COTE BLANCHE HYDROLOGIC RESTORATION (TV-04)

I. INTRODUCTION

I.1. Project Description

The project is located in St. Mary parish, Louisiana, at approximately Lat 29° 40’ 45” Long 91° 33’ 40”. Within the landscape, the 30,000-acre (12,140.8-hectare) project area is located on the eastern side of the Vermilion-Cote Blanche Bays system and is west of the Wax Lake Outlet. The project’s eastern boundary is the flood protection levee west of Bayou Sale. East Cote Blanche Bay is the southern boundary, along with an indefinite east-west line from East Cote Blanche Bay to the levee just south of South Bend, LA. West Cote Blanche Bay is the western boundary and the Gulf Intracoastal Waterway (GIWW) is the northern boundary (figure 1).

The project was proposed as a candidate for the Second and Third Priority Project Lists, and was selected for the third list. A WVA was completed for the project for each year’s list. The project was originally proposed to be approximately 32,400 acres (13,112.3 hectares) with the eastern boundary continuing south past the terminus of the levee, along Highway 317 and the western bank of Bayou Sale to its mouth at East Cote Blanche Bay (USDA SCS and State of Louisiana 1992). During the third year WVA process, the project boundary was adjusted to eliminate the southern area between South Bend and the Burns Point area (USDA SCS and State of Louisiana 1993).

The originally proposed project features consisted of 10,000 linear feet (3,048 linear meters) of low-level rock shoreline protection along the southern boundary, two rock plugs on oilfield canals, 10 passive rock weirs on natural and oilfield channels that lead into the bays, and two flap-gated culverts on two oilfield canals that are connected to the GIWW. All of these features were included when the project was approved for the Third Priority Project List (LCWCRTF 1993).

During the project investigation and development phase in 1994, the two flap-gated culverts and five weirs (on Bayou Mascot, Bayou Zenor, two unnamed bayous opening onto W Cote Blanche Bay, and Yellow Bayou) were eliminated from the proposed plan. The structures were eliminated from those waterways because it was determined that the tidal exchange at each of those locations was not contributing to interior erosion within the respective drainage areas. In addition, the two rock plug features (on Humble-F Canal and the British-American Canal) were changed to passive weir structures to maintain access and allow continued freshwater and sediment delivery (1994 Revised NRCS Project Plan Map; October 1994 C. Schexnayder briefing by K. Roy; March 2002 C. Steyer communication with L. Broussard).

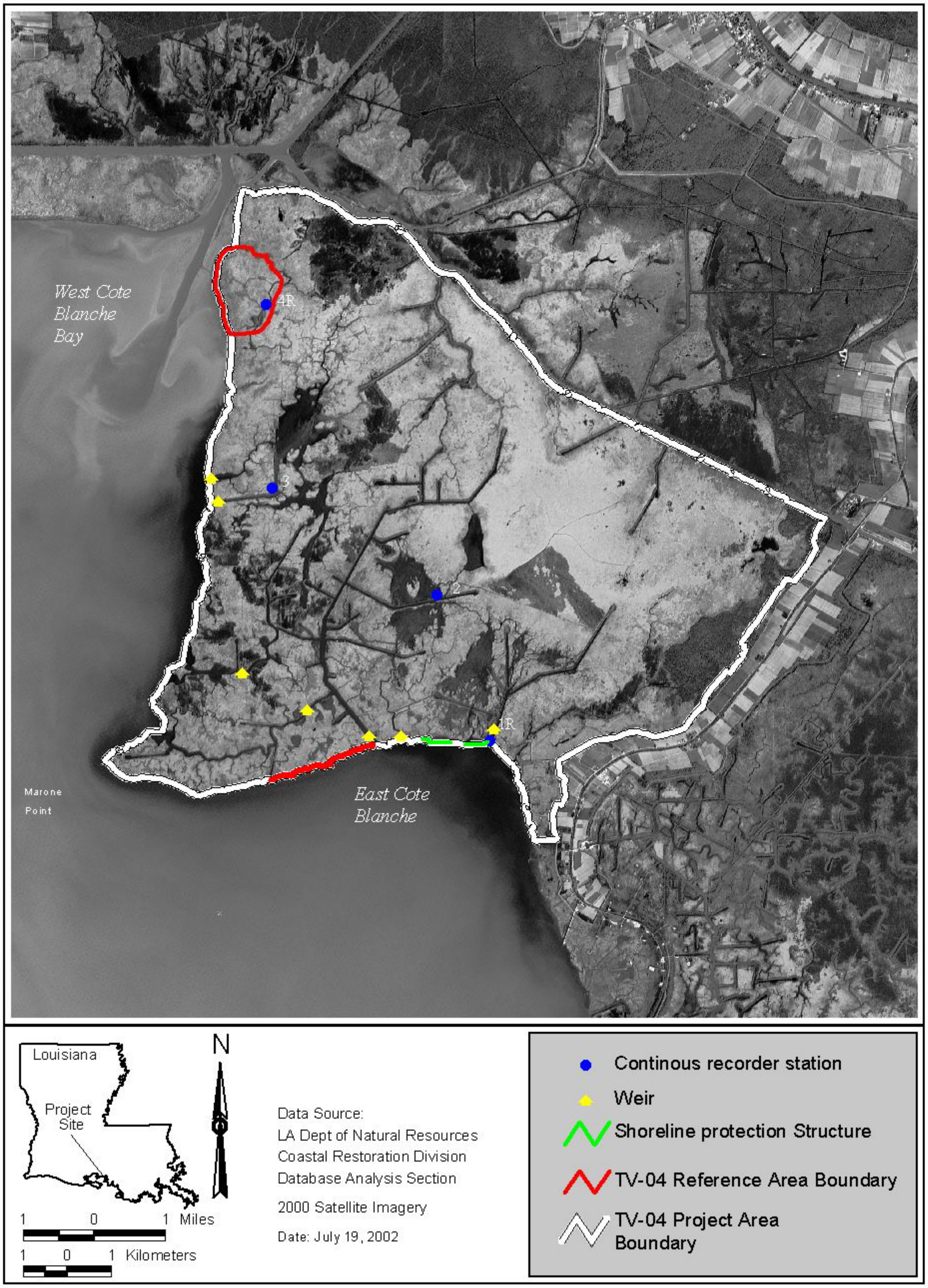

Figure 1. The Cote Blanche Hydrologic Restoration (TV-04) project and reference area boundaries and monitoring stations.

The project plan that was recommended in the EA, and that was permitted, consisted of seven passive water control structures, and 10,000 linear feet (3,048 linear meters) of rock foreshore dike along the shoreline between the British-American Canal and Jackson Bayou (USDA NRCS 1995). Six of the structures, on Mud Bayou, Humble-F Canal, Bayous Long and Carlin, Jackson Bayou, and British-American Canal, were to be rock or sheet piling low-level weirs with boat bays. The seventh structure on the Humble Canal was to be a rock or sheet piling weir with a barge bay. The use of rock or sheet piling would be determined in the design phase after the geotechnical investigation was completed.

The project, constructed between April 1998 and January 1999, consists of seven weirs and approximately 4,000 linear feet (1,219.2 linear meters) of new shoreline protection. Locations, elevations and other dimensions of the project features per NRCS TV-4 Construction Unit #1 As-Built Plans, April 1999, are as follows:

Four low-level weirs with boat bays are on Mud Bayou, Bayous Long and Carlin, and Jackson Bayou. These weirs were built with steel sheet piling with crest elevations of –1.5 (-.457 m) NAVD and bay bottom elevations of –2.5 ft (-.762 m) to –3.5 ft (-1.067 m) NAVD, except for Mud Bayou which was built at –5.5 ft (-1.676 m) NAVD. Bays were provided to allow boat access.

Two structures on the Humble-H and British-American Canals, with crest elevations of -.5 ft (-.152 m) NAVD and bay bottom elevations at –2.5 (-.762 m) NAVD, were built with a combination of steel sheet piling wing walls and a rock weir middle. This combination of materials was per a landowner's request to allow future access by large oilfield equipment without destroying or eliminating a structure. The rock in the center of the structure could be temporarily removed and replaced in accordance with negotiated conditions.

One weir on Humble Canal was a low-level weir at –1.5 ft (-.457m) NAVD with a –7.0 ft (-2.134 m) NAVD barge bay built with a combination of sheet piling and rock. In the case of this structure, use of the combination of materials was due to cost and not access (March 2002 C. Steyer interview with L. Broussard).

The shoreline protection is a vinyl sheet piling wall that was built in two main sections. One project wall section extends 1,640 feet (499.9 meters) west from the British-American Canal to the east end of an existing wooden sheet piling wall (approximately 40-50 years old) which is approximately 1,200 feet (365.8 meters) in length. The other wall section extends west approximately 2,310 linear feet (704.1 linear meters) from the west end of the existing wooden wall. The vinyl material was chosen to construct the wall when the geotechnical investigation revealed that the soils were unsuitable for supporting even a low elevation rock dike. The final length and footprint of the wall was the result of budget and design limitations.

I.2. Project Personnel

Project Phase	Name	Position	Agency
1. Planning	Kevin Roy	Project Manager (formerly NRCS)	USFWS
2. Planning & Implementation	Cindy Steyer	Project Manager	NRCS
3. Planning & Implementation	Jerry Hall	District Conservationist	NRCS
4. Planning & Implementation	Terrell Rabalais	District Conservationist	NRCS
5. Planning & Implementation	Loland Broussard	Planning Engineer	NRCS
6. Planning	Garrett Broussard	Planning Engineer	DNR
7. Planning & Implementation	Herb Juneau	Engineer	DNR
8. Design	Steve Garner	Engineer	NRCS
9. Construction	Wayne Melancon	Engineer	NRCS
10. Monitoring	Shannon Holbrook	Monitoring Mgr	DNR
11. Monitoring	Christine Thibodaux	Monitoring Mgr	DNR
12. O&M	Herb Juneau	Engineer	DNR
13. O&M	Brad Sticker	Engineer	NRCS

II. PLANNING

II.1. Causes of Loss

What was assumed to be the major cause of land loss in the projected area?
The project area marshes are situated on highly organic soils formed in the interdistributary basin between Bayou Sale and Bayou Cypremort. Marsh deterioration and breakup began to occur prior to construction of some of the oilfield canal system but there was no direct connection with the bays and GIWW. Expansion of the oilfield canal system beginning in the 1950's appeared to accelerate the removal of organic substrate due to increased tidal action and rapid water exchange between very fragile interior marshes and East and West Cote Blanche Bays through several large canals. NRCS Soils investigations in 1991 showed that available sediment was not accreting within the project area and that the original substrate was continuing to erode (USDA SCS 1992). Areas incurring the greatest loss were adjacent to the larger canals and have highly organic soils that cannot withstand high velocity water flow (USDA SCS 1969).

Shoreline erosion was occurring at the rate of 10 to 15 feet (3.1 to 4.6 meters) per year. Shoreline surveys by Miller and Assoc. conducted between 1958 and 1975, and measurements from aerial photography showed increasing erosion rates from 1950's to 1990. Local citizens reported observing an increase in wave and tidal amplitude following the removal of shell reefs southwest of Point Chevreuil in the 1970's. Some shoreline areas were identified as critical where further breaching and loss would result in large interior open water areas being captured by East Cote Blanche Bay (USDA SCS and State of Louisiana 1993).

What were assumed to be the additional causes of land loss in the projected area? Subsidence and sea level rise. Subsidence estimated for the area is .07 in/year (.18 cm/year) and sea level rise is approximately .09 in/year (.23cm/year) (USDA SCS 1992). (See discussion on discrepancy with other data in the Physical Response section discussion on elevation.)

II.2. Background

Hydrologic restoration became the focus in order to create a lower energy environment by reducing the larger openings that penetrated already fragile interior marsh and were direct conduits for increased tidal influence. At the same time, to the maximum extent possible, the plan was to allow continued delivery of freshwater and sediments to the project area.

At the time, it was particularly evident, through examination of aerial photography, field observations, and the fact that intertidal mudflats were accreting at the Jaws, that sediment laden water was entering the project area through connections with the GIWW and West Cote Blanche Bay near the Jaws. This was prior to the removal of the Wax Lake Outlet weir that was projected to restore the outlet flow from a range of 27% to 33% to approximately 42% to 44% of the Atchafalaya River discharge (USACE 1994). Consequently, it was expected that sediment carried through the GIWW to the project vicinity would further increase following weir removal.

The result was that the proposed plan was revised to locate structures only where there existed connections to interior areas especially vulnerable to erosion from increased tidal exchange. All other connections to the project area would remain open to allow continued sediment delivery to the project area.

II.3. Project Goals and Objectives

How were the goals and objectives for the project determined?
See above.

Are the goals and objectives clearly stated and unambiguous?
WVA:
1) reduce further shoreline loss from wave erosion
2) reduce excessive tidal fluctuations and rapid tidal exchange to prevent scouring of interior marsh

3) develop a hydrologic regime conducive to sediment and nutrient deposition
4) re-establish vegetation in eroded areas.

EA: Objective is to reduce the rate of wetland loss and subsequently improve habitat conditions for fish and wildlife. Goals:

1) reduce shoreline erosion from wave energy in critical areas
2) reduce excessive water level fluctuations and water exchange
3) reduce interior wetland loss rates
4) encourage the growth of emergent and submerged vegetation in eroded areas.

The original project goals & objectives in the WVA and EA were reworded during the monitoring plan development process to eliminate ambiguity in the terms "excessive" and "conducive" and are described in Thibodeaux (1995).

Are the goals and objectives attainable?
The group interpreted this question to mean either 1) that the stated goals and objectives as stated are attainable under any possible circumstances, rather than for this particular project, or 2) whether or not data collected is sufficient to determine if goals and objectives have been obtained.

The answer to the first interpretation is yes, the goals as stated are attainable. The answer to the second interpretation is that it is too early to determine because additional data collection and analysis is needed.

Do the goals and objectives reflect the causes of land loss in the project area?
A "qualified" yes.

III. ENGINEERING

III.1. Design Features

What construction features were used to address the major cause of land loss in the project area?
The construction features were four (4) steel sheet pile weir structures, three (3) combination steel sheet pile structures w/ rock weirs, and two segments of PVC wall. Structures were designed to reduce cross sectional areas of major waterways and thereby reduce tidal action and water level exchange between the bays and interior fragmented marsh areas via passive means. The purpose of the PVC wall was to reduce the rate of the shoreline recession. PVC wall was used in lieu of rock riprap because of foundation concerns. The wall was designed to be at an elevation sufficient to dissipate most of the energy from wind-generated waves during mean high tides.

What construction features were used to address the additional causes of land loss in the project area?
None

What kind of data was gathered to engineer the features?
Aerial photography, geotechnical borings and evaluations, and preliminary field engineering surveys of the various openings to and from the project area, local reports of wave and tidal amplitude provided data to engineer the features. As all weir structures were provided with a boat or barge bay to allow prevailing navigation the continued use of the bayous/canals, the depths and widths of the notch of the respective weir structures were ultimately dictated by draft demand of the navigation users.

The results from the geotechnical investigation by Eustis Engineering indicate poor foundation conditions in the project area with approximately forty feet of Holocene deltaic deposits overlaying a Pleistocene Prairie complex surface. The poor geotechnical soil properties of the deltaic deposits forced a composite aggregate rock, reef shell and steel sheetpile structure that was designed for three of the structures. The large anticipated settlements on the remaining structures precluded an aggregate rock and reef shell structure, especially in regard to their wing walls where Eustis Engineering estimated a six to seven foot settlement. The estimated settlement for the foreshore structure was even worse. An ultimate settlement of seven to eight feet was anticipated in order to maintain the design crest elevation with six to one side slopes. This left sheet piling as the primary choice for the remaining five structures, including the foreshore structure. An anchored sheet pile design was considered with batter piling, but due to concerns about dewatering and the minimum three foot centers to center recommendation, along with the allowable pile load capacity chart presented in Eustis' report, a cantilever sheet pile section was chosen for all but the foreshore structure.

One of the guiding principals throughout this design was to find solutions that did not require dewatering. With this in mind a cellular steel sheet piling structure was also considered for this project, but was deemed cost prohibitive.

The Eustis geotechnical report noted evidence of preconsolidation in the canals, due to previous overlaying deposits that were removed. This would indicate that some consolidation could already be accounted for in the center of the canals, especially those receiving the aggregate reef shell and rock weirs. This would also explain the steel sheet piling lengths and moment of inertia strength requirements following a somewhat counter-intuitive reversal as the sheet piling reaches the banks.

The effects of scour were studied in the case of flow over the three largest weirs and due to eddying at their banks. It was determined that with the anticipated flows no appreciable scour would result with the rock riprap armor at a three to one slope.

A course of rockfill was added to the reef shell and rock riprap composite weirs due to concerns about reef shell fines leaching through the rock riprap protective armor. This rockfill filter was sized in accordance with NRCS Part 633, Chapter 26, Gradation of Sand and Gravel Filters.

What engineering targets were the features trying to achieve?
NRCS used "agricultural run off curves" with a safety factor of 50% to compute possible discharge and thus, the minimum discharge capacity that will be necessary for the structures. Also, see answer to 3 above.

III.2. Implementation of Design Feature(s)

Were construction features built as designed? If not, which features were altered and why?
Structures were all constructed to NGVD 88 Datum.
All structures, with exception of the PVC Shoreline Protection Component, were constructed as designed and provided for by the Plans and Specifications. During construction, it became apparent that the PVC Shoreline Protection wall was somewhat weak in structural integrity. Waves were causing the wall to sway and some of the structural components began to fail. The Engineering Element of NRCS reviewed the design of the supporting framework and essentially "doubled" same by addition of timber piling and using larger walers. This fixed the problem, and since completion, the PVC Shoreline Protection Wall is still sound. The only current problem that is apparent, though this is minor, is that some of the metal caps on the timber piling are experiencing severe corrosion. At Humble Canal, an existing old shell fill (Closure) that was immediately to the SE of the weir, was topped by riprap to + 3.0 ft (+.9 m) to prevent water from flanking the structure via an old oilfield slip and an existing slough that is nearby.

III.3. Operation and Maintenance

Were structures operated as planned? If not, why not?
Structures are all passive and are operating as planned.

Are the structures still functioning as designed? If not, why not?
Was maintenance performed?
Since project completion in Jan '99, two "Hard" TBM's and all water surface gauges and sondes have received attention by a "Static" GPS Survey and are now resolved to Datum of NAVD 88. A maintenance contract for $289,000 was consummated in Calendar Year 2001 to extend/repair the wingwalls of all weir structures, except Bayou Carlin, to "make the marsh hard" at ends of the Steel Sheet Pile Weirs-Wingwalls, where existing, were constructed of small 1in - 1 ½ in (2.54 to 3.81 cm) stone and were eroding away during flows of tides higher than + 3.0 (+.9 m) NAVD 88. Larger 110# top size stone was placed as maintenance/repair work to arrest the erosive action of these high tidal flows.

Other questions:
Recommend extension of the wall and additional sections of shoreline protection.

IV. PHYSICAL RESPONSE

IV.1. Project Goals

How well do the monitoring goals and objectives match the project goals and objectives?
The objectives stated in the monitoring plan (Thibodeaux 1995) dated July 17, 1995 (revised July 23, 1998) are (1) Reduce water exchange between marshes of Cote Blanche and West and East Cote Blanche Bays to prevent scouring of interior marsh and approximately 31,637 ac (12,803 ha) of fresh marsh and (2) Protect shoreline on southern boundary between Humble and British-American canals from wave erosion. The goals stated in the plan are (1) Decrease variability in water level within the project area, (2) Reduce erosion rate of shoreline along southern project boundary, and (3) Decrease rate of marsh loss. The goals and objectives in the monitoring plan were clear, non-conflicting and consistent with the project features. They are realistic and attainable.

The monitoring plan goals and objectives were interpreted from the project plan and environmental assessment (EA) dated August 1995 and the "future with project conditions" from the WVA. The EA uses the term project purpose rather than objectives and states "Project measures are proposed to reduce wetland loss from shoreline erosion and unnatural water exchange and improve habitat conditions for fish and wildlife on approximately 30,000 acres (12,140.8) of fresh and intermediate marsh". The stated goals are to (1) reduce excessive water level fluctuations and water exchange, (2) reduce shoreline erosion from wave energy in critical areas, (3) reduce interior wetland loss rates, and (4) encourage the growth of emergent and submergent vegetation in eroded areas. Inconsistency in stated goals and objectives from project authorizing documentation through planning and monitoring is problematic. Although similarly stated, subtle differences among them actually have significant implications for monitoring if taken literally. It is highly recommended that all project developmental documents pay attention to specificity and consistency in stated goals and objectives. Primary goals and objectives need to be clearly distinguished from secondary goals and objectives.

The goals and objectives in the monitoring plan were worded slightly different to ensure measurability. Terms such as excessive and conducive were eliminated because they could not be defined and measured. The stated project goal of encouraging the growth of emergent and submergent vegetation was not included in the monitoring plan because it was considered a secondary goal and because there was insufficient budget to monitor this goal. There were also discussions during the monitoring plan development process to include measurements of water velocity. This variable was not included for measurement because of insufficient budget and lack of technology to measure this variable in the marsh.

It was noted that all goals and objectives in the monitoring plan could be improved if specific targets were identified for each variable. An example would be to change the goal "Decrease the rate of marsh loss" to "maintain an average annual percent marsh loss less than 0.084%". It was also noted that there was a large difference in the project boundary acreage between the 1995 WVA and EA which identified 31,637 ac (12,803.3 ha) and the monitoring plan that identified 30,899 acres (12,504.7 ha). The boundary did not change. This difference was generated from going from lower resolution quad sheets and maps in the planning stage to higher resolution spot imagery in the monitoring plan development stage.

IV.2. Comparison to adjacent and/or healthy marshes

IV.2.1. Elevation

What is the range of elevations that support healthy marshes in the different marsh types?
Does the project elevation fall within the range for its marsh type?
The project area is comprised of fresh and intermediate marsh types. Marsh elevation averaged 1.33 ft (.41 m) NAVD 88 at station 2, 1.29 ft (.39 m) at station 3 and 1.55 ft (.47 m) at reference station 4. There is insufficient information to suggest if these elevations support healthy marsh. An elevation survey is scheduled for April-May 2002 to re-establish elevations for all of the structures and water level recorders. Healthy marsh in the project area within both the fresh marsh and intermediate marsh class will be identified and surveyed for marsh elevation provided funds are available.

Did the project meet its target elevation?
There was no target marsh elevation identified for this project. Structure elevation targets were established to reduce water exchange. The fixed crest weirs were to be set at –2.5 ft (-.76 m) NAVD for sites 1, 2, 3, 4, 6, and 7. The fixed crest weir with barge bay at site 5 was to be set at –7 ft (-2.13 m) NAVD.

What is the subsidence rate and how long will the project remain in the correct elevation range?
The Marsh Plan and the WVA stated that subsidence estimated for the area is .07 in/year (.18 cm/yr) and sea level rise is approximately .09 in/year (.23 cm/yr). According to the EA (Penland, et al. 1989), subsidence rates ranged from .437 in/yr (1.11 cm/yr) at Morgan City to .606 in/yr (1.54 cm/yr) at Calumet. It was noted in the EA that this could be a high number because this data was collected during a flood period.

Erick Swenson of LSU recently analyzed long-term water level records and came up with the following relative sea level rise estimates:

Station	Period of Record	ft per year	cm per year
Grand Isle	1955-2000	0.035	1.06
Leeville	1956-1995	0.025	0.77
Catfish Lake	1976-1993	0.037	1.28
Houma	1959-1995	0.049	1.49
Morgan City	1935-2000	0.042	1.28

The Coast 2050 Report, which looked at a larger regional area, showed this area to have an intermediate subsidence rate of .335 cm/yr to .61cm/yr (1.1 to 2 feet per century). Also, interestingly, the report shows that there are two branches of a major fault trend running east-west through the project area.

Discrepancies in subsidence estimates are a common problem. The new coastwide benchmark system should help refine subsidence estimates. The differences in the subsidence data that was used for this project may be reconciled somewhat with additional surveying. The USGS (Jeff Williams) and UNO (Shea Penland) have been funded to refine subsidence estimates for Louisiana. Details on their activities need to be explored. Improvements on this project can be made if Sediment Erosion Table (SET) measurements were conducted. If the Coastwide Reference Monitoring System (CRMS) is approved by CWPPRA for implementation, 8 CRMS stations (which include SET measurements) will be employed in the project area (Steyer et al. 2002).

IV.2.2. Hydrology

What is the hydrology that supports healthy marshes in the different marsh types? Researchers at the Coastal Ecology Institute (Sasser, et al, 2002) compiled (literature estimates and data compiled from various CEI research projects) as a "first attempt" to quantify the critical variables for each vegetation type (using the Visser, et al 1998, classification). A healthy fresh *Sagittaria lancifolia* (bulltongue) marsh should have a flooding regime with 12-30 flooding events per year. The marsh should be flooded a total of 75% of the time (water at or above the marsh surface). In addition, the water levels in the marsh should closely track the water levels in the adjacent open water areas. A regression between marsh water levels (using only times when marsh is flooded) and open water levels ("connectivity index") should have a slope 0.9 to 1.0 with an r-square of at least 0.85. An oligohaline *Sagittaria lancifolia* (bulltongue) marsh should have a flooding regime with 20-50 flooding events per year. The marsh should be flooded a total of 50% of the time. The connectivity should be the same as the fresh bulltongue.

The ideal inundation depth has not been determined. A greenhouse study by Howard and Mendelssohn (1995) indicated that plants subjected to increased water depth (15 cm, or 5.9 in) had higher mean and maximum leaf heights (compared to a control) but no effect was noted on above ground biomass, however, the root biomass was reduced. A field study by Webb and Mendelssohn (1996) indicated that *Sagittaria lancifolia* plants which were submerged 15 cm

(5.9 in) exhibited decreased growth. The authors indicated that the die back in *S. lancifolia* dominated communities can be alleviated by decreasing submergence, even at somewhat elevated salinities. Recent greenhouse work by Sicard and Shaffer with 3 species of *Sagittaria*, found that bulltongue did better at 5 cm (2 in) flooding depth than at 30 cm (11.8 in) (http://www.selu.edu/Academics/ArtsSciences/connections/journal1/r-sicard/sicard.html)

Does the project have the correct hydrology for its marsh type?
The percent of time flooded in the project area is within the target presented above (the reference area values are actually lower than the target).

What were the hydrology targets for the project and were they met?
The purpose of this project was to limit drastic water exchange that can carry marsh soil from the project area during frontal events. If the project has been successful in reducing excessive water exchanges, the water level variability would be reduced and therefore the frequency of inundation would be reduced. There was a concern that the duration of inundation might be increased.

Preliminary analysis of water level data indicate significant differences in water levels between project and reference stations prior to construction, suggesting caution when conducting and interpreting project versus reference comparisons. Pre-construction versus post-construction comparisons of hourly data showed significant reductions in water elevation and drainage depth post-construction at project stations 2 and 3 and reference station 4R. Mean inundation depths changed less than 0.5 inch (1.27 cm) between pre- and post-construction (figure 2a), and average inundation duration increased in post-construction project stations by an average of approximately 3 hours per event. A significant reduction occurred at station 2 where drainage depth was reduced by 6.36 inches (16.2 cm), compared to 1.68 inches (4.3 cm) at station 4R (figure 2b). Range of water level was used as one index of variability, and mean weekly range decreased in post-construction at most stations, with the greatest reduction occurring at station 2 (figure 3). Another index of variability, coefficient of variation, was calculated on inundation and drainage depths, durations, and ranges, and the results suggest that variability decreased in project stations more than the reference station. The number of inundation and drainage events by depth of event illustrate how the extreme events are being reduced at the project stations (figure 4).

The degree that the structures are benefiting project hydrology and affecting vegetation response will be undetermined until the first post-construction photography is conducted in fall 2002. However, the data indicate a significant reduction in variability at station 2 and overall suggest that the project is heading in the right direction.

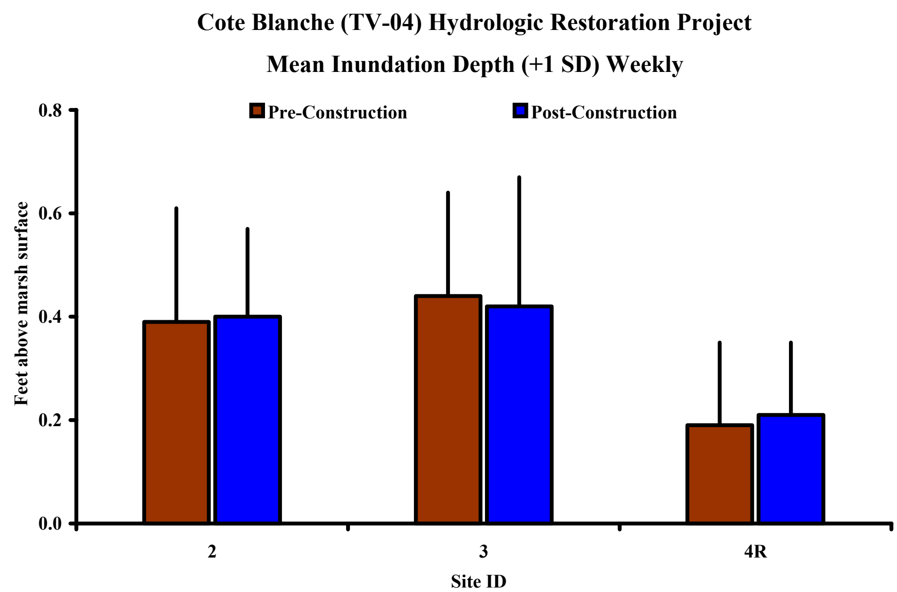

Figure 2a. The weekly mean inundation depth at project stations 2 and 3 and reference station 4R within the Cote Blanche Hydrologic Restoration Project (TV-04).

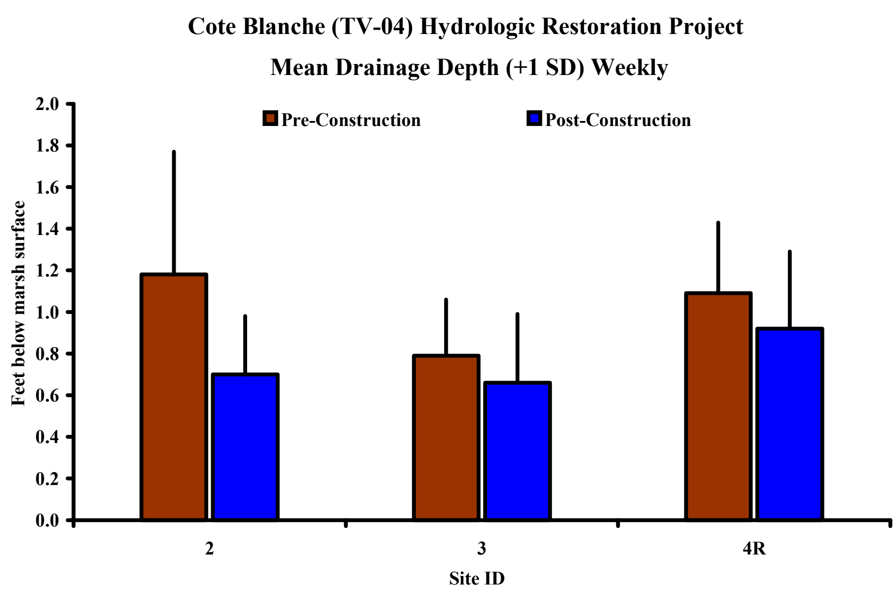

Figure2b. The weekly mean drainage depth at project stations 2 and 3 and reference station 4R within the Cote Blanche Hydrologic Restoration Project (TV-04).

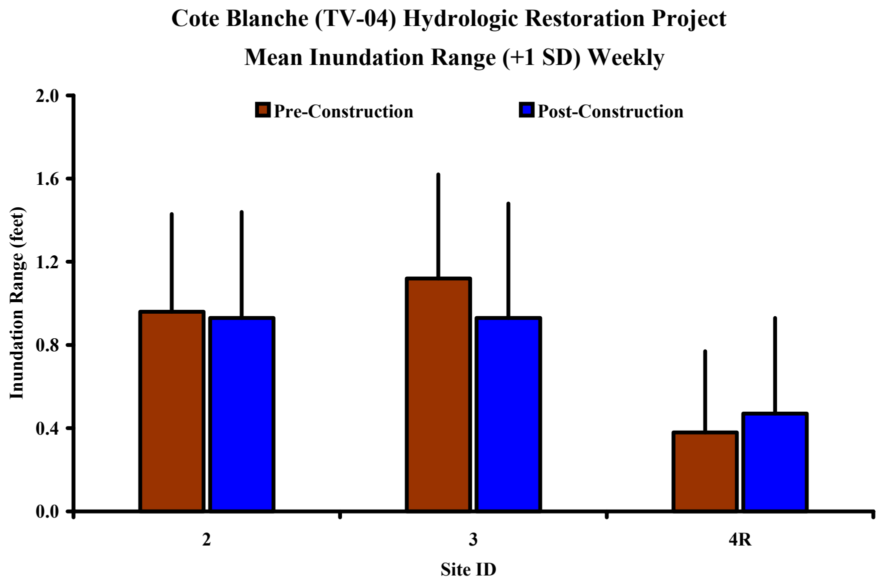

Figure 3a. The weekly mean inundation range at project stations 2 and 3 and reference station 4R within the Cote Blanche Hydrologic Restoration Project (TV-04).

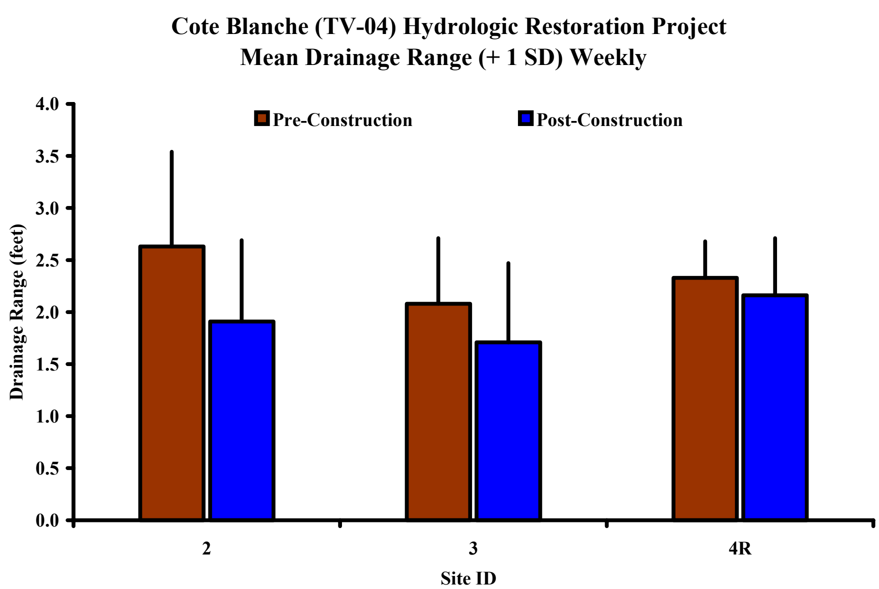

Figure 3b. The weekly mean drainage range at project stations 2 and 3 and reference station 4R within the Cote Blanche Hydrologic Restoration Project (TV-04).

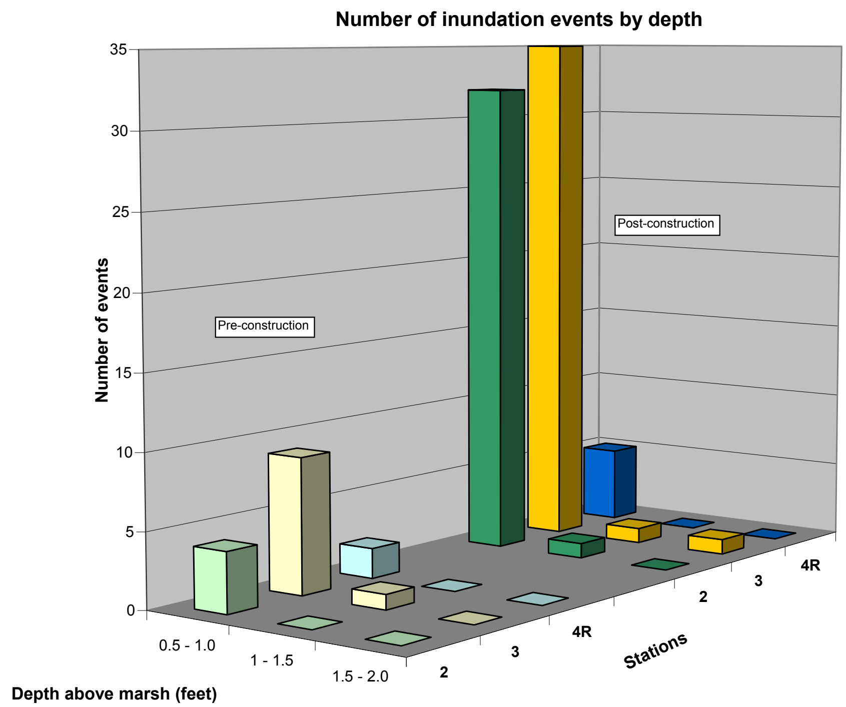

Figure 4a. The frequency of inundation events by depth of event at project stations 2 and 3 and reference station 4R within the Cote Blanche Hydrologic Restoration Project (TV-04).

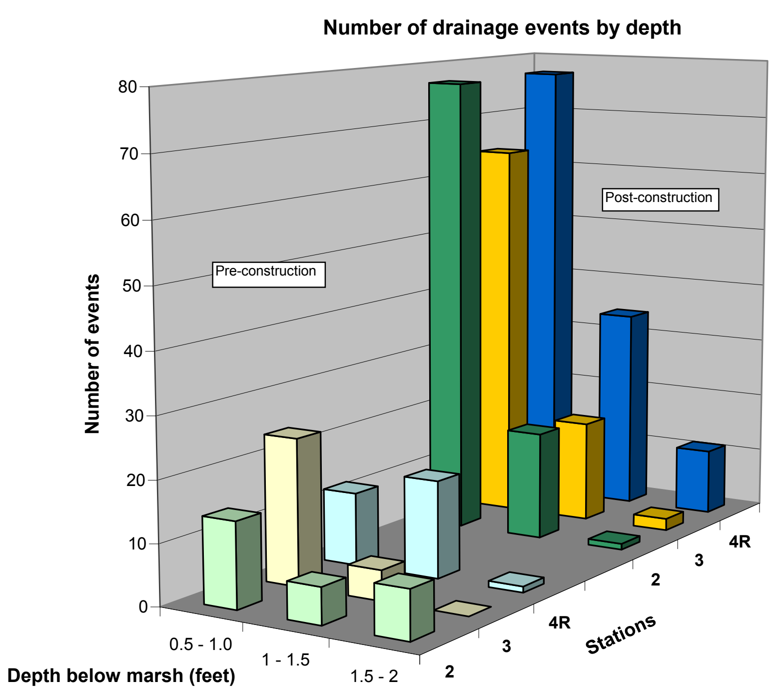

Figure 4b. The frequency of drainage events by depth of event at project stations 2 and 3 and reference station 4R within the Cote Blanche Hydrologic Restoration Project (TV-04).

The direct effect of the project on water velocity (the major factor implicated in the marsh loss) was not measured but it was assumed that the reduced range in water levels should have resulted in lower velocities (decreased velocity and/or shorter length of time for the higher velocities).

IV.2.3. Salinity

What is the salinity regime that supports healthy marshes in the different marsh types?
Chabreck (1972) documented a salinity range of 0.2 – 5.99 ppt for fresh and intermediate vegetation types in the hydrologic unit encompassing Cote Blanche. Dominant species in the project area such as *Sagittaria lancifolia*, *Typha* spp., and *Alternanthera philoxeroides* have optimal biomass at salinities between 1.0 – 2.0 ppt (Southwest Texas RC&D 1992, La Peyre 2001). Stress and recovery experiments on *Sagittaria lancifolia* by McKee and Mendelssohn (1989) and Webb and Mendelssohn (1996) found tolerances up to 4.6 ppt but tissue damage after 35 days at 4.8 ppt. Grace and Ford (1996) found that *Sagittaria lancifolia* had substantial capacity for recovery to a 1-week exposure to 15 ppt salinity during a flooding event.

Does the project have the correct salinity for its marsh type?
Although salinity was not a required monitoring element on this project, salinity was measured with water levels as part of the equipment deployment. Average annual salinities in the project area fall within the lower range identified by Chabreck (1972), and are assumed to be correct for the marsh types. Salinities in 1999 and 2000 were higher on average than previous years. Station 2 in the south-central project area had an approximate average annual salinity of 2.4 ppt in 2000 with salinities exceeding 4 ppt from July through October with a peak of 9.7 ppt (Note: this was during the second of two consecutive drought years). The salinity literature associated with extended exposures and tolerances is incomplete, thus unable to verify if the extended exposures in 2000 were significant.

What were the salinity targets for the project and were they met?
Since salinity was not a concern, no salinity targets were established for the project. One could perhaps assume that a goal of the project was to maintain the project area as a fresh/intermediate marsh. Assuming that the appropriate salinity range for fresh/intermediate marsh is 0-5 ppt, then that may represent a reasonable salinity target for this project, though it is not stated in any of the project documents.

IV.2.4. Soils

What is the soil type that supports healthy marshes in the different marsh types?
According to Hatton (1981), fresh marshes in the Mississippi River Deltaic Plain are characterized by:

	Streamside	Inland
Bulk Density:	0.11±0.03 g/cm^3	0.09±0.01 g/cm^3
Organic Carbon:	23.1±4.2 %	29.6±3.1 %
Nitrogen:	1.5±0.3 %	1.8±0.2 %
Phosphorus:	927±171 ug/g	944±82 ug/g

Does the project have the correct soil for its marsh type?
According to the EA, project area soils are highly organic mixed with very fluid clay. The predominant soil series found throughout the project area is Kenner, with limited occurances of Allemands and Larose soils toward the southern part of the project area. The typical moist bulk density of Kenner soil series is .05 to .25 g/ cm^3 in the top horizon (0 to 65 in, or 165.1 cm), and the typical organic carbon content is 17.4 to 34.9%. The typical moist bulk density of the Allemands and Larose series is .05 to .25 g/ cm^3, and the typical organic carbon is 17.4 to 49.4% (USDA SCS 1984, USDA NRCS 2000a, and USDA NRCS 2000b). Note that this is much more general information than that from Hatton (1981; from Gosselink 1984) above, though we did not find any reference to grain size there. Because of this, we are not in a position to compare data on the same parameters from the project area, to those determined by Hatton (1981).

In addition, there are no soil parameters being monitored in the project monitoring plan, so there is no way to determine if soil parameters are changing over time. However, it may be worth noting that the highly organic soils at the site as discussed in the EA, are consistent with the low bulk density and high organic matter content found by Hatton (1981).

A geotechnical investigation of the project area by Eustis Engineering was used as a reference for this project. Their report indicates a stratigraphy of Holocene deltaic deposits overlaying a buried Pleistocene prairie complex surface. The Holcene deltaic deposits include interdistributary marsh and inland swamp deposits composed primarily of loose black humus, extremely soft to very soft gray and dark gray organic clays and inland swamp deposits, are abundant throughout these soils. In the lower portion of the Holcene deposits, very soft gray silty clays, loose gray clayey silts and loose gray silty sands are present.

The surface of the Prairie Complex was approximately forty feet below the water surface. The Prairie Complex is composed of stiff to very stiff clays and silty clays. However, in some areas, soft to medium stiff clays and silty clays are present immediately below the Prairie Complex surface.

What were the soil targets for the project and were they met? If not, why?
No soil targets were established. See above discussion.

IV.2.5. Shoreline Erosion

This will be addressed in the separate shoreline protection report.

IV.3. Suggestions for physical response monitoring

Are there other variables that could be monitored to substantially increase the ability to understand the results of the project?
The project makes the contention that an important cause of the loss is increased water exchange between marshes in the project area and adjacent water bodies, leading to excessive water velocities. The goals of objective 1 address this issue. However, no monitoring of water velocities was proposed to test this. Water level changes were assumed to provide a surrogate measure for this. Maybe current speeds should have been measured at key locations for this project. At the time this project was proposed, velocity measurements in shallow marsh ponds was not feasible using the existing flow meter technology. To make those measurements now would be expensive and it would be difficult to arrive at any conclusion since there is no pre-project data.

The relationship between water level changes and water velocities (particularly over the marsh surface and along marsh pond edges) is a "generic issue" that needs to be studied. A determination of the water velocities that are actually responsible for erosion of the different types of marsh soils is also needed in order to interpret the water velocity data. There are now acoustic flow meters that are able to measure velocities down to millimeters per second in water depths in the centimeter range. These meters are in the $10,000 price range.

Other variables that could be monitored here include SET measurements, which would give insight into sedimentation and subsidence.

In the discussion, it was recommended that vegetative monitoring be added as an element to determine if there were positive or negative effects of changes in flooding and duration on plant communities and production. Also, it was recommended to monitor for longer pre-project monitoring periods.

BIOLOGICAL RESPONSE

V.1. Project Goals

See IV.1

V.2. Comparison to adjacent and/or healthy marshes

V.2.1. Vegetation

What is the range in species composition and cover for healthy marshes in each type?
There were no vegetation goals and objectives on this project and therefore no vegetation data collection. The entire project area has been classified as fresh

marsh based on Chabreck and Linscombe 1988 and 1997, and predominately intermediate marsh in 2001. USDA (1993) and USDA (1995) identified the following most common plant species in the project area pre-construction: *Sagittaria lancifolia* (bulltongue), *Colocasia antiquorum* (elephantsear), *Typha* sp. (cattail), *Alternanthera philoxeroides* (alligatorweed), *Vigna luteola* (deerpea), *Polygonum* sp. (smartweed)., *Eichhornia crassipes* (water hyacinth), *Myriophyllum spicatum* (Eurasian watermilfoil), *Ceratophyllum demersum* (coontail), *Najas guadalupensis* (southern naiad), *Cabomba caroliniana* (fanwort), and *Heteranthera dubia* (waterstargrass).

Does the project have the correct species composition and cover for its type?
DNR monitoring personnel observed emergent and submersed vegetation species during post-construction hydrologic field monitoring. The emergent species are *Paspalum repens*, *Iris virginica*, *Hymenocallis occidentalis*, *Sagittaria lancifolia*, *Phragmites australis*, *Cicuta mexicana*, *Sesbania drummondii*, *Colocasia esculenta*, *Spartina patens*, *Physostegia intermedia*, *Schoenoplectus americanus*, *Alternanthera philoxeroides* and *Hydrocotyle* sp. and the submersed and floating species are *Echhornia crassipes*, *Zannichellia palustris*, *Myriophyllum spicatum*, *Ceratophyllum*, *Valisineria americana* and *Cabomba caroliniana*. *Morella cerifera*, *Salix nigra, Persea palustris*, and *Quercus virginiana* are some of the woody vegetation seen on higher points of elevation in the project area.

All vegetation in this area appears to be healthy and is indicative of a fresh to intermediate marsh environment. The community composition for fresh and intermediate marsh is consistent with O'Neil (1949) and Chabreck (1972). The weirs that were constructed in this area may be holding water on the marsh for longer periods of time than before construction (see physical response). However, the vegetation listed is well adapted to increased water levels, except for *Spartina patens*, which is a remnant dominant from before the 1970's when the marsh was predominately brackish.

What were the vegetation targets for this project and were they met? If not, what is the most likely reason?
The vegetation targets for the project were to maintain the project area as fresh/intermediate marsh. So far, that has been accomplished.

V.2.2. Landscape

What is the range in landscapes that supports healthy marshes in different marsh types?
Is the project changing in the direction of the optimal landscape? If not, what is the most likely reason?
The land:water ratio for the project area was monitored in 1996 pre-construction and will be obtained in 2002, 2009, and 2015 post-construction. The land:water ratio was 83.4% land and 16.6% water in 1996. This compares with 1984 and 1990 land:water estimates of 93:7 and 87:13, respectively, obtained from the WVA. It should be noted that the project boundary acreage in the 1995 WVA

was 31,638 acres (12,803.7 ha) and in the 1996 analysis it was 30,898.8 acres12,383.2 ha). As previously mentioned, the boundary did not change. This difference was generated from going from lower resolution quad sheets and maps in the planning stage to higher resolution spot imagery in the monitoring plan development stage. As part of the "brown marsh" investigations, photography was flown in September of 2000. Visual observations of the unrectified 2000 photography with the 1996 photography suggest little change has occurred in the project area.

Habitat classification of the project area in 1996 pre-construction identified 22,633 acres (9,159.4 ha) of fresh marsh, 880 acres (356.1 ha) of floating aquatics, 111 acres (44.9 ha) of submerged aquatics, 1,861 acres (753.1 ha) of wetland forested and 1,359 acres (550 ha) of wetland scrub-shrub as the predominant classes. Habitat classification post-construction will be completed after the fall 2002 flight. Chabreck-Linscombe habitat classifications conducted in 1997 and 2001 covered the project area. The 1997 classification was almost identical to the 1988 classification that identified the project area as primarily fresh marsh (~96%). Visser and Sasser (1998) further classified the 1997 Chabreck-Linscombe data into the following subclasses within the project area (fresh bulltongue, fresh spikerush, fresh maidencane, oligohaline wiregrass, oligohaline spikerush, oligohaline bulltongue and mesohaline wiregrass). The 2001 classification showed that 61% of the project area was intermediate marsh, with the northwest, northeast and southeast remaining fresh (~35%). Salinity data do not confirm nor refute the change in classification; however, salinities in 1999 and 2000 were higher on average than previous years. Station 2 in the south-central project area had an approximate average annual salinity of 2.4 ppt in 2000 with salinities exceeding 4 ppt from July through October with a peak of 9.7 ppt.

The project appears to be maintaining the optimal landscape of fresh to intermediate marsh since construction. The unrectified 2000 color-infrared photography suggests the landscape is maintaining its integrity and that submerged aquatic vegetation is extremely abundant in all waterbodies. The fall 2002 data is needed before further interpretation can be completed.

V.2.3. Other

None.

V.3. Suggestions for biological response monitoring

Are there other variables that could be monitored to substantially increase the ability to understand the results of the project?
Monitoring the species composition and cover of emergent vegetation in the project area, especially in the vicinity of the structures, could help determine if new growth is being encouraged per the original project goal. This can be accomplished adjacent to the structures using the Braun-Blanquet protocols described in Steyer et al. (1995) or throughout the entire project area using Visser

and Sasser (1998) subclasses when Chabreck-Linscombe surveys are conducted. The vegetation surveys can indirectly help determine at a finer scale whether water flow in the area has been reduced sufficiently to eliminate erosive scouring.

Spot imagery at 10m (32.8 ft) resolution could also provide a quick evaluation of landscape integrity. One pre-construction and 3 post-construction analyzes of habitat changes are temporally insufficient to adaptively evaluate landscape changes over time.

VI. ADAPTIVE MANAGEMENT

VI.1. Existing improvements

What has already been done to improve the project?
Maintenance has been performed to address changes of some structure bay bottom elevations due to movement of some rock. Preventive work has also been conducted to address potential structure circumvention. Elevation surveys are in the process of being conducted that will improve accuracy of the water level information.

VI.2. Project effectiveness

Are we able to determine if the project has performed as planned?
Not yet.

If not, why?
Project construction has only been completed since January 1999. This was followed by two years of historic drought conditions so significant biological response to the structures has likely not occurred. The hydrologic response to the structures appear positive under these conditions, and longer datasets over a variety of environmental conditions will be necessary to better discern whether the project is performing as planned. This data, along with aerial photography that will be conducted in fall 2002, will improve evaluations of the project.

What should be the success criteria for this project?
The project may have performed in decreasing the rate of marsh loss; however, we will not know for certain until after the fall 2002 flight and analysis is conducted. The success criteria for this project should be maintaining an average annual percent land loss less than 0.084%, which is the short-term loss from 1983-1990. The scientific literature is insufficient to set targets for water level depth, duration, and frequency of flooding. The analysis of water level data to date will help establish targets for the future.

VI.3. Recommended improvements

What can be done to improve the project?
Some additional monitoring elements that should be considered are water velocity, vegetation, and sediment accretion.

The shoreline protection should be extended further west. If a different material can be used that is engineeringly sound and more economical, then that should be used. Shoreline protection should be added to prevent erosion from circumventing the structures in Mud and Jackson Bayous (and Humble-F Canal?). Shoreline protection should be investigated where E Cote Blanche Bay is encroaching on School Bus Bayou (W of Humble Canal) and investigating the enlargement of some of the openings from the GIWW (NE) to allow more sediment delivery into the project area.

The landowner was going to try to have the oilfield company perform some work items prior to selling or abandoning the field. Our project recommendations should be integrated with the landowner needs. Also, if there is no longer an operator, determine if landowner would entertain idea of reducing the structure opening sizes.

As a follow-up to the previous paragraph, the land owner and the land manager when contacted stated that there would likely be no objection to changing the weir with boat bay structures on the British-American and Humble-F Canals to rock plugs, as long as an option remained to temporarily remove rock to permit access if the need arose (Miami Corp. 2002).

VI.4. Lessons learned

1. The monitoring needs addressed in this document support a good argument for CRMS. Project planners constantly find that water level, elevation, salinity and other data is lacking in many coastal areas that is needed to better understand project area systems and develop appropriate project plans and features.
2. Sufficient geotechnical investigations (this was done for this project) and hydrologic modeling should be built into the design and evaluation of projects of this type.
3. EA, WVA and Monitoring Plan Goals and Objectives should have been more consistent. Agencies are attempting to do that now with more recent projects.
4. It was difficult to find a satisfactory reference area for this project, hence an area embedded inside the project boundaries was chosen. This particular reference area will provide adequate comparison for water level fluctuations, but not for land loss comparisons.

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APPENDIX A: INFORMATION CHECK SHEET

Project Name and Number: Cote Blanche, TV-04
Date: 20 June 2002

INFORMATION TYPE	YES	NO	N/A	SOURCE/COMMENTS
Fact Sheet	X			Cindy Steyer, NRCS
				PPL3 Report to Congress
Project Description	X			Pre-selection Plan, NRCS
Project Information Sheet	X			Cindy Steyer, NRCS
Wetland Value Assessment	X			Cindy Steyer, NRCS
Environmental Assessment	X			Cindy Steyer, NRCS
Project Boundary				Candidate list, WVA,
				PPL Report, Eng. Design
Planning Data	X			Cindy Steyer, NRCS
				Marsh Management Plan
Landrights	X			Cindy Steyer, NRCS
Preliminary Eng. Design	X			Cindy Steyer, NRCS
Geotechnical	X			Cindy Steyer, NRCS
Engineering Design	X			John Jurgensen, NRCS
				Contract Package
As-built Drawings	X			Cindy Steyer, NRCS
Modeling Output		X		
Construct Completion Report		X		
Engineering Data	X			John Jurgensen, NRCS
Monitoring Plan	X			Christina Thibodeaux, DNR
Monitoring Reports	X			Christina Thibodeaux, DNR
Supporting Literature				
Monitoring Data	X			Christina Thibodeaux, DNR
Operations Plan			X	Passive
Operations Data			X	
Maintenance Plan	X			Ann Inspection Reports, DNR
Maintenance Data	X			Ann Inspection Reports, DNR
				Maintenance Contract, DNR
O&M Reports	X			Herb Juneau, DNR
Permit	X			Cindy Steyer, NRCS
Cost Sharing Agreement				Cindy Steyer, NRCS