State of Louisiana

Coastal Protection and Restoration Authority

2012 Monitoring Plan

for

Replace Sabine Refuge Water Control Structures at Headquarters Canal, West Cove Canal, and Hog Island Gully (CS-23)

State Project Number CS-23
Priority Project List 3

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Cameron Parish

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MONITORING PLAN
PROJECT NO. CS-23
REPLACE HOG ISLAND GULLY, WEST COVE, AND HEADQUARTERS CANAL STRUCTURES

ORIGINAL DATE: June 16, 1999
REVISED DATES: August 14, 2003; March 29, 2012

Preface

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. As a result of a joint meeting with DNR, USGS, and USFWS (federal sponsor), the recommendations for this Monitoring Plan were to discontinue project-specific monitoring and utilize the 10 CRMS sites within the project area (figure 1) to evaluate project effects. It was recommended that the SAV monitoring continue as originally proposed. Satellite imagery collected through CRMS-*Wetlands* will be used to evaluate changes in land and water areas within the project area. These recommendations have been incorporated into the Monitoring Elements section.

Project Description

The Replace Hog Island Gully, West Cove and Headquarters Canal Structures (CS-23) project area is located within the Sabine National Wildlife Refuge, approximately 9 mi (14.5 km) south of the town of Hackberry in Cameron Parish, Louisiana (figure 1). Established on December 6, 1937, the Sabine Refuge is bound on the east by Calcasieu Lake, on the west by Sabine Lake, on the north by broken marsh, and on the south by pasture land and coastal ridges. The refuge encompasses approximately 124,511 acres (50,402 ha) of interspersed fresh, intermediate, brackish, and saline marshes. The project area comprises 42,247 acres (17,102 ha) and supports diverse vegetative and wildlife communities (United States Fish and Wildlife Service [USFWS], 1999).

O'Neil (1949) characterized the project area wetlands as fresh to intermediate marshes dominated by Jamaica sawgrass (*Cladium jamaicense*). The Black Lake area, located north of the project, experienced an 81% reduction in the acreage of emergent wetlands between 1952 and 1974 (Adams et al. 1978). By 1972, the Black Lake area was characterized as brackish marsh (Chabreck and Linscombe 1978). A number of factors such as salinity stress, erosion, subsidence, burning and

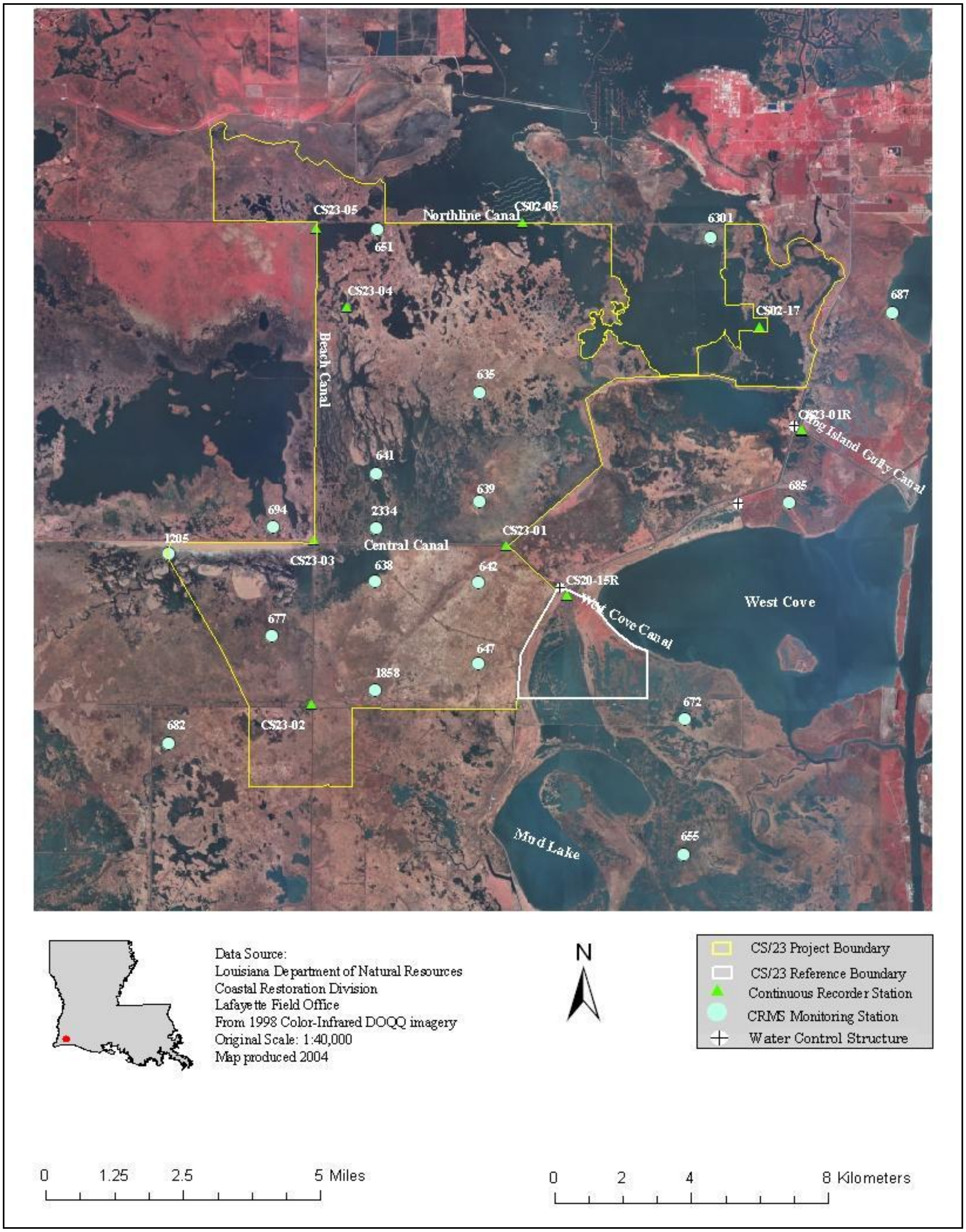

Figure 1. Replace Hog Island Gully, West Cove Canal, and Headquarters Canal Structures (CS-23) project features, project area boundaries, and reference area boundaries.

hydrologic modification influenced this habitat change. For example, in 1957, Hurricane Audrey inundated the area with saltwater, impacting freshwater emergent vegetation which disappeared in the late 1950's and early 1960's (Valentine 1979), leaving large expanses of open water in the refuge. Rogers and Herke (1985) indicated that the soil is highly organic and subject to erosion when unvegetated. In addition, the extraction of oil and gas in the area may have induced subsidence, as documented in east Texas (Weaver and Sheets 1962). Prescribed burning has also influenced habitat change. It is a management practice conducted every three to four years to control the growth of undesirable plant species. The largest influence has probably been manmade changes to the hydrology of the area. The Calcasieu Ship Channel was dredged to its current depth of 40 ft (12.2 m) in 1968 (Good et al. 1995), and construction of Highway 27 has increased water and soil salinities, changed the distribution and circulation of saltwater, and disrupted the natural hydrology and ecology of a large portion of the refuge marshes (Valentine 1979).

Former Water Control Structures

Since there are primarily three avenues for water passage (Hog Island Gully, West Cove Canal, and Headquarters Canal) in the area, the feasibility of water management by weirs was investigated in the 1970's and the first structures were completed in 1981. These structures have corroded with the continuous exposure to saline water to the extent that they are inoperable.

Due to the detrimental impacts of excessive salinity on brackish and intermediate marshes, the ability to occasionally reduce or halt the inflow of saline water is critical. This level of control was not available with the former structures as evidenced by the large volumes of high salinity water (> 20 ppt) which flowed over the weir crests (which were set at +1.5 ft MSL) during periods of high tide. The inability to manipulate gate structures jeopardized the integrity of thousands of acres of interior brackish and intermediate marshes which are lower in elevation and often occur in highly organic semifloating soils. The estimated subsidence rate in the project marshes ranged between 0.12 in/yr and 0.16 in/yr (0.32 and 0.42 cm/yr) (Penland et al. 1989). Because of the restricted cross-sectional area of the former structures and culverts, the lower elevation interior marshes experienced longer periods of vegetative water logging stress than the marshes located east of Highway 27. The former structures afforded the primary avenues for drainage and were inadequate to provide sufficient discharge to evacuate excess water. Due to the project area not being fully enclosed, secondary drainage for the area occurred to the west through Sabine Lake via North, Central and South line canals.

Project Features

In September 1996, the USFWS began development of the draft environmental assessment (EA) plan addressing the Replacement of Water Control Structures at Hog Island Gully, West Cove Canal, and Headquarters Canal (CS-23). The project features included the complete removal of the Hog Island Gully Structure, West Cove Canal Structure, and Headquarters Canal Structure and replacement with additional structures and culverts to provide larger cross sections for water removal and to minimize saltwater intrusion.

The Hog Island Gully structure is located approximately 200 ft (61 m) east of the pre-existing structure and increased the cross sectional area by 212.5 ft^2 (19.1 m^2) (table 1). The structure contains four 7.5 ft (2.3 m) wide gates and two 3.0 ft (0.9 m) wide gates. Each bay is 8 ft (2.4 m) deep and equipped with dual slide gates to preclude all water flow if necessary. Of the four 7.5 ft (2.3 m) gates, three have exterior flapgates so that water flows can be precisely regulated at critical periods throughout the year.

The West Cove Canal structure is located approximately 200 feet (61 m) east of the pre-existing structure and increased the cross sectional area by 182.5 ft^2 (16.4 m^2) (table 1). The structure contains three 7.5 ft (2.3 m) wide gates and two 3.0 foot (0.9 m) wide gates. Each bay is 8 ft (2.4 m) deep and equipped with dual slide gates to preclude all water flow if necessary. Of the three 7.5 ft (2.3 m) gates, two have exterior flapgates so that water flows can be precisely regulated at critical periods throughout the year.

The Headquarters Canal Structure was refurbished in its present location and the cross sectional area was increased by 46.4 ft^2 (4.2 m^2) (table 1). The new structure consists of three 5.0 ft (1.5 m) diameter culverts. The top of each culvert is set at approximate marsh level. The center culvert is equipped with an exterior sluice gate and an interior flap gate. The two outer culverts do not contain the exterior sluice gates.

Construction began in November 1999 and was completed on the Hog Island Gully, West Cove, and Headquarters Canal structures in August 2000, June 2001, and February 2000, respectively. However, the Hog Island Gully and West Cove structures were not fully operational due to an electrical service problem, exacerbated by the damage to the structures from Hurricane Rita in 2005 and Hurricane Ike in 2008. On December 5, 2011 completion of the structure repairs and modifications was finalized and all structures were accepted as operational. The replacement structures are operated to more effectively discharge excess water, increase cross sectional area for ingress/egress of estuarine dependent species and more effectively curtail saltwater intrusion into the interior marshes. High saline waters can be precisely controlled, water discharge capacities will be increased, and vegetative stress through water logging will be minimized, thus enhancing emergent and submergent vegetative growth. The proposed action is estimated to restore 367 acres (149 ha), protect 586 acres (237 ha), and enhance 42,247 acres (17,102 ha) of intermediate and brackish marshes over the 20-yr life of the project (LDNR 1983).

Table 1. Cross sectional area of existing and proposed water control structures affecting the (C/S-23) project area (United States Fish and Wildlife Service, 1999).

Structure	**Existing**		**Proposed**		**Increase in Area**	
	(f^2)	**(m^2)**	**(f^2)**	**(m^2)**	**(f^2)**	**(m^2)**
Hog Island Gully	93.5	(8.4)	306.0	(27.5)	212.5	(19.1)
West Cove Canal	59.5	(5.3)	242.0	(21.7)	182.5	(16.4)
Headquarters Canal	12.6	(1.1)	59.0	(5.3)	46.4	(4.2)

Total	165.6	(16.8)	607.0	(54.5)	441.4	(39.7)

Project Objective

1. Increase the cross-sectional area of the project features to improve hydrologic conditions that control high saline waters, increase water discharge capacities, and maintain emergent vegetation.

Specific Goals

1. Reduce the occurrence of salinities that exceed target levels at stations CS23-02 (BS), CS23-03 (BC), CS23-05 (BN) and CS02-05 (5R). Target levels range from 2 – 8 ppt during the growing season and 3 – 10 ppt during the non-growing season.

2. Minimize frequency and duration of marsh flooding events.

3. Maintain existing intermediate and brackish vegetation communities.

4. Increase occurrence of submerged aquatic vegetation (SAV).

Reference Area

The importance of using appropriate reference areas cannot be overemphasized. Monitoring on both project and reference areas provides a means to achieve statistically valid comparisons, and is therefore the most effective means of evaluating project success. The evaluation of sites was based on the criteria that both project and reference areas have a similar vegetative community, soil type, and hydrology. The project area, classified as a brackish/intermediate marsh and the reference area, classified as a brackish marsh (Chabreck and Linscombe 1978), contain mainly the organic Creole and Bancker soils (United States Department of Agriculture [SCS] 1995).

The area north of Magnolia Road and east of Hwy 27 has been chosen as a suitable reference area for the monitoring of emergent and submerged aquatic vegetation, water levels, and salinities (figure 1). Both areas are influenced hydrologically by the Calcasieu Ship Channel and Calcasieu Lake through West Cove Canal and are dominated by *Spartina patens* (marshhay cordgrass). The reference area presently being used is the reference utilized for the East Mud Lake (CS-20) project. Pre and Post-construction data for vegetation, water level and salinity data within the reference area is available from 1995 and 2008. The (C/S-23) data collection procedures and dates will coincide with (CS-20) data collection procedures and dates to comply with budgetary constraints.

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. **Aerial Photography-** To document land and water acreage and land loss rates in the hydrologic unit, reference area, and whole project area, color infrared aerial photography (1:12,000 scale with ground controls) of the project and reference areas will be obtained. The photography will be georectified by National Wetlands Research Center (NWRC) personnel following procedures described in Steyer et al. (1995), but detailed photo interpretation, mapping, and GIS is not planned. The photography will be obtained prior to construction in 1999.

   Based on the CRMS review, the aerial photography originally scheduled for 2004, 2009, and 2018 was eliminated. CRMS will collect aerial photography in a 1km^2 area surrounding each of the 10 CRMS sites within the project area, and CRMS will also classify satellite imagery into land and water for the entire hydrologic basin. The CS-23 project area will be subsampled from this basin-level imagery.

2. **Salinity-** Salinities will be monitored hourly utilizing nine continuous recorders. Six will be located in the project area, two in the reference area and one outside of the project area within Hog Island Gully Canal. Six recorders are associated with this project, two associated with Rycade Canal (CS02-05, CS02-17) and one from East Mud Lake (CS20-15R) (figure 1). Discrete salinities were being collected bi-weekly at 15 stations in the project and reference areas by USFWS and provided to DNR each month but this has been discontinued. The continuous data was used to characterize frequency and duration of average annual salinities throughout the project and reference area. Salinity data was also used to identify occurrences of salinities that exceed target levels at stations CS23-02 (BS), CS23-03 (BC), CS23-05 (BN) and CS02-05 (5R). Salinity was monitored in 1998-1999 (pre-construction) and in 2000-2008 (post-construction).

   Based on the CRMS review, salinity sampling at these stations was replaced by salinity sampling at the 10 CRMS stations within the project area after 2004. The 5 data recorders needed to monitor salinity thresholds for operations will be maintained. Since these data are needed for O&M, CRD will work with the O&M manager to ensure that these sondes are serviced.

3. **Water Level-** To document annual duration and frequency of flooding, water levels were monitored hourly at 9 continuous recorder stations located in the project and reference area sites (figure 1). A staff gauge was surveyed adjacent to the continuous recorders so as to tie recorder water levels to a known datum. Marsh elevations have been established at stations (CS23-02, CS23-03, CS23-05, CS02-05, CS02-17, CS20-15R) and were used to evaluate 1998-1999 (pre-

construction) and 2000-2008 (post-construction) data sets.

Based on the CRMS review, water level sampling at these stations was replaced by water level sampling at the 10 CRMS stations within the project area after 2004. The 5 data recorders needed to monitor water level thresholds for operations will be maintained. Since these data are needed for O&M, CRD will work with the O&M manager to ensure that these sondes are serviced.

4. **Vegetation-** Species composition, richness and relative abundance will be evaluated in the project and reference areas using techniques described in Steyer et al (1995). More specifically, the Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974) will be utilized. Fifty $4m^2$ sample areas (replicate 2m x 2m plots) will be used to monitor percent cover, species composition, and height of dominant plants. Forty plots will be located in the project area and ten existing plots will be in the reference area. The plots will be established along a North/South transect line and will be marked by GPS points and PVC poles to allow revisiting over time. Vegetation was monitored in 1999 (pre-construction) and 2004 (post-construction).

   Based on the CRMS review, post-construction vegetation sampling scheduled for 2009, 2014, and 2018 was eliminated and replaced by vegetation sampling at the 10 CRMS stations within the project area.

5. **Submerged Aquatic Vegetation-** To determine the occurrence of submersed aquatic vegetation (SAV) within the project and reference area, eight ponds will be randomly sampled for presence or absence of SAV using the modified rake method (Nyman and Chabreck1996). Five ponds will be located in the project area and three in the reference area. Transect lines will be set up within each pond and a minimum of 25 samples will be taken along each transect line, not to exceed 100 samples per line. Depending on pond configuration and wind direction, the number of transect lines within each pond will vary. SAV's were monitored in 1999 (pre-construction) and 2004, 2009 (post-construction) and are scheduled again for years 2014, and 2018.

Supplemental Project-Specific Information

The following monitoring elements do no address specific project goals, but will be collected from all project and reference CRMS stations to evaluate the condition of the marsh.

1. **Soil Properties** - Soil cores were collected at each CRMS site upon establishment. Analyzed soil properties include soil pH, salinity (EC), bulk density, moisture, percent organic matter, wet/dry volume, and texture (Particle Size Distribution).

2. **Rod Surface Elevation Tables (RSET)-** RSET will be used to measure precise changes in marsh surface elevation over time relative to a fixed datum. Data will be collected biannually in the spring and fall at each CRMS site.

3. **Accretion-** Accretion plots will be used to measure surface accretion (i.e., sedimentation) near the RSET at each CRMS site. Vertical accretion is to be used in conjunction with the RSET to provide information on below ground processes that influence surface elevation change. Accretion data collection will be collected biannually in the spring and fall coinciding with the RSET.

Anticipated Statistical Analyses and Hypotheses

The following paragraphs describe statistical tests that will be used to analyze data collected for each monitoring element included in this monitoring plan to evaluate the accomplishment of the project goals. The numbers to the left correspond to the monitoring elements described above. These are followed by statements of the project goals, and the hypotheses that will be used in the evaluation.

1. Aerial Photography: Descriptive and historical data (for 1956, 1978, and 1988) 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.

Goal: Reduce existing rate of loss of emergent marsh.

Hypothesis[1]:

H_0^1: Marsh loss rate within the project area at time point *i* will not be significantly less than marsh loss rate pre-construction.

H_a^1: Marsh loss rate within the project area at time point *i* will be significantly less than marsh loss rate pre-construction.

Hypothesis[2]:

H_0^2: Marsh loss rate within the project area at time point *i* will not be significantly less than post-construction marsh loss rate within reference area.

H_a^2: Marsh loss rate within the project area at time point *i* will be significantly less than post-construction marsh loss rate within reference area.

2. Salinity: Within a given sampling period, appropriate parametric and/or nonparametric methods will be used to test the following hypotheses.

Goal: Reduce the occurrence of salinities that exceed target levels.

Hypothesis[1]*:*

H_0^1: The occurrence of salinities that exceed target levels in the project area post-construction will not be significantly lower than the occurrence of salinities that exceed target levels in the project area pre-construction.

H_a^1: The occurrence of salinities that exceed target levels in the project area post-construction will be significantly lower than the occurrence of salinities that exceed target levels in the project area pre-construction.

Hypothesis²:

H_0^2: The occurrence of salinities that exceed target levels in the project area post-construction will not be significantly lower than the occurrence of salinities that exceed target levels in the reference area post-construction.

H_a^2: The occurrence of salinities that exceed target levels in the project area post-construction will be significantly lower than the occurrence of salinities that exceed target levels in the reference area post-construction.

3. Water Level: Within a given sampling period, appropriate parametric and/or nonparametric methods will be used to test the following hypothesis.

Goal: Decrease duration and frequency of inundation.

*Hypothesis*¹:

H_0^1: Duration and frequency of inundation post-construction in the project area will not be significantly lower than duration of inundation pre-construction in the project area.

H_a^1: Duration and frequency of inundation post-construction in the project area will be significantly lower than duration of inundation pre-construction in the project area.

*Hypothesis*²:

H_0^2: Duration and frequency of inundation post-construction in the project area will not be significantly lower than duration of inundation post-construction in the reference area.

H_a^2: Duration and frequency of inundation post-construction in the project area will be significantly lower than duration of inundation post-construction in the reference area.

4. Vegetation: Within a given sampling period, appropriate parametric and/or nonparametric methods will be used to test the following hypothesis.

Goal: Maintain the percent cover, richness and vegetation height within the project area.

Hypothesis¹:

H_0^1: Percent cover, richness and vegetation height within the project area post-construction will be less than mean percent cover, richness and vegetation height within the project area pre-construction.

H_a^1: Percent cover, richness and vegetation height within the project area post-construction will be the same or greater than mean percent cover, richness and vegetation height within the project area pre-construction.

Hypothesis[2]*:*

H_0^2: Percent cover, richness and vegetation height within the project area post-construction will be less than mean percent cover, richness and vegetation height within the reference area post-construction.

H_a^2: Percent cover, richness and vegetation height within the project area post-construction will be the same or greater than mean percent cover, richness and vegetation height within the reference area post-construction.

5. <u>Submerged Aquatic Vegetation</u>: Within a given sampling period, appropriate parametric and /or nonparametric methods will be used to test the following hypothesis.

Goal: Increase the frequency of occurrence of SAV's in shallow open water within the project area.

Hypothesis[1]*:*

H_0^1: Frequency of occurrence of SAV in the project area post-construction will <u>not</u> be significantly greater than the frequency of occurrence of SAV pre-construction.

H_a^1: Frequency of occurrence of SAV in the project area post-construction will be significantly greater than the frequency of occurrence of SAV pre-construction.

Hypothesis[2]*:*

H_0^2: Frequency of occurrence of SAV in the project area post-construction will <u>not</u> be significantly greater than the frequency of occurrence of SAV post-construction in the reference area.

H_a^2: Frequency of occurrence of SAV in the project area post-construction will be significantly greater than the frequency of occurrence of SAV post-construction in the reference area

Available ecological data, including both descriptive and quantitative data, will be evaluated in concert with the statistical analyses to aid in determination of the overall project success. This includes ancillary data collected in this monitoring project but not used directly in statistical analyses, as well as data available from other sources (USACE, USFWS, DNR, LSU, etc.).

Notes:

1.	Implementation:	Start Construction 11/23/1999 End Construction 09/10/2003 Repairs/Modifications 12/2011	
2.	USFWS Point of Contact:	Darryl Clark	(318) 291-3111
3.	CPRA Project Manager: CPRA Monitoring Manager:	Dion Broussard Mike Miller	(337) 482-0686 (337) 482-0662

4. The twenty year monitoring plan development and implementation budget for this project is $836,094. Pursuant to the CRMS review, it was authorized by the Task Force to maintain $356,692 with the project, and utilize $479,402 to support CRMS. Comprehensive reports on coastal restoration efforts in the Calcasieu-Sabine hydrologic basin will be available in 2005, 2008, 2011, 2014, and 2017. These reports will describe the status and effectiveness of the project as well as cumulative effects of restoration projects in the basin.

5. Salinity and water level data within the project and reference area were collected from March 1998 to December 2004 at 6 stations (CS23-01,CS23-02,CS23-03,CS23-05,CS23-01R & CS02-05) and from December 2005 to June 2008 at 5 stations (CS23-02,CS23-03,CS23-05,CS23-01R & CS02-05) to obtain pre and post construction data.

6. Since 2004, OM&M data are collected at five continuous recorder stations CS23-02, CS23-03, CS23-01R, CS02-17 and CS20-15R (figure 1) to aid in structure operations.

7. Structure operations will be performed by Sabine National Wildlife Refuge personnel with the assistance of CPRA.

8. Prescribed burning, to control growth of undesirable plant species is practiced by the USFWS every three to four years within the vegetative sampling area. Vegetative markers used to locate vegetative plots over time will need to be fire retardant.

References:

Adams, R. D., P. J. Banas, R. H. Baumann, J. H. Blackmon, and W. G. McIntire 1978. Shoreline erosion in coastal Louisiana: inventory and assessment. Baton Rouge: Louisiana Department of Transportation and Development, Coastal Resources Program. 139 pp.

Chabreck, R. H. and G. Linscombe 1978. Vegetative type map of the Louisiana coastal marshes. New Orleans: Louisiana Department of Wildlife and Fisheries. Scale1:62,500.

Good, B.,J. Buchtel, D. Meffert, J. Radford, K. Rhinehart, and R. Wilson 1995. Louisiana's Major Coastal Navigational Channels. Unpublished report. Baton Rouge: Louisiana Department of Natural Resources, Office of Coastal Management and Restoration. 57 pp.

Louisiana Department of Natural Resources (LDNR) 1983. Wetland Value Assessment Community Model for Replacement of Water control structures at Hog Island Gully, West Cove Canal, and Headquarters Canal (XCS-47/48). pp. 12

Mueller-Dombois, D. and H. Ellenberg1974. Aims and Methods of Vegetation Ecology. New York: John Wiley and Sons. 547pp.

Nyman, J. A., and R. H. Chabreck 1996. Some effects of 30 years of weir management on coastal marsh aquatic vegetation and implications to waterfowl management. Gulf of Mexico Science 14: 16-25.

O'Neil, T. 1949. Map of the southwestern part of Louisiana showing vegetation types of the Louisiana marshes. New Orleans, La. Louisiana Department of Wildlife & Fisheries.

Penland, S., K. E. Ramsey, R. Macbride, T. F. Moslow, and K. Westphal 1989. Relative sea level rise and subsidence in coastal Louisiana and the Gulf of Mexico. Coastal Geology Technical Report No. 3. Baton Rouge: Louisiana Geological Survey.

Rogers, B. D., and W. H. Herke 1985. Estuarine dependent fish and crustacean movements and weir management. Fourth Coastal Marsh and Estuary Management Symposium pp.201 -219

Siegel, and N. J. Castellan 1988. Nonparametric statistics for behavioral sciences. New York: McGraw-Hill, Inc., 2nd edition. 384 pp.

Steele, R. G. D., and J. H. Torrie. 1980. Principles and procedures of statistics: a biometrical approach. New York: McGraw-Hill, Inc. 633 pp.

Steyer, G. D., R. C. Raynie, D. L. Steller, D. Fuller, and E. Swensen 1995. Quality management plan for Coastal Wetlands Planning, Protection, and Restoration Act monitoring program. Open-file series no. 95-01. Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division.

United States Department of Agriculture, Soil Conservation Service 1995. Soil survey of Cameron Parish, Louisiana. Publication No. 1995!386!441/00020. Washington, D.C.: U.S. Government Printing Office. 135 pp, 122 maps. Scale 1:20,000.

United States Fish and Wildlife Service, Sabine National Wildlife Refuge 1999. Draft Environmental Assessment. Replacement of Water control structures at Hog Island Gully, West Cove Canal, and Headquarters Canal. Hackberry, Louisiana: Sabine National Wildlife Refuge.

Valentine, J. M. 1979. An evaluation of the proposed water control structures on water quality, vegetation, estuarine-dependent fisheries, and other wildlife-Appendix L. U.S. Fish and Wildlife Service.

Weaver, P., and M. M. Sheets 1962. Active Faults, subsidence, and foundation problems in the Houston Texas area. In *Geology of the Gulf Coast and Central Texas*. Houston, Tx.: Houston Geological Society. pp. 254-265.

_______ n. d. Salinity and water level data collected at Sabine National Wildlife Refuge. Unpublished report.