 was 1.19 ppt and ranged from 0.17 ppt to 4.58 ppt throughout the five-year period. Salinities were within the acceptable tolerance range for *S. californicus* (0-5 ppt) (Neill 2020). The ideal water level for healthy *P. australis* growth is 0.5 feet above or below the marsh surface elevation, and this species tolerates moderate salinities (Magee 2020). The low survival of *P. australis* (only installed in Area 1) can be attributed to continuous inundation of the plants above their tolerance range.

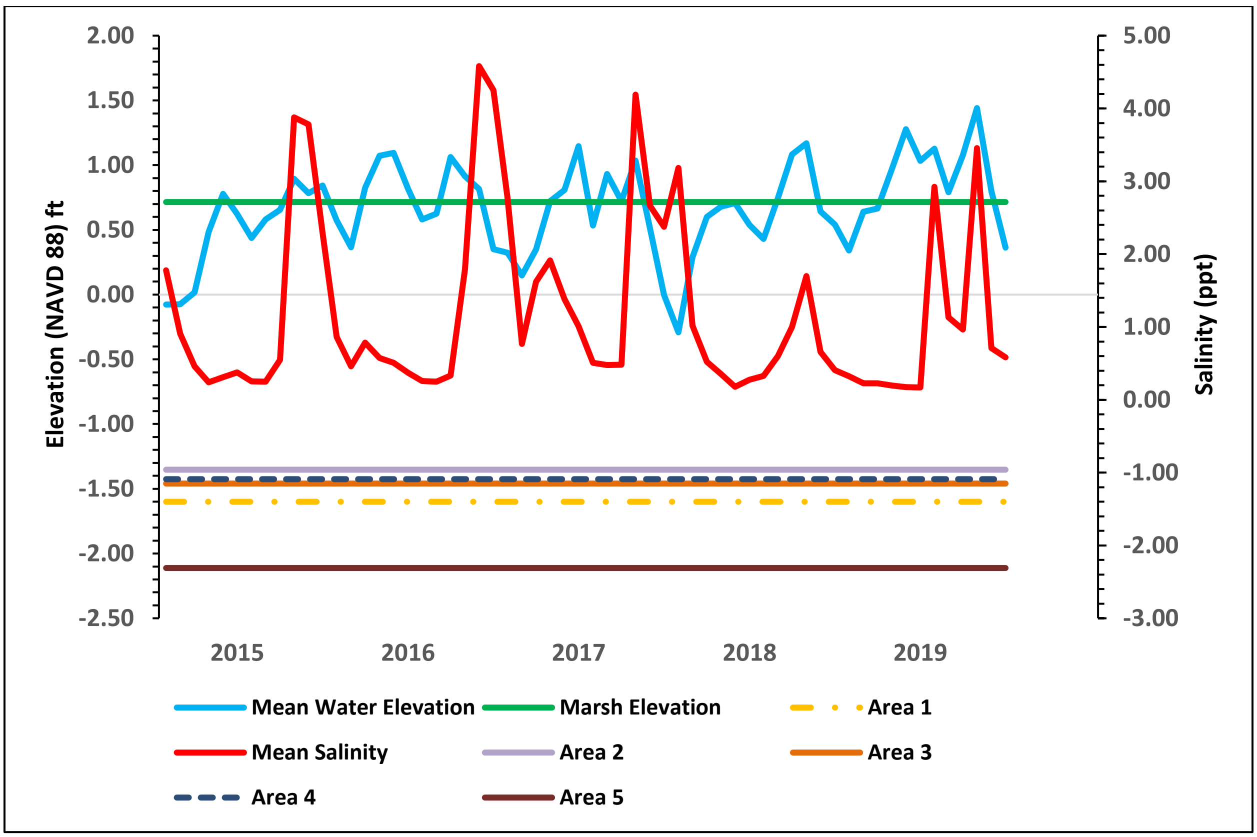

Figure XXII-14. Five-year timespan of average monthly water elevations (left y-axis) and salinity (right y-axis) from CRMS0398-H01 are plotted relative to average planting elevations (left y-axis) measured throughout the Year 6 DeCade Vicinity plantings.

c. Planting Failure/Success Causation

Survival was most successful in Section 2 behind the northern shoreline of Bayou DeCade where plants were protected from wind-driven waves and boat wakes. Though large gaps existed where plants did not survive, rows nearest to the bankline formed the healthiest and most continuous solid rows of survivors. Conversely, the year 2 deepwater test sections and the area polygon plantings to the southwest (Section 1) had the lowest survival. These plantings were in large open water expanses where there was little protection from wind-driven waves, where the water levels were at the high end of inundation tolerance for the planted species, and where mats of floating aquatic vegetation (FAV) may have remained long enough to raft over them and bury them. FAV were observed in these areas north of the bayou, but not to the extent that they were to the south.

Section 3 experienced an intermediate level of success in survival, and like Section 2, the survivors expanded in size and height, but there were gaps, and even some areas where no rows were visible. The plants that did survive appeared to be robust and healthy. Water depths were lowest in this area, but plantings remained continuously flooded and subject to wind-driven waves. By the end of the growing season, FAV were very thick in much of this area and most certainly contributed to plant loss. Though CRMS0398-H01 data indicates the salinity range typically remained within tolerance for the planted species, field crews observed some stress in the southern most sections following a saltwater pulse from tropical storm activity in 2019.

Section 4 along the western rim of Lake DeCade experienced lower survival due to the shoreline breaches. Plantings were subjected to the high-energy wind-driven waves and sudden salinity and water level changes from the lake. The triple row segments had slightly higher survival than the double row configuration, but both of these configurations experienced a reduction in mean cover and height. The area polygon to the south of the row segments experienced the lowest lake rim survival due to water depths being too high and large FAV presence.

Finally, the Section 5 field trials in the deepest portion of the LA-0039 Year 6 DCV plantings had the highest survival one year post-planting. The test planting, though in open water and subject to moderate presence of FAV and SAV, was mostly successful. This test section was on a much smaller scale than the other areas, but bears further examination for expansion into shallower areas. It appears that the larger 3-gallon and 10-gallon root balls gave the plants a better chance at survival, even in the deepest of water. They appear to have withstood the onslaught of FAV and wind-driven waves moderately well. The highest survival was in the 3-gallon grid plot.

C. Conclusions

Overall, survival of the planted species *S. californicus* throughout the LA-0039 Year 6 DeCade Vicinity plantings had mixed success. The Year 2 *Phragmites australis* had no survival. In most areas, although survival decreased, surviving *Schoenoplectus californicus* plantings generally expanded in cover and height. The double row plantings along the interior shorelines of Bayou DeCade had the highest success due to protection from wind-driven waves and boat wakes. Typical-sized (1 and 2 gallon sized) plantings in deeper, open-water expanses and along the high-energy western rim of Lake DeCade had low survival; however, a small test-trial of larger *S. californicus* (3 and 10 gallon sized) in deeper (approximately 3 ft), marsh ponds had promising survival and growth results.

1. Project Effectiveness

As per the project goals:

- The goal of survival and expansion of plantings in open deepwater areas in order to reinforce marsh platform in Section 1 with the Year 2 planting effort was not successful. *S. californicus* had low survival and *P. phramites* experienced no survival. FAV presence and water depths beyond the tolerance threshold for these species contributed to lack of success in this planting.
- The goals of survival and expansion of plantings along the interior shoreline north of Bayou DeCade (Section 2) with double and triple row plantings in order to protect existing marsh was successful. Rows in closest proximity to the shoreline experienced better success and reinforced the shoreline between the spoil bank and Bayou DeCade.
- The goals of survival and expansion of plantings in order to reinforce marsh platform in broken marsh and shallow open water expanses (Section 3), and protect existing marsh behind the southern shoreline of Bayou DeCade met with moderate success. A combination of continuous indundation, wind-driven waves and FAV presence contributed to the loss of some of the plants. The double-row plantings nearest to the bayou shoreline had low success where FAV stacked up and rafted over them. Though many gaps exist in the open-water double-row plantings, survivors were robust and expanding in size, and may form enough protection to break wind fetch and dampen wave energy, provided water levels and salinities do not increase beyond the species tolerance range, and provided conditions influencing plant health (water levels, salinity, and FAV presence) remain moderate.
- The goals of survival and expansion of plantings in order to protect existing marsh behind the western Lake DeCade shoreline (Section 4), had very low success for all planting strategies (double row, triple row, and an area planting). The breaches along the shoreline rim making this area more vulnerable to wave action, heavy FAV presence, and water depths contributed to plant loss.
- The goals of testing survival and expansion in large (3- and 10-gallon) plantings in an open, deepwater area on a very small test scale (Section 5) was successful. Three-gallon plants have outperformed 10-gallon plants.

2. Recommended Improvements

Replanting interior to the shoreline along the western rim of Lake DeCade is not recommended until the shoreline can be protected or elevated to prevent breaching due to its high-energy exposure.

Replanting the interior southern shoreline of Bayou DeCade is not recommended due to the combination of heavy FAV presence and prevailing southern winds which raft the FAV onto the plantings, making it difficult for them to survive.

It is suggested that future plantings in continuously-inundated, open-water expanses between broken marsh, such as that found in Section 3, may experience increased survival by installing larger plants with more substantial root balls anchored in place. This suggestion is based upon the moderate success at the deep-water field trials in Section 5, and the lack of success with trade-gallon sized plants at the deep-water test sections in Section 1. Section 3 has the acceptable salinity range, and though water levels are for the most part within tolerance for *S. californicus*, this area experiences water depths that are at times near threshold. Larger plants and grid-like configurations may give plants the edge they need to overcome effects from FAV rafting and wind-driven waves.

3. Lessons Learned

The high-energy Lake DeCade shoreline is not conducive to plantings where it does not have substantial shoreline protection or elevation to prevent breaching.

Larger-sized *S. californicus*, grown in 3- or 10-gallon sized containers, tolerated deeper (3+ ft) planting conditions than the standard depth maximum of 2 ft. Surprisingly, the 3-gallon plants have outperformed the 10-gallon plants, but the reason is unknown. 3-gallon plants would be less expensive and easier to handle.

XXIII. Year 7 Little Vermilion Bay 2

Prepared by Bernard Wood – CPRA Lafayette Regional Office

A. Site and Planting Description

Little Vermilion Bay 2 (LVB 2), a Year 7 planting site for the Coastwide Vegetative Planting project (LA-0039), is located in two terrace fields in Vermilion Parish (Fig. XXIII-1). Both areas are within Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) project areas designed to trap sediments at the confluences of multiple water bodies including the Vermilion River, the Gulf Intracoastal Waterway (GIWW), Freshwater Bayou Canal (FBC), and Little Vermilion Bay. Both terrace projects have succeeded in creating tidal flats between and around the constructed terraces. The eastern planting area is within the ~250 acre terrace field of the Four Mile Canal Terracing and Sediment Trapping project (TV-0018), located along the western shore of the Vermilion River Cutoff Canal (VRCC), also known as Four Mile Canal, (Thibodeaux and Aucoin 2008) (Fig. XXIII-2). The western planting area is interspersed within the western side of approximately 200 acres of the Little Vermilion Bay Sediment Trapping (TV-0012) project terraces between FBC and Little Vermilion Bay (LVB) (Wood and Aucoin 2016) (Fig. XXIII-3). This is the second planting in LVB area following a successful planting for LA-0039 Year 3 Little Vermilion Bay.

A combined total of 15,930 trade gallons of *Schoenoplectus californicus* (California bulrush) were planted in the east and west planting locations by November 2nd, 2018, with the final construction inspection occurring on November 10th, 2018. These plantings included 46 double row and 6 area plantings of *Schoenoplectus californicus* in the east and west planting locations along with a few auxiliary rows from extra plants. The areas that were planted are categorized as intertidal mudflat habitat surrounded by terraces and shallow open water. The double row plantings were designed to create thick, robust hedgerows and dense areas of *Schoenoplectus californicus* along preexisting sediment flats within both the TV-0012 and TV-0018 project terraces to enhance the sediment deposition and natural recruitment of volunteer species to the area. The dominant emergent vegetation present on the terraces in the TV-0018 project area (East) pre plantings was *Typha domingensis* (southern cattail), *Schoenoplectus californicus* (California bulrush), and, to a lesser extent *Sagittaria lancifolia* (bulltongue arrowhead), combined covering approximately 25% of the project area. The dominant emergent vegetation present on the terraces in the TV-0012 project area (West) pre plantings was *Schoenoplectus californicus* (California bulrush), *Spartina alterniflora* (smooth cordgrass), and, to a lesser extent *Sagittaria lancifolia* (bulltongue arrowhead), combined covering less than 40% of the project area. The existing *Schoenoplectus californicus* and *Spartina alterniflora* vegetation in the project area were previously planted as part of the project construction, LA-0039 - Year 3 LVB, and as an ongoing effort by the Vermilion Soil and Water Conservation District office (SWCD). The plantings are designed to establish perennial emergent vegetation in areas devoid of vegetation and/or in areas with sparse annual vegetation in order to increase water bottom friction and trap sediments. Increasing vegetation in this sediment rich environment should increase water bottom elevation and the colonization of other emergent species to the area along with the enhanced survival and expansion of the *Schoenoplectus californicus* plantings.

East Plantings

Twenty-nine (29) **double rows** of *Schoenoplectus californicus* were planted in parallel rows fifteen feet (15 ft) apart with plants on five-foot (5 ft) alternating centers. The double rows ran primarily north to south and diagonally across shallow open water within TV-18 terrace cells. These plants were installed at elevations ranging from ~ -0.5 ft to -1.6 ft, with a typical elevation of ~ -0.5 ft NAVD 88 GEOID 12A. Excess plants were placed along two of the double rows for an East area total of 5,204 *Schoenoplectus californicus* trade-gallon sized plants (Fig. XXIII-2).

West Plantings

Schoenoplectus californicus trade gallons were planted in seventeen (17) **double rows** consisting of parallel rows fifteen feet (15 ft) apart with plants on five-foot (5 ft) alternating centers and in six (6) **area plantings** in parallel rows ten feet (10 ft) apart with plants on ten-foot (10 ft) alternating centers. The double row (2,710 plants) and area (8,016) planting alignments were parallel to the project terraces on the western side of the TV-12 project areas. These plants were installed at elevations ranging from ~ 0.5 ft to -1.0 ft with an average elevation of ~ -0.20 ft NAVD 88 GEOID 12A (Fig. XXIII-3).

B. Monitoring Activity

1. Monitoring Goals

The LA-0039 Year 7 Little Vermilion Bay 2 plantings were designed to create thick, robust hedgerows and dense areas of *Schoenoplectus californicus* along preexisting sediment flats within both the TV-0012 and TV-0018 project terraces to enhance the sediment deposition and natural recruitment of volunteer species to the area.

The goals of LA-0039 Year 7 Little Vermilion Bay 2 plantings are:

- Double Row plantings exceed 50% cover and moderately expand between terraces.
- Area plantings exceed 50% cover and moderately expand among the grid plantings.
- Recruit new emergent marsh species to the tidal flats in and around TV-0012 and TV-0018 plantings.

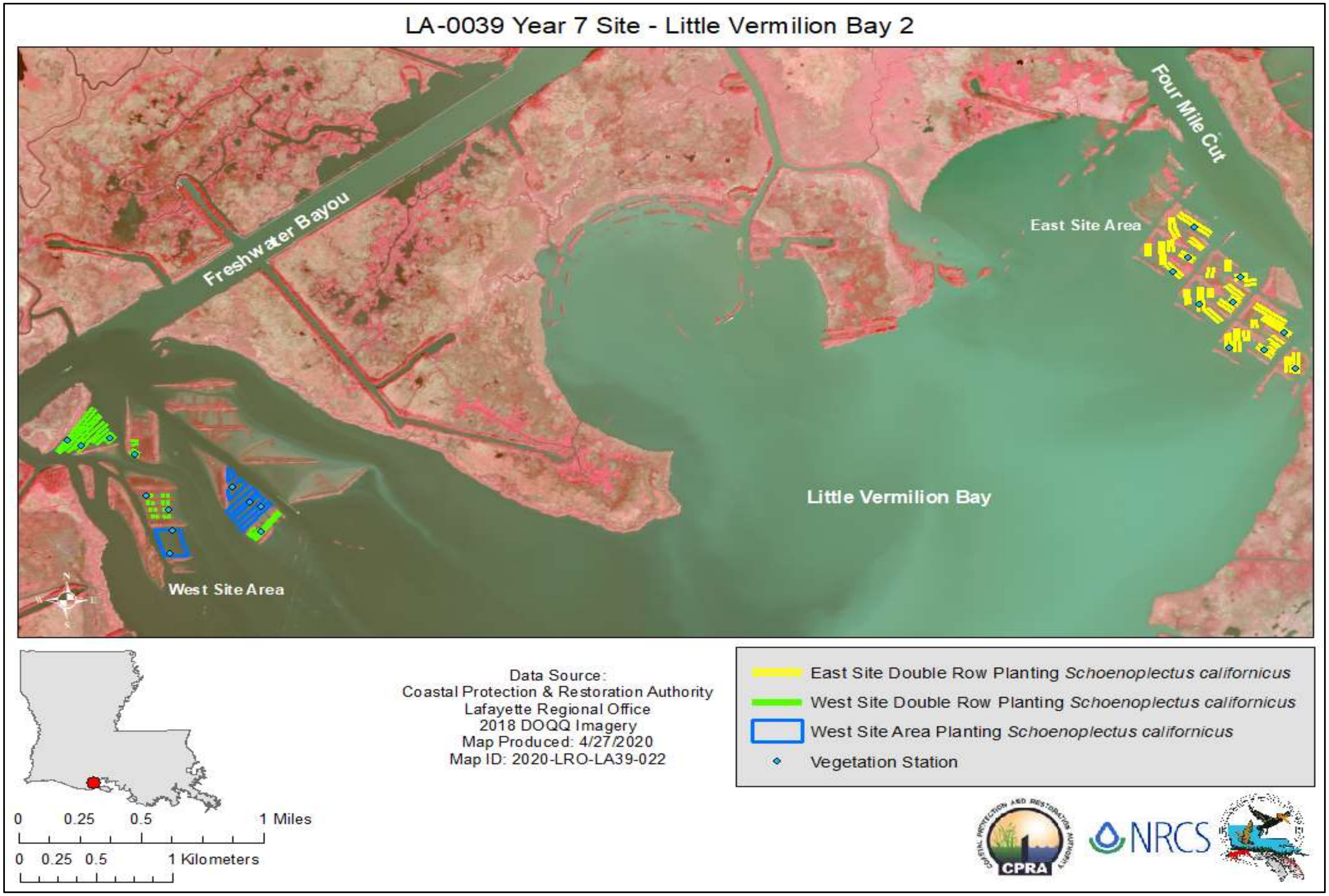

Figure XXIII-1. LA-0039 Year 7 Little Vermilion Bay 2 planting sites overview map showing location of plantings and vegetative monitoring stations. All plants were trade-gallon sized.

Figure XXIII-2. LA-0039 Year 7 Little Vermilion Bay 2 East Plantings site map showing location of plantings and vegetative monitoring stations within the TV-0018 terraces.

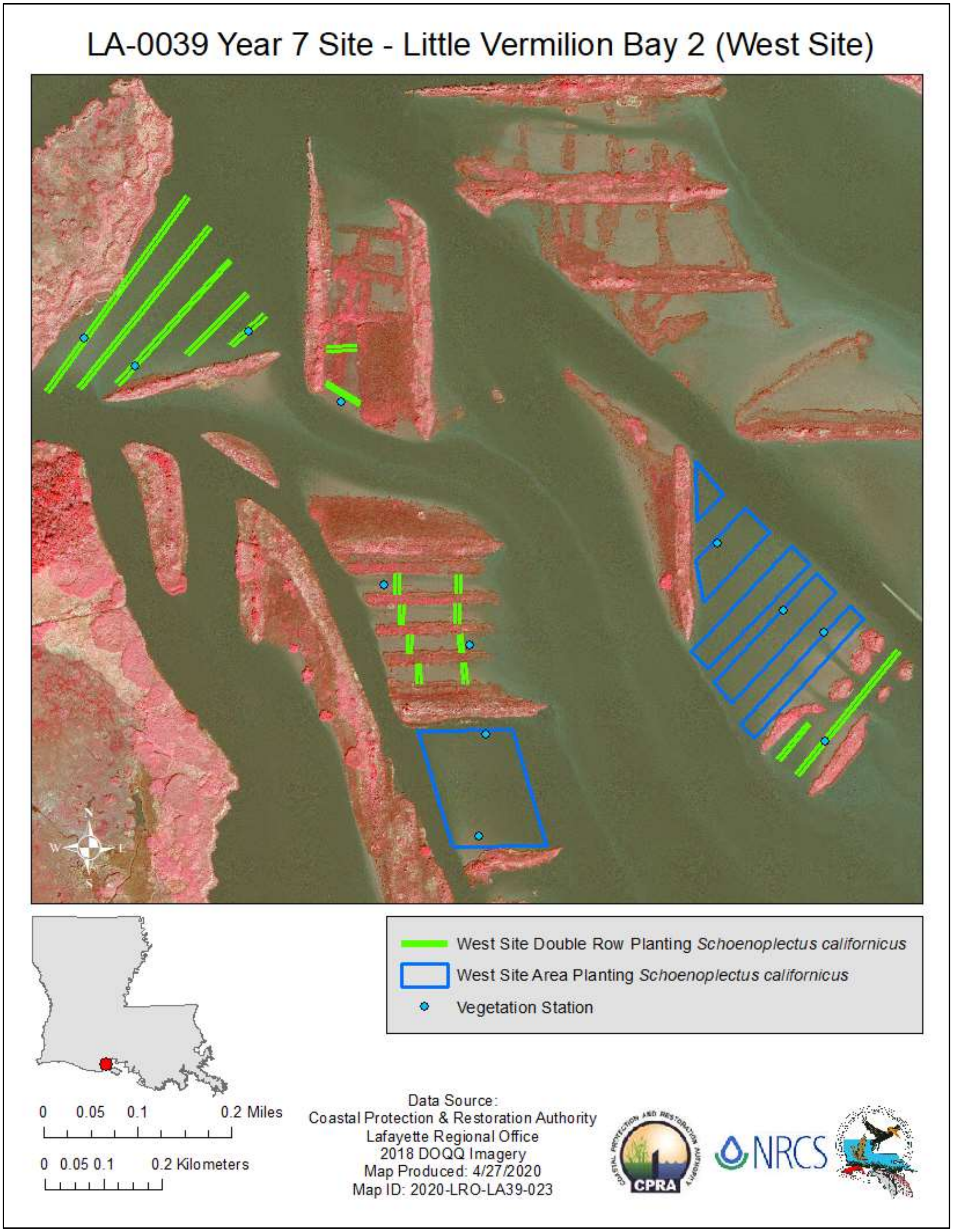

Figure XXIII-3. LA-0039 Year 7 Little Vermilion Bay 2 West Plantings site map showing location of plantings and vegetative monitoring stations within the TV-0012 terraces.

2. Monitoring Elements

The monitoring elements include procedures to assess plant survival and effects on the planting area for the project plantings and the recruitment of any other emergent marsh vegetation to the area. Vegetation stations were intended to monitor planting survival and vegetative cover representative of the double row and area plantings within LA-0039 Year 7 Little Vermilion Bay 2 project area over time. Survival of the plantings was assumed to be 100% at the time of the planting in late October/early November 2018. The plantings were monitored about six months after planting on April 23, 2019 and about one year after planting on October 24, 2019. A three-year post-planting trip is scheduled for fall 2021.

Vegetation Assessment

To assess planting status, an ocular estimate of percent survival and plant condition was conducted for each reach, segment, and/or row. Planting survival and percent vegetative cover data were also collected at the vegetation station level; stations were established randomly among live plants. Percent survival was calculated from a set number of plants at each vegetation station; plants were characterized as live or dead/absent. PVC poles were placed on both ends of the plants monitored for survival. Percent cover of species present, vegetative stand height, and height of dominant species were measured in 4 m^2 vegetation stations (Folse et al. 2014). Flooding depth, surface water salinity and temperature were also collected at all sampling stations during each sampling event. Conditions occurring outside of the stations were noted along with photo documentation.

East plantings: Ten (10) vegetation stations were established along the double rows planted within shallow open water and tidal mudflats surrounding the interior terraces of the TV-0018 terrace field. Percent survival of 10 plants per station, vegetation cover data, and plant height were recorded at each station.

West plantings: Twelve (12) vegetation stations were established in double rows (7 stations) and area (5 stations) plantings within shallow open water and tidal mudflats surrounding the interior terraces of the TV-0012 terrace field. Percent survival of 10 plants per station, vegetation cover data, and height were recorded at each station.

Hydrology

Water-level elevations from the nearby site CRMS2041, located between the West and East areas, were used to convert water depth (ft) at vegetation stations to estimated planting elevations (ft, NAVD88 Geoid 12A). The water elevations and estimated planting elevations were then used to create a water-level hydrograph depicting flood levels, duration, and frequency.

3. Monitoring Results and Discussion

a. Vegetative Assessment

Overall, the *Schoenoplectus californicus* plantings in the LA-0039 Year 7 Little Vermilion Bay 2 have performed at or beyond expectations, with plants growing together, spreading, and becoming indistinguishable from one another by a year after planting (Figs. XXIII-4 and 5). Along with these success criteria, percent survival of the original specimens was estimated at 88.3% as of the October 2019 vegetation survey (Table XXIII-1). This all took place in a high-water year, along with the damage endured from Hurricane Barry which came ashore near Little Vermilion Bay in July 2019. The lower survival in the West Double Row is attributable damages to the north-south double rows between Year 4 LVB double rows from debris, channelization, and boat traffic.

Table XXIII-1. Overall Percent Survival of LA-0039 Year 6 Little Vermilion Bay 2 plantings were estimated over time.

		Overall Survival (%)		
Plantings	Planting Type	Oct/Nov 2018	Apr 2019	Oct 2019
East	Double Row	100	93.8	96.7
West	Double Row	100	87.9	74.3
West	Area	100	95	91

Figure XXIII-4. Typical view of an area planting vegetation station in LA-0039 Year 7 Little Vermilion Bay 2 West about six months (A – April 2019) and a year (B and C - October 2019) after planting. Note *Schoenoplectus californicus* were planted on 10 ft centers.

Figure XXIII-5. View of a more protected double row across an expansive tidal flat in LA-0039 Year 7 Little Vermilion Bay 2 East about six months (A – April 2019) and a year (B and C - October 2019) after planting. C is looking down the center of the double row a year after planting.

In terms of total percent cover at vegetation stations after one year, the LA-0039 LVB 2 West plantings (~55% cover) have generally outperformed the East plantings (~40 %); the West has area plantings in addition to double row plantings and is generally more protected from wave and wake damage (Fig. XXIII-6A). The 20% increase of cover in the West is impressive in the aftermath of Hurricane Barry. Percent cover of the East stations has remained stable from the April to October 2019 sampling (Fig. XXIII-6A). The area plantings, which tend to rapidly grow together (27 % increase of cover) forming dense stands of *Schoenoplectus californicus*, were planted less densely (alternating 10 ft centers) than the double rows (alternating 5 ft centers) and, therefore, had greater potential for increasing cover (Fig. XXIII-6B). The double row planting had a slight percent cover increase but given the error around the means should be considered to have remained stable during the 2019 growing season at approximately 45% (Fig. XXIII-6B). Some of both types of planting arrangements were experiencing significant intraspecific competition at the end of one growing season, even though spacing on the area plantings had been increased over previous efforts. As the plants continue to grow, other emergent marsh species will likely recruit to the area as has happened in the previous LVB planting (Figs. XXIII-4 and 5).

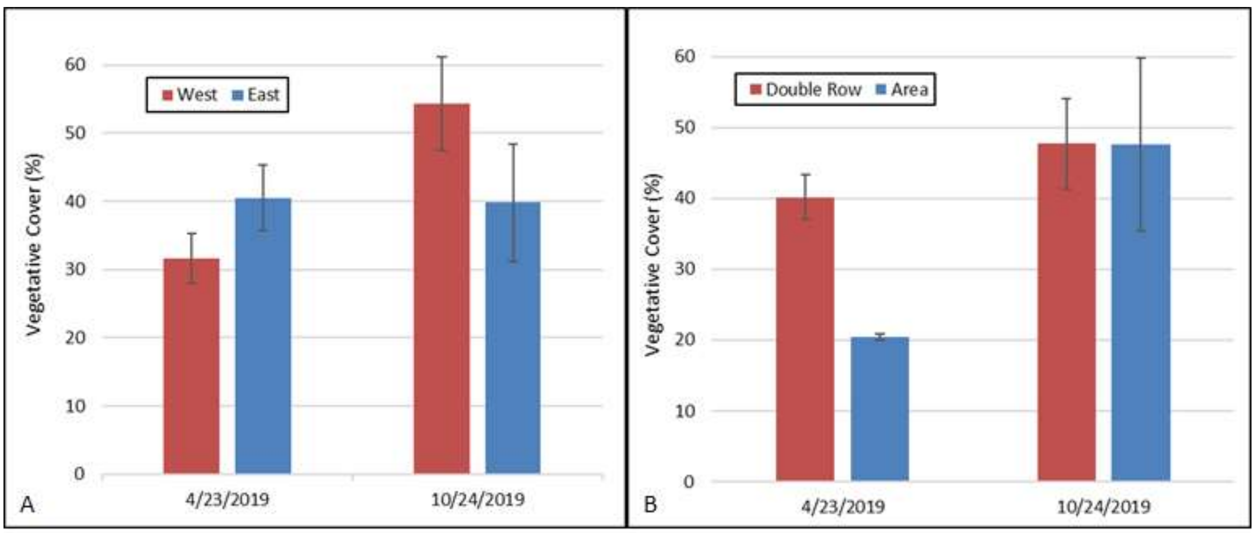

Figure XXIII-6. (A) The emergent vegetative cover at LA-0039 LVB 2 increased 25% in the West and remained the same in the East over one year, even after a significant hurricane impact. The West includes area plantings and double row plantings, whereas the East plantings were exclusively double rows. (B) Vegetative cover increased slightly in the double rows and more than doubled in the area plantings over one year, even after a significant hurricane impact. The double rows were planted more densely on 5 ft alternating centers, whereas the areas were planted on 10 ft alternating centers.

Hydrology

The water level in the planting area has become shallower near older planting efforts, but remains highly variable due to tidal action. As the older plantings have matured, sedimentation has opened new areas to potential plantings as has been the case with some of the current effort. The optimum water depth for establishment of *S. californicus* is reported as between 1 to 2 feet (Materne and Fine 2000). Water depth within this range was common place in the project area from 2018-2019 only routinely exceeding the 2 ft depth threshold for brief periods as well and draining below the planting elevation occasionally (Fig. XXIII-7). During the 2019 growing season, as previously mentioned, water levels temporarily exceeded the root zone by over four feet due to tropical storm surge. This did significant damage to some of the more exposed locations, especially in the East planting locations, as water levels were higher and the alignment of the Vermilion River Cut-off Canal provided larger wave potential (Fig. XXIII-8).

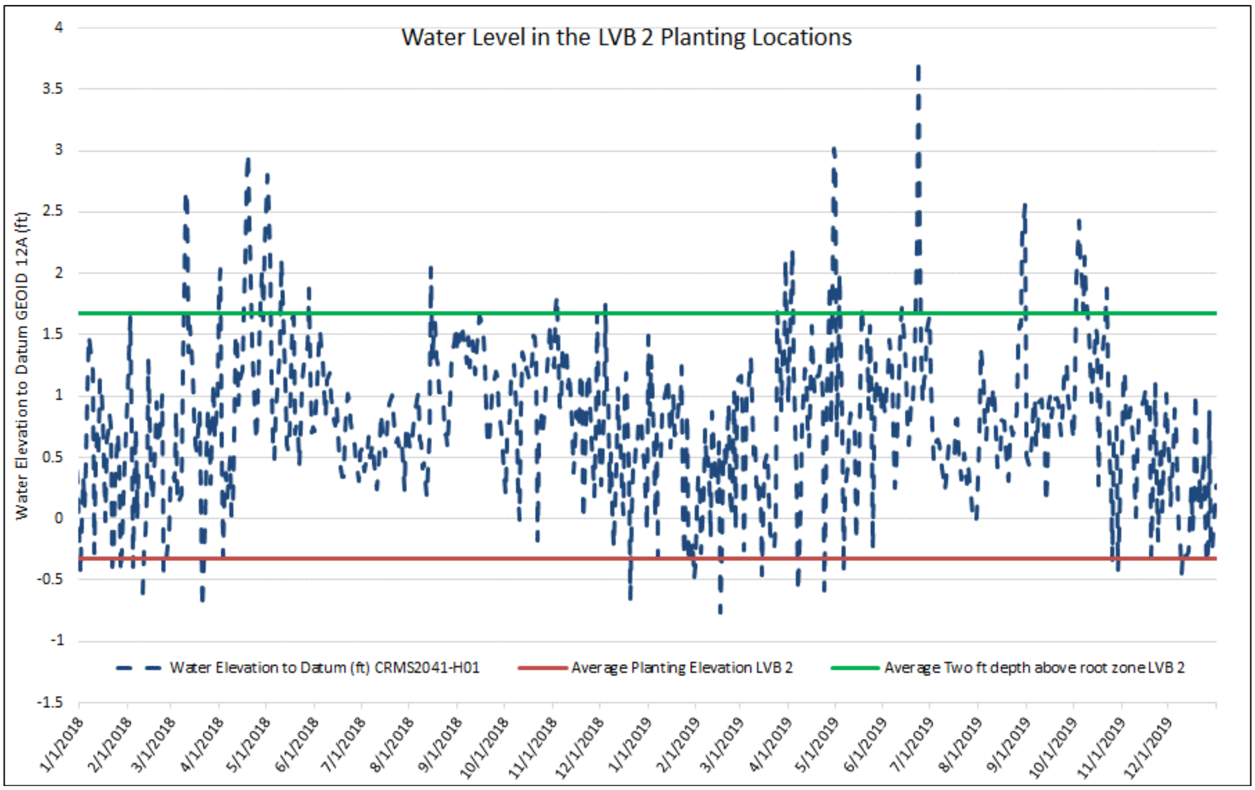

Figure XXIII-7. Hydrograph of nearby CRMS2041 displaying water levels in the LA-0039 Year 7 Little Vermilion Bay 2 planting area during 2018 through 2019.

Figure XXIII-8. Image of a LA-0039 Year 7 Little Vermilion Bay 2 East planting (double row with an additional row of auxillary plants) taken as part of the monitoring effort in October 2019. Although still alive at the time of monitoring, some planted and naturally occurring vegetation in the East suffered damage from wind and wave energy, presumably from Hurricane Barry.

b. **Planting Failure/Success Causation**

As of the fall 2019 sampling effort, there was little in the way of systemic stress-related plant failures; however, there were abundant stressed individuals among the double rows on the Vermilion River Cutoff Canal side of the east planting area and physical damage to the north-south double row segments connecting the older double rows. The East double rows were damaged in large part due to the wind and surge produced in the area via Hurricane Barry; naturally occurring plants of various species also appeared damaged. These individuals were expected to recover as of the spring of 2020, but after two devastating tropical events in the fall of 2020, those expectations are tempered. A future sampling in the fall of 2021 will help to evaluate this planting's success or failure under these unprecedented conditions. The north-south double row segments in the West were damaged by floating debris, channelization, and boat traffic between the older Year 4 LVB double rows.

C. Conclusions

1. Project Effectiveness

As per the project goals:

- Double row plantings on the tidal mudflats in LA-0039 LVB 2 have been successful, with total vegetative cover increasing from a 3% estimate at planting (Oct/Nov 2018) to near 50% after one full growing season post planting (Oct 2019).

- Area plantings on the tidal mudflats in LA-0039 LVB 2 have been successful, with percent cover increasing from a 3% estimate at planting (Oct/Nov 2018) to ~50% after one full growing season post planting (Oct 2019).

- The recruitment of new emergent plants to the LA-0039 LVB 2 plantings have not had time nor particularly agreeable environmental conditions in which to do so. However, if LA0039-Year 4 LVB is an indicator, this can be expected assuming the plantings survived the 2020 hurricane season.

2. Recommended Improvements

The density of plantings in the project area in both the area and double row planting could be further reduced in future plantings to increase the overall coverage. The area and double row plantings were experiencing significant intraspecific competition at the end of one year; wider spaced plantings could grow for a longer period of time before resource limitations decrease growth while increasing the overall project footprint.

3. Lessons Learned

It appeared that area plantings on 10 ft centers were more stable and resilient in the face of tropical forces than the double rows. This trend may not have the opportunity to be fully investigated due to the consecutive damages suffered in the LVB area during 2019 and 2020. In the more protected areas, the 10 ft spaced area plantings still appeared to endure some intraspecific competition at the end of one growing season. This could be a benefit under hurricane conditions but also may offer the potential for larger grid spacing in future area plantings on fertile, sediment receiving soils.

XXIV. Summary

A. Project Effectiveness

The LA-0039 Coastwide Planting project has successfully developed a program to facilitate a consistent and responsive planting effort in coastal Louisiana that is flexible enough to routinely plant on a large scale and be able to rapidly respond to locations of opportunity or need following storms or other damaging events. Within the traditional CWPPRA project process, the time from project selection to construction typically takes 5-10 years. Within LA-0039, a site selected for planting can be planned, bid for contract, awarded, and planted within 1-2 years. This is a much more expedited time frame than other CWPPRA projects. As such, the monitoring portion of the project must also be efficient in data collection and analysis to put information back into the planning process to move the capabilities of the project forward.

Overall, *Schoenoplectus californicus* (California bulrush) plants have been successfully transplanted and established at many LA-0039 project locations (summary table provided in Appendix A-1). This has led to the expanded usage of this species in more recent planting sites. However, *Spartina alterniflora* Vermilion (smooth cordgrass) has not been shown to adapt well after transplant in the sites selected by LA-0039 (summary table provided in Appendix A-2); this is likely due to the depth of many of the planting locations, but other factors such as wave erosion, lack of tidal exchange, organic soils, and rafting vegetation are also factors causing mortality in smooth cordgrass plantings. The more successful planting locations for smooth cordgrass has been on terrace slopes experiencing water exchange. The site selection and planting strategy process is refined in an adaptive management framework as planting locations are selected, planted, and monitored allowing for both a more streamlined approach to site selection and better planting outcomes.

B. Recommended Improvements

Many of the plantings are installed at or near the depth thresholds for the successful establishment of California bulrush, leaving the new plants susceptible to unforeseen flood events. Focusing the plantings on slightly higher elevations may provide increased survivorship in the event of flooding conditions immediately following plant installation. Even in locations that have been successfully colonized with new plantings, negative long-term outcomes are still possible due to the physical smothering of plants with floating aquatic vegetation rafts. This is typically more of a concern in fresher locations. Plant species selection and planting design may be able to mitigate some of these losses in the future by avoiding long linear rows and using *Zizaniopsis miliacea* (giant cutgrass) which appears to be less susceptible to this form of damage. *Zizaniopsis miliacea* was utilized in the second Jaws planting (LA-0039 Year 7 Jaws 2) with some success (summary table provided in Appendix A-3).

The density at which rows and areas are planted may need to be refined as California bulrush plantings seem to cause interspecific competition by year one post planting when survival is high; this limits the area of impact for the specific location and the growth potential of individual plants. Also, California bulrush appears to rapidly cycle through the resources in a given location, failing to maintain vigorous growth through years two and three in some locations depending on nutrient and sediment input. Overall, California bulrush has shown good potential in many fresh to intermediate planting locations and should continue to be the main focus while employing other species in limited applications to expand the available species and habitat types in which LA-0039 can operate successfully.

C. Lessons Learned

Shoreline plantings along large water bodies with wind fetch created waves have failed to become established and as such have not proven beneficial in reducing shoreline erosion. Even in cases where shoreline plantings have been established such as Boston Canal/Vermilion Bay Shoreline Stabilization Project (TV-0009), the reduction in erosion may not be significant and/or may not persist beyond a few years. Therefore, focusing the resources of the LA-0039 project on more protected locations would likely increase the overall success rate of plantings. These interior locations, however, don't appear to be favorable to smooth cordgrass as that species has failed when planted in continuously flooded interior areas with diminished tidal cycles. Smooth cordgrass has repeatedly been very successful in conjunction with terrace construction, marsh creation, and naturally accreting mudflats as a pioneer species either planted or naturally occurring. Therefore, areas with tidal exchange and undergoing siltation may be good candidates to be planted with smooth cordgrass.

Planting *Phragmites australis* (Roseau cane) in deeper, open water has not been successful (summary table provided in Appendix A-3). The plantings were attempted with new shoots. Future attempts should include older, more robust plants.

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APPENDIX A

Latest Estimated Survival of Planting Sites by Vegetation

Table A-1. LA-0039 Coastwide Vegetative Planting Project sites planted with *Schoenoplectus californicus* (California bulrush). Planting Types are Area (A), Single Row (SR), Double Row (DR), Hedge Row (HR), Shoreline (Sh), Interior (Int), Open Water (OW), Broken Marsh (BM), Marsh Perimeter (MP), and Terrace (Terr). Superscipts indicate amount of time if different from column (m = months, y = years). FAV is Floating Aquatic Vegetation. NA is Not Assessed. See chapters for more details.

			Estimated Survival (%)		
Chp	Selection Year - Site	Planting Type	3 Year	5 Year	Notes
III	Y1 South Lake DeCade	DR - Sh DR – OW A - Bankline	20 20 80	<1 <5 5	Initially successful, eventually FAV rafted
V	Y1 Marsh Island	DR – Protected Sh	0^{2m}	0^{7m}	Bad storms after planting
VI	Y2 West Little Lake	SR & DR – Sh HR – Cove A DR HR – OW	0 50 70	- NA NA	Wrack deposition NA – Replanted or Inaccessible
VII	Y2 The Prairie	A – OW DR - OW	100 100	100 100	Plantings robustly expanded
VIII	Y3 The Jaws	DR - OW	93^{1y}	10^{3y}	Robust expansion at 1 year but eventually FAV rafted.
IX	Y3 Little Vermilion Bay	DR – b/n Terr Area – b/n Terr	70-100 100	50-100 60	Robust expansion in absence of herbivory, intraspecific competition, and wrack deposition
X	Y3 Willow Lake	DR – OW A – OW Deeper OW	23 75 50	2 10 1.5	First year success but Chronic inundation, weak soils, FAV rafting
XI	Y4 Green Island Bayou Northern Southern	SR – Sh Lg Pond DR – Sh Sm Pond A – OW SR – Sh Lg Pond DR – Sh Sm Pond A - OW	4 65 40-95 1.5 <5 0-15	2.5 60 30-80 0.1 0 0-20	Highly variable by location. Poorer performing Area plantings had weaker soils. Lg pond Sh plantings were too exposed. Others are doing well.
XII	Y4 Pointe-aux-Chenes	DR - OW	>75	NA	DRs had grown together by 3 yrs. Minor losses were result of boat trails.

XIII	Y4 Rockefeller Unit 4	DR - OW	10	NA	Poor initial conditions and large wind fetch. Some survival along marsh and protected areas.
XIV	Y5 Rockefeller Terraces	SR – Terr Sh	90	NA	Good expansion
XVI	Y6 West Little Lake 2	A – Ponds DR – Lg Pond	76^{1y} Good	NA NA	Filling in small ponds. Good for exposed cove.
XVII	Y6 Gentilly Unit	DR – OW A - OW	$>90^{1.5y}$	NA	Plants robustly expanded in low water levels
XIX	Y6 The Jaws 2	Clusters - OW	95^{1y}	50^{3y}	Doing well in areas where present, 2 of 4 areas.
XX	Y6 Willow Lake 2	A – OW HR - OW	38^{1y} 50^{1y}	$<1^{3y}$ $<1^{3y}$	Chronic inundation, FAV rafting, 2020 hurricanes
XXI	Y6 Belle Isle Lake	HR – b/n Terr DR – on reduced Terr	90^{1y} 77^{1y}	NA NA	Expanding well Decrease with elevation 2020 imagery looks good.
XXII	Y6 DeCade Vicinity	Varies	94^{v}	64^{v}	Decreased 30% over 1 year
XXIII	Y7 Little Vermilion Bay 2	DR – b/n Terr A – b/n Terr	85^{1y} 91^{1y}	NA NA	DRs parallel between terraces performing better than perpendicular

Table A-2. LA-0039 Coastwide Vegetative Planting Project sites planted with *Spartina alterniflora* 'Vermilion' (Vermilion smooth cordgrass). Planting Types are Area (A), Single Row (SR), Shoreline (Sh), Open Water (OW), Broken Marsh (BM), Marsh Perimeter (MP), and Terrace (Terr). Superscipts indicate amount of time if different from column (m = months, y = years). NA is Not Assessed. See chapters for more details.

			Overall Survival (%)		
Chapter	Selection Year - Site	Planting Type	3 Year	5 Year	Notes
III	Y1 South Lake DeCade	BM A - OW	0 0	0 0	Failed within a year from inundation stress
IV	Y1 Cameron Creole	A – OW MP BM	0.5 6 5	0 1.25 1.75	Failed within a year from inundation stress
V	Y1 Marsh Island	Bay Sh A – OW SR - OW	15^{2m} 1^{2m} 0^{2m}	0^{7m} 0^{7m} 0^{7m}	Bad storms after planting and erosive conditions. Poor conditions - inundation
VII	Y2 The Prairie	SR - MP	NA	NA	Not visible or overgrown by other plantings
XIV	Y5 Rockefeller Terraces	SR – Terr Slope	90	NA	Ideal water level on terrace slope
XV	Y5 East Grand Terre	A – Pond	20^{3m}	1^{1y}	Isolated ephemeral ponds
XVIII	Y6 Sabine Unit 1 Overflow	SR – Sh A - OW	$<5^{1y}$ 0^{1y}	NA NA	Chronic flooding soon after installation. High natural recruitment in area.
XXI	Y6 Belle Isle Lake	A - OW	80^{1y}	NA	Decrease with elevation. 2020 imagery looks good for 3 of 4 areas (deepest is absent).

Table A-3. LA-0039 Coastwide Vegetative Planting Project sites planted with less common planting species (JURO – *Juncus roemerianus*; PHAU – *Phragmites australis*; PAVA – *Papspalum vaginatum*, PAAM - *Panicum amarum*; ZIMI – *Zizaniopsis miliaceae*). Planting Types are Area (A), Single Row (SR), Open Water (OW), and Terrace (Terr). Superscipts indicate amount of time if different from column (m = months, y = years). FAV is Floating Aquatic Vegetation. NA is Not Assessed. See chapters (Chp) for more details.

				Overall Survival (%)		
Species	Chp	Selection Year - Site	Planting Type	3 Year	5 Year	Notes
JURO	V	Y1 Marsh Island	SR - OW	0^{2m}	0^{7m}	Poor conditions - inundation
PAAM	XV	Y5 East Grand Terre	Beach/ Dune	20^{3m}	15^{1y}	Plants on dune survived better than beach right after installation.
PAVA	XIV	Y5 Rockefeller Terraces	DR – Terr Crown	56	NA	Established well, then replaced by other species
PHAU	X	Y3 Willow Lake	Deep OW	0	0	Too deep for new plants
PHAU	XXII	Y6 DeCade Vicinity	Deep OW	$<1^{1.5y}$	0^{3y}	Too deep for new plants
ZIMI	XIX	Y6 The Jaws 2	Clusters - OW	95^{1y}	50^{3y}	Doing well in areas where present, 2 of 4 areas.