ATTACHMENT 34

DEVELOPMENT OF A COASTAL SALT MARSH IN SOUTH SAN DIEGO BAY

THE CHULA VISTA WILDLIFE RESERVE

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INTRODUCTION

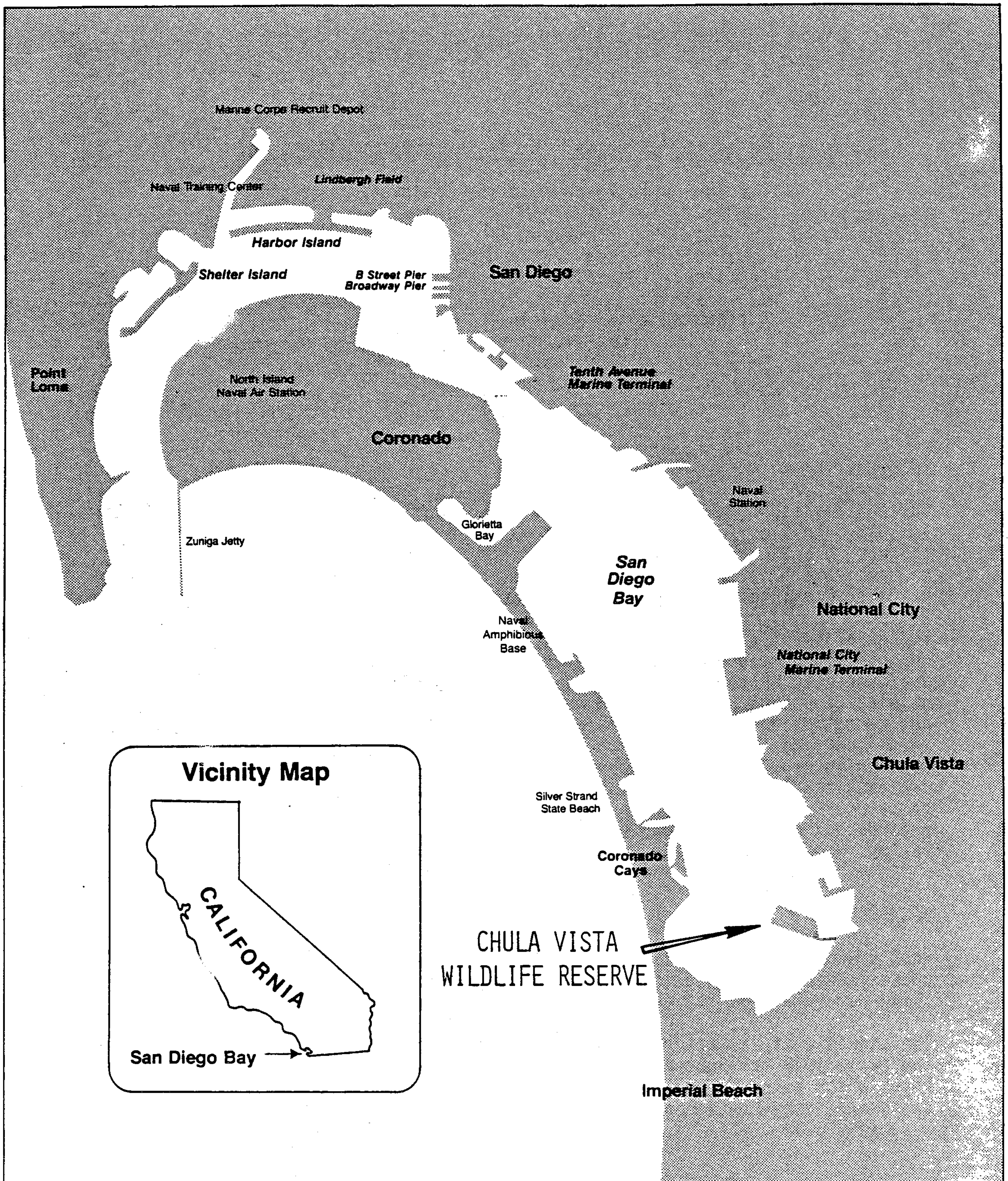
The Chula Vista Wildlife Reserve consists of an island constructed by the San Diego Unified Port District in the shallow waters of South San Diego Bay (Figure 1). The Reserve is the District's first attempt to beneficially use dredged materials to create new wildlife habitat in the bay, and to add to the bay's scarce inventory of salt marsh, mud flat and coastal sand dune habitats.

The development of a coastal salt marsh within the Reserve is described through its conceptual design, planting, and monitoring stages. Discussions are presented on the preliminary feasibility studies; the development of physical and biological program goals and objectives; the permitting processes and coordinating efforts involved; the development of planting programs, specifications and construction methods; and the subsequent marsh planting and monitoring results. Also characterized are the types and extent of habitats created, their suitability to the marsh plants selected for transplanting, and their use by various avian and marine organisms. Observations are also made regarding the newly created habitat's potential with respect to the goals of various recovery plans for endangered bird species.

BACKGROUND

Past dredging and landfill operations in San Diego Bay, particularly the channel deepening projects undertaken during the 1930-1940's, destroyed a large percentage of the bay's native salt marshes.

The significant ecological importance of marshes became fully recognized in the early 1970's. Subsequently the San Diego Unified Port District's Master Plan, which acknowledged the desirability for habitat rehabilitation, designated conservation areas in South San Diego Bay for this specific purpose.



Scale
0 8000'
Planning Department

Figure 1
San Diego Bay and Vicinity

Date 4/87
Drawn Check
Base
No.

PORT OF SAN DIEGO UNIFIED PORT DISTRICT

The specific project described here consists of the creation of a Wildlife Reserve and salt marsh in South San Diego Bay using dredge materials from Chula Vista Harbor. Chula Vista Harbor was constructed in the late 1960's, however it was not dredged to depth except for a small access channel serving the Chula Vista public boat launching ramp. About two thirds of the Harbor (an area of about 2100 by 700 feet, or 34 acres) was covered by an intertidal mud flat of low productivity.

In 1974, the Board of Port Commissioners directed staff to determine the feasibility of removing the mud from the Harbor to make it operational, and depositing the materials to create a Wildlife Reserve nearby, thus adding to the inventory of scarce salt marsh habitat.

FEASIBILITY STUDY

The feasibility study undertaken to explore the possibility of creating a productive coastal salt marsh within the Reserve concentrated its initial efforts on establishing the interactions amongst the ecological, engineering, and economic considerations of the project. Major study phases involved issue identification, plan development, and evaluation. The feasibility study started with the appointment of a carefully selected Advisory Panel of local experts from academia composed of a senior marine biologist, ornithologist, and marsh ecologist.

A deliberate survey was made of the technical expertise available from the regulatory agencies and their special staff interests. Persistent and open communications were initiated by both the Port and the Advisory Panel with the community's environmental groups. The salt marsh development concept was exposed to public scrutiny at a very early stage. Direct, but informal contacts were made to eight state and local regulatory agencies, seven federal regulatory agencies, and five active environmental groups. Private sector contacts were made with seven engineering firms and private consultants.

An important aspect of the study was to have all information received analyzed and immediately evaluated to allow flexibility in the feasibility study program. For example, at the request of the resource agencies, a marine biological reconnaissance was undertaken to obtain and verify species data; this was carried out at a considerably earlier stage in the project than originally anticipated. Further, due to an early and informal agency contact which indicated possible heavy metals contamination, sediment chemistry samples were taken and analyzed. These responsive actions helped materially in providing timely project information as requested by various regulatory agencies and environmental groups.

The feasibility study determined that using the Reserve to create a salt marsh was feasible on both an engineering and ecological basis. The salt marsh concept which was developed, concluded that habitat diversity was the key element necessary for a balanced wetlands ecosystem. This resulted in the establishment of both the conceptual engineering design for the Reserve, and parameters for the Reserve's ultimate salt marsh development objectives.

The Reserve was to include substrate elevations ranging from shallow subtidal to supratidal, with soil compositions ranging from coarser materials at the higher elevations to finer materials at the lower elevations. To promote the initial establishment of marsh vegetation, the Reserve's location was planned within the low-energy shallow waters of the bay adjacent to the existing San Diego Gas & Electric Company South Bay Power Plant cooling water separation dike. Additional dikes, to be used as dredged material containment dikes, would further provide initial protection of the salt marsh from the shock of direct wave action. A diversity of salt marsh vegetation was planned, ranging from cordgrass at the lower elevations to pickleweeds, Batis (sp.), Sueda (sp.), sand spurry, etc. at the higher elevations.

MARSH PLANTING GOALS AND OBJECTIVES

Based on the conceptual marsh development opportunities established in the feasibility study, the District contracted with the joint venture firm of David D. Smith and Associates, Environmental Quality Analysts, Inc., and Marine Biological Consultants, Inc. to develop a formal Marsh Generation Program for the Reserve.

The consultant's initial considerations concentrated on isolating critical parameters related to location, size and configuration, vertical zonation, soils constraints, etc. Members of the consultant team visited and examined salt marsh rehabilitation projects both in California and in the East Coast and the Gulf States. This provided an information base for the establishment of ecosystem parameters.

Development Criteria

The program development criteria required the critical review of marsh generation practices, programs and results throughout the United States and an analysis of their local applicability; a quantification of the knowns and unknowns of marsh generation practices, and their applicability to the anticipated location, size, soils and salinity conditions of the Reserve; a definition of program goals and objectives which could be reasonably achieved; a recommended planting program, including plant community composition, planting methods, timing and monitoring criteria; and continued coordination with the resource agencies in association with the marsh planting design.

Program Objectives

A recommended Marsh Generation Program for the proposed Chula Vista Wildlife Reserve was completed in April, 1976. The program objectives were defined as: 1) resolve uncertainties regarding plant species and planting techniques by instituting a phased planting program, incorporating an initial small-scale test planting (Phase I) with extensive monitoring and results-anaylsis for the development of subsequent final planting program criteria (Phase II); 2) ultimately, generate an ecologically desirable salt marsh commensurate with reasonable cost and in a reasonable time... The marsh should have a diversity of habitat characterized by heterogeneous substrate and topography, with maximum habitat edge effect to benefit animals requiring more than one type of vegetative cover; 3) produce a type of marsh plant community favorable to San Diego Bay's two endangered marsh bird species, the light-footed clapper rail and the Belding's savannah sparrow; 4) incorporate the most effective and economic marsh development procedures and techniques available; 5) be designed and organized so as to provide an effective basis for ecological and wildlife management research programs by University faculty and graduate students, and by conservation agency personnel... Such research could include scientific experimentation, study, and monitoring.

Program Description

The Marsh Generation Program developed to meet these objectives included the following elements.

Resolve Uncertainties: Resolving the uncertainties regarding the probable success of planting cordgrass (Spartina foliosa) would require the identification of suitable local sources of vegetative stock, and some testing, utilizing a small-scale transplanting program.

Detailed Planning of Planting Phases: The planting phase work would be based on input from the District's Engineering Department regarding acreages to be expected at given elevation zones. This would include preparation of a detailed design for the planting work at the beginning of the first and second phase growing seasons. These designs would specify the extent of the areas to be planted in each elevation zone, the spacing of the plants, the nature and amount of the plant material to be used, the planting procedure, and any required post-planting action.

Monitoring and Evaluative Work: Concurrent with preparation of the detailed planting design, the specifications for the monitoring and evaluative work to follow the first phase planting program would be prepared. The monitoring and evaluation of Phase I results would provide the basis for changing the Phase II planting work so as to optimize around the successes of the Phase I planting program.

Organize Planting Phases: Arrangements for the acquisition of planting stock, specifically for *Spartina foliosa*, would be required; as well as the preparation of detailed specifications for the Phase I planting and monitoring/evaluative work. The identification of appropriate contractors, review of proposals, and selection of a contractor would follow. The planting phases would cover two or three growing seasons. Based on using a phased program, the planting phases would require two to three years to carry out. Planting would commence after the Reserve was judged suitable for planting. The first phase may require 9 to 12 months to complete. Planting would be done in early spring to ensure maximum plant development in the growing season.

Coordinate with Conservation Agencies: Interaction with the California Department of Fish and Game and other resources agencies with respect to their interests in Reserve management, and the arrival at a concensus regarding the operation and management of the Reserve would be needed.

PERMITTING PROCESS

Permits for the combined Chula Vista Harbor dredging and Wildlife Reserve construction project were required from the U.S. Army Corps of Engineers, the California Coastal Commission, and the San Diego Regional Water Control Board. Early contact and continued coordination with the staff of each of these agencies was maintained during the preparation of the project's feasibility study and during the subsequent development of the marsh generation program for the Reserve. Because of this active coordination, the expertise of agency staff was directly available and utilized in formulating the ultimate marsh development program criteria, and the dredged material containment scheme.

The Coastal Development Permit for the project was issued by the San Diego Coast Regional Commission on October 8, 1976; the San Diego Regional Water Quality Control Board permit was issued on January 24, 1977; and the Army Corps of Engineers permit was issued on March 14, 1977.

The Coastal Permit and the Corps of Engineers Permit both required the initiation of the marsh generation program on the Reserve. The program was to pursue, to the maximum extent feasible, the establishment of a productive, diverse wildlife habitat on the Reserve which was to be maintained as a wildlife refuge.

The Coastal permit also required the formal establishment of a Marsh Advisory Committee, (composed of those agencies and environmental groups previously involved in the feasibility study and who participated in preparation of the marsh development criteria) to provide input to the District on the design and implementation of the final marsh generation program for the Reserve.

WILDLIFE RESERVE CONSTRUCTION

Construction of the Chula Vista Wildlife Reserve involved the mechanical and hydraulic placement of about 800,000 cubic yards of dredged materials on a 72-acre site. Construction of permimeter dikes, enclosing 58 acres of the Reserve, began in May, 1977 and the final placement of materials into the dikes was completed in December, 1980.

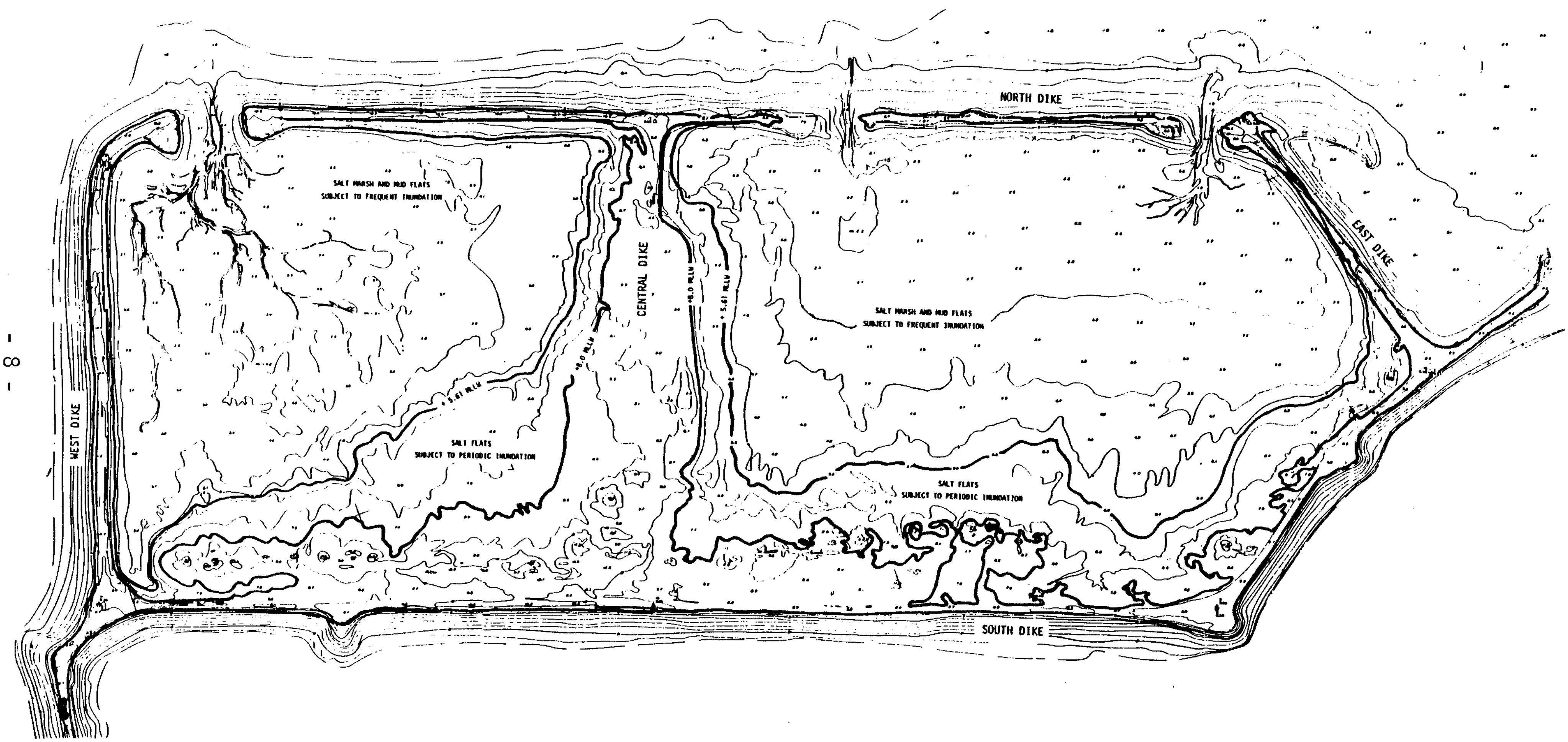
During the hydraulic filling process, the endangered California least tern nested on recently placed materials at the southeast corner of the Reserve. This happenstance during the fill process precluded the placement of the designed amount of fill in that area. After consultation with the Corps of Engineers and the resource agencies, the excess fill was placed along the Reserve's central dike, changing the geometry of the Reserve into two distinct bowl-shaped basins. Also, due to the very fluid nature of the hydraulic fill material, the final slopes of the Reserve's interior basins changed somewhat from the original concept. The Reserve's basins were intended to slope linearly from about +10.8 feet Mean Low Lower Water (MLLW) at the south dike down to +1.8 feet MLLW at the inside toe of the north dike. However, the hydraulic fill ponded within the basins, resulting in the basins' taking on a "slumped" profile, with details of the topography currently under analysis.

Following the dredging, the site was dewatered to the maximum extent feasible, and most of the remaining water was allowed to evaporate over a period of about one year. Subsequently, the residual hyper-saline water was removed by pumping. Once the partially dried, and to some extent stabilized hydraulic fill material had solidified enough to allow access (about April 1982), the District conducted a one-year-long study of the physical and chemical characteristics of the soils, which was completed in June, 1983.

The findings of the soils study indicated that some soils within the Reserve's basin areas still showed elevated salinity levels. It was determined that breaching of the Reserve's perimeter dikes prior to planting would likely assist in further reducing soil salinity levels. Topographic maps of the Reserve were prepared, based upon aerial photo mapping flights. These led to placement of breach sites at appropriate locations to optimize drainage and tidal exchange, which was expected to allow natural tidal meanders to establish themselves.

In November, 1983, the Reserve's dikes were breached, opening the island to tidal influence. The newly created Reserve contained about 14 acres of shallow subtidal mud flats, about 35 acres of intertidal mud flats, about 11 acres of salt flats, and about 12 acres of supratidal sand and dune substrates (Figure 2).

Shallow Subtidal Mudflats	14 Acres
Intertidal Mudflats	35 Acres
High Tidal Saltflats	11 Acres
Sand and Dune Substrates	12 Acres



0 100 200 300 400

Approx. Scale in Feet

FIGURE 2
CHULA VISTA WILDLIFE RESERVE
1986 CONTOURS

MARSH PLANTING PROGRAM

The development of a cordgrass (Spartina foliosa) marsh at the proper intertidal elevation was a major goal established for the Chula Vista Wildlife Reserve. The San Diego Unified Port District contracted Dr. Joy B. Zedler, San Diego State University, and Dr. Ted P. Winfield to provide technical guidance to the Port in designing, implementing, and monitoring the initial establishment of a cordgrass marsh at the Reserve.

The process of establishing a cordgrass marsh was divided into two separate transplanting actions. The Phase I planting program was experimentally designed in order to establish those areas in the Reserve which would support the healthy growth of cordgrass. Based on the results and observations of the Phase I planting program, a plan was developed to complete the planting of selected intertidal areas within the Reserve as a part of the overall marsh generation program, which would incorporate a diversity of salt marsh vegetation.

Phase I Planting Program (April, 1984)

Prior to the test planting (Phase I), a preliminary site survey was performed in February, 1984. During this survey, soil salinity was measured at selected locations using a refractometer and the sediment characterized as to grain size and consistency. The information developed during this initial survey was utilized along with data generated by Jones & Stokes and Associates, et al, on soil salinity, soil nitrogen, and pH redox to develop a final planting design. The final design established four transects and one large nursery area in the Reserve's west basin and five transects in the east basin. (Figure 3). The nursery site was established in the area with the lowest soil salinities (less than 60 ppt). The transects were spaced at somewhat equal distances apart and were located in areas with relatively high soil salinity values (generally greater than 60 ppt).

A donor site (source of plant material for transplanting) was located in the Sweetwater Channel south of the National City Marine Terminal. This area was to be ultimately dredged as a part of the Sweetwater River Channelization project (a separate Caltrans project), and contained a sufficient number of cordgrass plants to serve as a source population for the Reserve's Phase I and Phase II transplanting activities.

A total of 1530 plants were transplanted along each transect and at the nursery site during the first two weeks of April, 1984. A plant was defined as being a shoot of cordgrass and attached tillers and roots approximately four inches in diameter and ten inches below the ground surface. Plants were placed directly into pre-dug holes and care was taken to see that the surface of the transplant was level with the surrounding soil. A total of 125 plants were planted along the transects. The plants along each transect were planted on six-foot centers between +4 and +5 feet Mean Low Lower Water (MLLW). The number of plants per transect was variable ranging from 5 at transect WB-1 to 30 at EB-9, and was dependent on the length the transects lying within the +4 to +5 foot MLLW elevations (see Figure 3 for transect locations).

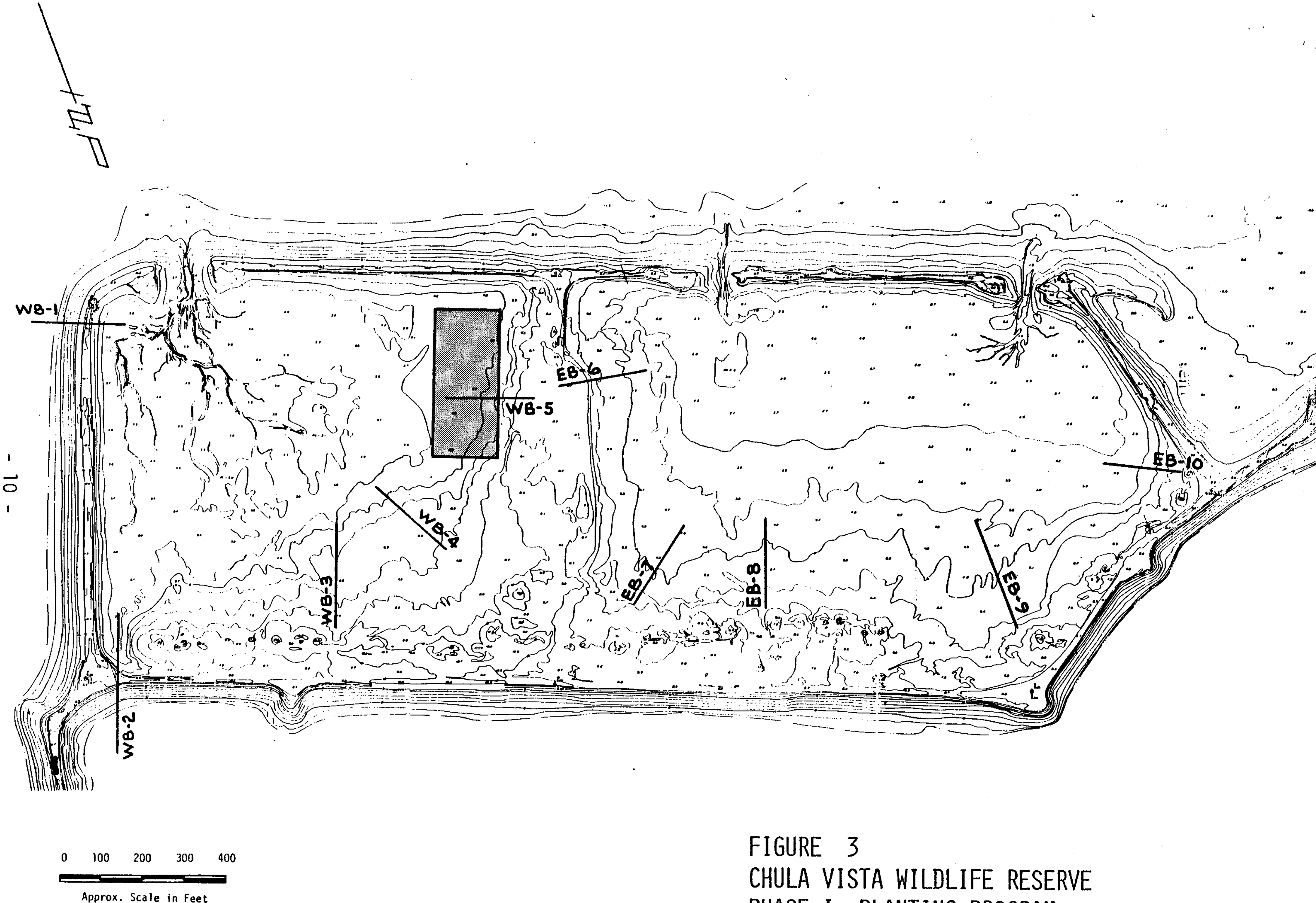


FIGURE 3
CHULA VISTA WILDLIFE RESERVE
PHASE I PLANTING PROGRAM
NURSERY AREA AND TRANSECT LOCATIONS

A total of 1,405 plants were transplanted to the nursery site. The planting array consisted of alternating rows, 31 rows with 25 plants and 30 rows with 21 plants. Twenty-one plants were transplanted between +4 and +5 feet MLLW on three-foot centers on all 61 rows, and four plants were transplanted in each of the alternating long rows between 5 feet and 5.6 feet (MLLW) on 12-foot centers. Six rows were augumented by the placement of clean sand in the hole with the plant to help offset immediate salinity shock from the highly saline soils. The overall planted area encompassed about 1.3 acres.

After completion of the transplanting, the nursery site was fertilized using urea (45-0-0) at a rate of 50 pounds per acre.

Phase II Planting Program (April, 1986)

The final, Phase II planting program was developed after reviewing the results of the Phase I transplanting activity and after determining the plant resources available at the Sweetwater Channel donor site. The successful establishment of *Spartina foliosa* at the nursery area, and generally within the lower areas of the transect sites, indicated the viability of planting additional cordgrass within the Reserve. The observations made regarding the natural invasion of pickleweeds and saltwort, generally in the upper intertidal areas of the Reserve, indicated the apparent suitability of the soils for these salt marsh species (see Phase I Planting Program Results).

The Phase II planting program was, therefore, designed by the District's consultants to accommodate a heterogeneous plant mixture. Spartina was transplanted at designated sites between elevations +4 and +5 feet MLLW; mixed associations, including one or more of plant species, *Spartina foliosa*, *Batis maritima*, *Salicornia bigelovii*, and *Salicornia virginica* were transplanted at designated sites between elevations +4 and +5 feet MLLW; and mixed associations of one or more of plant species *Spartina foliosa*, *Batis maritima*, *Suaeda californica*, *Limonium californicum*, *Distichlis spicata*, and *Salicornia bigelovii* were transplanted at designated sites between elevations +5 and +6 feet MLLW (see Figure 4). All transplants consisted of plugs of plant material with attached tillers, roots and surrounding soil, approximately 12 inches square and six inches below surface.

At transect WB-1, three rows of 35 Spartina plugs per row were planted on twelve-foot centers within a 9,800 square-foot area between elevations +4 and +5 feet MLLW.

At transect WB-3, nine rows of 21 patches of mixed association plants per row were planted on twelve-foot centers within a 23,000 square-foot area between elevations +4 and +6 feet MLLW according to the designed vertical zonation of the mixed association species compositions.

At transects WB-4 and WB-5, a total of 1,466 patches of Spartina and mixed association plants were planted on twelve-foot centers within a 75,200 square-foot area between elevations +4 and +6 feet MLLW.

WB-1	Spartina foliosa	9,800 sq.ft.
WB-2	No Additional Planting	
WB-3	Mixed Association Plants	23,000 sq.ft.
WB-4&5	Spartina foliosa, and Mixed Association Plants	75,200 sq.ft.
EB-6	Mixed Association Plants	49,300 sq.ft.
EB-7&8	Mixed Association Plants	108,000 sq.ft.
EB-9	Mixed Association Plants	69,000 sq.ft.
EB-10	Mixed Association Plants	22,000 sq.ft.

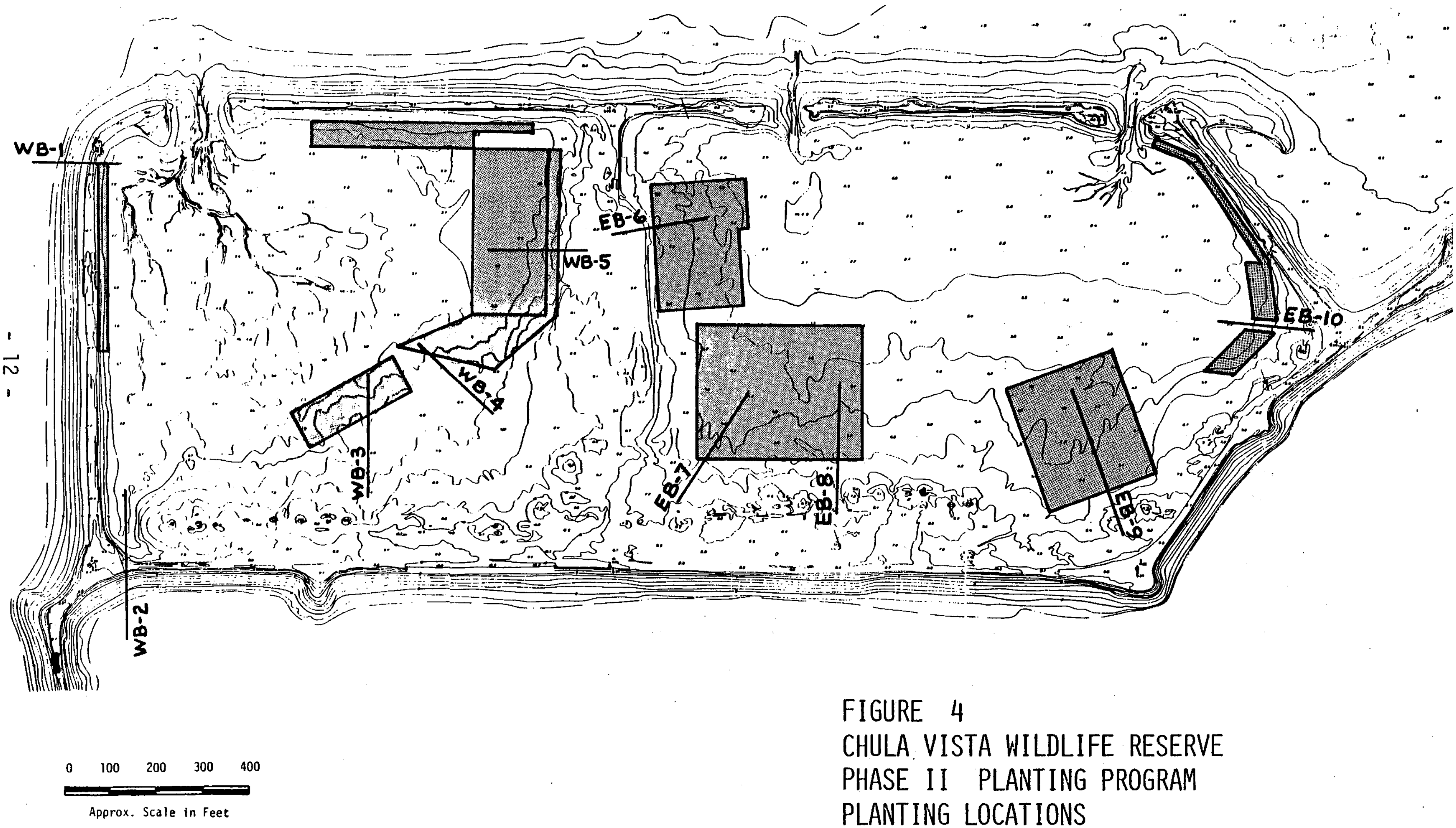


FIGURE 4
CHULA VISTA WILDLIFE RESERVE
PHASE II PLANTING PROGRAM
PLANTING LOCATIONS

At transect EB-6, a total of 1,672 patches of mixed association plants were planted on twelve-foot centers within a 49,300 square-foot area between elevations +4 and +6 feet MLLW.

At transects EB-7 and EB-8 a total of 3,244 patches of mixed association plants were planted on twelve-foot centers within a 108,000 square-foot area between elevations +4 and +6 feet MLLW.

At transect EB-9, a total of 2,100 patches of mixed association plants were planted within a 69,000 square-foot area between elevations +4 and +6 feet MLLW.

At transect EB-10, a total of 948 patches of mixed association plants were planted within a 22,000 square-foot area between elevations +4 and +5 feet MLLW.

The planting method and fertilization rate for the Phase II marsh planting program was the same as used in the Phase I effort, however, the sand augmentation procedure was not applied. The total planting effort encompassed an area of about 8.2 acres within the +4 to +6 foot MLLW intertidal elevations of the Reserve.

MONITORING RESULTS

1984-1985 Marsh Monitoring

The survival of the transplanted cordgrass plants was assessed monthly through two growing seasons, under the direction of Dr. Ted Winfield of Woodward-Clyde Consultants. For "survival" definitions, a plant with over 50 percent of above ground tissue being brown and leaves curled was judged to be "stressed", and a plant was judged to be "dead" if there was no green tissue on the lower culms.

Many of the transplanted cordgrass plants showed signs of transplant shock up to two months after being transplanted. This was evident by the browning of plant tissues, curling of the blades, and general poor appearance of the plants. In some cases, the above-ground tissue appeared to have died but many of these plants generated new shoots from their root system several months after being transplanted. After three months, a total of 11 plants appeared to have died, ten of those at the nursery site, resulting in a mortality rate of less than one percent. By the end of the growing season (September) the mortality rate had increased to just less than two percent (1.8 percent).

During the first growing season the individual plant bundles had expanded up to one meter in some areas but the density of shoots in a given plant cluster associated with any one of the original plant bundles was sparse. The plants in the nursery exhibited the best growth and good growth also observed along some of the transects, especially WB-1 and WB-4.

At the beginning of the second growing season (May, 1985), the estimated number of dead plants had actually decreased to 20 compared with 28 at the end of the previous growing season (September, 1984). This suggests that the root system of several plants considered dead in 1984 were actually alive, which is not unusual in stressful environments. By the end of the second growing season (September, 1985) the original plant bundles in the nursery area had expanded such that cover was more-or-less continuous. An estimated ten plants were dead although it was difficult to distinguish the original plant bundles, especially between +4 and +5 feet MLLW elevation. Plants along several of the transects continued to show good growth, especially along WB-1, WB-4 and at the lower elevations along transects EB-6, EB-7, EB-8, and EB-9. The plants along EB-10 did not show the same robustness as they did during the first growing season. This may have resulted from increased competition from the annual pickleweed which was abundant in the east end of the east basin by the end of the second growing season. An additional two plants had died during the second growing season resulting in overall loss along the transects of 12 plants.

After two growing seasons, the initial transplant continued to exhibit remarkable success. The plants obviously adapted to what appeared to be a stressful environment as indicated by high sediment salinity values. Just how they adapted, however, remains unclear. One possible explanation was that the root system was able to expand to the areas between sediment columns. The sediment in the areas between columns was less consolidated, which allowed for better flushing/exchange with tidal waters. As a result, the salinities were probably lower (less stressful) to the plants resulting in more productive growth. In addition, the availability of nutrients, specifically nitrogen, may have been greater in the more unconsolidated areas between the sediment columns which would also facilitate greater productivity in the plants.

The initial transplant program indicated that cordgrass was a viable species to establish in the lower marsh elevations at the Chula Vista Wildlife Reserve. Observations also indicated that the intertidal areas of the Wildlife Reserve would also support other salt marsh species. Common pickleweed (*Salicornia virginica*), annual pickleweed (*Salicornia bigelovii*) and a patch of salt wort (*Batis martima*) had become established naturally in the intertidal areas of the Reserve. Not all areas were favorable for cordgrass, as suggested by the findings of the two-year monitoring program, but pickleweed, especially annual pickleweed, appeared to be able to colonize widely throughout the Reserve's intertidal areas.

1986 Marsh Monitoring

The following discussion reflects the monitoring results of the Phase II planting effort through the end-of-season (April-September, 1986) of its initial transplant year. In some cases, the discussion refers back to the two-month monitoring results for various transplants, relfecting the "die-back" - "resprouting" episodes experienced in the Phase I planting program (see Figure 4 for East and West Basin transect locations).

Area WB-1: All the plants transplanted to the area were still alive. New shoots up to twelve inches from the original plant bundle were associated with the plants along the lower elevations. Little expansion was observed along the upper elevations. The plants along the original transect had grown to form a vegetated swath about 12-feet wide along the length of the transect.

Area WB-2: No additional transplanting occurred in the vicinity of this transect. Several small patches of cordgrass from the original transplanted material were still remaining. The remaining plants at the higher elevation along this transect appeared to be doing better in terms of visible growth and density of shoots than plants found at the lower elevations.

Area WB-3: Only one patch was considered "dead". The cordgrass in the mixed association patches along the east half of the extreme upper elevations (+6 MLLW) was all dead. The cordgrass originally transplanted along WB-3 was still present, with the best growth occurring between about +4.8 and +5.4 feet MLLW. Annual pickleweed and common pickleweed continued to colonize this area naturally, especially the bushy form of the annual pickleweed. Natural colonization was especially dense above about +5 feet MLLW.

Area WB-4/WB-5: The transplanted material south and adjacent to the nursery and northwest of the nursery continued to show good growth at elevation levels below +5.6 feet MLLW. Above this elevation, plant growth was poorer, especially east of the nursery, which had nine patches judged to be "dead". The cordgrass below +5 feet MLLW appeared robust and many of the bundles contained multiple seed heads.

The cordgrass plants transplanted during the Phase I planting program were robust, many had multiple seed heads and continued expansion was evident. The original transect lines in the nursery were no longer visible due to expansion of the original plants. Larval fish were common in isolated pools throughout this area of the west basin.

Area EB-6: The natural colonization of the upper elevation of this area resulted in difficulty in estimating mortality. However, plant growth of the recently planted material continued to be good and none of the patches were judged to be dead. Cordgrass growth was better at lower elevations below about +4.8 feet MLLW and the cordgrass along the original transect was in good condition with many of the plants having multiple seed heads.

Area EB-7/EB-8: Forty-two patches were judged to be dead, all of these above +5.6 feet MLLW. This was a decrease of fourteen patches from the two-month monitoring survey, indicating a recovery of the transplanted material below +5.6 feet MLLW. The remaining plant material above +5.6 feet MLLW appeared to be in poor condition, especially cordgrass. The cordgrass along the original transects appeared to be robust, especially that below the +5.0 feet MLLW elevation, which possessed multiple seed heads and were continuing to expand.

Sea lavendar (Limonium californicum) survived at all portions of this area, except for one location at the southern end of the area. Natural colonization was patchy in the area between EB-7 and EB-6, although some dense patches of annual pickleweed were evident.

Area EB-9: The largest percent mortality (approximately eight percent) occurred in this area. Forty-one patches were judged to be dead, a decrease of twenty-two patches from the two-month monitoring survey. The mortality was restricted to the southwestern corner between +5 and +6 feet MLLW. Cordgrass planted below +5 feet MLLW and along the original transect appeared to be robust, and many of the plants had multiple seed heads.

Natural recolonization by annual and perennial pickleweed was poor above about +5 feet MLLW but was relatively dense in the lower areas.

Area EB-10: The condition of the transplanted materials in this area remained unchanged. All the planted material was still surviving. Natural revegetation (especially by the annual pickleweed) was dense, especially in the vicinity of the original transect and extending west toward EB-9. Scattered cordgrass plants were still evident along the original transect.

1987 Marsh Monitoring

The following discussion reflects the monitoring results of the Phase I and Phase II marsh transplant efforts through the end of the 1987 growing season. Monitoring was performed in April and later in September, 1987. During the growing season, a scale insect infestation of the cordgrass marsh became apparent and is reflected in the monitoring results. As a result of this infestation, a program was developed during the winter of 1987 to study the effects of the scale insect on the marsh during 1988.

Area WB-1: Cordgrass plants along the lower two rows exhibited more robust growth in terms of the number of shoots, density of shoots, and overall size of individual shoots. A survival rate of 98 percent for the "patches" of cordgrass transplanted in the spring of 1986 was achieved.

Poorer growth of cordgrass along the upper row was probably due to a combination of both physical and biological factors. The upper row was located in an area where the sediments are better drained which probably was more favorable for the establishment of annual and perennial pickleweed and other species. The dense stands of pickleweed (primarily the annual species) probably competed directly with cordgrass for available resources (space, nutrients).

Area WB-2: Several patches of cordgrass were present and continued to show limited expansion. Growth in these patches appeared to be comparable to growth observed elsewhere in the West Basin. The dense establishment of volunteer annual pickleweed was perhaps a limiting factor for the continued expansion of these cordgrass patches.

Area WB-3: The growth of cordgrass at the lower elevations continued to be observably more robust that at the higher elevations. The individual shoots were more numerous and greater in height at the lower elevations. The occurrence of volunteer plants, primarily annual pickleweed, was relatively dense at the higher elevations but extended into the lower elevations beyond the planted area.

The density of volunteer plants made it difficult to estimate the mortality of original "patches", but all the original "patches" appeared to have produced plant material during this growing season.

Area WB-4/WB-5 (Nursery): The cordgrass between the transect (WB-4) and the nursery area exhibited the same pattern observed throughout the two basins: better growth with decreasing elevation. At the upper elevations, volunteer plants (primarily annual pickleweed) were dense.

The area west of the nursery supported some growth of both volunteer plants (pickleweed) and transplanted plant stock. An overall survival rate of 95 percent for plants placed along the eastern edge of the nursery, and 98 percent of all plants placed at WB-4/WB-5 (nursery) was found. Volunteer plant growth was more restricted at the higher elevations east of the nursery which suggested that the sediments and other physical factor combined to render that area relatively unfavorable for good plant growth.

Area EB-5: Cordgrass at elevations below five feet MLLW and along the original transect exhibited relatively robust growth with no apparent mortality of original plan stock planted in 1986. Volunteer plants were sparse at the lower elevations and more dense at the higher elevations.

Area EB-7/EB-8: Cordgrass growth was better at the lower elevations and was particularly poor above approximately elevation 5.6' MLLW. Occurrence and density of volunteer plants was greatest at the lower elevations, similar to the transplanted cordgrass, and less at the upper elevations, especially above elevation 5.6' MLLW. Volunteer plants were rare in the area extending east toward EB-9. The sediments in this area appeared to be poor for supporting plant growth.

Area EB-9: The growth of cordgrass appeared to be less robust with an increase in elevation. Growth of cordgrass was especially good below about 5 feet MLLW. The occurrence and density of volunteer plants was also related to depth with greater density of volunteer plants occurring at the lower elevations. Along the original transect the patches of cordgrass plants showed signs of continued expansion.

Area EB-10: Growth of both the transplanted plants and volunteer plants was such that it was impossible to discern the transplanted material from volunteers in much of the planted area.

Scale Insect Infestation: Cordgrass occurring around the margins of both the West and East Basins were found to be infested with a small scale insect belonging to the family of oyster shell scale insects (Diaspididae). This particular scale insect (Haliastis spartina) is found to occur specifically on Spartina. The scale insect was found to occur on the upper surface of the leaves of cordgrass with the density being greatest near the base of the leaf. The cordgrass stock from the original plant in 1984 generally had a higher degree of infestation than did the younger stock planted in 1986 or the volunteer cordgrass plants. Cordgrass in certain sections of the original nursery area appeared to be especially hard-hit by the infestation.

The cause of the infestation was unknown but may be due, at least in part, to the lack of an adequate predator population. The two transplant actions may have only transplanted a limited number of Diaspididae predators which were either unable to keep up with the scale or were adversely affected by some unknown factor and eventually reduced in number (or eliminated) which resulted in the observed outbreak.

Miscellaneous Observations: A perceptible increase in the occurrence and density of volunteer plants in both basins was observed. The most notable observation was the occurrence of several dozen small patches of volunteer cordgrass in the West Basin. In the past there has been an occasional patch of volunteer cordgrass observed in the West Basin, however, in 1987 there was an increase in volunteer cordgrass in both basins, with the greatest occurrence being in the open areas of the West Basin below four feet MLLW. There was also a noticeable increase in the occurrence of volunteer annual pickleweed and sea blite. The recruitment of these two species was greatest in the West Basin and the eastern end of the East Basin. Glasswort and perennial pickleweed were observed throughout both basins whereas the occurrence of glasswort was greatest in the eastern part of the East Basin.

Small tidal channels were observed to be forming in both basins but were better developed in the western end of the West Basin near WB-1. In the West Basin these small tidal channels extended into the lower elevation of the transplant areas.

The small tidal channels, cracks, and depressions in the sediment surface which retain water during low tide were observed to support numerous larval fish. During high tide these larval fish, as well as subadult/juvenile fish, probably utilized the vegetation on the marsh surface as a refuge, returning to the tidal channels, cracks, and depressions during low tide. Other species observed in abundance included fiddler crabs, mud snails, and castings of the rove beetle, as well as a multitude of shorebirds.

<u>1988 Marsh Monitoring</u>

Tidal channels continued to develop and extend into the vegetated areas throughout the West Basin, especially in the western and eastern areas of the basin. The West Basin now supports an increasingly dense expanse of vegetation in the non-planted areas in addition to numerous shorebirds, waders, and invertebrates. The hornsnail (<u>Cerithidea californica</u>) was abundant throughout the basin and was observed in high numbers during both the spring and fall surveys. Fiddler crab (<u>Uca crenulata</u>) burrows and signs of rove beetle (Staphylinidae) activity are common throughout the basin. Larval and juvenile fish are common in tidal pools and cracks in the sediment that retain water at low tide. Shorebirds are a common sight at low tide foraging on the tidal mudflats.

Colonization of the West Basin by marsh vegetation continued to occur in both planted and unplanted areas. A volunteer stand of cordgrass (Spartina foliosa) colonized near the mouth of the West Basin. This small stand was present in the spring and expanded noticeably during the 1988 growing season. The occurrence of isolated, growing patches of cordgrass was common in the West Basin. Patches of volunteer cordgrass were present during 1987, and these appear to have persisted and expanded. The main area of colonization appears to be the mudflat areas below 4 feet MLLW elevation.

The primary colonizing plant continued to be annual pickleweed (Salicornia bigelovii). Annual pickleweed appears to have two growth forms -- a bushy form, and a less bushy more solitary form. This plant was colonizing the low mudflat areas below 4 feet MLLW as well as the higher intertidal elevations (above 4 feet MLLW) which were planted. This species was the most abundant species during both surveys. Common pickleweed (Salicornia virginica) was common during both surveys and appeared to be increasing in abundance, especially in the western end of the West Basin. This species was most common toward the upper end of the intertidal zone.

During the spring, seedlings of sea-blite (Suaeda esteroa) were common along the upper intertidal zone. By fall, their abundance had decreased but the species was still common. Saltwort (Batis maritima) was aslo common during both surveys.

Area WB-1: Cordgrass plants along the lower two rows continued to exhibit more robust growth in terms of the number of shoots, density of shoots, and overall size of individual shoots. The poorer growth of cordgrass along the upper row was in continued evidence as in the 1987 monitoring survey. Scale insect infestation was evident on the leaves of cordgrass. The reduced occurrence of flowering shoots at this station and throughout the West Basin, reduced growth and increased standing dead suggested that the scale insect was having an impact on the growth of cordgrass in the West Basin.

Area WB-2: The stand of cordgrass at this station continued to expand in the last two years. The cordgrass at this station exhibited poor growth for the first two years following the 1984 transplanting. However, conditions in the past two years have apparently been more favorable for plant growth and as a result, the original stock of cordgrass had expanded appreciably. Other species have also become established at this station including annual pickleweed, common pickleweed, saltwort, and sea-blite.

This station and the areas between it and WB-1 along the western side of the West Basin and between WB-2 and WB-3 to the east is a favored resting place for Great Blue Herons. Up to 24 individuals have been observed in this region at one time.

Area WB-3: Cordgrass has expanded at the lower elevations and exhibits better growth in terms of stem density, height, and robustness than cordgrass plants at the higher elevations. Annual pickleweed is the most abundant plantat this station. Common pickleweed, sea-blite, and saltwort are common at the higher intertidal elevations. Scale continued to infest the growing plants and the reduced growth observed suggests that the scale has had a definite impact on the cordgrass marsh.

Area WB-4: Cordgrass at the lower intertidal elevations continued to exhibit better growth than cordgrass at the higher elevations which remained isolated, while at the lower elevation, the small, transplanted patches had coalesced into a larger more-or-less continuous band. The occurrence of scale infestation was widespread at this station, and, as observed elsewhere in the West Basin, the scale appeared to be having an impact on plant growth and production.

Area WB-4/WB-5 (Nursery): The cordgrass nursery area continued to be a conspicuous element of the intertidal landscape in the West Basin. The sensitivity of cordgrass within the nursery was variable and related to the age of the respective areas. The density appeared to be lower in the main nursery area that was planted in 1984 and higher in the more recent planted area (1986) along the northern boundary of the West Basin. In both areas, growth appears to be greater at the lower elevations.

The scale infestation was widespread in the nursery. The 1988 growth of cordgrass was obviously impacted by the scale infestation of the previous year, although the actual degree of infestation appeared to be somewhat less. This apparent impact resulted in lower shoot density, shorter plants and fewer flowering shoots.

Annual pickleweed was also abundant in the nursery and was successful in colonizing open areas resulting from the reduced growth of cordgrass. Annual pickleweed appeared to be gaining a competitive advantage over cordgrass in the nursery and throughout both basins as a result of the weakened condition of cordgrass due to the scale insect infestation. Common pickleweed, sea-blite, and saltwort were also common at the higher intertidal elevations. Shoregrass (Monanthochloe littoralis), sea lavender (Limonium californicum), and alkali heath (Frankenia grandifolia) became established in the upper intertidal areas on the east side of the nursery area.

Area EB-6: Cordgrass was well established at this station. The growth of the cordgrass at this station was dense enough to limit the growth of the annual pickleweed at the lower elevations. Other common species include common pickleweed, sea-blite, and saltwort in the upper intertidal areas. Shoregrass has also become established in scattered locations in the extreme upper intertidal areas along the western edge of this station.

Area EB-7/EB-8: Cordgrass growth was better at the lower elevations but was particularly poor above approximately elevation 5.6 MLLW. The poorest overall growth of any plant species in either basin occurs in the southeastern quarter of this planted area. Cordgrass plants were infested with the scale insect but not to the extent observed in the nursery in the West Basin. Three sea lavender plants were present and had flowering stalks. These plants were located along the southern most row on the western end. The presence of volunteer plants exhibited a pattern of occurrence and density similar to the growth pattern of cordgrass. Occurrence and density of volunteer plants was greatest at the lower elevations, and less at the upper elevations, especially at elevation 5.6 MLLW and above. Transplanted common pickleweed and saltwort had not expanded much beyond their original boundaries but volunteer plants of the species were becoming more evident. Sea-blite is also becoming more evident in this area.

Area EB-9: Growth of cordgrass was especially good below about 5 feet MLLW. The growth of cordgrass was less robust with an increase in elevation. Scale was evident on a majority of the cordgrass plants. The occurrence and density of volunteer plants was related to elevation with greater density of volunteer plants occurring at the lower elevations. Growth of all vegetation continued to be poor in the upper six rows, with few cordgrass plants remaining. Transplanted common pickleweed and saltwort were still somewhat restricted to the original transplant area but volunteer plants of these species were becoming increasingly common. Sea-blite was also becoming common at this station.

Area EB-10: Cordgrass from the original planting continued to expand. During the first growing season (1984), the transplanted cordgrass exhibited good growth. However, in the following two years, the occurrence of cordgrass was reduced to a few scattered individuals. During 1987 and 1988, there was a noticeable increase in the density and extent of cordgrass at this station. Annual pickleweed continued to be the dominant vegetation at this station. Common pickleweed, saltwort, and sea-blite were also common. Patches of volunteer cordgrass plants were also beginning to appear at this station.

VEGETATION MONITORING PRELIMINARY CONCLUSIONS

The transplant program at the Chula Vista Wildlife Reserve may be the most successful large-scale program of its type along the west coast. The transplanted material provided a source of plants for the continued colonization of the unvegetated tidal areas, especially for species that are slow to colonize such as cordgrass. Movement of plant materials (seeds) into the two basins by way of the tidal waters, through the air, (and those that were present in the dredged material) contributed to the rapid colonization of the non-planted areas within the Reserve.

The monitoring surveys have documented the rapid conversion of the intertidal areas of the Chula Vista Wildlife Reserve from bare mudflat to well vegetated intertidal marsh. The colonization of the intertidal areas would have occurred naturally, but the resulting vegetation would probably have been less diverse. It is doubtful it cordgrass would have established itself to the degree that it is now in both basins without a transplant program. The planting effort, therefore, has been the key action supporting the rapid development of the intertidal marsh at the Chula Vista Wildlife Reserve.

PRELIMINARY RESULTS OF SCALE INSECT INFESTATION STUDY

Dr. Kathy Williams of the Department of Biology, San Diego State University, studied the scale insect problem during the 1988 growing season. The objective of this study was to conduct a preliminary investigation of the extent and magnitude of the scale insect infestation on the cordgrass plants at the Chula Vista Wildlife Reserve. The results of the study were to be used to develop a recommended future course of action to reduce the extent and magnitude of the scale insect problem. Dr. Williams' preliminary report contained the following summary of results and recommendations:

- Periodic monitoring showed a general increase in scale abundance thought he summer.

- Abundance was significantly related to area sampled, with highest abundance found in the area of dense Spartina growth of the "second planting" area. That area was not severely infested in 1987.

- Haliaspis (scale insect) density was strongly related to Spartina density, possibly reflecting ease of movement and enhanced reproduction in sense, healthy stands of food plants.

- Spartina that had mature, live scales on old leaves, apparently from the previous year, had significantly more scales than plants without old scales.

- Sweep samples of the Chula Vista Wildlife Reserve marsh made during the summer contained no potential predators of Haliaspis. Samples of "healthy" marshes along the Sweetwater River contained high number of predator coccinelid beetles (Coccinella californica, Chilocorus orbus, Hippodamia convergens, and Coleomegilla fuscilabris). Coleomegilla fuscilabris was collected from Sweetwater marsh at a rate of 49 ± 12 per 100 sweeps.

- Cage experiments showed that Coleomegilla is a ravenous predator of Haliaspis adults (covered with waxy "armor") and juveniles. When 20 beetles/cage were allowed to feed on moderately infested Spartina for 4 days, they consumed means of 45 ± 8 adult, and 23% ± 5% of juvenile Haliaspis. Coleomegilla will apparently feed, mate, and oviposit in captivity and it appears that they could be cultured in a laboratory setting for later release as biological control agents.

SCALE INSECT STUDY

The scale insect problem is an example of what can happen if appropriate biological controls are eliminated or reduced in an artificial system. Scale is present in most marshes in low numbers due in large part to the activities of insect predators. Without these predators, the scale will increase, as has occurred at the Chula Vista Wildlife Reserve. Re-introduction of the appropriate biological control agent may be the most appropriate treatment option.

In 1989, the San Diego Unified Port District entered into an agreeemnt with the San Diego State University to undertake an extensive scale insect control program at the Reserve. The program provided for the re-introduction of the scale insect predator Coleomegilla into the Reserve's cordgrass marsh. The results of this program have not yet been ascertained.

HABITAT OVERVIEW

The Chula Vista Wildlife Reserve contains about 14 acres of shallow subtidal mud flats, about 35 acres of regularly innundated intertidal mud flats, about 11 acres of periodically innundated salt flats, and about 12 acres of supratidal sand and dune substrates. Tidal meanders and ponded areas have formed within the lower mud flats of the Reserve's interior basins, and shallow subtidal and lower intertidal mud flats have formed within the Reserve's water area.

The natural invasion of salt marsh and salt flat plants (mainly pickleweeds, saltwort and sea-blite) into the Reserve was observed in early 1984, shortly after the breaching of its perimeter dikes. Its supratidal areas were also quickly invaded by alkali weed. Subsequently, the District's marsh generation program was implemented in a phased sequence, with an objective to create an ecologically diverse habitat on the Reserve and to produce habitat types favorable to endangered species.

The planting of about nine and one-half acres of new, diverse coastal salt marsh vegetation on the Reserve was accomplished over a two-year period. The plant community established included cordgrass, pickleweeds and glasswort, saltwort, sand spurrey, sea-blight, marsh rosemary, salt grass, and the invasives, including alkali weed.

The habitat types developed on the Reserve were intended to accommodate the recovery plans for various endangered species, especially for the California least tern, the light-footed clapper rail, and the Belding's savannah sparrow.

The California least tern utilized the Reserve's coastal sand dune areas during the 1980-1985 and 1988-1990 nesting seasons, and the Reserve provided for the highest tern nesting activity in all of San Diego Bay in 1981, 1982 and 1983. To accommodate the future use of the Reserve as a nesting site by the least tern, the District has implemented yearly nesting substrate enhancement measures, trespass reporting procedures, and recently initiated an active predator control program.

The Belding's savannah sparrow has utilized the Reserve's mud flat, salt marsh and salt flat vegetation, and maritime sage scrub fringe areas for foraging and cover since 1985. Sparrow nesting at the Reserve is assumed, but has not yet been verified.

The Reserve's tidal basins and water areas have also been used by numerous species and individuals of migratory over-wintering waterfowl and annual shorebirds. Also, as the Reserve's cordgrass and pickleweed marshes develop, the use of the Reserve as a sanctuary by the endangered light-footed clapper rail is anticipated.