ECOLOGICAL REVIEW

Castille Pass Channel Sediment Delivery
CWPPRA Priority Project List 9
(State No. AT-04)

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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 October 27, 2005.

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In August 2000, the Louisiana Department of Natural Resources (LDNR) 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 Castille Pass Channel Sediment Delivery (AT-04) project is located in Atchafalaya Bay in the eastern portion of the Lower Atchafalaya River (LAR) Delta, St. Mary Parish, Louisiana. The project area extends southeastward to Four League Bay and is bordered to the north by Natal Pass, to the southwest by Roger Brown, Gary, and Ibis islands, and includes Castille Pass and East Pass channels (Figures 1 and 2).

The purpose of the Castille Pass Channel Sediment Delivery project is to redirect flow from the Atchafalaya River into the areas east of the delta in order to promote natural sub-delta formation. The need for this project has arisen because channel dredging and concomitant dredged spoil placement east of the channel does not promote sedimentation and natural subaerial land formation in the adjacent shallow water. Without construction of this project, it is anticipated that 160 acres of land will be built within the project area through natural land-building processes (Coastal Wetlands Planning, Protection and Restoration Act [CWPPRA] Environmental Working Group 1999). With construction, this project is expected to create 1,236 acres of subaerial land (666 acres in the cove area, sub-delta natural formation over the 20-year project life plus 570 acres of initially created marsh from project construction dredge material) over the 20-year project life through the promotion of natural sub-delta formation and the beneficial use of dredged material. This results in a net increase of 1,076 acres (1,236 created acres minus 160 future-without-project acres) of marsh attributable to the project's construction.

Coast 2050 has identified maximizing land building in Atchafalaya Bay as a Region 3 ecosystem strategy that entails the maintenance of land-building processes which preserve the mainland wetlands in the Atchafalaya-outlets area (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation Restoration Authority [LCWCRTF and WCRA] 2001). This project (AT-04) will augment land building in Atchafalaya Bay already initiated by the Atchafalaya Sediment Delivery (AT-02) project and the Big Island Mining (AT-03) project, both of which are in the vicinity of this project (Figure 1).

II. Goal Statement

- Facilitate natural sub-delta formation in the shallow-water areas between East Pass and Four League Bay to build approximately 666 acres of land over the 20-year project life.

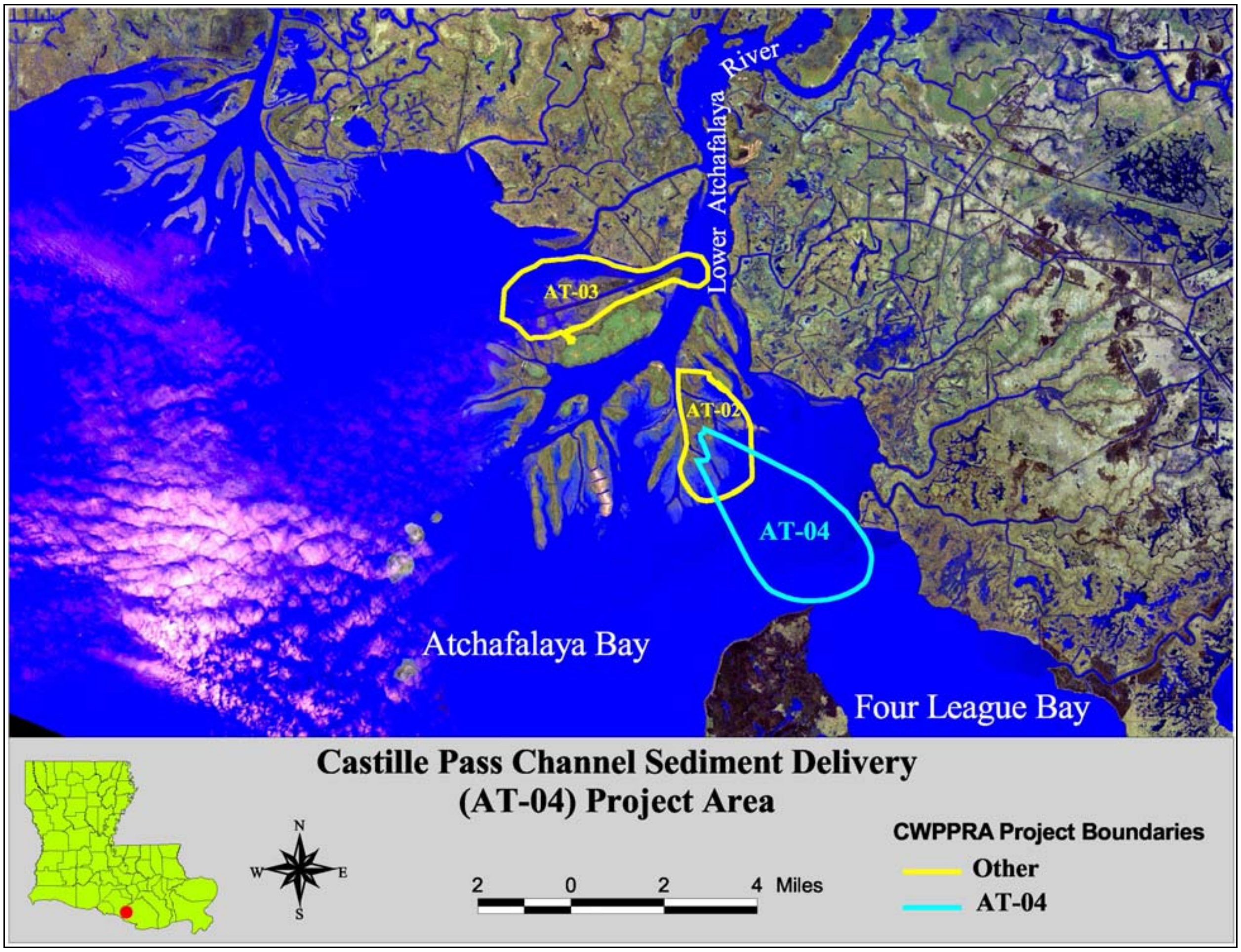

Figure 1. Castille Pass Channel Sediment Delivery (AT-04) project area.

- Initially create approximately 570 acres of emergent land, suitable for establishment of marsh vegetation over the 20-year project life, using dredged material.
- As a result of these goals, approximately 1,236 acres of marsh will exist in the project area at the end of the 20-year project life.

III. Strategy Statement

- East, Castille, and Natal passes will be dredged, and conveyance channels with bifurcation channels will be built in the open water area east of the existing delta.
- Every six years following construction, the project will be reviewed to determine the need to re-dredge existing channels and create new bifurcating channels.
- Sediment excavated during canal dredging throughout the project life will be used to create conveyance channel banks and new sub-delta lobes.

IV. Strategy-Goal Relationship

Dredging of existing channels in the eastern portion of the LAR Delta, and maintenance dredging as needed, will facilitate natural sub-delta formation in the adjacent shallow, open-water areas between East Pass and Four League Bay by maintaining efficient flow of water and sediment through these passes. Strategic placement of the dredged spoil will not only serve to promote channelization of existing passes into the open-water areas but will also provide emergent platforms suitable for establishment of marsh vegetation.

V. Project Feature Evaluation

Project Features

Channel Dredging

Three channels are proposed to be dredged in an effort to increase flow and land building in the eastern portion of the LAR Delta. East Pass will be widened and deepened from its entrance to Castille Pass and the East Pass exit channel will be extended toward the southeast. The existing Castille Pass and Natal Pass branch channels will also be extended southeastward into the bay (Figure 2).

Channel Banks/Beneficial Use of Dredged Material

Dredged material from the widening and deepening of the channels will be placed along the channel banks to redirect the flow of water and sediment into the shallow bay. The configuration of the channel extensions and channel bifurcations will create three still-water coves which will receive diverted water flows and thereby facilitate natural sub-delta formation. The still-water coves, consisting of approximately 666 acres of shallow bay bottom, are located between East Pass and Castille Pass extensions, between the two Castille Pass extensions, and between Natal Pass and Castille Pass extensions (Figure 2).

The disposal areas (DA) are designed to contain the hydraulically dredged materials. The project disposal areas are strategically located to direct flood flows, to accommodate channel dredging, and to create new marshland acreage. The disposal areas are constructed by placing perimeter diking around each area. Temporary effluent control boxes will be placed in the dike at selected places to control the discharge from the DA to extend the retention time allowing the hydraulically dredged material time to settle within the DA.

The planned placement height of the hydraulic dredge disposal material in the DA is between elevation +2.0 feet to +2.5 feet North American Vertical Datum of 1988 (NAVD 88) behind the front dikes, next to the channels. The material will flow and settle to an elevation near the rear DA dike at approximate elevation +1.0 feet NAVD 88. Allowing for a 20% shrinkage that is anticipated for the placed material as it dries in the first year, the initially created marsh will be considered intertidal as the elevation range will be from +0.75 feet to +2.0 feet NAVD 88 (BCG 2005). In the two DAs along the East Pass entrance at the Atchafalaya River, the placement of the dredged material is planned at elevation +2.5 feet NAVD 88 and +2.0 feet NAVD 88 feet across the width of the DA to ensure a solid and defined channel entrance.

Maintenance Dredging

Maintenance dredging will be required on average every 6 years to remove shoals which are expected to form at the channel bifurcations.

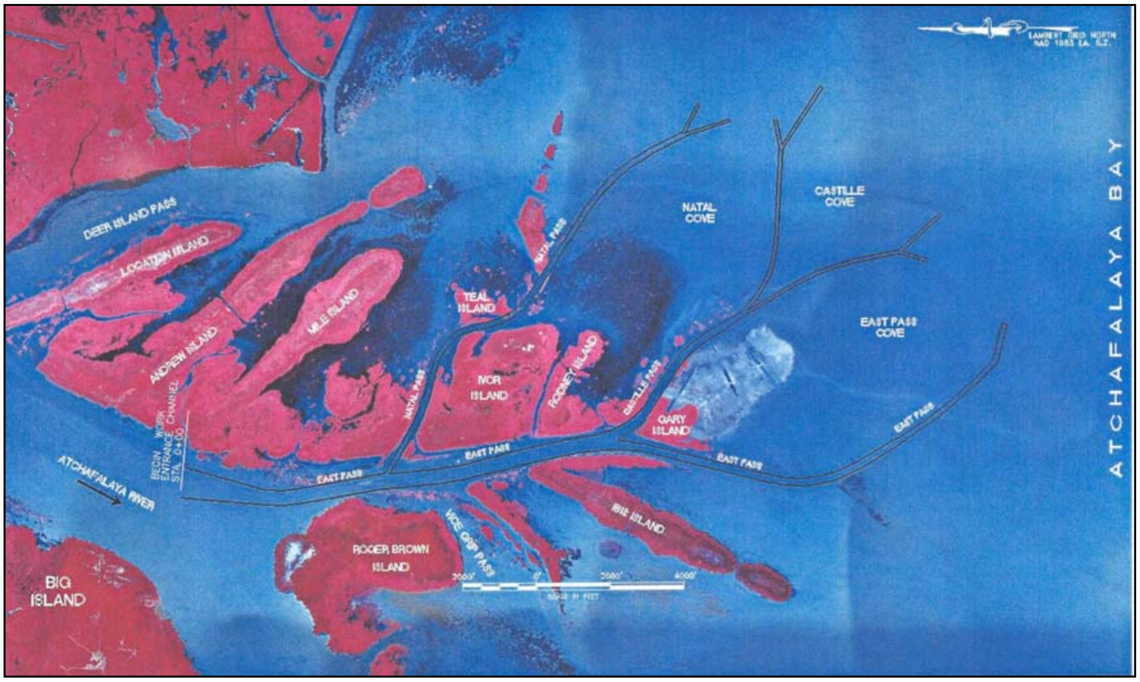

Figure 2. Castille Pass Channel Sediment Delivery (AT-04) project plan map (Brown Cunningham Gannuch 2005).

Hydrodynamic Model

Hydrodynamic Model Description

Louisiana State University developed a model to simulate deltaic bar and distributary channel formation and sediment transport within the LAR Delta (Mashriqui 2003). The TABS-MD model was chosen to explain the dominant processes that control flow, sediment transport, and delta growth in the LAR Delta. The model suite includes hydrodynamic (RMA2) and sediment transport (SED2D) modules. It was chosen over other models because of its ability to run on a desktop and to interface with Surface-Water Modeling System (SMS) software. The SMS software, developed by Brigham Young University (BYU) in cooperation with United States Army Corps of Engineers (USACE) - Waterways Experiment Station (WES), provides a tool whereby the user may perform tasks such as mesh generation, data interpolation, and graphical visualization.

Data used to develop the LAR Delta model were derived from a variety of sources (Mashriqui 2003). The bathymetry data used were from the 1998-1999 hydrographic survey of the Atchafalaya River System by the USACE, New Orleans District (NOD). Depth configurations of the Atchafalaya Bay were available from a 1994 terrain model developed at LSU (Fitzgerald 1998). Additional bottom depth data were taken from the TABS model developed for the Atchafalaya River Reevaluation Study done by USACE-WES. Information regarding the Atchafalaya River navigation channel was provided by USACE-NOD. Hydrologic data were taken from USACE sources. Periodic flows, stage and sediment data were collected from Tarbert Landing, Mississippi for the Mississippi River and from Simmesport, Morgan City, and Calumet at Wax Lake Outlet (WLO) for the Atchafalaya River. Suspended sediment data have been collected by USACE since 1952 at Simmesport, and since 1980 at Morgan City and WLO. From these data, both total sediment load and grain size distribution could be calculated for use in the model. In order to calibrate the sediment model developed for the entire LAR Delta for use in modeling specific passes within the delta, detailed bathymetry, flow, tide and sediment information were collected in 2001 and 2002.

Hydrodynamic Model Modifications (Brown Cunningham Gannuch [BCG] 2005)

Based on results of the initial model run and subsequent Louisiana Department of Natural Resources (LDNR) comments, the model was modified and re-run. The first step in the modification of the Castille Pass numerical hydrodynamic and sediment transport models developed by LSU was to reproduce previously reported model results using the SMS version 8.1 software. This was successfully accomplished by the use of the RMA2 version 4.35 hydrodynamics model and SED2D version 4.54 sediment transport model. Computer simulations of the new base and two plans were performed with these models.

The original model base mesh was edited to include the new design features and to incorporate some new survey information into a new base mesh. Depths in the new base mesh were then changed to reflect project features with and without a dam in lower East Pass. The boundary conditions were the same as used in the previous model evaluation except that the peak tidal boundary heights were limited to 3.4 feet NAVD 88, compared to the original 3.8 feet NAVD 88. A peak tidal elevation of 3.4 feet NAVD 88 was deemed more reasonable based on tidal data collected at the riverside of Bayou Boeuf Lock and near Eugene Island.

The results from the new base model run were very similar to the original base. The flow in East Pass increased from 6.4 to 6.9 percent of the flow in the lower Atchafalaya River as a result of the changes in base geometry mentioned in the last paragraph.

Modeling Alternatives

Three plan configurations were modeled and analyzed:

1. Base Flow – No improvements.
2. New Plan with Dam – All plan improvements and a closure dam at the existing mouth of East Pass to divert flow towards the project target area.
3. New Plan without Dam – All plan improvements and no closure dam at the existing mouth of East Pass.

Modeling Results (BCG 2005)

The projected emergent marsh creation targets within the three created still-water coves at the end of the 20-year project life are based on the annual occurrence of a continuous headwater flow of 350,000 cubic feet per second (cfs) in the Atchafalaya River at Morgan City, Louisiana, during the four month peak flow period (March through June). It is assumed that this rate of discharge is sufficient to transport the sand fraction of the river's sediment load toward the accreting face of the LAR Delta.

Water surface profiles, flow distribution, and silt deposition were extracted from model results for all three of the plan configurations. The water surface profile data was prepared as an aid in determining the top-of-dike elevations for the containment dikes in the new project plan. However, the probability of the high tide elevation of +3.4 feet NAVD 88 used in the model boundary condition occurring in nature at the same time as the peak headwater flooding from the project appeared low. Additionally, the collected tidal data records indicated that the duration of the elevation +3.4 feet high tide stage was only about one day. Due to these factors, BCG concluded that the model predictions for the water surface were artificially high and not practical for utilization to set the top-of-dike elevations for the project. The top-of-dike elevations were set based upon the model prediction of the 0.5-feet of water surface fall between the channels and the bay and the annual mean high tide recorded at the Amerada Hess Gage (south of the project area), elevation +2.3 feet NAVD 88. Combining these two data and rounding to the nearest foot, a design water surface elevation of +3.0 feet NAVD 88 was determined for the project. This design water surface elevation was used for determining the top-of-dike elevations.

The flow distribution data were prepared to determine the impacts to the project of a closure dam at the mouth of East Pass and the impact of the revisions of the new plan. The flow distribution reporting ranges were taken as close to the original model reporting range locations as practical, given the geometric changes involved in the revised project design.

The silt deposition data was prepared to provide predictions of sedimentation. The same seven sediment-reporting areas of the original model were utilized (as close as practical given the geometry changes involved with the revised project design).

Selection of Preferred Alternative (BCG 2005)

The modeling results were presented to LDNR on May 20, 2005. The modeling results predict little impact to the project from a closure dam located at the mouth of East Pass. Consequently, the sponsoring agencies, LDNR and the National Marine Fisheries Service (NMFS), decided that the "New Plan without Dam" configuration should be utilized.

Sedimentation Predictions (BCG 2005)

The reported data for the model prediction of the sedimentation rate of the three plan configurations spans a one-month period. This sedimentation rate prediction for the "New Plan without Dam Configuration" was expanded to predict the sedimentation (on average) within the East Pass Cove, Castille Pass Cove and Natal Pass Cove.

VI. Assessment of Goal Attainability

Background

The majority of the Louisiana deltaic plain is receiving too little sediment to offset the effects of subsidence and erosion and is, thus, in the abandonment phase of the deltaic life cycle (Cahoon 1991). The Atchafalaya basin is the major exception to this scenario, with delta-building occurring on two fronts: at the mouth of the LAR, and at the mouth of WLO (Adams and Baumann 1980). The Atchafalaya River has been a distributary of the Mississippi River since the 1500's and has a hydrologic advantage over the Mississippi River. Because of this, flow of the Mississippi River would have been captured by the Atchafalaya River if it were not for the construction of the Old River Control structure in 1963. Through the use of this structure, the USACE now maintains flow of the Atchafalaya River at 30% of the combined flows of the Mississippi and Red Rivers. The flow of the Atchafalaya River splits at Calumet, Louisiana,. At this point, an average of 40% of the original flow moves through WLO, while the remainder discharges through the LAR Delta;

however, the fraction moving through WLO may be as low as 30% during project flood conditions (USACE 1995 in Majersky et al. 1997).

Sediments carried by the Atchafalaya River are dominated by silt-clay fractions, and concentrations increase in a non-linear fashion with regard to discharge. Sediment concentrations generally increase sharply as discharge increases through the lower ranges, level off with moderate flows, and begin to decrease as flow increases above flood stages (Mossa 1990; Figure 4.8 in Mashriqui 2003). Mean annual suspended sediment (SS) concentrations are higher in the Atchafalaya River than in the Mississippi River because the Atchafalaya receives flow from the Red River, which can exceed Mississippi River SS concentrations two- to five-fold (Mossa 1990). Sand transport into the bay is minimal relative to silt (Mashriqui 2003). Data from sediment/erosion curves indicate that at a discharge less than 400,000 cfs at Morgan City, the majority of sand would not be transported to the bay. Further, modeling results indicate that very little transport of coarse sediments (sands) may be expected beyond 1,000 meters of the mouth of the proposed AT-04 feeder channel even during high discharge. Because these heavier materials are important components of land building, it is notable that flood conditions would be required to transport the sand fraction of the sediment load toward the accreting face of the delta. This is congruent with historical land building in the delta, which has been characterized by higher rates of land building in years following a major flood relative to years following minor floods (van Heerden and Roberts 1988).

Both outlets for Atchafalaya River water open into Atchafalaya Bay. The broad, shallow configuration of this bay has allowed for rapid progradation of these deltas during above average flood discharges in the early phases of subaerial growth. These deltas first became emergent after the flood of 1973, and have continued to grow since that time. While the WLO delta has been allowed to develop naturally, a large portion of the growth in the LAR Delta is a result of placement of material dredged during channel maintenance onto existing shallow-water or emergent portions of the delta. Because a navigation channel is maintained in the Atchafalaya River from Morgan City to the Gulf of Mexico, this portion of the river is regularly dredged and the dredged material is disposed within the LAR Delta as part of the USACE Beneficial Use of Dredged Material Program ([BUMP]; Penland et al. 1996). The years and locations of dredged material placement in the delta are shown in Figure 3. Between 1958 and 1974, dredged material was placed unconfined in open water on either side of the navigation channel. In 1974, the channel dimensions were enlarged and the resulting dredged material was placed in open water and on subaerial levees of existing delta lobes on the west side of the navigation channel. This practice continued between 1979 and 1985, and it was during this period that Big Island was created. At the request of the Louisiana Department of Wildlife and Fisheries and the U. S. Fish and Wildlife Service, the USACE began placing dredged material east of the main channel beginning in 1987 in an effort to encourage natural land formation in the eastern portion of the delta. As a result of these activities, 1,436.55 of the total 4,286.06 acres (33.5%) of emergent land existing in November 1994 in the LAR Delta had formed naturally, with the rest the result of dredged spoil placement. Between December 1985 and November 1994, natural processes created 1,134.55 acres of emergent land in the LAR Delta, or about 136 acres per year (Penland et al. 1996).

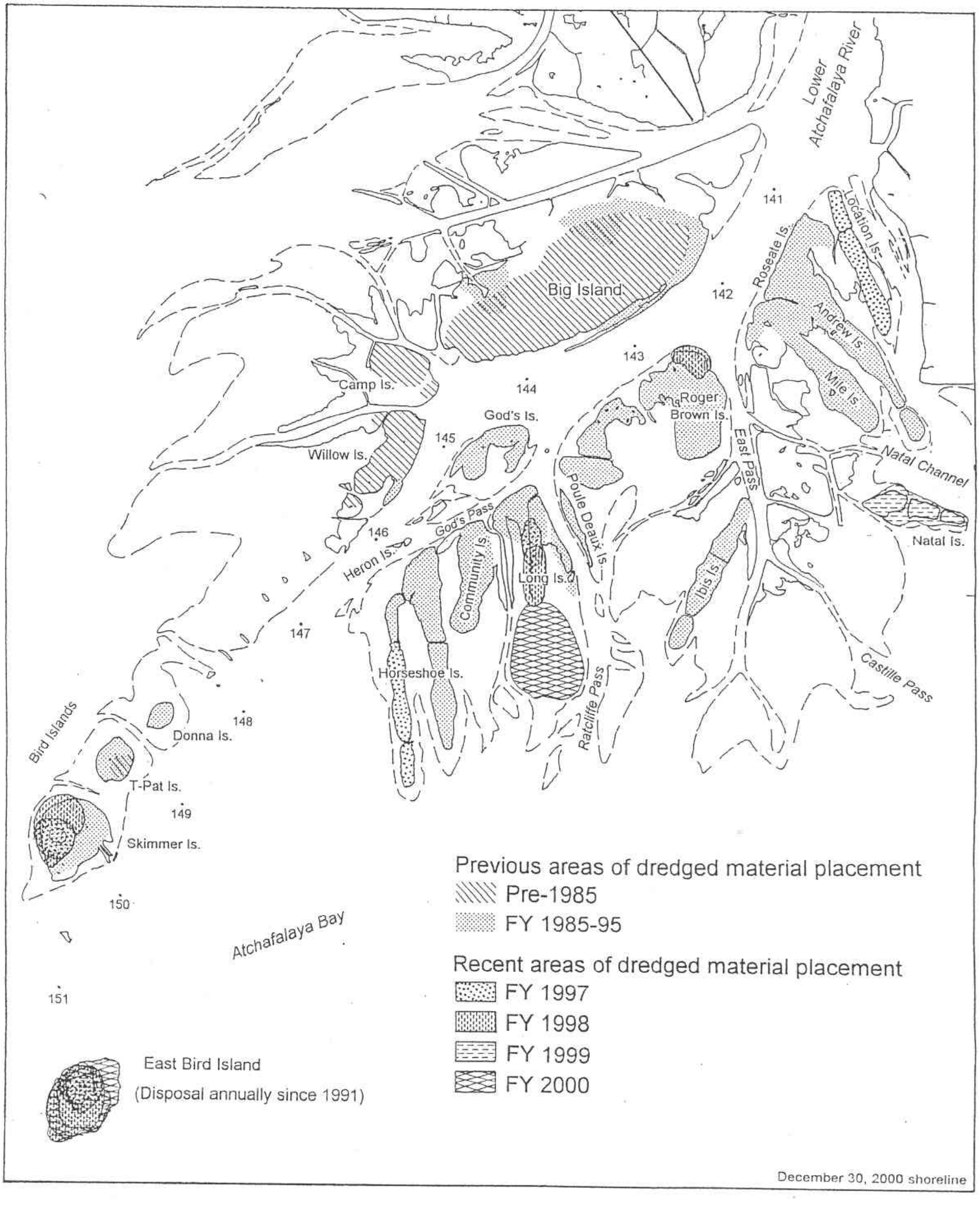

Figure 3. Dredged material disposal history for the LAR bay and bar reaches (Figure 8 in Penland et al. (1996)).

In a paper by van Heerden and Roberts (1988), two distinct stages of natural growth in the eastern, less disturbed portion of the LAR Delta were identified. The first was characterized by channel extension, bifurcation, and development of overbank channels. During the later growth-phase of the delta, filling and abandonment of many tertiary channels led to the fusion of islands formed earlier in the delta's life, thereby reducing the efficiency of water, sediment, and nutrient transport within and through the delta. In contrast to the LAR Delta, these processes all occurred simultaneously in the WLO Delta, indicating more efficient sediment retention by this system (Roberts and van Heerden 1992; van Heerden 1994; Majersky et al. 1997).

The lower sediment-trapping efficiency of the LAR Delta has been attributed to the maintenance of the main shipping channel (Adams and Baumann 1980). This deep channel effectively bisects the delta and, combined with high channel banks created when dredged material was placed to create islands, reduces the sediment trapping efficiency of the delta by providing an avenue for sediment to move seaward of the land formation (Roberts 1998). The proposed AT-04 project aims to enhance the delta-building ability of the Atchafalaya River in the southeastern portion of the LAR Delta by dredging existing bifurcations of the river to dimensions that will allow a larger volume of water (and associated sediment) to flow to the east of the main channel, and by creating still-water coves to encourage the deposition and retention of a larger fraction of sediment than the delta is currently retaining. Ultimately, this could result in subaerial expression in these areas.

Other CWPPRA Projects in the LAR Delta

Several CWPPRA projects have aimed to reverse the negative impacts of human activity in the delta by restoring the efficiency of water transport through and beyond the existing delta in order to promote continued splay development. Results from those projects located within the LAR Delta are described below:

- The Big Island Mining (AT-03) project, located along the right descending bank of the Atchafalaya Delta, was created to address a problematic situation that arose when spoil material was deposited along the western portion of the navigation channel. This 2-mile long island limited the westward flow of sediment-rich Atchafalaya River water (LDNR 1998); therefore, the Big Island Mining project was designed to enhance natural delta building processes by creating an avenue for sediment transport to the areas north and west of Big Island. This was done by dredging several distributary channels in a network pattern, designed to emulate natural bifurcations of a main distributary channel. Construction of the project ended September 20, 1997. A total of 7,510,088 cubic yards of dredged material was placed to create five disposal areas. Habitat mapping of 1998 aerial photography, taken immediately following construction, showed that the project created 157 acres. Of the 157 acres created, 106 were classified as scrub-shrub and 51 as fresh marsh. Elevation of the two intensively studied disposal areas ranged from approximately 0.5 feet to 4.0 feet NAVD 88, which is nearly 2 feet higher than most naturally created islands in the Atchafalaya Delta (LDNR 1998). Due to the quick colonization by black willow (*Salix nigra*), the areas classified as scrub-shrub have grown, and large portions of the project could now be considered forested wetland.

- The Atchafalaya Sediment Delivery (AT-02) project area overlaps with the proposed AT-04 project area (Figure 1). This project was authorized to enhance natural delta growth, which has been reduced as a result of maintenance dredging of the Atchafalaya River navigation channel. This was achieved by re-opening Natal Channel and Radcliff Passes to restore freshwater and sediment delivery to the East Delta lobe of the Atchafalaya River Delta. The AT-02 project, completed in March 1998, restored the sediment trapping efficiency of the eastern portion of the delta by dredging Natal and Castille passes, and using dredged spoil to create islands suitable for emergent wetland habitat. Prior to construction, Castille Pass had a subaqueous bar at its head which restricted flow; however, beyond the bar was a well-defined channel 6 feet deep and 120 feet wide. Castille Pass was dredged to a width of 125 feet and a depth of 10 feet from its head to a distance of approximately 2,000 feet (Rapp et al. 2001). Dredged material was pumped onto the adjacent marsh and shallow mudflats to increase marsh elevation and create new marsh. Evaluation of monitoring data indicated that only 70 of the projected 432 acres of marsh were created from the initial deposition of dredged material; however, this is twice the amount of land that was created naturally within the previous four years (Rapp et al. 2001). Additionally, the majority of the created habitat was forested wetland instead of marsh, indicating that sediment elevations were too high.

The proposed AT-04 project will build on the above AT-02 project by further increasing the volume of water, sediment, and nutrients reaching the eastern portion of the Atchafalaya Delta.

Maintenance Dredging

The features of this project are expected to build natural sub-deltas similarly to the way artificial crevasses cut through the levee of the Mississippi River build land: by increasing the delivery of sediment-laden freshwater into broad, shallow open-water areas which are conducive to sediment deposition and accumulation. Artificial crevasses, used as a restoration technique since the early 1980's in the Mississippi River Delta, have proven to be both cost-effective and successful in building marsh (Trepagnier 1994; Turner and Boyer 1997; Troutman and MacInnes 1999). Wells and Coleman (1987) outlined the life cycle of a natural crevasse splay as follows. A deltaic marsh is formed naturally when there is a break in the levee, usually during a flooding or overbanking event. This diversion of water often results in the formation of a new channel that directs flow into a shallow receiving bay. The bay then fills with sediment, and a subaerial splay forms and becomes emergent marsh. The splay expands as a series of bifurcations form the maturing crevasse. Under natural conditions, the channel eventually becomes inefficient at sediment delivery, fills in, and is abandoned as a freshwater distributary by the parent pass. The abandoned marsh is then left to subside, deteriorate, and eventually revert back to open water without nourishment from the parent pass. It is estimated that natural crevasse splays have a life span of 10 to 150 years, depending upon characteristics of the crevasse and adjacent parent pass (Coleman and Gagliano 1964; Wells and Coleman 1987; Trepagnier 1994; Boyer et al. 1997). However, it is generally understood that the majority of land growth by natural crevasses occurs within the first 10-15 years of its formation (LDNR 1999), and artificial crevasses may have similar life spans. Recent CWPPRA projects often incorporate a plan to deepen existing channels to their original dimensions and to dredge bifurcating channels every few years in an effort to encourage continued splay growth (USACE 1993; Boyer 1996; LDNR 1999). While this strategy is conceptually intriguing, its success is largely unproven.

Maintenance dredging and dredging new bifurcation channels are also strategies proposed to extend the land-building years for the proposed AT-04 project. In addition to knowledge gained from artificial crevasses, the performance of Natal Pass in the AT-02 project supports the need for these events in order to ensure that the land-building capacity of this project will be sustained throughout the 20-year project life. As previously mentioned, Natal Pass began shoaling at the head of the channel, and there was a loss in depth of the channel within just a few years of being dredged. Without these events, the newly dredged passes could shoal and reduce their discharge capacity very early in the project life, thereby minimizing the project's ability to achieve the goal of creating 1,326 acres of new land via natural sub-delta formation.

Marsh Creation

Marsh creation through the use of dredged material has been practiced in the U.S. for decades. It has been spurred not only by coastal wetland restoration efforts, but also by the desire to use material dredged during navigation channel maintenance in a beneficial way. In addition to the USACE Beneficial Use of Dredged Material Program [(BUMP); USACE 1995)] and the Louisiana Department of Natural Resources Dedicated Dredging program (LDNR 2000), several marsh creation projects have been constructed in coastal Louisiana through CWPPRA efforts. Results from selected projects are presented below:

- The Atchafalaya Sediment Delivery (AT-02) project, completed in March 1998, demonstrates the importance of placing dredge spoil at existing marsh elevation in order to promote growth of target plant species. This project was designed to utilize material obtained from maintenance dredging of two distributary channels of the east pass of the Atchafalaya River to create delta-lobe islands in the northwestern region of the Atchafalaya Delta in St. Mary Parish, Louisiana (Rapp 2001). Problems with the elevation surveys made prior to construction caused the dredge material to be piled nearly 0.75 feet higher than intended. Two years post-construction, the desired height still had not been achieved through processes of settlement, dewatering, and compaction. As a result, upland woody vegetation colonized the islands rather than the targeted emergent marsh species that colonized a nearby natural crevasse splay. This was attributed to differences in flooding frequency and duration, caused by differences in elevation between the natural and created emergent land.

- The Bayou LaBranche Wetland Restoration Project (PO-17), designed to create marsh in the open-water area of Bayou LaBranche in St. Charles Parish, Louisiana, was completed in April 1994. Utilizing sediment dredged from Lake Pontchartrain, approximately 305 acres of marsh was to be created at a ratio of 70% emergent marsh to 30% open water. The target elevation for the created marsh was estimated at 0.65 to 1.62 feet NAVD 88. The target elevation was generally met during construction; however, most of the project area was constructed in the upper range of the target elevation, which is not suitable for marsh plant species colonization. Further hampering the ability to reach target elevation was the fact that local interests constructed unauthorized water control structures, which reduced the rate of dewatering of the dredged material (Raynie and Visser 2002). Nonetheless, surveys conducted two and three years post-construction indicated that elevations decreased significantly from an average of 1.42 feet NAVD 88 to 1.27 feet

NAVD 88 in nineteen months time (Troutman 1998). Since 1998, mean sediment elevation has stabilized at about 0.7 feet NAVD 88, which is close to that of the reference marsh (Boshart 2003). Additionally, a shift towards higher frequency of wetland plants relative to upland species has occurred over time, most likely in response to the changes in sediment elevation. It is expected that, with time, the project marsh will achieve the desired marsh-water ratio and that the upland vegetation will be supplanted by wetland species (Troutman 1998).

- The Lake Chapeau Sediment Input and Hydrologic Restoration (TE-26) project, completed in May 2000, is an example where dredged material was not piled high enough for successful establishment of marsh plants. The land platform was constructed at an average elevation of 1.5 feet NGVD. It was expected that, after dewatering and consolidation, the final elevation would be 0.5 feet NGVD, which is the average marsh elevation as determined by cross section surveys of the fill area. However, some portions of the project area were not filled to the correct elevation, and there were problems with containment levees and the dredge discharge pipeline corridor. Consequently, the created marsh has a lower elevation than the adjacent natural marsh, leading to more frequent and longer inundation than desired in the creation of a healthy marsh. Although this project created marsh, it did not create as much acreage as intended (Raynie and Visser 2002).

Influence of Elevation on Plant/Animal Associations

The general pattern of delta formation in Atchafalaya Bay involves repeated mouth-bar development from deposition of suspended sediments at the ends of the delta distributaries, resulting in a series of islands forming at the point of channel bifurcations (van Heerden and Roberts 1988). Because of the physical processes controlling deposition patterns, each naturally-forming island has its highest elevation at the upstream end and along the leading edge with elevation decreasing towards a flat at the back of the island. Johnson et al. (1985) provided a description of vegetation associations with elevation in the Atchafalaya Delta. *Salix nigra* exist on the island-head levees where elevations are highest and flooding frequency is lowest. *Typha latifolia* and *Sagittaria spp.* are in areas with intermediate water levels, while *Najas spp.* are found on the flats at the downstream ends of the island, where elevations are lowest and flooding frequency is highest.

The structural complexity created by these gently sloping gradients also supports a wide variety of animal species. Both marsh and submerged aquatic vegetation (SAV) habitats generally support much higher densities of nekton (e.g., fish, crabs, and shrimp) than unvegetated sites, because they are used as refuge from predators, foraging, and nursery grounds (Rozas and Odum 1987; Castellanos and Rozas 2001). Castellanos and Rozas (2001) noted that nekton used vegetated areas (flooded marsh and SAV beds) of the LAR Delta in higher densities than unvegetated water bottom. Also, the shallow elevation gradient across the backmarsh (behind the main channel) provides a refuge for nekton, and extensive SAV beds adjacent to the backmarsh may also afford protection at low tide when organisms are forced out of the previously flooded marsh. Additionally, waterfowl utilize shallow water, vegetated habitat for both refuge and food (Fuller et al. 1988; Johnson 1995). Johnson (1995) observed that green-winged teal (*Anas crecca*) feeding was highest in areas where water was less than 15 cm deep, while mallards (*A. platyrhynchos*) would feed in water as deep as 27 cm. In another study conducted by Fuller et al. (1988), over twice as many waterfowl were observed in WLO Delta than in the LAR Delta despite the fact that the LAR Delta was twice as large. This was attributed to habitat composition. In the WLO Delta, over 70% of the vegetated area was *Sagittaria spp.*, of which nearly one half was the known waterfowl food *S. platyphylla*. In contrast, the LAR Delta, where elevations are higher than natural marsh elevation because of dredged spoil placement, *S. nigra* and *T. latifolia* communities dominated.

Target Elevation

Study results indicate that elevation is the most important factor to consider when creating marsh platforms (Montz 1976; Troutman 1998), as elevation is a major factor controlling variability among vegetation associations (Johnson et al. 1985). In fact, in the LAR Delta, a difference of just a few inches will result in different species becoming established and thriving in each elevation zone (Montz 1976). The consequences of creating supra-tidal land with dredged material may be observed in the habitat types created by BUMP efforts in the LAR Delta. The dominant habitat types in the man-made areas were forested wetland (33.7%), followed by scrub/shrub (23.8%), marsh (22.5%), and bare (20%) (Penland et al. 1996). In contrast, the dominant habitat type in the natural areas was overwhelmingly marsh (88.9%), followed by shrub/scrub (9.4%), and bare (1.7%) (Penland et al. 1996). Elevation differences account for the large differences in habitat type between the natural and man-made land. The average elevations of two surveyed created islands were +3.59 feet Mean Sea Level ([MSL] Horseshoe Island) and +4.74 feet MSL (Andrew Island). Based on simultaneous elevation and vegetation surveys conducted in this study, the optimal elevation for the establishment of intertidal marsh species in this portion of the LAR Delta appears to be less than +2.0 feet MSL. Another study conducted in the Atchafalaya Delta by Montz (1976) concluded that the maximum elevation for establishment of intertidal marsh vegetation is 1.56 feet MSL.

Factors such as settlement, dewatering, subsidence, shrinkage, and the elevation of existing natural marsh need to be considered when determining the elevation to which material should initially be piled. Additionally, alternatives to a one-time fill, such as staged construction or maintenance events for marsh nourishment should be considered in order to sustain the marsh platform at the target elevation for the duration of the project life (Raynie and Visser 2002). This (AT-04) project will effectively be nourishing the land platforms through overbanking during high water stages. Therefore, it would be preferable to err on the side of initially piling material too low than to chance piling material too high. The former scenario would allow natural physical processes the opportunity to create an elevation gradient suitable for the establishment of intertidal marsh species while encouraging the establishment of SAV in the adjacent subtidal shallow water.

Summary/Conclusions

The following four types of marshlands are expected to be created within the Castille Pass Channel Sediment Delivery project area:

1. Uplands - having an elevation greater than +3.0 feet NAVD 88.
2. Shrub/Scrub marsh - having an elevation range from +2.0 feet to +3.0 feet NAVD 88.
3. Intertidal marsh - having an elevation range from +0.75 feet to +2.0 feet NAVD 88.
4. Subaqueous marsh - having elevations at less than +0.75 feet NAVD 88.

The planned project diking will be mostly upland acreage with some shrub/scrub acreage along their slopes. The resulting elevation of the hydraulically dredged material in the DAs post-shrinkage (20% anticipated in the first year) will be between +0.75 feet NAVD 88 to +2.0 feet NAVD 88, thereby falling in the intertidal marsh category. This approximates the Penland et al. (1996) conclusion that the maximum elevation for the establishment of intertidal marsh vegetation is +2.0 feet NGVD (~MSL) which can be interpolated as corresponding to +1.8 feet NAVD 88 using USACE CORPSCON for Windows, Version 5.11.08. The projected accretion within the three cove areas will be classified as subaqueous marsh.

This project is to be constructed in a river mouth which may be classified as a dynamic area and as such, the impacting conditions (wind, wave, rain, and flow) will keep the channels, diking, and disposal areas in a constant state of change. Thus, to sustain the integrity and effectiveness of this project, maintenance of project features will be required every 6 years, on average, with dredging to re-establish dikes and dredging of shoals within the channels. This recommendation is based upon the observations made of the channel shoaling on the Big Island Mining (AT-03) project, which showed that a shoaling of channel bottoms to elevations from -3.0 feet to -5.0 feet NAVD 88 has occurred in six years (BCG 2005).

VII. Recommendations

Based on the evaluation of available ecological, geophysical, and engineering information, in addition to the investigation of similar restoration projects, the proposed strategies of the Castille Pass Channel Sediment Delivery (AT-04) project will likely achieve the desired ecological goals. At this time, the Louisiana Department of Natural Resources, Coastal Restoration Division recommends that this project be considered for CWPPRA Phase 2 authorization.

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