West Galveston Island Bayside Marsh Restoration
TCEQ Contract No. 582-16-60135

Final Report

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I. Executive Summary

The West Galveston Island Bayside Marsh Restoration Project is located in an area of West Galveston Bay referred to as Gangs Bayou, Oxen Bayou, and Melager Cove. As with most all other near shore areas within West Bay, these areas have suffered severe habitat loss. The loss of shoreline features such as vegetated land spits, shoreline ridges, and oyster reefs that protected intertidal marshes from erosional forces is one reason for the area's decline in wetland habitats. Others include stream channelization, sediment diversion, hydrologic alterations, increased channel dredging, and dredge and fill activities, residential development, subsidence, and cattle grazing. Because of the tremendous natural and economic values of these areas and their habitat, allowing them to disappear is not acceptable. In response to losses, Texas Parks and Wildlife Department (TPWD), along with our many partners, has been proactively seeking resources to protect and restore shoreline habitats in West Bay and the Texas Gulf Coast.

The West Galveston Island Bayside Marsh Restoration Project, West Galveston Bay, Texas (the Project) constructed 3,800 linear-foot of rock breakwater that provides protection and enhancement to approximately 9.1 acres of existing estuarine marsh (emergent marsh, irregularly exposed mud flat, vegetated, non-vegetated sand flat, protected shallow open water) and approximately 13.8 acres of restored estuarine marsh complex (intertidal fringe marsh, salt flat marsh, sand flat and protected shallow water). After construction, the newly restored estuarine marsh complex, 3,235 linear feet of eroded shoreline, and 139 acres of former marsh that has converted to shallow water due to relative sea-level rise were planted with 93,000 sprigs of *Spartina alterniflora*.

II. Introduction

Productivity of Texas Coastal Wetlands

Texas coastal wetlands are highly productive biologically. They serve as nursery grounds for over 95 percent of the recreational and commercial fish species found in the Gulf of Mexico. Intertidal marsh serves as nursery areas for commercial fishery species such as brown and white shrimp (*Farfantepenaeus aztecus* and *Litopenaeus setiferus*), blue crab (*Callinectes sapidus*), Gulf menhaden (*Brevoortia patronus)*, sand seatrout (*Cynoscion arenarius*), southern flounder (*Paralichthys lethostigmata*), red drum (*Sciaenops ocellatus*), bay anchovy (*Anchoa mitchilli*) and other marine organisms (Green, 1992). Commercial fish species associated with Galveston Bay estuarine wetlands are Gulf menhaden, brown and white shrimp and blue crab (Green, 1992).

Galveston Bay estuaries, including West Galveston Bay, consist of habitat types that are classified as essential fish habitat for species under federal fishery management plans (FMPs) such as brown shrimp, white shrimp and pink shrimp (*Litopenaeus duorarum*), Gulf stone crab (*Menippe adina*), red drum, gray snapper (*Lutjanus griseus*), and blue fish (*Pomatomus saltatrix*). These species spend a portion of their juvenile life stages in estuarine nurseries. These estuarine habitats also benefit numerous other fishery species not under FMPs (Minello, 1999).

In addition to being highly productive biologically, coastal wetlands perform chemical and physical functions, including temporarily retaining pollutants, such as suspended material, excess nutrients, and disease-causing microorganisms. Additionally, wetlands help greatly in reducing flood damage by storing significant quantities of runoff during heavy rainfall events. Coastal wetlands also help reduce damages from storm events by acting as a buffer between shoreline and inland areas. These important coastal hazard mitigation benefits have received significant attention after the devastating hurricanes that struck the western Gulf coast in 2005 and 2008.

The Texas coast is an important waterfowl area in North America, supporting seasonal waterfowl. Colonial waterbirds in the Galveston Bay system either feed primarily in marsh or marsh edge habitat or depend primarily on food sources that are marsh-dependent (Green, 1992); including the recently state and federally de-listed endangered species, the brown pelican (*Pelicanus occidentalis),* which is known to occur in the project area. The reddish egret (*Egretta rufescens)* and white-faced ibis (*Plegadis chihi*), species of special concern to the USFWS and listed by TPWD as threatened, also forage in and nest near the project areas. The status of these species is an indication of the overall condition of coastal habitat and may be negatively affected by the loss of wetland/seagrass habitat.

Coastal Wetland Loss in Texas

Coastal wetland loss in Texas and in the Galveston Bay system is significant and is a continuing concern because of the essential roles that wetlands perform. Wetland loss in coastal Texas has been rated by the Environmental Protection Agency (EPA) as severe (U.S. EPA, 1999). Wetland loss in the Galveston Bay system is greater than many other areas of the state. The Galveston Bay system lost a *net* of nearly 35,000 acres (20%) of its wetlands, and 1,800 acres (70%) of its seagrasses between the 1950s and 1985 (White et al., 1993). Based on USFWS National Wetlands Inventory (NWI), aerial photography and wetland status and trends information, much of the wetland loss, and most of the seagrass loss occurred in West Galveston Bay. This documented loss includes the wetlands and adjacent habitats along the entire north shoreline of west Galveston Island and within the proposed project area. White et al. (2004) has documented that these habitat losses have continued through 2002. Substantial wetland and associated habitat loss in the Galveston Bay system may have contributed to chronic declines in blue crabs and white shrimp, as well as estuarine-dependent bird species, such as tricolored herons (*Egretta tricolor)*, snowy egrets (*Egretta thula)*, black skimmers (*Rynchops niger)*, roseate spoonbills (*Ajaia ajaja)*, and great egrets (*Casmerodius albus)* (Shipley and Kiesling, 1994). Recent research indicates and aerial photography demonstrates that wetland loss is continuing.

Many causes have contributed to wetland and seagrass loss in the Galveston Bay system including dredging, stream channelization and filling, subsidence, sediment diversion, saltwater intrusion, erosion, hydrologic alteration (White et al., 1993) cattle grazing and sea level rise. Seagrass had virtually disappeared from West Galveston Bay due to development, dredging, discharges, runoff, and erosion (Pulich and White, 1991). Dredged channels physically displaced many acres of seagrass during the 20-year period between 1956 and 1976. Activities associated with development contributing to seagrass loss include increased boat traffic, channel maintenance, wastewater discharge, and runoff containing high nutrient levels, herbicides, and pesticides.

Texas coastal wetlands are also extremely important economically. In Galveston Bay alone, the recreational and commercial fishing industries combined are valued at over $3 billion annually, and support over 40,000 jobs in the area (U.S. EPA, 2005). The wildlife diversity in this area draws people from around the world, supporting the important and fast-growing nature tourism segment of the area's $7.5 billion tourism industry (U.S. EPA 2005).

Historical Shoreline Change

Historically, the north shoreline of west Galveston Island had a continuous band of regularly flooded estuarine intertidal emergent wetlands vegetated by *Spartina alterniflora* (smooth cordgrass), tidal inlets, creeks, and ponds. Waterward of the *Spartina* marshes was shallow open water vegetated with seagrasses *Halodule wrightii* Asch (shoalgrass) and *Ruppia maritima* (widgeon grass). *Batis maritima* (saltwort), *Salicornia* spp. (annual and perennial glasswort), *Borrichia frutescens* (sea ox-eye daisy), and *Distichlis spicata* (saltgrass) occurred just inland and at slightly higher elevations than the intertidal marshes. At slightly higher elevations these habitats graded into coastal prairie interspersed with brackish to freshwater marshes vegetated with *Typha latifolia* (cattail), *Scirpus* spp. (bulrush), *Juncus roemerianus* (blackrush), *Eleocharis* spp. (spikerush) and *Spartina patens* (saltmeadow cordgrass). Other fresh to brackish marsh species occur in swales on Galveston Island.

Erosion poses a significant threat to the marshes and adjacent habitats along much of Galveston Island's north shoreline, including the project area. Average rates of erosion along West Galveston Bay shorelines have increased from 0.8 ft/yr during the historical period of 1852 to 1930 to 2.1 ft/yr during the recent period of 1930 to 1982 (Pulich and White, 1991). Shoreline ridges, vegetated land spits, and other features that once protected intertidal marshes from erosional forces, are disappearing at a more rapid rate than protected inlets. In addition, subsidence of approximately one to two feet between 1906 and 1987 (White et al., 1993) has rendered the marsh systems more vulnerable to erosion during winter, as well as during tropical storms. In addition to subsidence, sea level rise has also contributed to the drowning and fragmentation of the marsh. White et al. (2004) mapped the rates of shoreline change and habitat loss within West Galveston Bay including the project areas. From the mid-1950's to 2002 the amount of estuarine marsh in West Galveston Bay has decreased by 32%. Estuarine tidal flats declined by 61% and palustrine marshes decreased by 50% from the mid-1950's to 2002.

III. Project Significance and Background

The West Galveston Island Bayside Marsh Restoration Project, West Galveston Bay, Texas (the Project) was initially proposed in 2009 as a part of the American Recovery and Reinvestment Act (ARRA) but was removed at request of the National Oceanic & Atmospheric Administration's (NOAA). The project was subsequently "re-packaged" by the Texas General Land Office (GLO) and submitted to Coastal Impact Assistance Program (CIAP) for funding. In October 2012 CIAP awarded the project $2,510,398. NRG Texas Power LLC provided an in-kind donation of 80,000 *Spartina alterniflora* sprigs at a $100,000 value. The GLO funded the project $50,000 from the Coastal Erosion Protection Restoration Act (CEPRA) cycle 7 funds and Texas Parks and Wildlife Department (TPWD) provided a $10,000 in-kind value. In August 2015, the Galveston Bay Estuary

Program (GBEP) of the Texas Commission on Environmental Quality (TCEQ) provided $200,000 to fund the planting of *Spartina alterniflora* at the project site.

The site visits prior to the engineering and design (E&D) phase of the project revealed that the original scope of the project would not be achievable due to the presence of seagrass within the project area. The major changes were removing the use of dredged material to construct/restore estuarine marsh within the two areas (~181 acres) of deteriorated estuarine marsh and their leading edges, adding the construction of rock breakwater to protect existing estuarine marsh, adding the construction/restoration of estuarine marsh directly behind the constructed rock breakwater utilizing dredged material, and adding a large planting component to the project. Bathymetric data from the E&D was used to develop a project planting plan and map. One-hundred and thirty-seven (137) acres of deteriorated estuarine marsh (estuarine marsh converted to mostly open water); 3,235 linear feet of eroded shoreline waterward of the planting areas; and 12 marsh mounds within 13.8 acres of restored estuarine marsh complex (intertidal fringe marsh, salt flat marsh, sand flat and protected shallow water) were planted with *Spartina alterniflora*.

The project's E&D was managed with the E&D of another project located in Carancahua Cove at the Galveston Island State Park (GISP), each project had very similar E&D criteria and therefore would have very similar construction techniques and construction equipment. The projects maintained their own separate budgets but were managed together to benefit from the economies of scale (cost advantages obtained due to size) for both the E&D and construction. Because the projects construction were to be managed together this project's construction was significantly delayed while an additional $3.2 M were sought for the GISP project.

IV. Methods

Construction Activities/Methods

The project was awarded to Apollo Environmental Strategies, Inc. (Apollo) and the notice to proceed was issued on August 8, 2016. Apollo began mobilization to the project site on September 16, 2016 and began constructing the rock breakwater on September 22, 2016. Construction of the rock breakwater began and was completed November 5, 2016. The rock breakwater is constructed of crushed limestone that is barged from Pine Bluff Sand and Gravel located in Kentucky. Loaded barges are brought down the Mississippi River to New Orleans, LA (NOLA) from NOLA to Peninsula Marine on Port Bolivar, TX via the Gulf Intracoastal Waterway (GIWW). At Peninsula Marine the barges are offloaded and reloaded onto Apollo owned barges or stockpiled on site. From Peninsula Marine the barges are brought to deeper water adjacent to the project site, these barges are lighted loaded to smaller barges with shallower draft and situated within reach of an excavator, also on a barge that is located directly adjacent to the breakwater alignment (Figures 1-4). The excavator unloads the crushed limestone from the shallow draft barge and places it along the alignment to a 3.5 NAV88 elevation. The base of the breakwater ranges in width from 21-27 feet depending on water depth.

Figure 1. Construction of Breakwater. Excavators moving rock from barge to breakwater.

Figure 2. Construction of Breakwater. Excavator moving rock from barge to breakwater.

Figure 3. Construction of Breakwater. Excavators moving rock from barge to breakwater.

Figure 4. Smaller barge with shallower draft being brought to barge with excavator.

The construction/restoration of estuarine marsh began on October 3, 2016 and was completed on November 12, 2016. The marsh restoration technique (Figures 5-8) utilized at the project has been successfully used at seven other restoration projects (Jumbile Cove, J-Cove, Delehide Cove, Starvation Cove, Starvation Cove Gap, Carancahua Cove, and McAllis Point) in West Galveston Bay. A hydraulic dredge was used to pump sediments from a nearby designated borrow area to restore the site to intertidal marsh elevations by constructing mounds. The dredged sediments were pumped to a 2.3 NAVD88 elevation The selected elevation range takes into consideration and allows for bulking (compaction of the dredge material as it dewaters), sea-level rise, and location of the mound. Portions of the dredge material is placed above intertidal elevation and is a suitable elevation for restoring salt flat marsh/sand flat habitat in addition to intertidal *Spartina alterniflora* marsh and will also allow for the migration of intertidal marsh to higher elevations in response to sea level rise.

Figure 5. Hydraulic dredging of dredged material to construct marsh mound.

Figure 6. Hydraulic dredging of dredged material to construct marsh mound. Construction of rock breakwater in background.

Figure 7. Hydraulic dredging of dredged material to construct marsh mound.


Figure 8. Completed marsh mounds. Rock breakwater in background.

The day to day construction activities for the duration of the project is provided in Appendix A, “Contractor Weekly Reports Compilation Aug. 8, 2016-Nov. 13, 2016” and “Engineering Reports Compilation Sept. 13, 2016-Dec. 13, 2016”.

Planting Activities/Methods

The Request for Proposals (RFP) for services to harvest and plant *Spartina alterniflora* was advertised on the Electronic State Business Daily (ESBD) on September 20, 2016 for seven (7) days. The work was awarded to Apache Ecological Service, Inc. (Apache) on October 18, 2016. Planting activities began on October 26, 2017 and were completed December 7, 2016. Apache harvested 93,020 donated sprigs (minimum of three live stems) from the NRG EcoCenter in Baytown, TX. The project had six planting areas that are shown in Figure 9.

Planting Areas A, B, C, D were planted with approximately 70,080. Planting Area A, was planted with 17,000 plant units on approximate 10-foot centers. Planting Area B, was planted with 3,950 plant units on approximate 10-foot centers. Planting Area C, was planted with 36,000 plant units on approximate 10-foot centers. Planting Area D, was planted with 13,130 plant units on approximate 5-foot centers. Three lengths of shoreline totaling 3,235 linear feet were planted with 12, 940 plant units, four rows one foot apart with a planting spacing of one foot. The 12 newly constructed Marsh Mounds were planted within the intertidal zone with 10,000 plant units, a minimum of 833 plant units per mound.

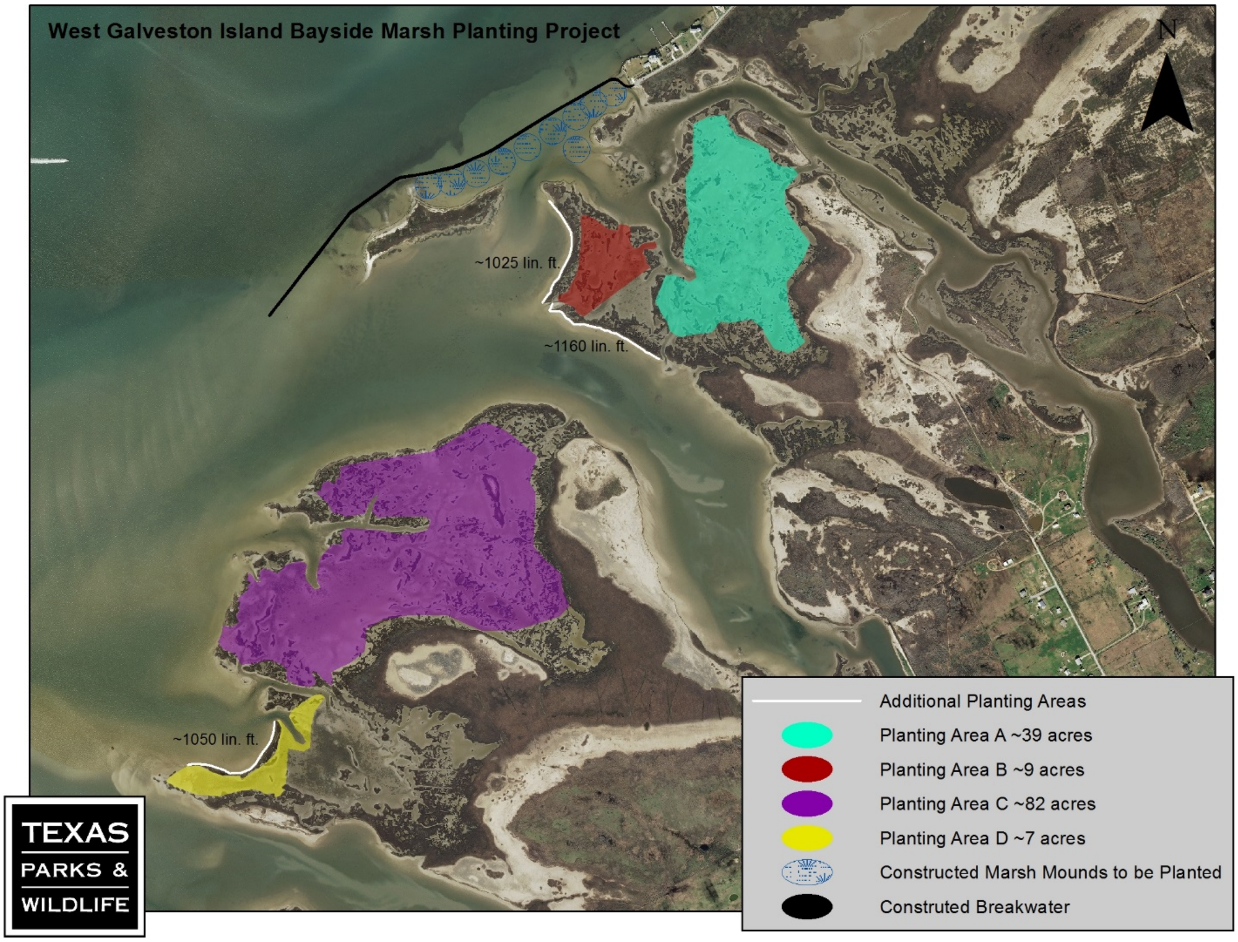

Figure 9. Project planting areas.

The day to day planting activities for the duration of the project is provided in Appendix B "Planting Reports Compilation Oct. 26, 2016 - Dec. 7, 2016."

V. Results and Observations

The West Galveston Island Bayside Marsh Restoration Project (Figure 10) constructed 3,800 linear-foot of rock breakwater that provides protection and enhancement to approximately 9.1 acres of existing estuarine marsh (emergent marsh, irregularly exposed mud flat, vegetated, non-vegetated sand flat, protected shallow open water) and approximately 13.8 acres of restored estuarine marsh complex (intertidal fringe marsh, salt flat marsh, sand flat and protected shallow water). After construction, the newly restored estuarine marsh complex, 3,235 linear feet of eroded shoreline, and 139 acres of former marsh (marsh that has converted to shallow water due to relative sea-level rise) were planted with 93,020 sprigs of *Spartina alterniflora*.


Figure 10. Arial of completed project construction.

The plant units planted at the constructed marsh mounds required an eighty percent (80%) survival of the original total number of planting units. Per the contractors Survival Assessment Report provided in Appendix B, the overall survival of the planted Marsh Mounds in slightly less (78.8%) than the required 80% survival. The initial planting inspection (Dec. 22, 2016) after the mounds were planted indicated some loss of plants. For instance mounds 1 and 2 were both reported to have been planted with 1,000 plant units however, counts during the initial planting inspection revealed approximately 686 and 833 plant units on mounds 1 and 2, respectively. It's my opinion that survival was affected by some of the mounds being reshaped by the tidal exchange in and out of the project area, causing some of the planted sprigs to become dislodged (aka floaters) and being "washed" out of the project area. Additionally, the project area is heavily used by anglers that may have trampled the planted sprigs while wading and kayaking in the area affecting their survival. I received an email on January 15, 2017 from an adjacent resident suggesting that placing "Restoration Area – Keep Off" signs until the marsh got establish might be helpful, an indication of the high use of the area and concern that it might be affecting the plants and their survival.

The August 14, 2017 assessment of planting that occurred on the 12 constructed mounds directly behind the constructed breakwater are showing continued growth. Most of the planting units (3 live stems) have multiplied and now have between 15- 25 live stems. Despite the apparent loss of plants the marsh mounds are vegetating nicely with good coverage.

A percent survival for Areas A, B, C, D and shoreline was not required due to experimental nature of the water depths that the plant units were being planted in. A site inspection of all the planted areas on August 14, 2017 indicated very low survival of the planted plants in Areas A, B, C, D and the shoreline. As discussed in the Dec. 1, 2016 thru Feb. 28, 2017 QPR, for this project, plants were planted in deeper water than you would typically find *Spartina alterniflora* growing. The envelope might have been pushed a little on the planting depths within Areas A, B, C, D, and shoreline. It now seems that it will take a minimum of a year to determine if some of the planting areas will be successful and their level of success. We have shown at other project sites that by planting deeper than where you "naturally" find *Spartina* it can grow and even thrive. Attempting to determine how deep of water we can successfully plant in (in this area) is an objective of the project.

Another issue that might have affected the survival of the planted plant units in Areas A, B, C, D and the shorelines and the success of this planting project are the water levels at the project site, most of the planting days occurred during extremely high tides that continued for several months after the planting was completed.

Based on tidal datum from the Galveston Railroad Bridge Station 8771486, during the planting duration of October 25, thru December 7, 2016, water levels exceeded mean tide level (MTL) 94.8% of the time. After the planting duration December 8, 2016 thru August 8, 2017, water levels exceeded MTL 75.8% of the time. The duration of the project relative to the planting (not construction), October 25, 2016 thru August 8, 2017, water levels exceeded MTL 79.1 % of the time. The high tides likely negatively affected the survival of the plants. Appendix C has the plotted tidal datum from Oct. 25, 2016 thru Aug. 8, 2017 demonstrating the elevated waters levels for the duration of the project.

The high tides also influenced which ponds and plants were harvested from the NRG EcoCenter. The high tides forced the planters to harvest taller plants with less developed root systems. The taller plants were needed in order to be able to visually see the plants as they were planted and to determine appropriate spacing and which areas had been planted.

The major advantages of this technique include its low cost and eliminating several aspects of a typical restoration project such as; the engineering solicitation and selection process; engineering fees and associated subcontracts such as sediment analysis; the construction solicitation, review, and selection process. This restoration techniques eliminates most aspects of traditional restoration projects except surveying and planting.

New surveying techniques, Low Altitude Aerial Scanning (LAAS) is a surveying technique that performs and creates a highly detailed topographic survey. A project surveyed using this technique in Brazoria County surveyed 12.5 Miles of canal, acquiring data at a rate of 1/2 acre per second, taking approximately 22 minutes, and collecting approximately 47 million survey points, utilizing only one ground survey control point and completing the data collection in one day. Approximately two weeks after the field work was completed, a ground classified data point file, 3-dimensional digital terrain model, contour map in .dwg format (Figure 11), and GIS grid file where created and transmitted to the client via email as well as on a flash drive.

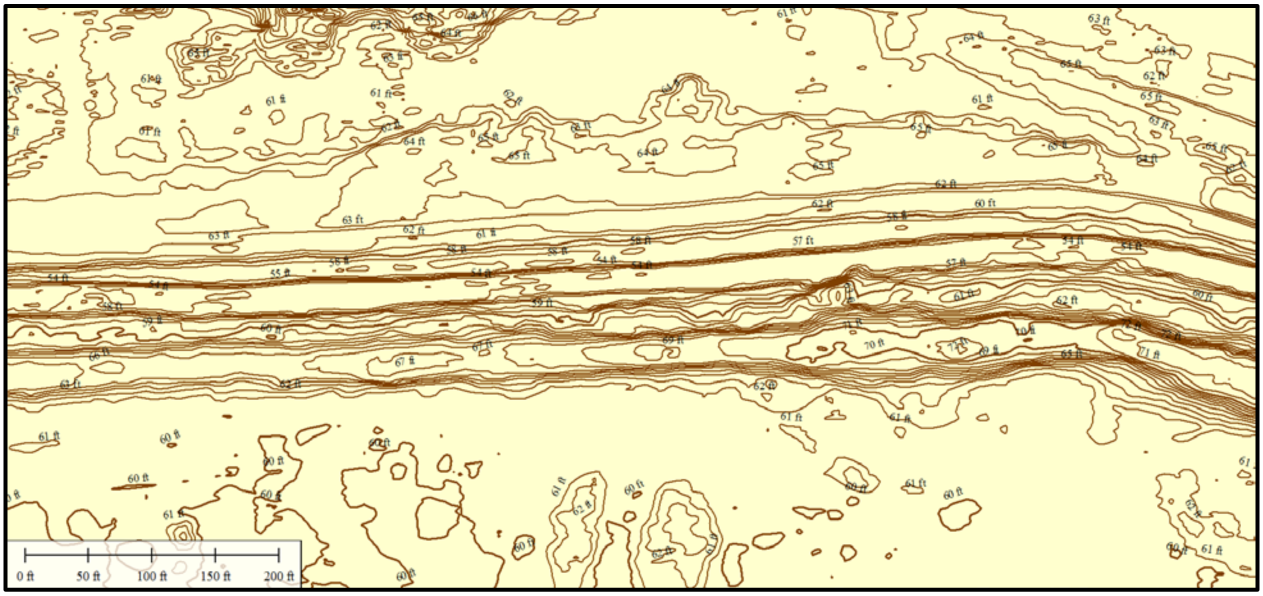

Figure 11. Contour Map Created Utilizing Low Altitude Aerial Scanning.

The LAAS data collecting equipment has the ability to penetrate vegetative cover and is survey grade with horizontal and vertical accuracies on the order of 0.2 feet. Low altitude aerial scanning technology can also be utilized for the mapping of railroads, highways, utility corridors, large acreage tracts, and levee systems and can be performed from helicopters and drones. Compared to traditional surveying techniques, this method provides a greatly increased amount of survey data at a fraction of the time and is significantly more cost effective.

Planting projects can utilize this technique to create detailed contour maps and create planting zones that would optimize the success of a project. One potential drawback is that this technique cannot collect data through a water column however, appropriately timed projects could take advantage of winter fronts that cause "blow-outs", removing the water from an area so that the area can be successfully surveyed utilizing the LAAS technique. However, new technology is being developed and continually improved including techniques that can collect through the water column.

Even though the success of this planting project is uncertain or maybe even doubtful I am still confident that this restoration technique is a viable technique that can be successfully utilized in West Bay and around Galveston Bay.

Appendix A

Construction Activities

Contractor Weekly Reports Compilation Aug. 8, 2016 – Nov. 13, 2016

Engineering Reports Compilation Sept. 13, 2016 – Dec. 13, 2016

Appendix B

Planting Activities

Planting Reports Compilation Oct. 26, 2016 – Dec. 7, 2016

Survival Assessment Report

Appendix C

Plotted Tidal Datum from Oct. 25, 2016 – Aug. 8, 2017

Appendix D

References

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