MONITORING PLAN

PROJECT NO. C/S-21 LA. HIGHWAY 384 HYDROLOGIC RESTORATION

ORIGINAL DATE: December 11, 1996
REVISED DATE: July 23, 1998
SECOND REVISION DATE: January 4, 2000

Preface

Pursuant to a CWPPRA Task Force decision on April 14, 1998, the original monitoring plan was modified to conform with monitoring of projects of similar type. Specifically, submersed aquatic and emergent vegetation will be monitored every three years post-construction and water level and salinity will be monitored continuously through 2002. Upon collection and evaluation of the water level and salinity data set, the Technical Advisory Group (TAG) will determine if additional data collection is necessary. If additional monitoring is recommended, funds will be solicited.

Pursuant to a decision made on November 9, 1999 by the Natural Resources Conservation Service and the Louisiana Department of Natural Resources, the project area boundary was revised to exclude the northernmost third of CTU 1 and all associated structural measures due to landrights constraints. The monitoring plan was modified to reflect changes in reference areas and elimination of shoreline change monitoring.

Project Description

The La. Highway 384 Hydrologic Restoration project (State project No. C/S-21, CWPPRA project no. PC/S-25) is comprised of 935 ac (374 ha) of deteriorated wetlands located along the northeast shoreline of Calcasieu Lake in Cameron Parish (figure 1). The project area is bounded by Calcasieu Lake to the west, the Gulf Intracoastal Waterway (GIWW) to the east, and higher elevation prairie formations to the north and south.

The La. Highway 384 Hydrologic Restoration plan subdivides the project area (figure 1) into three Conservation Treatment Units (CTU's). CTU 1, which extends from Calcasieu Lake easterly to the La. Highway 384 embankment, includes 250 ac (100 ha) of open water and brackish marsh. A shell oilfield access road forms its northern boundary and prairie formations form its southern boundary. CTU 2 includes 226 ac (90 ha) of open water and intermediate marsh. This unit extends easterly from the La. Highway 384 embankment. The northern boundary of CTU 2 is the prairie formation on which the community of Grand Lake is located. A continuous oil field road embankment joins the prairie formations north and south of the project area and forms the remainder of the southern and eastern boundaries of CTU 2. CTU 3 lies between CTU 2 and the GIWW and includes 459 ac (184 ha) of intermediate marsh.

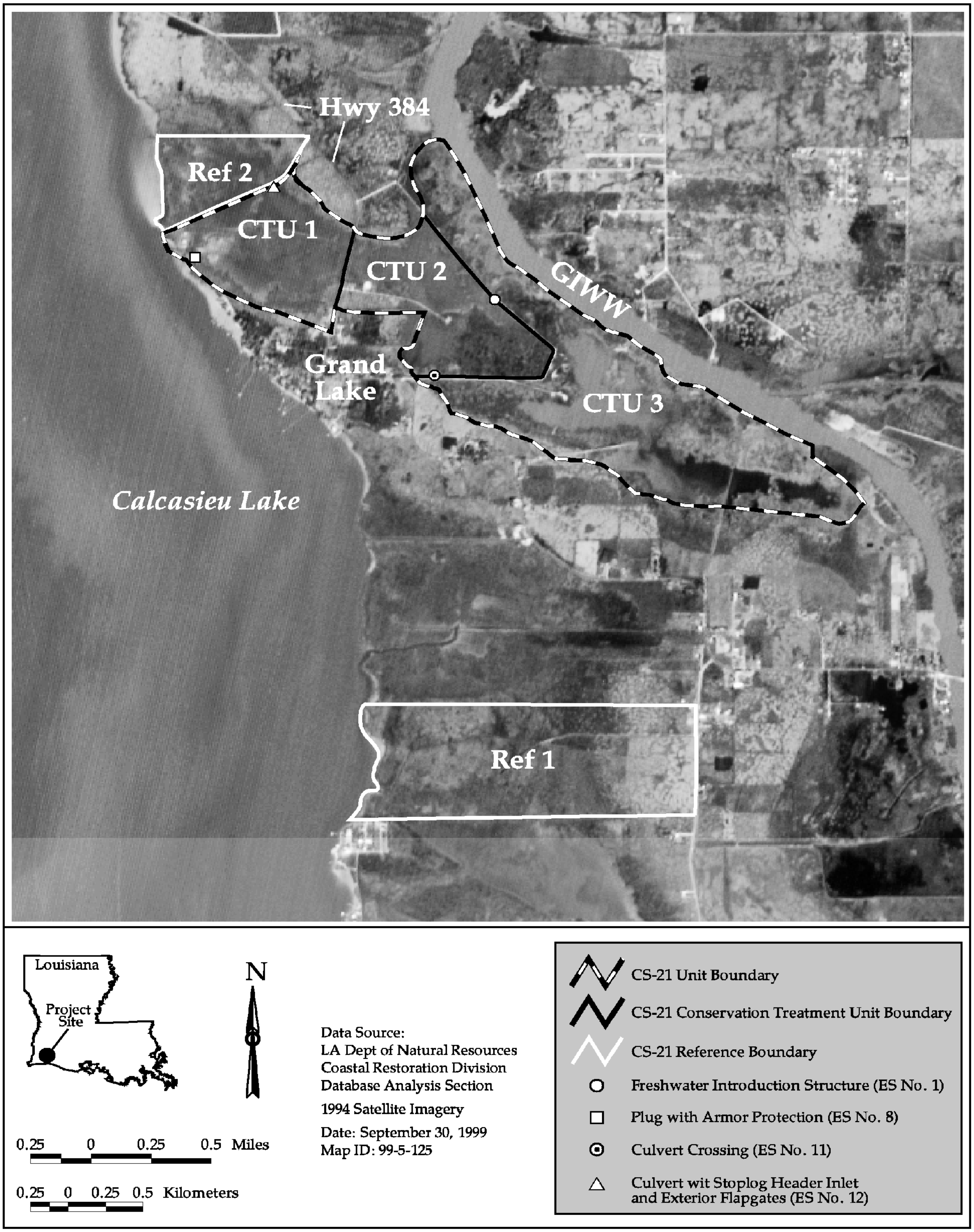

Figure 1. Louisiana Highway 384 Hydrologic Restoration (CS-21) project and reference areas, and locations of proposed project features.

Historically, the western portion of the project area was intermediate marsh with slightly brackish marsh immediately adjacent to Calcasieu Lake (USDA/NRCS 1995, 1996a, 1996b). The eastern portion of the project area was fresh marsh up to the GIWW. In the late 1980's, Chabreck and Linscombe (1988) characterized the La. Highway 384 wetlands as brackish and intermediate. CTU 1 is currently classified as brackish marsh, and CTU's 2 and 3 are classified as intermediate marsh. CTU's 1 and 2 are exposed to greater tidal energy than CTU 3, to the extent that pond bottoms in CTU's 1 and 2 are regularly exposed on very low tides. CTU 3 is generally exposed to more stable water levels and lower salinity regimes than CTU's 1 and 2, but regularly experiences higher salinity that can be detrimental to the salt-intolerant species common in fresh and intermediate marsh habitats.

Increased tidal volumes, enlargement of tidal exchange routes, and salt water intrusion resulting from human-induced changes to the area's hydrology are the primary causes of wetland loss in the project area (Louisiana Coastal Wetlands Conservation and Restoration Task Force [LCWCRTF] 1993). The Calcasieu Ship Channel was constructed in 1941 and redredged to its current depth of 40 ft (12.2 m) and bottom width of 400 ft (122 m) in 1968 (Good et al. 1995). This channel radically altered the area's hydrology by increasing the height and duration of tidal fluctuations, which in turn increased water levels and saltwater intrusion into the low salinity marshes surrounding Calcasieu Lake (Suhayda et al. 1988). Spoil banks along the GIWW, which was constructed in the 1940's, have effectively blocked the project area's historical connection to the Mermentau River Basin, and now block off the major source of freshwater for the project area, the GIWW east of Calcasieu Lock. Construction of a drainage canal through the project area prior to 1940, and construction of an oil field road before 1963 both provided hydrologic exchange points connecting the fragile interior marsh soils of the project area to Calcasieu Lake (USDA/NRCS 1995, 1996a, 1996b).

Five soil types occur in the project area (U. S. Department of Agriculture, Soil Conservation Service [USDA/SCS] 1995). Gentilly muck, a poorly drained organic soil with an organic surface layer and an underlying alkaline layer, makes up 82% of the area. The remaining 18% consists of soils of the Mowata-Vidrine Series (8%) and Morey Series (6%) on the prairie formations, Aquents Series soils (4%) associated with spoil along canals, and Udifluvents Series soils (<1%) that comprise the bulk of the remaining spoil along the GIWW (USDA/NRCS 1995, 1996a, 1996b).

Hydrologic exchange between the project area and Calcasieu Lake allowed salt water to eradicate much of the non-salt tolerant emergent vegetation, exposing the fragile organic surface layer of the marsh soil to erosion and tidal scour. As a result, the organic surface layer has been largely transported out of the project area and into Calcasieu Lake. The loss in elevation of the soil surface provided by the organic surface layer of the soil has led to prolonged inundation of the emergent vegetation, which causes die-back of many wetland plant species (Mendelssohn and McKee 1988), and finally, the conversion of emergent marsh to open water (Gosselink et al. 1979).

Comparison of aerial photographs of the project area from 1940 to 1990 indicates that within this 50 yr period, 317 ac (127 ha) or 39% of the emergent marsh in the project area converted to open water (USDA/NRCS 1996a, 1996b), with most of the loss having occurred within CTU's 1 and 2. In 1940, the ratio of emergent marsh to open water in the project area was 91:9. By 1990, the ratio was 52:48. The greatest loss occurred between 1953 and 1963 when 205 ac (82 ha) or 26% of the emergent marsh converted to open water. Calcasieu Lake shoreline erosion has also contributed to the loss of vegetated wetlands in the project area, as shown by analysis of aerial photographs from 1940 to 1989. Erosion of the lake shoreline along the west side of CTU 1 averaged 9.18 ft/yr (2.8 m/yr) between 1940 and 1963, 18.48 ft/yr (5.6 m/yr) between 1963 and 1968, 9.24 ft/yr (2.8 m/yr) between 1968 and 1978, and 1.32 ft/yr (0.4 m/yr) between 1978 and 1989 (USDA/NRCS 1996a, 1996b). The retreat rate has decreased dramatically since the 1960's, down to approximately 0.1 ac/yr (0.03 ha/yr) between 1978 and 1989. Wind-driven wave erosion of interior pond shorelines has also contributed to the increasing acreage of open water in the project area.

The La. Highway 384 project plan includes structural measures designed to improve hydrologic conditions within the project area. By reducing rapid water exchange and salinity, future conditions in the project area will resemble the low-energy conditions under which these marshes were formed. Structural measures planned and their intended functions are listed below, along with their respective Evaluation Site (ES) locations, which are identified on figure 1.

1. Set of 3 culverts, each with a manual sluice gate on the exterior and a flapgate on the interior to provide controlled freshwater introduction from the GIWW (CTU perimeter levee at ES No. 1).

2. Approximately 95 ft (28 m) of armored plugs to reduce hydrologic exchange with Calcasieu Lake and to decrease tidal scour and salinity in the project area (existing exchange point at ES No. 8).

3. Set of 2 culverts, each with a variable-crested weir inlet and flapgated outlet to reduce and stabilize tidal ranges and salinity in project area south of the central shell road in CTU 1 (existing shell road at ES No. 12 in CTU 1).

4. Maintenance of approximately 10,000 ft (3 km) of existing road embankment to maintain the hydrologic barrier between CTU 2 and CTU 3 (existing embankment forming the southern and eastern perimeter of CTU 2).

5. Maintenance of 1 flow-through culvert to maintain an existing storm water drainage point for the adjacent prairie formation (existing perimeter embankment of CTU 2 at ES No. 11).

Project Objective

1. Protect and maintain approximately 935 ac (374 ha) of intermediate to brackish wetlands by reducing water level variability, thereby increasing the abundance of emergent vegetation. This will be achieved through structural modification of hydrological conditions.

Specific Goals

The following measurable goals were established to evaluate project effectiveness:

1. Decrease the rate of marsh loss in the project area.

2. Reduce water level variability within the project area.

3. Maintain salinity levels within CTU 1 at $\leq$ 10 ppt.

4. Maintain salinity levels in CTU 2 and CTU 3 within the 0–5 ppt target range for intermediate marsh vegetation.

5. Increase the coverage of emergent wetland vegetation and submersed aquatic vegetation (SAV) in shallow open water areas within the project area.

Reference Area

The importance of using appropriate reference areas cannot be overemphasized. Monitoring of both the project and reference areas provides a means to achieve statistically valid comparisons, and is therefore, the most effective way to evaluate project success. The main criteria for selecting reference areas are similarities in soil type, vegetation community, and hydrology to the project area.

Two small reference areas have been selected for monitoring this project. Reference Area 1 is comprised of 424 ac (170 ha) of deteriorated brackish marsh and open water located 2 mi (3.2 km) south of the community of Grand Lake along the east bank of Calcasieu Lake (figure 1). Reference Area 2 consists of approximately 106 ac (42 ha) of open water and deteriorated brackish marsh located along the north side of the shell road that forms the northern boundary of CTU 1.

The predominant soil type in the project area and both reference areas is Gentilly muck, with soils of the Mowata-Vidrine Series occurring on prairie formations in both areas (USDA/NRCS 1995, USDA/SCS 1995). The plant community in the project area and both reference areas consists mainly of *Juncus roemerianus* (black needlerush), *Spartina patens* (marshhay cordgrass), *S. alterniflora* (smooth cordgrass), and *Distichlis spicata* (salt grass).

Like the project area, the two reference areas include historically low salinity marshes that have been degraded by human-induced hydrological changes. The project area and both reference areas have experienced increased open water to emergent marsh ratios. Analysis of aerial photographs taken in 1940 shows an emergent marsh to open water ratio of 91:9 for the project area (USDA/NRCS 1995, 1996a, 1996b) and 85:15 for reference area 1 (USDA/SCS 1989). More recent aerial photography indicates that there was an emergent marsh to open water ratio of 59:41 for the project area in 1978 (USDA/NRCS 1995, 1996a, 1996b) and 20:80 for reference area 1 in 1980 (USDA/SCS 1989). The land to open water ratio in reference area 2 has followed a similar trend (United States Geological Survey, National Wetlands Research Center [USGS/NWRC and LDNR 1999) . In 1956, there was no significant open water area within reference area 2. However, the land to open water ratio was 43:64 in 1978, and 50:50 in 1988. Both reference areas have also experienced land loss due to wave erosion of the adjacent Calcasieu Lake shoreline.

Despite its greater land loss rate over the past 50 years, the marsh west of Grand Lake Ridge will serve as an adequate reference area for the La. Highway 384 project. This reference area will be monitored for marsh loss, water level, salinity, emergent vegetation, SAV, and erosion along the Calcasieu Lake shoreline for comparison with data collected on these parameters in the project area.

The main limitation with the selected reference areas is that since they are tidal, brackish systems, they are comparable to CTU 1 and CTU 2 of the project area, but not to CTU 3, which is an intermediate marsh area that is not regularly influenced by tides. Examination of recent aerial photography of the area and consultation with the USDA/NRCS District Conservationist in Lake Charles, Louisiana (Midkiff 1996) did not result in the location of a suitable reference area for CTU 3. However, in light of the restoration features planned and their projected benefits, the proposed project will have minimal influence on CTU 3, so the lack of a suitable reference area is not critical to project monitoring. Project implementation is expected to result in significant increases in the acreage of emergent vegetation and SAV in CTU's 1 and 2, where mean salinity and water level variability are expected to be reduced. The main benefit of project implementation on CTU 3 will be the maintenance of intermediate marsh conditions in that unit. In lieu of an intermediate marsh reference area for comparison with CTU 3, salinity, water level variability, emergent vegetation, and SAV data collected in CTU 3 will be analyzed for significant changes over time, using a paired t-test and/or ANOVA.

Monitoring Elements

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

1. Habitat Mapping — To document land and water areas, and marsh loss rates, near-vertical, color-infrared aerial photography (1:12,000 scale, with ground controls) will be obtained in 1997 prior to construction, and for post-construction years 2002 and 2011. The photography will be photointerpreted, scanned, mosaicked, georectified, and analyzed by National Wetlands Research Center (NWRC) personnel according to the standard operating procedure described in Steyer et al. (1995).

2. Water Level

To monitor hydrologic conditions within the project and reference areas, water level variability will be monitored at least monthly at permanent discrete sampling stations within the project and reference areas, and by reading staff gauges installed inside and outside of the project area near the two proposed water control structures. In addition, four continuous data recorders will be deployed, one in each project area CTU (3 total), and one in Reference Area 1, to collect hourly water level data. To document the frequency, magnitude, and duration of head differences conducive to freshwater introduction into the project from the GIWW, the data recorders in CTU's 2 and 3 will be deployed near the freshwater introduction structure at ES 1, one on each side of the structure.

Upon collection of data (i.e., monthly readings from discrete stations and hourly readings from continuous data recorders) from 1997-2002, the Technical Advisory Group (TAG) will assist the Coastal Restoration Division (CRD) monitoring manager with evaluation of the data and determination of whether additional water level data collection is necessary. If additional monitoring is recommended, funds will be solicited.

Discrete and continuous data recorder stations may be added to or removed from the project and reference areas as data becomes available and a power analysis can be performed. Water level data will be used to document the variability in water level in the project and reference areas.

3. Salinity

Salinity will be monitored monthly at permanent discrete sampling stations within the project and reference areas. In addition, four continuous data recorders will be deployed to record salinity data, one in each project area CTU (3 total), and one in Reference Area 1.

Upon collection of data (i.e., monthly readings from discrete stations and hourly readings from continuous data recorders) from 1997-2002, the TAG will assist the CRD monitoring manager with evaluation of the data and determination of whether additional water level data collection is necessary. If additional monitoring is recommended, funds will be solicited.

Discrete and continuous data recorder stations may be added or removed within the project and reference areas as data becomes available and a power analysis can be performed. Salinity data will be used to characterize the spatial variation in salinity throughout the project area, and to determine if project area salinity is being maintained within the target range.

4. Emergent Vegetation — To document the condition of the emergent vegetation in the project area over the life of the project, vegetation will be monitored at a maximum of 30 sampling stations established uniformly along transect lines across the wetlands in the project and reference areas. The number of sampling stations established in each project area CTU and in the reference area will be proportional to the acreage of each unit, with a minimum of 5 sampling stations per unit allowed. At each sampling station, percent cover, species composition, and dominant plant heights will be documented in a 2.0 m^2 sampling plot marked with one corner poles to allow for revisiting each site over time. Vegetation will be evaluated at the sampling sites once pre-construction in 1997, and in post-construction years 2002, 2005, 2008, 2011, 2014, and 2017.

5. Submersed Aquatic Vegetation — To document changes in the frequency of occurrence of SAV in the project area, SAV will be monitored using the rake method (Chabreck & Hoffpauir 1962, Nyman and Chabreck 1996). Within each study area (CTU 1, CTU 2, CTU 3, and the reference area), 2 ponds will be sampled for presence or absence of SAV at 25 random points within each pond. Species composition and frequency of occurrence (frequency = number of occurrences/25 x 100) will be determined. SAV will be monitored during the fall (October or November) once preconstruction in 1996, and in postconstruction years 2002, 2005, 2008, 2011, 2014, and 2017.

6. Soil Characteristics — To characterize soil conditions and document changes over time, soil samples will be collected from the sampling plots to be established in the project and reference areas to monitor emergent vegetation, and analyzed for bulk density, percent organic matter, and soil salinity. Soil condition will be monitored concurrently with the emergent vegetation, once pre-construction in 1997, and in post-construction years 2005 and 2014.

Anticipated Statistical Analyses and Hypotheses

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

1. Habitat mapping. Descriptive and summary statistics on historical data (for 1956, 1978, 1988, and for any subsequent years) and data from aerial photography collected pre- and post-construction will be used, along with GIS interpretations of these data sets, to evaluate marsh to open water ratios and changes in the rate of marsh loss/gain in the project area. GIS interpretations of the aerial photography may also be used in the analyses of emergent vegetation.

   Goal: Decrease the rate of marsh loss in the project area.

2. <u>Water level variability</u>. Appropriate parametric and/or nonparametric statistical tests will be used to test the following hypotheses.

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

Hypotheses:

H_0: Annual water level variability within the project area postconstruction will not be significantly lower than annual water level variability within the reference area postconstruction.

H_a: Annual water level variability within the project area postconstruction will be significantly lower than annual water level variability within the reference area postconstruction.

Hypotheses:

H_0: Annual water level variability within the project area postconstruction will not be significantly lower than annual water level variability within the project area preconstruction.

H_a: Annual water level variability within the project area postconstruction will be significantly lower than annual water level variability within the project area preconstruction.

3. <u>Salinity and salinity variability</u>. Appropriate parametric and/or nonparametric statistical tests will be used to test the following hypotheses.

Goal: Maintain mean salinity within CTU 1 at $\leq$10 ppt after construction.

Hypotheses:

H_0: Mean salinity within CTU 1 will not be maintained at $\leq$ 10 ppt postconstruction.

H_a: Mean salinity within CTU 1 will be maintained at $\leq$ 10 ppt postconstruction.

Goal: Maintain mean salinity within CTU 2 and CTU 3 at $\leq$ 5 ppt after construction.
Hypotheses:

H_0: Mean salinity within CTU 2 and CTU 3 will not be maintained at $\leq$ 5 ppt postconstruction.

H_a: Mean salinity within CTU 2 and CTU 3 will be maintained at $\leq$ 5 ppt postconstruction.

4. Emergent vegetation. Appropriate parametric and/or nonparametric statistical tests will be used to test the following hypotheses.

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

Hypotheses:

H_0: Occurrence of emergent marsh vegetation within the project area postconstruction will not be significantly greater than the occurrence of emergent marsh vegetation in the reference area postconstruction.

H_a: Occurrence of emergent marsh vegetation within the project area postconstruction will be significantly greater than the occurrence of emergent marsh vegetation in the reference area postconstruction.

Hypotheses:

H_0: Occurrence of emergent marsh vegetation within the project area postconstruction will not be significantly greater than the occurrence of emergent marsh vegetation in the project area preconstruction.

H_a: Occurrence of emergent marsh vegetation within the project area postconstruction will be significantly greater than the occurrence of emergent marsh vegetation in the project area preconstruction.

5. Submersed Aquatic Vegetation. Appropriate parametric and/or nonparametric statistical tests will be used to test the following hypotheses.

Goal: Increase the mean frequency of occurrence of SAV.

Hypotheses:

H_0: Mean frequency of occurrence of SAV will not be greater in the project area than in the reference area postconstruction.

H_a: Mean frequency of occurrence of SAV will be greater in the project area than in the reference area postconstruction.

Hypotheses:

H_0: Mean frequency of occurrence of SAV within the project area will not be greater postconstruction than preconstruction.

H_a: Mean frequency of occurrence of SAV within the project area will be greater postconstruction than preconstruction.

Notes

1. Implementation: Start Construction: September 20, 1999
   End Construction: January 4, 2000

1.	Implementation:	Start Construction:	September 20, 1999
		End Construction:	January 4, 2000
2.	NRCS Point of Contact:	Loland Broussard	(318) 896-8503
3.	DNR Project Manager:	Garrett Broussard	(318) 893-8763
	DNR Monitoring Manager:	Karl A. Vincent	(318) 893-2246
	DNR DAS Assistant:	Laura T. Aucoin	(225) 342-0242

4. The twenty year monitoring plan development and implementation budget for this project is $394,931. Progress reports will be available in January 2001, and comprehensive reports will be available in January of years 2003, 2006, 2009, 2012, 2015 and 2019. These reports will describe the status and effectiveness of the project.

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