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Department of Natural Resources
Coastal Restoration Division and
Coastal Engineering Division

2004 Operation, Maintenance, and Monitoring Report

for

Highway 384 Hydrologic Restoration

State Project Number CS-21
Priority Project List 2

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Cameron Parish

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For
Hwy 384 Hydrologic Restoration (CS-21)

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I. Introduction

The Highway 384 Hydrologic Restoration project area contains 935 ac (378 ha) of deteriorated wetlands located along the northeast shoreline of Calcasieu Lake in Cameron Parish. 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 project area (figure 1) is divided into three Conservation Treatment Units (CTUs). CTU 1 extends from Calcasieu Lake easterly to the La. Highway 384 embankment and includes 250 ac (101 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 (91 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 (186 ha) of intermediate marsh. 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.

Two small reference areas have been selected for monitoring this project. Reference Area 1 (R1) is comprised of 424 ac (172 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 (R2) consists of approximately 106 ac (43 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 objective of the project is to protect and maintain approximately 935 ac (378 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 hydrologic conditions. Construction for the Highway 384 Hydrologic Restoration Project began on October 20, 1999 and was completed on January 4, 2000.

The principal project features include:

1. Set of 3 culverts (ES-1), each with a manual sluice gate on the exterior and a flap gate on the interior to provide controlled freshwater introduction from the GIWW (CTU 2/CTU 3 perimeter levee).

2. Approximately 95 ft (28 m) of armored plug (ES-8) to reduce hydrologic exchange with Calcasieu Lake and to decrease tidal scour and salinity in the project area (existing exchange point in CTU 1).

3. Set of 2 culverts (ES-12), each with a variable-crested weir inlet and flap gated outlet to reduce and stabilize tidal ranges and salinity in project area south of the central shell road in CTU 1 (existing shell road along north side of 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 southern and eastern perimeter embankment of CTU 2).

5. Maintenance of 1 flow-through culvert (ES-11) to maintain an existing storm water drainage point for the adjacent prairie formation (existing southern perimeter embankment of CTU 2).

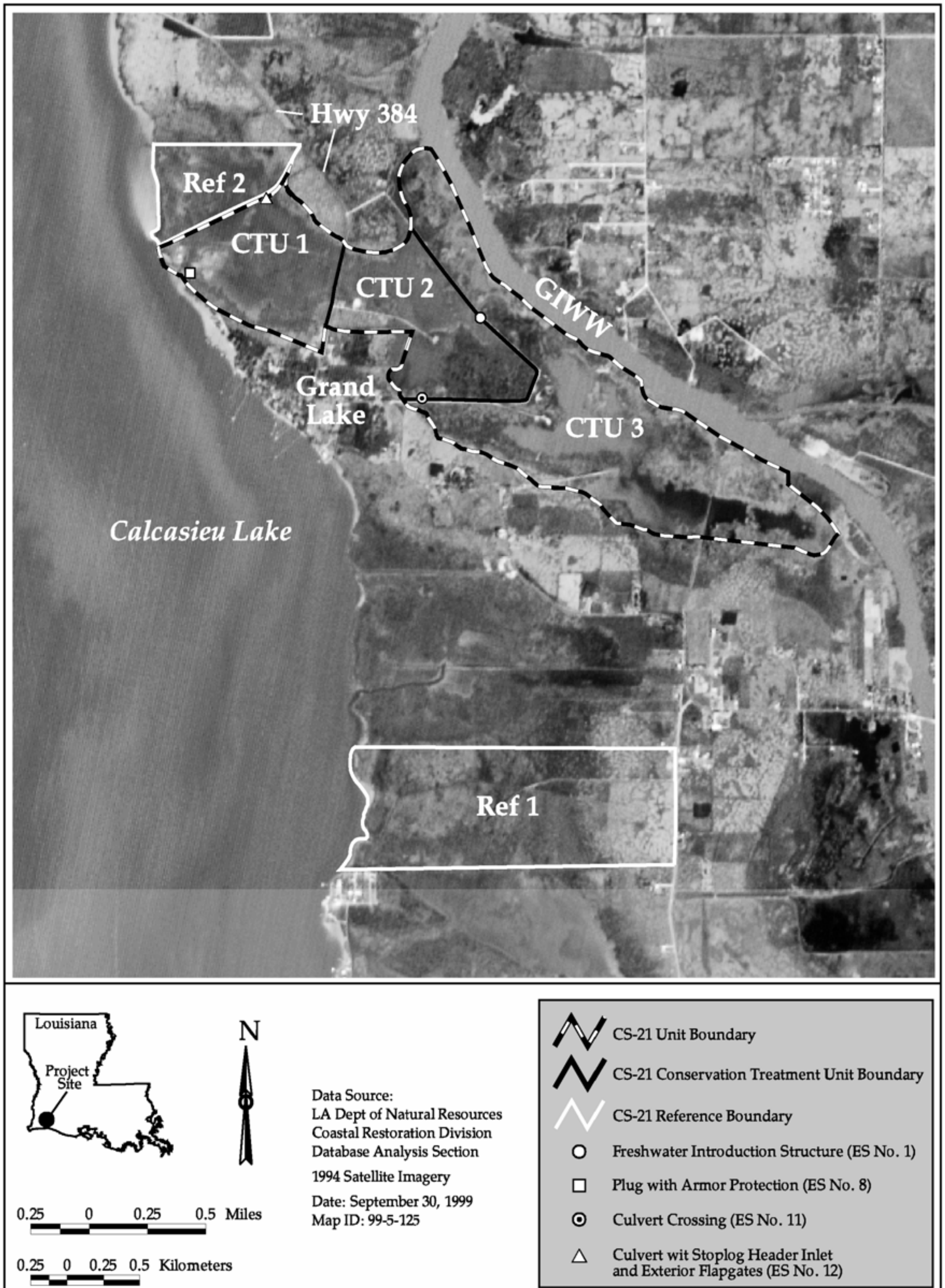

Figure 1. Highway 384 Hydrologic Restoration (CS-21) project and reference area boundaries and features.

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the annual inspection of the Highway 384 Hydrologic Restoration Project (CS-21) is to evaluate the constructed project features to identify any deficiencies and prepare a report detailing the condition of project features and recommended corrective actions needed. Should it be determined that corrective actions are needed, LDNR shall provide, in the report, a detailed cost estimate for engineering, design, supervision, inspection, and construction contingencies, and an assessment of the urgency of such repairs (LDNR 2003). The annual inspection report also contains a summary of maintenance projects, if any, which were completed since completion of constructed project features and an estimated projected budget for the upcoming three (3) years for operation, maintenance and rehabilitation.

b. Inspection Results

Structure #1

The structure is in excellent condition. Water levels were +1.2 NAVD on the inside and +1.3 NAVD on the outside. Rock placed on the bank during the maintenance of June 2002 is stable and in no need of repair. The hyacinth fence is in excellent condition. The road/levee leading up to the structure shows no specific sites where scouring is occurring. No maintenance is required at this site.

Structure #12

The structure is in very good shape. Water levels were +1.25 NAVD on the inside and +0.85 NAVD on the outside. There are slight depressions in the road approximately 200 feet east of the structure. These depressions appear to be the result of settling rather than water flow over the road. Pile caps on the inlet side and the padlocks on the stop log locking devices have rusted and will eventually need to be replaced. Rock that was placed during the maintenance of Nov. 2000 is stable. No other maintenance is required at this time.

Structure #8

Water levels on the inside were +1.2 NAVD and +0.8 NAVD on the outside. Dirt that was placed over the rock plug in June 2002 is completely gone. The gap in the rock plug caused by vandals is approximately the same as it was before the maintenance. There was some concern by DNR monitoring personnel that high tides were overtopping the marsh along the Calcasieu Lake shoreline allowing high salinity water to enter the project area. A survey was performed by Lonnie Harper & Associates at a cost of $3,344.50 to assess the situation. Lowest elevations located along the shoreline were approximately 2.5' NAVD 88.

Overall, the Highway 384 Hydrologic Restoration Project is in good condition and functioning as designed with only minor problems noted. The hyacinth fence that was installed during the maintenance project of June 2002 as well as the rock reinforcement of the bankline is performing well and should be incorporated into all structures of this type in the future.

c. Maintenance Recommendations

i. Immediate/ Emergency Repairs

Replace the cap of the rock plug (Structure #8) that was vandalized.
Place a 4' thick plug on the marsh side of the rock plug to elevation +3.0 NAVD88. Material to be used shall consist of 1,000 lb. rock for damage repair, and 400 lb. C stone for prevention of water flow. This maintenance work is proposed to be performed in May, 2005.

ii. Programmatic/ Routine Repairs

N/A

d. Maintenance History

i. Rock plug was repaired

ii. Hyacinth fence installed.

iii. Graded crushed stone installed on roads.

III. Operation Activity

a. Operation Plan

"WATER MANAGEMENT SCHEMES"

ES #1 Structure - 3-24" Aluminum culverts with Interior 24" Flapgates and Exterior 24" Sluice Gates.

	Culvert #1		Culvert #2		Culvert #3	
Water Level\1	Sluice	Flap	Sluice	Flap	Sluice	Flap
< +0.2' ML\2	open	down	open	down	open	down
> +0.2' ML	close	down	close	down	close	down

\1 - Average Water Level in CTU #2.

\2 - Average Marsh Level (approx. 1.1' msl).

NOTE: When salinities at ES #12 exceed 10 ppt, the ES #1 structure will be operated to allow maximum flow of freshwater into the project area. Normal structure operations are to resume when salinities fall below 10 ppt.

ES #12 Structure- 2-48" Aluminum Culverts, each w/ an Interior 10' Variable-Crested Weir Inlet with a 4" vertical slot and an Exterior 48" Flapgate.

	Culvert #1			Culvert #2		
Salinity*	Flap	Stoplog+	Slot	Flap	Stoplog	Slot
< 7 ppt	open	-24"	open	open	none	open
7 - 10ppt	down	-6"	open	open	none	open
> 10 ppt	down	-6"	open	down	-12"	open

* Salinity will be monitored on the northern side of the shell road at site #12.

+ Stoplog elevations relative to average marsh level (approx. 1.1' msl). "None" refers to removal of all stoplogs.

b. Actual Operations

The only operation during the year was on October 29, 2004 when one stop log was removed from each of the four bays on structure ES 12. This action was taken due to high salinity.

The contract with Simon and DeLany Resource Management, L.L.C. will be renewed for the coming year for the operation of the structures and data gathering.

IV. Monitoring Activity

a. Monitoring Goals

The objective of the Highway 384 Hydrologic Restoration Project is to protect and maintain 935 ac (378 ha) of intermediate and brackish wetlands by reducing water level variability, thereby increasing the abundance of emergent vegetation.

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

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 ≤ 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.

b. Monitoring Elements

Habitat Mapping

Near-vertical, color-infrared aerial photography (1:12,000 scale, with ground controls) was used to measure vegetated and non-vegetated areas for the project and reference areas. The photography was obtained preconstruction for the project area and reference area 2 in December 1996 and again in January 1997 due to overexposed frames. In March 1997, R1 was flown. Post-construction photography was obtained December 15, 2002. 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 the standard operating procedures (Steyer et al, 1995, revised 2000). No additional post-construction photography is scheduled.

Salinity

Water salinity was monitored monthly at 29 discrete sampling stations within the project and reference areas and at four continuous recorders in each of the project areas (CTUs 1-3) and reference areas R1 and R2 (figure 2). The recorders were deployed in May 1997 to log hourly salinity.

Water Level

Water level was monitored monthly at the same discrete sampling stations as salinity and at staff gauges installed inside and outside of the project area near the two CS-21 project water control structures. The four continuous data recorders that were deployed in May 1997 to recorded hourly water level in the three project areas and in R1. These data are available in raw and graphic formats. 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 2 & 3 were deployed near the freshwater introduction structure, one on each side of the structure (figure 2). All four recorders were surveyed to NAVD 88.

Emergent Vegetation

Vegetation was monitored at a maximum of 30 sampling stations established uniformly along transects in the project and reference areas (CTU 1, CTU 2, CTU 3, R1, and R2). At each sampling station, percent cover, species composition, and dominant plant height was documented in a 2m x 2m sampling plot marked with a pole in the southeast corner of the plot to allow for revisiting each site over time. Vegetation was evaluated at the sampling sites pre-construction in 1997, and post-construction in 2002. No additional vegetation sampling is scheduled.

Submersed Aquatic Vegetation (SAV)

SAV was monitored using the modified rake method (Chabreck and Hoffpauir 1962, Nyman and Chabreck 1996). Within each study area (CTU 1, CTU 2, CTU 3, and R2), 2 ponds were sampled for presence or absence of SAV at 25 random points within each pond. Species composition and frequency of occurrence [freq = (n occurrences SAV species / n total sampling points)*100] were determined. SAV was monitored once pre-construction in October 1996 and once post-construction in September 2002. No additional SAV sampling is scheduled.

Soil Characteristics

Soil samples were collected from the emergent vegetation sampling plots established in the project and reference areas and analyzed for bulk density, percent organic matter, and soil salinity. No additional soil sampling is scheduled

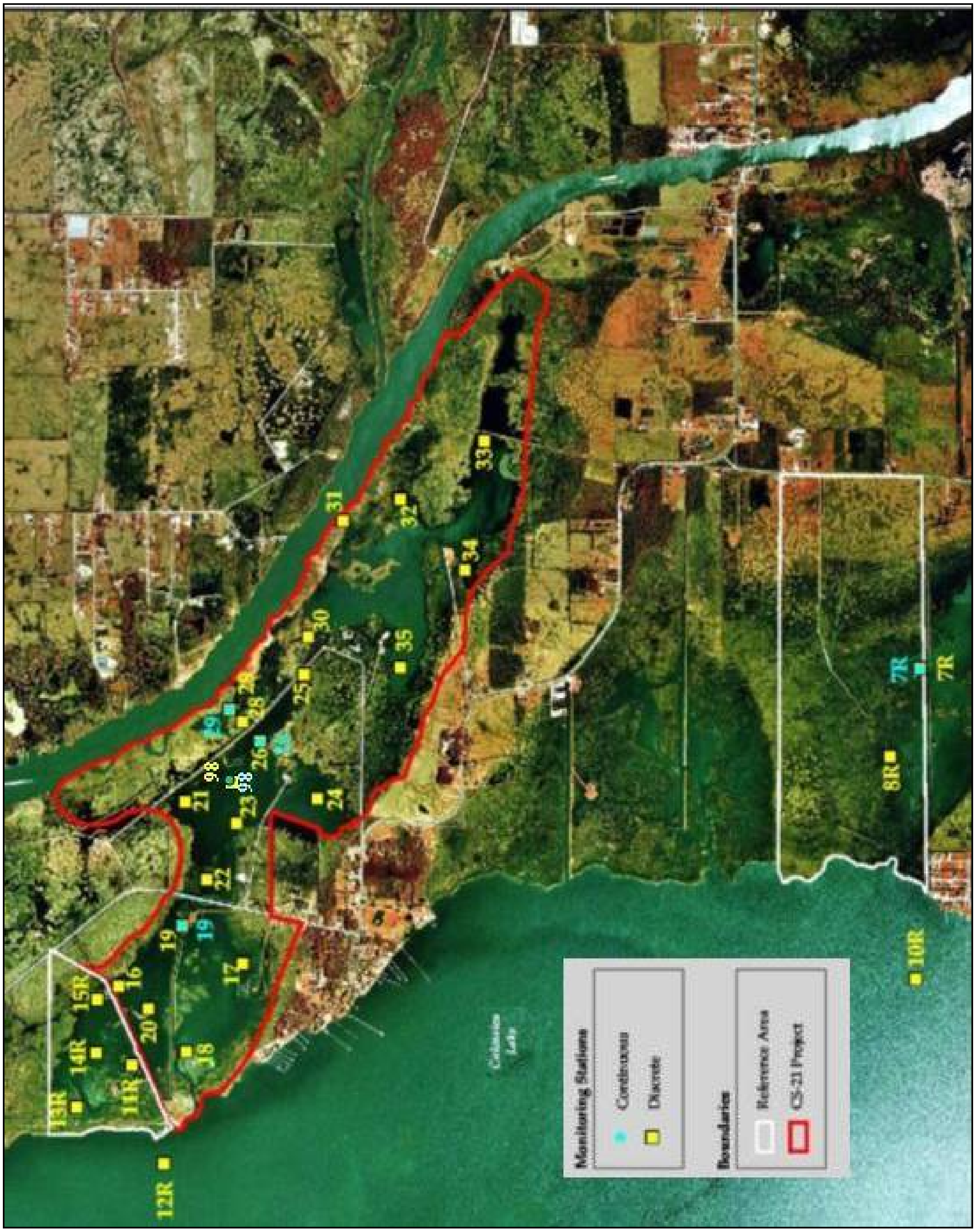

Figure 2. Location of continuous recorders and discrete water quality stations for Highway 384 Hydrologic Restoration (CS-21).

IV. Monitoring Activity (continued)

c. Preliminary Monitoring Results and Discussion

Habitat Mapping

Photography of the project area was obtained by USGS in 1997 and 2002 (figures 3 and 4). The two flights showed a modest increase in the percentage of each area that can be considered land (table 1, figure 5). The greatest increase in land was in CTU 3 where there was an increase of 4.2%. The total increase for the project areas combined was 3.4% while the reference areas collectively increased by 1.7%. Percent land increased in both the project and reference areas. The increases were small in both the project and reference areas although they were larger in the project areas. The 1997 percent land was subtracted from the 2002 percent land for each unit and project units were compared to reference units with a t-test. The test revealed that there was no significant difference between the project and reference in percent land increase ($F_{1, 4}$=3.79, p=0.1469).

Salinity and Water Level

Hourly salinity and water level data have been collected at the following continuous recorder stations:

Station	Period of data collection
CS21-19 (CTU 1)	January 1997 – December 31, 2003
CS21-26 (CTU 2)	January 1997 – January, 2002
CS21-98 (CTU 2)	January 2002 – December 31, 2003
CS21-29 (CTU 3)	January 1997 – December 31, 2003
CS21-07R (R1)	January 1997 – December 31, 2003

Due to low water levels, the recorder at CS21-26 was no longer able to function properly and was replaced by CS21-98 and moved approximately 100 yards north.

The project goals for salinity were to maintain salinities in a target range of 0-10 ppt in CTU 1 and 0-5 ppt in CTU 2 and CTU 3. Comparison of the percentages of time salinities were within the target range before and after construction (by years) in CTU 1 and R1 showed that the reference area has been above 10 ppt at least 30% of the year (1999) and up to 80% of the year (2000) from 1997 to 2003 (figure 6). Before construction (which was completed in early January, 2000), salinities in R1 and CTU 1 followed the same trend relative to the 10 ppt target level most of the time. In 2000 both units were inundated with salinities above the target range for CTU 1 over 80% of the time due to drought conditions. Following 2000, the project seems to have had an affect on salinities in CTU 1 as the amount of time water was above the target range has decreased in CTU 1 and the two units have ceased to follow the same trends. Closer management of the structure in accordance with a water management plan of closing the gates when salinities outside are more than 7 ppt would help bring the amount of time outside the target range in CTU 1 down even further which should help to achieve the overall project goal of protecting and maintaining intermediate and brackish marsh in the project area.

The project goals for salinity in CTU 2 and CTU 3 were to maintain salinities in a target range of 0-5 ppt. Comparisons of the percentage of time salinities were within the target range in those units showed a similar trend to CTU 1. Salinities in the reference area were above 5 ppt

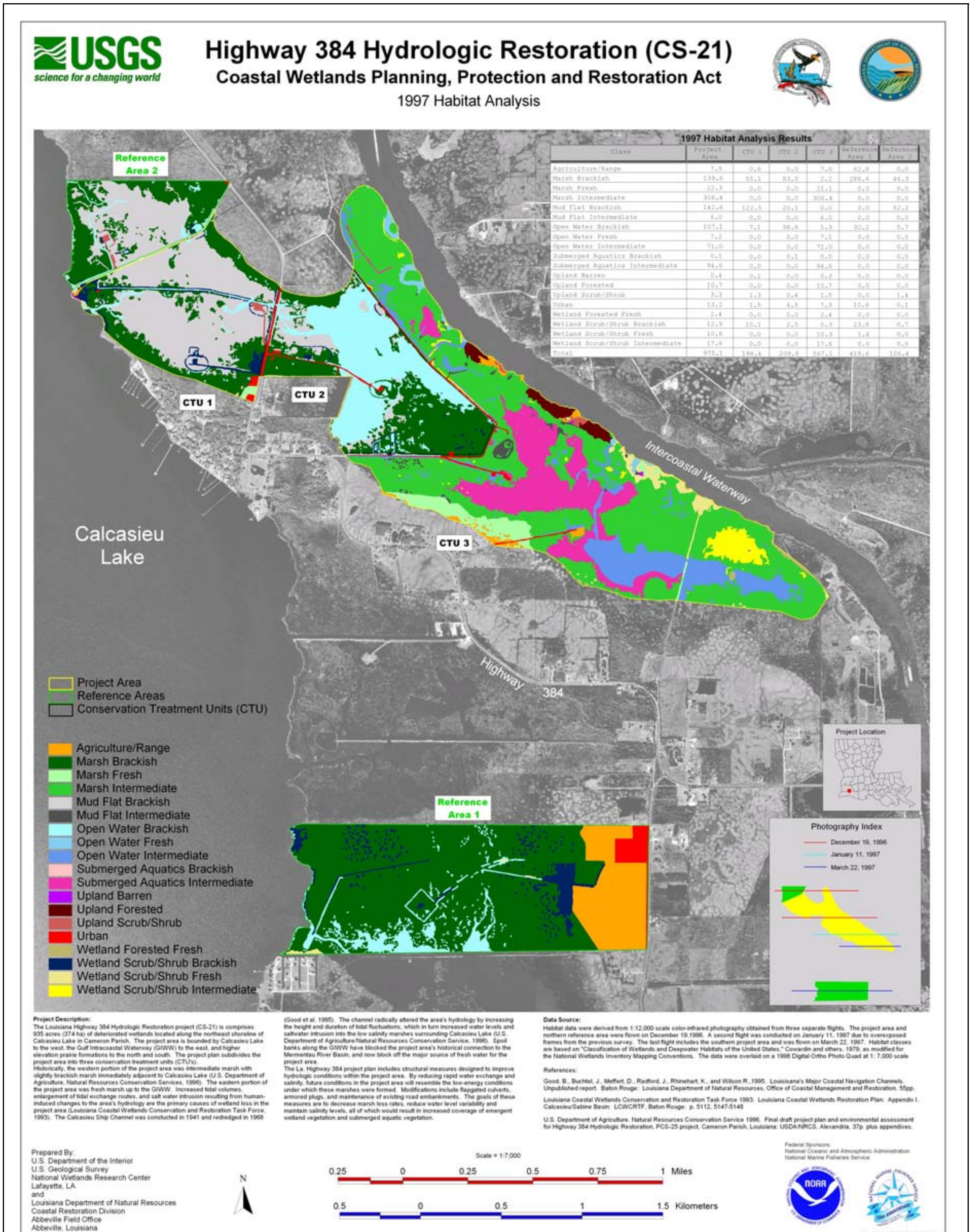

Figure 3. Habitat analysis from aerial photography flown January 11 and March 22, 1997.

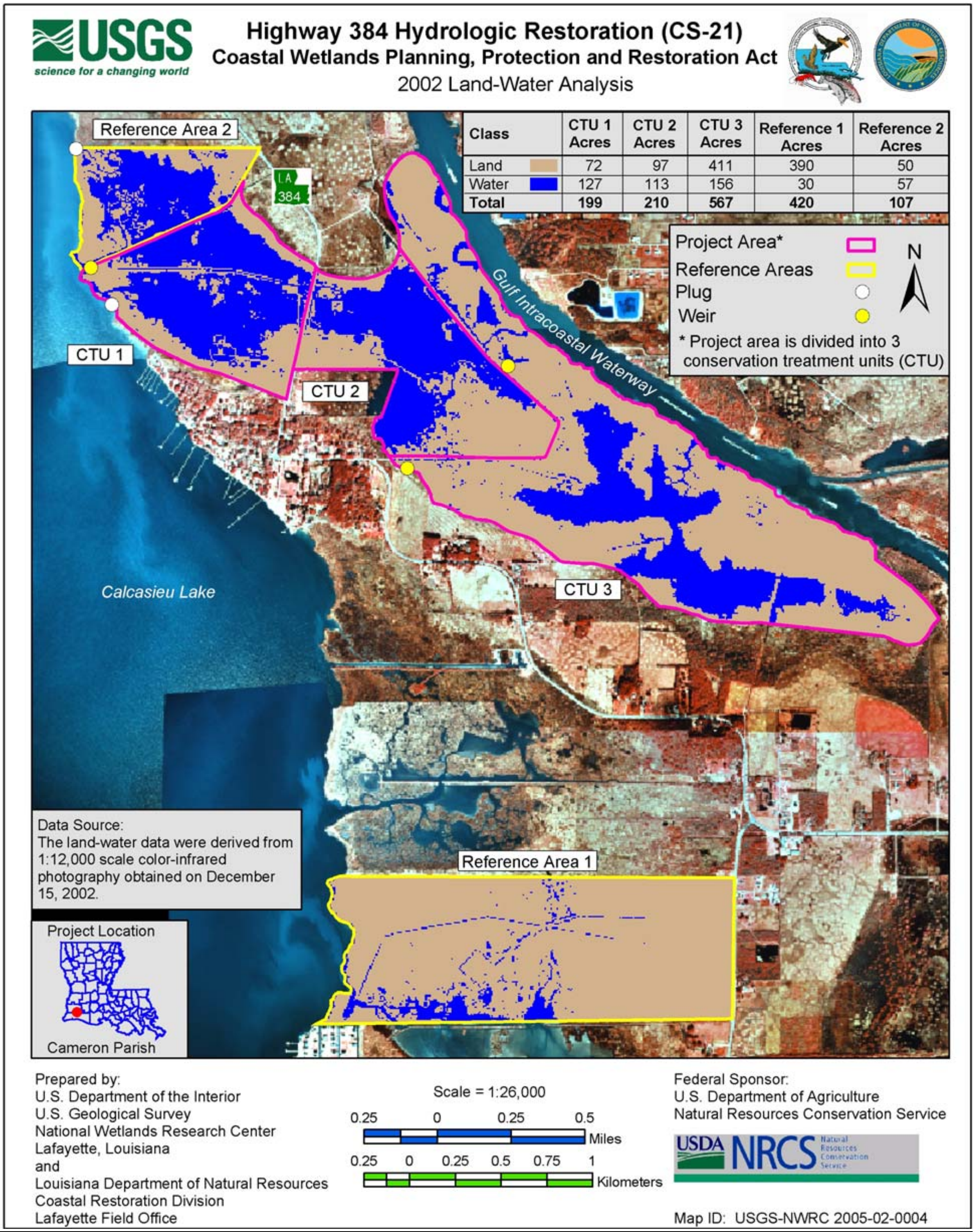

Figure 4. Land to water analysis from aerial photography flown December 15, 2002.

Table 1. Ratios of land and water for the Highway 384 Hydrologic Restoration (CS-21) project from aerial photography obtained pre-construction in 1997 and post-construction in 2002. The 1997 photography was classified by habitat (figure 2) while the 2002 photography was just classified by land and water so acreages of land were summed. Mudflats were considered land and upland habitats were included.

	Total Project		**CTU 1**		**CTU 2**		**CTU 3**		**Total Reference**		**R 1**		**R 2**	
	ac	**ha**	**ac**	**ha**	**ac**	**ha**	**ac**	**ha**	**ac**	**ha**	**ac**	**ha**	**ac**	**ha**
1997 Land	546.5	221.2	68.8	27.8	90.9	36.8	387.1	156.7	430.2	174.1	387.4	156.8	42.8	17.3
1997 Water	428.6	173.4	129.6	52.4	119	48.2	180	72.8	95.8	38.8	32.2	13	57.9	23.4
2002 Land	580	234.7	72	29.1	97	39.3	411	166.3	440	178.1	390	157.8	50	20.2
2002 Water	396	160.3	127	51.4	113	45.7	156	63.1	87	35.2	30	12.1	57	23.1
1997 Land %	56		34.7		43.3		72.1		81.8		92.3		40.2	
1997 Water %	44		65.3		56.7		33.5		18.2		7.7		54.4	
2002 Land %	59.4		36.2		46.2		72.5		83.5		92.9		46.7	
2002 Water %	40.6		63.8		53.8		27.5		16.5		7.1		53.3	
1997 TOTAL	975.1	394.6	198.4	80.3	209.9	84.9	537.1	217.4	526	212.9	419.6	169.8	106.4	43.1
2002 TOTAL	976	395	199	80.5	210	85.0	567	229.5	527	213.3	420	170	107	43.3

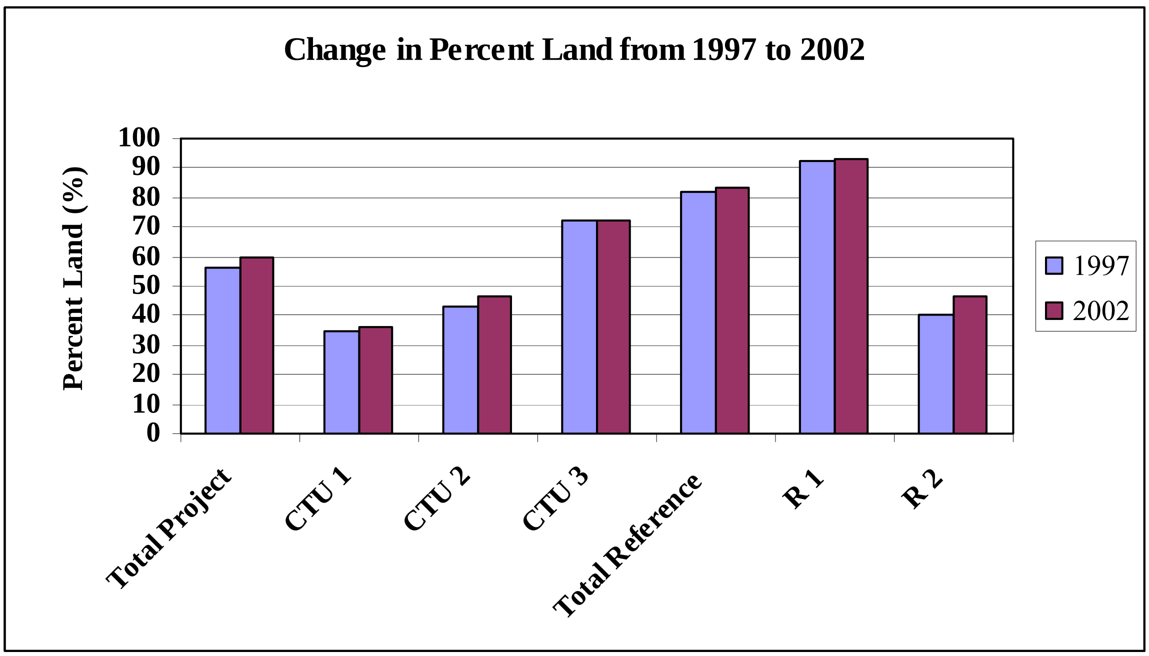

Figure 5. Percent of land area in 1997 and 2002 from aerial photography of each project CTU and the reference areas.

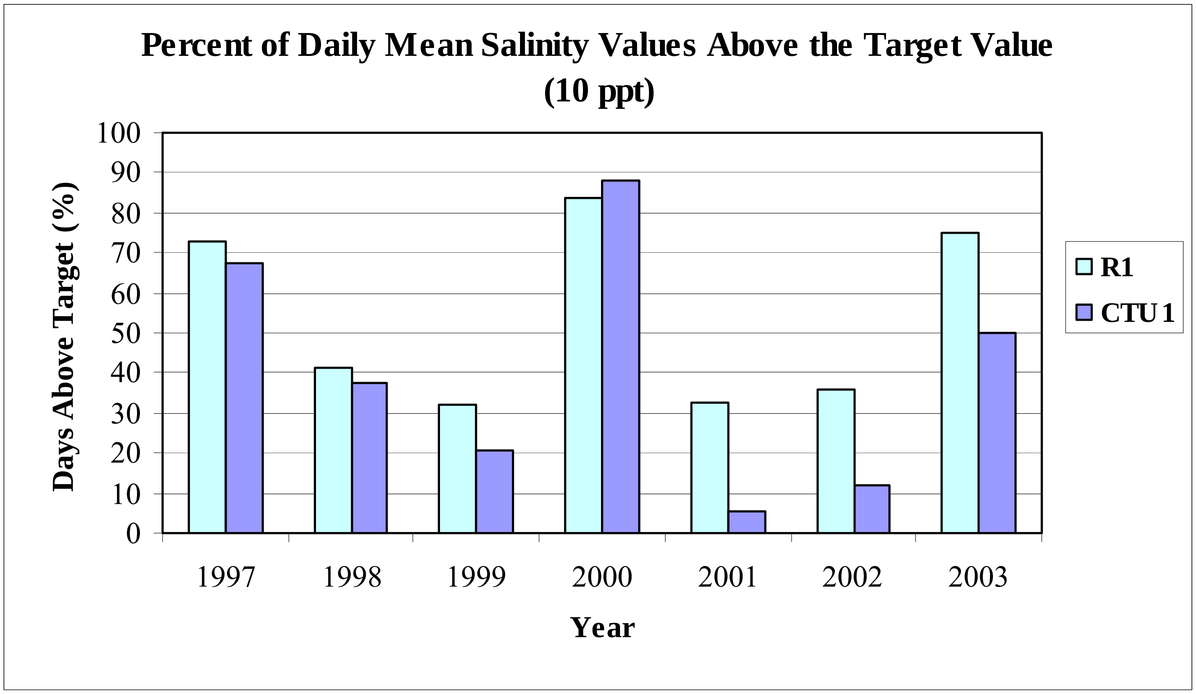

Figure 6. Percent of daily mean salinity values above the target value of 10 ppt in CTU 1 and R1 by years.

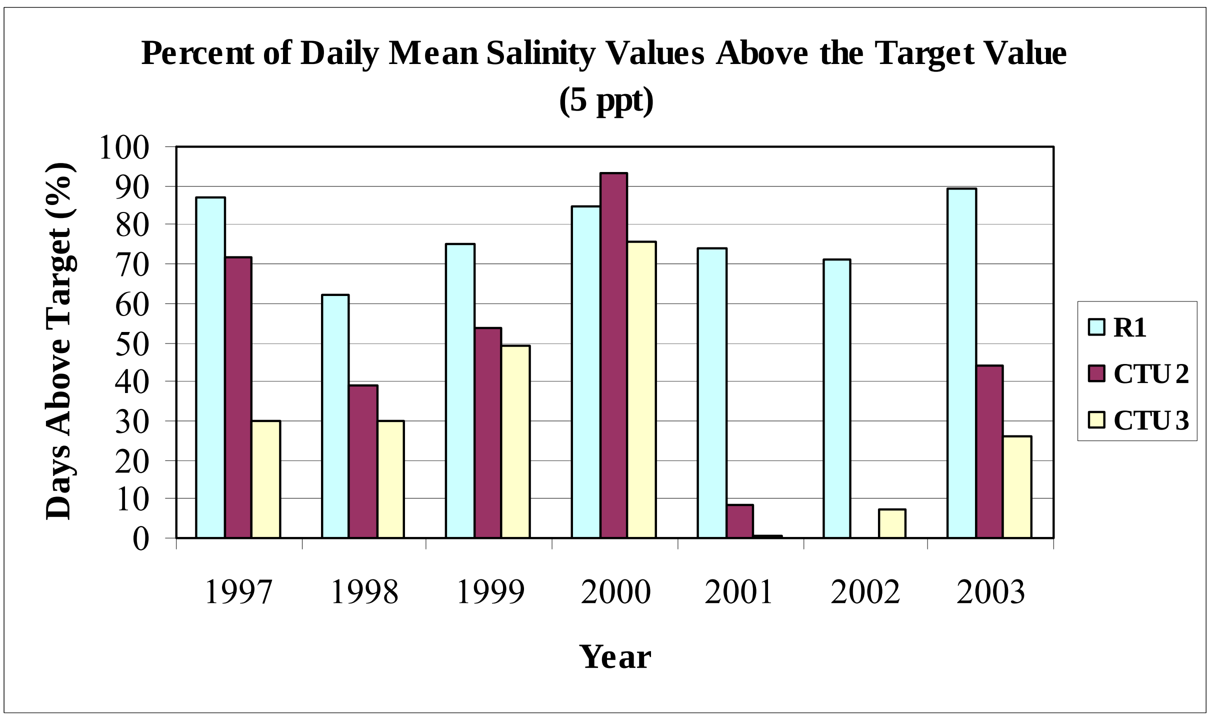

Figure 7. Percent of daily mean salinity values above the target value of 5 ppt in CTU 2, CTU 3, and R1 by years.

60% (1998) to almost 90% (2003) of the year from 1997 to 2003 (figure 7). Before project construction, salinities in CTU 2 and CTU 3 were rarely as high as in the reference area, but were consistently above the target range. During the drought of 2000, salinities in CTU 2 exceeded those in the reference area. Following project construction, salinities in CTU 2 and CTU 3 dramatically decreased and spent much more time within the target range, especially compared to the reference area, R1. CTU 3 has a breach that connects it to the GIWW so structure management does not directly affect the unit although construction of the project seems to have had an affect on water salinity in the CTU 3. Structure operation when salinities are above 7 ppt should increase the effect of the project on salinities in CTU 2.

The project goal for water level was to reduce water level variability in the project areas. This effect was tested using mean daily water level range (ft NAVD 88) by areas and years. It appears that the project greatly reduced water level variability (or range) in the three project areas (figure 8). The mean daily range of water levels has increased each year from 1997 to 2003 in the reference area, R1. Following project construction completion in early 2000, water level range significantly decreased in CTU 1 and CTU 2 from between 0.6 and 0.8 ft NAVD 88 pre-construction to below 0.2 ft NAVD 88 post-construction (figure 8). Similarly, water level range in CTU 3 decreased from between 0.3 and 0.6 ft NAVD 88 pre-construction to below 0.4 ft NAVD 88 post-construction. This result suggests that the project has reached the goal of decreasing water variability. Note that although water level range decreased in the project areas, overall mean water level does not appear to have been affected by the project (figure 9).

Submerged Aquatic Vegetation

The project goal for SAV was to increase frequency of occurrence of SAV in the three project areas relative to the SAV reference unit, R2. SAV was sampled twice pre-construction (1996 and 1997) and once post-construction. There was little cover in any unit in 1996 except for CTU 3 which had 11 species present and nearly 100% cover and a small amount of algae in CTU 1 (Table 2). 1997 saw near total cover in CTU 3 with 9 species present, 79% algae in CTU 2, and 5% more algae in CTU 1. Post-construction in 2002, cover had increased to 66% in CTU 1, all of it being *Ruppia maritima* (widgeongrass). Cover remained high in CTU 2 and SAV switched from mostly algae to being dominated by *Ruppia maritima* (widgeongrass). Cover remained near 100% in CTU 3 with 10 species present. The reference area (R2) had nearly 34% cover in 2002, mostly *Ruppia maritima* (widgeongrass).

Statistical comparisons were made for all of the project units relative to the reference unit pre and post construction with the data from 1996 and 1997 being pre-construction and the data from 2002 being post-construction. Collectively, there was no difference between project and reference units pre and post-construction ($F_{1,\ 1}$=0.0307, p=0.8627). Individual comparisons were made of each project unit to the reference unit pre and post-construction. Those tests revealed that CTU 1 and R2 were not significantly different from each other ($F_{1,\ 1}$=1.691, p=0.2296). Frequency of occurrence increased in both the project and reference area from 0% to 34% in R2 and from 5% to 67% in CTU 1. However, the standard error for each unit post-construction was 12% which made the difference insignificant. The high standard error was due to the fact that the two transects in CTU 3 were so different post-construction with one transect having 100% cover and the other with 33% cover. CTU 2 was not significantly different from R2 either ($F_{1,1}$=0.1705, p=0.6968). Frequency pre-construction was near zero in R2 and 37% in CTU 2. Post-construction, cover increased in both units, to 34% in R2 and to 86% in CTU 2. The magnitude of the change was statistically the same in each unit so differences were not statistically different. CTU 3 was significantly different from R2 pre and post-construction ($F_{1,1}$=46.083, p<0.0001). The difference in CTU 3 and R2 was due to the fact that cover remained near 100% in CTU 3 while it increased from near zero to 34% in R 2. Frequency of occurrence of SAV increased in all areas post-construction and, although the total cover of SAV was higher in the project units, the increase in SAV in R2 over the course of the project caused increases in project units to be statistically insignificant. It is likely that SAV in the entire project responds more to yearly weather and salinity trends more than to the CS-21 project itself. Or, if the differences in SAV are project effects, perhaps the reference area is impacted by the project also. CTU 3 has had lower salinities throughout the life of the project (figure 11).

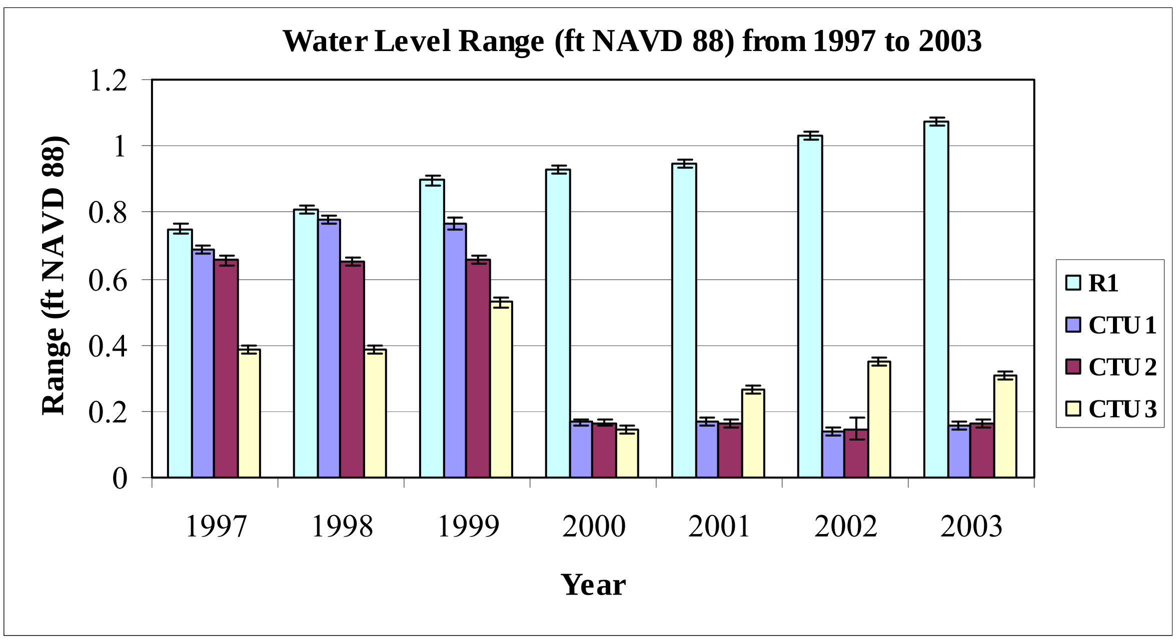

Figure 8. Water level range (ft NAVD 88) in the CS-21 Hwy 384 Project Area from 1997 to 2003.

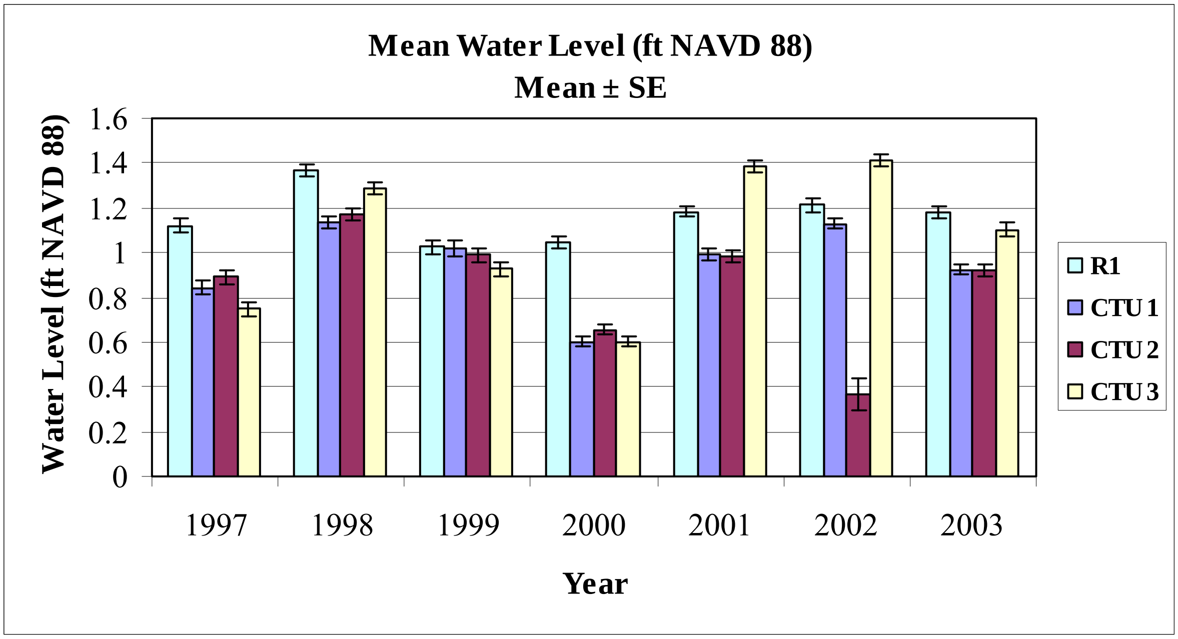

Figure 9. Yearly means of daily mean water level (ft NAVD 88) in the CS-21 Hwy 384 Project Area from 1997 to 2003.

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Table 2. Frequency of Occurrence of SAV species in the project area and reference areas.

	CTU 1			CTU 2			CTU 3			R2		
SAV Species	**1996**	**1997**	**2002**	**1996**	**1997**	**2002**	**1996**	**1997**	**2002**	**1996**	**1997**	**2002**
none	97.50	92.79	34.38	100.00	19.05	11.76	0.72	.	1.90	99.17	100.00	65.12
Alga	2.50	7.21	.	.	79.37	15.69	23.55	10.92	.	.	.	.
Alternanthera philoxeroides	.	.	.	.	.	.	.	.	0.95	.	.	.
Cabomba caroliniana	.	.	.	.	.	.	.	0.34	.	.	.	.
Ceratophyllum demersum	.	.	.	.	.	.	3.99	2.05	4.29	.	.	.
Chara sp.	.	.	.	.	.	.	6.52	8.87	36.19	.	.	.
Eleocharis parvula	.	.	.	.	.	.	8.33	15.02	2.86	.	.	.
Elodea canadensis	.	.	.	.	.	.	.	.	1.43	.	.	.
Myriophyllum spicatum	.	.	.	.	.	.	3.26	4.10	30.48	.	.	1.16
Najas guadalupensis	.	.	.	.	.	.	18.12	16.04	10.48	.	.	.
Nelumbo lutea	.	.	.	.	.	.	0.36	.	.	.	.	.
Nymphaea sp.	.	.	.	.	.	.	.	.	0.48	.	.	.
Potamogeton pusillus	.	.	.	.	.	.	0.72	.	.	.	.	.
Ruppia maritima	.	.	65.63	.	1.59	72.55	27.54	29.01	1.90	0.83	.	33.72
Utricularia foliosa	.	.	.	.	.	.	0.36	.	.	.	.	.
Vallisneria americana	.	.	.	.	.	.	6.52	13.65	9.05	.	.	.

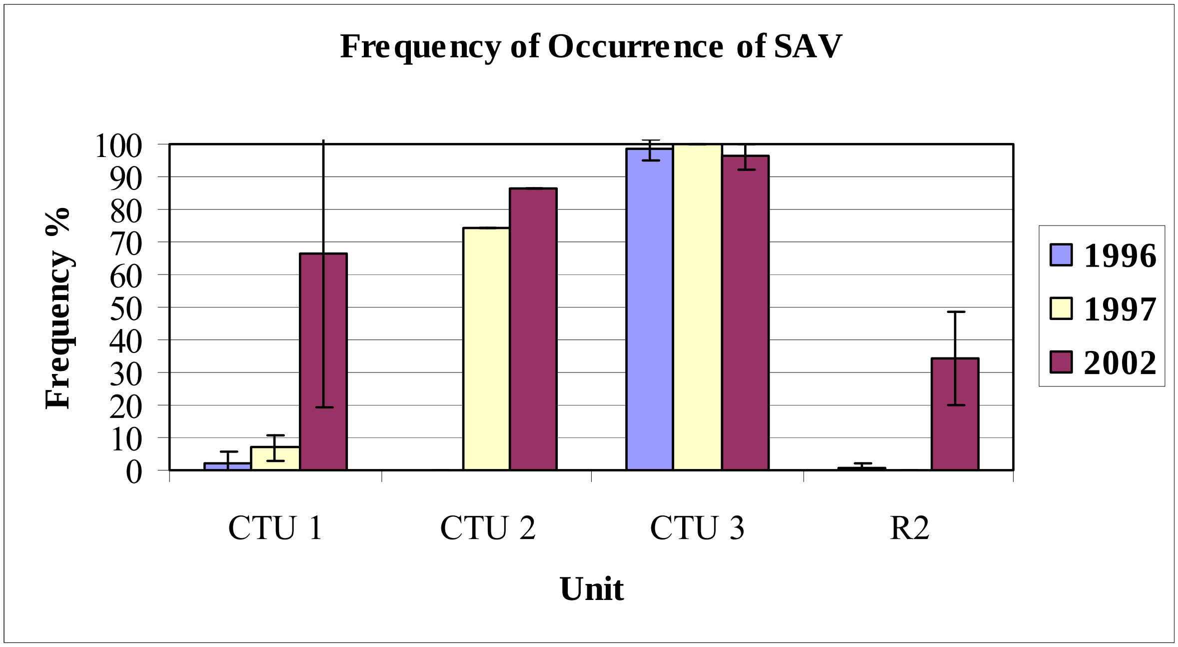

Figure 10. Total % Cover of SAV species in the CS-21 project and reference areas for sampling years.

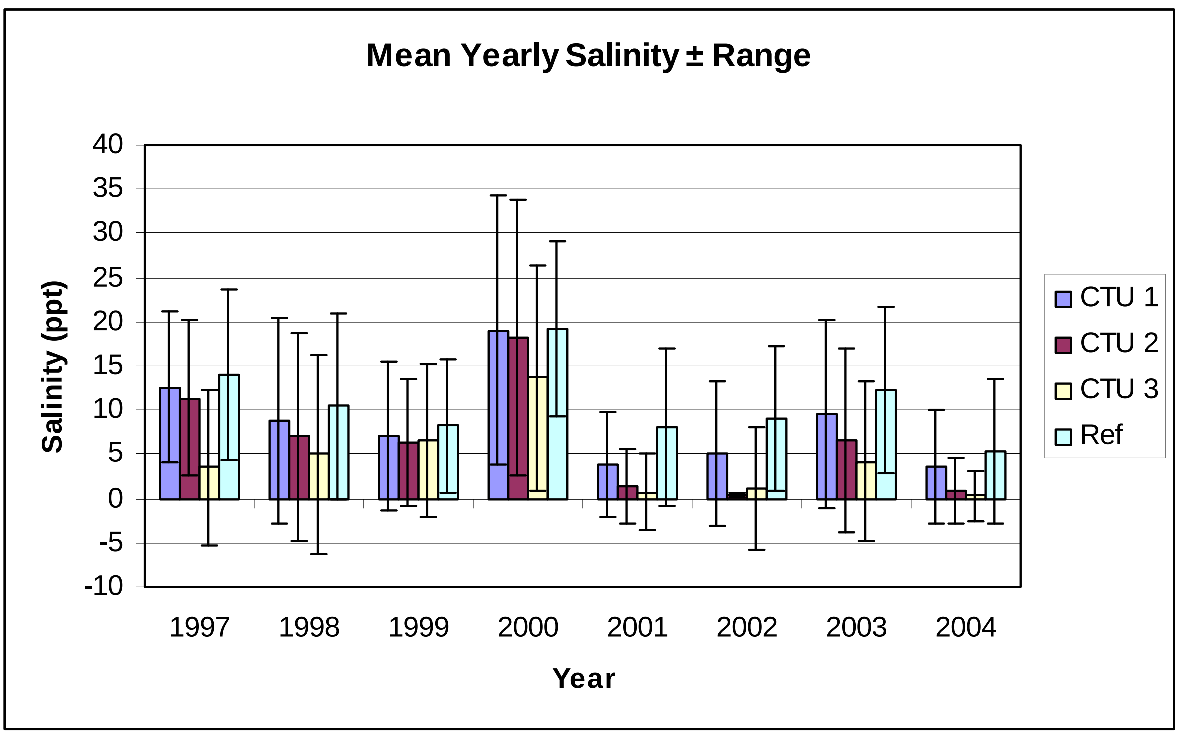

Figure 11. Mean salinity for each year the data sondes were deployed. All data was included even when data was missing from one sonde but not another. Error bars represent range of data for that year.

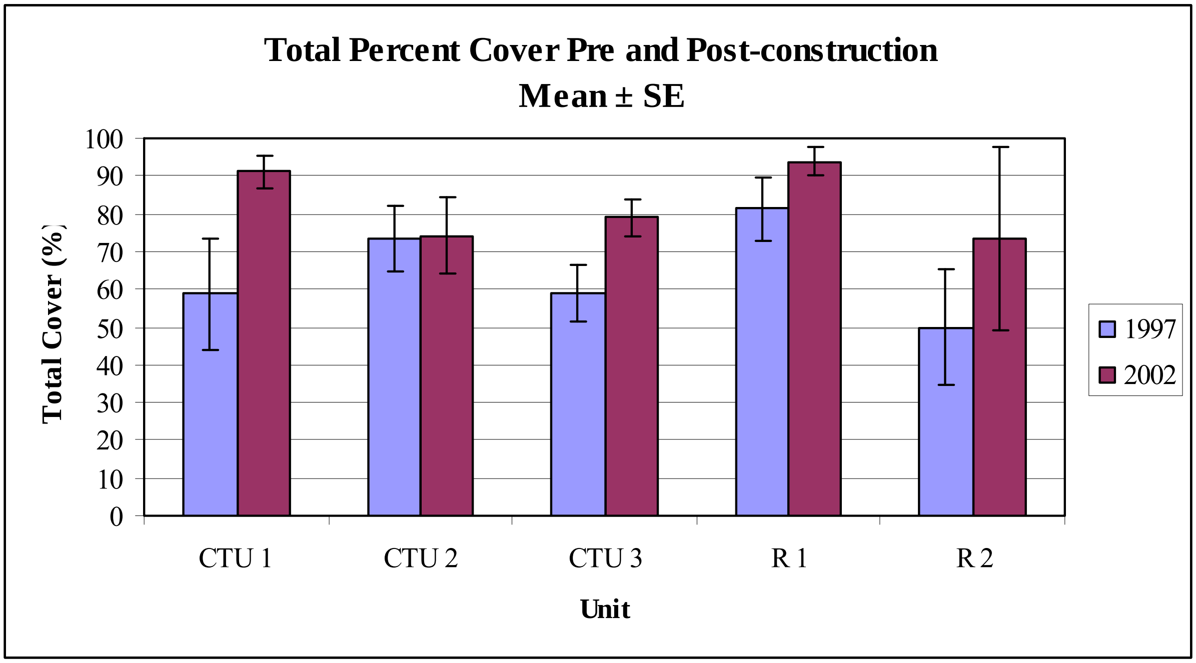

Figure 12. Total % Cover in vegetation plots at the CS-21 Hwy 384 Project pre and post-construction in 1997 and 2002.

Table 2. Pre-construction (1997) soil characteristic data for Highway 384 Hydrologic Restoration (CS-21) project and reference areas.

Unit	Percent (%) Organic Matter	Bulk Density	Percent (%) Water (Moisture)	Pore Water Salinity	Organic Matter Density	Mineral Matter Density
		(oven)			(oven)	(oven)
	(%)	(g/cm3)	(%)	(ppt)	(g/cm3)	(g/cm3)
CTU 1	0.20	0.68	0.72	17.65	0.13	0.54
CTU 2	0.21	0.70	0.71	18.32	0.12	0.58
CTU 3	0.12	0.85	0.49	12.63	0.09	0.75
Reference 1	0.26	0.49	0.75	18.53	0.12	0.37
Reference 2	0.11	0.81	0.63	17.10	0.39	0.72

Emergent Vegetation

The project goal for emergent vegetation was to increase cover in the project area. This goal specifically refers to intermediate marsh in CTU 2 and CTU 3 and brackish marsh in CTU 1. There are seven marsh type classifications for the Chenier Plain. These classifications are useful in determining the effect of restoration projects whose goals include specific vegetative assemblages. According to surveys performed pre-construction in 1997, CTU 1 was primarily dominated by *Juncus roemerianis* (needlegrass rush) with some *Spartina patens* (marshhay cordgrass) and some more saline species present including *Spartina alterniflora* (smooth cordgrass) and *Distichlis spicata* (seashore saltgrass). These species would fit into either the Oligohaline Wiregrass or Mesohaline Mixture classifications. Since the salinities were within the brackish range for that year, the marsh should probably be classified as Oligohaline Wiregrass pre-construction. The 2002 survey showed an increase in *Spartina patens* and the presence of *Schoenoplectus robustus* (sturdy bulrush). Total percent cover increased post-construction from 58.8 % to 91.3% and the post-construction assemblage was also Oligohaline Wiregrass which is in accordance with the project goal of increasing cover of brackish marsh in CTU 1 (figures 12 and 13).

Pre-construction in 1997, CTU 2 was dominated by *Spartina patens, Juncus roemerianis,* and *Eleocharis albida*. In 2002, several more species were present including *Paspalum vaginatum* (seashore Paspalum) and other intermediate marsh species (figure 14). The 1997 composition is consistent with the Visser et al. (2000) classification of Oligohaline Wiregrass due to the dominance of *Spartina patens*. The 2002 survey revealed that total percent cover had remained the same (73%) (figure 12) while species richness increased from 4.8 to 8.3 species per plot. The additional species and the decrease in the cover of common brackish species suggest Unit 2 is also on target for vegetation goals.

CTU 3 was dominated by *Spartina patens, Schoenoplectus californicus* (California bulrush), and *Sagittaria lancifolia* (bulltongue) in 1997 (figure 15). By 2002, the unit was dominated by *Spartina patens, Typha latifolia* (cattail), and *Juncus roemarianus,* species richness had increased from 6.6 to 10.5 species per plot, and total cover had increased from 59% to 79% (figure 12). Despite the shift in species assemblage, the vegetation type classification remained Oligohaline Wiregrass. These results are consistent with the project goals of increasing the cover of intermediate marsh.

Reference areas 1 & 2 showed little change from 1997 to 2002, being dominated by *Juncus* and *Spartina patens* (figures 16 and 17). *Spartina alterniflora* began to emerge and *Distichlis spicata* decreased post-construction in R 1. The Visser classification for both reference units should be Oligohaline Wiregrass. Total cover increased in both units (figure 12) and species richness slightly decreased in R 2 from 3.3 to 2.7 species per plot.

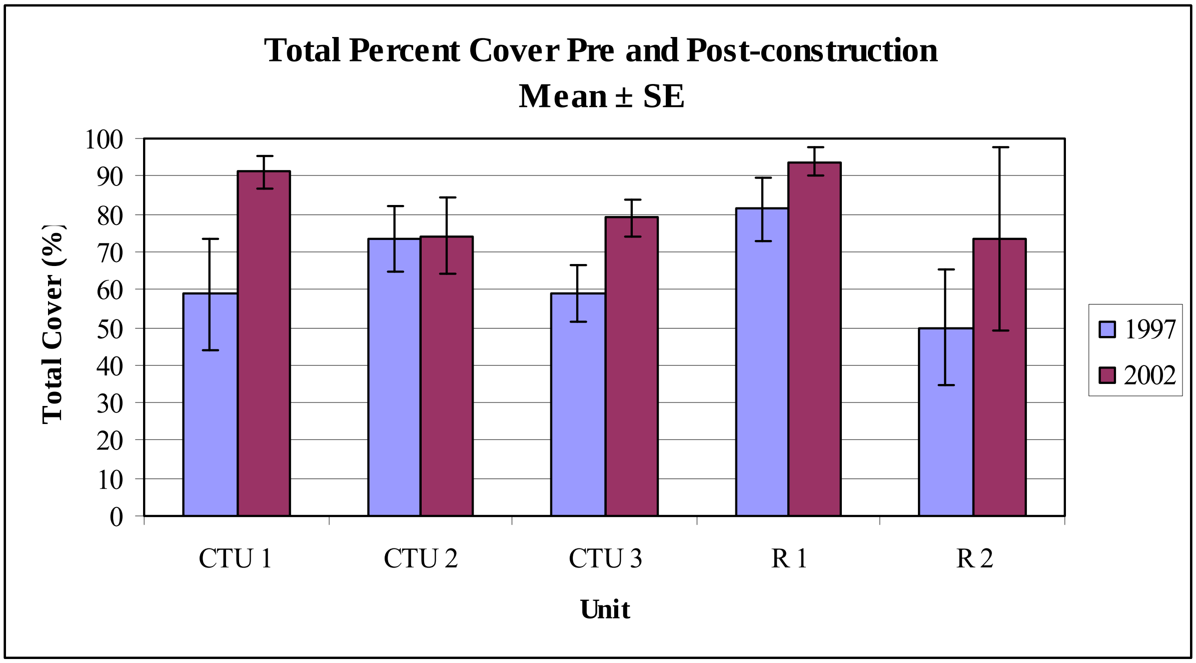

Figure 12. Total % Cover in vegetation plots at the CS-21 Hwy 384 Project pre and post-construction in 1997 and 2002.

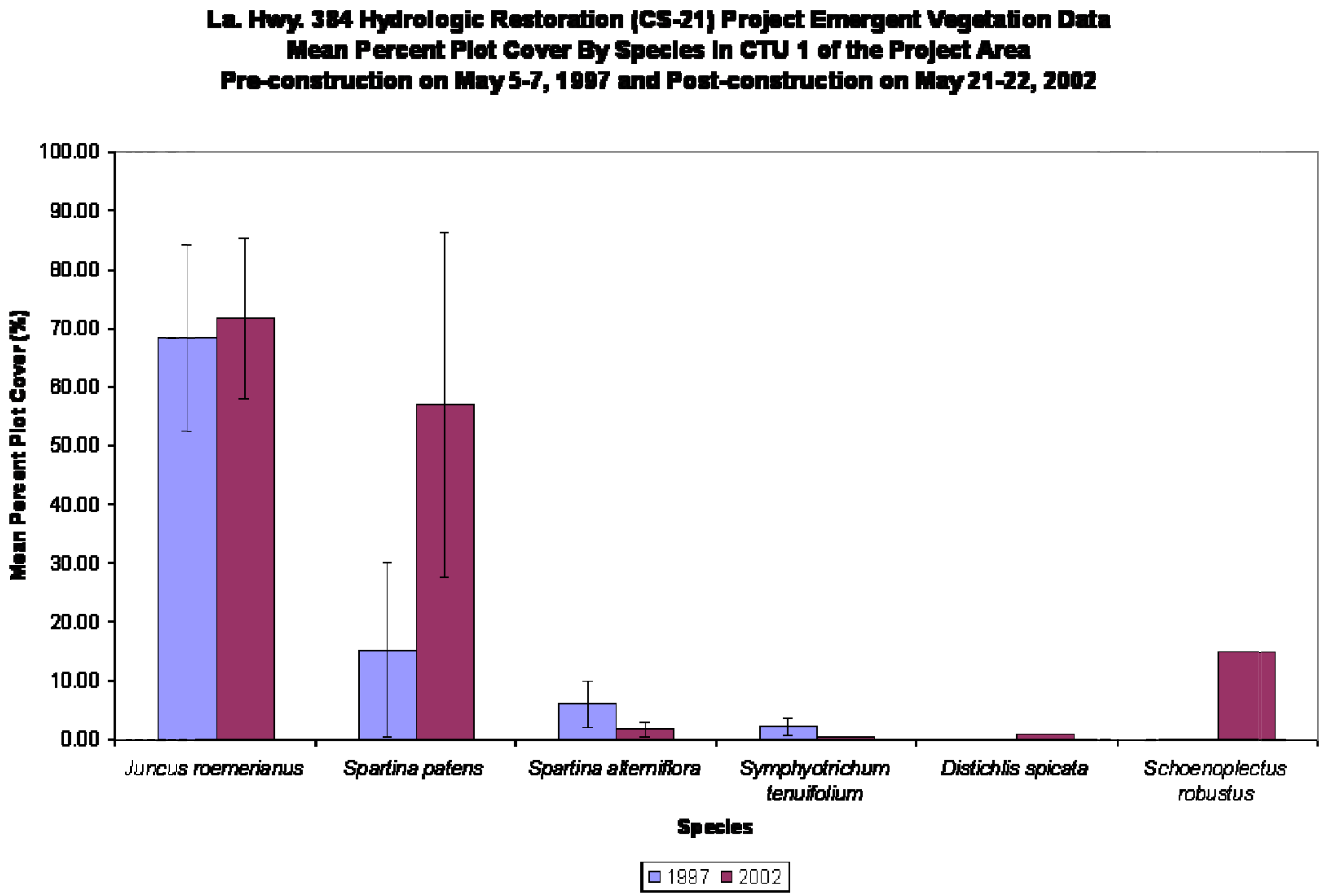

Figure 13. Percent cover of emergent vegetation in CTU 1 pre and post-construction.

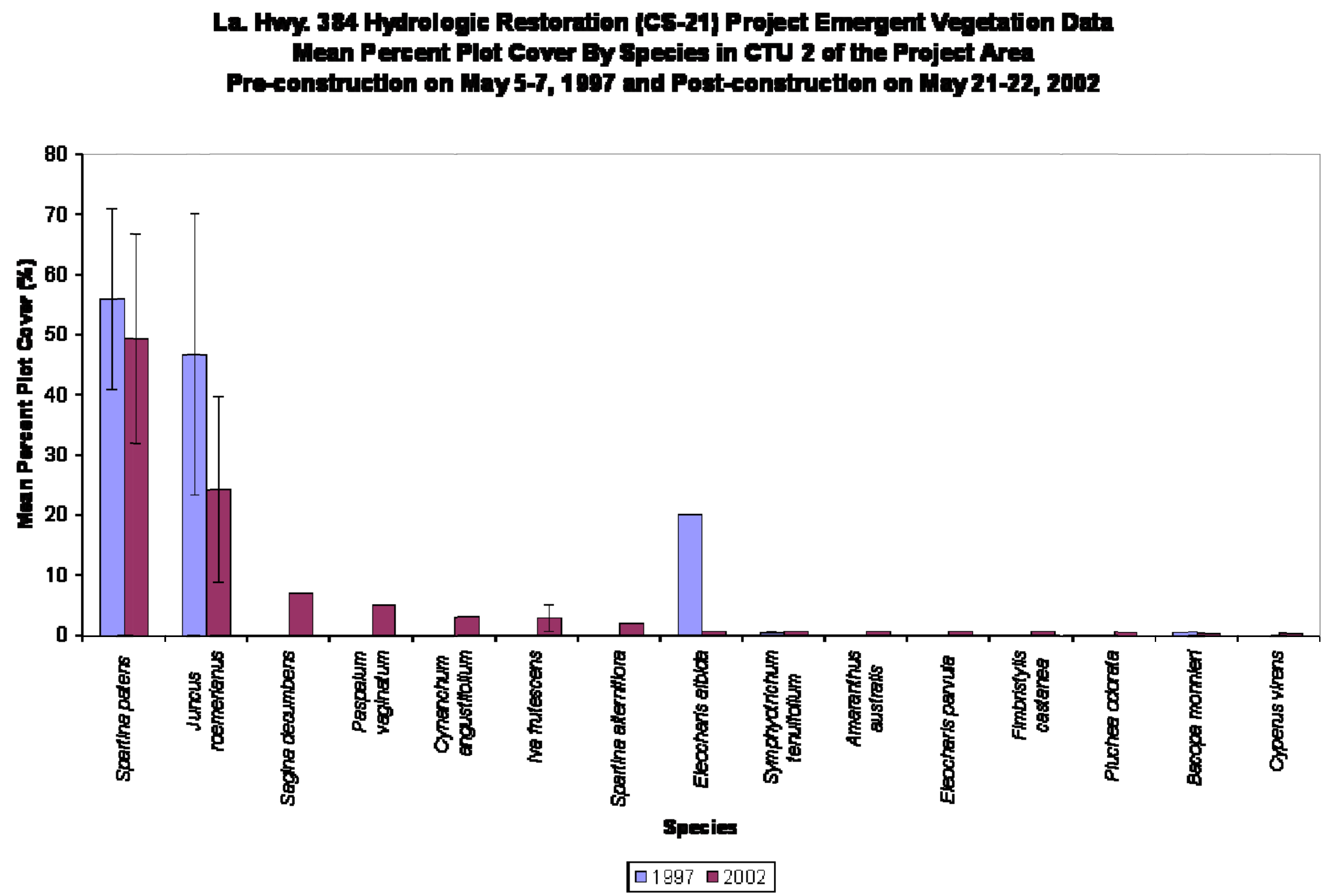

Figure 14. Percent cover of emergent vegetation in CTU 2 pre and post-construction.

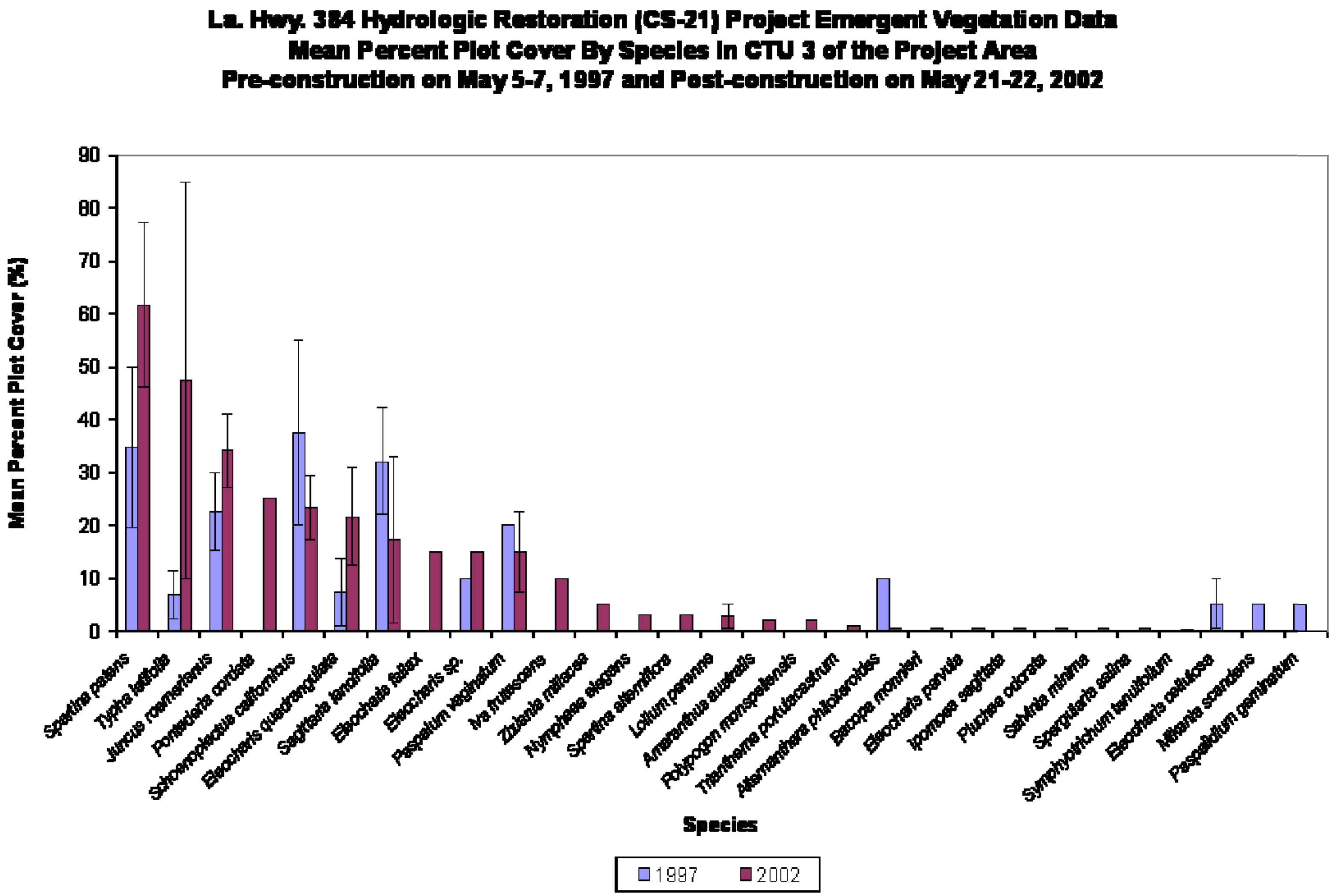

Figure 15. Percent cover of emergent vegetation in CTU 3 pre and post-construction.

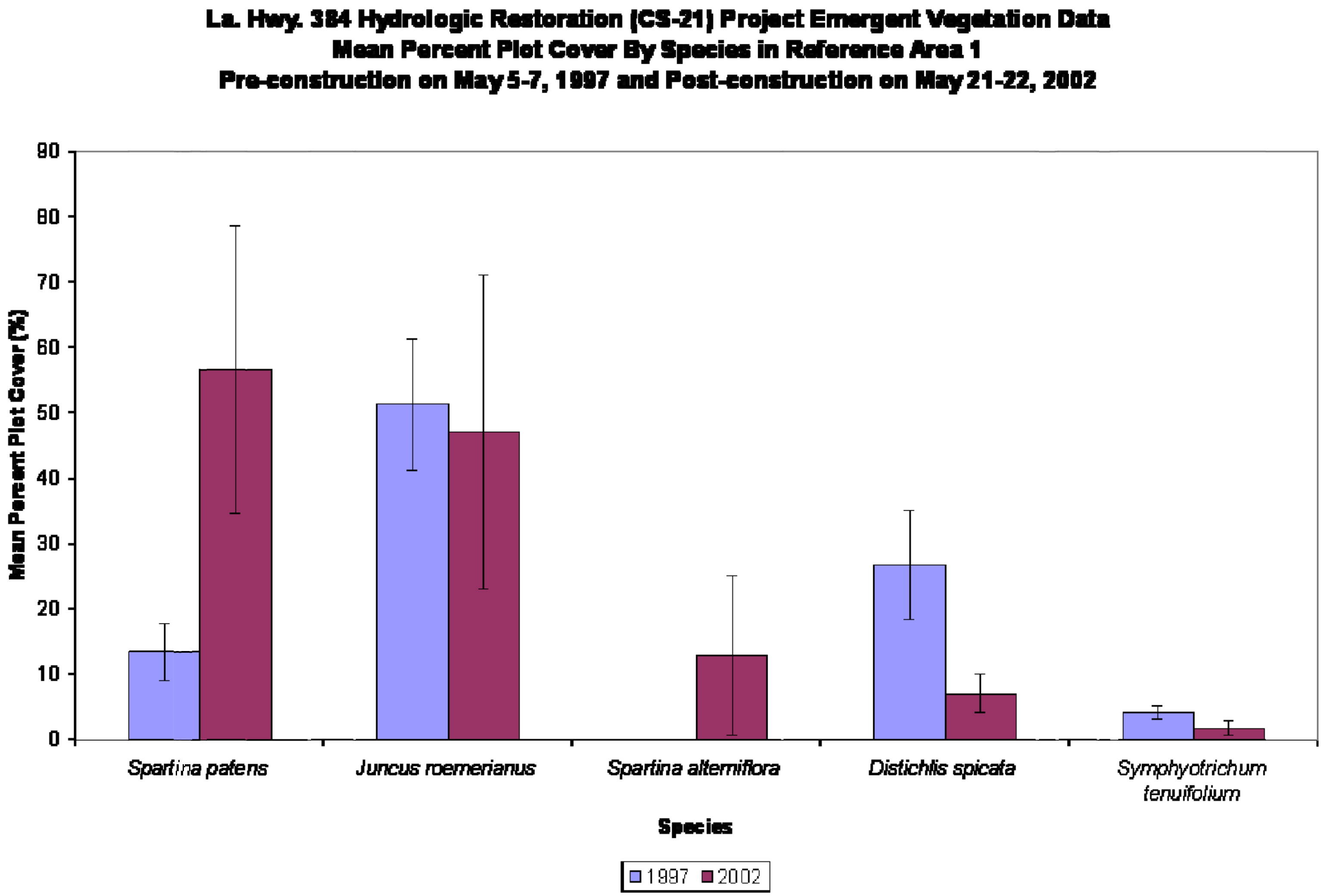

Figure 16. Percent cover of emergent vegetation in R1 pre and post-construction.

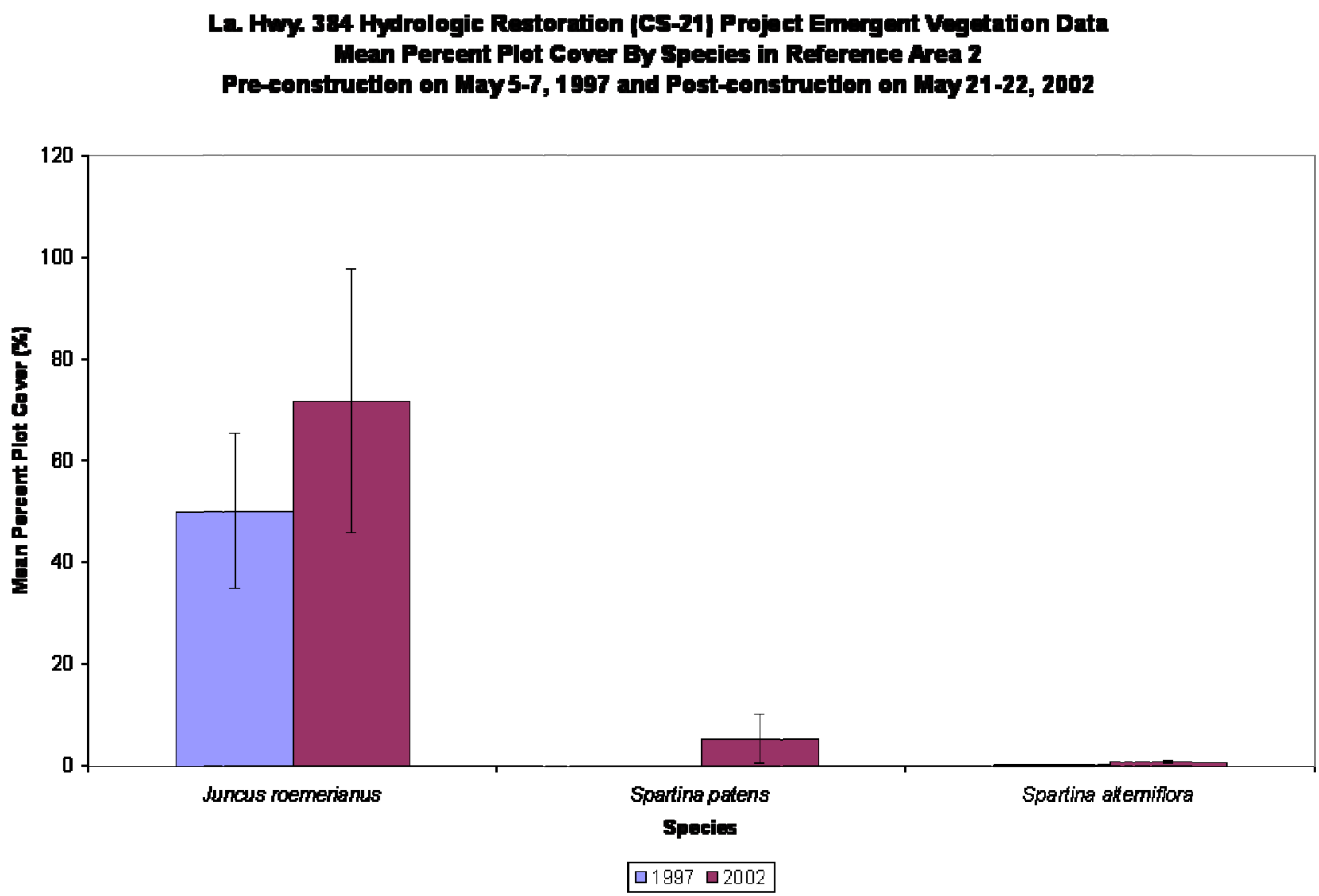

Figure 17. Percent cover of emergent vegetation in R2 pre and post-construction.

Soil Characteristics

Soil characteristics were originally collected in 1997. Soil characteristics are consistent with brackish type marshes (table 2; Palmisano 1972). Post-construction samples are to be collected in 2005 in conjunction with the vegetative sampling.

Table 2. Pre-construction (1997) soil characteristic data for Highway 384 Hydrologic Restoration (CS-21) project and reference areas.

Unit	Percent (%) Organic Matter	Bulk Density	Percent (%) Water (Moisture)	Pore Water Salinity	Organic Matter Density	Mineral Matter Density
		(oven)			(oven)	(oven)
	(%)	(g/cm3)	(%)	(ppt)	(g/cm3)	(g/cm3)
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Reference 2	0.11	0.81	0.63	17.10	0.39	0.72

V. Conclusions

a. Project Effectiveness

Land to water ratios in the project and reference areas pre- and post-construction did not change significantly (figure 5). Both project and reference areas maintained or made slight increases in land area.

Salinities in the project area were within the target range during the months data was collected in 2004 (figure 8). Water levels were below the marsh surface in all of the project areas until May, 2004 when they increased to around 0.4 ft above the marsh surface. Water levels in the reference area were above the marsh surface for most of the period measured (figure 9).

Cover of SAV increased in CTU 1 and in R2 post-construction. It reached nearly 80% in CTU 2 before construction and maintained that level post-construction. Cover remained near 100% in CTU 3 before and after construction (figure 10, table 2). This response was statistically insignificant. SAV dynamics do not appear to be affected by the project.

Total percent cover of emergent vegetation increased in all of the project and reference areas, most noticeably in CTU 1, CTU 3, and the reference areas (figure 12). Species richness increased in the two intermediate project areas (CTU 2 and CTU 3). The increases in cover and richness can most likely be attributed to the maintenance of salinity within the target ranges and the reduced water level range.

The monitoring plan stipulated that data collection should be discontinued if the project was functioning as designed. The data indicate that the structures are effective in meeting the project goals of reducing water level variability and increasing emergent marsh vegetation. Therefore, no additional monitoring will be conducted.

b. Recommended Improvements:

The structures have proven effective in achieving the goals of the project except during extreme weather conditions such as the drought in 2000. A revision to the permitted structure operations is recommended to provide increased control, restricting high salinity water from entering the project area from the GIWW, particularly CTU 1 and 2. This revision is also designed to increase the flow of freshwater into CTU 1 and 2 when freshwater is available.

This project is classified as Hydrologic Restoration (HR) project and was implemented within the first few years of the CWPPRA program. Engineering and Biological monitoring results indicate that the project is currently producing the predicted or desired results, although further investigations of the water flow patterns may be warranted. If project goals are not met in the future, hydrologic assessment should be conducted to determine if there are specific structures or existing topographic features that may be compromising the goals of the project. Additional surveys, calculations, and flow measurement may be required to properly evaluate flow patterns within the project boundary. In the event this targeted analysis of the system's features does not identify specific problems associated with the system's functionality, a more detailed Hydrodynamic model may be warranted. In this event, care should be taken selecting the model to insure that information developed is compatible with other modeling efforts that have been, or will be, conducted in the project basin.

c. Lessons Learned:

No salinity data was available for the GIWW during the design phase of this project. It was assumed that the Calcasieu Locks prevented high salinity water from entering the GIWW from Calcasieu Lake. Data gathered since construction of the project proved this assumption to be erroneous. CTU 3, the intermediate marsh adjacent to the GIWW, is particularly vulnerable to elevated salinity flow from the GIWW, as no provisions were made to restrict this flow through this portion of the project area. Future designs should be based on actual information gathered at specific locations.

If rock is to be used as a plug, the gradation shall be such that there will be no water flow through the plug. An earthen cover on a rock dike located adjacent to a large open water area as Calcasieu Lake will be shortlived.

VI. Literature Cited

Chabreck, R. H., and C. M. Hoffpauir 1962. The use of weirs in coastal marsh management in coastal Louisiana. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 16:103-12.

Louisiana Department of Natural Resources 2003. Operations, Maintenance, and Rehabilitation Plan for the La. Highway 384 Hydrologic Restoration (CS-21) Project. Louisiana Department of Natural Resources, Coastal Engineering Division.

Palmisano, A. W. and R. H. Chabreck. 1972. The relationship of plant communities and soils of the Louisiana coastal marshes. Louisiana Assoc. of Agronomists, 13th Meeting, Lake Charles, LA. 42pp.

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

Steyer, G. D., R. C. Raynie, D. L. Steller, D. Fuller, and E. Swenson 1995, revised 2000. Quality management plan for Coastal Wetlands Planning, Protection, and Restoration Act monitoring plan. Open-file series 95-01. Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division.

Visser, J. M., C. E. Sasser, R. H. Chabreck, and R. G. Linscombe. 1998. Marsh vegetation types of the Mississippi River Deltaic Plain, USA. Estuaries 21:818-828.