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Department of Natural Resources
Coastal Restoration Division and
Coastal Engineering Division

2004 Operations, Maintenance, and Monitoring Report

for

Black Bayou Hydrologic Restoration

State Project Number CS-27
Priority Project List 2

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Calcasieu and Cameron Parishes

Prepared by:

David Castellanos, Biological Monitoring Section (CRD)
and
Herb Juneau, P.E., Field Engineering Section (CED)
LDNR/Coastal Restoration and Management
Lafayette Field Office
635 Cajundome Boulevard
Lafayette, LA 70506

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I. Introduction

The Black Bayou Hydrologic Restoration Project (CS-27) is located approximately 18 miles (29 km) west-northwest of Hackberry, Louisiana in northwest Cameron and southwest Calcasieu Parish. The project is bordered to the north by the Gulf Intracoastal Waterway (GIWW), to the south by Black Bayou, to the east by Gum Cove Ridge, and to the west by the Sabine River (figure 1). Total project area is approximately 25,529 acres (10,336 ha) and is comprised of approximately 6,516 acres (2,638 ha) of fresh/intermediate marsh, 7,353 acres (2,977 ha) of brackish marsh, and 11,660 acres (4,721 ha) of open water. Fresh/intermediate marshes are dominated by *Juncus roemerianus* (black needlerush), *Phragmites australis* (common reed), *Schoenoplectus californicus* (california bullwhip), *Schoenoplectus robustus* (leafy three-square), *Spartina patens* (marshhay cordgrass), and *Typha sp.* (cattail). Brackish marshes are dominated by *J. roemerianus*, *P. australis*, *Schoenoplectus americanus* (three-corner grass), *S. robustus*, *S. patens*, and *Typha sp*..

Beginning in the late 1800's significant hydrologic changes effecting water level fluctuation and water circulation patterns occurred in the project area. Modifications to Calcasieu Pass such as the removal of the Calcasieu Pass oyster reef, in 1876, increased the magnitude and duration of tidal fluctuations in both the lake and the surrounding marshes. Construction of the GIWW, North Line Canal, Central Line Canal, and South Line Canal established a hydrological connection between the Calcasieu and Sabine basins, allowing the saline waters of the Calcasieu Basin to encroach on the Sabine Basin. Water level fluctuations are also influenced by wind. A strong north wind can cause drastic de-watering of the marshes, while a strong sustained southerly wind can result in drastic increases in water levels blown in from the gulf. The extensive system of navigation channels, natural drainage, bayous, oil exploration canals, and trenasses, have allowed increased water fluctuations and salinities to reach the interior of the marsh.

Marsh types and the associated vegetation in and around the project area also indicate that salinities have been increasing for the last 45 years. All of the project area was classified as fresh or low salinity (intermediate) marsh in 1949, except for the area adjacent to Sabine Lake and Sabine River just north of Black Bayou where brackish marsh conditions existed. Brackish marsh conditions in this area expanded north to the GIWW and eastward along Black Bayou to the Black Bayou Oil Field by 1968. By 1988, the majority of the project area was identified as brackish marsh with fresh marsh found only in the extreme northeast corner of the project area adjacent to the Gum Cove Ridge.

The Black Bayou Hydrologic Restoration Project includes structural and non-structural measures designed to allow freshwater from the GIWW near its confluence with the Vinton Drainage Canal into the wetlands south of the GIWW between the Sabine River, Gum Cove Ridge, and Black Bayou, and to create a hydrologic head that increases freshwater retention time and reduces salt water intrusion and tidal action in the Black Bayou watershed (figure 1).

Black Bayou structural features construction was completed in November 2001. Structural and non-structural features and their intended functions are listed below:

1. Breaches in the GIWW spoil bank west of the Gum Cove Ridge were repaired with approximately 22,600 linear ft. (6,889 m) of rock foreshore dikes.

2. A weir with a barge bay, 70 ft wide, with a sill of -7.0 ft North American Vertical Datum 1988 (NAVD88), made of graded stone was constructed at the GIWW in the Black Bayou Cut Off Canal to limit water exchange in and out of the project area.

3. A weir with a boat bay, 15 ft wide with a sill of -4.0 ft NAVD88, made of graded stone was constructed in the Burton Canal at its intersection with the Sabine River to limit water exchange in and out of the project area.

4. A rock weir with a 15 ft. (4.6 m) boat bay at -3 ft. (-0.9 m) NAVD88 bottom elevation was constructed at the intersection of Block's Creek with Black Bayou to limit water exchange in and out of the project area.

5. A self-regulating tide gate, within a sheetpile weir, 40 ft wide with a sill at +0.6 ft NAVD88 to limit flow into the impounded area during high water events was constructed where it connects to an existing canal that leads to Black Bayou Cutoff Canal.

6. Vegetative plantings of approximately 161, 496 linear ft. (49,224 m) of bullwhip, *Schoenoplectus californicus*. Approximately 32,000 plants in one gallon trade containers with a minimum of 5 stems per container were installed on 5 ft. (1.5 m) centers.

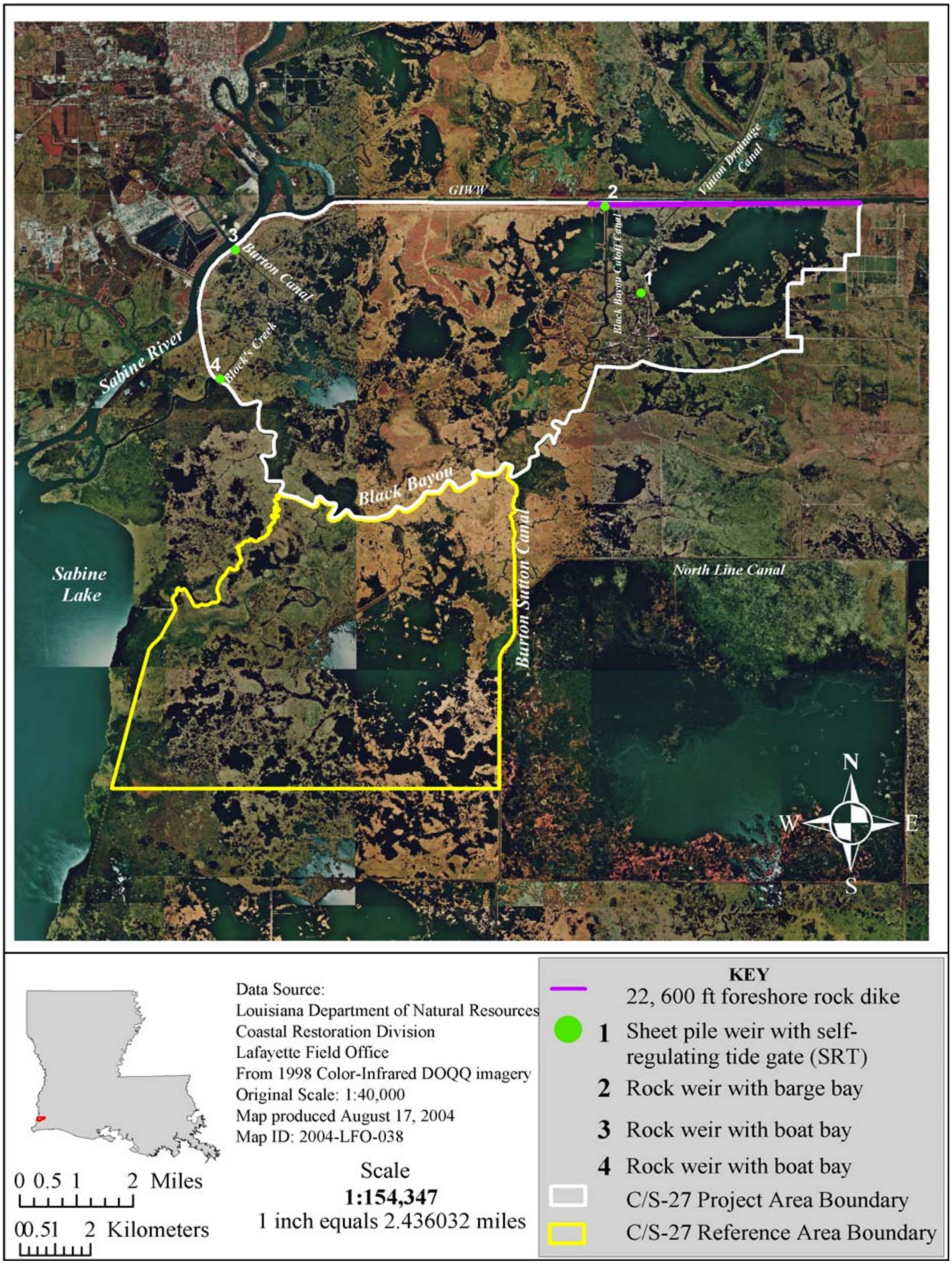


Figure 1. Black Bayou project and reference boundaries and project infrastructure.

Maintenance Activity

a. Project Feature Inspection Procedures

Since the project was still in construction, no O&M Inspection was performed in calendar year 2003/2004.

b. Inspection Results

N/A

II. Maintenance Activity (continued)

c. Maintenance Recommendations

i. Immediate/ Emergency Repairs

N/A

ii. Programmatic/ Routine Repairs

N/A

III. Operation Activity

a. Operation Plan

There are no active operations associated with this project.

b. Actual Operations

There are no active operations associated with this project.

IV. Monitoring Activity

a. Monitoring Goals

The objectives of the Black Bayou Hydrologic Restoration project are:

1. Increase freshwater retention that reduces salt water intrusion in the project area wetlands.

2. Establish emergent wetland vegetation in shallow open water areas.

3. Protect emergent marsh in project area by reducing erosion along GIWW.

4. Increase occurrence of SAV in project area.

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

1. Reduce mean salinities within the project area.

2. Increase the land to water ratio within the project area.

3. Reduce mean erosion rate of protected shoreline along GIWW.

4. Increase SAV in interior ponds within the project area.

b. Monitoring Elements

Aerial Photography:
Near-vertical color-infrared aerial photography (1:24,000 scale) was used to measure vegetated and non-vegetated areas for the project and reference areas. The photography was obtained in 2000 prior to project construction and will be obtained in 2004, 2009, and 2016 following construction. The original photography was checked for flight accuracy, color correctness, and clarity and was subsequently archived. Aerial photography was scanned, mosaicked, and georectified by USGS/NWRC personnel according to standard operating procedures.

Salinity:
Salinity was monitored at least monthly at permanent discrete sampling stations within the project and reference areas (figure 2). Salinity data were used to characterize the spatial variation in salinity throughout the project area, and to determine if project area mean salinity was reduced. Discrete salinities were monitored from June 1999 (preconstruction) through March 2004 (post construction). Hourly salinity and water levels were monitored with two

continuous recorders. The continuous recorders and adjacent staff gauges were surveyed relative to NAVD88.

Vegetation Plantings:

The species composition and relative abundance of all plant species and the percent survival of vegetative plantings were determined after one growing season post construction in 2003 in approximately 3% of the vegetation plantings (53 sampling plots) (figure 3). Each sampling plot consisted of 16 plantings, from one row with the sampling location determined by a random numbers table and marked with a labeled post. The sampling plots were divided proportionately among the areas containing vegetative plantings. Planting survival was determined as a percentage of the number of live plants to the number initially planted (percent survival = no. plants/no. planted x 100).

Shoreline Change:

To document shoreline movement along the southern shoreline of the GIWW, differential global positioning system (DGPS) surveys of unobstructed sections of the shoreline were conducted at the vegetative edge (figure 4). Surveys were conducted in 2000 (preconstruction), and 2002, and one more is planned for 2004. DGPS shoreline positions were mapped and used to measure shoreline change. No further shoreline surveys are planned after 2004.

Submersed Aquatic Vegetation:

To document changes in the frequency of occurrence of SAV, three transects per sample area (1-6) and three transects in the reference area were monitored using the modified rake method (figure 5). Transects were established in open water areas in each area and separated by an equal distance. Each transect had a minimum of 25 equally spaced sampling stations. At each station, aquatic vegetation was sampled by dragging a garden rake on the pond bottom for one second. The presence of vegetation was recorded to determine the frequency of aquatic plant occurrence (frequency = number of occurrences/25 x 100). When vegetation was present, the species present was recorded in order to determine the frequencies of individual species. SAV was monitored in October 1999 preceding construction, and post-construction in October 2003. Monitoring will continue in October of years 2005, 2007, 2010, 2012, 2014, 2017.

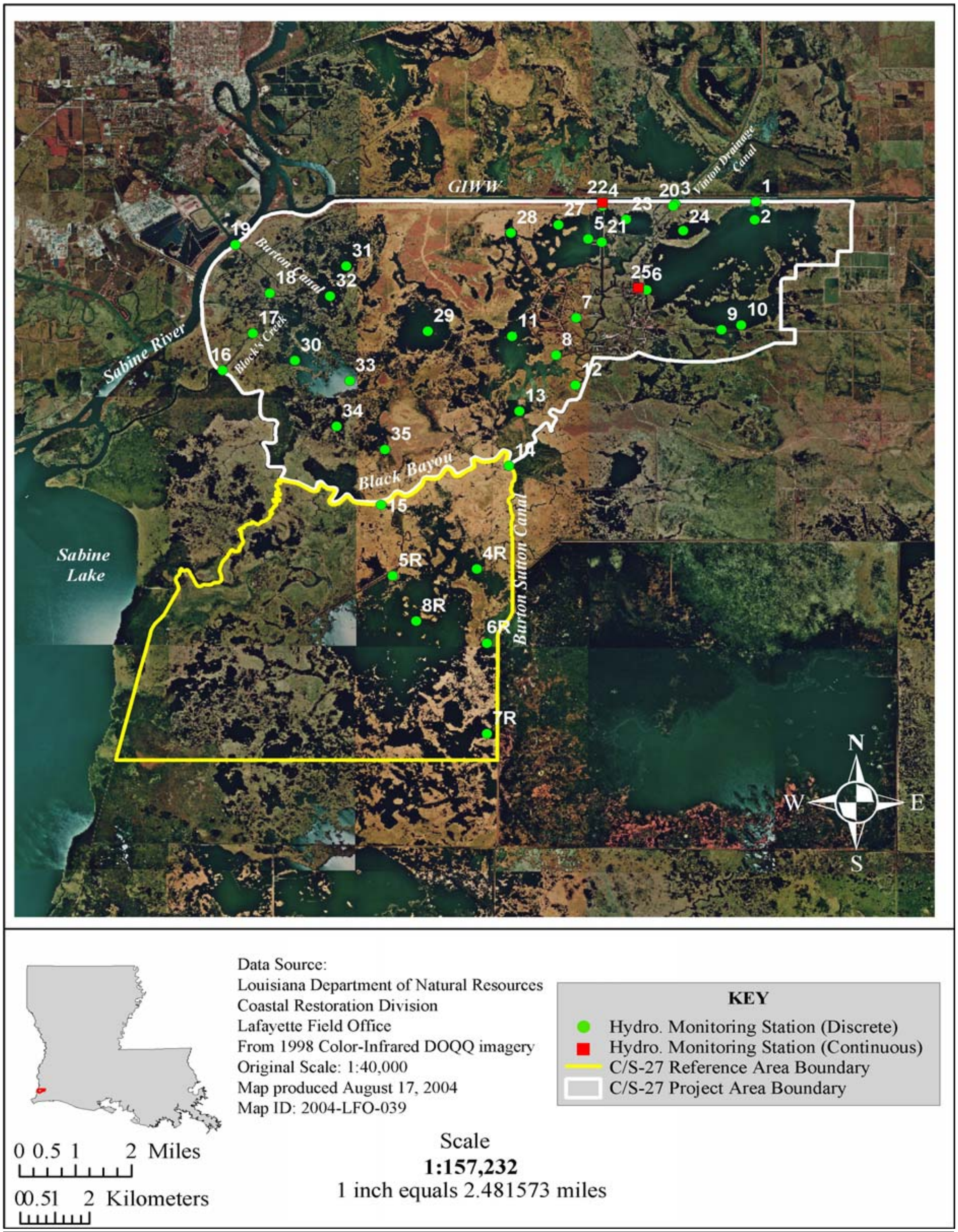


Figure 2. Black Bayou project and reference discrete (green circles) and continuous recorder station locations (red squares).

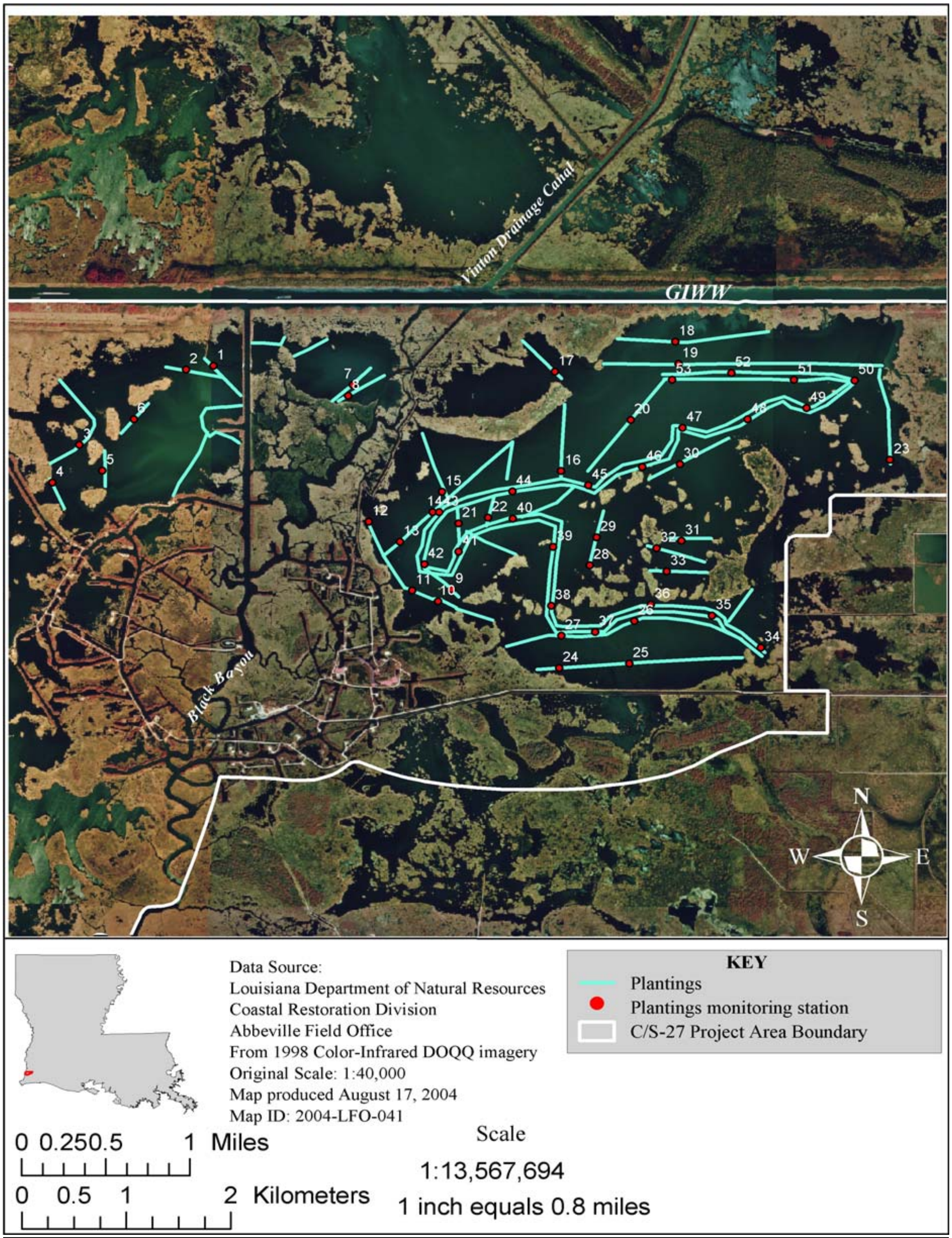


Figure 3. Black Bayou (CS-27) planting locations with monitoring sample locations.

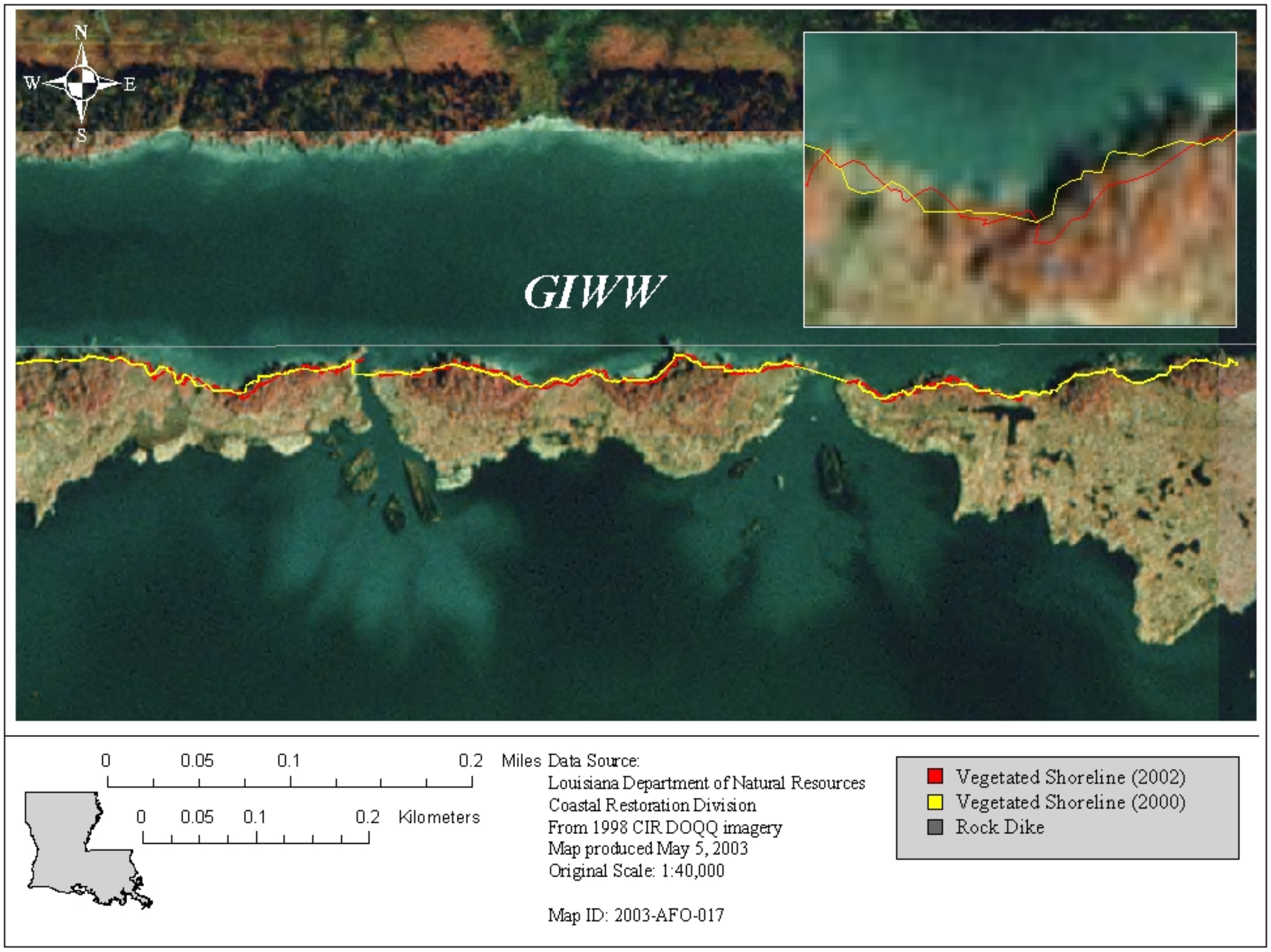


Figure 4. GPS surveys preconstruction (2000) and immediately postconstruction 2002 at the project section of GIWW bank. Picture inset shows a magnified view of the survey tracks.

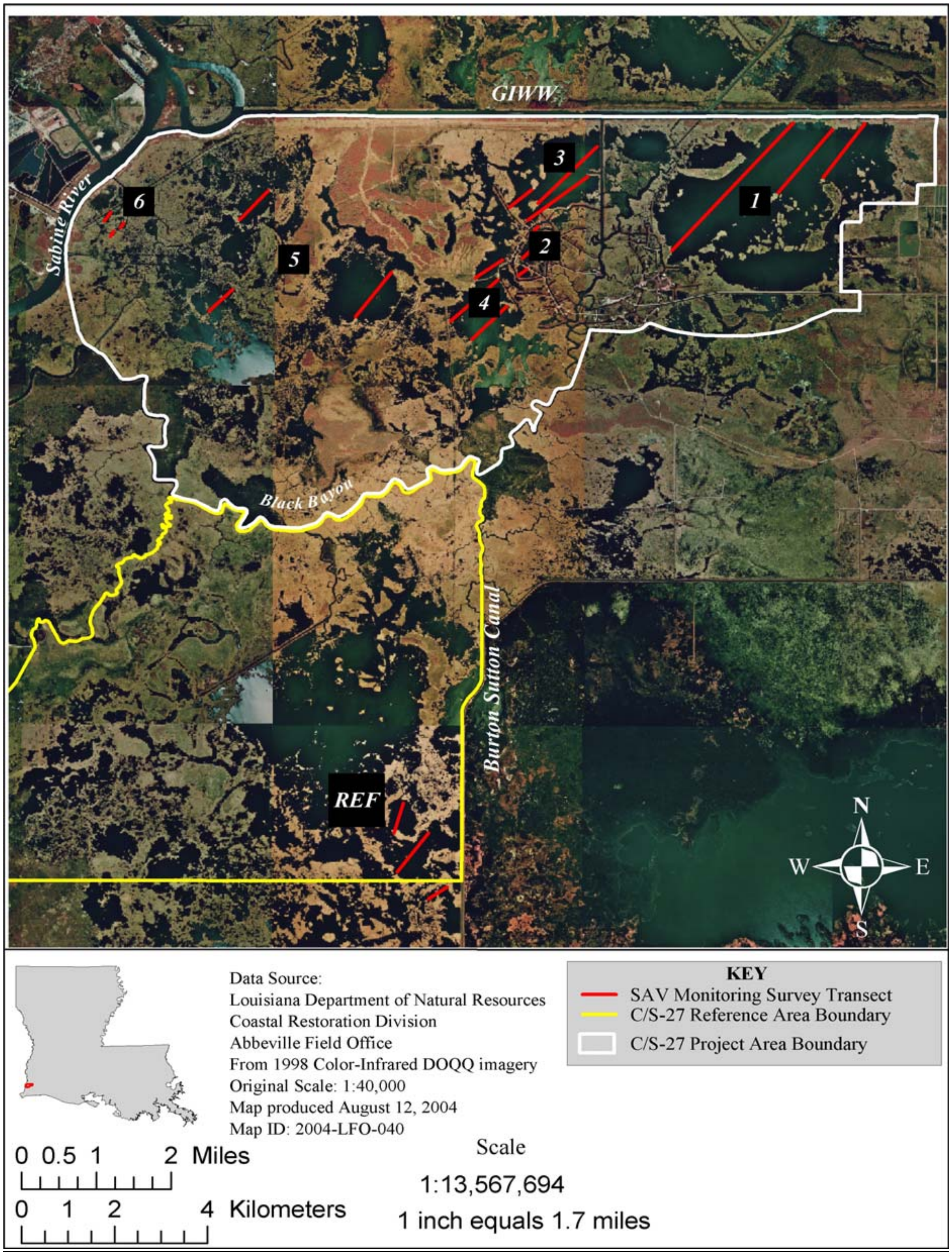


Figure 5. Location of SAV sampling in the project and reference areas.

IV. Monitoring Activity (continued)

c. Preliminary Monitoring Results and Discussion

Aerial Photography:

Aerial photography was acquired before construction in November 2000, and the area will be photographed again in 2004. The available photography and land water analysis is a preconstruction baseline for year 2000 (figure 6). The project area was 58 % land and 42 % water, and the reference area was 56 % land and 44 % water. Later photography, beginning in 2004 will be compared to the 2000 data to determine land loss or gain.

Salinity:

Hourly water level and salinity data have been collected at the following hydrologic data stations (figure 2).

Station	Period of data collection
CS27-22	May 2000 – March 2004
CS27-25	May 2000 – present
All Discrete Stations	June 1999 – March 2004

Discrete data show that salinities across the area are very similar with the lowest values in the impounded hydrologic unit (figure 7). The other areas that include stations that are actually within the project structures (Int east, Int west) also had a lower average salinity. The greatest difference was about 1ppt. Inference from this small and inconsistent data set however, should be conservative. Despite some missing data due to equipment malfunctions, continuous recorder data does provide some information. Salinities at station CS27-25, located within the impounded unit behind the self regulated tide gate track those at CS27-22, but high salinities spikes appear muted (figures 8a and b). In February, May, and July, salinity spike maximums are up to 1ppt lower at CS27-25 than CS27-22. Incidences of higher salinity values in August (10 ppt) and September (13 ppt) at CS27-22 occurred during a period of missing data at CS27-25 and no comparison can be made. The salinity charts in the 2002 summary data and graphics report also show a difference during high salinity events. Salinity in the rest of the project area that is not impounded is not measured with continuous recorders and thus comparison to the two other continuous data sets was not meaningful. Salinity means were not calculated because the periods of missing data are at different times for each station and the results would not be representative or comparable. Water levels were typically lower in the hydrologic unit compared to those at CS27-22 at the GIWW / Black Bayou Cutoff intersection (figures 8a and b).

Vegetation plantings:

Schoenoplectus californicus (bullwhip) plantings were installed in 2002. Monitoring was conducted in September approximately 1 year after planting. Sample plots had varying survival success. Individuals were recorded as alive, absent, or dead. Except for a few, most plants counted as absent or dead were absent. A total of 53 plots containing 848 plants were sampled. The mean percentage found alive was 68%, the maximum was 100%, and the least amount found alive in a plot was 6%. Some plots had robust, healthy plants almost indistinguishable, whereas, other plots had plants with few stems in deteriorated condition (figures 9 and 10).

Shoreline change:

A DGPS survey of a portion of the GIWW shoreline within the project boundary was conducted preconstruction (2000) and in spring 2002 after the rock dike feature was constructed. The reference area for this monitoring element was compromised because of another rock dike construction and therefore no meaningful comparisons can be made between project and reference. The GPS system we used is considered to have submeter accuracy. This means that each physical point should be within 3ft of the corresponding point on the map. An areal analysis of loss / gain was not conducted, but linear gains and losses as measured roughly in ArcMap were as much as 17ft and 27ft respectively (figure 4).

SAV:

SAV was sampled in many open water areas throughout the project and reference areas (figure 5). Total SAV coverage was very high in most of the ponds sampled preconstruction in 1999 (100% in three areas) and has remained high in the years between sampling (Castellanos, per. obs.) (figure 11). In 2003, when the first postconstruction monitoring was conducted, average percent cover was about 90% for nearly all areas (figure 11). The species collected at both sampling times were very similar, but the percent cover of each did change in some areas over time (figures 12 and 13). Overall, there was a decrease in *Myriophyllum spicatum*, *Ruppia maritima*, and *Najas guadalupensis*, with the notable exception of increase of *M. spicatum* in areas 1 and reference. We also documented *Chara sp*., *Nymphaea odorata*, and *Ottelia alismoides* for the first time in 2003.

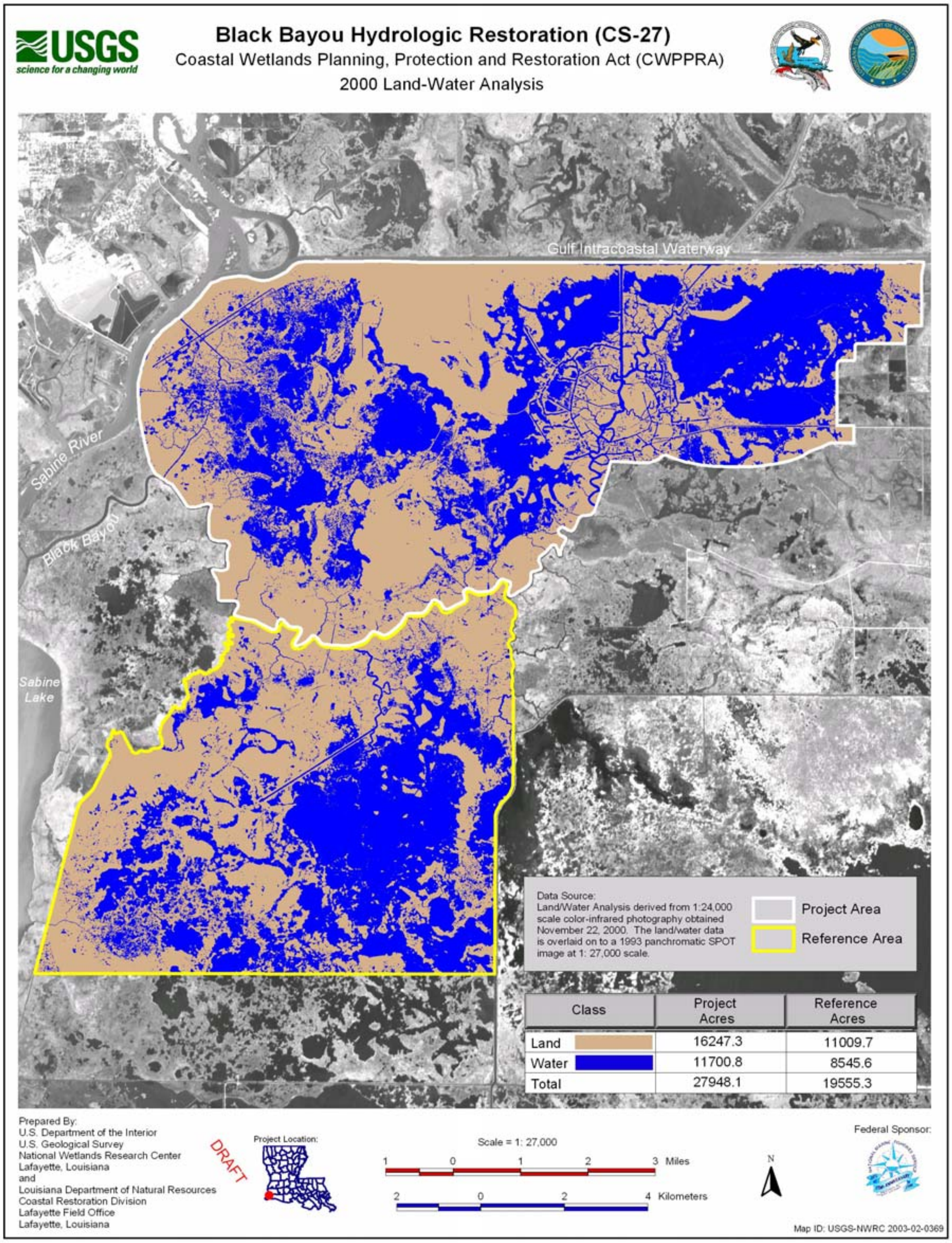


Figure 6. Preconstruction land / water analysis of project and reference areas from photography taken November 20, 2000**.**

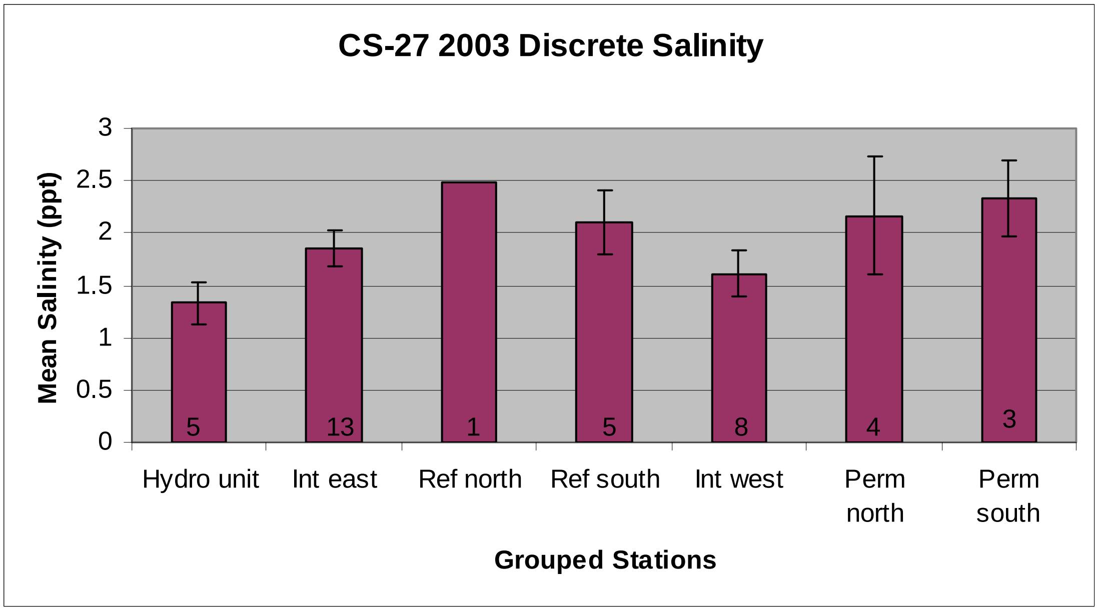
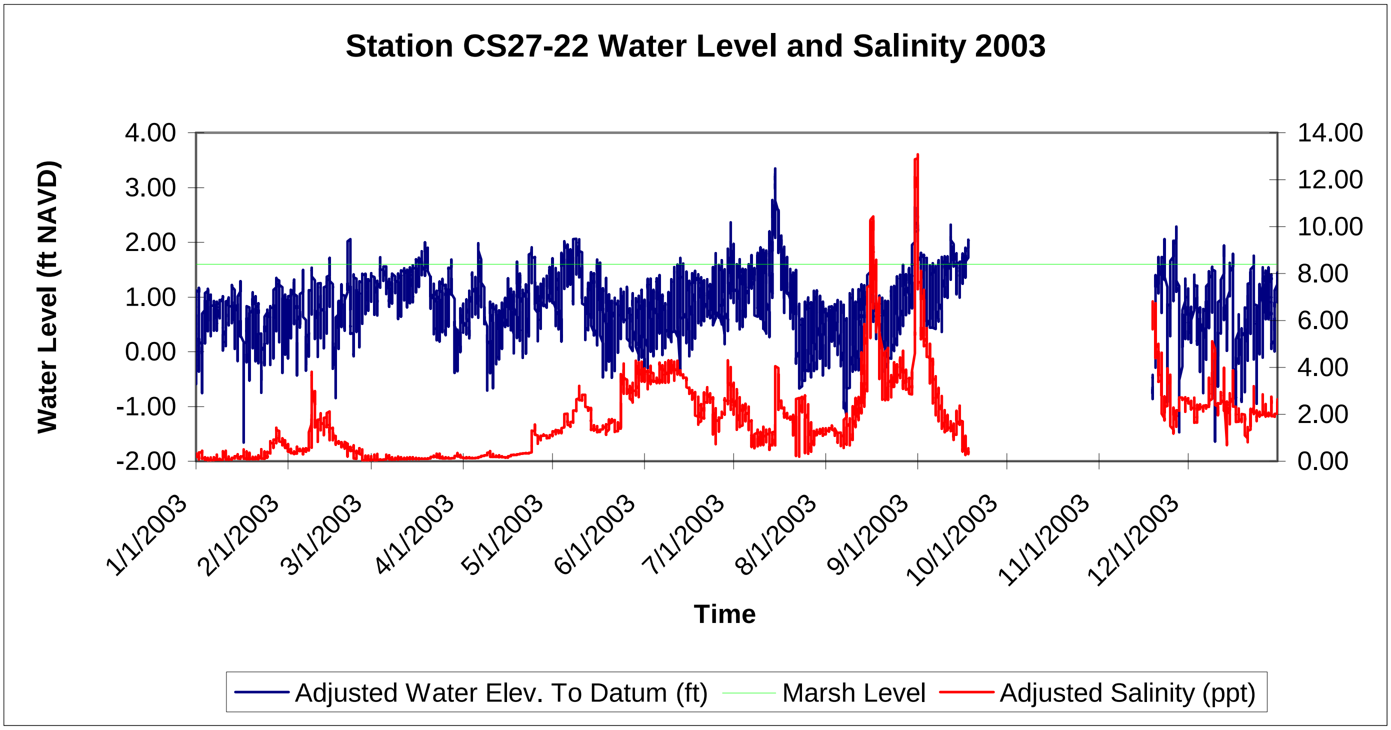


Figure 7. Mean salinity from discrete hydrologic data for grouped monitoring stations. The following is a list of the stations included in each grouping: Hydrologic unit – project stations 2, 6, 10, 24, 25, 26; Interior east – project stations 3, 5, 7, 8, 9, 11, 13, 20, 21, 23, 27, 28, 29; Reference north – project station 1; Reference south – reference stations 4R, 5R, 6R, 7R, 8R; Interior west – project stations 18, 30, 31, 32, 33, 34, 35; Perimeter north – project stations 4, 16, 19, 22; Perimeter south – project stations 12, 14, 15. Numbers on each column indicate number of stations in each group. Due to problems with low water access, not all stations were visited on each of the five discrete collection trips of 2003. Error bars represent ± 1 standard error.



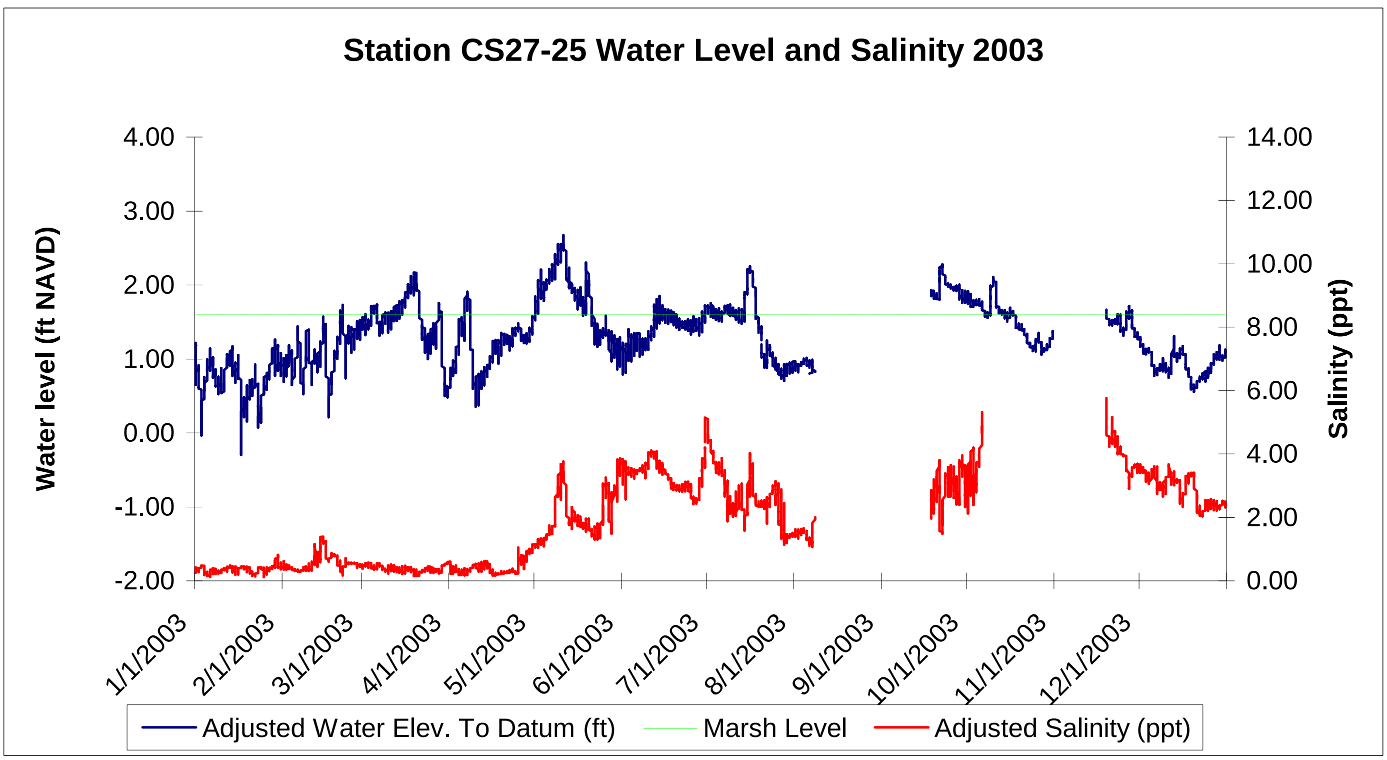


Figure 8a-b. Hourly water level and salinity data for year 2003 for stations CS27-22 and CS27-25.

Figure 9. Healthy stand of planted S. californicus.

Figure 10. In the foreground, 2 surviving S. californicus planting stems.

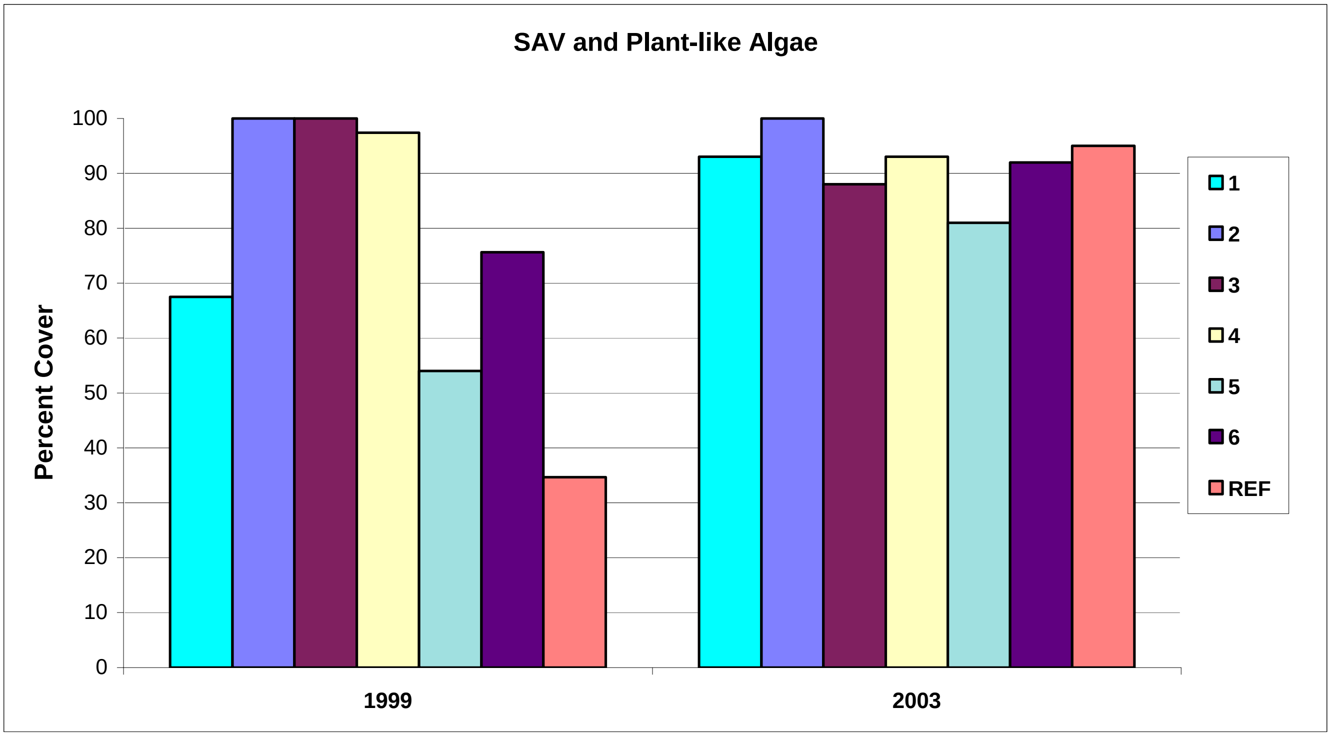


Figure 11. Total percent cover of SAV and structurally complex algae by area in 1999 and 2003 samples.

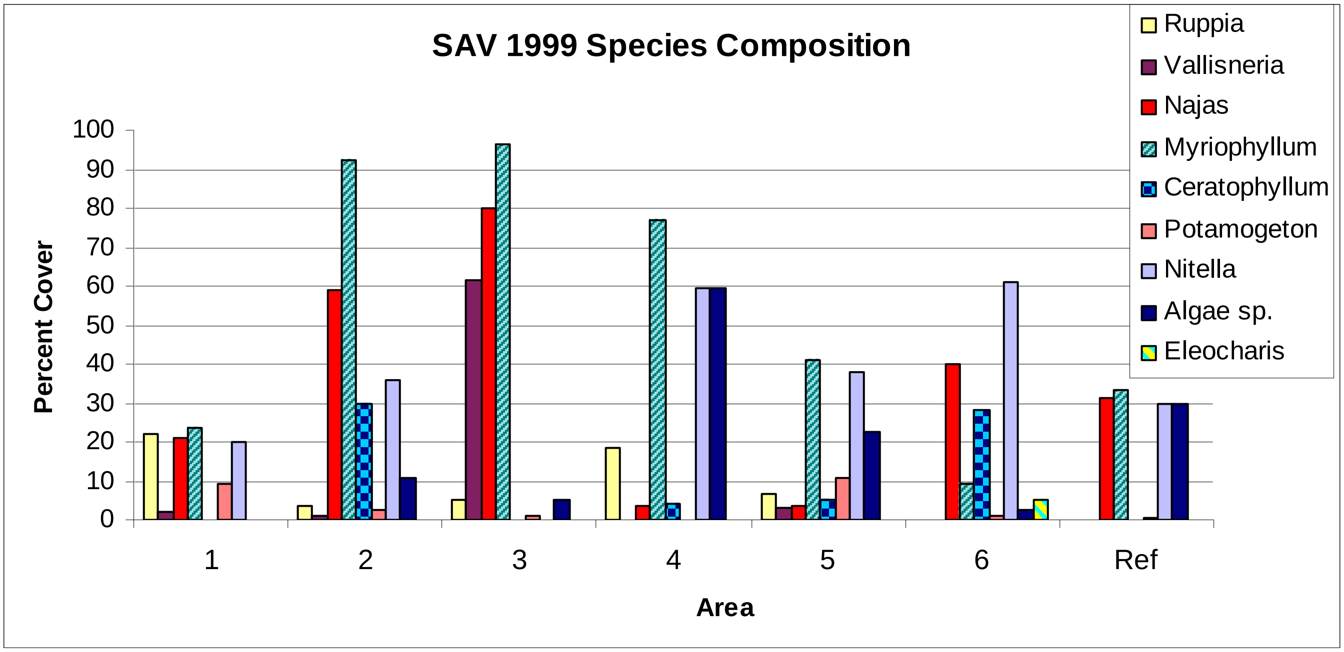


Figure 12. Percent cover of SAV species by sample area in 1999. Values are the mean of transect values within a particular area.

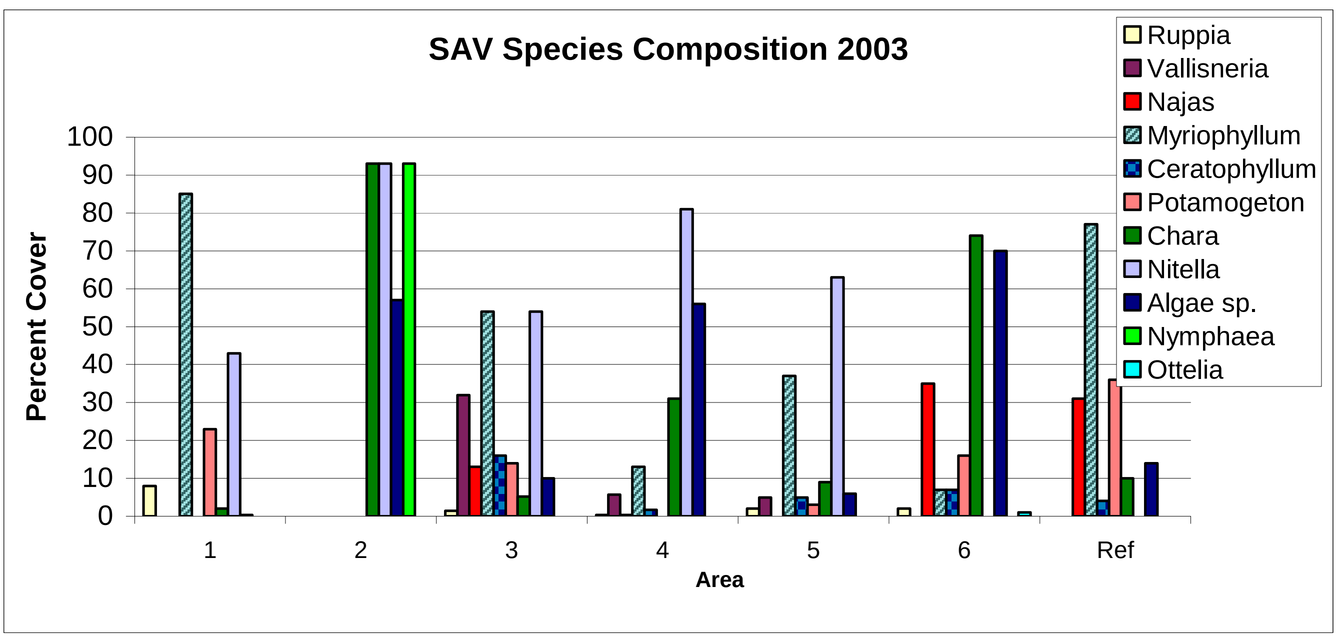


Figure 13. Percent cover of SAV species by sample area in 2003. Values are the mean of transect values within a particular area.

V. Conclusions

a. Project Effectiveness

Reduce mean salinities within the project area: The impounded hydrologic area 1 appears to be minimally effective in reducing mean salinity compared to the areas outside of the influence of the project structures. Related to this goal is the attenuation of salinity spikes. The results suggest that at least in the impounded hydrologic unit behind the SRT, sharp salinity increases are reduced. The differences that were recorded were not biologically significant, but at times of higher, possibly damaging salinity spikes, the SRT may be very effective.

Reduce mean erosion rate of protected shoreline along GIWW: The March 2002 postconstruction shoreline survey is considered as "immediately post construction" and was compared to the first survey to estimate preconstruction erosion conditions. Therefore, the erosion rate reduction potential of the rock dike will be evaluated after the 2004 shoreline survey is analyzed. Other shoreline protection projects using rock dikes near the CS-27 project along the GIWW have been successful in reducing shoreline erosion and we expect the same results.

Increase SAV in interior ponds within the project area: The SAV cover before construction in 1999 was relatively high already. Overall SAV cover did increase in some areas between the preconstruction and postconstruction samples. However, the data do not definitively link any increases or changes to project effects.

b. Recommended Improvements

Project infrastructure should be added to the GIS database.

More continuous hydrologic recorders in the project and reference areas are needed to adequately evaluate the goal of reducing mean salinities within the project area. With the implementation of CRMS, at least 4 more recorders will be added to the area and will greatly improve the characterization of salinity in the area.

A structural assessment survey performed by a licensed engineering/ land surveying firm is recommended to evaluate settlement and stability of the rock structure along with any evidence of accretion on the land side of the rock structure.

A Hydrodynamic model was developed and used during the design process, it is recommended that after sufficient post construction salinity and water level data are retrieved, the model be rerun to check for model validity, and to check for project validity.

c. Lessons Learned

To adequately monitor hydrologic conditions throughout such a large area and document short term high salinity events, more recording equipment must be deployed. Also, as true with most projects, longer preconstruction data collection is needed to accurately characterize the area before project features affect the area. Of course, many of these points are moot with the implementation of CRMS which should provide ongoing reference data for the entire coastal area.

SAV cover in the project area was approximately 25% or less prior to 1997. SAV cover in the project area was much greater (approximately 83 % overall) in 1999 (preconstruction). Because of the high variability of SAV cover and the inability of limited monitoring to causally link achievement of the goal to the project (i.e. no monitoring of turbidity, water flow, etc.), we should have considered eliminating the SAV cover monitoring element and goal from the monitoring plan. Our continuing SAV monitoring, however is useful in tracking species composition. Over time, our analysis will provide additional information to help characterize the vegetation community of the area.

Lessons were also learned concerning the construction/design of one of the structural project features. The Shoreline Protection feature of the original construction of the Black Bayou Hydrologic Restoration Project (CS-27) was constructed by use of stone riprap of designation type 650 pound graded stone. The resulting stone fill is porous and thus would allow significant water flow through same. This was a property and condition of a stone dike that was recognized during the design of the Shoreline Protection feature and therefore, a requirement to install earthen embankment type “plugs” in approximately five (5) open breaches of the existing south bank of the Gulf Intracoastal Waterway was work incidental to the placement of the shoreline protection rock dike. Local earthen materials was to be “borrowed” from the area between the Stone Dike and the breaches in the shoreline of the marsh and placed into a section to create a plug to “cut- off” the water flows that would occur during tidal events, of either of high or low elevation. This work effort was performed but local borrow material was of a very poor quality and in areas of poor foundation conditions. The plugs eventually failed or were eroded away only months after the work was initiated. Corrections to stop the flow of tidal exchanges then had to be designed and accomplished. Same were accomplished by use of stone riprap, of Type “C” Gradation that graded from “dust to stone approximately 6 -10 inches topsize”, was selected to effect and create more substantial plugs in the various breaches between the GIWW and the eastern marsh area of the Project. The Project was accomplished by construction contract and has been successful in stopping the tidal flow within the area. Lesson Learned from this experience is that for “plugs” of this nature, the construction of the cut-off embankments needs to be substantial and “hard”, and high enough, to serve the intended purpose.

Safety related issues also became apparent and were appropriately handled. Approximately two (2) years after the Project was completed, two (2) potential safety hazards/unsafe conditions on two features of the project became apparent. They were:1)The SRT Weir Structure was completed with approximately 80 linear feet of sheet pile cap that existed at Elevation +3.0 feet NAVD88, just 1 to 3 feet above the prevailing water surface on most days. As flow to and from the eastern marsh area of the project is usually always moving, sometimes at high velocity, the structure is a popular fishing and cast-net shrimping location and as such, provided a concern that someone might fall into the water and drown, especially if they were pulled into the existing fish slots, 1x4 feet in size and located underwater, that are a part of the sheet pile weir. After much thought, as it was not the intent to prevent sporting activity at the structure but to only make conditions safer to users, it was decided to install a handrail constructed of pipe that would permit sporting activity but minimize the potential of someone falling into the area of the flowing water. 2)At the site of the Black Bayou Cut-off Canal Weir with Bargebay Structure, another project feature that had been constructed, Directional Arrow Signs, a total of four (4), one at each quadrant of the bargebay opening in the weir, had been installed to aid in directing users to navigate through the Bargebay opening. Signs were simply an arrow type sign mounted on the top tip of creosote piling. Unfortunately, the barges navigating the channel bargebay eventually damaged or destroyed three of the four signs while sometimes navigating through swift currents. The solution to replacing these signs was to install large 4x8 foot rectangular signs mounted on a sizeable cube of concrete on each side of the bargebay opening. The damaged signs and associated piling that had been originally installed were removed. Lesson Learned is that signage of this nature in confined narrow reaches of a channel should be installed such that, they are protected from collision with boats, barges, and tows.