EAST MUD LAKE (CS-20)

I. INTRODUCTION

I.1. Project Description

Describe location, boundaries, and features and how they have changed from inception to final project.
The project area is bounded by an access canal and the southern tip of Mud Lake to the south, Highway 27 to the west, Magnolia Road to the north and an existing levee and property line near Oyster Bayou to the east (figure 1).

The Project area is divided into two Conservation Treatment Units (CTUs) to be managed independently and be separated hydrologically. CTU #1 contains Mud Lake and was planned to be managed passively, while CTU #2 was planned for active management for drawdown capabilities to encourage shallow areas to revert to emergent vegetation as stated in the Monitoring plan (revised 1998).

Boundary remained unchanged throughout life of project
Proposed Project Information Sheet (1992)
WVA Information Sheet (Sept. 14, 1992)
Final Project Plan/EA (May 1994)
Final Monitoring Plan (May 16, 1995)

Structural features are:
Six (6) 36" corrugated aluminum pipes w/ 10ft variable crested weir inlets and 4" vertical slots
Four (4) 36" corrugated aluminum pipes w/ 10ft variable crested weir inlets and flap gates
- One (1) 48" corrugated aluminum pipe w/ flap gate and screw gate
- Five (5) 24" corrugated aluminum pipes and flap gates
- Two (2) sheet pile variable crested weirs
- Three (3) earthen plugs
- 1,500 lf of levee construction
- 40,500 lf of levee rehabilitation

See section III.2 for structural changes since project inception.

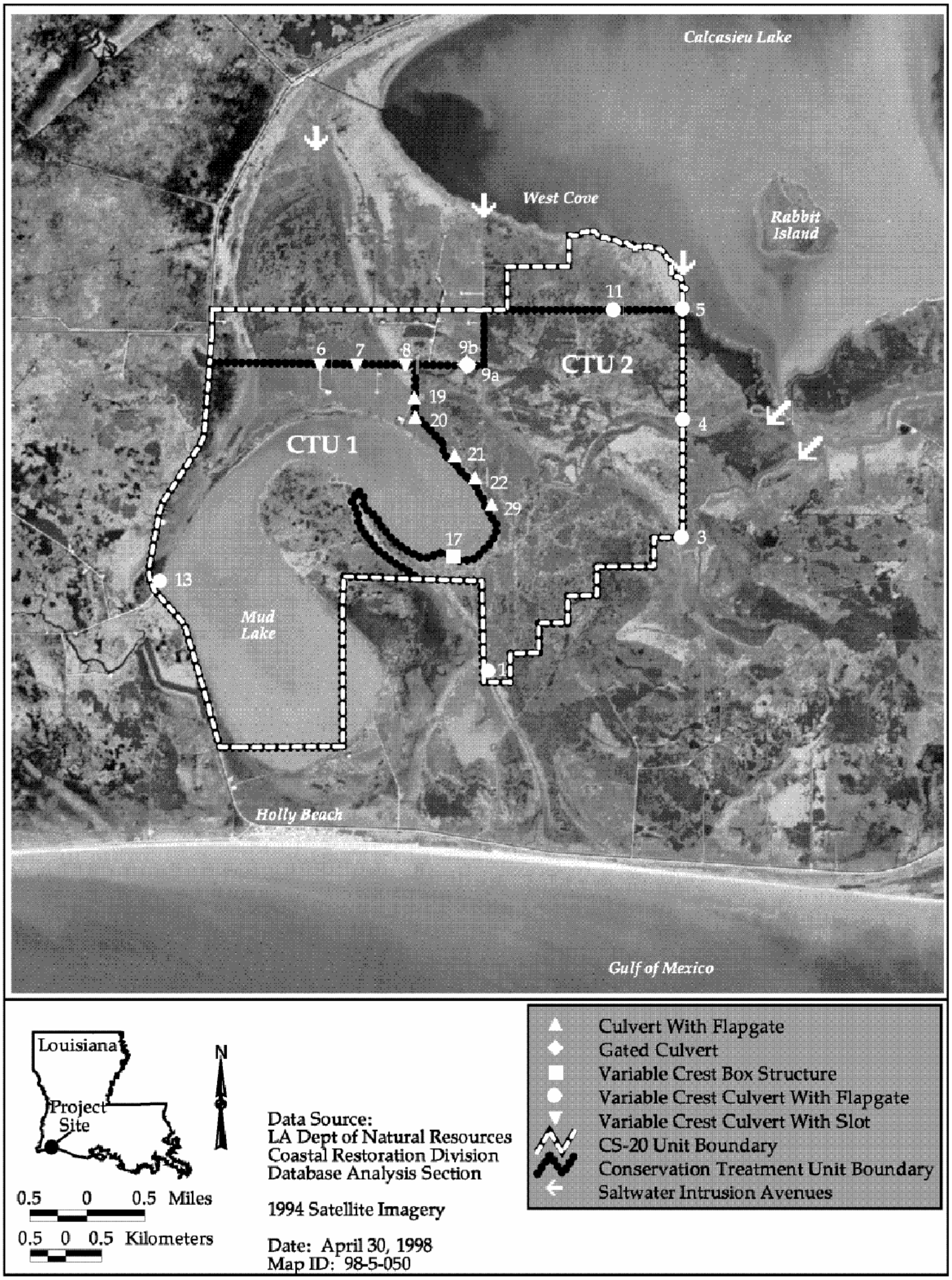

Figure 1. Location and features of the East Mud Lake Marsh Management Project (CS-20).

I.2. Project Personnel

Planning	Ed Hickey (retired)	NRCS
	Britt Paul	NRCS
	Garrett Broussard	LDNR
Implementation	Brad Sticker	NRCS
	Wayne Melancon	NRCS
	Garrett Broussard	LDNR
Monitoring	Marty Floyd	NRCS
	Dona Weifenbach	LDNR
	Shannon Holbrook (moved)	LDNR

II. PLANNING

II.1. Causes of Loss

What was assumed to be the major cause of land loss in the projected area?
What were assumed to be the additional causes of land loss in the projected area?
Final Plan/EA (May 1994) on page 9 listed the following as major changes in hydrology: inadequate water exchange points, unstable water conditions, subsidence and associated features. Soil erosion is the primary adverse effect of these major changes. The term “unstable water conditions” represents the following types of problems: 1) unnatural inundation of high water levels, 2) unnatural water level fluctuations, 3) high salinities (salinity spikes), and 4) unnatural salinity fluctuations.

II.2. Background

Provide background information on the rationale for selecting the restoration method(s).
The Natural Resources Conservation Service published a Project Plan/Environmental Assessment in 1994 as a rationale for the selected restoration method. The restoration method of marsh management was selected based on a consensus of the federal and state agencies and landowners after discussing the problems facing the area and the projected impacts over the next twenty years. The landowners stressed the importance of the shrimp fishery in the area and wanted project features to not have an adverse impact. The 1989 marsh conservation plan was used as a basis for the original proposed project plan and it evolved into the current features after consultation with the federal and state agencies and after going through the NEPA process.

II.3. Project Goals and Objectives

How were the goals and objectives for the project determined?
In 1989, SCS developed a marsh conservation plan for the project area at the request of the landowners. In 1993, SCS completed a draft report of the Calcasieu-Sabine Cooperative River Basin Study. The Task Force of CWPPRA developed a long-term Restoration Plan for coastal Louisiana wetlands which classified the East Mud Lake project as critical for the long-term protection, restoration and enhancement of coastal vegetated wetlands. The marsh conservation plan, used as a basis for the original proposed project plan, was the result of the collective experience of SCS engineers and biologists and the work done by the agency in coastal areas.

Are the goals and objectives clearly stated and unambiguous?
Yes, the goals are to reduce wetland degradation by reducing rapid fluctuations in water and salinity levels and prolonged periods of marsh inundation in the project are, and enhance regeneration of desired emergent and submergent vegetation. The goals in the monitoring plan are clearly stated. Terms of "increase" and "decrease" leave the amount of success of the project open to interpretation. Submersed vegetation is not listed as a goal in the monitoring plan and is not being monitored.

Are the goals and objectives attainable?
Yes.

Do the goals and objectives reflect the causes of land loss in the project area?
Yes, using drawdown as a means to recover mash loss is an effective restoration method. Using passive measures will only protect an existing condition; it requires active measures to restore an area that has already suffered losses.

III. ENGINEERING

III.1. Design Feature(s)

What construction features were used to address the major cause of land loss in the project area?
Structural features are:

- Six (6) 36" corrugated aluminum pipes w/ 10ft variable crested weir inlets and 4" vertical slots
- Four (4) 36" corrugated aluminum pipes w/ 10ft variable crested weir inlets and flap gates
- One (1) 48" corrugated aluminum pipe w/ flap gate and screw gate
- Five (5) 24" corrugated aluminum pipes and flap gates
- Two (2) sheet pile variable crested weirs
- Three (3) earthen plugs
- 1,500 lf of levee construction

- 40,500 lf of levee rehabilitation

What construction features were used to address the additional causes of land loss in the project area?
See previous paragraph. Not all causes can be fixed. A healthy, grown marsh has the best potential for keeping up with subsidence and these features are intended to attain that.

What kind of data was gathered to engineer the features?
The following references were used for this design:

- SCS National Engineering Handbook, Section 19
- SCS National Engineering Handbook, Section 20
- Fundamentals of Geotechnical Analysis; Dunn, Anderso, and Kiefer
- Steel Sheet Pile Design Manual; U.S. Steel
- National Design Specifications for Wood Construction, 1991 Ed.
- Quarried Stone for Erosion and Sediment Control; National Stone Association
- Modern Sewer Design; American Iron and Steel Institute
- Aluminum Construction Manual; Aluminum Association 1959
- Foundation Analysis and Design; Joseph Bowles
- Soil Mechanics in Engineering Practice; Terzaghi and Peck
- Introduction to Soil Mechanics and Foundations; Sowers
- Mechanics for Engineers; Beer and Johnson

A limited geotechnical investigation was conducted at site 17. A 12ft McCulley Auger was used to sample the soil to a depth of 11 feet. The soil was classified as a CL-CH. IN order to determine values for cohesion and saturated unit weight, the SCS Ft. Worth National Technical Center provided geotechnical reports for projects in the same general vicinity as the Mud Lake project. This information was compared to data found in the Cameron Parish soil survey. Three soil types were identified; Creole, Mermentau, and Bancker. Conservative values were chosen for cohesion (300 psf) and saturated unit weight (90 pcf) for designing the sheet pile weirs.

What engineering targets were the features trying to achieve?
The existing boundary levee was targeted for a constructed height of +4.1 feet NGVD. The new levee constructed between sites 14 and 15 was targeted for a constructed height of +3.6 feet NGVD. See monitoring for other project benefit targets.

III.2. Implementation of Design Feature(s)

Were construction features built as designed? If not, which features were altered and why?
Original plan called for 64,000 linear feet of *Spartina alterniflora* (smooth cordgrass) plantings along Mud Lake shoreline and approximately 86,000 linear feet throughout the marsh interior. This was altered significantly.

Apparently the local soil and water conservation district indicated that they could do the plantings as part of their program. This item was then removed from the federal project with the intent that this component would be done as part of the district program. When the work was actually done, it was not the same amount as previously planned. Not sure if this was due to cost constraints on their part or if it was just not clearly explained what was planned, and therefore the same amount didn't get implemented.

Doug Miller (former employee of NRCS) did the plantings as part of a Soil and Water Conservation District project. Doug monitored 10% of the plans with 20 plants per plot. His sampling included the interior marshes. Information as to total amount planted and construction quantities was not attainable within time constraints to draft this report. DNR monitored plantings in CTU 2 along the north and east levees, and the southern step levee only, not in interior marshes. DNR also monitored plantings in three locations along the Mud Lake shoreline. Because of drought conditions, the soil was too hard and dry to plant the shoreline in the Lake. DNR monitored 5% of the total excluding the interior marshes. Forty plots of 10 plants each were sampled for cover and species composition, indicating that 8,000 plants were installed.

A meeting was held 7/21/94 to discuss permit modifications of structures originally planned. The following modifications were made (1) ES1 added flap to facilitate drawdown. (2) ES13 changed from timber to steel to increase its lifespan and stability. (3) to shore up step levee, need 66,461 cu yds of dredge material instead of 4,850 cu yds.

III.3. Operation and Maintenance

Were structures operated as planned? If not, why not? Are the structures still functioning as designed? If not, why not? Was maintenance performed?
Structure No. 4 consist of 5- 36" corrugated aluminum pipes with aluminum variable crest weir on the west side and aluminum flapgate on the east side. The structure was constructed in 1972 by the Cameron Parish Gravity District as part of a drainage project. The existing structure was permitted by the permit holder (FINA) and incorporated into the East Mud Lake Project (CS-20). Structure No. 4 is a direct conduit to the Calcasieu Ship Channel via Oyster Bayou where high salinity water may enter the project.

On October 12, 1997 Menard and Broussard made a field inspection to structure 4 to inspect damage to the levee made by vandals. A hole had been cut 1 foot wide by 2 feet deep, but had been repaired by FINA representative Scott Rosteet with sacks of Easy Crete concrete and dirt. The removal of the flapgate from structure 4 by vandals was recorded in a monitoring field trip report October 28-29, 1997 (Weifenbach and Courville) and copies were provided to the NRCS project manager (Eldridge), the LDNR project manager (Broussard), monitoring supervisor (Libersat), and FINA representatives John Woodard and Rosteet.

An O & M Inspection was conducted on December 1, 1997 with representatives of LDNR (Juneau, Menard) and FINA (Rosteet). The inspection of Structure No. 4 noted one of the five flapgates was missing due to vandalism, deterioration of weir inlet tie-backs and minor erosion along the wingwall. The Permit Holder (FINA) expressed difficulty in removing, installing or adjusting stoplogs due to the structural design and deterioration of the aging structure. The Permit Holder (FINA) also requested in addition to replacing the missing flapgate, lifting devices should be added to the flapgates along with locking devices. At that point LDNR informed the Federal Sponsor (NRCS) of the situation and both agreed the maintenance work needed to be performed. E & D for the proposed maintenance work was to be performed in-house by the CRD Abbeville Field Office and was initiated in February 1998. A follow up site inspection with representatives of LDNR (Juneau, Aucoin), NRCS (Melancon, Midkiff) and FINA (Rosteet) was conducted on April 22, 1998. The inspection also noted the vandalism from October 1997 where vandals had dug a trench across the levee near Structure No. 4 to allow water flow that had been temporarily repaired by the Permit Holder (FINA) with bags of cement. At the request of the Permit Holder (FINA), the inspection also resulted in the expansion of the proposed scope of work to be performed to include approximately 100' of levee refurbishment, installation of a flapgate platform and locking device at Structure No. 3, and stoplog locking devices at Structure No. 1, 5, 6, 7, 8, 9A & 11. As mentioned earlier, Structure No. 4 was not a newly constructed feature, but an old existing Gravity District Drainage structure. The first order of business was to attempt to obtain drawings of Structure No. 4 in order to determine structural components and the best way to perform the modifications. The Gravity District had no set of structure drawings on record. Efforts were then made to contact the retired engineer who designed the project and after months of delay, a set of drawings was acquired by LDNR. Design surveys were performed and plans and specifications were developed, finalized and prepared for submission to Division of Administration by late summer 1998. In the mean time, on May 13, 1998, the Permit Holder (FINA) had initiated a stopgap measure of blocking the damaged pipe with plywood in an effort to keep flow from entering the Project Area. The LDNR Project Manager and the permit holder (FINA) determined that any resulting seepage through the stop gap measure of the one 36"pipe would be minimal and inconsequential to the Project.

In September 1998 the area was hard hit by Tropical Storm Frances causing severe damage to Structure No.4. The structure experienced severe scouring on the weir inlet side, additional damage to the structure, erosion of the adjacent levee, as well as erosion at various other structure sites. At that point, in consultation with NRCS & FINA, LDNR pulled back its previous efforts and revised the plans/specifications to address the additional maintenance work needed as a result of Tropical Storm Frances. Design surveys were conducted to address the additional work and plans/specifications were revised and submitted to NRCS for review and comment in May 1999. Comments from the NRCS review were incorporated into the plans/specifications. Final plans/specifications were submitted to Division of Administration in July 1999. The bid solicitation package was processed and advertised for bid by Division of Administration. Bids were opened October 8, 1999. The contract was executed and the work was completed January 28, 2000. The repair was not successful and the structure is now sinking on one side.

Unfortunately, although the plywood impeded flow through the vandalized flapgate, it did not stop flow, and contributed to salinities that were well above project target levels of 15 ppt for the latter half of 1999 and all of 2000.

At a recent meeting to discuss the proposed replacement of Structure 4, it was determined that a Tainter Gate was the best option. Essentially a Tainter Gate is a steel framework with a circular segment for its face and it is hoisted in the air about a trunnion pin at its center of curvature. The trunnion pin usually has much less friction than a roller pin, as used by a vertical lift or sliding gate, thereby making it comparatively light and easier to operate.

Structure No. 13, the freshwater input from Second Bayou in west Mud Lake is silted in and inoperable, hindering freshwater flow in low water conditions.

A PPL 12 candidate project, the Oyster Bayou Hydrologic Restoration, would have addressed the freshwater input faction of this project as well by allowing more freshwater to flow from Second Bayou through Mud Lake and into the western marshes near Oyster Bayou. This project was not selected for this list, so dredging Second Bayou, at least to the point that the structure is operable and water can flow through it should be included as regular maintenance.

IV. PHYSICAL RESPONSE

IV.1. Project Goals

Do monitoring goals and objectives match the project goals and objectives?
The 2nd Priority Project List Report, Project Information Sheet (Oct. 30, 1992) on page 181 listed the objectives as: "to create a hydrologic regime conducive to the restoration, protection, and enhancement of the East Mud Lake Wetlands. This will be accomplished through regulation of such critical water parameters as water movements and salinity. The major goal of the project is to reduce stress, caused by excessive salinities and undesirable water movements, on an extremely

productive brackish marsh system. Ultimately, a more favorable hydrologic regime will help ensure the long-term integrity of the East Mud Lake Wetlands".

WVA Information Sheet (Sept. 14, 1992) listed the objectives as: "to create a hydrologic regime conducive to the restoration, protection, and enhancement of the East Mud Lake Wetlands. This will be accomplished through regulation of such critical water parameters as water movements and salinity. The major goal of the project is to reduce stress, caused by excessive salinities and undesirable water movements, on an extremely productive brackish marsh system. Ultimately, a more favorable hydrologic regime will help ensure the long-term integrity of the East Mud Lake Wetlands".

Final Project Plan/EA (May 1994) on page 51 lists the project aim as "to create a hydrologic regime conducive to the restoration, protection, and enhancement of the East Mud Lake Wetlands. This will be accomplished through regulation of such critical water parameters as water movements and salinity. The major goal of the project is to reduce stress, caused by excessive salinities and undesirable water movements, on an extremely productive brackish marsh system. Ultimately, a more favorable hydrologic regime will help ensure the long-term integrity of the East Mud Lake Wetlands".

Final Monitoring Plan (May 16, 1995) listed the goals as: 1) "prevent wetland degradation in the project area by reducing vegetative stress, thereby improving the abundance of emergent and submergent vegetation" by "hydrologic structural management to reduce water levels and salinities"; and 2) "stabilize shoreline of Mud Lake through vegetative plantings".\

Project Objectives: (1) to prevent wetland degradation in the project area by reducing vegetative stress, thereby improving the abundance of emergent and submergent vegetation. This is achieved through hydrologic structural management to reduce water levels and salinities. (2) stabilize shoreline of Mud Lake through vegetative plantings.

Specific goals:
1. decrease rate of marsh loss.
2. increase vegetative cover along shoreline of East Mud Lake.
3. increase coverage of emergent vegetation in shallow, open water area.
4. increase abundance of vegetation in presently vegetated portion of project area.
5. reduce water level and salinity fluctuations to within target ranges for brackish vegetation. Target range for salinities is < 15 ppt and 6 in below marsh level to 2 in above marsh level for water levels.
6. decrease duration and frequency of flooding over marsh.
7. decrease mean salinity in CTU 2.
8. increase accretion in CTU 2.
9. maintain fisheries abundance–not a specific goal as addressed in the project documentation, but included due to concerns regarding fisheries abundance.

Monitoring goals adequately match project goals by addressing salinity and flooding problems. Emergent vegetative monitoring and habitat mapping address issues of vegetative cover and health. Submersed aquatics (SAV) are not incorporated into the monitoring plan and the classification of SAV in habitat mapping should not be used to interpret SAV in coastal Louisiana. Fisheries monitoring may not have been sufficient prior to installation of the project.

The Technical Advisory Group (TAG) provides direction on environmental parameters sampled, and methodology. Members of the TAG included Deborah Fuller (USFWS), Charles Sasser (LSU), Shannon Holbrook (DNR), and Marty Floyd (NRCS). Comments on the draft plan were provided by Jenneke Visser (LSU), Erick Swenson (LSU), Rick Hartman (NMFS), Terry McTigue (NMFS), and Nabendu Pal (ULL). Input on sampling was provided by Lawrence Rozas (NMFS), Andy Nyman (ULL), Don Cahoon (NWRC), and James Lynch (NWRC).

Were there other variables that could be monitored to substantially increase our ability to understand the results of the project?
Soil salinity measurements would have been extremely valuable in determining stress on emergent vegetation during drought and drawdown periods in 1996 and 1997. Submersed vegetation loss was given as a reason for the need of the project and was expected to increase by 40% over the life of the project (WVA).

This estuary is an important nursery area providing food, refuge from predation, and habitat for many species that have commercial and recreational value. Tom Minello and Rick Ruebsamen stated that every marsh management project should include fisheries monitoring. NMFS was concerned that by altering the hydrology of the area, fisheries access would be reduced and strongly recommended that we monitor this parameter. The area was impounded prior to construction, however, and the project was designed to increase volume through existing structures. Fish slots were included in the Magnolia Road structures.

The accretion and "substrate" monitoring element was added to the monitoring plan after a field trip by the TAG on November 3, 1994.

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

IV.2.1. Elevation

What is the range of elevations that support healthy marshes in the different marsh types?
This is a brackish marsh consisting mainly of *Spartina patens, Spartina alterniflora, Spartina cynosuroides, Distichlis spicata, Paspalum vaginatum*. Information sheet, PPL2, and the Environmental Assessment states the marsh is

an extremely productive one and therefore elevations in the area are considered healthy for brackish marshes.

Does the project elevation fall within the range for its marsh type?
Yes. Elevations in the project area range from 0.82 to 1.51 ft NAVD. This is based on elevation surveys taken on the tops of clumps of vegetation, primarily *Spartina patens*, by John Chance, Inc, 3/25/99. Marsh elevations within CTU 2 are comparable to those in the reference area north of Magnolia Road and south of CTU 2 in the Oyster Bayou area. The HICP study found that on the Chenier Plain, based on 177 marsh elevation measurements at 16 locations, over a two day period in 1999, average marsh elevation was 1.28 ft NAVD with standard deviation of 0.17 ft. The highest marsh elevation was 1.79 ft NAVD and the lowest was 0.84 ft NAVD.

This survey was taken at CTU 2. The original elevation of 1.4 ft NAVD came from a survey done along Louisiana Highway 27, which is located on a ridge. There are ridges in CTU 2, but vegetation in the lower elevations is suffering from structures operated at the higher number.

These target elevations were chosen from numerical targets. If Marsh elevation is 1.0 ft NAVD and the target range is 6" below marsh level to 2" above marsh level, then the target elevation is from 0.5 ft to 1.15 ft NAVD. The permit did not specify values other than "relative to marsh elevation.

Plants are growing here and also in reference area. If this were not the right elevations then we would not be able to see any growth. Despite not having numerical data to support this, actual visual observation leads us to believe the elevations are proper.

Did the project meet its target elevation?
The goal was to increase accretion. This goal was meant to keep up with subsidence and sea level rise, not necessarily to raise the elevation of the marsh. Accretion and elevation changes over time depend on hydrologic conditions. Accretion rates in the project area in 1996 were significantly lower than rates in the reference area (Table 1). Accretion rates in the project area increased in the project area but decreased in the reference area from 1996-1998. Accretion rates were not significantly different in 1998.

Table 1. Vertical accretion rates in the project and reference areas of East Mud Lake (lsmeans ± 1SE, n= number of plots). Accretion rates are standardized to reflect exact six month time intervals.

	7/96 to 12/96		12/96 to 7/97		7/97 to 12/97		12/97 to 7/98	
	n	*cm/6mo*	*n*	*cm/6mo*	*n*	*cm/6mo*	*n*	*cm/6mo*
Project	28	0.24 ± .20	34	0.26 ± .18	33	-0.11 ± .18	38	0.80 ± .17
Reference	32	1.10 ± .18	37	0.75 ± .17	31	-0.02 ± .19	36	0.83 ± .17

There is another dataset for accretion and elevation, but it has not been analyzed. Also, the SET data is available but all datasets have not been analyzed. Not all stations have marsh elevation since they were not accessible due to drought. A new survey to determine marsh elevation at each SET is due in June 2002. These data will be made available as soon as they are processed.

What is the subsidence rate and how long will the project remain in the correct elevation range?
Coast 2050, Region 4 Supplemental Information for the Mud Lake Mapping Unit estimated subsidence at 0-1 ft/century.

Plan/EA citing Penland et al. (1989) lists the combined subsidence and sea level rise in the Mud Lake area as approximately 0.25 in/yr.

Lowest and highest Accretion – subsidence=
-.23 in/yr (-0.29 cm/6mo)- 12 in/yr = -12.23
.76 in/yr (.97 cm/6mo) – 0.25 in/yr =0.5
Range of elevation in .82 ft to 1.51 ft NAVD = 9.84 in to 18.12 in above water

Given the wide range of subsidence measures, the project may remain in the correct elevation range past the life of the project or only for one year where subsidence is high and negative accretion occurs.

IV.2.2. Hydrology

What is the hydrology that supports healthy marshes in the different marsh types?
Target range for water levels is six inches below marsh level to two inches above marsh level, which will support healthy brackish marsh vegetation. Average marsh elevation in CTU 2 is 1.0 ft NAVD. The marsh surface needs to drain on a regular basis due to tidal fluctuation.

Does the project have the correct hydrology for its marsh type?
What were the hydrology targets for the project and were they met?
Target range for water levels is six inches below marsh level to two inches above marsh level, which will support healthy brackish marsh vegetation. Water levels were low for a large percentage of the post-construction period due to two consecutive drawdown years (1996 and 1997) and three consecutive dry years (1996-1998). In 1996, the most severe drought in 20 years lasted for six months, causing drying contraction, and compaction of the soil surface in the project area. At this time water levels were too low and water was not let into the project area due to high salinities, often above 20 ppt. Following the drought, tropical storms caused flooding with water remaining on the marsh for three months at high salinities (Figure 2).

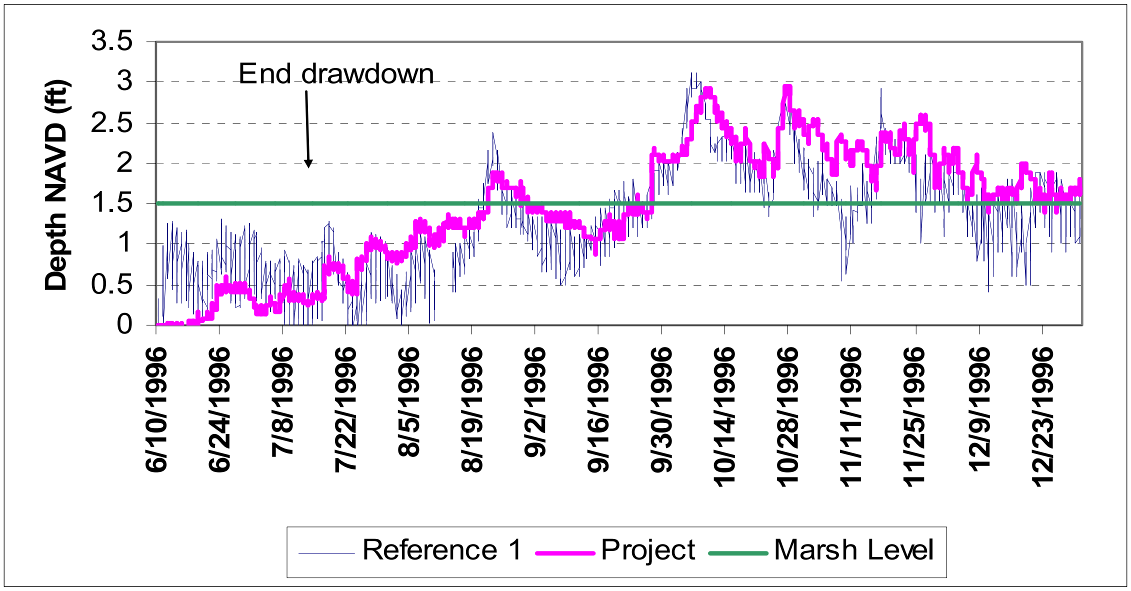

Figure 2. Water levels in the project and reference areas showing the extreme drought followed by inundation of saline water in 1996.

Since the operation plan was for two drawdowns within the first five years and dry conditions prevailed at construction end, we initiated a drawdown not knowing it would be the worst drought in 20 years. The following year, dry conditions again and after consulting with personnel from NRCS, Rockefeller SWF, Andy Nyman, a decision was made that it would be a good opportunity for pond edges that were colonized with *Paspalum vaginatum* during the first drawdown year, to become well established.

IV.2.3. Salinity

What is the salinity regime that supports healthy marshes in the different marsh types?
Target range for salinities is < 15 ppt are optimum for brackish marsh vegetation. Brackish marshes have an average salinity of 8.2 ppt with a maximum of 18.4 ppt. (Chabreck et al. 1989).

Chabreck (1972) from a sample size of 21 classified the range of salinities in brackish marshes in the vicinity of East Mud Lake as 0.49 – 15.79 ppt. The healthy marshes here are dominated by Spartina patens. *S. patens* is tolerant to a wide range of salinity. Greenhouse experiments have tested the effects of salinity over a range of 0 – 28 ppt and generally found growth to be unaffected from 0 – 8 ppt (Bandyopadhyay et al. 1993, Ewing et al. 1995, Baldwin and Mendelssohn 1998, La Peyre et al. 2001) and net photosynthesis and growth reduced above 10 ppt (Pezeshki et al. 1987, Mendelssohn and McKee 1992, Pezeshki and Delaune

1993, Broome et al. 1995, Ewing et al. 1995). In investigating the effects of 25 ppt salinity and hypoxia, Pezeshki and Delaune (1993) found net photosynthesis was reduced in aerated and hypoxic conditions by 23% and 44%, respectively.

Does the project have the correct salinity for its marsh type?
Yes, when structures are operated within target ranges. The structures were operated as planned between June 1996 and October 1997. Progress Report #4 shows salinities above 20 ppt in the late summer and early fall of 1996 post construction and prior to vandalization. Data after 1998 has not been analyzed.

What were the salinity targets for the project and were they met?
Salinity levels remain within target ranges for the majority of the sampling period after construction until vandals removed one of the five flap gates at structure 4 in late October 1997. This structure is a direct conduit to the Calcasieu Ship Channel via Oyster Bayou where high salinity water may enter the project. An attempt was made by the permit holder (FINA) by blocking the pipe with plywood. This impeded flow, but did not stop it and salinities were above target levels for the latter half of 1999. The structure was repaired in February 2000, and salinities are once again within target ranges. In addition, the freshwater input from Second Bayou in west Mud Lake has been silted in and inoperable since, hindering freshwater flow in low water conditions.

The WVA gave the baseline average annual salinity at 12 ppt. It was predicted to remain the same without the project but decrease to an average annual 10 ppt with project.

IV.2.4. Soils

What is the soil type that supports healthy marshes in the different marsh types?
Creole mucky clay, Mermentau clay, and Bancker muck are the soil types within the project. The Tables found with the Soil Survey of Cameron Parish, Louisiana (USDA-SCS 1995) will list most of the above information. However, as in all construction, site-specific investigation is necessary.

Does the project have the correct soil for its marsh type?
Nature defines this, not the project features. Therefore since we know of no way to alter the soil type, we can assume that the soil type is right for this marsh.

IV.2.5. Other

Describe any other physical characteristics of the project that have bearing on the projects' success
None.

IV.3. Suggestions for physical response monitoring

Are there other variables that could be monitored to substantially increase the ability to understand the results of the project?
Soil salinity and sulfide measurements would have been extremely valuable in determining stress on emergent vegetation during drought and drawdown periods in 1996 and 1997.

V. BIOLOGICAL RESPONSE

V.1. Project Goals

Use monitoring reports and interviews with project managers to determine the project goals.
Three documents: 1) 2nd Priority Project List Report, Project Information Sheet (Oct. 30, 1992) on page 181, 2) WVA Information Sheet (Sept. 14, 1992), and 3) Final Project Plan/EA (May 1994) on page 51, all listed the objectives as: "to create a hydrologic regime conducive to the restoration, protection, and enhancement of the East Mud Lake Wetlands. This will be accomplished through regulation of such critical water parameters as water movements and salinity. The major goal of the project is to reduce stress, caused by excessive salinities and undesirable water movements, on an extremely productive brackish marsh system. Ultimately, a more favorable hydrologic regime will help ensure the long-term integrity of the East Mud Lake Wetlands".

Final Monitoring Plan (May 16, 1995) listed the goals as: 1) "prevent wetland degradation in the project area by reducing vegetative stress, thereby improving the abundance of emergent and submergent vegetation" by "hydrologic structural management to reduce water levels and salinities"; and 2) "stabilize shoreline of Mud Lake through vegetative plantings".

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

V.2.1. Vegetation

What is the range in species composition and cover for healthy marshes in each type?
The Final Plan/EA (1994) on page 16 stated that O'Neil in 1949 classified the area as brackish, as did Chabreck in 1968 and 1988. Landowners and land managers stated that prior to 1957 the marsh between Mud Lake and Magnolia Road was fresh/intermediate dominated by California bulrush (*Scirpus californicus*), with the remainder being brackish dominated by marshhay cordgrass (*Spartina patens*). Shoreline along Mud Lake includes baccharis (*Baccharis halimifolia*) and roseau (*Phragmites australis*). Until the early 1960's, dense stands of wigeongrass occurred in the southern end of Mud Lake.

Chabreck (1972) characterized vegetation within the brackish marshes in hydrologic unit IX, which encompasses the East Mud Lake area. *Spartina patens* was dominant, followed by *Distichlis spicata, Paspalum vaginatum, Scirpus americanus, Bacopa monnieri, Scirpus robustus, Spartina spartineae, Setaria glauca* and others less than 1%.

Does the project have the correct species composition and cover for its type?
Species composition is changing from 1995 preconstruction sampling, especially in the project area, as a result of the severe drought in 1996. Species diversity is higher in the project area than the reference area.

Spartina patens, Distichlis spicata,and Paspalum vaginatum comprise 100% of the reference area in 1999, whereas the project area was dominated (95%) by those three species, but also had *Scirpus robustus, Scirpus americanus, Amaranthus australis, Borrichia frutescens, Typha* sp., *Iva frutescens, and Aster* sp.

What were the vegetation targets for this project and were they met? If not, what is the most likely reason?
Cover of *S. patens* had decreased dramatically from 1995 to 1997 in the project area (Figure 3) from a combination of drought stress, high soil salinity followed by three months of flooding conditions. As cover values of dominant species decreased, opportunistic species such as *Acnida australis, Cyperus odoratus*, and *Aster subulatus* increased. Overall species diversity was higher in the project area. A gradual increase of *Distichlis spicata* has occurred. As *S. patens* decomposes, it provides organic matter for other species. The project area did experience an increase in *Paspalum vaginatum* from colonization of pond edges after 2 consecutive drawdown years. In some areas, extending 10-12 feet into existing ponds.

V.2.2. Landscape

What is the range in landscapes that supports healthy marshes in different marsh types?
There is no optimal land:water ratio, interspersion or habitat composition that has been defined in the literature. Professional judgment has commonly suggested a 70:30 land:water ratio with an interspersion of large and small ponds with a diversity of vegetation types.

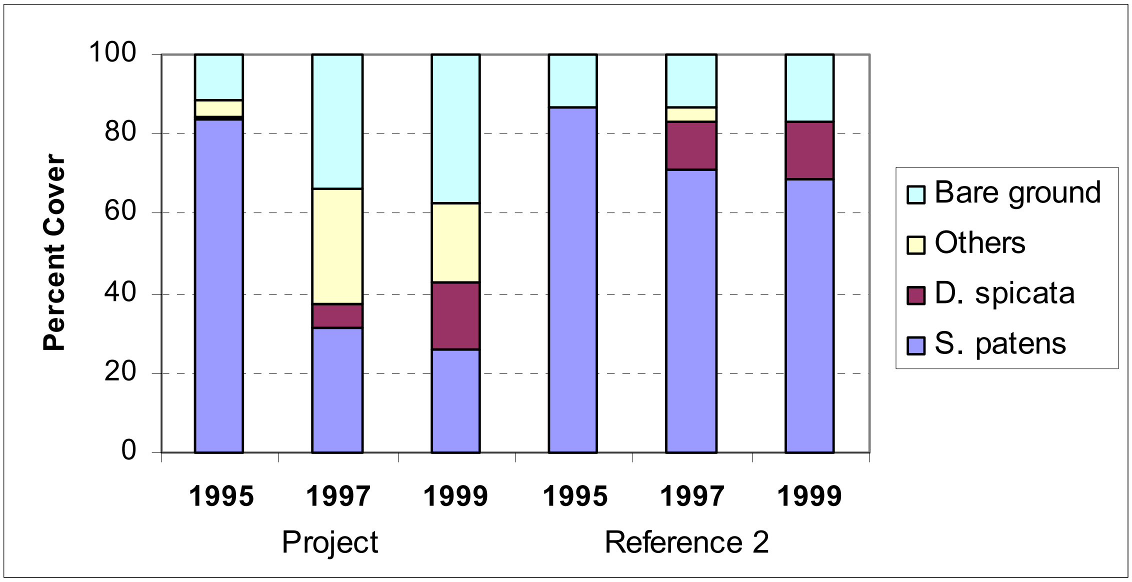

Figure 3. Change in vegetative cover of the project and reference sites from 1995 to 1999.

Is the project changing in the direction of the optimal landscape? If not, what is the most likely reason?
The land:water ratio for the project area was monitored in 1994 pre-construction and will be obtained in 2000, 2006, and 2012 post-construction. The land:water ratio was 41.9% land and 58.1% water in 1994 (Table 2). This compares with 1953, 1983, and 1992 land:water estimates of 99:1, 60:40, and 57:13 (excluding Mud Lake), respectively, obtained from USDA-SCS (1992) and the WVA (1992). The 2000 land:water analysis was completed in May 2002. As part of the "brown marsh" investigations, photography was flown in September of 2000. Visual observations of the unrectified 2000 photography with the 1994 photography suggest that small marsh islands within larger open water areas have been lost, with larger contiguous areas remaining fairly stable.

Table 2. Land to water ratios for the Mud Lake project and reference areas based on photography taken in 1994 and 2000. Numbers taken from draft habitat analysis provided by USGS.

	CTU 1	CTU 2	Reference 1	Reference 2
1994	28.9 L : 71.1	57.7 L : 42.3	56.6 L : 43.3	60.8 L : 39.2
2000	27.8 L : 72.2	61.8 L : 38.2	56.9 L : 43.1	60.3 L : 39.7

Habitat classification of the project area in 1994 pre-construction identified 2,827 acres of brackish marsh and 137 acres of wetland scrub-shrub as the predominant classes. Habitat classification post-construction was completed in May 2002. Chabreck-Linscombe habitat classifications conducted in 1988, 1997 and 2001 covered the project area. The 1988, 1997, and 2001 classification was almost identical, with approximately 100% brackish marsh. Less than 1% intermediate marsh was identified in the southwest project area in the 2001 classification. Salinity data as discussed previously is consistent with this classification.

The project is maintaining the landscape as brackish marsh since construction. Observations from the unrectified 2000 color-infrared photography suggests the landscape is not changing as rapidly post project construction as what occurred from 1983 to 1994.

The data suggests that the reference areas are remaining stable. CTU 1, which contains Mud Lake is experiencing some land loss, possibly from to shoreline erosion due to fetch across the lake. CTU 2 experienced a gain of approximately 4% land suggesting that it has recovered from the drought of 1996. A number of species replacing *Spartina patens* and colonization of pond edges with *Paspalum vaginatum* may account for this gain.

V.2.3. Other

Describe any other biological characteristics of the project that have bearing on the projects' success.

A question was brought up whether or not fisheries would be impacted and whether that would have an impact on the projects' success. In this project the pre-existing conditions were water control structures that were broken and silted-in. These structures were replaced with larger structures and the number of structures was increased. If anything, the fisheries impact would be assumed to be much more favorable with project features in-place.

V.3. Suggestions for biological response monitoring

Are there other variables that could be monitored to substantially increase the ability to understand the results of the project?

Soil salinity and hydrogen sulfide measurements are essential to look at soil toxicity that can occur with large ranges in water levels, such as what has occurred on this project. Spot imagery at 10m resolution could also provide a quick evaluation of landscape integrity as an interim measure between habitat analyses. One pre-construction and three post-construction analyzes of habitat changes are temporally insufficient to adaptively evaluate landscape changes over time. Fisheries monitoring is also being utilized on this project, thereby allowing a wider range than usual of the biological response being documented.

VI. ADAPTIVE MANAGEMENT

VI.1. Existing improvements

What has already been done to improve the project?
The structure operations were modified according to actual marsh elevation. Observations of excessive water retention, and slow drainage after high water events as well as large areas of dead Spartina patens in CTU lead monitoring manager to initiate an elevation survey. The biologists did our own survey in an area of extensive dieback of S. patens and found marsh level to be 1.0 ft NAVD. John Chance did their survey and found marsh elevation in all of CTU 2 to be 1.01 ft NAVD. At this point, the project manager, monitoring manager and structure operator changed operations to reflect the true value for marsh elevation.

VI.2. Project effectiveness

Are we able to determine if the project has performed as planned? If not, why?
A great deal has been learned from this project. It is difficult to determine if the project is working or not working due to extremes in weather and vandalism at a critical structure. However, operations have been adapted to these conditions.

What should be the success criteria for this project?
Emergent vegetative recovery, maintaining water level targets, and moderate to rapid drainage of water after flooding events. Specific targets need to be established for each variable monitored to establish success for meeting specific goals. For example, instead of "Decrease the rate of marsh loss" we could say maintain an average annual percent marsh loss less than a certain percentage.

VI.3. Recommended improvements

What can be done to improve the project?
Continue intensive monitoring and respond faster to maintenance of structures. Oversee operation of structures. Streamline the process such that when a problem is identified by the monitoring manager and brought to the attention of the project manager, it is addressed and repair is contracted and constructed in a timely manner. Minimize delays if possible.

VI.4. Lessons learned

See NRCS Post Construction meeting notes for lessons learned in construction and design and for recommendations for future structures.

In a brackish marsh, prevent ponds from drying out completely, even if outside water salinity is high. Reference area vegetation suffered less loss of cover and recovered more quickly than the project area even though it was exposed to salinities as high as the project area, however the project area was showing increased diversity as a result of freshening and therefore may have been more intolerant to elevated salinity levels.

VII. SUPPORTING DOCUMENTATION

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APPENDIX A: INFORMATION CHECK SHEET

Project Name and Number: East Mud Lake, CS-20
Date: 08Mar2002

INFORMATION TYPE	YES	NO	N/A	SOURCE/COMMENTS
Fact Sheet	X			John Jurgensen, NRCS
				PPL-3 Report to Congress
Project Description	X			John Jurgensen, NRCS
Project Information Sheet	X			John Jurgensen, NRCS
Wetland Value Assessment	X			John Jurgensen, NRCS
Environmental Assessment	X			John Jurgensen, NRCS
Project Boundary				Candidate list, WVA,
				John Jurgensen, NRCS
Planning Data	X			John Jurgensen, NRCS
				Preliminary structure sizing
Landrights	X			boundary changed due to Landowner input
Preliminary Eng. Design	X			John Jurgensen, NRCS
Geotechnical	X			John Jurgensen, NRCS
				Wasn't used in planning
Engineering Design	X			John Jurgensen, NRCS
As-built Drawings	X			John Jurgensen, NRCS
Modeling Output	X			John Jurgensen, NRCS
				Engineering (rating curves)
Construct Completion Report			X	
Engineering Data		X		
Monitoring Plan	X			Carl Vincent, DNR
Monitoring Reports	X			Carl Vincent, DNR
Supporting Literature	X			Sabine Data, DNR
Monitoring Data	X			Carl Vincent, DNR
Operations Plan	X			Garrett Broussard, DNR
Operations Data	X			Garrett Broussard, DNR
Maintenance Plan	X			Garrett Broussard, DNR
Maintenance Data	X			Garrett Broussard, DNR
O&M Reports	X			Garrett Broussard, DNR
Permit	X			Donna Weifenbach, DNR
Landowner data				Donna Weifenbach, DNR