State of Louisiana
Department of Natural Resources
Coastal Restoration Division

Monitoring Plan

for

Naomi Outfall Management (BA-03c)
Barataria Bay Waterway East Side Shoreline Protection (BA-26)

State Project Number BA-03c and BA-26
Priority Project List 5 and 6

August 2003
Jefferson and Plaquemines Parishes

Prepared by:

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LDNR/Coastal Restoration and Management

MONITORING PLAN

NAOMI SIPHON OUTFALL MANAGEMENT PROJECT (BA-03C)
BARATARIA BAY WATERWAY EAST BANK PROTECTION PROJECT (BA-26)

ORIGINAL DATE: June 16, 1999
REVISED DATE: August 14, 2003

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. The recommendations for modifying this Monitoring Plan are the result of a joint meeting with DNR, USGS, and the federal sponsor and a subsequent decision to better-coordinate monitoring with the BA-04 project, which is a similar project, but without outfall management. Based on those reviews habitat mapping in 2008 and 2017 were changed to land:water analyses, and emergent vegetation and hydrologic sampling were extended through 2012. The additional costs required to increase monitoring will be funded through the BA-03 project, which is state funded. These changes have been incorporated into this revised Monitoring Plan in the Monitoring Elements section.

Project Description

The Naomi Siphon Outfall Management (BA-03C) and the Barataria Bay Waterway (BBW) East Bank Protection Project (BA-26) were approved on the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) Fifth and Sixth Priority Project Lists, respectively. Due to the close proximity of the projects and because both projects compliment and influence each other, they will be included in a unified monitoring plan as approved by the Planning and Evaluation Subcommittee on March 26, 1999. All references to "project area" will refer to the unified area composed of both originally proposed project areas.

The project area lies within the Barataria Basin in Jefferson and Plaquemines Parishes, Louisiana. The area is bordered by the BBW and the town of Lafitte on the west and the Mississippi River back protection levee and the community of Naomi on the east. The area extends to the south of the Pen and includes the Dupre Cut portion of the BBW (figure 1). The project area totals 27,135 ac (10,854 ha), of which 12,074 ac (4,830 ha) are open water and 15,061 ac (6,029 ha) are marsh. The project seeks to manage the freshwater from the Naomi Freshwater Diversion Project (BA-03); an 8-pipe

siphon that was implemented by the Louisiana Department of Natural Resources (LDNR) and Plaquemines Parish. The Naomi siphon has been in operation since February 3, 1993, and has provided an average of 997 cfs/month of freshwater from the Mississippi River to the area. Specifically, the function of the siphon was to protect the project area from continued saltwater intrusion and reduce wetland loss by restoring riverine inputs of freshwater and sediments to the marsh.

Historically, wetlands in this area were divided into large interdistributary basins by the natural levee ridges of former Mississippi River distributaries and were formed as a result of a low energy environment (Frazier 1967). The natural ridges and meandering paths of its major water courses protected the marshes from direct influences of salinity and tidal action occurring to the south in Barataria Bay. However, the abandoned delta complexes of the Mississippi River now often experience subsidence rates in excess of 1 cm/yr (Penland and Ramsey 1990). Between 1956 and 1990, a large portion of emergent wetland marsh was degraded and lost in the project area (Barras et al. 1994). The average rate of change from marsh to non-marsh (including loss to both open water and commercial development) has been relatively consistent since the 1930's. Marsh loss rates for the Barataria quadrangle were 1.08 mi^2/yr (2.80 km2/yr) between 1939 and 1956, 1.20 mi^2/yr (3.11 km^2/yr) between 1956 and 1974, 0.70 mi^2/yr (1.81 km^2/yr) between 1974 and 1983, and 1.06 mi^2/yr (2.75 km^2/yr) between 1983 and 1990 (Dunbar et al. 1992). Furthermore, due to a combination of natural processes such as subsidence and sea level rise and anthropogenic factors including canal dredging and levee construction, the area has undergone a series of changes (Craig et al. 1979; Scaife et al. 1983; Turner et al. 1983). Levee construction has had a dramatic impact on the general ecology of the marsh by altering the once uniform distribution of freshwater from the river into the marsh-estuary complexes (Bowman et al. 1995). The construction of the BBW may have caused tidal fluctuation and salinity levels to intensify in the project area (Reed 1995). Additionally, use of the waterway by commercial and recreational traffic has eroded contiguous shorelines to the extent that very little of the original spoil bank remains. Several sections of the east bank of the BBW have eroded into interior open water areas, creating a direct link between the waterway and interior marshes. These reasons contribute to Louisiana having the highest rate of land loss in the United States (Wells and Coleman 1987; Dunbar et al. 1992).

In 1949, O'Neil classified the entire project area as fresh marsh dominated by *Scirpus americanus* (three-cornered grass). However, a comparison of vegetation maps from 1968 (Chabreck et al.1968), 1978 (Chabreck and Linscombe 1978), and 1988 (Chabreck and Linscombe 1988) illustrates the persistent northward shift of all marsh types through those years in response to encroaching saltwater. By 1988, brackish marsh dominated by *Spartina patens* (marshhay cordgrass) and *Scirpus olneyi* (olney bulrush) occupied greater than half of the project area terrain that was formerly occupied by fresh and intermediate marsh communities in 1968. Preliminary field investigations performed in 1997 (Boshart 1999; United States Department of Agriculture [USDA] / Natural Resource Conservation Service [NRCS] 1998) indicated that the prevalent vegetative

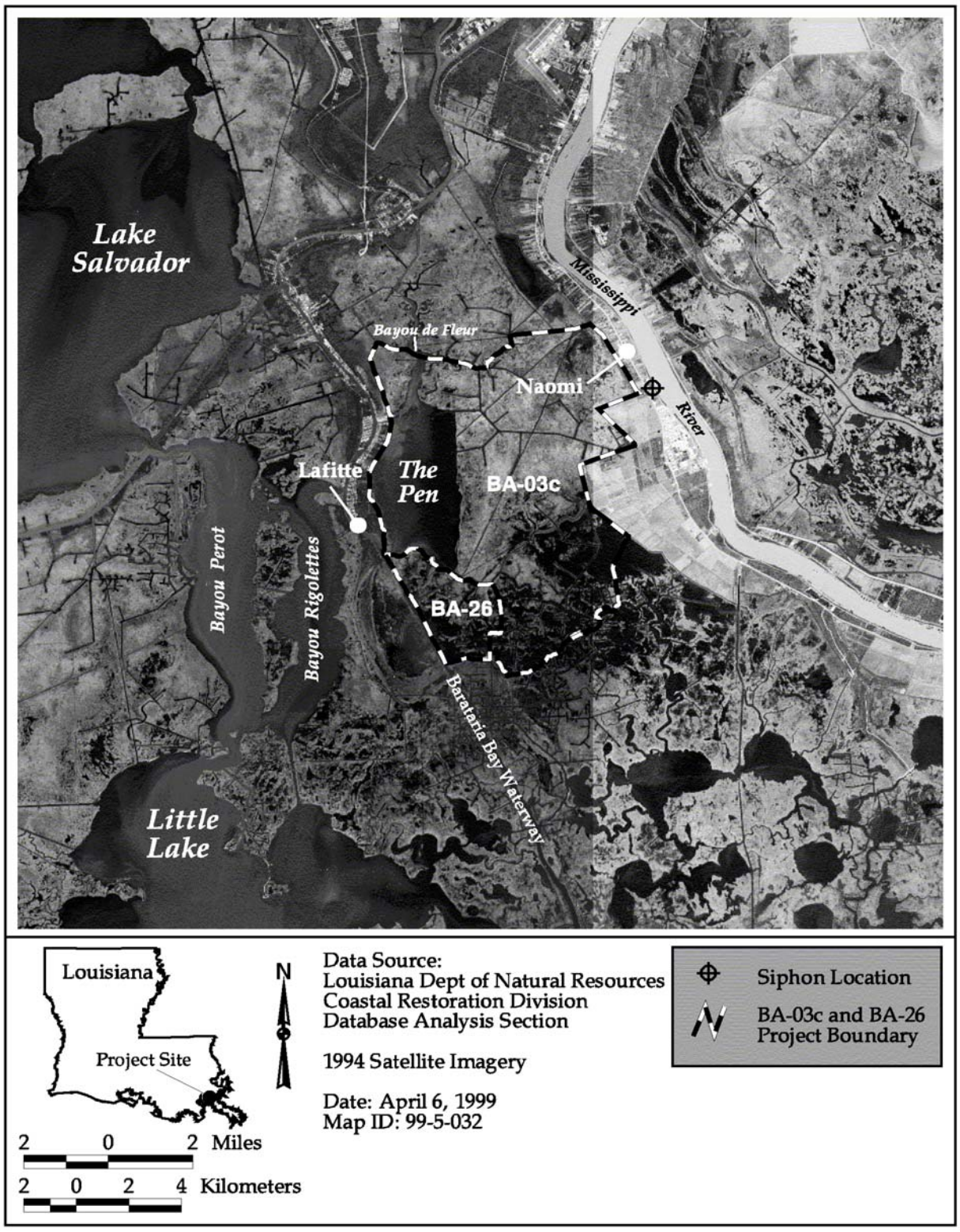

Figure 1. Location of the Naomi Outfall Management (BA-03C) and the Barataria Bay Waterway East Bank Protection (BA-26) project areas.

species recorded in the northern portion of the project area were *Sagittaria lancifolia* (bulltongue), *S. americanus*, *Polygonum* spp. (smartweed), and *Ludwigia leptocarpa* (false loosestrife), with traces of *Typha* spp. (cattail) and *Echinochloa walteri* (Walter's millet). The southern portion was dominated by *S. patens*. The vegetative community located south of Cheniere Traverse Bayou and Bayou Dupont was much more homogeneous and less diverse in 1997 than was the area historically, with *S. patens* composing greater than 70% of the emergent vegetation. Other major species common in the area included *Spartina alterniflora* (smooth cordgrass), *Juncus roemerianus* (black needlerush), and *Eleocharis* spp. (spikerush). The aquatic species recorded were *Eichhornia crassipes* (water hyacinth), *Ceratophyllum demersum* (coontail), *Salvinia rotundifolia* (salvinia), *Cabomba caroliniana* (fanwort), *Lemna minor* (duckweed), *Myriophyllum spicatum* (Eurasian water-milfoil), *Potamogeton* spp. (pondweed), *Najas guadalupensis* (southern naiad) and *Chara* spp. (muck-grass). The submerged aquatics occurred along the edges of ponds and broken marsh. Adjacent to the BBW, aquatic plants were absent presumably due to the increased exposure to wave energy and turbidity.

Soils in the project area consist largely of Allemands muck, Barbary muck, Kenner muck, the Lafitte-Clovelly association, Lafitte muck, Sharkey clay and Sharkey silty clay loam. These organic and mineral soils are generally found in brackish marshes with poor drainage and flooded conditions. Sharkey clay series are poorly drained, mineral soils in low areas on levees of the Mississippi River and its distributaries. Barbary muck was formed in clayey alluvium from the Mississippi River deposited in water and has never air-dried. Allemands muck was formed in moderately thick accumulations of decomposed herbaceous material with an underlying clayey alluvium. The Kenner and Lafitte mucks were formed in herbaceous plant material in freshwater marshes. The Lafitte organic soils occur in broad areas between natural streams and are characterized by a thick surface layer of semifluid saline muck and underlying material of semifluid, saline clay and silty clay loam. The Clovelly soils are characterized by a moderately thick surface layer of semifluid, saline muck with semifluid, saline clay as the underlying material and occur on submerged ridges along natural streams (SCS 1983 and NRCS 1998).

The primary purpose of the project is to manage the diverted freshwater from the Naomi siphon in the area via the installation of two water control structures designed to reduce freshwater loss and saltwater intrusion. Additionally, the east bank of the BBW will be rebuilt to protect the adjacent marsh from erosion due to boat wakes and saltwater intrusion. Furthermore, the rebuilt east bank of the waterway will help retain the freshwater that will enter the area from the Naomi siphon located to the North of the project area. Specifically, the following project features were constructed:

1) A fixed crested weir with a boat bay was installed in Goose Bayou at its intersection with the Pen, which is adjacent to Cochiara's Marina east of the LA Highway 45 bridge crossing. The wingwalls of the structure were tied into the protection levee on the south and the rock breakwaters on the north. The canal, at the time planning surveys was approximately 415 feet (127 m) wide and 11.1 feet (3.4 m) deep at mid-channel. The material for the construction will be either steel sheetpiling, rock riprap, or a combination of both depending on costs and geotechnical investigations. The weir included a boat bay at mid-section (i.e.,

centerline of channel) with a minimum crest width of 20 feet (6.1 m) and a depth of 6 feet (1.8 m) below mean low tide conditions (figure 2).

2) A fixed crested weir with a boat bay was installed in the Bayou Dupont Canal immediately east of the pipeline crossing near the canal's intersection with BBW. The canal, at the time planning surveys were conducted (NRCS 1997) was approximately 200 feet (61 m) wide and 17.8 feet (5.4 m) deep at mid-channel. The material for the construction will be either steel sheetpiling, rock riprap, or a combination of both depending on costs and geotechnical investigation. The weir included a boat bay at mid-section (i.e., centerline of channel) with a minimum crest width of 20 feet (6.1 m) and a depth of 6 feet (1.8 m) below mean low tide conditions (figure 2).

3) Approximately 17,600 linear feet (5366 m) of foreshore rock dike was installed along the east bank of the BBW (figure 2). This structure was constructed to the same dimensions (i.e., same top width and side slopes) as the dikes installed on the west side of the BBW for theBarataria Bay Waterway West Bank Protection (BA-23) Project (LDNR 1998). To provide additional foundation support to reduce dike settlement, geotextile fabric was placed between the rocks and channel bottom.

Project Objective

1. Manage the diverted freshwater from the Naomi siphon in the project area via the installation of two water control structures designed to reduce freshwater loss and saltwater intrusion and by rebuilding the east bank of the BBW to protect the adjacent marsh from erosion due to boat wakes and saltwater intrusion.

Specific Goals

The following measurable goals were established to evaluate project effectiveness:

1. Reduce the rate of conversion of marsh to open water in project area.

2. Increase relative abundance of intermediate to fresh marsh type plant species.

3. Decrease mean project area salinity.

Reference Area

The importance of using appropriate reference areas cannot be over emphasized. Monitoring on both project and reference areas provides a means to achieve statistically valid comparisons, and is

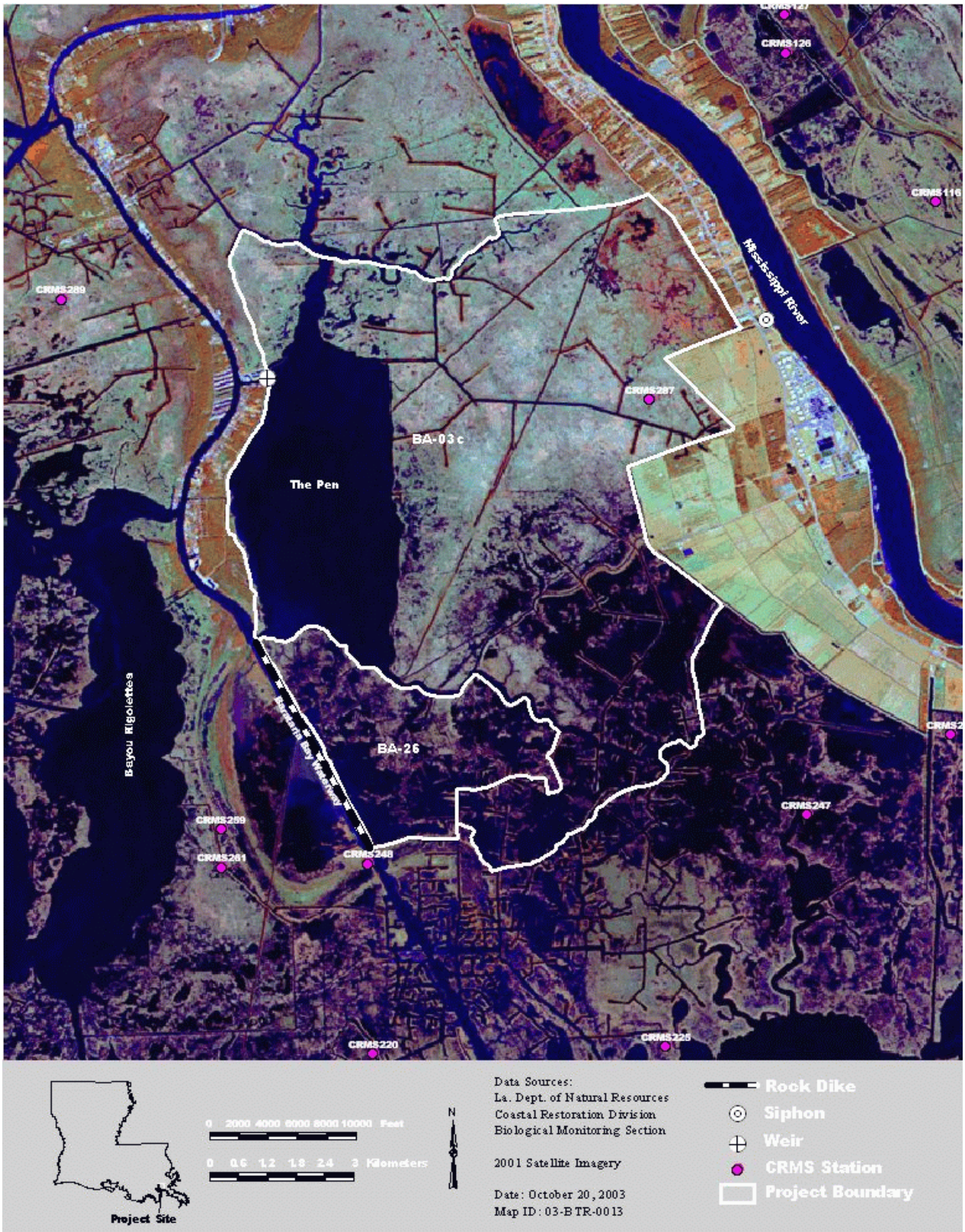

Figure 2. Naomi Outfall Management (BA-03C) and Barataria Bay Waterway East Bank Protection (BA-26) project features.

therefore the most effective means of assessing project effectiveness. Various locations were evaluated for their potential use as a reference area that best mimics the preconstruction conditions of the project area. The evaluation of sites was based on the criteria that both project and reference areas have similar vegetation community, soil, hydrology, or salinity characteristics. Areas to the north, south, and west of the project were not suitable due to impacts by future coastal restoration projects and/or dissimilar vegetation community, soil, hydrology, or salinity characteristics. For these reasons no proximate reference area will be use. However, 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 Limitations

Due to the relatively low construction costs for the original BA-03C project, the total monitoring budget was limited. The monitoring budget cannot exceed 50% of total fully funded project cost. Also, the original BA-26 project was classified as a shoreline protection project and as such has limited funding with which to evaluate an area that would have been more accurately defined as a hydrologic restoration. Thus, the combined project is one of the least funded hydrologic restorations currently planned. As a result, the amount of hydrologic monitoring which could be conducted on this project is limited to the first 10 years of the project life. However, monitoring of this (outfall management) project was extended by funds from the state-funded BA-03 project.

Monitoring Elements

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

1. Habitat Mapping — To document marsh to open water ratio and marsh loss rates, color-infrared aerial photography (1:12,000 scale, with ground control markers) will be obtained by the National Wetlands Research Center (NWRC) for the project area. The photography will be georectified, photo interpreted, mapped, ground-truthed, and analyzed with Geographic Information Systems (GIS) by NWRC personnel using techniques described in Steyer et al. (1995). Photography was obtained prior to construction in 2000, and post-construction photography will be obtained in 2009 and 2017; however, only land:water analyses will be conducted and vegetation data will be used to characterize habitat.

2. Vegetation — Species composition and relative abundance will be evaluated inside the project area using techniques described in Steyer et al. (1995).

More specifically, a modification of the Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974) will be utilized. **Forty plots ($4m^2$) were established in the project area and sampled in 1997 and 2000 pre-construction (figure 3). The first post-construction survey was completed in 2003, and vegetation will be surveyed again 2006, 2009, and 2012. Emergent vegetation will be supplemented by data from CRMS-287 and Chabreck and Linscombe vegetation surveys.**

3. Salinity

Salinity will be measured monthly at 24 stations and hourly with continuous recorders at three stations inside the project area (figure 4) using techniques described in Steyer et al. (1995). Mean salinity prior to construction will be statistically compared to mean salinity after construction within the project area. Data will be used to characterize the spatial and temporal variation in salinity throughout the project area. Salinity data will be collected every year from 1999-**2012**.

4. Water level

While not a goal of the project, water level will be monitored to ensure that no negative impact to vegetation results from flooding caused by the siphon structure. To monitor water level, three (3) continuous recorders and seven (7) staff gauges set to the North American Vertical Datum (NAVD) and measured monthly were established in the project area (figure 5). Frequency and duration of flooding prior to construction will be compared statistically to frequency and duration of flooding after construction. Data will also be used to characterize the spatial and temporal variation in water level throughout the project area. Water level data will be collected every year from 1999-**2012** at the **at the same stations as those for salinity.**

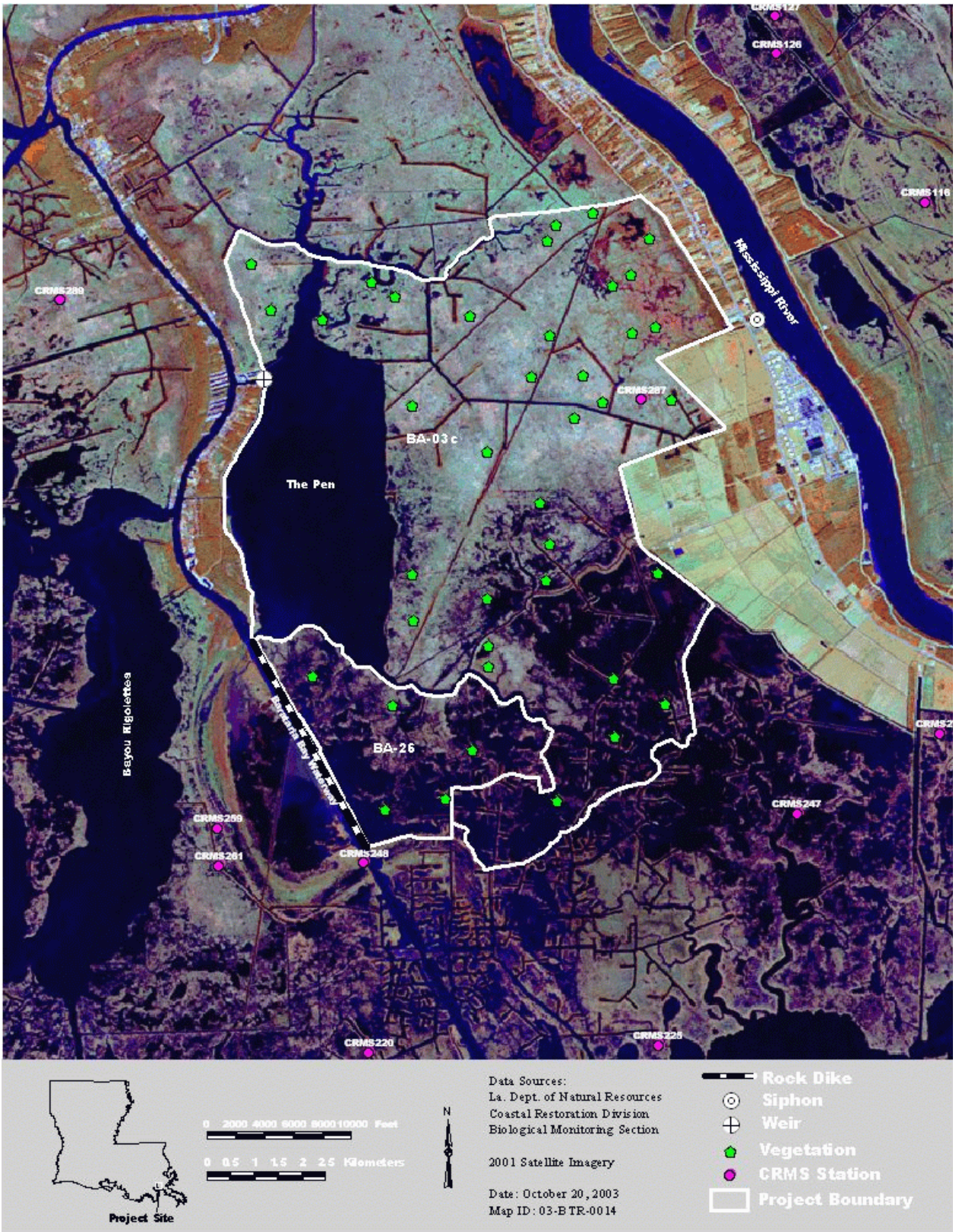

Figure 3. Location of Naomi Outfall Management (BA-3C) and Barataria Bay Waterway East Bank Protection (BA-26) vegetation sampling stations.

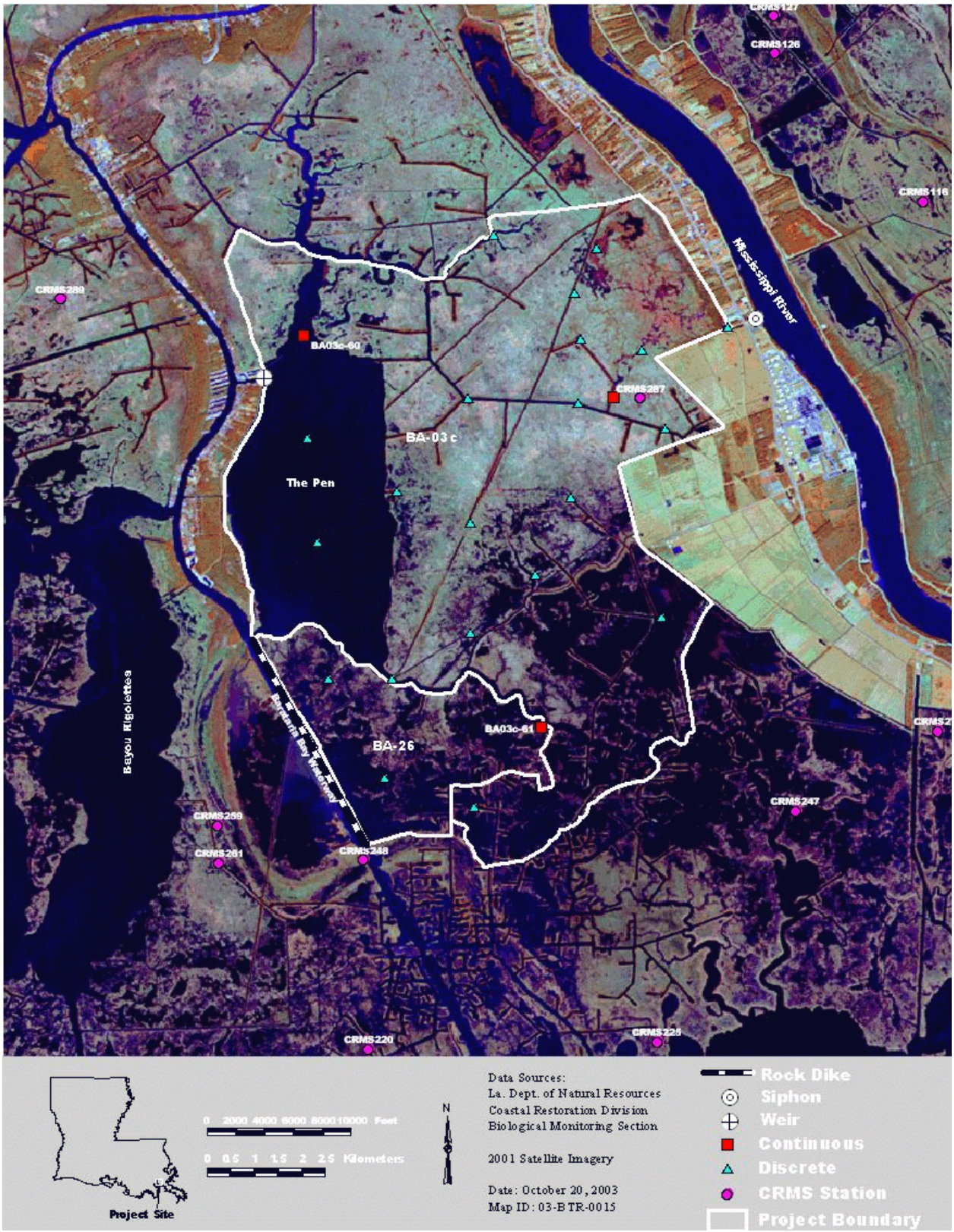

Figure 4. Location of Naomi Outfall Management (BA-03C) and Barataria Bay Waterway East Bank Protection (BA-26) salinity and continuous recorder sampling stations.

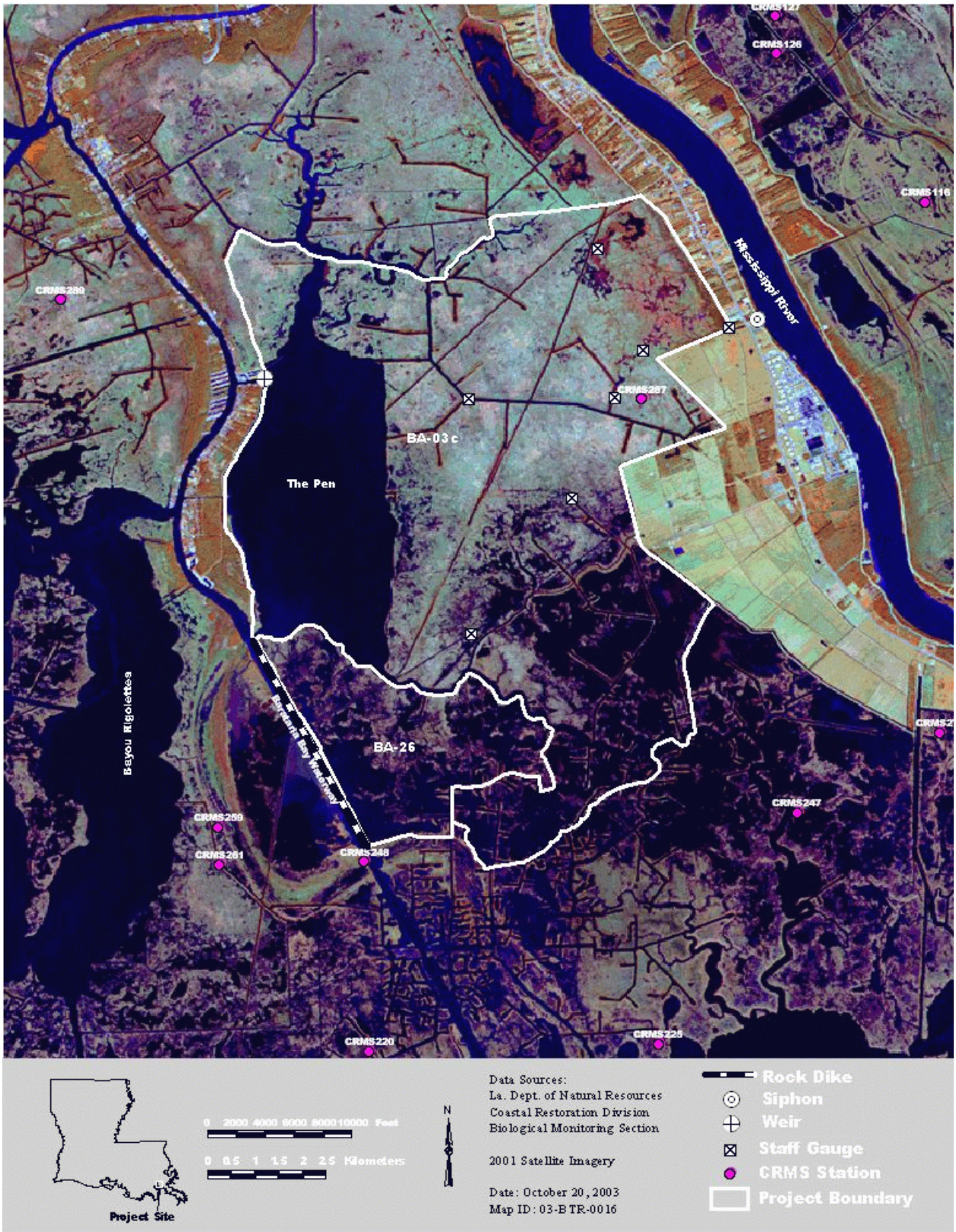

Figure 5. Location of Naomi Outfall Management (BA-03C) and Barataria Bay Waterway East Bank Protection (BA-26) water level staff gauges.

Anticipated Statistical Analyses and Hypotheses

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 from color-infrared aerial photography collected pre- and post-construction will be used to evaluate marsh to open water ratios and changes in the rate of marsh loss/gain in the project area. With available historic information available in digitized format from years 1956, 1978, 1988, and 1993 to use in comparison, regression analyses will be conducted to test for changes in slope between pre- and post-construction conditions.

   Goal: Reduce the rate of conversion of marsh to open water within the project area.

2. The primary method of analysis will be to determine differences in relative abundance of vegetation as evaluated by an ANOVA that will consider both spatial and temporal variation and interaction. The ANOVA approach may include terms in the model to adjust for station locations, proximity to structures, and seasonal fluctuations. Ancillary data (i.e., herbivory, historical) will be included as covariables when available. This additional information may be evaluated through analysis such as correlation, trend, multiple comparisons, and interval estimation.

   Goal: Increase relative abundance of intermediate to fresh marsh type plant species.

   Hypothesis:

   H_o: After project implementation at year i, mean relative abundance of target vegetation will be significantly less than before project implementation.

   H_a: After project implementation at year i, mean relative abundance of target vegetation will not be significantly less than before project implementation.

   If we fail to reject the null hypothesis, any possible negative effects will be investigated.

3. The primary method of analysis will be to determine differences in mean salinity as evaluated by an analysis of variance (ANOVA) that will consider both spatial and temporal variation and their interaction. The ANOVA approach may include terms in the model to adjust for station locations, proximity to structures, and seasonal fluctuations. Apart form the comparison between pre and post construction of the project area, region-wise study of salinity within the project area will be performed. The project area will be divided into two subregions. Subregion 1 will be the northern portion of the project area and is primarily composed of fresh/intermediate marsh. Subregion 2 will be the southern portion of the project area that is primarily brackish marsh. Mean salinity will be compared between the

two subregions as well as between pre and post construction. Since salinity level at a particular station can vary depending on the discharge level (major discharge, minor discharge and noflow), multivariate statistical techniques will be used in analyzing the data (using three discharge levels as a three dimensional profile of a station). For the six new proposed salinity stations pre-construction and/or historical data may not be available; hence "missing observations techniques" will be applied to analyze data sets. Historic data available from Louisiana Department of Health and Hospitals (LDHH) and U.S. Army Corps of Engineers (USACE) (as well as from any other available sources) will be used to augment those data collected by LDNR for use as pre-construction data. Ancillary data (i.e., precipitation, historical) will be included as co-variables when available. This additional information may be evaluated through analysis such as correlation, trend, multiple comparisons, and interval estimation. Exploratory data analysis will be used to determine an appropriate variable for hypothesis testing (e.g. daily, weekly intervals).

Goal: Decrease mean project area salinity.

Hypothesis:

H_o: After project implementation at year i, mean salinity will not be significantly less than before project implementation.

H_a: After project implementation at year i, mean salinity will be significantly less than before project implementation.

If we fail to reject the null hypothesis, any possible negative effects will be investigated.

NOTE: Available ecological data, including both descriptive and quantitative data, will be evaluated in concert with the above analysis to aid in determination of the overall project effectiveness. This includes ancillary data collected in the monitoring project but not used directly in statistical analysis, as well as data available from other sources (NRCS, USACE, USFWS, USGS, LSU, LDNR, etc.)

Notes

1.	Implementation:	Start Construction:	October 01, 1999
		End Construction:	August 15, 2002
2.	NRCS Point of Contact:	Richard Abshire	(337) 291-3064
	NWRC Point of Contact:	Bill Jones	(337) 266-8581
3.	DNR Project Manager:	George Boddie	(504) 280-4067
	DNR Monitoring Manager:	Bill Boshart	(225) 280-4063

4. Although the monitoring plans have been combined the budgets will remain separate. The twenty year monitoring plan development and implementation budget for BA-03C is $589,170.00 and for BA-26 is $78,790.00. Pursuant to the CRMS review, it was authorized by the Task Force to maintain $436,918 with the BA-03c project and the entire $78,790 withthe BA-26 project, and utilize $152,252 from the BA-03c project to support CRMS. Progress reports will be available in 2000 and 2002. Comprehensive reports on coastal restoration efforts in the Bataria 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. The Louisiana Department of Natural Resources/Coastal Restoration Division has collected data in this area since 1992 as part of its routine monitoring for the Naomi Freshwater Diversion Project (BA-03). Water level, salinity, temperature and some limited vegetation data are available.

6. Water level will be evaluated using the same method as that of salinity.

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