E C O L O G I C A L R E V I E W

South Shore of The Pen Shoreline Protection and Marsh Creation
CWPPRA Priority Project List 14
State No. BA-41

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This document reflects the project design as of the 95% Design Review meeting, incorporates all comments and recommendations received following the meeting, and is current as of December 26, 2007.

ECOLOGICAL REVIEW

South Shore of The Pen Shoreline Protection and Marsh Creation (BA-41)

In August 2000, the Louisiana Department of Natural Resources initiated the Ecological Review to improve the likelihood of restoration project success. This is a process whereby each restoration project's biotic benefits, goals, and strategies are evaluated prior to granting construction authorization. This evaluation utilizes monitoring and engineering information, as well as applicable scientific literature, to assess whether or not, and to what degree, the proposed project features will cause the desired ecological response.

I. Introduction

The proposed South Shore of The Pen Shoreline Protection and Marsh Creation (BA-41) project is located in Jefferson Parish along the southern shoreline of The Pen. The Pen was formerly an impounded area that was drained for agricultural use. However, as a result of levee failure and subsidence of the impounded marsh, the area is now open water. The project area is bounded by The Pen on the north, the Barataria Bay Waterway (BBWW) on the west, and Bayou Dupont on the east (Figure 1). An Enbridge Gas Pipeline Canal runs east to west near the southern boundary of the project area (Figure 1). The project area contains a total of 375 acres consisting of 157 acres of intermediate marsh, 12 acres of brackish marsh, and 206 acres of open water (Natural Resources Conservation Service [NRCS] 2007b). Without this project, the eventual loss of this triangular-shaped landmass would cause a more direct and undesirable connection between the freshwater of the upper Barataria Basin and the tidal processes of the lower Barataria Basin (NRCS 2005).

Shoreline erosion and interior marsh loss in the area are a result of a number of processes including wind-generated wave erosion, subsidence, and salt water intrusion. Shoreline erosion rates for the period 1978-2005 were determined by the United States Geological Survey (USGS) to be 2.83 acres per year (NRCS 2007b). The estimated adjusted interior land loss rates were determined to be -1.73% per year (NRCS 2007b).

The goals of this project are to eliminate shoreline erosion along the south shore of The Pen and to create marsh between The Pen and the BBWW. This proposed project is in accordance with the Region 2 *Coast 2050* strategies of preserving bay and lake shoreline integrity on the Barataria Landbridge and creating marsh on the landbridge through the use of dedicated dredging (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1999).

II. Goal Statement

- Eliminate shoreline erosion on the southern shoreline of The Pen over the 20-year project life.
- Create 175 acres and nourish 132 acres of marsh by the completion of project construction.

III. Strategy Statement

- Construction of a foreshore rock dike along the south shore of The Pen and Bayou Dupont.
- Dedicated dredging of material from a borrow area in The Pen to create and nourish marsh between The Pen and the BBWW.

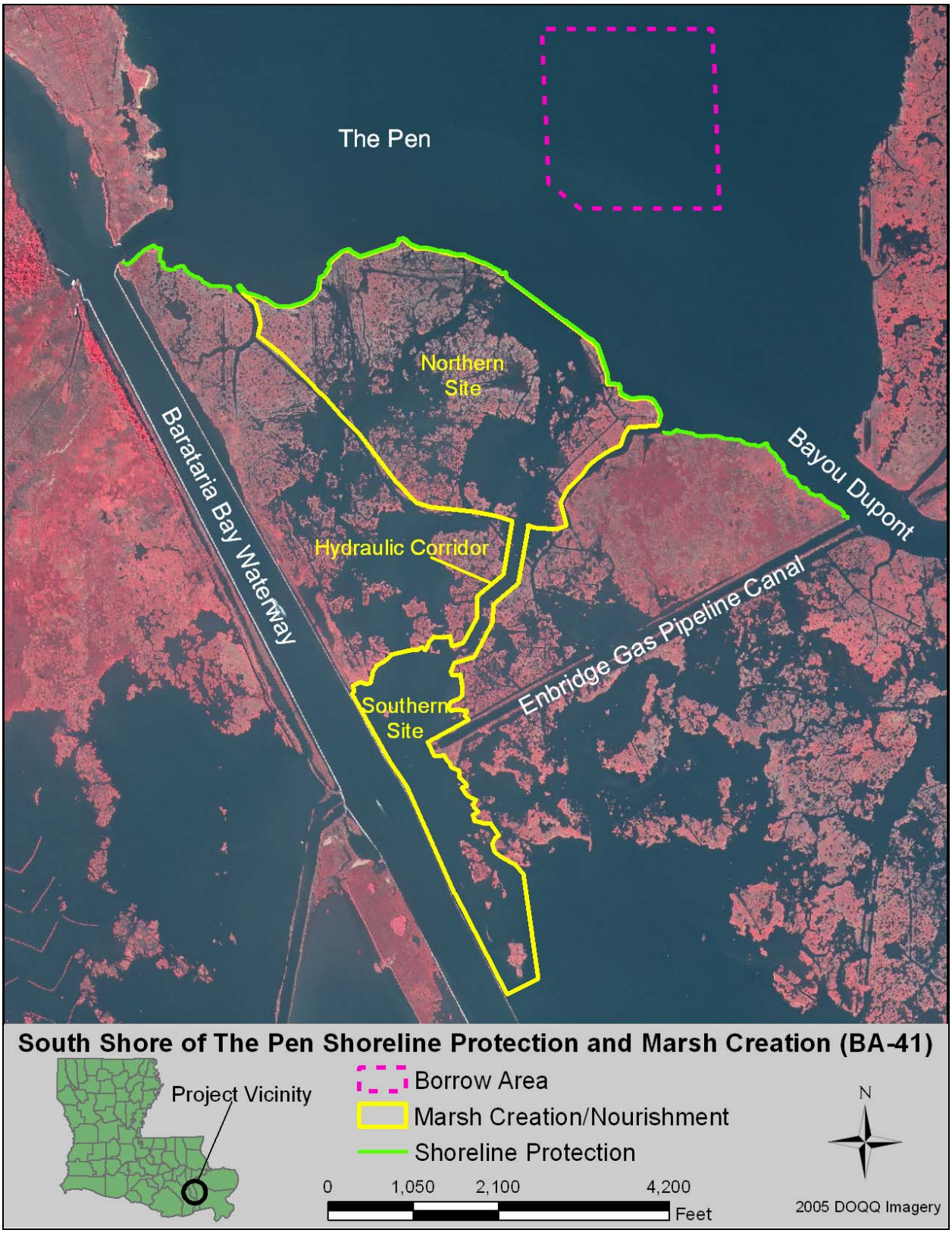

Figure 1. South Shore of The Pen Shoreline Protection and Marsh Creation (BA-41) project features.

IV. Strategy-Goal Relationship

An 11,750-foot foreshore rock dike will be constructed along the south shore of The Pen and Bayou Dupont (NRCS 2007a) to stop shoreline erosion and protect the marsh from wind-driven waves (Figure 1). Material will be hydraulically dredged from a borrow area in The Pen and placed into two areas, a 230-acre northern site and a 77-acre southern site, to create and nourish approximately 307 acres of marsh between The Pen and the BBWW (Figure 1).

V. Project Feature Evaluation

Rock Dike Design

An 11,750-foot foreshore rock dike will be constructed at or near the 0.0 foot NAVD 88 contour to protect the southern shoreline of The Pen (NRCS 2007a). The dike will be built to an elevation of +2.0 feet NAVD 88 with a crown width of 3.0 feet and side slopes of 2.5H:1.0V (Figure 2) (NRCS 2007a). Based on the geotechnical report, the entire length of shoreline can structurally support a rock dike with the dimensions listed above. Two openings will be left in the rock dike in order to allow existing bayous to remain open (NRCS 2007b). In addition to these openings, a site-specific opening will be constructed in the eastern section of the rock dike (NRCS 2007b) to allow fish and other organisms to access the marsh. This opening will be constructed with a sill elevation of -1.3 NAVD 88, a bottom width of 20 feet, and side slopes of 2.5H:1.0V (NRCS 2007a).

Due to the settlement that is expected to occur as a result of the placement of rock on organic soils, construction of the foreshore rock dike will be completed in stages. Rock will initially be placed to an elevation of +1.0 feet NAVD 88 along the entire length of the structure (NRCS 2007a). After completion of this stage, the entire structure will be raised to +2.0 feet NAVD 88 (NRCS 2007a). At the end of the project performance time (at or near 12 months after initially being constructed to grade), the dike will be brought back up to this grade to correct for settlement (NRCS 2007a). Due to a build tolerance of +0.5 feet, at the end of construction, the structure is expected to be at an elevation near +2.5 feet NAVD 88 (NRCS 2007a). Based on the current estimate, approximately 28,000 tons of rock will be needed for initial construction of the foreshore rock dike (NRCS 2007a). The draft Operation, Maintenance, and Rehabilitation Plan (O&M plan) for the BA-41 project states that due to settlement of the base of the rock dike structure, maintenance will be required at year 3 to replace 25% of the original structure and again at year 14 to replace 10% of the structure (LDNR 2007).

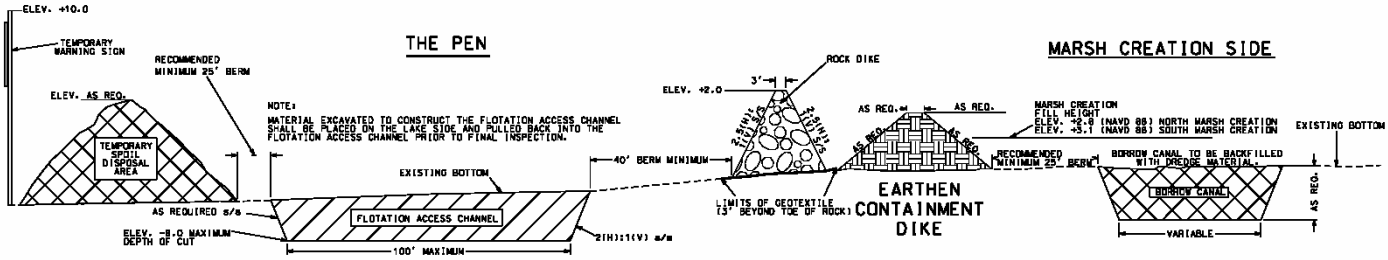

Figure 2. Design of the proposed rock dike, earthen containment dike, marsh fill, and interior borrow canal for marsh fill (NRCS 2007a).

Marsh Creation and Nourishment Design

Based on a survey of healthy marsh near the project area, including the LDNR Dedicated Dredging Program – Bayou Dupont (LA-01b) project area and the United States Army Corps of Engineers (USACE) beneficial use sites, the desired healthy marsh elevation was determined by

members of the project team to be +1.3 feet NAVD 88. The marsh creation and nourishment area was further divided into a northern site and a southern site, with a hydraulic corridor connecting the sites. The average elevation of the existing marsh is +1.17 feet NAVD 88 in the northern site and +1.16 feet NAVD 88 in the southern site. However, marsh in the northern site is interspersed with areas of shallow, open water and is not considered to be healthy marsh. The highly degraded southern site is mainly open water with only a few patches of broken marsh.

Approximately 175 acres of marsh will be created and an additional 132 acres will be nourished through the hydraulic dredging of material from a borrow area in The Pen (NRCS 2007a). The marsh creation and nourishment areas will be completely enclosed with containment dikes (NRCS 2007a). Areas in which marsh currently exists will be considered marsh nourishment areas, while areas of open water will be considered marsh creation areas (Quin Kinler, NRCS, personal communication, August 2007). The average elevation of the northern site is +0.2 feet NAVD 88, and the elevation of the southern site is much lower at -1.0 foot NAVD 88 (BCD 2007). Due to the anticipated consolidation and dewatering of the newly placed sediment, marsh in the northern site will be constructed to an elevation of +2.78 feet NAVD 88, and marsh in the southern site will be constructed to an elevation of +3.1 feet NAVD 88 (Figure 2) (NRCS 2007a).

Based on a review of nearby marsh creation sites, it is anticipated that the marsh creation and marsh nourishment areas will re-vegetate naturally (NRCS 2007a). Therefore, no plantings will be performed as part of the construction contract (NRCS 2007a). In the event that the marsh creation area does not re-vegetate naturally, there is a provision in the draft O&M plan to plant vegetation on approximately 30% of the marsh creation area within the first 3 years after construction (LDNR 2007).

Borrow Area for Marsh Fill Material

Settlement of the foundation material and self-weight consolidation of the borrow material were calculated to estimate the amount of material necessary to construct the proposed marsh creation and marsh nourishment features of this project. Based on these calculations, 1,044,177 cubic yards of in situ fill material will be needed for the northern site and 489,151 cubic yards of in situ fill material will be needed for the southern site to achieve a marsh elevation of +1.3 feet NAVD 88 approximately 5 years after construction (NRCS 2007a). Using a cut to fill ratio of 1.31 for the northern site and a cut to fill ratio of 1.19 for the southern site, approximately 2,251,224 cubic yards of material will have to be dredged from the 106-acre borrow site in The Pen in order to fill the marsh creation and nourishment areas as proposed (NRCS 2007a). This quantity includes 301,262 cubic yards of material that will be needed to backfill the borrow areas that will be used for the construction of containment dikes (NRCS 2007a). The depth of cut required to obtain the 2,251,224 cubic yards of material necessary for marsh creation and nourishment is approximately 16.2 feet, which equates to an elevation of -20 feet NAVD 88 (NRCS 2007a).

Containment Dikes

An earthen containment dike, extending approximately 25,000 feet, will be constructed around the perimeter of the marsh creation and nourishment sites (NRCS 2007a). The contractor will be responsible for the construction and maintenance of the containment dikes (NRCS 2007a). The assumed geometry is a containment dike that is 6 feet high with a 6-foot crest width and side slopes of 5.0H:1.0V (NRCS 2007a). Containment dikes will be constructed from in situ

material borrowed from within the marsh creation and nourishment sites. According to the draft O&M plan, within the first 3 years of the operations and maintenance phase, the remaining containment dikes will be strategically breached to aid in the formation of natural tidal features (LDNR 2007).

Evaluation of Subsidence

Review of a number of studies was undertaken in an attempt to identify subsidence rates for this project area. The conclusion of the review was that historical rates of subsidence in the project area are relatively low, and that the inclusion of an additional amount of fill material to offset a prospective amount of subsidence would not significantly benefit the design of the rock dike or the marsh creation and nourishment areas.

VI. Assessment of Goal Attainability

Environmental data and scientific literature documenting the effects of the proposed project features in field applications are included below to assess whether or not, and to what degree, the project features will cause the desired ecological response.

Shoreline Protection on Bays and Lakes

Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) and state-authorized shoreline protection projects similar to the South Shore of The Pen Shoreline Protection and Marsh Creation project have been constructed on other lake, bay, and cove shorelines as a means of protecting those banks from erosive elements. Design parameters of previously constructed shoreline protection projects are summarized in Appendix A, and selected projects are discussed below.

- The Bayou Chevee Shoreline Protection (PO-22) project is located on the southern shoreline of Lake Pontchartrain just west of Chef Menteur Pass within the northern section of the Bayou Sauvage National Wildlife Refuge. The project is delineated into two coves (northern and southern), and construction was completed in 2001 (Carter and Richard 2005). The total length of the project was 8,875 feet with the rock dikes constructed using 200-400 pound rock placed at an elevation of +3.5 feet NGVD 29 (Carter 2003).

  The shoreline position was documented in an as-built survey conducted in 2002 (Carter 2003). The first post-construction survey work was conducted at the end of January 2005 (Brady Carter, LDNR, personal communication, March 2, 2005). The areas behind the rocks showed little change from the shoreline survey of 2002, with the exception of the north facing bank on the southeast side of the North Cove project area (Carter and Richard 2005). This area had degraded significantly before the rocks were placed, and was probably too degraded to recover (Carter and Richard 2005). Also, the small island in the middle of the North Cove project area had lost the vegetation on the northern tip; however, the resulting mud flat may be of sufficient elevation to re-vegetate by the next shoreline survey (Carter and Richard 2005). The spoil placed behind the rocks in the South Cove project area has vegetated in two spots resulting in 0.67 acres of land gain (Carter and Richard 2005).

The North Cove reference area showed no discernable change from the 2002 survey (Carter and Richard 2005). Of particular interest was the lack of retreat for the shoreline of Lake Pontchartrain adjacent to the reference area; over the three years between surveys, this area has only retreated approximately one to two feet (Carter and Richard 2005).

The South Cove reference area has had markedly different results. A total of 5.27 acres was lost in three years (Carter and Richard 2005). This bank faces northwest and is exposed to the full force of waves created during cold fronts, which probably resulted in its deterioration (Carter and Richard 2005). Since the boundaries for the South Cove project and reference areas were decided long before the project was constructed, they now appear in open water (Carter and Richard 2005). This made determining the cut-off point between the two difficult; therefore, a straight line was drawn from the terminal end of the rocks to the shoreline to split the two (Carter and Richard 2005). Splitting them in that manner shows the "erosional shadow" realized by not having the rocks terminate on land, which accounted for the majority of land loss within the project area (Carter and Richard 2005).

- The Barataria Basin Landbridge Shoreline Protection (BA-27), Phase 1 (construction unit 1) project is located in Jefferson and Lafourche parishes and encompasses a variety of shoreline protection techniques along approximately 3,200 feet of shoreline (Babin and Hymel 2005). Geotechnical investigations revealed poor soil conditions throughout the area, prompting the testing of non-traditional protection techniques that included a rock dike placed on freshly excavated spoil material, a composite rock dike with light aggregate core encapsulated in geotextile fabric, or a composite rock dike using the furrow method to place and encapsulate lightweight aggregate core (to reduce the load), as well as testing of pre-stressed concrete pile and panel wall (sheetpile) as an alternative to the rock dikes (Babin and Hymel 2005).

  In 2001, all of the test sections for Phase 1 of the project were completed (Babin and Hymel 2005). Data collected by NRCS from January 2001 through February 2003 indicate that one of the Phase 1 test sections, the rock dike placed on freshly excavated spoil material, has settled as much as 12.3 feet on Bayou Perot and 4.3 to 6.3 feet on Bayou Rigolettes (Babin and Hymel 2005). On Bayou Perot, the composite rock dike with light aggregate core encapsulated in geotextile fabric and the composite rock dike using the furrow method to place and encapsulate lightweight aggregate core has settled approximately 3.5 feet, while on Bayou Rigolettes, the corresponding sections have settled 2.0 to 2.4 and 3.5 feet, respectively (Babin and Hymel 2005).

- The Lake Salvador Shoreline Protection Demonstration (BA-15) project evaluated a series of shoreline protection measures in Lake Salvador in St. Charles Parish. Phase II of this project was conducted in 1998 and evaluated the effectiveness of a rock dike to protect the lake shoreline from high energy wave erosion. The rock structure itself appears to be holding up well, showing little sign of deterioration and subsidence (Curole et al. 2002). Recent surveys of the area revealed that the rock dike was successful in stabilizing the shoreline and that some accretion is occurring behind the structure. Post-construction analysis from March 1999 to April 2001 indicated progradation of 2.85 feet

per year (Curole et al. 2002). However, the effectiveness of the structure over the long term may be in question since it was not built according to design specifications. The rock dike was designed to be constructed with a crest elevation of +4.0 feet NAVD 88. A 2002 survey of the rock dike determined that the average height of the structure was +2.49 feet NAVD 88. The average settlement of the structure, measured from 1998 to 2002, was approximately 0.26 feet. After applying this settlement rate retrospectively, it was concluded that the rock dike was built to an inadequate crest elevation of +2.75 feet NAVD 88 (Darin Lee, LDNR, personal communication, July 19, 2002).

- The Turtle Cove Shoreline Protection (PO-10) project was designed to protect a narrow strip of land in the Manchac Wildlife Management Area that separates Lake Pontchartrain from an area known as "The Prairie" (O'Neil and Snedden 1999). Wind-induced waves contributed to a shoreline erosion rate of 12.5 feet per year. A 1,642-foot rock-filled gabion was constructed 300 feet from shore at an elevation of 3 feet above mean water level with the goal of reducing erosion and increasing sediment accretion behind the structure. Post-construction surveys conducted during the period of October 1994 to December 1997 revealed that the shoreline had prograded at a rate of 3.47 feet per year in the project area (O'Neil and Snedden 1999). The rate of sediment accretion, as determined from elevation surveys conducted in January 1996 and January 1997, was 0.26 feet per year (O'Neil and Snedden 1999). The soils in "The Prairie" and Turtle Cove area consist of Allemands-Carlin peat which is described as highly erodible organic peat and muck soils (USDA 1973). Due to the weak and compressible nature of the subsurface soils, the gabions settled 0.59 feet in just over two years (October 1994 to January 1997) (O'Neil and Snedden 1999). In addition, five years after construction the rock-filled gabion structure exhibited numerous breaches and required extensive maintenance in August 2000 (John Hodnett, LDNR, personal communication, August 2004).

- The Boston Canal/Vermilion Bay Bank Protection (TV-09) project was designed to abate wind-driven wave erosion along Vermilion Bay (estimated at 7 feet per year) and at the mouth of Boston Canal (Thibodeaux 1998). To accomplish that goal, a 1,405-foot foreshore rock dike was constructed in 1995 at an elevation of +3.8 feet NGVD 29 along the bank of Boston Canal extending into Vermilion Bay. An increase of 57.4 acres of marsh is indicated in the land/water analysis of the project area with land gains noted behind the rock dikes (Thibodeaux and Guidry 2005). Data collection in the reference area was discontinued in 2000 as a result of the Oaks/Avery Shoreline Protection (TV-13a) project boundary incorporating the Boston Canal reference area within it (Thibodeaux and Guidry 2004). Comparison of shoreline from 1998-2001 indicated a net shoreline gain for the area of 7.06 acres, while a shoreline comparison from 2001-2004 indicated a net shoreline loss of 21.88 acres or 5.04 feet per year (Thibodeaux and Guidry 2005). The loss rates from 2001-2004 are likely due, in part, to wave induced erosion from the passage of Hurricane Lili (Thibodeaux and Guidry 2005). Plantings of *Spartina alterniflora* (smooth cordgrass) have become well established and have propagated to the point where individual plants are indistinguishable from each other along most of the shoreline (Thibodeaux and Guidry 2005). Sediment build-up behind the dike on the east

and west sides is continuing and vegetation has taken over the exposed mud flats (Thibodeaux and Guidry 2005).

Marsh Creation

Marsh creation through the use of dredged material has been practiced in the United States for decades. Despite years of experience with this technique, there is still ongoing debate in the scientific literature on the "success" of the created marsh, and whether created marshes are functionally equivalent to natural marshes (Streever 2000; Moy and Levin 1991). Research conducted in Galveston Bay, Texas comparing natural and created *Spartina alterniflora* marshes indicates that there are significant differences in physical parameters such as marsh-water edge ratios, area-perimeter ratio, marsh edge angle of exposure, and elevation (Delaney et al. 2000). Another study conducted in Galveston Bay indicates that densities of both fishes and decapod crustaceans are lower in created marsh 3 to 5 years in age (Minello and Webb 1997). In a study conducted in a tidal marsh in Virginia, a 12-year-old constructed marsh showed significant differences in habitat function in three areas: sediment organic carbon at depth, saltbush density, and bird utilization (Havens et al. 2002).

However, some research indicates that as marshes age, they progress to a general level of habitat function similar to that of natural marshes. A study conducted in North Carolina suggests that after 20 to 25 years, constructed marshes are similar to natural marshes in vegetation productivity, benthic infaunal density, and organic carbon accumulation, but that soil nutrient reservoirs are lower in constructed *Spartina* marshes (Craft et al. 1999).

Vegetation and soil development in created brackish marshes were found to be related, in part, to tidal inundation (Craft et al. 2002). Aboveground biomass of *Spartina alterniflora* reached levels comparable to natural marshes within 3 years after marsh creation (Craft et al. 2002). This vegetation was found in the lowest elevations (along the tidal creeks) of the created marsh and was inundated much of the time (Craft et al. 2002). Vegetation growing in the interior marsh where the elevations were higher and inundation was less frequent took longer to reach production levels comparable to that of natural marshes, and vegetation (growing in the highest elevation along the upland border of the marsh) that was infrequently inundated never attained equivalence to the natural marsh (Craft et al. 2002). Although these results pertain to brackish marshes, similar patterns of vegetation and soil development may occur in intermediate marshes.

In addition to the USACE dredged material beneficial use program (USACE 1995) and the Louisiana Department of Natural Resources Dedicated Dredging program (LDNR 2000), several marsh creation projects have been constructed in coastal Louisiana with CWPPRA funding that provide an opportunity to further study created marsh systems and better determine the success potential of the technique. Design parameters of previously constructed marsh creation projects are summarized in Appendix B, and selected projects are discussed below.

- The Bayou LaBranche Wetland Creation (PO-17) project, located on the southwestern shore of Lake Pontchartrain, was the first project constructed through the CWPPRA program, with construction completed on April 1, 1994. The project was designed to reach a minimum 70% emergent marsh to 30% open-water ratio 5 years after construction. In 1997, the project area was approximately 82% land and 18% water; however, only 51% of the land was emergent marsh with the rest being scrub-shrub and upland habitats (Boshart 2004). The low amount of emergent marsh was attributed to

sediment elevations being higher than suitable for emergent vegetation. The target range of sediment elevation for this project, after five years of consolidation, was estimated at +0.65 to 1.62 feet NAVD (Boshart 2004). As of August 2002, elevation at eleven of the 19 staff gauge stations was within this target range. In addition, soil properties and vegetation communities have continued to develop toward characteristic wetland habitats for the region.

- The Barataria Bay Waterway Wetland Restoration (BA-19) project intended to enlarge Queen Bess Island by creating 9 acres of vegetated wetlands using sediment from maintenance dredging of the waterway. The elevation of the marsh platform was projected to be +1.22 feet NGVD 29 after settlement and consolidation; however, two years after construction the elevation was +0.79 feet NGVD 29 (Curole 2001). Because of the low elevation, the project area is constantly flooded and no appreciable vegetation growth has occurred (Curole 2001).

- The Atchafalaya Sediment Delivery (AT-02) project was designed to utilize sediment dredged from two channels in the Atchafalaya Delta to create islands suitable for the establishment of emergent marsh vegetation (Rapp et al. 2001). However, inaccurate elevation surveys made prior to construction caused the dredged material to be piled too high (Raynie and Visser 2002). As a result of the lower flooding frequency and duration produced by this elevation, the created islands have become dominated by wetland forest vegetation rather than the targeted emergent marsh species that colonized nearby natural crevasse splays.

- The goal of the West Belle Pass Headland Restoration (TE-23) project was to reduce the encroachment of Timbalier Bay into the headland by creating 184 acres of marsh using sediment dredged from Bayou Lafourche. Failed containment dikes, though, allowed a large quantity of sediment to be washed out of the marsh creation sites before the material had settled/consolidated. Furthermore, large sections of the project area were filled to levels significantly higher or lower than the targeted +1.7 feet NAVD 88 elevation. As a result, only 31 acres of saline marsh were created by this project, with the remainder being upland, beach/bar/flat, and subaqueous habitats (Curole and Huval 2005).

- The goal of the Lake Chapeau Sediment Input and Hydrologic Restoration, Point Au Fer Island (TE-26) project was to create 260 acres of marsh, which would act as a hydrologic barrier between two watersheds in the project area. The marsh platform was designed to have an elevation of +1.5 feet NGVD 29 at construction, and +0.5 feet NGVD 29 (or existing marsh elevation) after settlement/consolidation. However, portions of the project area were not filled to the correct elevation, and some of the sediment was removed by tidal flow coming through containment dike failures and the dredge pipeline corridor (Raynie and Visser 2002). Consequently, the created marsh has a lower elevation than adjacent natural marsh, leading to more frequent and longer inundation than optimal for healthy marsh. The TE-26 project only created approximately 139.5 acres of new land (Lear and Triche 2007).

- The Sabine Refuge Marsh Creation, Cycle 1 (CS-28-1) project is part of an overall effort to create approximately 1,120 acres of emergent marsh using sediment from maintenance dredging of the Calcasieu Ship Channel. The goal of the first cycle, completed in February 2002, was to create approximately 125 acres. The marsh platforms were designed to have an elevation of +3.08 feet NAVD 88 at construction, and an elevation of +1.08 feet NAVD 88 after five years (Sharp and Juneau 2007). Although post-construction elevation surveys have not been conducted, vegetation surveys found that the marsh platforms were densely covered by emergent vegetation within two years after construction (Sharp and Juneau 2007).

Marsh Nourishment

Marsh nourishment is a relatively new restoration strategy that has not been widely used in CWPPRA-funded projects. The concept behind marsh nourishment is that the addition of sediment would increase plant growth by improving the conditions within the growing environment by adding a mineral and nutrient source, increasing oxygen levels through soil aeration, and reducing the frequency and duration of flooding because of the increased elevation. Interest in marsh nourishment as a coastal restoration technique began with studies evaluating the environmental effect of thin layer (~5 to 20 centimeters [~2 to 8 inches]) disposal of dredged material in marshes as an alternative to bucket dredging (Cahoon and Cowan 1988; Wilber 1993). These early studies concluded that dredged material disposed in thin layers in existing healthy marshes did not permanently negatively impact healthy marshes, though they also did not provide any benefits. Immediately following disposal of material there was some plant die-off; however, re-vegetation occurred within a few years. The model for marsh recovery varies according to the thickness of sediment placement and extent of soil modification, and will occur either through the new shoots from the surviving rhizomes, or through reseeding (Wilber 1993).

Leonard et al. (2002) found that adding 2-10 centimeters (~0.8 to 4 inches) of dredged material on the surface of deteriorated marshes led to a two-fold increase in vascular plant stem densities and to an increase in benthic microalgal biomass. By the end of the second growing season, the stem densities for deteriorated sites receiving the largest addition of sediment (10 centimeters) converged with the stem densities for non-deteriorated sites (Leonard et al. 2002). In addition, sites that received a sediment addition had higher oxygen levels, which may have led to the observed canopy improvement in deteriorated sites (Leonard et al. 2002). This improved plant cover increased the potential for flow baffling, lowering velocities in the amended deteriorated sites and leading to a decrease in the remobilization of surface sediments (Leonard et al. 2002). The study was unable to determine the optimal thickness of sediment (addition of 10 centimeters was the maximum application) that could be added to deteriorated marsh to provide benefits to the marsh while not causing detrimental effects (Leonard et al. 2002).

Mendelssohn and Kuhn (2003) investigated the effects on a salt marsh of 4 different thicknesses of sediment additions, ranging from trace amounts up to 60 centimeters (~24 inches). The sediment additions resulted from the accidental overflow of hydraulically dredged material being used to fill a gas pipeline canal adjacent to the marsh (Mendelssohn and Kuhn 2003). The marsh was divided into 5 areas based on the amount of sediment that each area received. The divisions were as follows: 1) no sediment addition, 2) trace amounts of sediment that were not quantifiable, 3) sediment addition not greater than 15 centimeters, 4) sediment addition between 15 and 30 centimeters, and 5) sediment addition greater than 30 centimeters (Mendelssohn and Kuhn 2003). The addition of sediment was shown to improve plant growth by increasing soil

aeration, mineral matter content, and available nutrients (Mendelssohn and Kuhn 2003). Areas receiving the 2 greatest additions of sediment (4 and 5 above) showed increased plant production (Mendelssohn and Kuhn 2003). Mendelssohn and Kuhn (2003) concluded that the addition of sediment to the marsh could play a positive role in deteriorated coastal marshes where rates of sea level rise are greater than the rates of vertical accretion.

Summary/Conclusions

A review of relevant literature, as well as monitoring data from previously constructed restoration projects similar in scope and design to the proposed project, was used to confirm the effectiveness of rock dikes as shoreline protection features. Monitoring results for the Lake Salvador Shore Protection (BA-15), Boston Canal/Vermilion Bay Bank Protection (TV-09), Cameron Prairie National Wildlife Refuge Shoreline Protection (ME-09), and other similar shoreline protection projects indicate that rock dikes have successfully reduced shoreline erosion in areas of poor soil conditions and some have even accreted land behind the structures. However, monitoring results for the Turtle Cove Shoreline Protection (PO-10) project have shown a lack of success with respect to structure integrity in an area with poor soil conditions. These findings provided insight as to how effective the constructed projects were at achieving their specified goals and can assist in predicting how well this proposed project may perform.

The bearing capacity of the soil and the elevation of the rock dike are critical to the success of the proposed shoreline protection. Geotechnical investigations for this project determined that the soils in the project area are capable of supporting the foreshore rock dike as proposed. Sufficient bearing capacities will allow easier construction and proper alignments for the proposed structure and will afford the structure a better opportunity to reach the intended goal. In the event of higher settlement rates than those currently anticipated, the maintenance events recommended in the draft O&M plan can be used to bring the structure back to the original +2.0 feet NAVD 88 elevation (NRCS 2007a).

Lessons learned from the monitoring of the Bayou LaBranche Wetland Creation (PO-17) project and other marsh creation projects demonstrate the need to build marsh to an elevation that is conducive to the development of the appropriate habitat. Achieving this elevation in the created or nourished marsh should result in an inundation regime that is similar to that of a natural marsh and should, therefore, allow for the establishment and production of vegetation on the newly created marsh platform. An important consideration related to vegetative production is that the borrow material that will be dredged for marsh creation and nourishment for this project consists of mostly fine-grained material, much of which contains organic matter. This fine-grained sediment is more likely to contain adequate nutrient supplies to support vegetative productivity than would coarser, sandy soils that generally have a lower organic content.

In order to increase tidal exchange and therefore productivity in the project area, Boshart (2004) suggests creating gaps or removing sections in the containment dikes. One component of the draft O&M plan is to gap the containment dikes within the first 3 years of the operations and maintenance phase if the dikes have not degraded sufficiently to allow tidal exchange to occur within the newly created marsh platform (LDNR 2007).

VII. Recommendations

Based on the evaluation of available ecological, geological, and engineering information, as well as scientific literature and environmental data, and a review of similar restoration projects, the proposed strategies of the South Shore of The Pen Shoreline Protection and Marsh

Creation project will likely achieve the desired ecological goals. At this time, it is recommended that this project be considered for Phase 2 authorization.

Appendix C of this document contains the responses to issues that were identified in the 30% Ecological Review.

References

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APPENDIX A

Design parameters of CWPPRA and state-funded constructed shoreline protection projects (sorted by construction date).

Project Name	Project Number	Coast 2050 Region	Construction Date and Maintenance Event(s)	Depth Contour (ft)	Structure Length (ft)	Structure Elevation (ft NAVD 88)	Distance from Shoreline (ft)	Effectiveness of Shoreline Protection
Blind Lake (State)	CS-BL	4	1989		2,339	4.0	70	Positive
Cameron Prairie National Wildlife Refuge Shoreline Protection	ME-09	4	1994	-1.0	13,200	3.7	0-50	Positive
Freshwater Bayou Bank Protection (State)	TV-11	3	1994, 1996*, 2001*		25,800	4.0		
Holly Beach (State)	CS-01	4	1991-1994		7.2 miles	4.0 ft NGVD 29	185-595	
Turtle Cove Shore Protection (State)	PO-10	1	1994		1,640**	3.0	0-300	Positive
Boston Canal / Vermilion Bay Bank Protection	TV-09	3	1995	-2.0	1,405	3.8 ft NGVD 29		Positive[1]
Freshwater Bayou Wetland Protection	ME-04	4	1995, 2002*, 2005*	-1.0	28,000	4.0	0-150	Positive[2]
Sabine National Wildlife Refuge Erosion Protection	CS-18	4	1995	-2.0	5.5 miles			Positive
LaBranche Shoreline Protection (State)	PO-03b	1	1996		8,850	5.3 ft NGVD 29	constructed onshore	
Vermilion River Cutoff Bank Restoration	TV-03	3	1996, 2005*		6,269	3.5 ft NGVD 29	landward toe @ waters edge	Inconclusive[3]
Clear Marais Bank Protection	CS-22	4	1997	-1.2	35,000	3.0 ft NGVD 29	0-50	Positive
Bayou Segnette (State)	BA-16	2	1994, 1998		6,800	3.0 to 5.0		
Freshwater Bayou Bank Stabilization	ME-13	4	1998, 2005*	-1.0	23,193	3.7 to 4.0	100	Positive
Lake Salvador Shore Protection Demonstration	BA-15 Phase II	2	1998	-1.0 to -1.4	8,000	2.51	100	Positive
West Belle Pass Headland Restoration	TE-23	3	1998	-2.0 MLG	17,000	6.0 MLG		Positive[4]
Quintana Canal/Cypremort Point (State)	TV-4355NP1	3	1998	-1.5 -1.0	3,700 2,900 1,500	3.5 ft NGVD 29 (seg. BW) 3.0 ft NGVD 29 (dike) 4.0 ft NGVD 29 (revetment)		

Design parameters of CWPPRA and state-funded constructed shoreline protection projects ([sorted by construction date] continued).

Project Name	Project Number	Coast 2050 Region	Construction Date and Maintenance Event(s)	Depth Contour (ft)	Structure Length (ft)	Structure Elevation (ft NAVD 88)	Distance from Shoreline (ft)	Effectiveness of Shoreline Protection
Cote Blanche Hydrologic Restoration	TV-04	3	1999, 2001*		4,140	3.0	60-450	Positive
Perry Ridge Shore Protection	CS-24	4	1999		23,300	3.0 to 4.0	60	Positive
Barataria Bay Waterway West Side Shoreline Protection	BA-23	2	2000		9,900	4.0		See comment: a
Barataria Bay Waterway East Side Shoreline Protection	BA-26	2	2001, 2006*		17,054	4.0 ft NGVD 29		See comment: b
Bayou Chevee Shoreline Protection	PO-22	1	2001		8,875	3.5 ft NGVD 29	300	Positive[5]
Cheniere Au Tigre Sediment Trapping Demonstration	TV-16	3	2001		1,800	3.5	200	Positive
Sweet Lake/Willow Lake Hydrologic Restoration	CS-11b	4	2001		17,460	4.0		Positive[6]
Black Bayou Hydrologic Restoration	CS-27	4	2001		22,600	3.0	10-60	See comment: c
GIWW-Perry Ridge West Bank Stabilization	CS-30	4	2001	-1.0	10,704	3.7	60	Positive[7]
Marsh Island Hydrologic Restoration	TV-14	3	2001, 2005*		3,600 1,800	5.0 4.0	50-70	Inconclusive[3]
Oaks/Avery Canal Hydrologic Restoration, Increment 1	TV-13a	3	2002		5,300 1,200 300	3.0 3.0 -24 to +5	0-30 0-30	
Oaks/Avery Structures (State)	TV-13b	3	2002		1,200	3.0	12-16 (onshore)	
Jonathan Davis Wetland Protection	BA-20	2	1998, 2001, 2003		1,385 (2001) 3,967 (2001) 13,088 (2003)	3.0 3.5 3.5		Positive
Mandalay Bank Protection Demonstration	TE-41	3	2003	-1.0 to -3.0	5,380***	1.5 to 3.0	10-200	See comment: d
Grand-White Lakes Landbridge Protection	ME-19	4	2004	-1.0 to -2.0	12,024	2.5	50-200	See comment: e

Design parameters of CWPPRA and state-funded constructed shoreline protection projects ([sorted by construction date] continued).

Project Name	Project Number	Coast 2050 Region	Construction Date and Maintenance Event(s)	Depth Contour (ft)	Structure Length (ft)	Structure Elevation (ft NAVD 88)	Distance from Shoreline (ft)	Effectiveness of Shoreline Protection
Lake Salvador Shoreline Protection Extension (State)	BA-15x1	2	2005	-1.0	10,000	3.5		
Cheniere Au Tigre (State)	CAT-01	3	2005		2,800		240	
Barataria Basin Landbridge Shoreline Protection, CU 1, CU 2, CU 3, CU 6	BA-27, BA-27c, and BA-27d	2	2006 (CU 6) 2004 (CU 3) 2004 (CU 2) 2001 (CU 1)	0 (CU 3) -2.0 (CU 2) -2.5 (CU 1)	31,500 (CU6) 10,835 (CU 3) 6,403 (CU 2) 3,200 (CU 1)	3.5 (CU 3) 3.5 (CU 2) 3.0 (CU 1)	0-50 (CU 3) 50-600 (CU 2) 50-100 (CU 1)	CU 1 tested four different designs See comment: f
Shoreline Protection Foundation Improvements Demonstration	LA-06	4	2006	-1.5	5,400	3.5	235	
South White Lake Shoreline Protection	ME-22	4	2006	-1.5	61,500	3.5	235	
Little Lake Shoreline Protection/ Dedicated Dredging Near Round Lake	BA-37	2	2007	-2.0	21,000	2.5		

* Denotes maintenance to shoreline protection structure(s).
** Denotes that structure was rock-gabion instead of rip-rap.
*** Four test sections were constructed as part of this demonstration project: 1,196' of submerged articulated concrete revetment mats; 1,749' of straight-walled fiberglass sheetpile; 1,241' of 24-inch A-Jacks®; 1,194' of staggered treated lumber fencing.

[1] Post Hurricane Lili monitoring results indicate shoreline loss.
[2] Erosion rates in the project area have increased since construction was completed in 1995. However, the shoreline protection has significantly reduced erosion rates relative to reference areas. Therefore, the shoreline protection was deemed effective, yet the hydrologic restoration and vegetation components do not appear to be effective.
[3] The most recent available monitoring report indicates that shoreline surveys were anticipated to be completed in upcoming years.
[4] The shoreline protection component of the project is considered effective, but the marsh creation component was not successful.
[5] The monitoring report (2007, in press) contains more detailed information. Due to a construction delay and as a result of continued shoreline erosion, the boundary between the project and reference areas for the South Cove portion of the project is difficult to determine. Therefore, accurate rates of land loss or gain are also difficult to determine. In addition, land loss has occurred as a result of the termination of the South Cove rock dike in open water as opposed to on land.
[6] The shoreline protection component of the project is considered effective. The open water and shoreline terraces are considered ineffective and moderately effective, respectively.

[7] Visual observations indicate vertical accretion between the rock dike and the shoreline.

a: Post-construction aerial photography to determine land to water ratio has been collected but not analyzed.
b: There is no monitoring activity associated with this project because it is classified as a shoreline protection project.
c: As of the most recent monitoring report (2007), data had not been analyzed to determine the effectiveness of the shoreline protection.
d: Analysis of data to determine the effectiveness of the shoreline protection will be made after data collection for 2008 is complete.
e: Analysis of data to determine the effectiveness of the shoreline protection will be made after additional aerial photography and shoreline surveys are completed.
f: Construction of additional phases of this project is ongoing. Analysis of data to determine the effectiveness of the shoreline protection will be made after additional aerial photography and shoreline surveys are completed.

APPENDIX B

Design parameters of constructed marsh creation projects (sorted by construction date).

Project Name	Project Number	Coast 2050 Region	Construction Date	Project Area (acres)	Dredged Material (cubic yards)	Marsh Created (acres)	Marsh Elevation (ft)	Project Summary	Monitoring Results
Queen Bess (State)	BA-05b	2	1993		152,000	8	3.22 NGVD29	Dredged material was added to the island, and a rock dike was installed around the perimeter of the original island to armor the shoreline in order to restore the island as a brown pelican rookery.	The island increased from 17 acres (1989) to 34.6 acres (1996) from combined efforts of this project and the CWPRRA-funded BA-19 project. Pelican nests continue to increase, and the area has become vegetated. The sediment deposition rate is 0.14 ft./yr. in the project area and 0.31 ft./yr. on the original island. These rates indicate that the containment dike breach created by these projects allowed a substantial amount of effluent to settle, as intended, in adjacent wetlands outside of the dredge-fill area.
Bayou LaBranche Wetland Creation (CWPPRA)	PO-17	1	1994	487	2.7 million	305	2.44 ± 0.19 NAVD88	Dredged sediment from Lake Pontchartrain was used to create vegetated wetlands in an open water area bounded by I-10, Lake Ponchartrain, and Bayou LaBranche.	The average salinity (5.3 ppt) was statistically higher than in the reference area (4.6 ppt) due to less tidal flushing because of the semi-impoundment of the project area. As of January 1999, sediment elevation was within the target range (0.65 to 1.62 ft NAVD) in most of the project area. 300 acres of open water converted to land in 3 years, although only 51% of project area was classified as marsh vegetation in 1997.
Wine Island (FEMA)	DSR-81558	3	1995					The island was repaired to pre-Hurricane Andrew condition with beneficial use of dredged material from Houma Navigational Canal maintenance and with vegetation planted to stabilize sediment.	
Barataria Bay Waterway Wetland Delivery (CWPPRA)	BA-19	2	1996	510		9	3.72 NGVD29	Vegetated wetlands were created adjacent to the state-funded Queen Bess project by constructing a 1,650-foot shell dike and filling the containment area with dredged material from the Barataria Bay Waterway (BBWW).	The island increased from 17 acres (1989) to 34.6 acres (1996) from combined efforts of this project and the state-funded BA-05b project. Vegetation has not colonized the project area because of low elevation and persistent inundation with water.
East Island Repair Protection (FEMA)	DSR-81560	3	1996					An elevated marsh platform was constructed in an area of a Terrebonne Parish project destroyed by Hurricane Andrew. Vegetation was planted to stabilize the sand.	
Timbalier Island Repair (FEMA)	DSR-81559	3	1996					A major breach created by Hurricane Andrew was closed. A 300-ft-wide elevated marsh platform was constructed, and vegetation was planted to stabilize the sand.	

Design parameters of constructed marsh creation projects (sorted by construction date [continued]).

Project Name	Project Number	Coast 2050 Region	Construction Date	Project Area (acres)	Dredged Material (cubic yards)	Marsh Created (acres)	Marsh Elevation (ft)	Project Summary	Monitoring Results
West Belle Pass Headland Restoration (CWPPRA)	TE-23	3	1998	2,459	2.7 million	184	2.0 NAVD88	Dedicated dredging was used to create marsh on the west side of Belle Pass. A water control structure and 17,000 linear feet of riprap were used to reduce the encroachment of Timbalier Bay into the marshes on the west side of Bayou Lafourche. Several restorative measures have been undertaken or proposed to alleviate the failures and impacts of the project.	Only a 5.4% increase in saline marsh area was attained. The inability to create a saline marsh environment was a direct result of construction failures and adverse impacts. Only 1.23 million of the planned 2.7 million cubic yards of material was dredged, creating just 31.2 acres. Target elevations were not met. Also, 9.5 acres of vegetated wetlands were damaged by marsh buggies, and disposal of flotation channel refuse buried 8 acres of existing wetland vegetation. In contrast to the marsh creation phase, the shoreline protection phase was successful in lowering the shoreline erosion rate.
Atchafalaya Sediment Delivery (CWPPRA)	AT-02	3	1998	4,248	720,000	280		Dredged material was obtained from the re-opening of Natal Channel and was placed at elevations mimicking natural delta lobes in order to allow natural marsh growth. By reestablishing water and sediment flow into the eastern part of the Atchafalaya Delta, an additional 1,200 acres of new habitat are expected to be naturally created over the project life.	Project created more scrub-shrub habitat than emergent marsh because sediment was stacked too high during construction. It is too early to tell whether the project will create the projected 1,900 acres. One year post-construction, only 78.4 acres were created.
Big Island Sediment Mining (CWPPRA)	AT-03	3	1998	3,400	3.4 million	922	1.5 to 3.0 NGVD29	The project includes the creation of a western delta lobe behind Big Island to enhance the accretion of land beyond the west bank of the Atchafalaya River. A main stem and five branch channels designed to mimic natural channel bifurcations were dredged, and material was placed at elevations mimicking natural delta lobes. Re-established water and sediment flows are expected to add an additional 2,000 acres over the project life.	The channels are maintaining adequate depth and still delivering sediment into the delta. However, the project created substantially more scrub-shrub and beach/bar/flat habitats than emergent marsh.
Lake Chapeau Sediment Input and Hydrologic Restoration, Point Au Fer Island (CWPPRA)	TE-26	3	1999	13,024	850,000	160		The objectives of the project are to restore the marshes west of Lake Chapeau, to re-establish the hydrologic separation of the Locust Bayou and Alligator Bayou watersheds, and to re-establish the natural drainage patterns within the Lake Chapeau area. The hydrologic separation of the watersheds was established using dredged material from Atchafalaya Bay, and the restoration of island hydrology by plugging oil field access canals and gapping artificial spoil banks.	Plants are vigorously growing and spreading.

Design parameters of constructed marsh creation projects (sorted by construction date [continued]).

Project Name	Project Number	Coast 2050 Region	Construction Date	Project Area (acres)	Dredged Material (cubic yards)	Marsh Created (acres)	Marsh Elevation (ft)	Project Summary	Monitoring Results
Barataria Bay Waterway, Mile 31 to 24.5 (WRDA)	N/A	2	1999					Dredged material from miles 31 to 24.5 of the Barataria Bay Waterway (BBWW) was used to create marsh habitat.	
Brown Lake (WRDA)	N/A	4	1999		1.6 million	315		Dredged material was pumped to an elevation conducive to marsh creation in Brown Lake area near Calcasieu River, 16 miles south of Lake Charles.	
MRGO (1999), Mile 14 to 11 (WRDA)	N/A	1	1999		3.5 million			Dredged material from miles 14.0 to 11.0 of the Mississippi River Gulf Outlet (MRGO) navigation channel was placed unconfined in shallow water adjacent to the south jetty at mile 15.3. The material was placed at an elevation conducive to marsh vegetation establishment.	
Dedicated Dredging Program - Lake Salvador (State)	LA-01a	2	1999		114,089	26		Two sites adjacent to Baie du Cabanage in the Salvador Wildlife Management Area were filled by using dredged material to nourish and rebuild marshes.	
Isle Dernieres Restoration, East Island (CWPPRA)	TE-20	3	1999	449	3.9 million			Sand dredged from adjacent waters was used to build dunes and an elevated marsh platform. Sand fences were installed and vegetation was planted to stabilize sand and minimize wind-driven transport. A claim submitted to FEMA to repair damage to this project caused by Hurricane Katrina is still pending.	The island increased 187.3 acres in size from 1996 to 2002. Fences have accumulated sand to create dunes. Vegetation survival was high (70%) after one growing season. Non-planted and non-seeded vegetation increased from <1% (2001) to >23% (2003). There has been an increase in species richness and vegetative cover each year.
Isle Dernieres Restoration Trinity Island (CWPPRA)	TE-24	3	1999	776	4.85 million			Sand dredged from adjacent waters was used to build dunes and an elevated marsh platform. Sand fences were installed and vegetation was planted to stabilize sand and minimize wind-driven transport. A claim submitted to FEMA to repair damage to this project caused by Hurricane Katrina is still pending.	The island increased 92.64 acres in size from 1996 to 2002. Fences have accumulated sand to create dunes. Vegetation survival was high (>80%) after one growing season. Vegetative cover decreased from 34.4% (2001) to 7.8% (2003) in dune plots. There has been an increase in overall species richness and bay plot vegetative cover each year.
Calcasieu River & Pass Phase I - Phase III (WRDA)	N/A	4	1992 1996 1999		4.0 million			Four million cubic yards of dredged material was removed between miles 7.5 and 11.5 of the Calcasieu Ship Channel and deposited in 3 phases within the Sabine National Wildlife Refuge at an elevation conducive to marsh creation.	

Design parameters of constructed marsh creation projects (sorted by construction date [continued]).

Project Name	Project Number	Coast 2050 Region	Construction Date	Project Area (acres)	Dredged Material (cubic yards)	Marsh Created (acres)	Marsh Elevation (ft)	Project Summary	Monitoring Results
Barataria Bay Waterway, Grand Terre Island (Phase I - Phase II) (WRDA)	N/A	2	1996 1999		500,000			Dredged material from the Barataria Bay Waterway (BBWW) was placed beneficially to create wetlands on Grand Terre Island.	
Dedicated Dredging Program - Bayou Dupont (State)	LA-01b	2	2000		448,725	160		Three sites adjacent to Bayou Dupont and The Pen were filled utilizing dredged material to nourish and rebuild marshes.	
East Timbalier Island Sediment Restoration, Phase II (CWPPRA)	TE-30	3	2000	9,330	2.8 million	216	3.0 NGVD29	Dredged material was placed along the landward shoreline of the island. Additional rock was placed on the existing breakwater in front of the island. A claim submitted to FEMA to repair damage to this project caused by Hurricane Katrina is still pending.	Created habitats are now supporting a range of new, emergent vegetation.
Whiskey Island Restoration (CWPPRA)	TE-27	3	2000	4,926	2.9 million	657		Back barrier marsh was created, the breach at Coupe Nouvelle was filled, and *Spartina alterniflora* was planted as part of this project. A claim submitted to FEMA to repair damage to this project caused by Hurricane Katrina is still pending.	The island increased 168.03 acres in size from 1996 to 2002. Vegetation survival was very low (<30%) after one growing season due to drought after planting. More than 21,600 cubic yards of sediment was lost from wind and overwash events in 1.5 years due to the lack of sand fencing and the lack of aerial seeding of Cynadon dactylon. There was a decrease in species diversity and percent cover from 2001 to 2003 due to lack of sand fencing.
Brown Marsh (Other)	BRM-01	3	2002			44		Thin layer marsh creation and nourishment in Lafourche Parish.	
Sabine Refuge Marsh Creation, Cycles 1-5	CS-28	4	2002 Cycle 1 2007 Cycle 3	6,006	1.0 million 828,767	214 232	3.08 NAVD88 2.03 to 2.71 NAVD88	Two of the five planned cycles have been completed using material dredged from Calcasieu River Ship Channel to create marsh in large, open water areas in order to block wind-induced saltwater intrusion.	The first cycle resulted in densely covered marsh more quickly than anticipated. Interior marsh quickly filled with vegetation (Spartina patens) one year post-construction. The next four cycles should produce similar results.
MRGO, Mile 14 to 12 (2002) (WRDA)	N/A	1	2002		1.6 million			Dredged material was pumped behind the MRGO jetty to create marsh habitat. The project was fast tracked due to the impact of Hurricane Lili and Tropical Storm Isidore.	

Design parameters of constructed marsh creation projects (sorted by construction date [continued]).

Project Name	Project Number	Coast 2050 Region	Construction Date	Project Area (acres)	Dredged Material (cubic yards)	Marsh Created (acres)	Marsh Elevation (ft)	Project Summary	Monitoring Results
Dustpan Maintenance Dredging Operations for Marsh Creation in the Mississippi River Delta Demonstration (CWPPRA)	MR-10	2	2002	N/A	222,000	40		This project demonstrated the beneficial use of dredged material from routine maintenance of the Mississippi River Navigation Channel by using a dustpan hydraulic dredge to create and restore adjacent marsh that had converted to shallow open water.	Vegetation successfully colonized marsh creation area one year following project completion.
MRGO, Mile 14 to 12 (2003) (WRDA)	N/A	1	2003		4.3 million			Dredged material from miles 14 to 12 of the MRGO navigation channel was placed at an elevation conducive to marsh vegetation establishment.	
Timbalier Island Dune and Marsh Creation (CWPPRA)	TE-40	3	2004	663	4.6 million	273	1.6 NAVD88	Beach, dunes, and marsh were restored on the eastern end of the island. A claim submitted to FEMA to repair damage to this project caused by Hurricane Katrina is still pending.	
Dedicated Dredging Program - Pass a Loutre (State)	LA-01c	2	2005			26		Twenty-six acres of sustainable freshwater marsh was created in the vicinity of Pass a Loutre using dredged material.	
South White Lake Shoreline Protection (CWPPRA)	ME-22	4	2006	5,473		172		This project included the construction of segmented breakwaters to protect approximately 61,500 linear feet of shoreline along the south shore and interior marshes of White Lake. Material dredged to create a flotation channel was placed beneficially behind the breakwaters to create marsh substrate.	

Design parameters of constructed marsh creation projects (sorted by construction date [continued]).

Project Name	Project Number	Coast 2050 Region	Construction Date	Project Area (acres)	Dredged Material (cubic yards)	Marsh Created (acres)	Marsh Elevation (ft)	Project Summary	Monitoring Results
Freshwater Introduction South of Highway 82 (CWPPRA)	ME-16	4	2006	24,874	243,390	14.5	2.5 NAVD88	The project goals were to address saltwater intrusion and the lack of freshwater and sediment input in the project area. Project construction included installing four water control structures, breaching spoilbanks in areas near Highway 82 to allow water to flow across the chenier, and removing plugs to facilitate water flow from the lakes subbasin into the chenier subbasin. Sediment obtained from channel widening was spread via spray dredge to a height of 10 in. to nourish adjacent marshes. In addition, 26,000 linear feet of vegetated earthen terraces were constructed in open water areas to create marsh, reduce fetch and wave energy, retain sediments, and maintain SAV habitat.	
Dedicated Dredging Program - Terrebonne Parish School Board (State)	LA-01d	3	2006			40		Forty acres of sustainable marsh was created just north of Lake DeCade along the western bank of Minors Canal using dredged material.	

Prepared by Summer R. Martin

APPENDIX C

The 30% Ecological Review recommended that the two issues below be addressed prior to scheduling the 95% Design Review conference. The response that was received to address each issue is included below each of the numbered items.

Issue 1
At the end of construction, if the marsh platform has not dewatered and consolidated to the point where it is stable, consideration should be given to leaving the containment dikes in place until the marsh platform is stable and gapping the containment dikes to allow for tidal exchange to occur. A post-construction O&M event could be considered to fund a separate mobilization to degrade the dikes once the marsh platform has consolidated fully.

Response
The text below was taken from the draft Operation, Maintenance, and Rehabilitation Plan (O&M plan) for the South Shore of The Pen Shoreline Protection and Marsh Creation (BA-41) project. This draft report was received on October 26, 2007, and a revised draft was received on December 17, 2007.

> "Within the first 3 years of the O&M phase, the remaining containment dikes will be strategically breached to aid in the formation of naturally occurring tidal features. It is estimated that 10 gaps will be required and dredged to a -3 NAVD to a width of 50 feet."

Issue 2
The curves provided for the projected settlement of the marsh platform over the 20 year project life indicate that the majority of the settlement (from an initial fill elevation of +2.78 feet NAVD 88 in the northern area and +3.1 feet NAVD 88 in the southern area to +1.3 feet NAVD 88) takes place less than one year after construction. Further, the straight line nature of the curves from year 2 through year 20 post-construction indicates that no settlement of the marsh platform will occur after year 2. While total settlement of the marsh platform over the project life is anticipated to be 1.48 feet in the northern area and 1.8 feet in the southern area, as detailed in the geotechnical report, the depiction of the settlement of the marsh platform as provided by the settlement curves seems unrealistic. Syed Khalil (Geologist, LDNR, personal communication, October 1, 2007) concurs with this opinion.

Response
Ronnie Faulkner (NRCS, Project Engineer) received an email response on October 19, 2007, from Burns Cooley Dennis, Inc. (NRCS contractor for the geotechnical investigation) regarding the settlement curves provided in the Addendum Report on the Geotechnical Investigation for the South Shore of The Pen Shoreline Protection and Marsh Creation (BA-41) project. The email contained the following information related to the flat slopes of the settlement curves after the initial settlement occurs: "each data point shown on the plots through 20 years has a specific value associated with it that resulted from the model and although the lines appear to be horizontal in comparison to the early settlement, they actually have a very flat downward slope. It is also noteworthy that in all of these figures the changes in slope of the settlement curves occur near the normal water elevation for this site".