State of Louisiana
Department of Natural Resources
Coastal Restoration Division and
Coastal Engineering Division

2003 Operations, Maintenance, and Monitoring Report

for

GIWW (GULF INTRACOASTAL WATERWAY) to CLOVELLY HYDROLOGIC RESTORATION

State Project Number BA-02
Priority Project List 1

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Lafourche Parish

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Operations, Maintenance, and Monitoring Report
For
GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration

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I. Introduction

The GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration project is located in Lafourche Parish, Louisiana, southeast of the GIWW, east of Bayou Lafourche, and north of the Superior Canal (figure 1). The project area totals 14,948 ac (6,049 ha) of wetlands (86% land/marsh, 14% water) and is part of the last contiguous marsh tracts in the Barataria Basin. Of the 14,948 ac in the project area, 209 ac (85 ha) are classified as freshwater marsh, 14,006 ac (5,668 ha) are classified as intermediate marsh, 254 ac (103 ha) are classified as brackish marsh, and 478 ac (193 ha) are classified as scrub/shrub and forest.

Within the GIWW to Clovelly Hydrologic Restoration project the average rate of change from marsh habitat to non-marsh habitat (including wetland loss to both open water and commercial development) has been increasing since the 1950's. The mean wetland loss rates were 0.36%/year between 1945 and 1956, 1.03%/year between 1956 and 1969; and 1.96%/year between 1969 and 1980. Impacts from the numerous oilfield canals constructed in the GIWW to Clovelly Hydrologic Restoration project area include changes in hydrology, increased marsh subsidence, marsh impoundments, reduction in sediment accretion, and saltwater intrusion. The Clovelly Canal is connected to Little Lake on the eastern end and likely facilitates the transport of more saline waters from Little Lake to western regions of the project area.

Since 1949, marsh types have changed throughout the project, especially in the southern area. The entire project area was characterized as freshwater marsh by O'Neil in 1949. Since 1968, areas of intermediate and brackish marsh have encroached into the eastern reaches of the area around Bayou Perot and Little Lake. In 1988, none of the project area was characterized as freshwater marsh. It is unclear whether the changes in these areas have been due to an increase in salinity, a change in the water level regime, or a combination of the two. Increasing land loss rates for the Cut Off area (1932-1985: 0.10%, 1983-1990: 0.25%), along with the changes in marsh types, are raising concerns that the quality of the marsh is declining and marsh will be converted to open water.

The project objective is to protect intermediate marsh in the project area by restoring natural hydrologic conditions that promote greater use of available freshwater and nutrients. This will be accomplished by limiting rapid water level changes, slowing water exchange through over-bank flow, reducing rapid salinity increases, and reducing saltwater intrusion.

Construction of project features occurred in two phases. Phase I, Construction Unit No. 1 has a twenty year (20 yr) economic life which began in November 1997 and Phase II, Construction Unit No. 2 has a twenty year (20 year) economic life which began in October 2000.

Project features include:

Phase I, Construction Unit No1.

- Construction of three fixed crest rock weirs with boat bays, from 200 pound class rock riprap cap on top of geotextile with a crest elevation approximately 3.8 to 4.0 ft NAVD 88, and a crest width approximately 8 to 8.9 ft (2.6 m). (figure 2; sites 3, 4, and 7). Plug lengths varied depending upon their locations.
- Construction of two rock riprap channel plugs on top of geogrid. The plugs varied in crest elevation and length depending upon their locations (figure 2; sites 43 and 4B).
- Construction of one rock riprap weir with a boat bay (figure 2; site 8).
- Construction of one 102 linear ft (36.6 m) rock filled channel plug with a crest elevation of 3.2 ft NAVD 88, with a 10 gauge corrugated aluminum pipe through the plug embankment, and an aluminum flapgate (figure 2; site 91).

Phase II, Construction Unit No2.

- Construction of approximately 5,665 linear ft (1,727m) of lake-rim shoreline protection from 650 pound class rock riprap on top of geotextile with an average crest elevation of 3.0 ft NAVD88 and a crest width of 4 ft (1.2 m), along the southwestern shorelines of Little Lake, Bay L'Ours, and Brusle Lake (figure 2).
- Construction of approximately 5,023 linear ft (1531 m) of bank stabilization from 200 pound class rock riprap on top of earthen and rock fill on top of geotextile with an average crest elevation of 2.0 ft (0.6 m) NAVD88 above normal ground elevation and a crest width of 4 ft (1.2 m), along the northern shoreline of Breton canal (figure 2).
- Construction of approximately 11,711 linear ft (3,570 m) of earthen bank stabilization on top of geotextile with an average crest elevation of 2.0 NAVD 88 above normal ground elevation and a crest width of 4 ft (1.2 m) to 14 ft (4.3 m), along dead-end oil field canals on the northern edge of Breton canal (figure 2).
- Construction of one 263 linear ft (80 m) fixed crest weir with a 20 ft (6.1 m) barge bay from rock riprap with a crest elevation of 4.0 ft NAVD88 and the invert of the barge bay set at -6.4 ft NAVD88 below marsh level (figure 2; site 1).
- Construction of one 1,665 linear ft (507.5 m) fixed crest rock riprap weir with an 80 ft (24.4 m) barge bay, with a crest elevation of 4.0 ft NAVD88 and the invert of the boat bay at an elevation of -6.5 ft NAVD88 (figure 2; site 14A).
- Construction of one 511 linear ft (155.8 m) rock riprap channel plug with a crest elevation of 3.5 ft NAVD88 (figure 2; site 4B).
- Construction of one 213 linear ft (64.9 m) rock riprap channel plug with a crest elevation set at 4.0 ft NAVD 88 (figure 2; site 90).
- Construction of one 80 linear ft (24.4 m) sheet pile variable crest weir with a 10 ft (3 m) wide variable crest section containing a 10 ft (3 m) wide stop log bay containing 12 stop logs. The stop logs can be adjusted from 1.0 ft to -3.0 ft

NAVD88 using a rotatable crane with a hand winch. The fixed crest section of the structure was constructed with earthen wingwalls to a crest elevation of 2.89 ft NAVD88 on either side of the weir (figure 2; site 35).

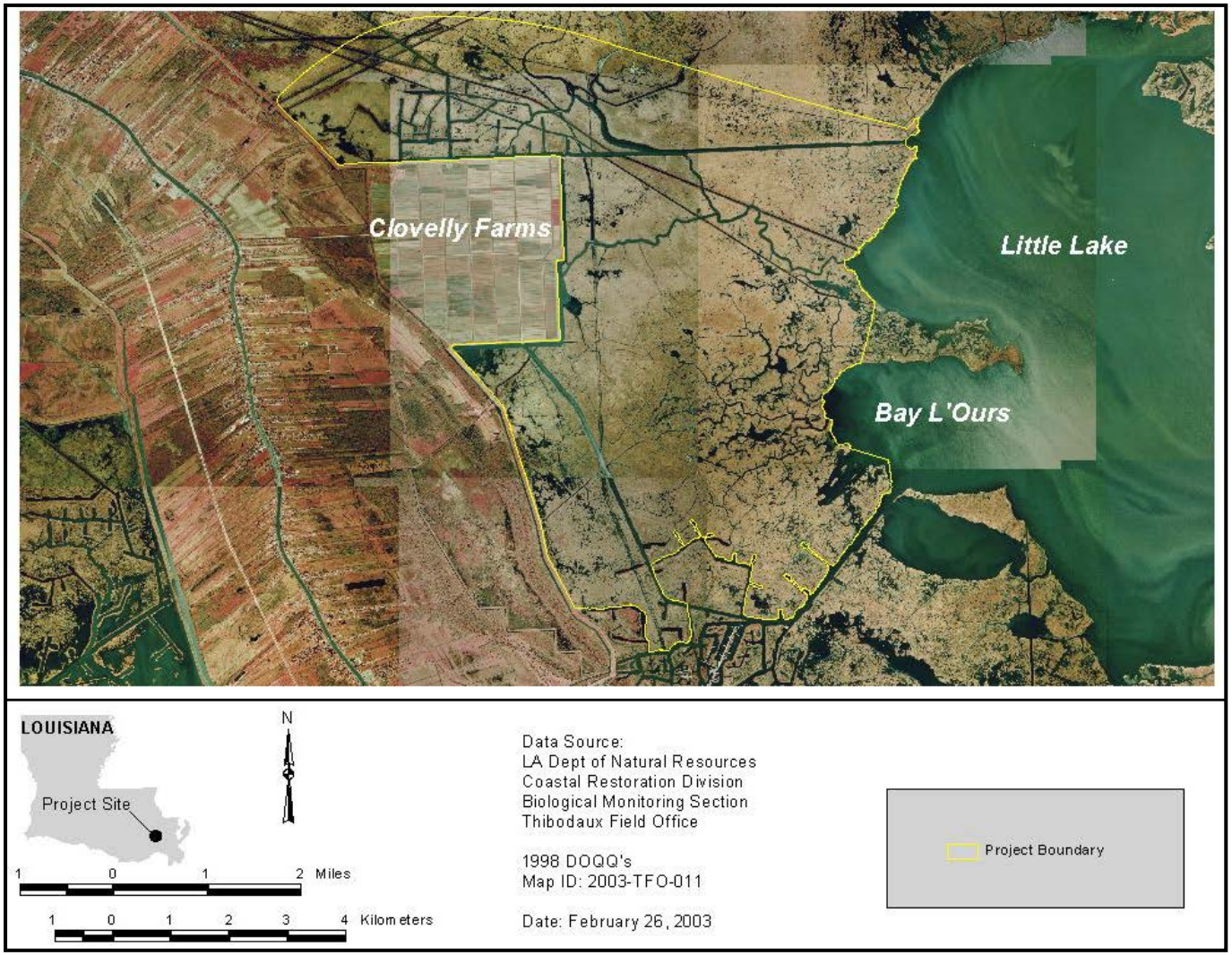

Figure 1. Location map with project boundary for the GIWW (Gulf Intracosastal Waterway) to Clovelly Hydrologic Restoration project.

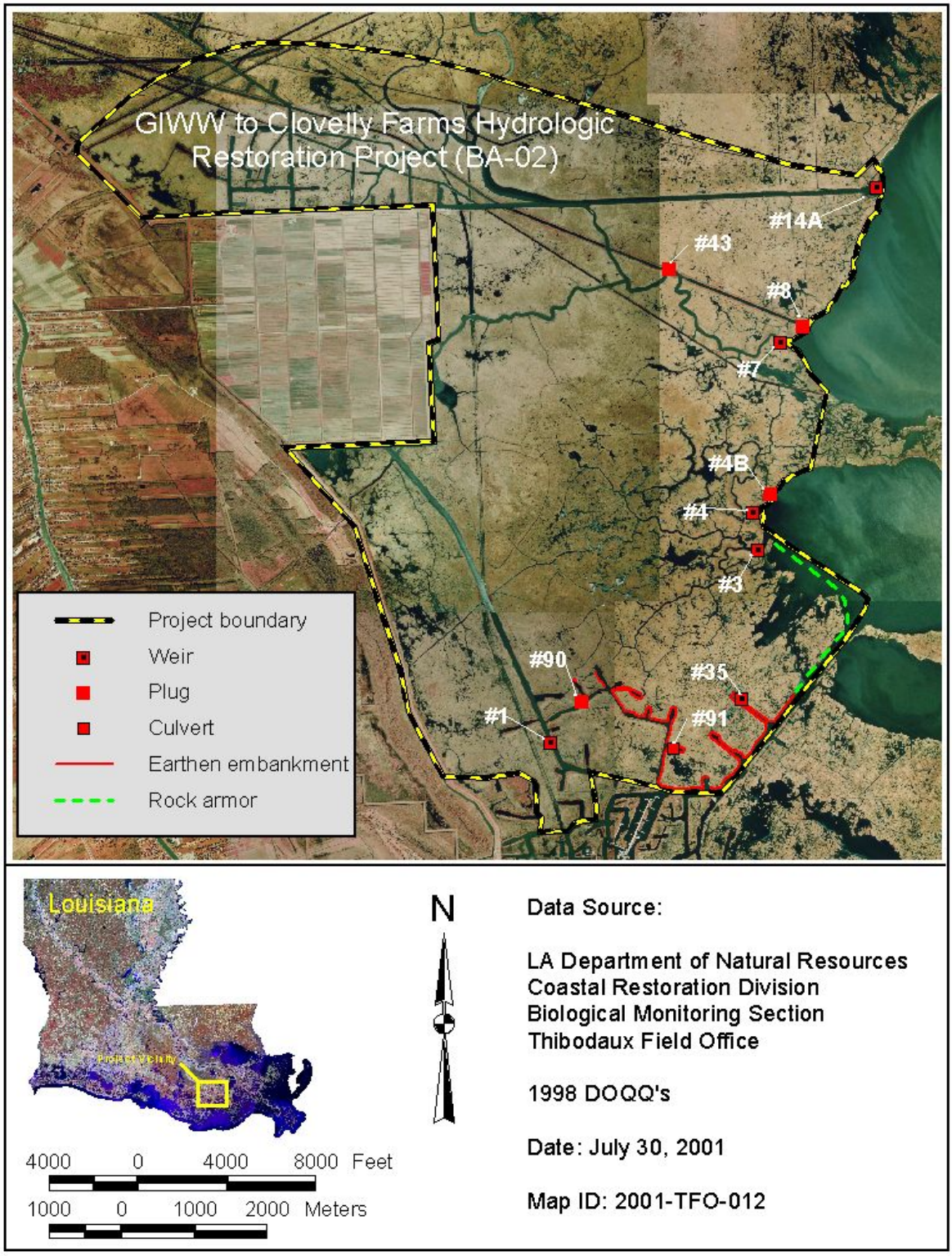

Figure 2. Project infrastructure map for the GIWW (Gulf Intracoastal Waterway) to Clovelly (BA-02) Hydrologic Restoration project.

II. Maintenance Activity

a. Project Feature Inspection Purpose and Procedures

The purpose of the annual inspection of the GIWW to Clovelly Hydrologic Restoration Project (BA-02) is to evaluate the constructed project features, identify any deficiencies and prepare a report detailing the condition of such features and to recommend corrective actions needed, if any. Should it be determined that corrective actions are needed, LDNR shall provide, in report form, a detailed cost estimate for engineering, design, supervision, inspection, construction contingencies, and an assessment of the urgency of such repairs (O&M Plan, 2002).

An inspection of the GIWW to Clovely Hydrologic Restoration Project (BA-02) was held on February 19, 2004 under clear skies and mild temperatures. In attendance were Brian Babin and Shane Triche from LDNR and Brad Sticker with NRCS. The attendees met at the Clovelly Canal Public Boat Launch. The inspection began at approximately 8:15 a.m. and ended at 11:30 a.m.

The field inspection included a complete visual inspection of the entire project site. Staff gauge readings were used to determine approximate elevations of water, rock weirs, earthen embankments, lake-rim dike and other project features. A handheld Global Positioning System (GPS) unit was used to mark the locations of low areas along the earthen embankments and rock structures that may require corrective action or periodic visual inspection on future site visits.

b. Inspection Results

CONSTRUCTION UNIT NO.1

Site No.4 – Fixed crest rock weir with boat bay

During the inspection, we observed slight settlement of the rock weir on both sides of the structure. After probing the rock at the bottom of the boat bay, it was determined that the average depth of water above the boat bay was 4.1'. The translation from an estimated water elevation of 0.0' NAVD to the rock beneath the boat bay was estimated to be at an elevation of -4.1' NAVD. Signs and supports were in good condition. Although the rock structure had settled slightly, LDNR and NRCS agree the physical condition of the rock structure was good and no maintenance will be required at this time.

Site No.7– Fixed crest rock weir w/ boat bay

The north side of the rock weir has experienced slight settlement since the placement of rock rip-rap. The signs, sign supports and earthen embankment also appear to be in good condition. From field measurements taken, it was determined that the rock lining the channel below the boat bay was at approximately -5.5' NAVD. NRCS and DNR agree

that integrity of the structure is good and that no maintenance will be required at this time.

Site No.8– Rock rip-rap weir

At the time of the inspection, the rock-lined channel, timber piles, signs, supports and earthen embankments appeared to be in good condition. No maintenance is planned for structure no. 7 as a result of this inspection.

Site No.43 – Rock rip-rap channel plug

During the 2003 annual inspection, it was noted that a 10 ft. section of the rock plug was breached on the east side of the structure. The same observation was made during the 2004 annual inspection, though it appears that the breach has not increased in width or depth. We believe that the rock plug has settled slightly since construction. NRCS and LDNR agree that this structure is in fair condition and should be monitored periodically on future field trips and investigations. No maintenance will be required at this time.

Site No.91 – Rock plug with culvert and flap gate

Rock plug at site no. 91 appeared to be in good condition with no noticeable settlement. The culvert, flap gate, signs, timber supports and earthen embankments were also in good condition. While inspecting the flap gate attached to the corrugated pipe, we did notice excessive barnacle growth on the frame and gate. By physically moving the gate, it appeared that the barnacle growth was not affecting the operations of the structure. LDNR and NRCS agree that no maintenance will be required as a result of this inspection.

CONSTRUCTION UNIT NO.2

Site No.1 – Fixed crest rock weir w/ barge bay

The rock weir structure with barge bay at Structure no. 1 seems to be in very good condition. From estimated water level readings, field measurements show that the bottom of the rock lined barge bay is at -6.0’ NAVD. The signs, supports and earthen embankments were also in very good condition. We did notice that the pile clusters on each side of the barge bay supporting the warning signs were slightly damaged due to larger vessels rubbing the timbers while accessing the barge bay. LDNR and NRCS agree that no maintenance is required as a result of this inspection.

Site No. 4B – Rock rip-rap channel plug

The rock plug at Structure 4B appeared to be in fair condition. We did notice slight washout of the earthen embankment on the south side of the structure. The signs and timber supports were in good condition and the earthen embankments were found to be in

fair condition. NRCS and DNR agree that the washout is minor and no immediate maintenance will be required at this time.

Site No.14A – Fixed crest rock weir with barge bay

The overall condition of the rock weir at site 14A was good with no apparent settlement of the rock dike. Navigation lights were serviced in January by Automatic Power, Inc. and appeared to be in good condition. From the 2003 annual inspection, we observed that a timber batter pile supporting the navigation lights was slightly damaged. This batter piles was in the same condition as the previous inspection and no maintenance is planed to repair the pile at this time. LDNR and NRCS agree that this structure is in good condition and maintenance is not required as a result of this inspection.

Site No.35 – Variable crest weir , water control structure

The variable crest weir structure appeared to be in very good condition at the time of the inspection. The steel bulkhead, stop logs, handrails, cables, signs, supports and other hardware were in good condition with no signs of corrosion. We did notice that the paint on the channel cap of the steel bulkhead was beginning to flake. LDNR and NRCS agree that the structure was in good condition and no maintenance is needed at this time. The paint on the channel cap of the structure will be monitored on future site visits. Also, between ongoing contracts to operate the structure, the hand crank to the boom and cable system had been misplaced. The replacement hand crank is on order through Hercules Wire Rope and Sling Company Inc. of Houma and should be delivered by the end of March.

Site No. 90 – Rock rip-rap channel plug

Structure no. 90 seemed to be in good condition with no noticeable settlement of the rock weir. Signs and supports were also in good condition. No maintenance is required at this time.

Lake Rim Restoration

During the inspection, we noticed that several locations along the lake rim which appeared to have settled. Low areas were also noticed from Sta. 7+00 to Sta. 13+00. This section of rock was estimated to be at elevation +1.5’ NAVD by water level readings at the time of the inspection. Also, from Sta. 36+00 to Sta. 41+00 along the rock dike appeared to have settled with estimated crest elevations ranging from 1.0’ to 1.5’ NAVD. The original armored rock dike was constructed to an elevation of +2.0’ NAVD. NRCS and DNR agree that settlement of the rock dike at the locations described above will not require maintenance at this time. However, these locations shall be monitored on future site visits to determine if further settlement has occurred.

Earthen bank stabilization

Overall, the earthen embankment constructed along several oil field canals appeared to be in good condition. Earthen embankment at Sta. 560+00, located at the end of an existing

location canal south of Superior Canal adjacent to an existing pipeline, has eroded away. The breach was estimated to be approximately 200 ft. wide. Since this breach is located at the end of the location canal and encroaches onto an existing pipeline right-of-way that does not appear to experience large flows, NRCS and DNR decided that the repair of this breach can be performed at a later date. A smaller breach was also identified at Sta. 122+00 along the east bank of the second location canal off of Brenton Canal from the Bay L' Ours. This breach was approximately 10' wide with water exchanging through the opening. The breaches mention above shall be monitored and re-evaluated on future site visits to determine if change in condition has occurred. No maintenance will be undertaken at this time.

Navigation Aids Maintenance: Since the completion of the GIWW to Clovelly project, the navigation aids located adjacent to the barge bay at Structure 14A have been serviced on two (2) separate occasions. Below is a short description of repairs, dates and cost associated with the service of the navigation aids:

5/16/02 – Automatic Power of Larose, La. performed maintenance service to repair navigation lights at Structure 14A. 17 – bulbs were replaced at a total cost of $421.50.

12/16/03 – Automatic Power performed maintenance service to repair navigation lights at Structure 14A. The battery and bulbs were replaced in all four (4) navigation lights at a total cost of $2,189.80.

II. Maintenance Activity (continued)

c. Maintenance Recommendations

Overall, the project features of the GIWW to Clovelly Project appeared to be in good condition with only slight deficiencies noted in the inspection results such as slight settlement of the armored rock dike of the Lake Rim and several rock weirs, a large breach in the earthen embankment along a location canal south of Superior Canal and a small breach located along the bank of an existing location canal north of Brenton Canal. LDNR and NRCS agree that a cost effective approach to maintenance of these features is to delay the repair of the breached sections of earthen embankments until other maintenance items are identified for repair to be included under a single contract.

As a result of the 2004 Annual Inspection, LDNR and NRCS agree that no maintenance work is needed at this time. However, there are several areas along the rock dike and earthen embankment which have settled or are breached which may require a re-evaluation prior to the next annual inspection. It is recommended that on future site visits LDNR will visit these locations and assess the condition of these structures and determine a plan of action, should one be needed.

This annual inspection was an evaluation of the physical integrity of the constructed project features and does not represent an analysis of the overall effectiveness of the project. Should monitoring data collected in the field show that the deficiencies outlined in this report are having an adverse affect on the performance of the project, the conclusions and recommendation concerning maintenance objectives may change.

III. Operation Activity

2003 Structure Operations: In accordance with the operation schedule outlined in the Operation and Maintenance Plan, Structure 35 of the GIWW to Clovelly Hydrologic Restoration Project was manipulated during the months of April and November beginning in March 2002.

IV. Monitoring Activity

a. Monitoring Goals

Specific objectives of the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration project are (1) to protect and maintain approximately 14,948 ac (6,049 ha) of intermediate marsh by restoring natural hydrologic conditions that promote greater freshwater retention and utilization, prevent rapid salinity increases, and reduce the rate of tidal exchange, and (2) to reduce shoreline erosion through shoreline stabilization.

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

1. Increase or maintain marsh to open water ratios.
2. Decrease salinity variability in the project area.
3. Decrease the water level variability in the project area.
4. Increase or maintain the relative abundance of intermediate marsh plants.
5. Promote greater freshwater retention and utilization in the project area.
6. Reduce shoreline erosion through shoreline stabilization.
7. Increase or maintain the relative abundance of submerged aquatic vegetation (SAV).

b. Monitoring Elements

Habitat Mapping

To document vegetated and non-vegetated areas and marsh loss rates, color-infrared aerial photography (1:24,000 scale, with ground control markers) has been obtained by NWRC for the project area. For each flight, the photography is geo-rectified, photo-interpreted, mapped, ground-truthed, and analyzed with GIS by NWRC personnel using techniques described in Steyer et al. (1995, revised 2000). Photography was obtained prior to construction in November 1993 and in December 1996, and after construction in December 2002. Based on the CRMS (Coastwide Reference Monitoring System) review, land-water analysis instead of habitat mapping will be performed on photography collected in 2008 and 2015.

Water Level

To monitor water level variability, seven continuous recorder stations were located within the project area, however two stations (station BA02-58 and BA02-59) were discontinued due to severe scouring around the instruments. Discrete water levels were measured monthly at 5 stations inside the project area using techniques described in Steyer et al. (1995, revised 2000). Staff gauges were surveyed to North American Vertical Datum of 1988 (NAVD88) adjacent to the continuous recorders in order to tie recorder water levels to the DNR South Louisiana Coastal Wetland GPS network (SLCW) datum. Marsh elevation was surveyed and used in conjunction with continuous recorders to determine duration and frequency of flooding.

Salinity

To monitor salinity variability, seven continuous recorder stations were located within the project area, however two stations (station BA02-58 and BA02-59) were discontinued due to severe scouring around the instruments. Discrete salinity was measured monthly at 25 stations inside the project area using techniques described in Steyer et al. (1995, revised 2000).

Vegetation

Species composition and relative abundance were evaluated inside the project area using a modification of the Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974)). Twenty-five plots were originally located in the project area. Eight of these plots in the northern portion of the project area had to be dropped from monitoring due to land rights issues. Vegetation species composition and relative abundance were evaluated once prior to construction in 1996, once after Phase 1 construction in 1999, and twice after Phase II construction in 2000 and 2002. Additional data collection will commence at years 2005, 2008, 2012, and 2016.

Soil Samples

To evaluate effects of freshwater retention and saltwater intrusion, soil samples were taken to determine percent organic matter, bulk density, and soil porewater salinity using techniques described in Steyer et al. (1995, revised 2000). Twenty-five plots were originally located in the project area. Eight of these plots in the northern portion of the project area had to be dropped from monitoring due to land rights issues. Soil samples from the remaining seventeen project area plots were evaluated once prior to construction in 1996, once after phase 1 construction in 1999, and twice after Phase II construction in 2000 and 2002. Additional data collection will commence at years 2005, 2008, 2012, and 2016.

Shoreline Change

To evaluate marsh edge movement along the shoreline protection structures placed in Bay L'Ours and along the pipeline canal at the southern border of the project area, controlled GPS was used to document marsh edge position using techniques described in Steyer et al. (1995, revised 2000). GPS measurements were taken in 2000 immediately after Phase II construction and in 2003 post-construction. Measurements will also be taken at years 2005, 2008, 2012, and 2016. In addition, historical rates (as m yr^{-1} loss) of erosion will be obtained and compared to erosion rates after project implementation.

Submerged Aquatic Vegetation (SAV)

The frequency of occurrence of SAV was analyzed for the project area. Ten ponds inside the project area were sampled once in the fall of 1996 (November) pre-construction. The three ponds in the northern portion of the project area were dropped from monitoring due to land rights issues. Data collection on the remaining seven ponds occurred four times after Phase 1 construction in the spring (April) of 1999, in the fall of 1999 (October), in the spring of 2000 (May), and in the fall of 2000 (August). Post-construction data collection occurred during fall 2002 (November).

IV. Monitoring Activity (continued)

c. Monitoring data analysis

Habitat Mapping

Aerial photography was obtained prior to construction in November 1993 and in December 1996, and post-construction in December 2002 and is currently being analyzed by USGS/NWRC. Photomosaics of the 1993 and 1996 aerial photography have been completed (figures 3-4).

Figures:

Figure 3. 1993 photomosaic of the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration project.

Figure 4. 1996 photomosaic of the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration project.

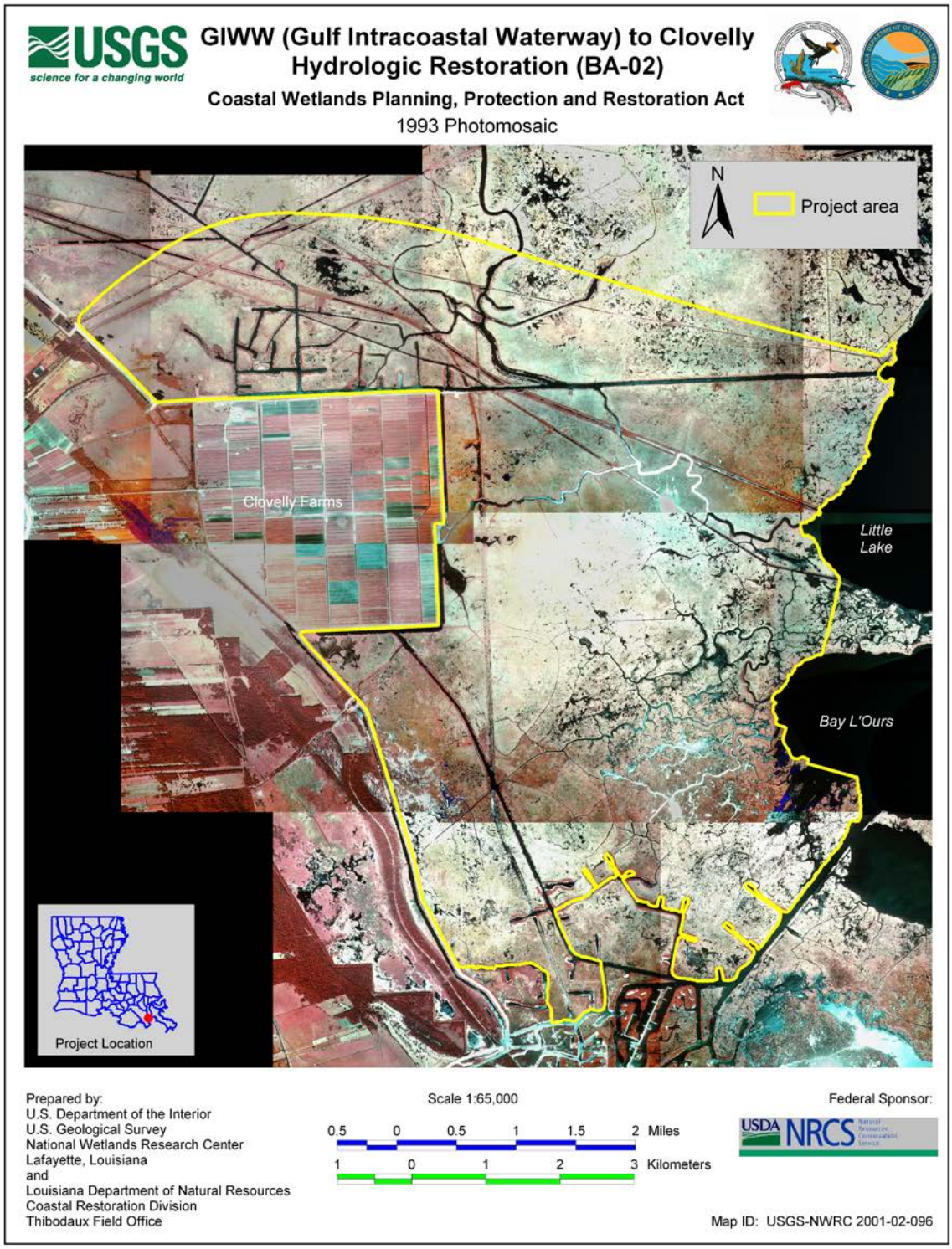

Figure 3. 1993 photomosaic of the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project area.

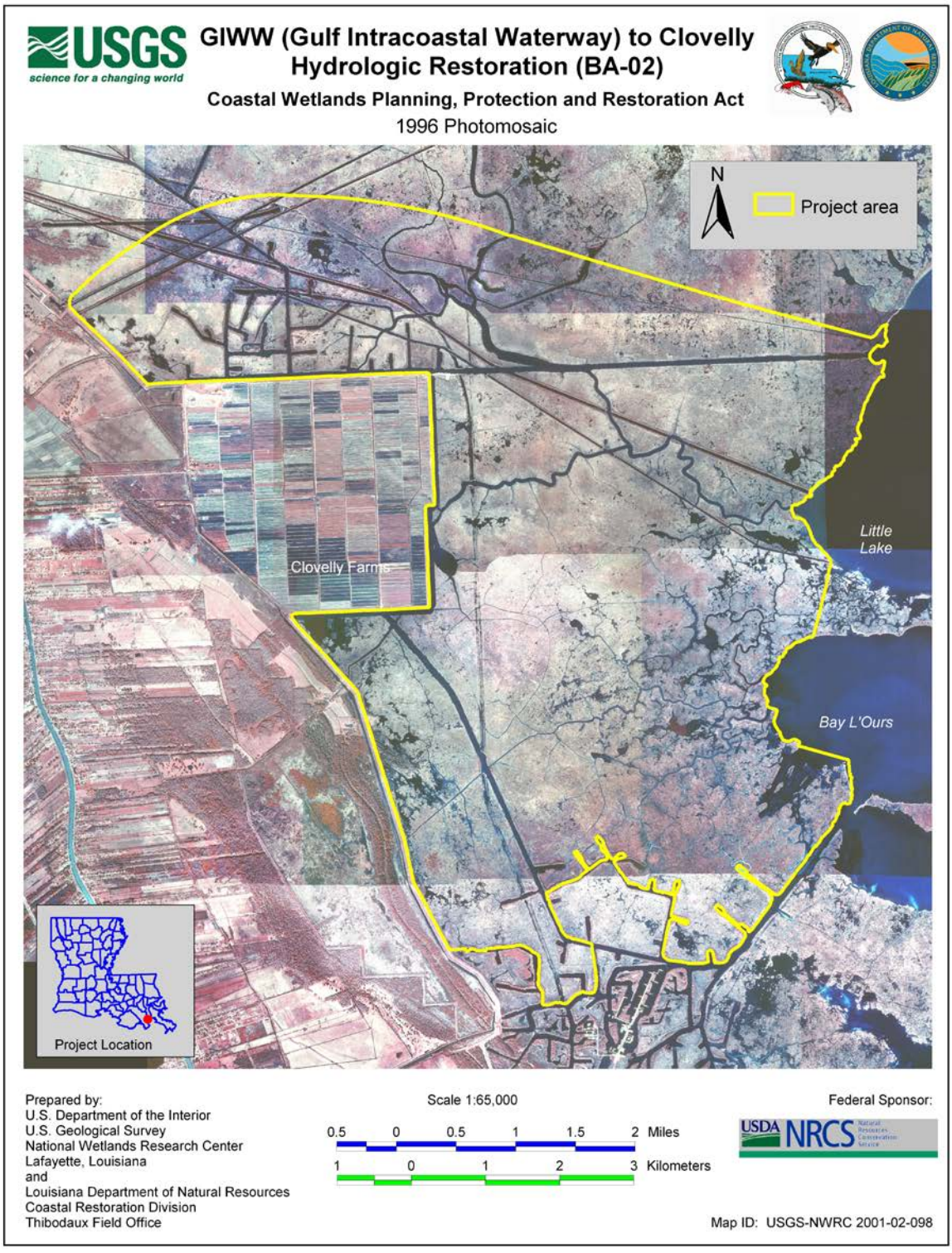

Figure 4. 1996 photomosaic of the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project area.

Water Level

Continuous recorder stations where hourly water level data have been collected. (table 1; figure 5):

Station	Data collection period
BA02-53	7/1/1997 - present
BA02-54	7/2/1997 – present
BA02-55	6/24/1997 – present
BA02-56	6/24/1997 – present
BA02-57	7/1/1997 – present
BA02-58	7/1/1997 -7/24/2002
BA02-59	7/1/1997 – 10/12/1998

*The entire 4 x 4 setups along with the continuous recorders at BA02-58 and BA02-59 were lost due to the scouring out of the channel bottoms where the stations were located.

Figures:

Figure 5. GIWW (Gulf Intracoastal Waterway) to Clovelly (BA-02) continuous recorder station locations.

Data Analysis Methods for Water Level:

Since project construction was completed in two phases and only a portion of the structures were in place when the monitoring equipment was installed or in use, water level continuous and discrete monitoring data was broken into periods of partial and post-construction. Additionally, one of the continuous recorder station (station BA02-59) was gone, presumed to be scoured out, during pre-construction, therefore there are no comparative post-construction data available for this station. Finally, reference areas selected to the north and northeast of the project boundary were eliminated due to land rights issues, leaving only the Little Lake DCP station for reference data collection.

Generalized Linear Model (GLM) procedures for Analysis of Variance (ANOVA; SAS 1999) were used to compare mean weekly water level between partial and post-construction at each BA-02 continuous recorder station and the Little Lake DCP. As tidal cycles may be longer than one 24-hour period, weekly means for water level were used in all analyses to account for tidal variation. To prevent time periods when only a few stations were recording data from skewing any results (e.g., seasonal variation), only data where all stations (i.e., BA02-53, BA02-54, BA02-55, BA02-56, BA02-57, and Little Lake DCP) had observations were used in each analysis. BA02-58 was scoured out in July 2002 and removed from most analyses to provide longer data sets. Pre-construction data was not used because only a few months of data were available.

Correlations for water level and salinity were used to determine whether freshwater via precipitation or upland input or saltwater pushed inland from southerly winds was the primary source of water and salinity into the project area.

An analysis similar to the Before-After-Control-Impact (BACI) design (Stewart-Oaten et al. 1986, Underwood 1994) was used to determine partial and post-construction effects whereas the differences in water level were calculated by subtracting concurrent water level value for each BA-02 continuous recorder from the Little Lake DCP values. The mean differences for partial and post-construction were compared via t-tests (on log transformed data) and Mann-Whitney *U*-tests (SAS 1999, Sokal and Rohlf 1995). Water levels tended to vary similarly among all stations and with the Little Lake DCP. Observations and errors associated with this method are independent and homoscedastic (Stewart-Oaten et al. 1986, Underwood 1994). Although the Little Lake DCP water levels are reported in a different vertical datum, calculated differences would remain relative when comparing partial and post-construction among each station.

We used the marsh elevation at BA02-53 to estimate intervals in which the project area was flooded. That is, the data when water level was either above this elevation or below this elevation was used in determining changes in water levels between partial and post-construction. Correlations were also used to indicate the source of water during episodes when the project area was flooded.

Given tidal cycles and high variability in the data, events were characterized from when water level starts to rise, through its maximum to when it starts to rise again. During each of these events, the maximum, minimum, and range (or magnitude from minimum to maximum) in water level as well as the duration of this event were compared for partial and post-construction via GLM at each station and the Little Lake DCP.

Salinity

See table 1 and figure 5 referenced above under water level for station locations and data collection durations.

Data Analysis Methods for Salinity:

See data analysis methods for water level above. The same analysis methodology was used for salinity.

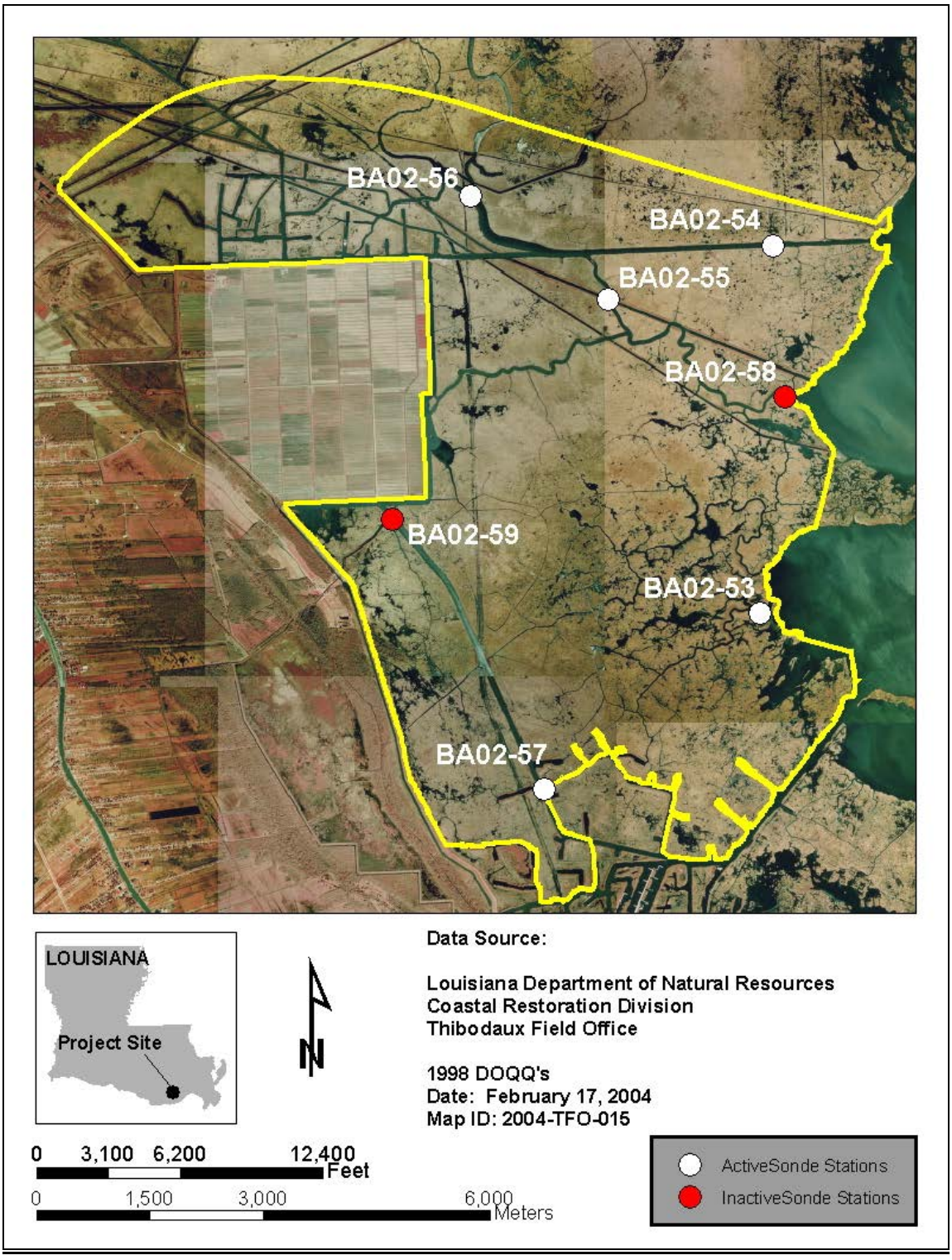

Figure 5. The GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project continuous recorder station locations.

Discrete Salinity Data

Discrete staff gauge readings have also been recorded each field trip since September 1997 at stations BA02-53, BA02-54, BA02-55, BA02-56, BA02-57, BA02-58, and BA02-59. The staff gauge was not replaced at BA02-59 after October 1998 therefore discrete staff gauge data is not available past this date for this station. Additional discrete salinity and water level data were collected at stations throughout the project area during each field trip since September 1997 (figure 6).

Figures:

Figure 6. Location map of discrete salinity stations at GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

Data Analysis Method for Discrete Salinity:

The SAS System for Windows © 2002, Version 8.0 was used to determine mean bottom salinities for each discrete station for partial and post-construction data. SAS results were entered into a Microsoft® Excel 2002, Version 10.43 worksheet and a bar chart was generated for graphic representation of the data.

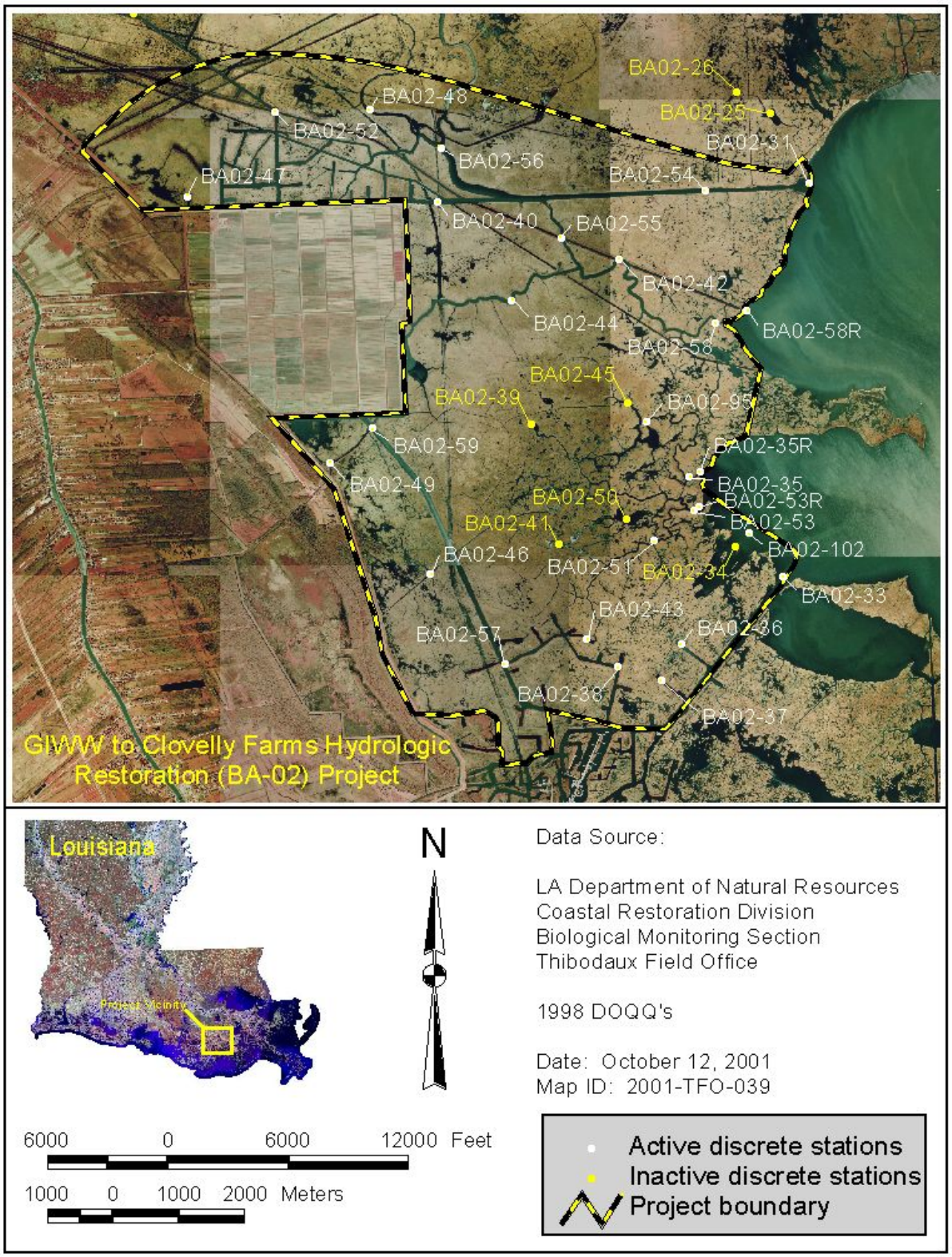

Figure 6. Location map of discrete salinity stations at GIWW to Clovelly Hydrologic Restoration (BA-02) project.

Vegetation

Vegetation data were not collected during 2003 for this project, however data were collected in previous years (figures 7-8).

Figures:

Figures 7-8. Location map of vegetation stations for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

Data Analysis Method for Vegetation:

The SAS System for Windows © 2002, Version 8.0 was used to determine mean percent cover for each species by year. SAS results were entered into a Microsoft® Excel 2002, Version 10.43 worksheet and a bar chart was generated for graphic representation of the data.

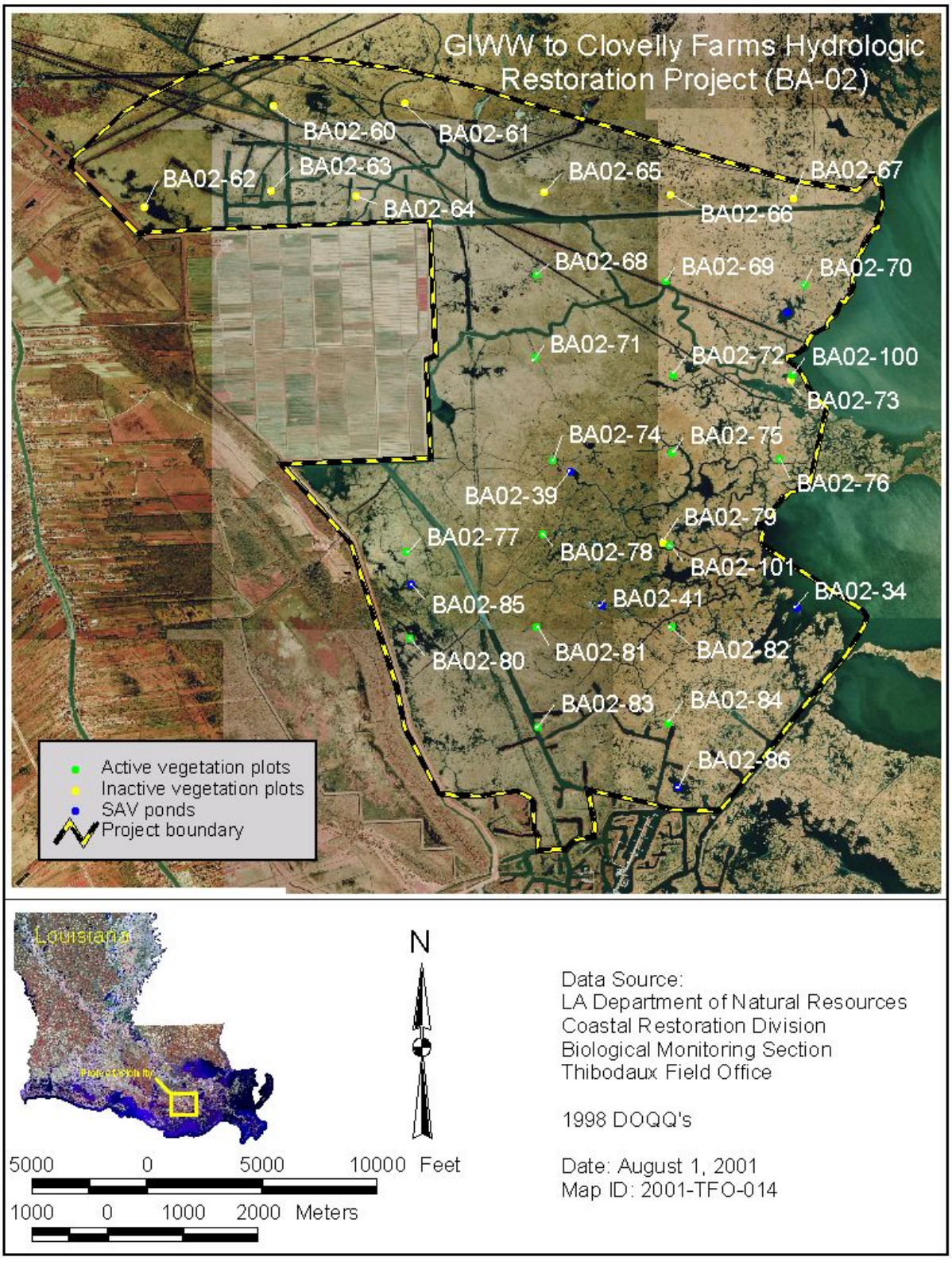

Figure 7. Location of active and inactive vegetation plots for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

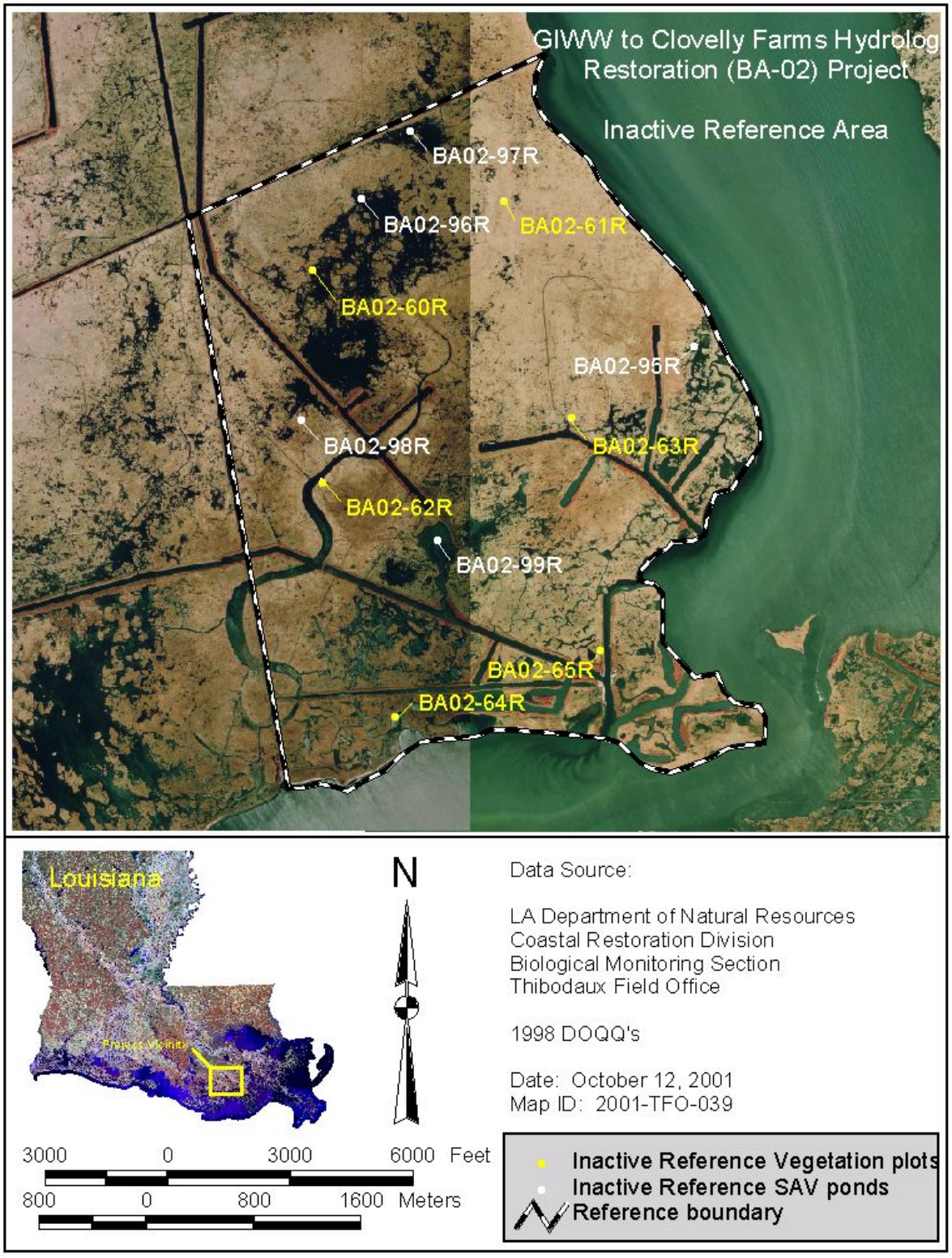

Figure 8. Location map of inactive reference vegetation stations for the GIWW to Clovelly Hydrologic Resoration (BA-02) project.

Soils

Soils data were not collected during 2003 for this project, however they were collected in previous years (figure 9).

Figures:

Figure 9. Location map of soils stations for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

Data Analysis Method for Soils:

Percent bulk density, percent organic matter, and percent soil moisture for each station by year were entered into a Microsoft® Excel 2002, Version 10.43 worksheet and bar charts were generated for graphic representation of the data.

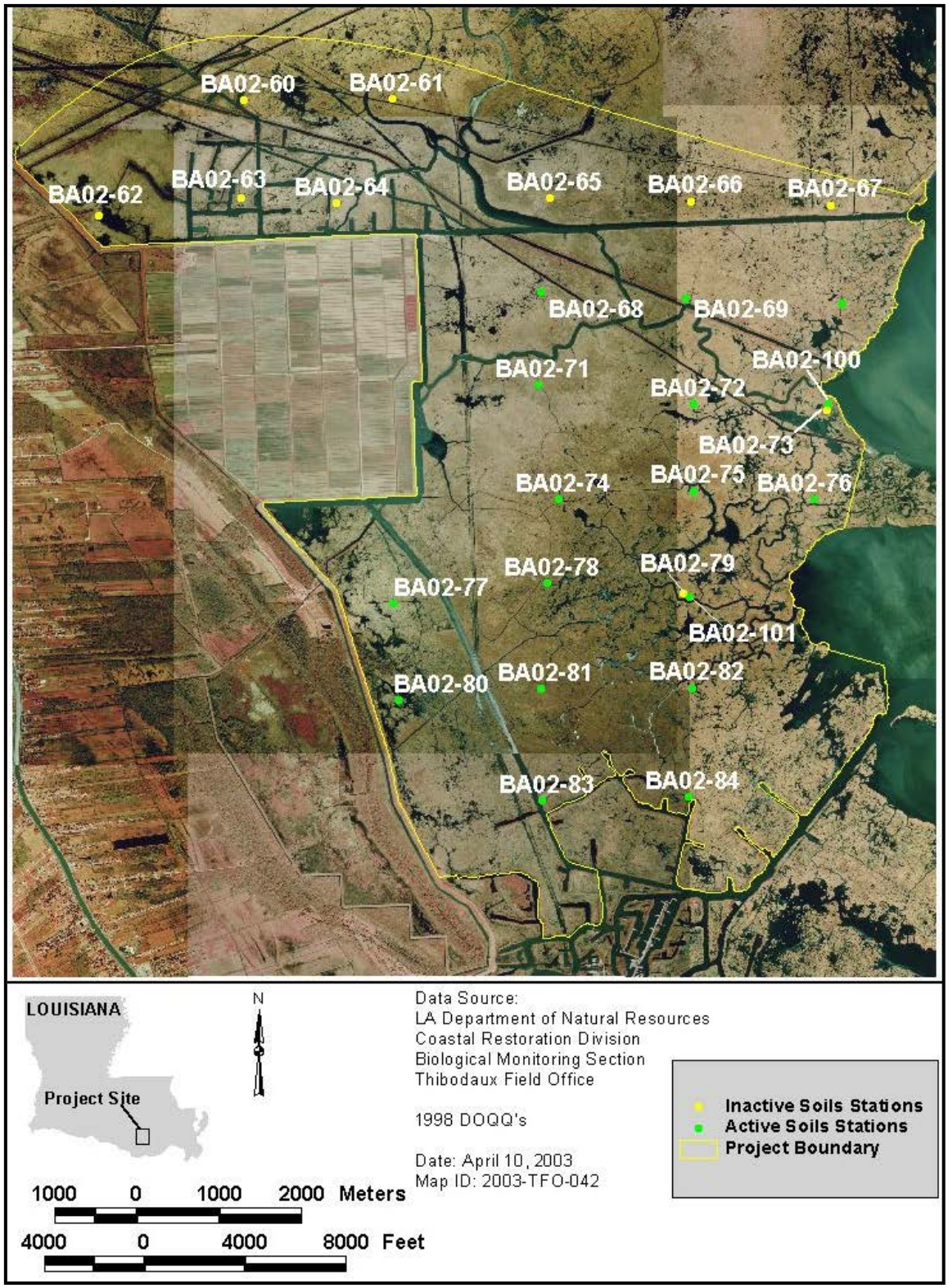

Figure 9. Location map of active and inactive soils data collection stations for the GIWW to Clovelly Hydrologic Restoration (BA-02) Project.

Shoreline Change

Shoreline position data for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project was collected immediately after Phase II construction in 2000 and three years post-construction in 2003 (figures 10-14).

Figures:

Figures 10-14. Location maps indicating the November 2000 and March 2003 shorelines along the twenty-one randomized 300 ft (91.4 m) segments where DGPS data was collected for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

Data Analysis Method for Shoreline Change:

Georectified DGPS shoreline segments from year 2000 were entered into ArcView GIS® Version 3.2 and converted to shapefiles. Polygons were created from these segments in order to have a pre-extisting area from which to calculate area and linear changes with polygons created from subsequent data collection years. Year 2003 shoreline segments were also entered into ArcView GIS® Version 3.2 as shapefiles. Year 2000 and 2003 shapefiles were entered into Autodesk Map © 2004 where polygons were created for the 2003 segments. Area and distance calculations were made between the polygons and segments for each year using the area command function in Autodesk Map© 2004. Data generated from these calculations were entered into a Microsoft® Excel 2002, Version 10.43 worksheet and additional calculations were performed to determine the change rate per year for each shoreline segment. A bar chart was created for graphic representation of the data.

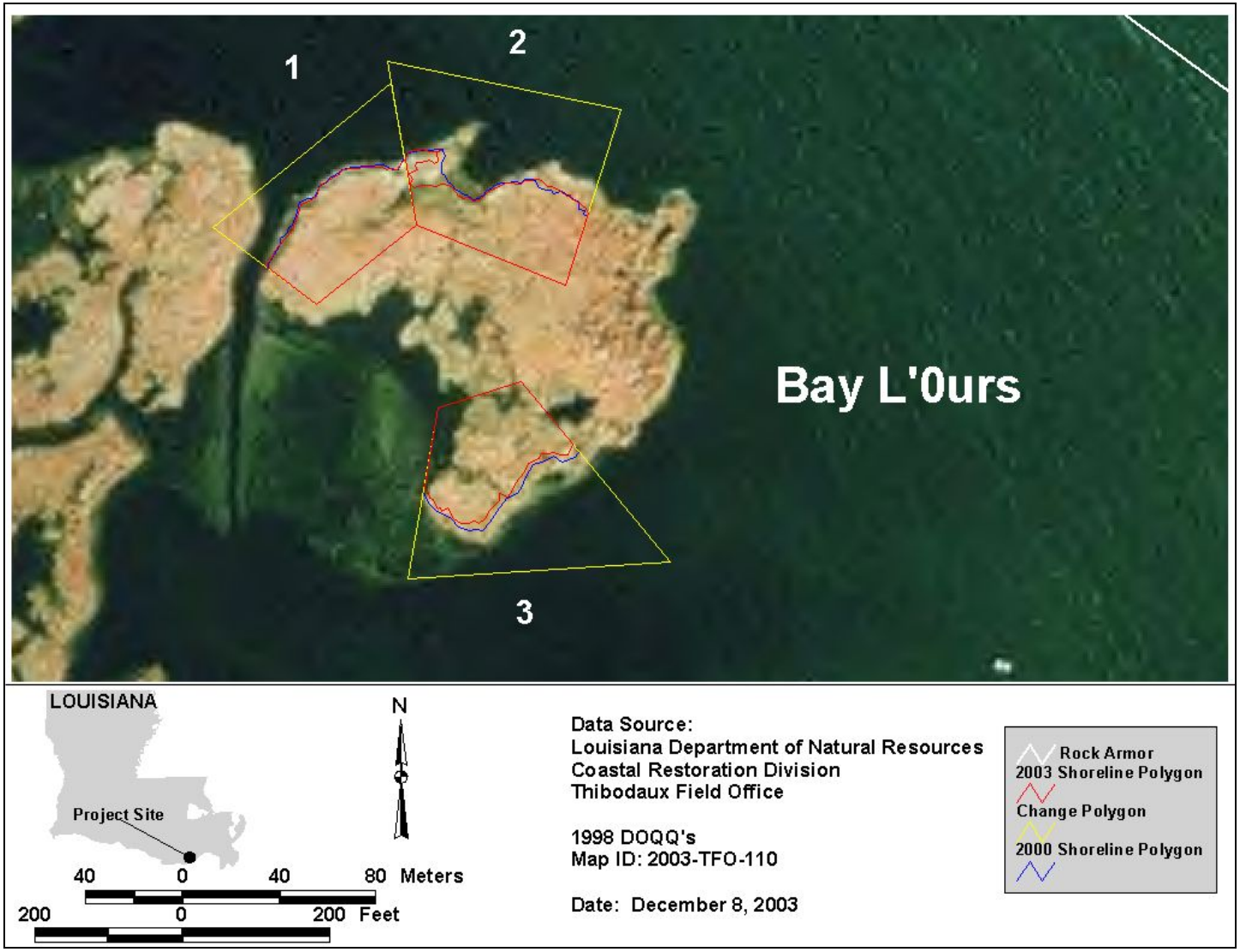

Figure 10. Shoreline positions for segments 1, 2, and 3 at years 2000 and 2003 for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

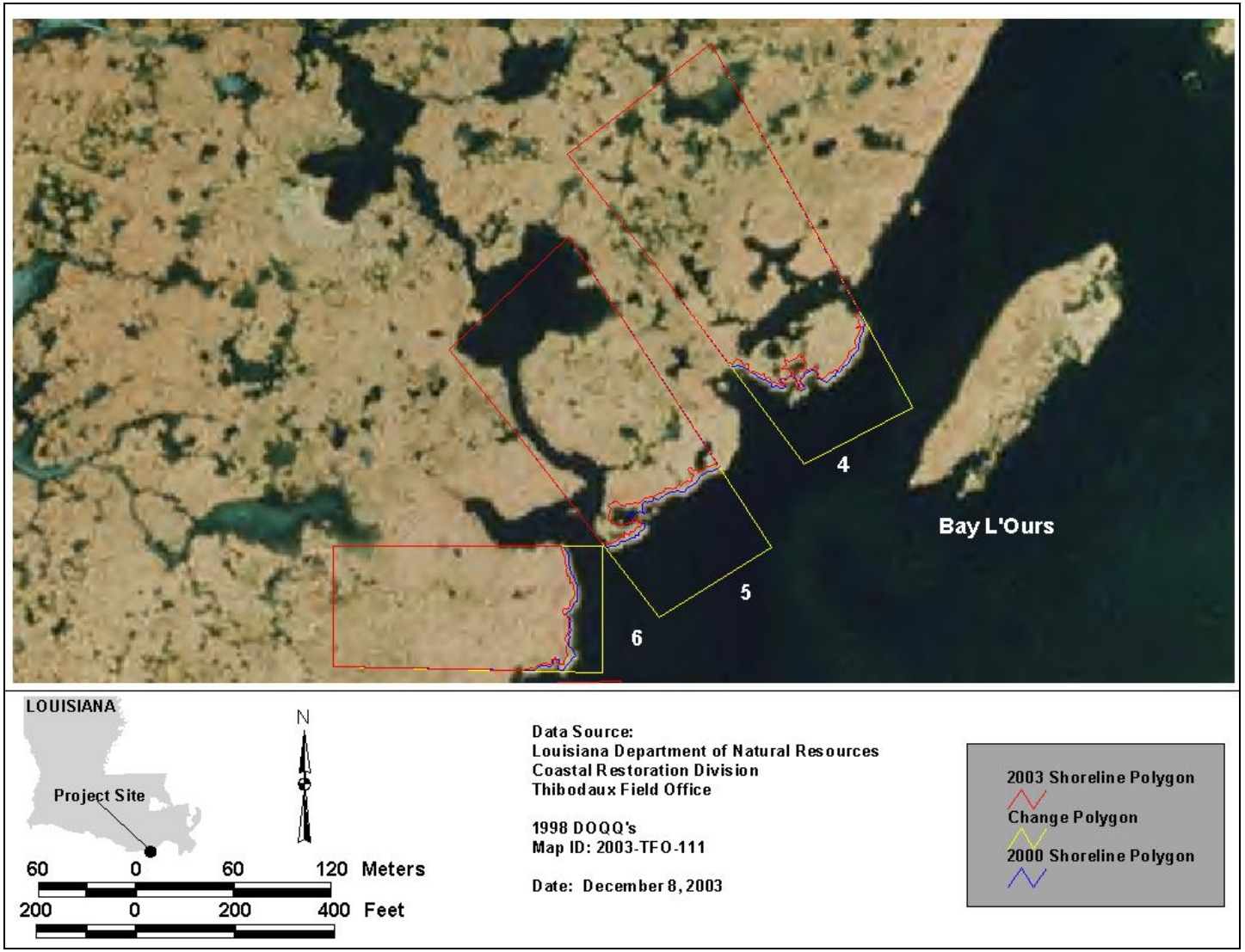

Figure 11. Location of 2000 and 2003 shoreline segments 4, 5, and 6 for GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

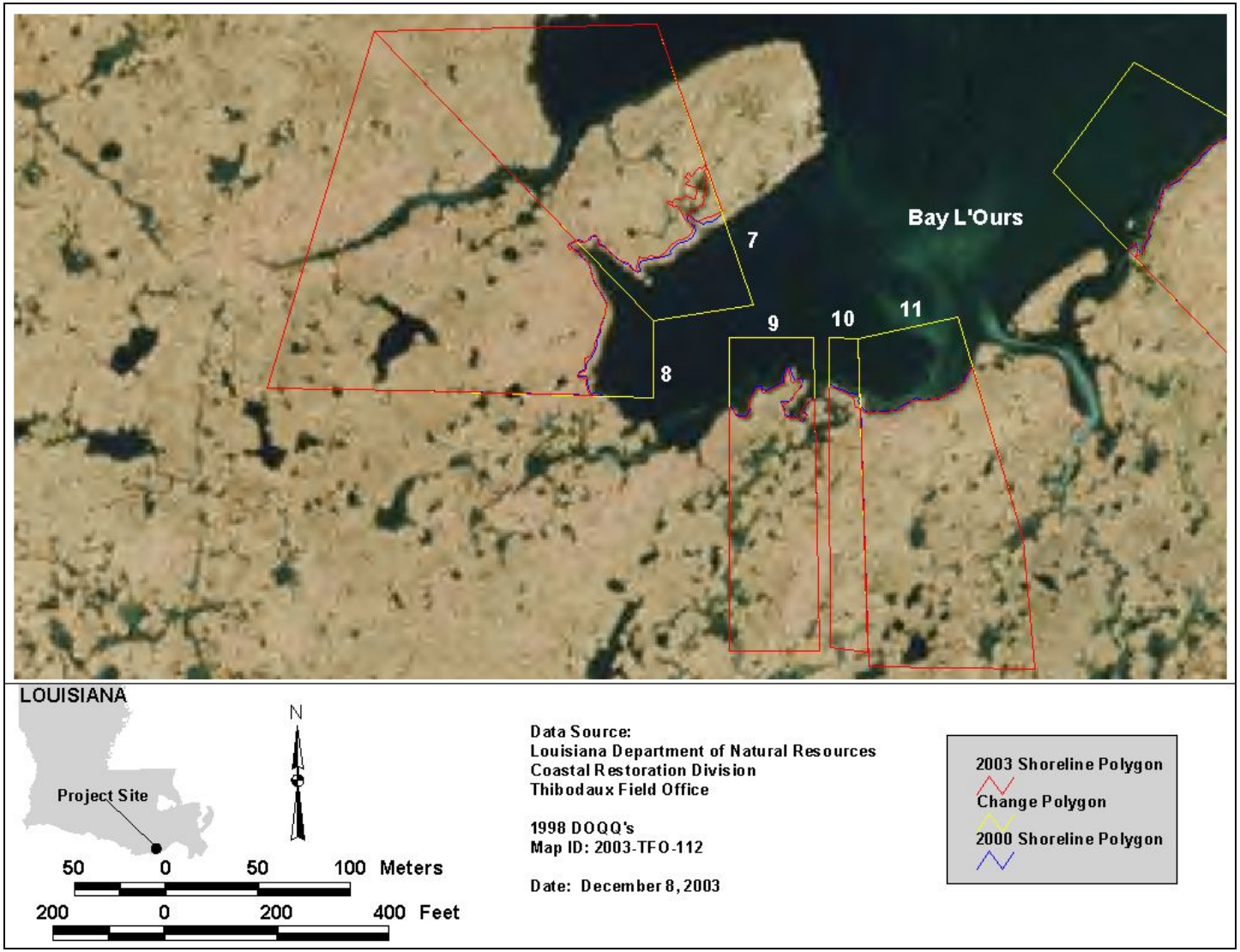

Figure 12. Location of 2000 and 2003 shoreline segments 7, 8, 9, 10, and 11 for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

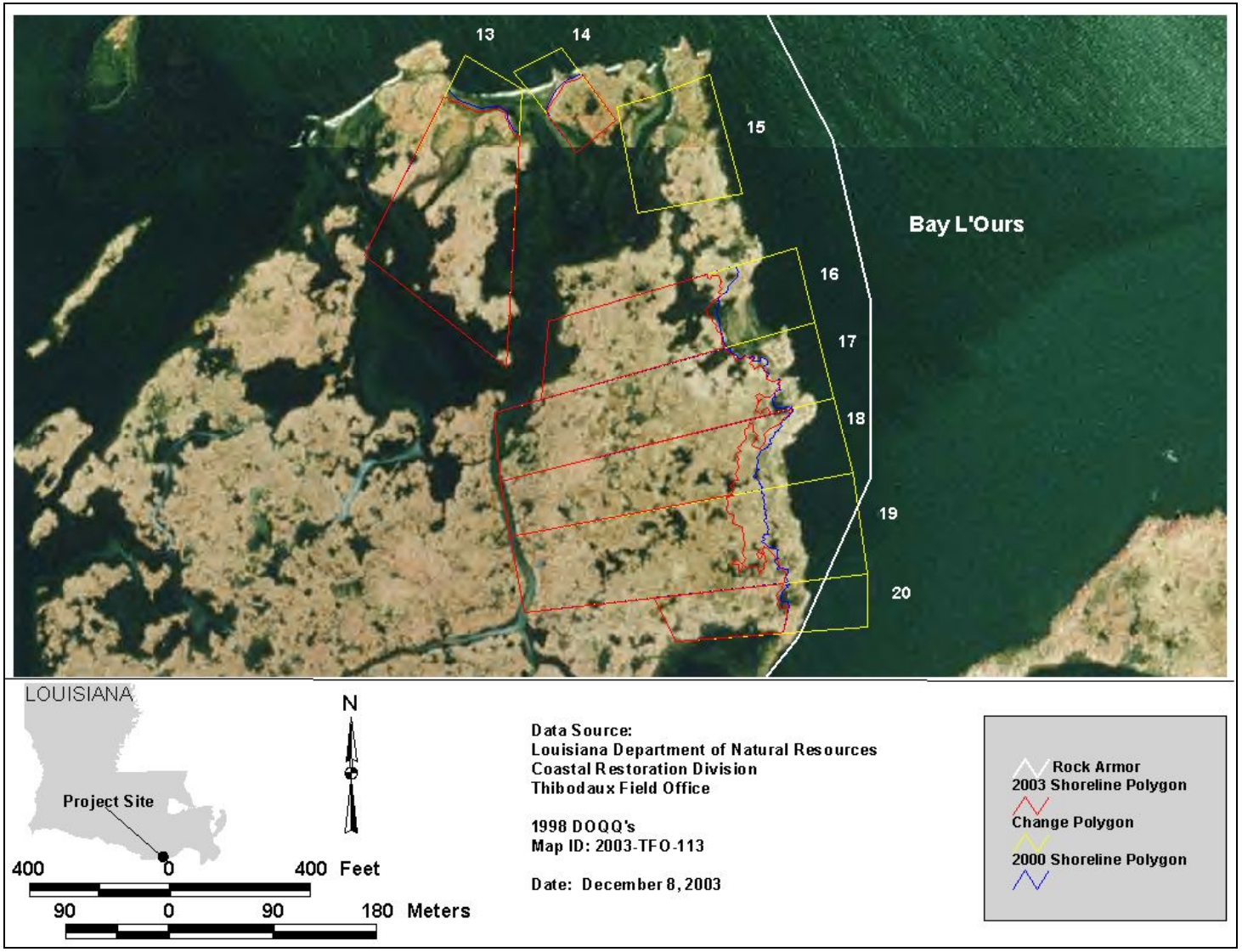

Figure 13. Location of 2000 and 2003 shoreline segments 12 through 20 for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

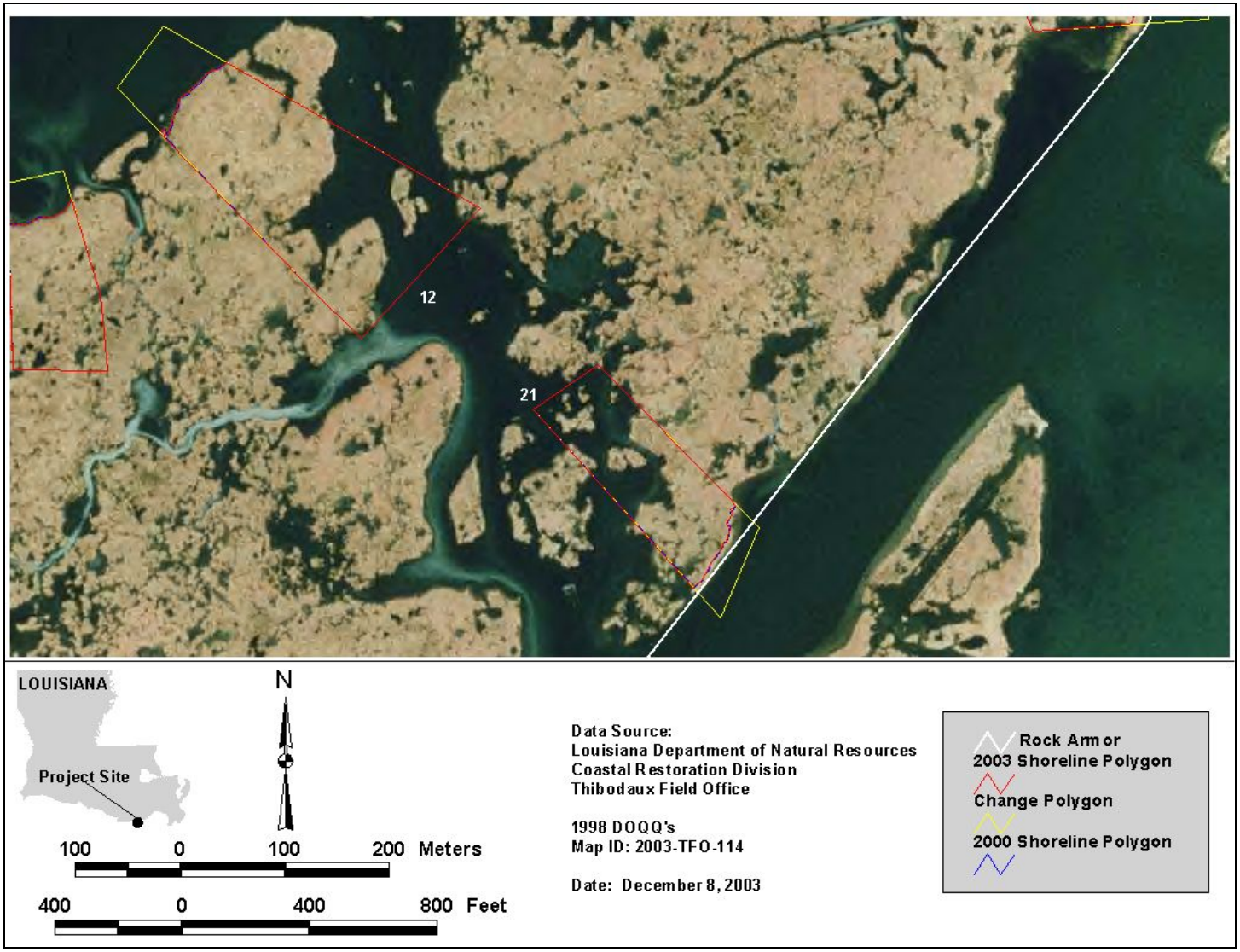

Figure 14. Location of 2000 and 2003 shoreline segments 12 and 21 for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

Submerged Aquatic Vegetation (SAV)

SAV data were not collected during 2003 for this project however data were collected in previous years (figures 15-16).

Figures:

Figures 15-16. Location map of active and inactive Submerged Aquatic Vegetation (SAV) stations for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

Data Analysis Method for Vegetation:

The SAS System for Windows © 2002, Version 8.0 was used to determine relative frequency of occurrence for each species by year. SAS results were entered into a Microsoft® Excel 2002, Version 10.43 worksheet and a bar chart was generated for graphic representation of the data.

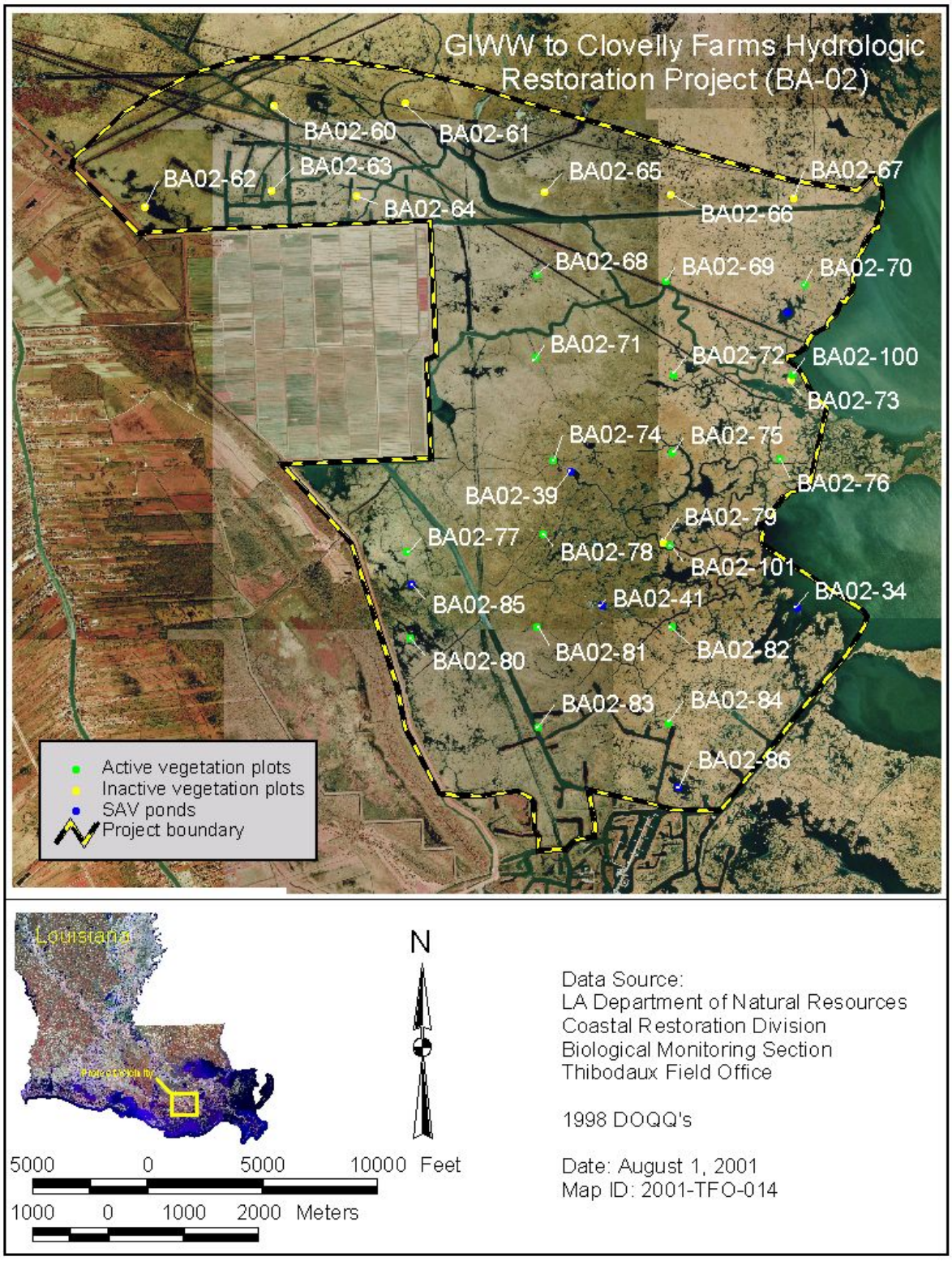

Figure 15. Location map of active and inactive Submerged Aquatic Vegetation (SAV) stations for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

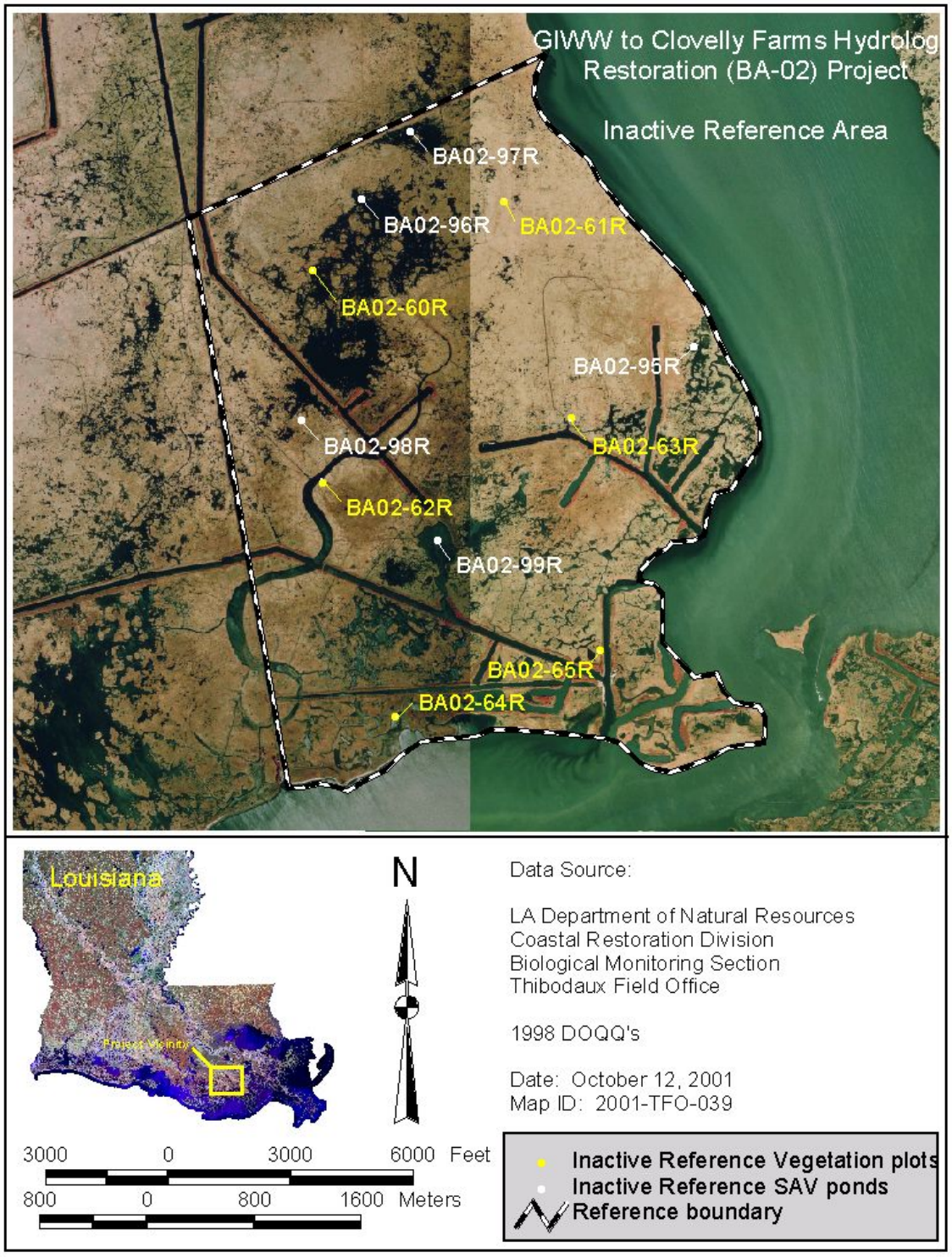

Figure 16. Location map of inactive reference area Submerged Aquatic Vegetation (SAV) stations for the GIWW to Clovellly Hydrologic Resoration (BA-02) project.

IV. Monitoring Activity (continued)

d. Preliminary Monitoring Results and Discussion

Habitat Mapping:

Aerial photography flown in 1993, 1996, and 2002 is currently being analyzed. Photointerpretation remains incomplete, therefore data are not available for preliminary results or conclusions.

Water level:

Initial observations displayed little change of water levels between partial and post-construction among project stations and the Little Lake DCP (figure 17). Water levels tended to be greater in the more northwestern project stations suggesting an overall movement of water from a northwest to southeast direction towards Little Lake. Personal observations during field trips support the idea of net water movement towards Little Lake. GLM analysis revealed no significant differences between partial and post-construction periods for any of the stations or the Little Lake DCP (table 2). The Little Lake DCP does not use the same vertical datum and thus any comparisons with project stations other than partial versus post-construction would be invalid. When BA02-58 is used in the analysis, BA02-55 had a significant decrease while none of the other stations had a significant decrease (table 3). However, these results may be misleading as longer datasets revealed no significant differences suggesting that water levels were higher overall in the latter part of 2002 and all of 2003.

Figures:

Figure 17. Bar chart of the mean weekly averages in water level at five project constant recorder stations and the Little Lake DCP partial vs. post-construction for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

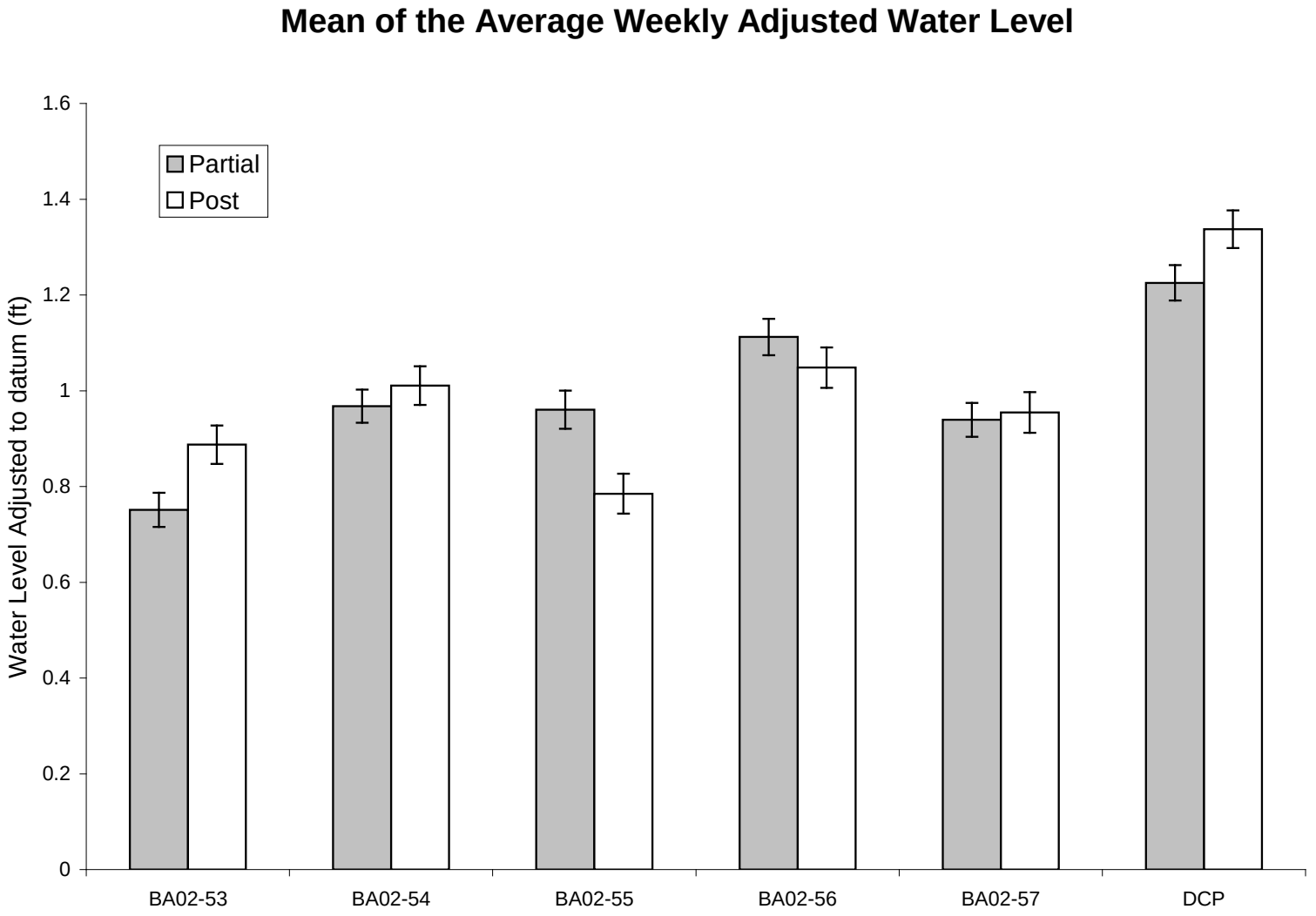

Figure 17. Mean weekly averages in adjusted water level (ft) at five project continuous recorder stations and the Little Lake DCP both partial and post-construction for the GIWW to Clovelly Hydrologic Restoration (BA-02) project. Note: Partial to post-construction changes for all of the above stations were not significant (P>0.05).

Table 2. Partial vs post-construction trends for five project stations and the Little Lake DCP for the mean weekly average adjusted water levels. Note: Significance level where p<0.05 is significant.

	BA02-53	BA02-54	BA02-55	BA02-56	BA02-57	Little Lake DCP
Partial vs Post P values	0.4209	0.9998	0.09	0.9939	1	0.7201
Trend	Higher	Higher	Lower	Lower	Higher	Higher

Table 3. Partial vs post-construction trends for six project stations and the Little Lake DCP for the mean weekly average adjusted water levels. Note: Significance level where p<0.05 is significant.

	BA02-53	BA02-54	BA02-55	BA02-56	BA02-57	BA02-58	Little Lake DCP
Partial vs Post P values	1	0.9991	0.0003	0.2593	0.9288	0.2081	1
Trend	Higher	Lower	Lower	Lower	Lower	Lower	Lower

Correlation of water level and salinity was inconclusive. High as well as low water levels were attributed to both high and low salinities. In some cases, peaks in water level were associated with minima in salinity suggesting freshwater forcing events such as precipitation or upland water input (see Appendix A for hydrographs). Conversely, some instances are apparent in which peaks in water level were associated with salinity maxima suggesting southerly winds pushing saltwater inland from the Gulf of Mexico.

BACI analyses showed that there may be an effect between partial and post-construction in water level. The mean water level at the Little Lake DCP and at BA02-53 increased about the same amount between partial and post construction and thus the mean differences showed no statistically significant changes (figure 18). Conversely, differences in water level were significant between partial and post-construction among BA02-54, BA02-55, BA02-56, and BA02-57. Average water level at these stations either slightly decreased or increased when compared to the large increase at Little Lake DCP. Therefore the project was essentially maintaining a more consistent water level relative to what we saw in Little Lake except at BA02-53.

When water levels were compared partial and post-construction for values where water level was either above or below BA02-53 marsh elevation, only BA02-55 showed a significant decrease in water level in both cases (figure 19). This result is intriguing as BA02-55 does not have a significant decrease when all the data are used. BA02-55 was mid-range for water level during partial construction but had the lowest average water level of each of the project stations post-construction. Moreover, upon completion of construction the water level at BA02-55 became the lowest in relation to all other stations as they varied together.

Figures:

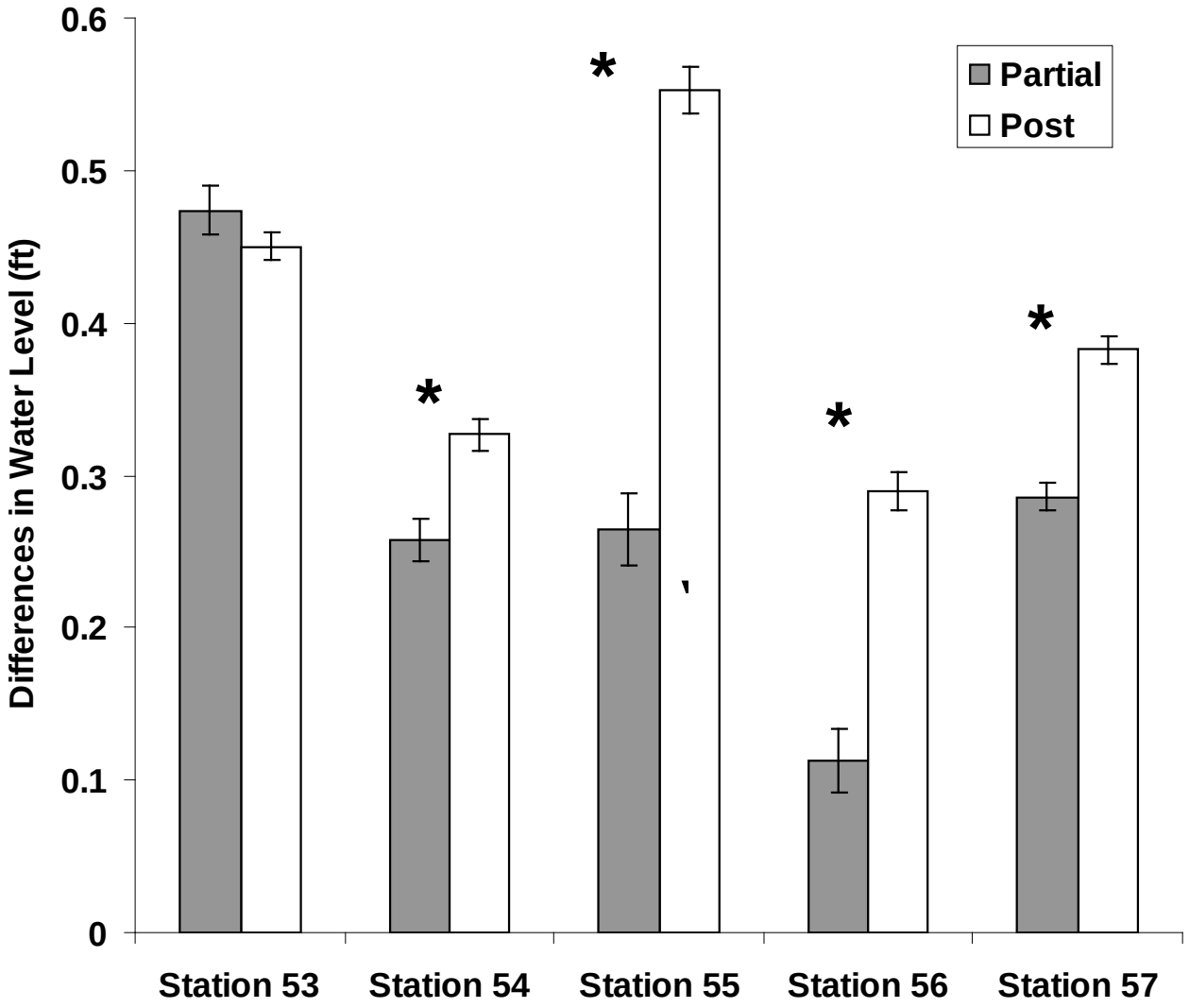

Figure 18. Differences in water levels between the Little Lake DCP and five of the project continuous recorders partial vs post-contruction for the GIWW to Clovelly Hydrologic Restoration (BA-02) project. Note: * indicates significance value where P<0.05.

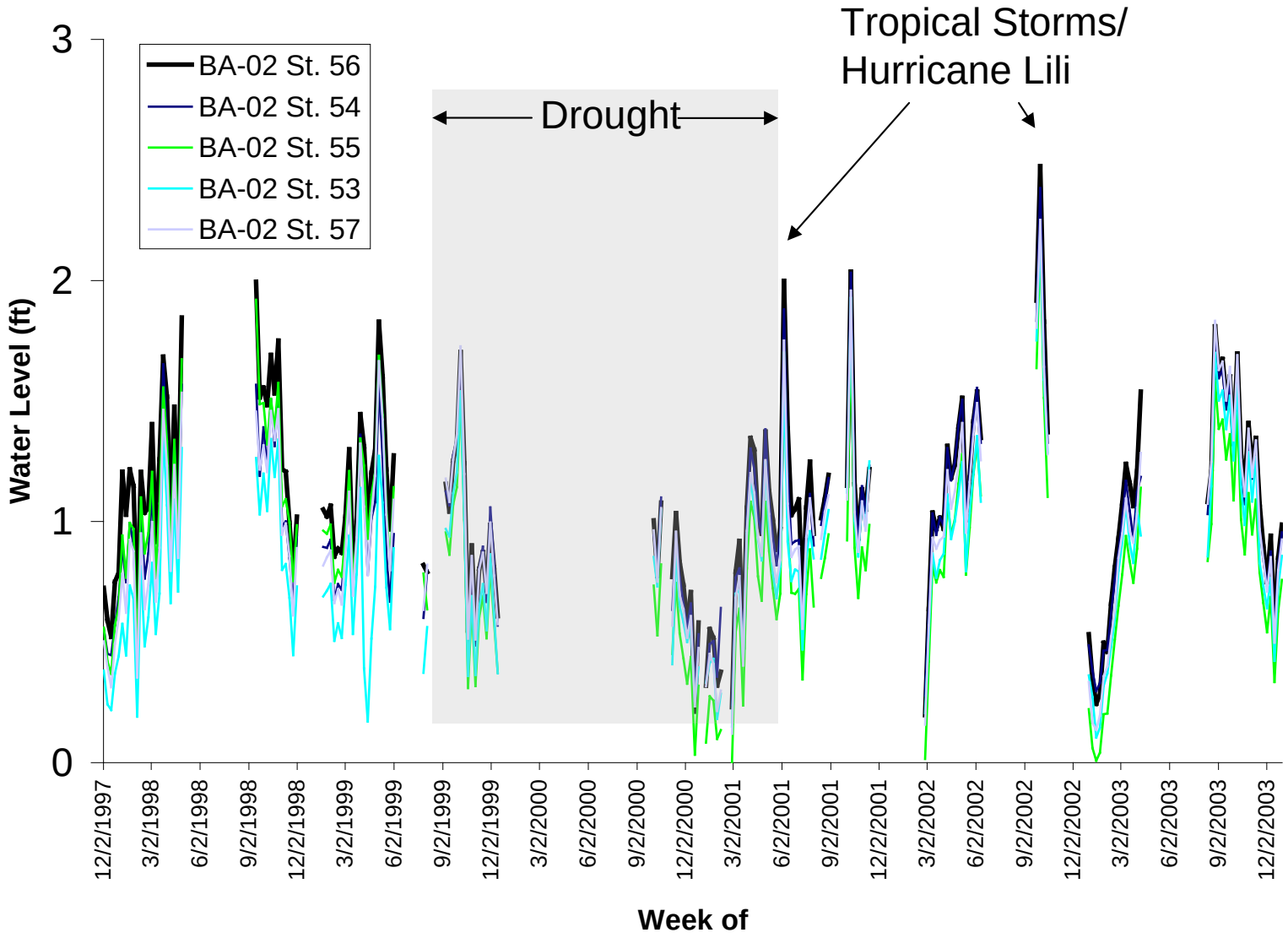

Figure 19. Mean weekly water levels at each project continuous recorder where water levels were above or below BA02-53 marsh elevation for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

The range of water level events increased significantly at BA02-53 and at the Little Lake DCP during post construction while the other stations tended to decrease although not significantly (versus did not change) (table 4). Interior project stations tended to behave similarly. BA02-56 had a significant decrease in minimum and maximum water levels while stations located closer to the edge of the project (i.e., BA02-57 and BA02-53) tended to behave more like Little Lake and showed significant increases in range, minimum, and maximum water levels. Durations increased significantly at BA02-53, BA02-54, BA02-55, and at the Little Lake DCP.

In the shorter dataset (i.e., BA02-58 included in the analysis) BA02-53 and the Little Lake DCP do not act similarly suggesting that dataset length has an effect on the results. Additionally, the disparity between the short-term and long-term results indicates that age of project structures may decrease project effectiveness, especially along the project boundary.

Interestingly, when BA02-58 was used in GLM analyses, Little Lake DCP water level ranges were significantly higher post-construction while BA02-53 and BA02-58 did not change in these shorter datasets.

Table 4. Changes in tidal cycle water level event for the long and short data set. Arrows represent a significant change (p<0.05) in the indicated direction.

	Water Level							
	Longer Data Set (excludes BA02-58)*				Shorter Data Set (includes BA02-58)**			
	Range	Minimum	Maximum	Duration	Range	Minimum	Maximum	Duration
BA02-53	↑	↑	↑	→				
BA02-54				→				
BA02-55		↓	↓	→		↓	↓	→
BA02-56					↓	↓	↓	
BA02-57		↑	↑					→
BA02-58	n/a	n/a	n/a	n/a		↓	↓	
LL DCP	↑		↑	→	↑			→

*Data set spans November 1, 1997 to December 31, 2003

**Data set spans November 1, 1997 to July 24, 2002

Salinity:

The Little Lake DCP showed a significant decrease in salinity while each of the project stations decreased but were not significant (figure 20; table 5). Stations located in the southeastern portion of the project, or closer to Little Lake, tended to have overall greater salinity. When BA02-58 is used in the analysis, there are no significant differences between partial and post-construction data (table 6).

Table 5. Partial vs post-construction trends for five project stations and the Little Lake DCP for the mean weekly average adjusted salinities. Note: Significance level where p<0.05 is significant.

	BA02-53	BA02-54	BA02-55	BA02-56	BA02-57	Little Lake DCP
Partial vs Post P values	0.1667	0.0639	0.1822	0.1722	0.2608	<0.0001
Trend	Lower	Lower	Lower	Lower	Lower	Lower

Table 6. Partial vs post-construction trends for six project stations and the Little Lake DCP for the mean weekly average adjusted salinities. Note: Significance level where p<0.05 is significant.

	BA02-53	BA02-54	BA02-55	BA02-56	BA02-57	BA02-58	Little Lake DCP
Partial vs Post P values	1	1	1	1	1	1	0.9481
Trend	Higher	Lower	Lower	Lower	Higher	Lower	Lower

Figures:

Figure 20. Bar chart of the mean weekly averages in salinity at five project constant recorder stations and the Little Lake DCP partial vs. post-construction for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

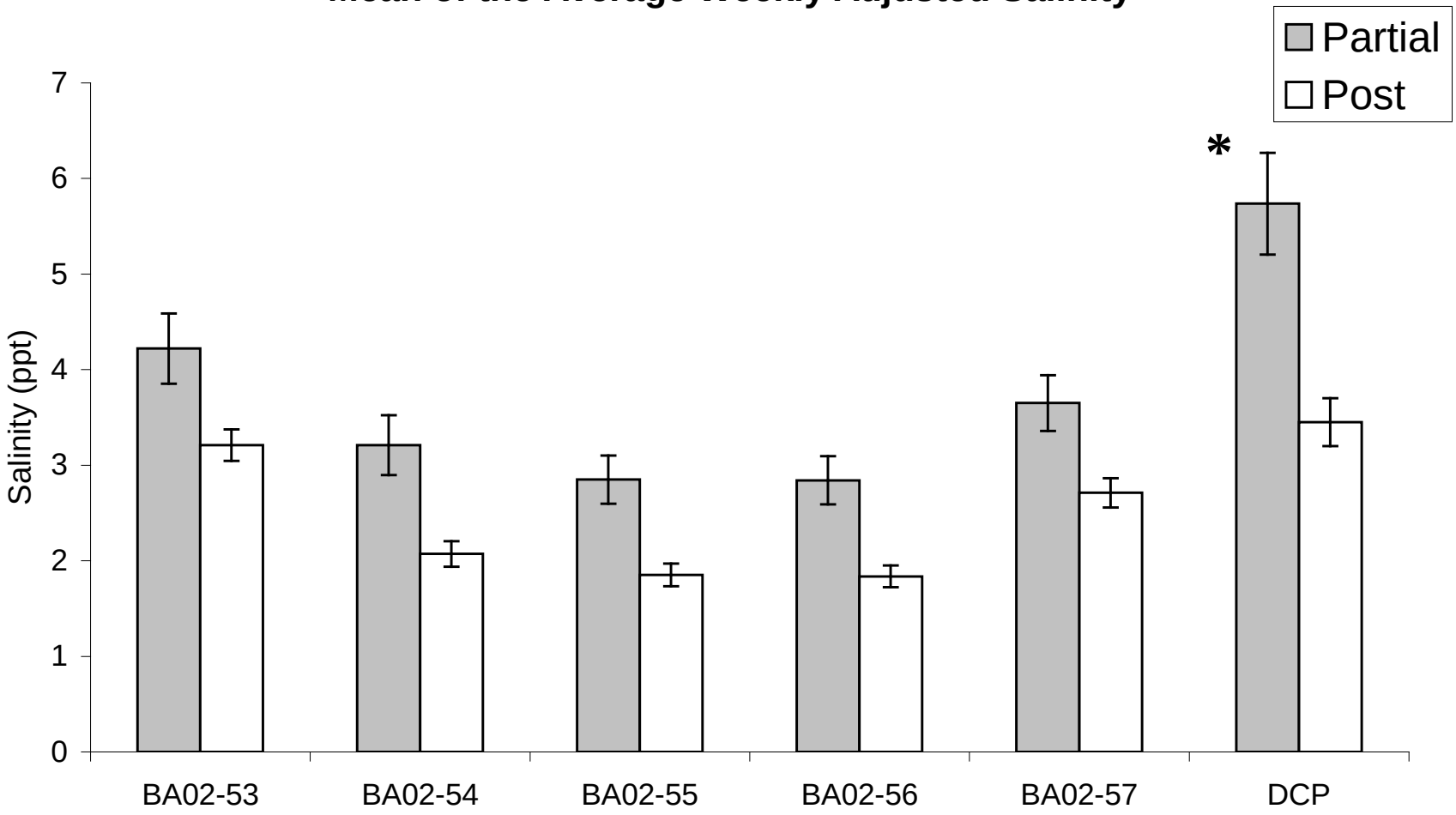

Figure 20. **Mean weekly averages of the adjusted Salinity (ppt) at five project continuous recorder stations and the Little Lake DCP station both partial and post-construction for the GIWW to Clovelly Hydrologic Restoration (BA-02) project. Note: * indicates significance value of P<0.05.**

Results for salinity from BACI analysis are similar to those found for water level where salinity differences decrease significantly for each project station during post-construction (figure 21). That is, salinity in Little Lake decreased significantly while project stations did not. Usually Little Lake was more saline than each of project stations. However, there was a period of time late in 2003 where many of the project stations had higher salinity than the Little Lake DCP (Appendix A). This occurrence may be due to Mississippi River water diverted into Davis Pond during August 2003. Unfortunately we are unable to confirm if this event caused a decline in the salinity in Little Lake during this observed time period.

When salinities were compared partial and post-construction for values where water level was either above or below BA02-53 marsh elevation, no significant differences are apparent in salinity for either case (figure 22).

Figures:

Figure 21. Bar graph of differences in salinity between the Little Lake DCP and five project stations partial vs post-construction for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

Figure 22. Hydrograph of mean weekly average salinities above or below the BA02-53 marsh elevation for all project continuous recorders and the Little Lake DCP partial vs. post-construction for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

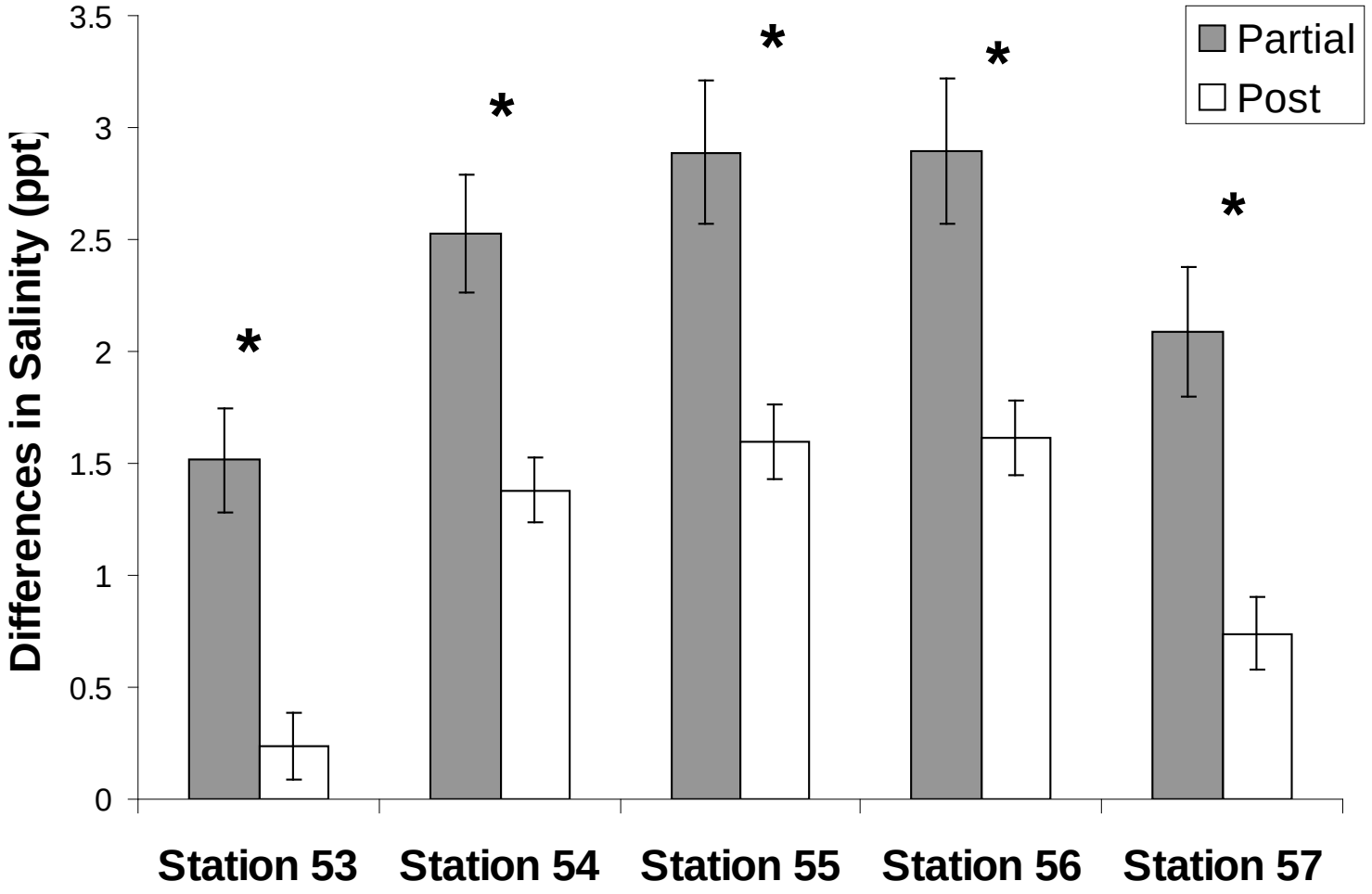

Figure 21. Differences in salinities between the Little Lake DCP and five project continuous recorders partial vs. post-construction for the GIWW to Clovelly Hydrologic Restoration (BA-02) project. Note: * indicates a significance value of P<0.05.

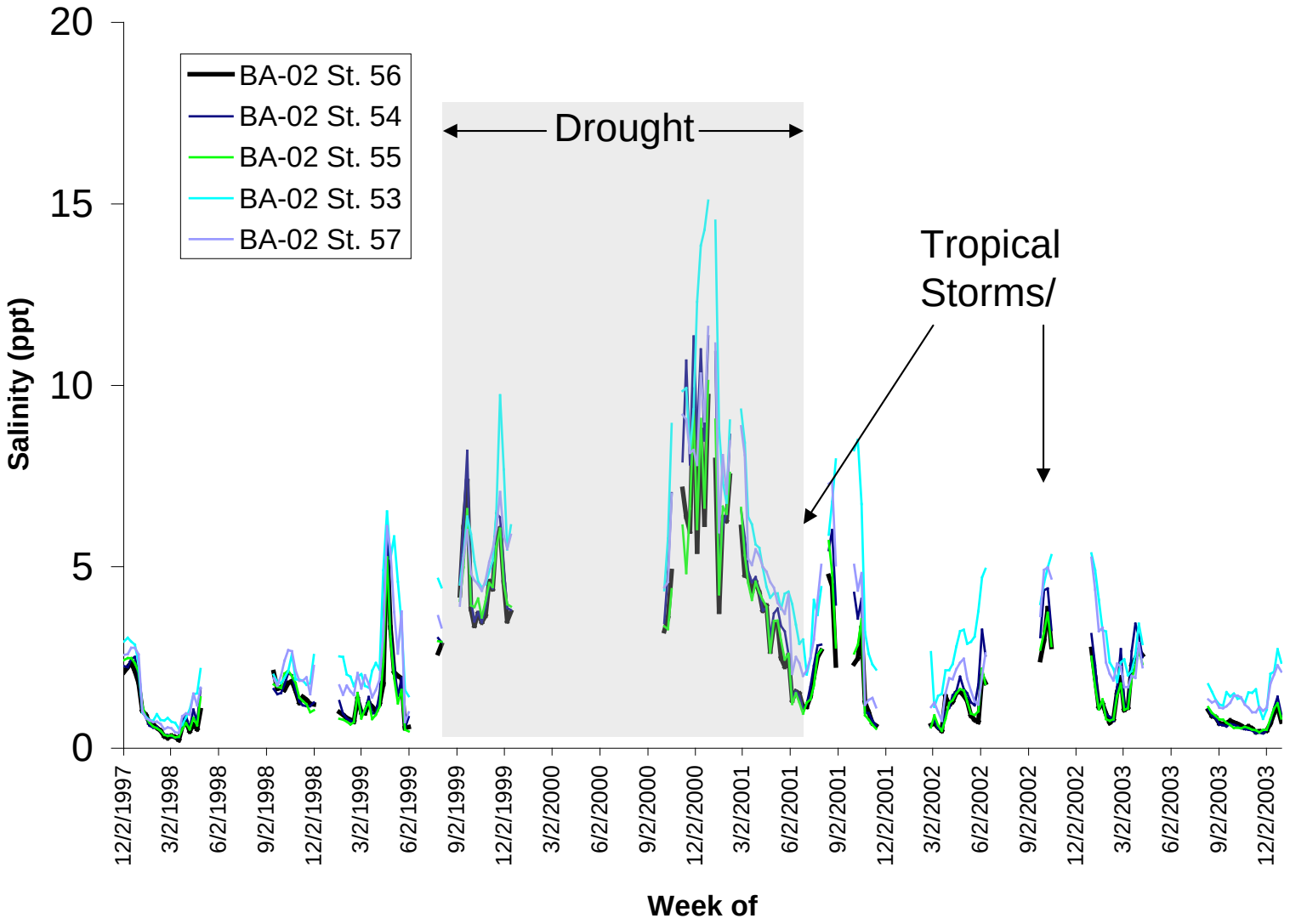

Figure 22. Average weekly salinities at each project continuous recorder where water levels were above or below BA02-53 marsh elevation for the (BA-02) GIWW to Clovelly Hydrologic Restoration project.

The range in salinity events decreased significantly between partial and post-construction for BA02-53, BA02-54, BA02-57, and the Little Lake DCP (table 7). Minimums and maximums significantly decreased at each station as well as at the Little Lake DCP. There were significant increases in duration at stations BA02-53, BA02-54, BA02-55, and BA02-57, while a significant decrease in duration occurred at station BA02-56 and the Little Lake DCP. The results for water level and salinity events further support that stations on the edge of the project area and Little Lake tend to behave more similar to Little Lake than those on the interior of the project.

Additionally, BA02-53 and the Little Lake DCP showed opposite changes in salinity range post-construction but were not significant. These results may indicate that initially the fixed-crest weirs (sites 4 and 7) were having an effect on project stations located on the edge of the lake. However, when longer datasets are analyzed and as the fixed-crest weir next to BA02-53 (site 4) settled, this project station acted more like the Little Lake DCP.

Table 7. Changes in tidal cycle salinity event for the long and short data set. Arrows represent a significant change (p<0.05) in the indicated direction.

	Salinity							
	Longer Data Set (excludes BA02-58)*				Shorter Data Set (includes BA02-58)**			
	Range	Minimum	Maximum	Duration	Range	Minimum	Maximum	Duration
BA02-53	↓	↓	↓	→		↑	↑	→
BA02-54	↓	↓	↓	→		↓		→
BA02-55		↓	↓	→				
BA02-56		↓	↓	←		↓	↓	←
BA02-57	↓	↓	↓	→				
BA02-58	n/a	n/a	n/a	n/a	↑			
LL DCP	↓	↓	↓	→		↓	↓	

*Data set spans November 1, 1997 to December 31, 2003

**Data set spans November 1, 1997 to July 24, 2002

Discrete Salinity

Mean discrete bottom salinities appear to have dropped at all of the stations throughout the project area from partial to post-construction (figure 23).

Figures:

Figure 23. Bar chart of mean bottom salinities at each discrete station throughout the project area during partial and post-construction.

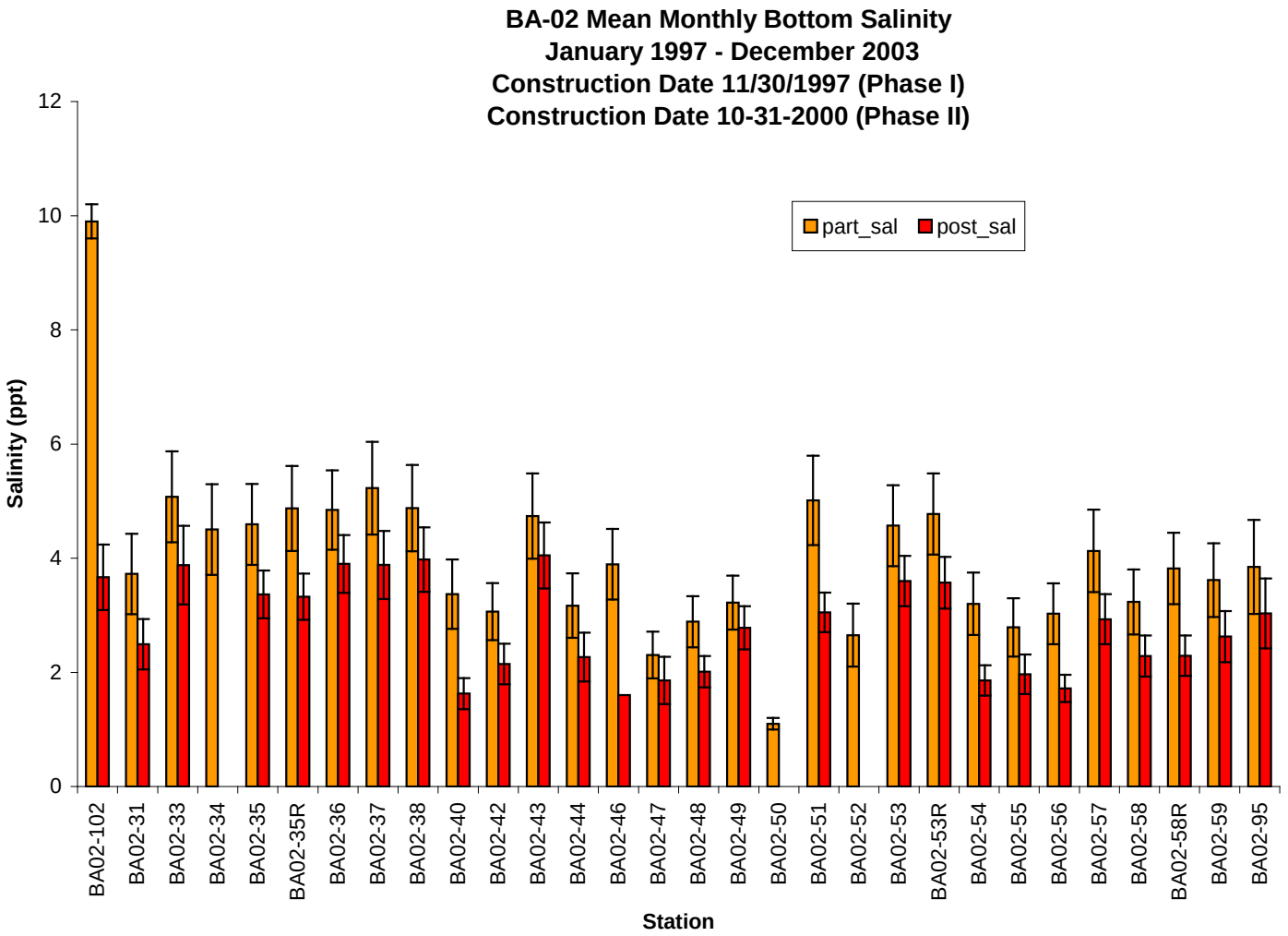

Figure 23. Mean Monthly Discrete Bottom Salinity partial vs. post-construction for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project

Vegetation

Vegetation data were not collected during 2003 for this project, however data collected in previous years indicate that the percent cover of *Spartina patens* (Ait.) Muhl. (marshhay cordgrass) a brackish marsh species, has been increasing within the project area. The increase in cover suggests a net overall change of the dominate marsh vegetation from intermediate to more saline marsh species (figure 24).

Figures:

Figure 24. Mean percent cover of selected species at the GIWW to Clovelly Hydrologic Restoration (BA-02) project and reference areas.

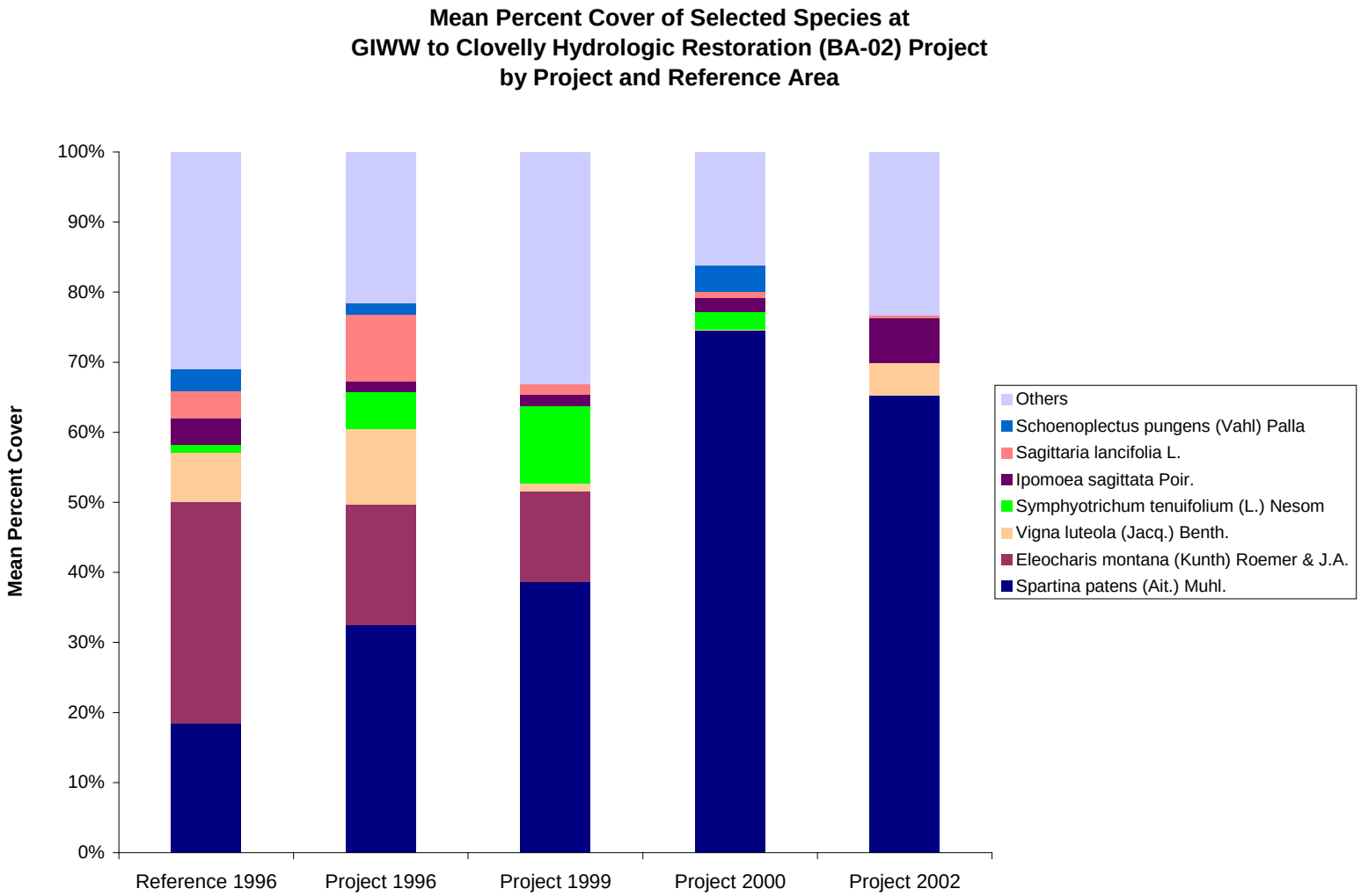

Figure 24. Mean percent cover of selected species at the GIWW to Clovelly Hydrologic Restoration (BA-02) preject and reference areas.

Soils

Soils data were not collected during 2003 for this project, however they were collected in previous years (figures 25-27). Although bulk density was not determined for the year 2002, a majority of the stations appear to have experienced a downward trend in percent organic matter, and percent soil moisture. Percent bulk density increased slightly from 1999 to 2000 for most of the stations, however there was a decrease for some of the stations located in the western half of the project interior.

Figures:

Figure 25. Percent organic matter in soil samples collected from the GIWW to Clovelly Hydrologic Restoration (BA-02) project area.

Figure 26. Percent bulk density in soil samples collected from the GIWW to Clovelly Hydrologic Restoration (BA-02) project area.

Figure 27. Percent soil moisture in soil samples collected from the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

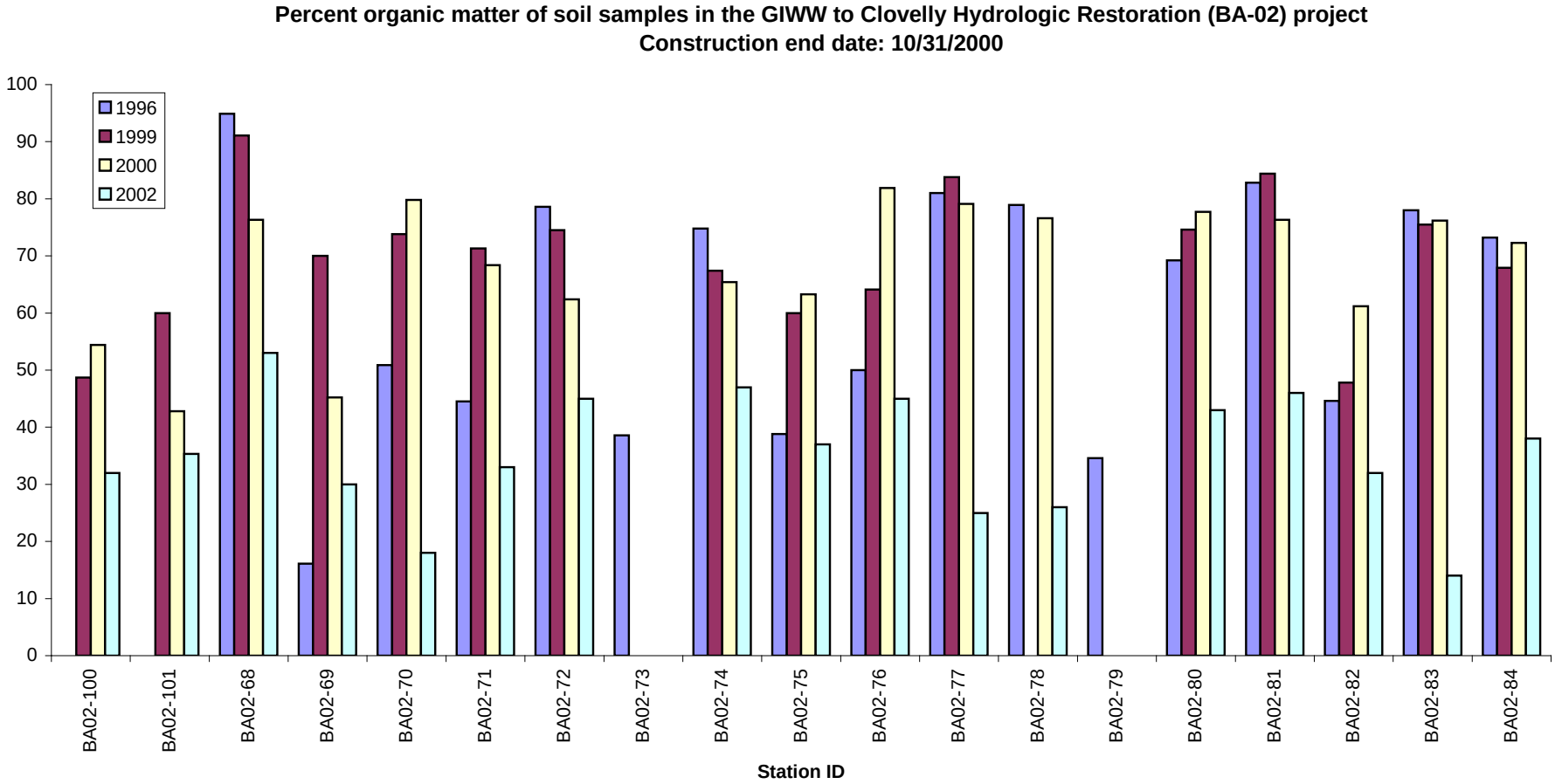

Figure 25. Percent organic matter for soil samples collected in the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

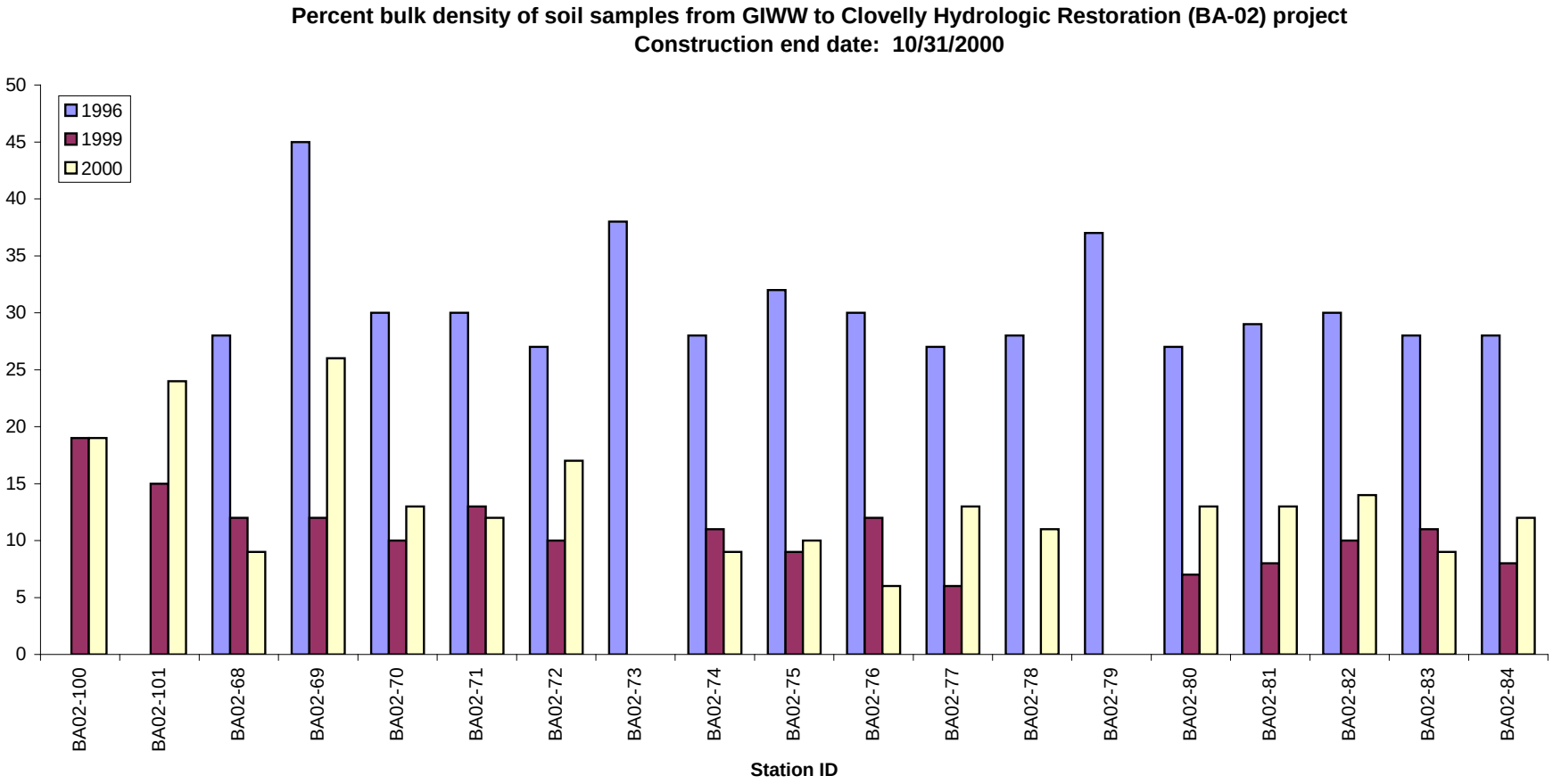

Figure 26. Percent bulk density of soil samples collected at the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

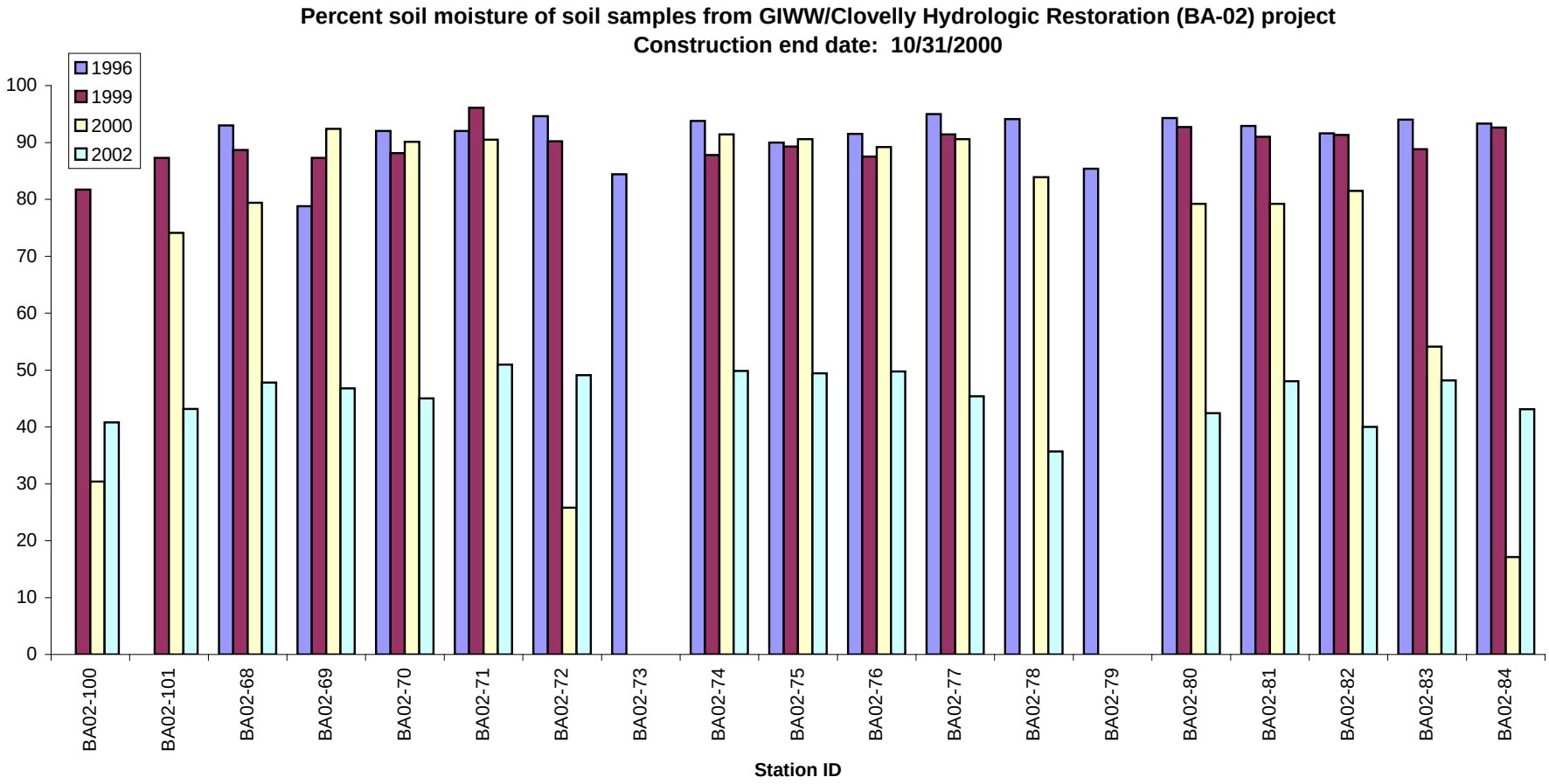

Figure 27. Percent soil moisture in soil samples collected at the GIWW to Clovelly Hydrologic Restoration (BA_02) project.

Shoreline Change:
The average shoreline change rate for the project shoreline between November 2000 (as-built) and March 2003 (post-construction) was -1.40 m yr^{-1} (-4.56 ft yr^{-1}) (figure 28). Shoreline losses were greatest along segments 3, and 5, and 16 through 19. The change rates along segments 16, 18, and 19 were equal to or greater than the historical rate of -3.05 m yr^{-1} (10 ft yr^{-1}). Additionally, inspections conducted on the project's rock rim shoreline protection structure indicated that the riprap dike has settled along two sections (figures 29-30). The areas of settlement included stations 7+00 through 13+00 and stations 36+00 through 41+00. These two areas bear closer scrutiny since settlement may have left the shoreline more vulnerable to wave energy which could explain the greater shoreline losses behind these stations.

Figures:

Figure 28. Bar chart: Shoreline change rate from as-built 2000 to post-construction 2003 for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

Figure 29. Graphic of stations 7+00 through 13+00 of the rock shoreline dike and the DGPS'd shoreline segments for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

Figure 30. Graphic of stations 36+00 through 41+00 of the rock shoreline dike and the DGPS'd shoreline segments for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

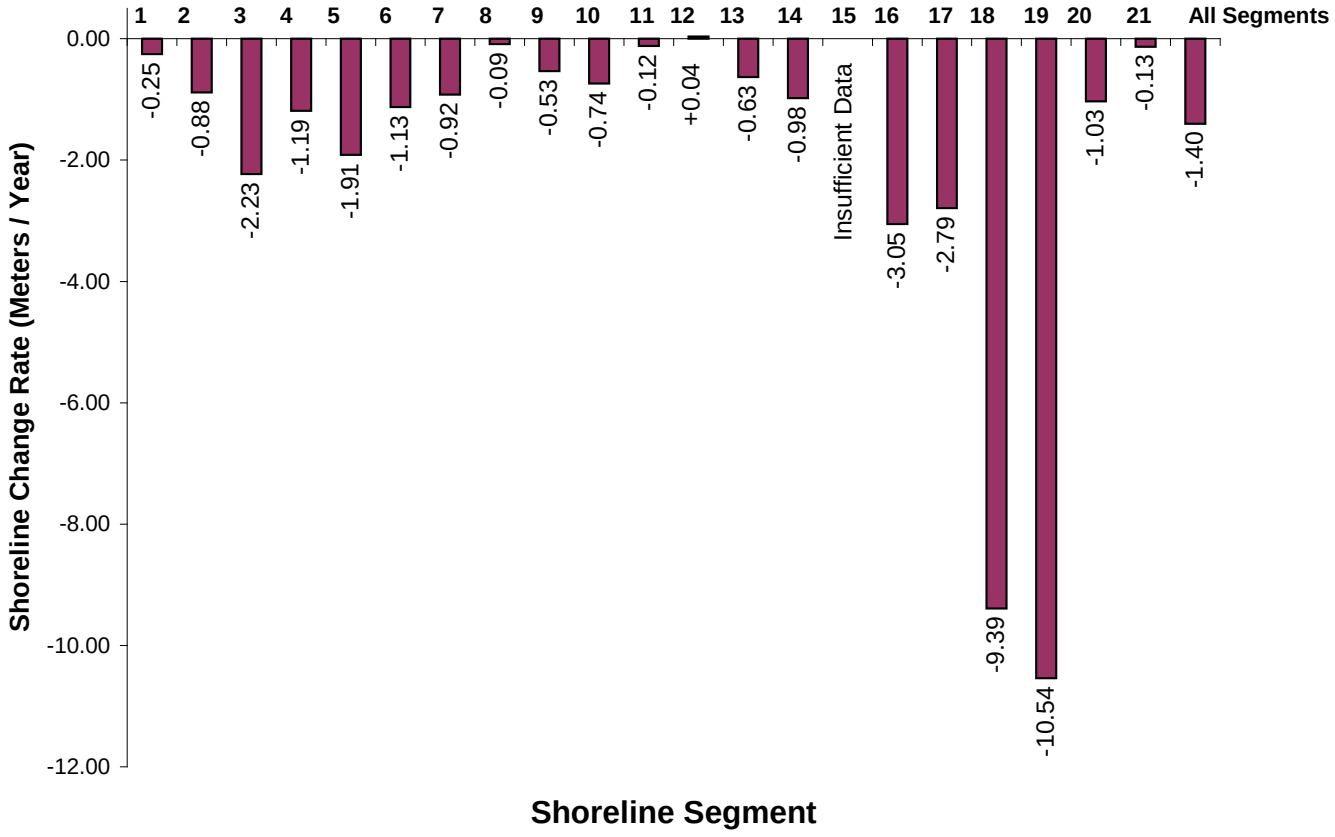

Figure 28. Shoreline Change rate in meters per year for each segment of shoreline where data was collected for the GIWW (Gulf Intracoastal Waterway) to Clovelly Hydrologic Restoration (BA-02) project.

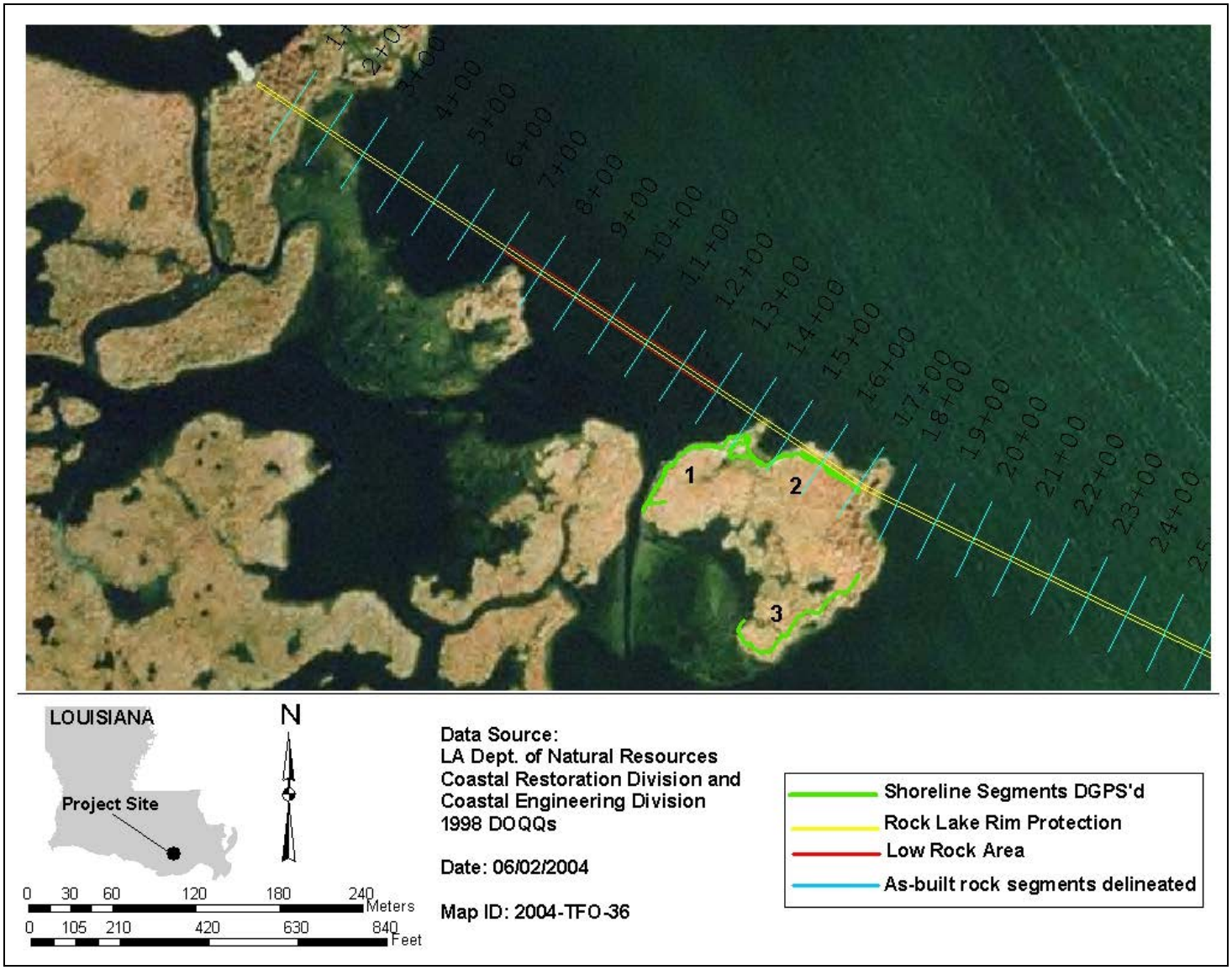

Figure 29. Low areas (7+00 through 13+00) along the lake rim rock dike in relation to the shoreline segments DGPS'd for change rates by DNR personnel for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

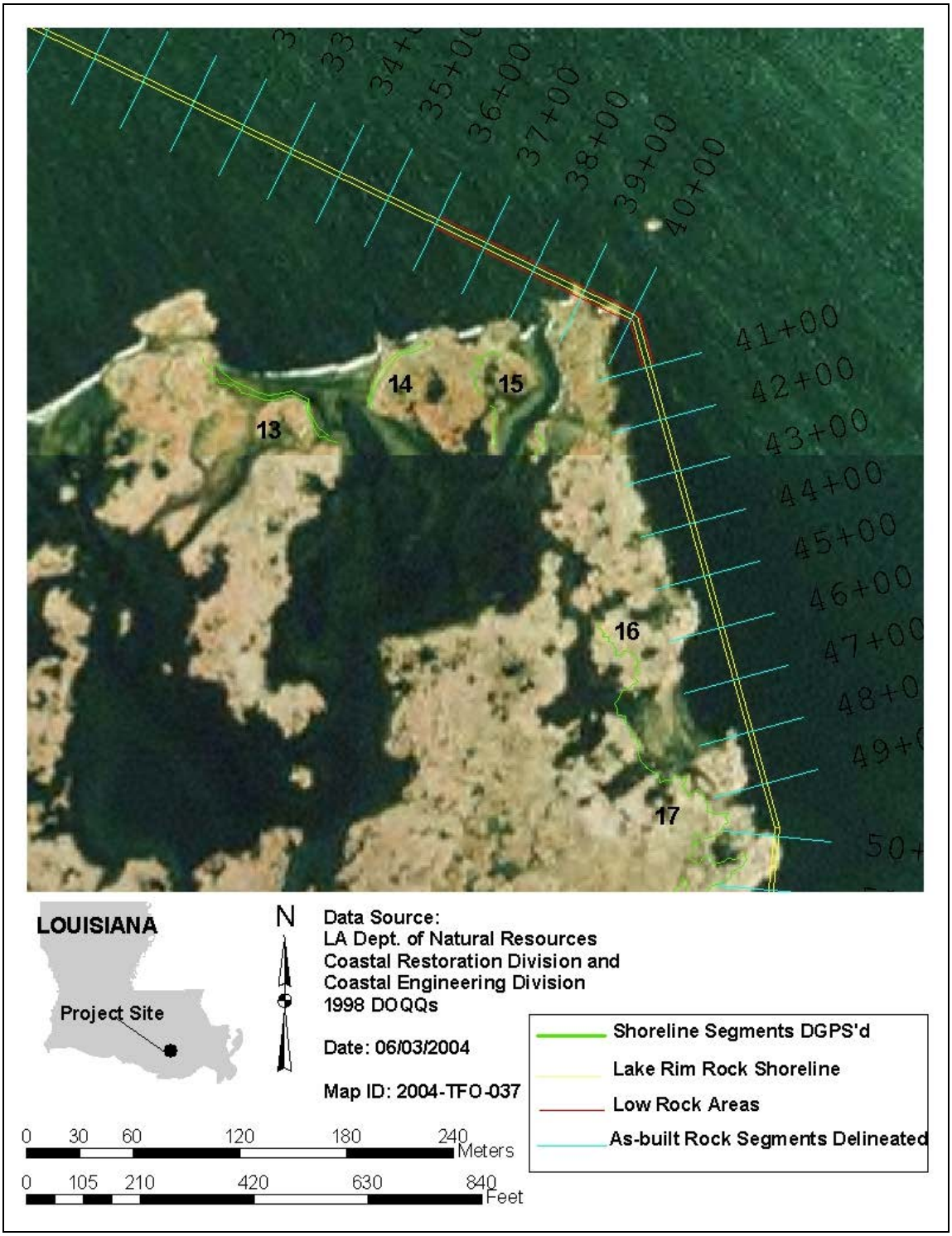

Figure 30. Low areas (36+00 through 41+00) along the lake rim rock dike in relation to the shoreline segments DGPS'd for change rates by DNR personnel for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

Submerged Aquatic Vegetation (SAV)

SAV data was not collected in 2003, however data from previous years indicates variability in relative abundance of SAV (figure 31). An increase in the frequency of occurrence of empty pulls (samples with no SAV) occurred immediately following the drought in 2000.

Figures:

Figure 31. Relative frequency of occurrence of selected Submerged Aquatic Vegetation (SAV) species from Fall 1996 to Fall 2002 for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

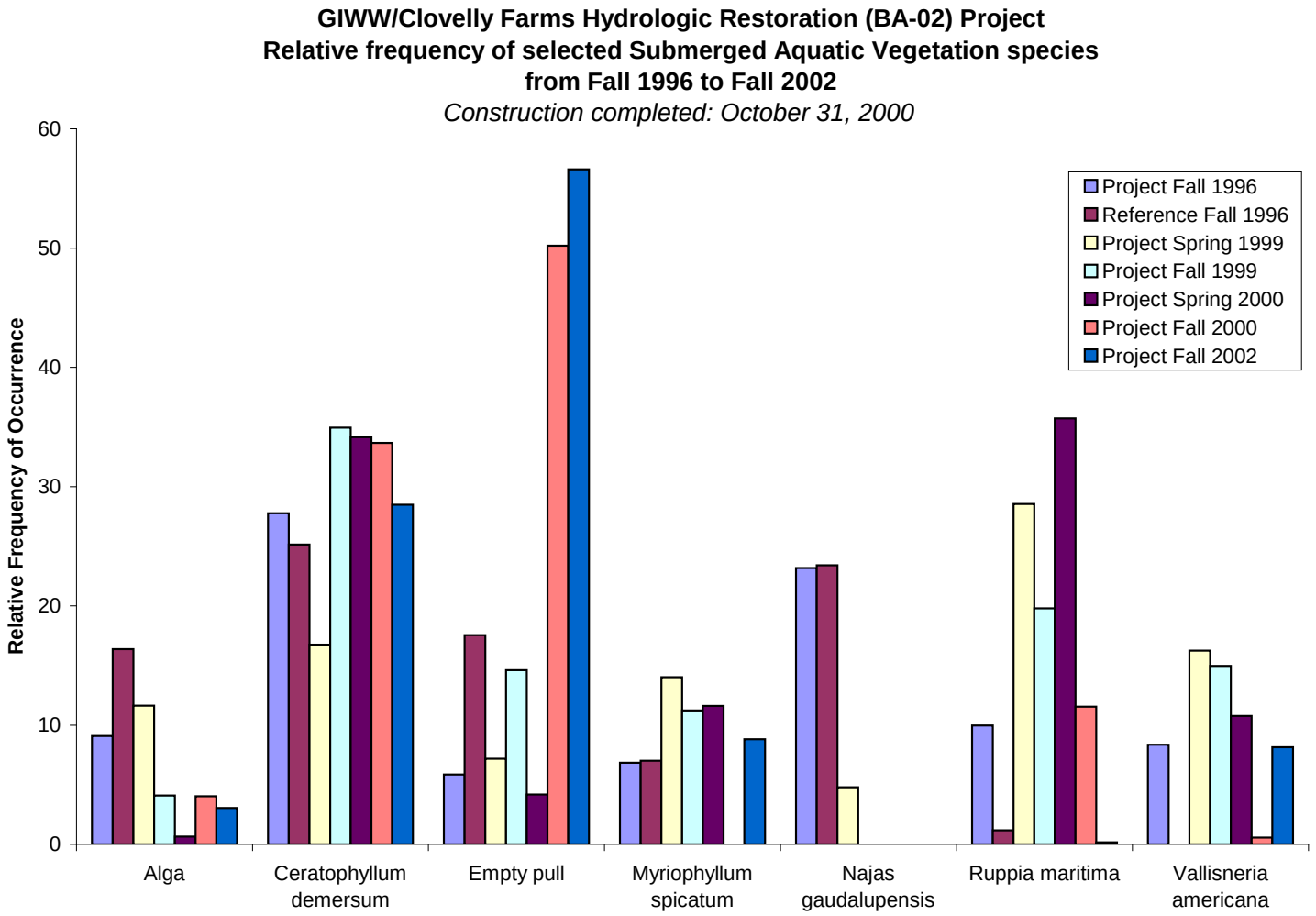

Figure 31. Relative frequency of occurrence of selected Submerged Aquatic Vegetation species for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

V. Conclusions

a. Project Effectiveness

Spatial analyses are not yet complete, therefore conclusions cannot be made regarding marsh to open water ratios.

Mean weekly average water levels both inside and outside the project experienced no significant differences from partial to post-construction and water levels tended to be higher at the more northerly stations suggesting an overall water movement from northwest to southeast toward Little Lake.

Correlation of water level and salinity was inconclusive since high as well as low water levels were attributed to both high and low salinities.

Mean water level differences between the Little Lake DCP and four interior project stations partial versus post-construction changed significantly among the stations, but no significant changes in mean water level differences between the Little Lake DCP and station BA02-53. That is, the mean weekly average water level at the Little Lake DCP and station BA02-53 increased about the same magnitude while the other stations did not increase as much or even decreased between partial and post-construction. These results indicate there may be some project effect, since a more consistent water level was maintained relative to the Little Lake DCP and station BA02-53, which was located on the rim of the lake.

The range, minimums, and maximums of water level and salinity events indicates that stations on the edge of the project area closer to Little Lake functioned more similar to the Little Lake DCP than those on the interior of the project post-construction. The results may also indicate that initially the fixed-crest weirs at sites 4 and 7 were having an effect on project stations located on the lake rim but as the weir (site 4) next to BA02-53 settled, this project station acted more like the Little Lake DCP. Using this analysis, it appears that there is less project effect on the perimeter stations closest to Little Lake, while interior water level stations may be experiencing a project effect resulting in more consistent water levels and salinities relative to Little Lake and BA02-53.

There was no initial project effect on salinities, but there was a project effect when more years of data were added (i.e., removing BA02-58 from the analysis) suggesting that Little Lake was overall less saline during the latter part of 2002 and all of 2003 except for a few events where southerly winds pushed Gulf water landward. Also, project salinities remained stable after the drought (August 1999-June 2002) while the Little Lake DCP salinities were lower. Three conclusions present themselves as this effect is considered: 1) higher overall salinities inside the project area and lower salinities in the lake could be a normal physical response of marshes after a drought (a lag in salinity), 2) a stabilizing effect on salinities inside the project, though they were higher than the lake salinity was what the project was designed to do, and 3) higher

salinities inside the project area post-construction was not the intended result (freshwater retention), therefore the effect was not a desirable one.

Vegetation data indicate that the abundance of S*partina patens* has been increasing within the project area. This species is indicative of both brackish and intermediate marshes, however when coupled with the salinity data, it appears that with the exception of the severe drought in 2000, the salinities have remained within the range suitable for intermediate marsh (2 – 10 ppt).

According to the revised WVA (9/24/91), the historical shoreline erosion rate was 3.05 m/yr (10 ft/yr) along the Little Lake shoreline. Based on post-construction shoreline data (November 2000 – March 2003), erosion at most stations has been reduced (less than -3.05 m/yr), however at stations 16 (-3.05 m/yr), 18 (-9.39 m/yr), and 19 (-10.54 m/yr), shoreline erosion is equal to or higher than the reported historic rate.

Based on SAV data collection in 1996, 1999, 2000, and 2002, it is evident that SAV occurrence is variable from year to year. However, after the drought of 2000 a dramatic increase in empty pulls (void of SAV) were recorded. In addition there was a marked decrease in abundance of *Najas guadupensis* and *Ruppia maritima*, however *Ceratophylum demersum, Myriophyllum spicatum*, and *Vallisneria americana* remained abundant both prior to and after the drought. Due to the marked increase in empty pulls, it appears that the goal of increasing or maintaining SAV abundance is not being met.

Overall, it appears that the project has been effective at maintaining the area as an intermediate marsh, however shoreline erosion is still prevalent along the Little Lake shoreline. Overall shoreline erosion has been reduced, however some areas are still experiencing shoreline erosion equal to or exceeding historical rates of shoreline erosion.

b. Recommended Improvements

Currently, the interior marshes seem to be maintaining the intermediate vegetation species, but the data also suggests a vegetation cover shift to more saline marsh species. More will be learned once the spatial mapping is completed. However shoreline erosion remains persistent (but at lower than historic levels) at virtually all locations along the shoreline protection feature along Little Lake and remains severe near stations 16, 18 and 19. Similar shoreline treatments at other projects have resulted in a complete cessation of shoreline erosion. Additional attention may be needed to address this continued shoreline erosion.

Possible settlement of the weirs at sites 4 and 7 appear to have had some effect and this may be something which needs continued monitoring. Recommendations are for cross-section surveys of these structures to determine settlement.

c. Lessons Learned

Pre-construction data for hydrologic modeling and for monitoring purposes were needed for this project but were sparse. Modeling did not occur and would have presented a clearer picture of the structures needed for the intended project effects. A lack of significant pre-construction monitoring data makes it difficult to determine what effects the structures actually had on project hydrology and salinities. This in turn makes it impossible to track the pre- to post-construction biological response inside the marshes, and ultimately whether the project is meeting its objective.

Appendix A

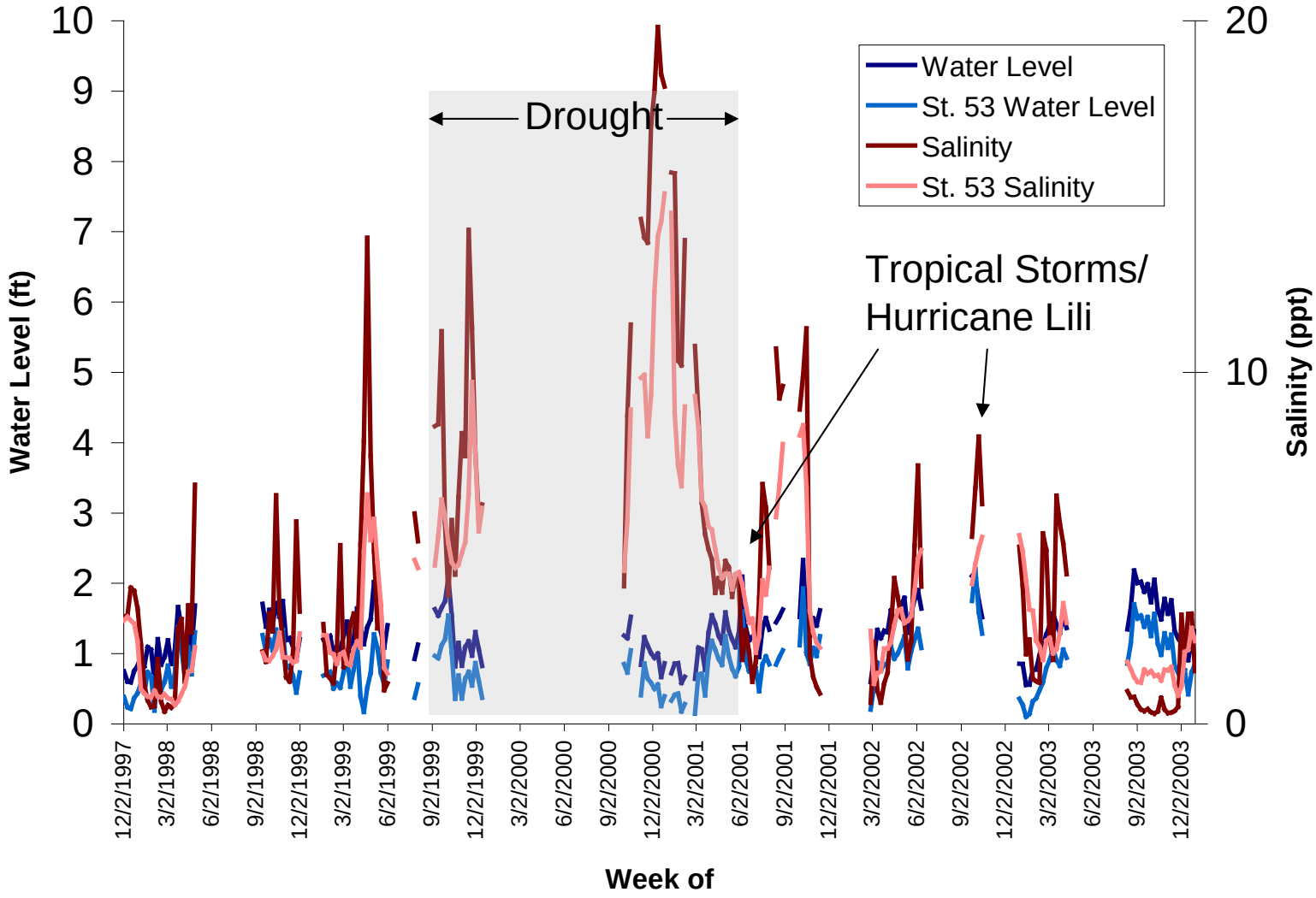

Figure A-1. Mean weekly average water levels and salinities for the Little Lake DCP vs. station BA02-53 for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

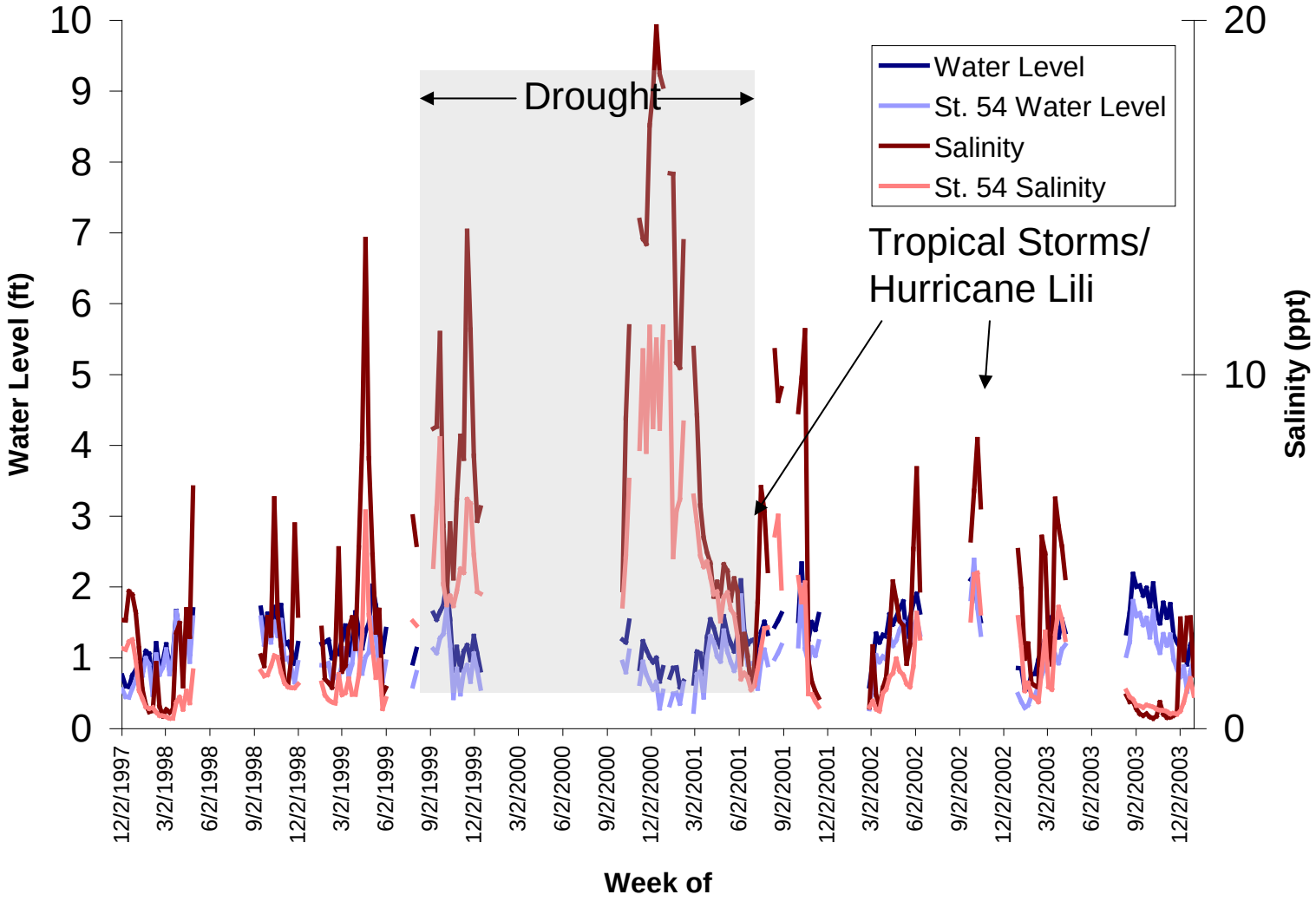

Figure A-2. Mean weekly average water levels and salinities for the Little Lake DCP vs station BA02-54 for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

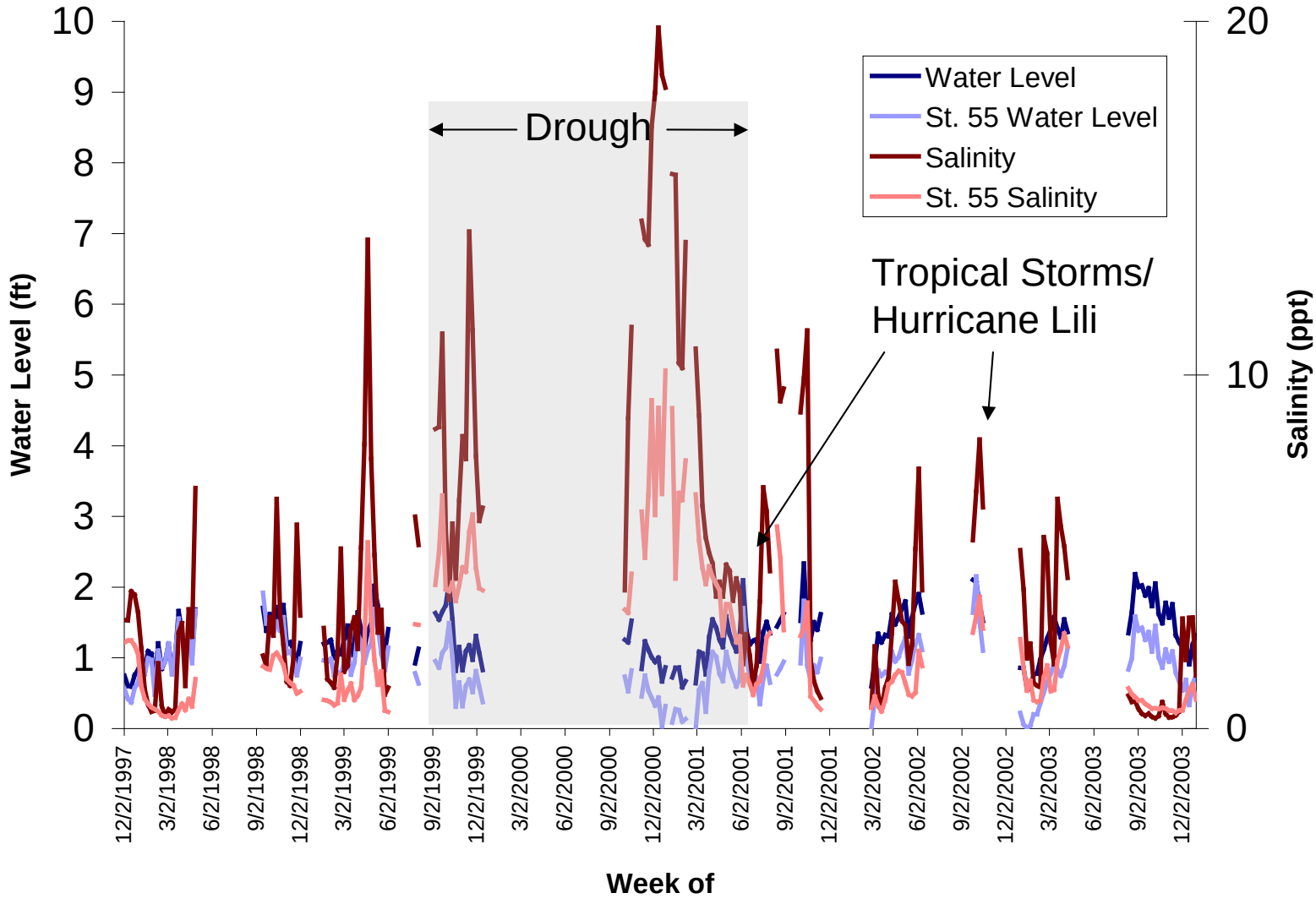

Figure A-3. Mean weekly average water levels and salinities for the Little Lake DCP vs station BA02-55 for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

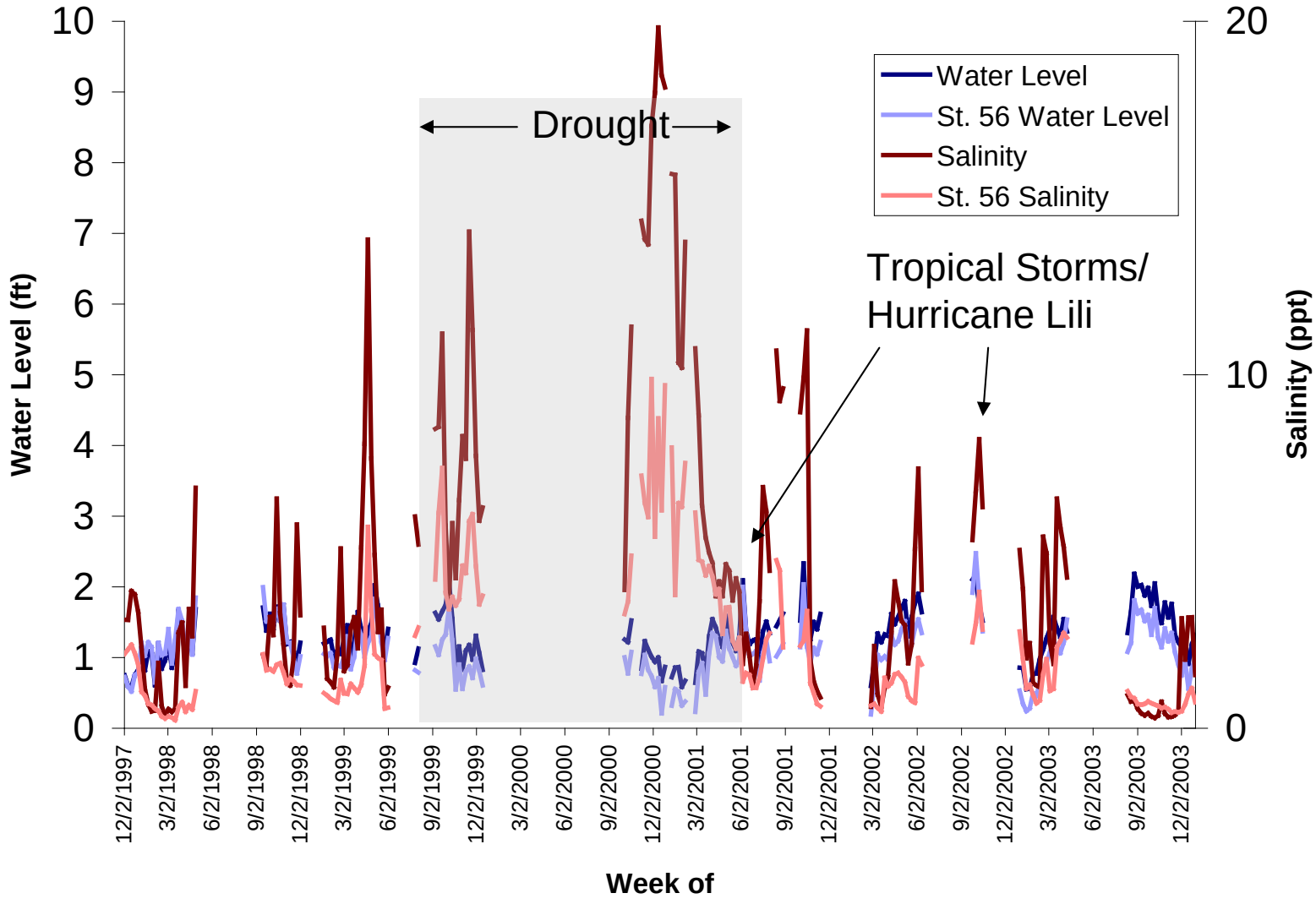

Figure A-4. Mean weekly average water levels and salinities for the Little Lake DCP vs station BA02-56 for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.

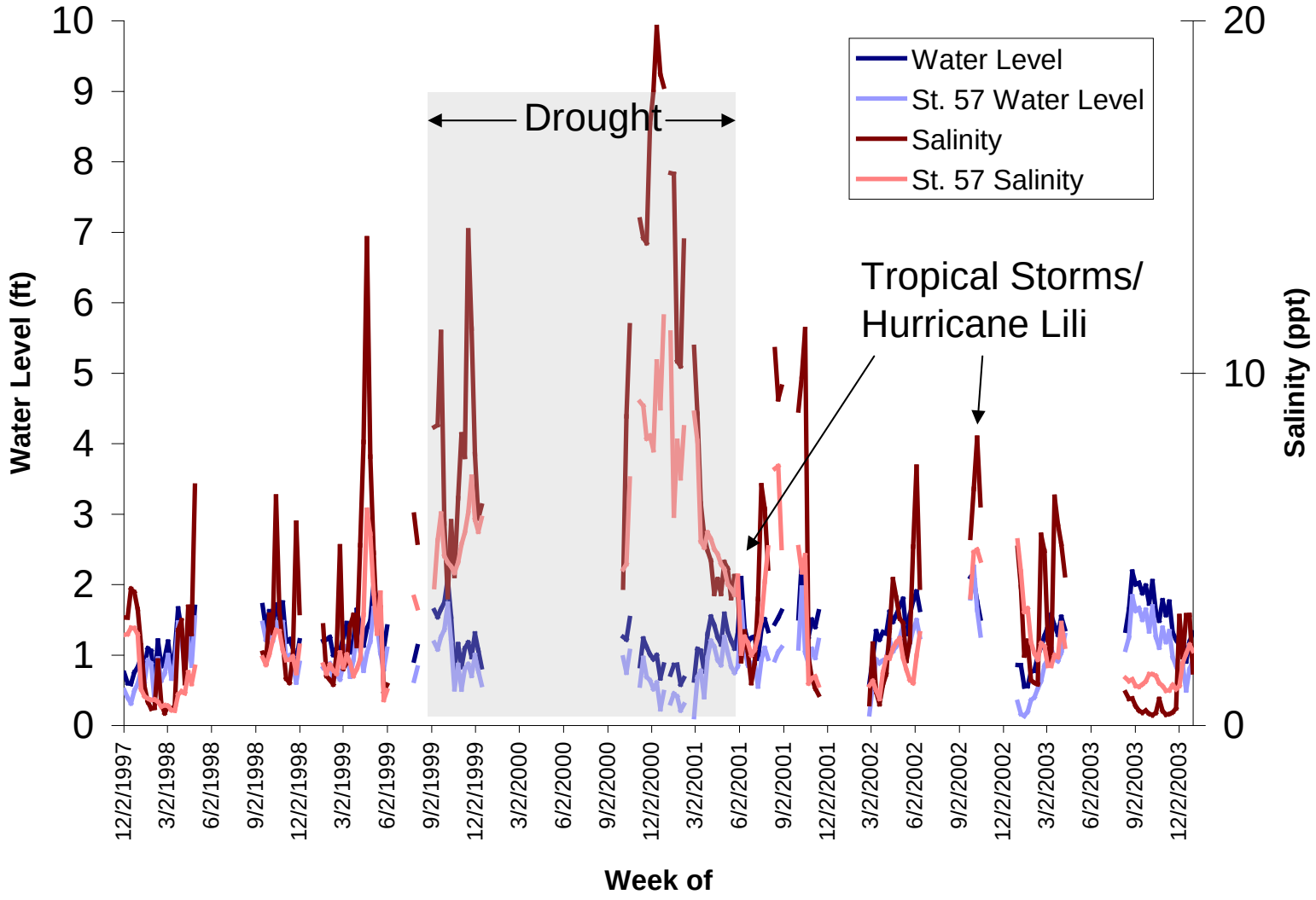

Figure A-5. Mean weekly average water levels and salinities for the Little Lake DCP vs station BA02-57 for the GIWW to Clovelly Hydrologic Restoration (BA-02) project.