State of Louisiana
Department of Natural Resources
Coastal Restoration Division

Monitoring Plan

for

Freshwater Bayou Wetland Protection

State Project Number ME-04
Priority Project List 2

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Vermilion Parish

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MONITORING PLAN

PROJECT NO. ME-04 FRESHWATER BAYOU WETLANDS

ORIGINAL DATE: April 10, 1996

REVISED DATES: July 23, 1998; August 14, 2003, January 2, 2014

Preface

Pursuant to a CWPPRA Task Force decision on April 14, 1998, the original monitoring plan was reduced in scope due to budgetary constraints. Specifically, water level and salinity will be monitored continuously through 2004. Upon collection and evaluation of this data set, the Technical Advisory Group (TAG) will assist in development of a sampling plan based on an approximate 30% reduction of effort, if technically advisable.

Pursuant to a CWPPRA Task Force decision on August 14, 2003 to adopt the Coastwide Reference Monitoring System (CRMS-*Wetlands*) for CWPPRA, updates were made to this Monitoring Plan to merge it with CRMS to provide more useful information for modeling efforts and future project planning while maintaining the monitoring mandates of the Breaux Act. The implementation plan included review of monitoring efforts on currently constructed projects for opportunities to 1) determine if current monitoring stations could be replaced by CRMS stations, 2) determine if monitoring could be reduced to evaluate only the primary objectives of each project and 3) determine whether monitoring should be reduced or stopped because project success had been demonstrated or unresolved issues compromised our ability to actually evaluate project effectiveness. The recommendations for modifying this Monitoring Plan are the result of a joint meeting with DNR, USGS, and the federal sponsor. Based on this review and based on the fact that there are 5 CRMS stations located within the project area, it was recommended that project-specific monitoring as originally designed be discontinued and replaced by monitoring at the 5 CRMS stations. These changes have been incorporated into this revised Monitoring Plan in the Monitoring Elements section.

Project Description

The Freshwater Bayou Wetlands project area encompasses 36,928 ac (14,945 ha) of fresh, intermediate, and brackish marsh located between Intracoastal City and Pecan Island in Vermilion Parish, Louisiana (figure 1). Centered approximately at Lat. 29° 40' 00" N and Long. 92° 18' 00" W, the area is bounded on the north by the old Intracoastal Waterway (Schooner Bayou), on the west by LA Hwy 82 and the Acadiana Marina Canal, on the south by Humble Canal, and on the east by Freshwater Bayou Canal.

Wetlands in the project area are adversely affected by the influence of high water levels from the Grand/White Lake system to the west, where elevated water levels are artificially maintained by several locks and water control structures for navigation and agricultural purposes (LWCRTF 1993). Water flowing out of White Lake can enter the project area from the west via oil field canals, the borrow canals and culverts under LA Hwy 82, and from the north via natural openings along the

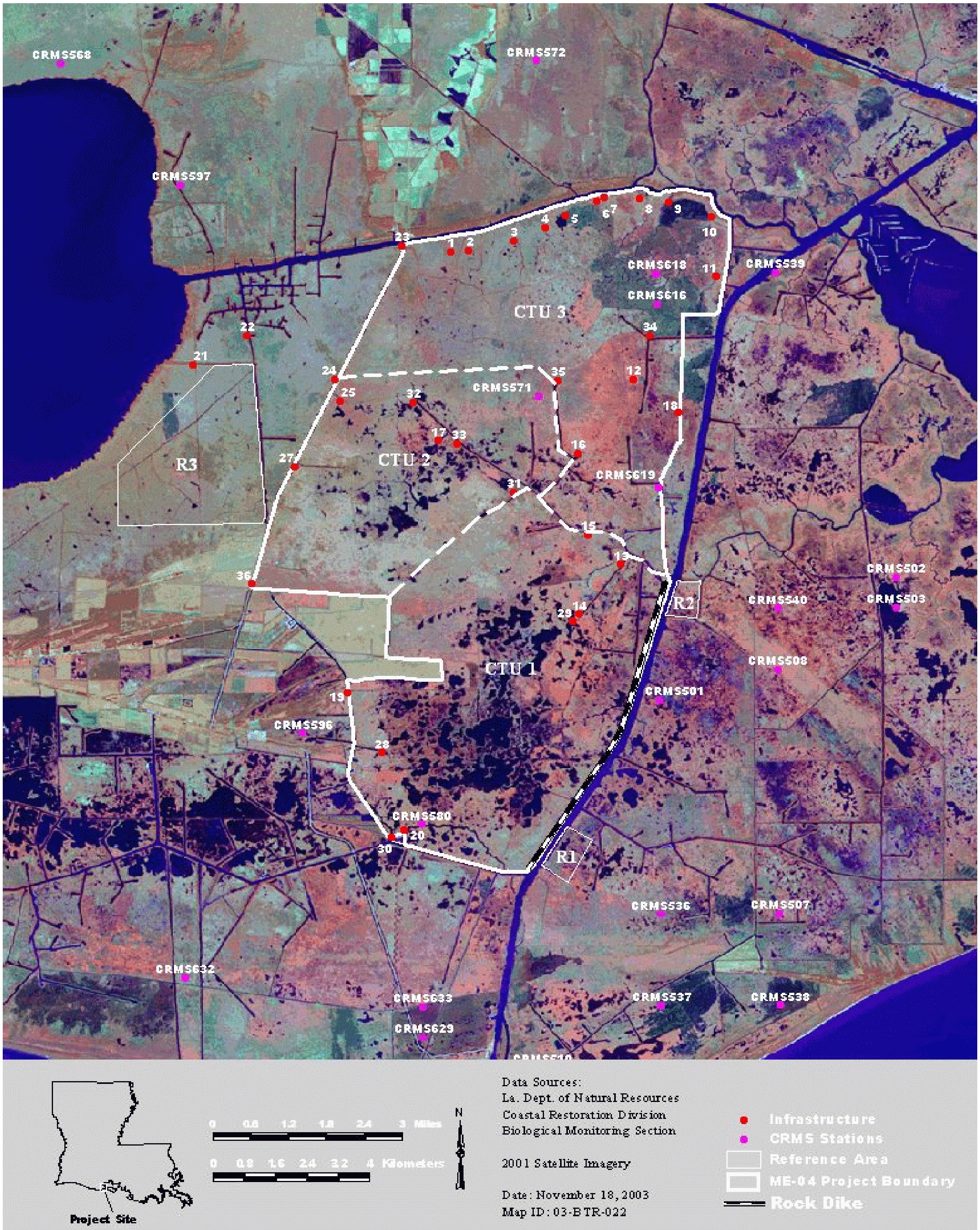

Figure 1. Freshwater Bayou Wetlands (ME-04) project area map showing pre-existing and ME-04 project features.

south bank of Schooner Bayou. Physiological stresses on vegetation associated with soil waterlogging during periods of prolonged high water levels (Mendelssohn and McKee 1988) have likely contributed to wetland loss in the project area through vegetation die-back, ponding, and shifts to marsh communities with reduced primary productivity and reduced fish and wildlife value.

Some wetland acreage in the project area has been lost through the dredging of oil field access canals. However, most wetland loss in the project area has resulted from the gradual degradation and conversion of fresh marsh to open water, mainly between 1956-1978. In 1956, wetlands accounted for 97.9% of the project area and only 1.3% of the area was open water. By 1978, wetlands accounted for only 88.9% of the project area, the open water areas having increased to 8.3% of the area. By 1990, wetlands accounted for only 87.5% of the project area, while the open water area had increased to 8.9% of the project area. Thus, between 1956 and 1990, approximately 7.6% (3,720 ac [1,514 ha]) of the emergent wetlands in the project area were lost.

Because sediment input into the project area is very low, its organic marshes rely mainly on the production and accumulation of organic matter to overcome losses in elevation due to subsidence and sea level rise. The rates of subsidence and sea level rise in the project area are estimated to be 0.33 cm/yr and 0.64 cm/yr, respectively (Penland et al. 1989). Based on recent studies of the importance of organic matter accumulation to vertical accretion (Nyman et al. 1993), any reduction in plant productivity would be expected to increase the rate of marsh loss in the project area.

The potential for tidal exchange between Vermilion Bay and the interior marshes in the project area has greatly increased over the past 40 years through the construction of numerous oil and gas exploration canals, the old GIWW, and Freshwater Bayou Canal. Initially, the fragile organic soils of the interior marshes were protected from saltwater intrusion and tidal scour by spoil banks along these channels. However, much of the spoil banks along Humble Canal and Freshwater Bayou Canal have been destroyed, largely by boat wake-induced shoreline erosion, exposing the interior wetlands to mechanical destruction and increased salinities.

Based on data provided in a feasibility report by Brown and Root (1992), between 1968-1992, an average of 34,051 large vessels (crew boats, jack-up barges, supply boats, and fishing boats) traveled through the Freshwater Bayou Canal lock and channel each year, contributing to an average shoreline erosion rate of 12.5 ft per year (3.8 m/yr) on each bank for this period.

The marshes along the northern and western borders of the project area appear to benefit somewhat from the influx of fresh water from White Lake and Schooner Bayou, which may result in the deposition of some sediment as the water filters through the marsh. Marshes along Freshwater Bayou Canal have shifted from fresh marsh towards intermediate to brackish marsh communities, as a result of the influence of increased tidal exchange associated with the loss of spoil banks along the canal.

Project Features

Since 1990, several conceptual plans for restoring the Freshwater Bayou Wetlands have been developed (LDNR 1990, 1991; USDA and LDNR 1992; LCWCRTF 1992, 1993; USDA 1994). Phase 1 of the ME-04 restoration project was implemented in October 1994 to prevent further wetland loss in the project area through bank erosion and tidal scour along Freshwater Bayou Canal.

Under an emergency authorization to dismantle the Wax Lake Outlet weir, approximately 140,000 tons (127,400 metric tons) of limestone armor stone was barged in from Wax Lake Outlet to construct 28,000 linear ft (8.5 km) of free-standing rock breakwater in shallow water along the west bank of the Freshwater Bayou Canal between its confluence with Humble Canal and North Prong Belle Isle Bayou (see figure 1). Dike construction was completed in January 1995. The Phase 1 dike is expected to reduce tidal exchange along the canal, but this porous structure will not eliminate tidal exchange, especially in areas where the spoil bank has eroded away, leaving marsh on the shoreline. The impact of this structure is being monitored using habitat mapping and shoreline markers (LDNR 1995).

As presently planned, the remaining restoration efforts being implemented under Phase 2 of this project will involve the installation, operation, and maintenance of eight water control structures in an effort to reduce ponding and increase the acreage of emergent marsh in the interior of the project area. The Phase 2 project plan is to lower water levels or reduce the frequency and duration of marsh inundation in the project area, in an effort to manage water levels to mimic natural conditions. Salinity will be maintained at low levels suitable for the growth of fresh to intermediate marsh. These goals will be accomplished through active and passive management of water control structures (figure 1, tables 1 and 2). The volume of water flowing into the project area from the west through canals and other channels will be reduced by installing plugs and gated culverts that will restrict channel flow and promote sheet flow over the marsh surface. In addition, the discharge capacity from the central and southern sections of the project area will be increased by installing additional variable-crest water control structures. Since each of these structures will include a fixed-crest weir with a vertical slot, implementation of Phase 2 is also expected to maintain fisheries access into and out of the project area.

The project plan (USDA/SCS 1994) divides the project area into three Conservation Treatment Units (CTU's), two of which benefit directly from the shoreline protection work implemented under Phase 1 of the project (see figure 1). Phase 2 of this CWPPRA project authorizes the installation of eight (8) box-type water control structures with a single flapgate, a variable-crest weir, and two fixed-crest weirs (one with a 4 inch vertical slot) in the project area. Three structures will be located in CTU 1, three in CTU 2, and two in CTU 3 (sites 28-35 in figure 1 and table 2). A number of water control structures are already in place (figure 1, table 1). Additional structures (figure 1, table 2) will be installed by the landowner at the landowner's expense, to enhance the operation of the eight CWPPRA structures.

The southernmost unit, CTU 1, consists of 13,800 ac (5,585 ha) of predominantly fresh marsh with zones of intermediate and brackish marsh along its eastern and southern boundaries. It is predominated by *Sagittaria lancifolia* (bulltongue) and *Spartina patens* (wiregrass), and is managed for waterfowl, alligators, furbearers, and fisheries. Ponds range in depth from 1.7-2.0 ft (0.52 - 0.61 m), and contain over 50% cover with aquatic plants (USDA/SCS 1994). To enhance water management capabilities, three box-type water control structures with a single flapgate, a variable-crest weir, and two fixed-crest weirs (one with a 4-inch [10 cm] vertical slot) will be

Table 1. Freshwater Bayou Wetlands (ME-04) project. Existing natural openings and water control structures in the project area. (See figure 1 for map locations.)

Site No.	Structure Location	Channel Width (ft)	Channel Depth (ft)	Structure Type	Crest Width (ft)	Structure Length (ft)
1	Schooner Bayou	60	4.3	Natural opening	n/a	n/a
2	Schooner Bayou	45	3.5	Natural opening	n/a	n/a
3	Schooner Bayou	50	4.1	Natural opening	n/a	n/a
4	Schooner Bayou	45	6.3	Natural opening	n/a	n/a
5	Schooner Bayou	15	3.5	Natural opening	n/a	n/a
6	Schooner Bayou	25	4.7	Natural opening	n/a	n/a
7	Schooner Bayou	18	3.4	Natural opening	n/a	n/a
8	Schooner Bayou	n/a	n/a	Variable-crest weir	15	40
9	Schooner Bayou	n/a	n/a	36" Screw gate	n/a	40
10	Schooner Bayou	n/a	n/a	Variable-crest weir	16	n/a
11	Spoil bank	n/a	n/a	36" Screw gate	n/a	n/a
12	Spoil bank	n/a	n/a	Double-flapgated, variable-crest weir box	5.5	20
13	Spoil bank	n/a	n/a	Double-flapgated, variable-crest weir	5.3	20
14	Spoil bank	n/a	n/a	Double-flapgated, variable-crest weir box	6.0	20

15	Spoil bank	n/a	n/a	Double-flapgated, Variable-crest weir box	5.2	20
16	Spoil bank	n/a	n/a	Double-flapgated, variable-crest weir box	5.5	20
17	Spoil bank	n/a	n/a	Double-flapgated, variable-crest weir box	4.7	20
18	Spoil bank	n/a	n/a	Double-flapgated, variable-crest weir box	5.0	20
19	Spoil bank	n/a	n/a	36" Culvert with variable-crest weir	3.0	20
20	Spoil bank	n/a	n/a	Double-flapgated, variable-crest weir box	4.7	20

Table 2. Freshwater Bayou Wetlands (ME-04) project. Proposed water control structures and other restoration features in the project area. (See figure 1 for map locations.) Site numbers in **bold type** are CWPPRA structure locations.

Site No.	Structure Location	Channel Width (ft)	Channel Depth (ft)	Structure Type	Crest Width (ft)	Structure Length (ft)
21	Oil field canal	100	5.0	Armored earthen plug	n/a	n/a
22	Oil field canal	100	5.0	Armored earthen plug	n/a	n/a
23	Trenaisse	10	3.0	Rip-rap plug (1 on each side of LA Hwy 82)	n/a	n/a
24	Trenaisse	10	3.0	Rip-rap plug	n/a	n/a
25	Trenaisse	10	3.0	Rip-rap plug	n/a	n/a
26	n/a	n/a	n/a	OMIT	n/a	n/a
27	Spoil bank	n/a	n/a	Spoil bank maintenance	n/a	n/a
28	Spoil bank	n/a	n/a	Box with 1 flapgate, 1 variable-crest weir, and 2 fixed-crest weirs (1 slotted)	20	40
29	Spoil bank	n/a	n/a	Box with 1 flapgate, 1 variable-crest weir, and 2 fixed-crest weirs (1 slotted)	20	40
30	Spoil bank	n/a	n/a	Box with 1 flapgate, 1 variable-crest weir, and 2 fixed-crest weirs (1 slotted)	20	n/a
31	Spoil bank	n/a	n/a	Box with 1 flapgate, 1 variable-crest weir, and 2 fixed-crest weirs (1 slotted)	20	n/a
32	Spoil bank	n/a	n/a	Box with 1 flapgate, 1 variable-crest weir, and 2 fixed-crest weirs (1 slotted)	20	20

33	Spoil bank	n/a	n/a	Box with 1 flapgate, 1 variable-crest weir, and 2 fixed-crest weirs (1 slotted)	20	20
34	Spoil bank	n/a	n/a	Box with 1 flapgate, 1 variable-crest weir, and 2 fixed-crest weirs (1 slotted)	20	20
35	Spoil bank	n/a	n/a	Box with 1 flapgate, 1 variable-crest weir, and 2 fixed-crest weirs (1 slotted)	20	20
36	LA Hwy 82 east borrow canal	80	5.0	Earthen plug with 2 48" culverts with screwgates	n/a	30
n/a	Humble Canal	n/a	n/a	Bank protection	n/a	14,750

installed at evaluation sites (ES) 28, 29, and 30 (figure 1, table 2). The Phase 1 dike is now protecting the eastern edge of CTU 1 from wave erosion and salt water intrusion from Freshwater Bayou Canal. The landowner intends to install 14,750 ft (4,496 m) of bank protection along the north bank of Humble Canal. The existing structures at ES 19 (36-inch [91 cm] culvert with variable-crest weir), and at ES's 13, 14, and 20 (double-flapgated, box-type structure with variable-crest weir) will also be maintained (figure 1, table 1).

CTU 2 consists of 9,300 ac (3,764 ha) of fresh marsh, dominated by *Echinochloa walteri* (Walter's millet) and *S. lancifolia*, located in the west central portion of the project area. This unit is managed for waterfowl, alligators, furbearers, and fisheries. Pond depths range from 1.7-2.3 ft (0.52 - 0.70 m). To enhance water management capabilities (figure 1, table 2), three additional box-type water control structures with a single flapgate, a variable-crest weir, and two fixed-crest weirs (one with a 4-inch [10 cm] vertical slot) will be installed at ES 31, 32, and 33. An earthen plug, with a double-flapgated 36-inch (91 cm) culvert, will be installed at the mouth of each of two trenasses located at ES 24 and 25, to regulate channel flow from the LA Hwy 82 borrow canal into CTU 2. The sides of La Hwy 82 at the mouth of an old boundary canal at ES 23 to restrict channel flow from the existing spoil bank at ES 27 (figure 1) will be repaired to facilitate water management within CTU 2. An earthen plug with two 48-inch (1.22 m) culverts fitted with screw gates will be installed in the LA Hwy 82 borrow canal at ES 36 to help regulate north-to-south water flow in the borrow canal, and thus east-to-west flow into the project area. The existing structure at ES 17 (double-flapgated, box-type structure with variable-crest weir) will also be maintained.

The northern section of the project area comprises CTU 3, which consists of 13,800 ac (5,585 ha) of predominantly fresh marsh dominated by *S. lancifolia*, *E. walteri*, and *Alternanthera philoxeroides* (alligatorweed), with intermediate and brackish marsh zones dominated by *S. patens* and *Scirpus americanus* (Olney's bulrush) along its eastern boundary along Freshwater Bayou Canal. Pond depths range from 2.2-3.0 ft (0.67 - 0.91 m) in CTU 3, which is managed for waterfowl, alligators, and furbearers. To enhance water management (figure 1, table 2), two box-type water control structures with a single flapgate, a variable-crest weir, and two fixed-crest weirs (one with a 4- inch [10 cm] vertical slot) will be installed at ES 34 and ES 35. An earthen plug with a double-flapgated 36-inch (0.91 m) culvert were installed on both highway borrow canal into CTU 3. The existing structures (figure 1) at ES's 12, 15, 16, and 18 (double-flapgated, box-type structure with variable-crest weir) will also be maintained.

In an effort to reduce the volume of water flowing from White Lake and Schooner Bayou into the project area via borrow canals and culverts associated with La Hwy 82, an armored, earthen plug was installed on each of two oil field canals located between White Lake and the highway at ES 21 and ES 22 (figure 1, table 2). It is anticipated that the plugs will restrict channel flow into the project area, while at the same time encouraging sheet flow over the marsh surface.

The structures described above, along with the thirteen pre-existing water control structures in the project area, shall be operated in accordance with the operational schedule provided in the USACE and CMD permits to be obtained for the project. In lieu of a final plan and the operational scheme to be detailed in the USACE and CMD permits, the water management scheme for the project area includes the following elements.

1. A spring drawdown phase to encourage the growth of emergent plants.

2. A maintenance phase for time periods other than drawdowns, with a target water level of 6 in (15 cm) below marsh level.

3. Authorization to open all gates and weirs following heavy rainfall and/or storm events to preserve the integrity of the management system.

4. Provisions to manage water salinity for maintenance of the project area as fresh to intermediate marsh, and to operate the structures so as to reduce the impact of high salinity spikes.

<u>Project Objectives</u>

1. Protect the existing emergent wetlands along the west bank of Freshwater Bayou Canal and prevent their further deterioration from shoreline erosion and tidal scour.

2. Prevent the widening of the Freshwater Bayou Canal channel into the Freshwater Bayou Wetlands project area.

3. Reduce ponding and marsh loss in the project area wetlands.

4. Maintain target salinity levels in the project area wetlands.

5. Increase vegetation cover in shallow open water areas within the project area wetlands.

Specific Goals

The following goals will contribute to the evaluation of the above objectives:

1. Decrease the rate of spoil bank erosion along the west bank of Freshwater Bayou Canal using a rock breakwater.

2. Reduce water levels to within the target range for fresh to intermediate marsh vegetation, which is 6 in (15 cm) below to 2 in (5 cm) above marsh level.

3. Maintain salinity levels within the target range for fresh to intermediate marsh vegetation, which is 0-5 ppt.

4. Decrease the duration and frequency of flooding over the marsh.

5. Decrease the rate of marsh loss.

6. Increase the coverage of emergent vegetation in shallow open water areas within the project area.

Reference Areas

To assist in evaluating project success over time, reference areas will be monitored concurrently with the project area. Data collected within the project and reference areas will be used to make statistically valid comparisons of what the shoreline erosion rate, marsh loss rate, emergent and submergent vegetation, salinity, and water level would be with and without the project.

The main criteria for selecting reference areas are similarities in vegetative community, soil type, and hydrology. Another very important criterion in this case is the amount and type of boat traffic on the channel. Based on these criteria, reference areas R1 and R2 (see figure 1) were selected to monitor shoreline erosion along unprotected banks of Freshwater Bayou Canal for comparison with erosion rates along the section of canal bank now protected by the ME-04 rock dike constructed during Phase 1 of this project (LDNR 1995). These criteria were also used to select reference areas R2 and R3 (see figure 1) to monitor Phase 2 of this project.

The recommended reference area for Phase 1 consists of two 0.5 mi segments of shoreline located along the east bank of Freshwater Bayou Canal, one opposite the south end and one opposite the north end of the ME-4 dike (R1 and R2). The vegetation type is identical to the project area, and like the project area shoreline, each of the two segments selected includes both intact and deteriorated sections of spoil bank.

The soil type is Banker muck in both reference segments, while the project area soil is classified as Larose mucky clay (U.S. Soil Conservation Service, unpublished data). The soils in the reference area differ slightly from the soils in the project area. Typically, the Banker soil series has 0–6 in (0 -15 cm) of muck overlying 6–18 in (15 - 46 cm) of mucky clay, over a base of semifluid clay. The Larose soil series has 0–6 in (0 - 15 cm) of muck overlying a base of clay and semifluid clay. The amount of boat traffic can be expected to be the same for the project area and both reference segments. Thus, data collected can be used to compare erosion rates between the project area and reference area, as well as between the two reference areas.

Habitat mapping and shoreline markers will be evaluated in the reference areas R1 and R2. Aerial photography will be flown for both the project and reference areas to provide a data base for habitat mapping. A proportional number of shoreline markers (1 every 1,000 ft [305 m]) will be established in the reference areas for comparison with data gathered from similarly dispersed stations in the project area.

The project area has experienced ponding and marsh loss, particularly in CTU 1. This appears to be due in part to exposure of the vegetation to prolonged periods of high water levels, compounded by an inadequate capacity to discharge water from the project area, and occasional salt water intrusion. These conditions tend to stress emergent marsh vegetation, which reduces plant productivity, and thus vertical accretion (Nyman et al. 1993). Reference areas R2 and R3 will be monitored to evaluate the effects of implementing Phase 2 on these and other variables.

Reference area R2 is a tidally influenced, brackish/intermediate marsh located along the east bank of Freshwater Bayou Canal opposite from the north end of the ME-04 rock dike (figure 1). This tidal marsh is partly impounded by spoil banks, and shows signs of ponding. The site is somewhat representative of what present day conditions in the southern part of the ME-04 project area would be like in terms of salinity regime and vegetation types, without implementing this project.

Several of the project features are designed to decrease the flow of fresh water into the project area from the west. However, the area between White Lake and LA Hwy 82, where reference area R3 is located (figure 1), is expected to continue experiencing prolonged periods of elevated water levels, and also shows signs of ponding. Reference area R3 is representative of much of the fresh marsh in the project area today, in terms of water levels and the frequency and duration of inundation.

Monitoring of water levels, salinity, and vegetation in the project area and in reference areas R2 and R3 should provide an opportunity to evaluate the effect of maintaining (reference area R3) or decreasing (project area) water levels, as compared with natural water level conditions (reference area R2). Comparison of data from the project and reference areas R2 and R3 should be adequate for evaluating the influence of salinity, water level, and flooding duration on project area vegetation.

CRMS will provide a pool of reference sites within the same basin and across the coast to evaluate project effects. At a minimum, every project will benefit from basin-level satellite imagery and land:water analysis every 3 years, and supplemental vegetation data collected through the periodic Chabreck and Linscombe surveys. Other CRMS parameters which may serve as reference include Surface Elevation Table (SET) data, accretion (measured with feldspar), hourly water level and salinity, and vegetation sampling. A number of CRMS stations are available for each habitat type within each hydrologic basin to supplement project-specific reference area limitations.

Monitoring Elements

The following monitoring elements will provide the information necessary to evaluate the specific goals listed above:

1. Habitat Mapping — To document land and water areas, marsh loss rates, and shoreline movement in ponded areas in the ME-04 project area, near-vertical, color-infrared aerial photography (1:12,000 scale, with ground controls) will be obtained. The photography will be obtained in 1997 (pre-construction) and in 2001 post-construction. The photography will be georectified, photointerpreted, mapped, and analyzed with GIS by National Wetlands Research Center (NWRC) personnel using standard operating procedures described in Steyer et al. (1995).

   Based on the CRMS review, habitat mapping originally scheduled for 2007 and 2016 was eliminated. Calculation of land and water areas will be available through CRMS satellite imagery for the entire project area, and through CRMS photography for the 5 CRMS stations within the ME-04 project area. In addition, habitat data will be available through periodic Chabreck and Linscombe vegetation surveys to supplement the land:water analyses.

2. Shoreline Change — To document shoreline movement along Freshwater Bayou Canal, shoreline markers will be placed at maximum intervals of 1,000 ft (305 m) on the vegetated marsh edge along the west bank of the canal between its confluence with the Humble Canal and with North Prong Belle Isle Bayou, at 31 points corresponding to the pre-construction survey cross-sections, and at 3 points along each of the two 0.5 mi (0.8 km) long reference areas located along the east side of the channel opposite the north and south ends of the proposed breakwater. Shoreline position relative to shoreline markers will be documented by direct measurement in 1995, 1996, 1998, 2001, 2011, and 2014 post-construction. In addition, aerial photography (1:12,000 scale) and differential GPS measurements will also be used to document long-term shoreline movement, and to provide a template for mapping shoreline position and shoreline changes over time.

Shoreline positions will be compared to historical data sets available in digitized format for 1956, 1978, and 1988 shorelines (Steyer et al. 1995).

Based on the CRMS review, the shoreline surveys originally scheduled for 2004, 2007, and 2016 were eliminated.

3. Water Level

To evaluate the extent of ponding within the project area, water level relative to marsh level and NGVD will be monitored at least monthly at permanent discrete sampling stations within the project and reference areas, and by reading staff gauges installed inside and outside of the project area near existing/proposed water control structures and beside the continuous data recorders. Continuous data recorders will be deployed to record water level data at 6 locations in the project area and at 1 location in each of reference areas R2 and R3. Following a site visit to establish permanent sampling stations, a sampling station map will be prepared and added to this monitoring plan. Additional discrete and continuous data recorder stations may be established within the project and reference areas as data becomes available and a power analysis can be performed. Water level data will be used to document the variability in water level, and the frequency, duration, and range of marsh inundation in the project and reference areas. Water level will be monitored in 1996-1998 (pre-construction) and in 1999-2006 (post-construction).

Based on the CRMS review, hydrologic monitoring at the original stations was discontinued (originally scheduled to end in 2004), and replaced by hydrologic monitoring at the 5 CRMS stations within the project area. Discrete sampling was eliminated.

4. Salinity

Salinities will be monitored at least monthly at permanent discrete sampling stations within the project and reference areas. In addition, continuous data recorders will be deployed to record salinity data at 6 locations in the project area and at 1 location in each of reference areas R2 and R3. Following a site visit to establish permanent sampling stations, a sampling station map will be prepared and added to this monitoring plan. Additional discrete and continuous data recorder stations may be established within the project and reference areas as data becomes available and a power analysis can be performed. Salinity data will be used to characterize the spatial variation in salinity throughout the project area, and to determine if project area salinity is being maintained within the target range. Salinity will be monitored in 1996-1998 (pre-construction) and in 1999-2006 (post-construction).

Based on the CRMS review, hydrologic monitoring at the original stations was discontinued (originally scheduled to end in 2004), and replaced by hydrologic monitoring at the 5 CRMS stations within the project area. Discrete sampling was eliminated.

5. Emergent Vegetation To document the condition of the emergent vegetation in the project area over the life of the project, vegetation will be monitored at sampling stations established systematically in the project and reference areas. Six east-west transects were established uniformly across the project area. Sampling stations will be established uniformly along each transect line to obtain an even distribution of sampling stations throughout the project area. Similar east-west transects were delineated across reference areas R2 and R3 to establish four sampling stations in each reference area. Percent cover, dominant plant heights, and species composition are documented in 2.0 m^2 sampling plots marked with 2 corner poles to allow for revisiting the sites over time. Descriptive observations of submergent vegetation are noted during monitoring of emergent vegetation. Vegetation was evaluated at the sampling sites in the fall of 1996 (pre-construction) and in the fall of 1998, 2001.

Based on the CRMS review, vegetation sampling originally scheduled for 2004, 2007, 2010, 2013 and 2016 was eliminated. Vegetation sampling will be continued through sampling at each CRMS station and will be supplemented with periodic vegetation surveys by Chabreck and Linscombe.

<u>Anticipated Statistical Analyses and Hypotheses</u>

The following hypotheses correspond with the monitoring elements and will be used to evaluate the accomplishment of the project goals:

1. Descriptive and summary statistics on historical data (for 1956, 1978, and 1988) and data from color-infrared aerial photography collected pre- and post-construction will be used, along with GIS interpretations of these data sets, to evaluate marsh to open water ratios and changes in the rate of marsh loss/gain in the project area. If sufficient historical information is available, regression analyses will be done to test for changes in slope between pre- and post-construction conditions. Habitat mapping data may also be used in the analyses of emergent vegetation, to evaluate the project goal of increasing the occurrence (coverage) of emergent marsh vegetation in the project area, as discussed under item 6 below.

1, 2. Paired-t tests, analysis of variance (ANOVA), descriptive, and summary statistics will be used to compare measured rates of shoreline movement (ft/yr) in the project area with that of reference areas. Also, historical values for the area, as well as data available from other surveys (USACE, USFWS, LDNR, LSU) will be compiled for documentation and for use in statistical analysis of the long-term shoreline movement along the Freshwater Bayou Canal section of the project area. Data will be obtained from aerial photography, ground truthing, and direct measurements from established shoreline markers. When the H_o is not rejected, the possibility of negative effects will be examined.

The following pair of hypotheses will be tested using the available data to evaluate the accomplishment of the project goal.

Goal: Decrease the rate of shoreline erosion along the west bank of the Freshwater Bayou Canal adjacent to the Freshwater Bayou Wetlands project area.

Hypotheses:

H_0: Shoreline erosion rate in the project area post-construction will not be significantly less than the shoreline erosion rate in the reference area.

H_a: Shoreline erosion rate in the project area post-construction will be significantly less than the shoreline erosion rate in the reference area.

3. The primary method of analysis for water levels will be to determine differences in mean water levels as evaluated by an analysis of variance (ANOVA) that will consider both spatial and temporal variation and interaction. The ANOVA model used will be a BACI (Before-After-Control-Impact) type model, which will determine if there are detectable impacts in the project area after construction, (e.g., a decrease in water level). Multiple comparisons will be used to compare individual means across different treatment levels. All original data will be analyzed and transformed (if necessary) to meet the assumption of an ANOVA (e.g., normality). When the H_0 is not rejected, the possibility of negative effects will be examined.

Goal: Decrease mean water levels within the project area.

Hypothesis:

H_0: Mean water levels within the project area after construction will not be significantly lower than mean water levels within the reference area after construction.

H_a: Mean water levels within the project area after construction will be significantly lower than mean water levels within the reference area after construction.

The primary method of analysis for water level variability will be to determine differences in mean water levels as evaluated by an analysis of variance (ANOVA) that will consider both spatial and temporal variation and interaction. The ANOVA model used will be a BACI (Before-After-Control-Impact) type model, which will determine if there are detectable impacts in the project area after construction, (e.g., a decrease in water level variability). Multiple comparisons will be used to compare individual means across different treatment levels. All original data will be analyzed and transformed (if necessary) to meet the assumption of an ANOVA (e.g., normality). When the H_0 is not rejected, the possibility of negative effects will be examined.

Goal: Decrease the variability in water level within the project area.

Hypothesis: .

H_0: Water level variability within the project area after construction will not be significantly lower than water level variability within the reference area after construction.

H_a: Water level variability within the project area after construction will be significantly lower than water level variability within the reference area after construction.

4. The primary method of analysis for salinities will be to determine differences in mean salinities as evaluated by an analysis of variance (ANOVA) that will consider both spatial and temporal variation and interaction. The ANOVA model used will be a BACI (Before-After-Control-Impact) type model, which will determine if there are detectable impacts in the project area after construction, (e.g., a decrease in salinity). Multiple comparisons will be used to compare individual means across different treatment levels. All original data will be analyzed and transformed (if necessary) to meet the assumption of ANOVA (e.g. normality). When the H_0 is not rejected, the possibility of negative effects will be examined.

Goal: Maintain low mean salinity (0-5 ppt) in the project area after construction.

Hypothesis:

H_0: Mean salinities within the project area after construction will not be significantly lower than mean salinities in the reference area after construction.

H_a: Mean salinities within the project area after construction will be significantly lower than mean salinities in the reference area after construction.

The primary method of analysis for salinity variability will be to determine differences in mean salinities as evaluated by an analysis of variance (ANOVA) that will consider both spatial and temporal variation and interaction. The ANOVA model used will be a BACI (Before-After-Control-Impact) type model, which will determine if there are detectable impacts in the project area after construction, (e.g., a decrease in salinity variability).

Multiple comparisons will be used to compare individual means across different treatment levels. All original data will be analyzed and transformed (if necessary) to meet the assumption of ANOVA (e.g. normality). When the H_0 is not rejected, the possibility of negative effects will be examined.

Goal: Decrease the variability in salinity within the project area after construction.

Hypothesis:

H_0: Salinity variability within the project area after construction will not be significantly lower than salinity variability in the reference area after construction.

H_a: Salinity variability within the project area after construction will be significantly lower than salinity variability in the reference area after construction.

5. The primary method of analysis for emergent vegetation cover will be to determine differences in mean vegetation cover as evaluated by an analysis of variance (ANOVA) that will consider both spatial and temporal variation and interaction. The ANOVA model used will be a BACI (Before-After-Control-Impact) type model, which will determine if there are detectable impacts in the project area after construction, (e.g., an increase in vegetation cover). A repeated measure design will be used in the ANOVA model. Multiple comparisons will be used to compare individual means across different treatment levels. All original data will be analyzed and transformed (if necessary) to meet the assumption of ANOVA (e.g. normality). When the H_0 is not rejected, the possibility of negative effects will be examined.

Goal: Increase the occurrence (coverage) of emergent marsh vegetation in the project area.

Hypothesis:

H_0: Occurrence of vegetation within the project area after construction will not be significantly greater than the occurrence of vegetation in the reference area after construction.

H_a: Occurrence of vegetation within the project area after construction will be significantly greater than the occurrence of vegetation in the reference area after construction.

<u>Notes</u>

1. Implementation: "Phase 1" (rock breakwater):

Start Construction	October 10, 1994
End Construction	January 31, 1995

	"Phase 2" (plugs, water control structures):		
		Start Construction	February 1, 1997
		End Construction	October 1, 1998
2.	NRCS Point of Contact:	Joseph Conti	(318) 473-7687
3.	DNR Project Manager:	Pat Landry	(337) 482-0680
	DNR Monitoring Manager:	Karl A. Vincent	(318) 482-0689
4.	Vermilion Corp. Point of Contact:	W. P. "Judge" Edwards	(318) 893-0268

5. The twenty year monitoring plan development and implementation budget for this project is $891,466. Pursuant to the CRMS review, it was authorized by the Task Force to maintain $471,327 with the project, and utilize $365,776 to support CRMS. Progress reports will be available in October 1999, 2000, and 2002 and a project-specific comprehensive report will be available in 2001. Periodic comprehensive reports on coastal restoration efforts in the Mermentau hydrologic basin will describe the status and effectiveness of the project as well as cumulative effects of restoration projects in the basin.

6. The TAG recommended the monitoring of submersed aquatic vegetation (SAV) and fisheries access. Upon further field review, adequate reference areas were not found. Therefore, proposed SAV and fisheries monitoring designs have not been included in this monitoring plan.

7. Monitoring of the rock breakwater will be conducted to determine maintenance needs.

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