David Bilo
11/23/94

BENEFICIAL USES GROUP

RECOMMENDED BENEFICIAL USE PLAN SUMMARY

FOR

PLACEMENT OF DREDGED MATERIALS

JULY 1994

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

BACKGROUND

Introduction

The Interagency Coordination Team (the ICT) established by the U.S. Army Corps of Engineers (the Corps), was charged with oversight of a range of environmental issues attendant upon the proposed Houston Ship Channel (HSC) Modernization Project. The Beneficial Uses Group (the BUG) was created in early 1990 as a subcommittee of the ICT with the assigned task to evaluate possible beneficial uses of dredged material and incorporate them into a dredged materials placement plan for the HSC Modernization Project. The BUG's membership includes five (5) federal agencies (U.S. Fish & Wildlife Service [USFWS], U.S. Environmental Protection Agency [EPA], U.S. Army Corps of Engineers [the Corps], U.S. Soil Conservation Service [SCS], and National Marine Fisheries Service [NMFS]), two (2) state agencies (Texas Parks & Wildlife Department [TPWD], and Texas General Land Office [TGLO]), and the Port of Houston Authority (PHA).

At the outset, an essential point was agreed upon; the participation in development of a beneficial use plan for dredged materials would not constitute an endorsement of the HSC Modernization Project by those agencies individually or collectively. When developed, the BUG Plan would be submitted in the context of all the key environmental issues being addressed by the ICT.

Purpose

The formally adopted purpose of the BUG is stated as follows:

To develop a disposal plan that utilizes dredged materials in an environmentally sound and economically acceptable manner that incorporates, to the extent possible, other public benefits into its design.

Principles

That statement of purpose arises from recognition of three basic principles by the BUG.

1. Dredged material is a potential valuable resource and should be considered and treated as such;

2. Development of an environmentally acceptable disposal plan is intrinsic to eventual approval of this project, other environmental concerns not withstanding; and

3. Any disposal plan put forward by the BUG must have long-term environmental benefits for the Galveston Bay system.

Approach

The approach utilized by the BUG for Galveston Bay makes this effort unique and precedent setting; what is being attempted, in its totality, has never been done before. This uniqueness can be enumerated as described below:

1. The BUG is an interagency group developing a disposal plan - rather than reviewing a proposal in a regulatory setting.

2. The BUG is addressing one of the largest navigation projects in recent years- approximately 52.0 million cubic yards (MCY) of new work material and an estimated 160.0 MCY of maintenance material over the next fifty (50) years for the bayou, bay, and entrance reach of the HSC.

3. The BUG is committed to the objective that the final plan shall have a net positive environmental effect over the 50-year life of the project.

4. The BUG actively solicited beneficial use suggestions from Bay interests and user groups - whose collective ideas have been given full consideration during the development of the recommended plan.

SUMMARY

Introduction

After consideration of the sediment probing study, NMFS studies, locations of existing and proposed oil and gas sites, pipelines, oyster reefs, public groups and agency inputs, and other sources, the ICT approved the BUG's Recommended Beneficial Use Plan on October 2, 1992 (the 1992 BUG Report). The 1992 BUG Report is a "stand alone" report that addressed the disposal plan for a two-phase project (45' x 530' and 50' x 600').

Since adoption of the 1992 BUG Report, two significant changes have occurred which required revisions to the Beneficial Use Plan. First, the 1992 BUG Report was completed on schedule to achieve a 1994 congressional authorization request. However, the authorization schedule was deferred from 1994 to 1996 - this delay allowed the BUG more time to evaluate the construction techniques necessary to help achieve the BUG's intent to create "ecologically functional" marshes. Secondly, the 50' x 600' element of the project was eliminated; this change required significant refinements in the original beneficial use plan relative to the allocation of material and the sizing of marshes. These changes are discussed in the latter sections of this report.

Beneficial Use Plan

The BUG's Recommended Beneficial Use Plan for the 45' x 530' HSC Modernization Project is discussed on the following pages.

When completed, the plan comprises approximately 4,582 acres of marsh restoration, upland restoration, and bird island creation with a bay bottom footprint of approximately 4,480 acres (Note: Goat Island is in the bayou reach of the HSC, not the bay, and therefore is not included in the total acreage). The acreages presented are for the channel reach from Boggy Bayou to Bolivar Roads. These acreages do not include the restoration of Red Fish Island. The plan does not require any new upland sites for placement of dredged materials.

Features

The features of the Beneficial Use Plan are:

1. Construction of 4,250 acres of intertidal marsh, one of the most ecologically productive habitats in Galveston Bay, to partially restore losses caused by the conversion of wetland to shallow water habitat through erosion, subsidence, and other man-made impacts (Exhibits 3 and 4).

2. Construction of boater access channels and anchorages in mid and lower Galveston Bay (Exhibit 3).

3. Construction of an island in lower Galveston Bay to provide for avian nesting habitat (Exhibits 3 and 4).

4. Restoration of Goat Island to its approximate 1944 configuration (Exhibit 3).

5. Restoration of Red Fish Island in response to public and agencies input if suitable material is available (Exhibit 3).

TABLE 1
45′ x 530′ BENEFICIAL USE PLAN

SITE NAME	SITE NUMBER	SITE EMERGENT (ACRES)	BAY BOTTOM COVERAGE (ACRES)	MATERIAL DISTRIBUTION (MCY)
Bolivar Marsh	3	930	970	16.1
Bird Island	5	12	20	NA
Mid Bay Marsh	19	1,790	1,910	41.9
Atkinson Marsh	15	1,530	1,580	30.2
Goat Island	18	320	NA	NA
TOTAL		4,580	4,480	88.2
Upland Disposal Areas 14/15/16	15	1070	0	13.8

Note: NA - Not Applicable

Benefits

The benefits derived from the implementation of the Beneficial Use Plan are many. These include:

(1) Creates and restores wetland habitat lost to Galveston Bay;*

(2) Minimizes impacts to productive bay habitats through the placement of beneficial use sites within areas presently used as unconfined disposal areas;

(3) Provides for avian habitat through the creation of a bird island;*

(4) Provides boater cross-cuts and anchorages;

(5) Provides for restoration of Goat Island; and

(6) Provides shoreline protection.

* **Note**: In the "State of the Bay" report, the Galveston Bay National Estuary Program (GBNEP) indicated that habitat loss is a priority problem. Specifically, GBNEP estimates a net loss of 33,400 acres of wetlands over the last 40 years - primarily due to man's activities. GBNEP's proposed Comprehensive Conservation Management Plan (CCMP) recommends the creation or restoration of 8,600 acres of estuarine emergent marsh over the next ten years. The BUG Plan provides for approximately 1,910 acres of marsh creation in the first twenty years of the 45' x 530' Project, approximately 20% of the CCMP objective. Overall, the 45' x 530' BUG Plan provides for approximately 50% of the total acreage recommended by the CCMP for Galveston Bay at the completion of the 50-year project life.

Additionally, GBNEP recognizes that nesting habitat for colonial nesting waterbirds has been degraded and/or eroded and have recommended specific habitat protection plans regarding nesting islands. Included in these recommendations is the use of dredged material to build islands at a location and of a size amenable to colonization, and where there is a demonstrated need (i.e., under-utilized feeding habitat). The BUG Plan meets the objectives of the CCMP through the construction of a bird island in lower Galveston Bay.

RECOMMENDED BENEFICIAL USE PLAN - 45' X 530' PROJECT

Introduction

The philosophy, approach and objectives contained within the 1992 BUG Report are unchanged: dredged material is a resource; properly constructed and maintained, the BUG Plan can have a net positive environmental effect on the bay system. All of the new work and subsequent maintenance material in the bay will be used beneficially to create several thousands acres of intertidal marsh, and construct a bird island. In addition, the plan includes three small boater cuts along the channel to allow boater access to the eastern side of Galveston Bay, and thus possibly reducing recreational boater traffic in the HSC. In addition to the construction of three boater cuts, protected anchorages at two locations (Mid Bay and Bolivar Marsh) are also included (Exhibit 3). The plan also provides for restoration of Red Fish Island if suitable material can be found.

In addition to the beneficial use of material from the bay reach of the HSC, a portion of the new work materials from the bayou reach will be used to restore Goat Island which will provide shoreline protection and upland habitat.

Development of Candidate Sites - Public Participation

This element was approached carefully, and was an effort to solicit input from a wide range of bay users. Briefly, the process was:

1. An information packet was developed by the BUG, supplemented by graphics and slides for meetings;

2. A list of bay interests, user groups and local government entities was developed, and the packets were mailed to them; and

3. Those groups expressing an interest were contacted. Numerous letters were received, and approximately fourteen (14) meetings, scheduled at interested group's convenience, were held over a six-month period. The ground rules for the meeting were few but direct:

a. No organization's name would be used in any way, either as an expression of support or opposition to the project - it was simply a solicitation for their ideas and perceptions on beneficial uses of dredged material.

b. All organizations were asked that IF the project was authorized, how would they like to see the dredged material used beneficially.

c. In the context above, it was requested that the meetings be small (20 or less participants if possible), and secondly, that only potential beneficial uses of dredged material be discussed, not the merits of the project.

d. While all input would be fully considered, the final decision on the recommended plan would be made by the BUG - environmental enhancement of Galveston Bay would be the primary consideration.

Public Participation Results

The results of the process were quite rewarding, with many suggestions for use of dredged materials submitted; far more potential uses were identified than the total material available for construction. A composite of these suggestions is presented in Exhibit 1. Common threads to all of the meetings were:

1. Beneficial uses should stress restoration.

2. Wetlands, bird areas and shoreline protection (from erosion) should be emphasized.

3. Sacrificing productive habitat for creation of new habitat was to be avoided.

4. Restoration of Red Fish Island was highly desired.

Ultimately, the plan will have to undergo formal public and agency scrutiny through the NEPA process. In its current form, however, the BUG's recommended plan has taken into consideration all of the public's ideas for beneficial uses of dredged material.

Beneficial Use Site Selection and Screening Process

Based on input received in the public meetings and other input from individuals and agencies, the potential beneficial uses were consolidated into twenty-three (23) groupings reflecting those suggestions.

The BUG adjusted these twenty-three (23) groupings to avoid existing oyster reefs and major concentrations of oil and gas wells. These initial eighteen (18) sites (Exhibit 2), with the sizes shown below, were provided to the Corps' Waterways Experiment Station (WES) for simulation of impacts on the bay in its Hydrodynamic & Salinity model (H&S).

TABLE 2
18 INITIAL BENEFICIAL USE SITES

SITE NUMBER	SIZE (acres)	LOCATION
1	100	Pelican Island
2	1,500	Texas City
3	1,500	Bolivar Roads
4	200	East Bay
5	200	Lower Galveston Bay
6	100	Dickinson South
7	200	Dickinson North
8	500	Red Fish Island
9	200	Seabrook
10	500	West Trinity
11	100	Vingt-et-Uns
12	100	Double Bayou
13	100	Trinity Bay
14	300	Houston Point
15	1,500	Cell 14/15
16	200	La Porte
17	200	Pasadena Point
18	500	Goat Island

ENGINEERING CONSIDERATIONS

Introduction

Although the focus of the Beneficial Use Plan is upon development of beneficial uses that provide a net-positive environmental benefit to Galveston Bay, the BUG continuously balanced identification of beneficial use and site locations with consideration of the economic and engineering practicality without sacrificing existing productive habitat. One of the BUG's objectives has been that the beneficial use sites selected will be practicable to construct, feasible to maintain, and provide long-term environmental benefits to Galveston Bay. Consequently, a variety of engineering considerations have been investigated (material quantities and behavior, foundation conditions, and others).

In many instances, several of the construction techniques proposed for implementation of the BUG Plan have not been used to construct marsh areas to the extent proposed here (hydraulic levee construction, fill placement, consolidation, ditching, pond construction, and others).

1. *Hydrodynamic and Salinity Impacts*

WES completed two series of model runs to evaluate the 18 initially identified, potential beneficial use sites' impact on circulation and salinity within the Galveston Bay system (1992 BUG Report).

The ICT concluded, based on the WES model runs, that changes in bay circulation and salinity caused by inclusion of all 18 sites would be minor and localized. To the extent beneficial use sites are deleted or reduced in size, the hydrodynamic condition in the bay approaches that of the base condition.

As noted in the 1992 BUG Report, the existing HSC dimensions were used for the two series of runs. The total area of emergent marsh for the 18 alternative sites equaled 8,000 acres for the two initial model runs. In contrast, the current BUG Plan, proposed for the 45' x 530' project, comprises approximately 4,250 acres of emergent marsh. Presently, WES is performing a model run for evaluation of circulation and salinity impacts for the current Beneficial Use Plan (Exhibit 3). As discussed above, given the reduction in total plan area from 8,000 acres to 4,250 acres, the current BUG Plan is expected to have no significant impact upon circulation and salinity.

2. *Siting Considerations*

Continued review and analysis of the 1992 BUG Report resulted in the changes discussed below.

Dollar Point Marsh Site. At the originally proposed Dollar Point marsh site, concerns about potentially impacted existing oyster reef and proposed shoreline development adjacent to the site prompted a detailed site investigation by the BUG. A survey of existing oyster reef and shell-on-mud complexes within the proposed site area was completed by the BUG.

The results of the survey indicated that the proposed site configuration would probably impact existing reef in the area unless the site was reduced in size. In accordance with the BUG's principle that existing, productive habitat would not be sacrificed for the creation of new habitat, in addition to changes in the anticipated shoaling rates for the HSC, caused the Dollar Point marsh site to be eliminated from further consideration. New work and maintenance dredged material initially destined for the Dollar Point site was re-directed to the Bolivar and Mid-Bay marsh sites.

Bolivar Marsh Site. After additional studies of the GIWW materials and maintenance dredging history, the Bolivar site was enlarged to accommodate and provide beneficial use of the dredged material from the impacted reach of the GIWW. Also, the high percentage of sand in the GIWW material makes it ideal for use in the construction and maintenance of the nearby bird island. To more efficiently use the available new work materials of the HSC, a third cell will not be entirely constructed at first, to provided dual service as a boater destination and GIWW disposal site. In project year 40, the third cell will be closed for marsh creation and a boater anchorage provided by the additional levee construction (Exhibit 4).

Configuration of Marsh Sites. The BUG refined the shapes and development sequence for all the sites utilizing "lessons learned" from the construction of the Demonstration Marsh, site visits to other marshes and bird islands, along with design considerations obtained from the bioengineering study and others.

HSC Entrance Material. The BUG has recommended that the new work materials from the deepening of the entrance channel (new work) be utilized to construct an underwater berm that will provide topographic relief in the relatively flat near-shore area along the eastern end of Galveston Island. This recommendation is the result of material analyses indicating that due to a minimal quantity of sand, placement directly upon the beaches of the island would be impracticable. Maintenance material not suitable for berm re-nourishment, will be placed in the Corps' existing offshore disposal area (Exhibits 13 & 14).

Goat Island Restoration. The Goat Island site will be constructed using approximately 6.0 MCY of new work material to restore the island to its approximate 1944 configuration. A 500-acre site, as originally proposed in the 1992 BUG Report, is now reduced to a 320-acre site due to: 1) a reduction in available materials due to the reduced project size; 2) competing uses of new work material for levee rehabilitation at the existing upland disposal areas; and 3) avoidance of existing pipelines in the area.

Dredged Material Characteristics

3. Material Types and Distribution

Subsurface investigations in the form of core borings performed by the Corps in 1962, 1963, 1972 and 1992 were analyzed with respect to dredgeability, transport, and construction uses. The material types considered suitable for the construction of containment levees are medium to stiff clays, stiff to hard clays, sands, and shell. The remaining materials, consisting of soft to very soft silts and clays, were considered suitable only as fill material for marsh construction.

The approximate materials distribution along the channel for the 45' x 530' project is described as follows. From Morgans Point to the south for a distance of 60,000 feet, an estimated 11.0 MCY are levee quality material. Another 2.0 MCY are soft materials and will be used as fill to construct the initial "new work" marshes during widening and deepening.

The middle reach of the bay section (40,000 feet) consists of approximately 7.1 MCY of soft clays that are considered suitable for fill purposes only and will be used to construct the initial marshes at the mid-bay and lower bay beneficial use sites.

The lower reach of the channel from Bolivar Roads to 40,000 feet to the north contains 5.1 MCY of material suitable for levee construction. Additional borings and geophysical techniques will be used to refine the quantity calculations during the Project Design Memorandum (PDM) phase.

4. Shoaling Quantities

One of the goals of the BUG was to initiate the creation of a marsh with each maintenance dredging cycle of the channel. To achieve this goal required dividing the beneficial use sites into cells of specific acreage that would be able to contain the dredge slurry, yet settle, consolidate and become firm substrate at inter-tidal elevations (Exhibit 10). As the containment levees are constructed in advance of the maintenance dredging, precise estimates of the shoaling rate and maintenance material distribution along the deepened and widened channel become paramount to achieve the marsh per maintenance dredging cycle goal.

After detailed review of historical dredging records and trends, along with an evaluation of the hydrodynamic and dredged material disposal conditions, shoaling rates and quantity distribution estimates were developed to aid in determining the size of the marsh cells at each of the sites. The resulting overall size of the sites exceeded the 45' x 530' project's ability to provide enough levee material for the 50-year life of the project. However, all the available levee materials are utilized to construct a sufficient number of cells to provide capacity for the new work dredging plus approximately the first 20 years of the project. The remaining levee material required for future cell construction will be obtained from borrow dredging in the adjacent HSC.

Because the shoaling rate and distribution quantities are estimates and controlled primarily by nature, cells at the marsh sites will be constructed and operated in pairs. A lack of maintenance material to fill a cell to the desired elevation during a particular dredging cycle can be corrected during the next cycle. However, a surge in the amount of material (i.e., storm event) will be dealt with by directing that the excess material be used to fill the adjacent (contingency) cell. This operating concept will allow the marsh managers to adjust to changes in shoaling and distribution of materials throughout the life of the project.

Current estimates of the shoaling rate for the new channel are 187,000 cubic yards per year (cy/yr) in the lower bay (Redfish Reef to Bolivar Roads) and 1,155,000 cy/yr in the upper bay (Redfish Reef to Morgans Point). Overall, approximately 66 MCY of maintenance dredged material will be dredged during the 50-year life from the bay reach of the project.

5. *Erosion Protection*

5.a. *Introduction*

Since the material used to construct the levees is an erodible surface, erosion protection will be required for the beneficial use sites. For containment levees exposed to high energy regimes, such as those levees directly exposed to the HSC, stone rip-rap or other suitable structural alternative is expected to be used. However, placement of stone rip-rap or other similar types of structural levee protection measure is expensive. Consequently, for levees exposed to lesser energy environments, a less-expensive levee protection measure may be used.

Cost-effective alternatives to conventional stone rip-rap were explored by the BUG. The Demonstration Marsh (discussed in the latter sections of this report), provided the opportunity to evaluate possible cost-effective alternatives for levee protection, and thus potentially lower the costs of maintaining beneficial use sites.

5.b. *Evaluation*

The BUG evaluated thirteen erosion protection alternatives that varied from slope paving, geotextile and concrete revetment systems to vegetation establishment for levee protection. Some of the parameters used in this evaluation included:

- Geotechnical evaluation of foundation conditions including determination of shear strength for slope stability and bearing capacity.
- Determination of expected wave generation and erosive duration for average winds and rare events, i.e., 20-year event.
- Cost effectiveness, including ease of installation, maintenance, and degree of erosion protection in comparison to stone rip-rap.

Formulation of recommended levee protection measures were balanced with the recognized purposes for levee protection: 1) to evaluate cost-effective alternatives to stone rip-rap for shoreline protection (presently $250 per linear foot [LF]), and 2) provide long-term protection for the future marshlands contained within the levee area.

After evaluation and screening of approximately thirteen different shoreline protection measures by the BUG, three structural shoreline protection alternatives were installed, all at a cost less than placement of stone rip-rap, along approximately 3,300 LF of the Demonstration Marsh levee. A discussion of these three types of shoreline protection measures follows.

5.c. Demonstration Marsh Shoreline Protection

(1) Geotubes

Description. A woven geotextile that is formed into a tube. The tube's diameter and length is determined by project requirements. Designed with appropriately sized openings, the geotextile tube retains fill material while allowing water to permeate out through the tube wall, permanently trapping granular material in both dry and underwater construction.

Installation. The geotube is rolled out at the base of the embankment and filled with dredged material by direct coupling to a hydraulic piping system conveying dredged material. Approximately 2,500 LF of Geotube was installed along the Demonstration Marsh levee.

Cost. The installation cost per linear foot is approximately $80.

(2) Geoweb

Description. A cellular confinement system composed of a filter fabric and cellular confinement system filled with coarse aggregate and/or suitable in-situ material.

Installation. Slope is graded to a smooth plane surface to ensure that continuous contact is achieved between the slope face and the filter fabric, and between the filter fabric and the entire bottom surface of the cellular confinement system. Construction of anchor, side and toe trenches are required. Beginning at the bottom of the slope, coarse aggregate fill material is placed into the cellular confinement system's compartments across the entire width for approximately 400 LF.

Cost. The installation cost per linear foot is approximately $200.

(3) Pyramat

Description. Erosion enforcement matrix formed into a uniform configuration with a strong and stable matrix in all dimensions.

Installation. Slope is graded to a smooth plane surface to ensure that continuous contact is achieved between the slope face and the erosion reinforcement matrix. Construction of anchor, side and toe trenches are required. Pyramat was installed for a distance of approximately 400 LF along the levee.

Cost. The installation cost per linear foot is approximately $90.

In addition to the installation of three types of structural shoreline protection described above, a fourth shoreline protection measure was installed.

The BUG transplanted *Spartina alterniflora* along the exterior of the northern portion of the levee for approximately 2,200 LF. To date, a vigorous fringe marsh has now been established along the lower slope of the levee and is providing erosion protection as well as fringe marsh habitat.

5.d. Summary

The Contractor initiated construction in February 1994 with completion in May 1994. The three types of levee protection installed are presently being evaluated for ease of construction under typical site conditions, degree of erosion protection provided, and maintenance requirements.

If proven successful, the use of one or all of these types of levee protection measures for the proposed construction of approximately 68,000 LF of levee for the Houston Ship Channel Modernization Project, potentially will provide a substantial project cost-savings in levee protection versus the cost of using stone rip-rap.

ENVIRONMENTAL CONSIDERATIONS

Introduction

The development of a disposal plan for the HSC Modernization Project that provides a net-positive benefit to Galveston Bay is the principal goal of the Beneficial Use Disposal Plan. Several future work tasks were proposed and adopted by the ICT which provided for continued effort by the BUG in developing recommendations for design, monitoring and management of beneficial use sites which are discussed below.

1. Contaminant Testing and Results

Introduction

The ICT Contaminant Subcommittee has evaluated the contaminant potential of maintenance material from the bayou, bay and entrance reaches of the proposed Houston Ship Channel Modernization Project. Testing was performed on maintenance material from the existing project. The evaluations performed on maintenance material and the results are summarized below.

1.a. Testing Framework - Bay Reach

It was anticipated that maintenance material from the bay reach would be utilized for beneficial uses in the bay. The subcommittee agreed to follow the testing protocols described in the Corps/EPA Testing Manual *"Evaluation of Dredged Material Proposed for Ocean Disposal"* (the Green Book).

Historical grain size analysis and sediment analyses for priority pollutants, dioxin, water column bioassays, solid phase bioassays, and bioaccumulation analyses were completed.

1.b. Conclusions - Bay Reach

Based on the evaluations and results described above, the Contaminant Subcommittee concludes that there are no contaminant concerns related to dredging and the beneficial uses of maintenance material from the bay reach of the project.

1.c. Testing Framework - Entrance Reach

It was anticipated that maintenance material from the Bolivar Roads reach could be deposited in either the ocean or the bay. Consequently, the testing requirements of both the Ocean Dumping Act and Section 404 of the Clean Water Act were addressed.

Historical grain size analysis and sediment analyses for priority pollutants were completed. Given the high sand content in this reach of the channel, the high energy area, and no indication of a contaminant problems based on the sediment analyses, the testing exclusion requirements of both the Ocean Dumping Act and the Clean Water Act were satisfied.

1.d. Conclusions - Entrance Reach

Based on evaluations and results described above, the Contaminant Subcommittee concluded that there are no contaminant concerns related to dredging and disposal of maintenance material from the entrance reach of the project.

1.e. Testing Framework - Bayou Reach

It was anticipated that maintenance material from the bayou reach would be deposited in existing upland disposal areas along the HSC. The subcommittee agreed that the testing protocols described in the Corps/EPA Testing Manual (the Green Book) were not appropriate for upland disposal. A separate study was performed to evaluate the potential for release of contaminants from the upland disposal areas.

Historical grain size analysis, sediment analyses for priority pollutants, and sediment analyses for dioxin were completed. In addition, a disposal area monitoring study was performed that involved the monitoring of actual dredging operations. Besides monitoring the effluent at four disposal areas, a caging study using blue crabs and *Rangia* clams was performed at one of the sites to evaluate the potential for uptake of effluent. Adequate dilution existed at the sites to meet the standards. No indications of bioaccumulation were found.

1.f. Conclusions - Bayou Reach

Based on evaluations and results described above, the Contaminant Subcommittee concluded that there are no contaminant concerns to the receiving water related to dredging and the upland confined disposal of maintenance material from the project.

2. *Site Selection and Potential Productivity*

2.a. Introduction

The foundation of the BUG Plan is the study performed by NMFS (Site Selection for Beneficial Use of Dredge Material through Marsh Creation in Galveston Bay, 1993), which concluded that the replacement of some open water bay bottom habitat with intertidal brackish and salt marsh habitats would provide a net-positive benefit to the Galveston Bay ecosystem. In addition, the study determined the areas within the bay most likely to provide the greatest potential for marsh establishment.

2.b. Summary

The NMFS undertook a quantitative biological study to evaluate potential sites for marsh creation by comparing various habitats and locations in Galveston Bay during September, 1991. The study was designed to compare marsh to open water utilization by shellfish, shrimp, and juvenile fishes within and between the various sites in Galveston Bay, defined by the September 1991 standing crop measurements. The results of the study provide a comparison of relative nursery habitat utilization (standing crop) of juvenile living marine resources (LMR). It can be inferred from the NMFS' study that by increasing available marsh nursery habitat for juvenile LMR, there should be an increase in overall LMR productivity.

2.c. Study Conclusions

Conclusions developed from the study were:

(1) Utilization is greater in marsh for penaeid shrimps, blue crab, and spotted seatrout, whereas utilization was greater in the open bay for mysids, bay anchovies, and Atlantic croaker. Species such as grass shrimps, cyprinodontids, and gobiids were predominately found in marsh.

(2) Marshes created in the lower and eastern sides of the bay have the best chance of achieving significant gains in commercial and recreational fishery gains.

(3) Abundance and biomass were usually significantly higher in the marsh than the open bay.

(4) Brown shrimp, white shrimp, blue crab and grass shrimp were consistently more numerous and had greater biomass in the marsh throughout the zones measured in Galveston Bay.

3. *Demonstration Marsh*

3.a. *Purpose*

The purpose of the Demonstration Marsh is to identify key environmental and design parameters and management requirements needed for the establishment, growth, and survival of created marsh. These requirements include identification of the key operating requirements for the typical dredging equipment most likely to be utilized for the future placement of maintenance dredged material for beneficial uses.

3.b. *Project Description*

The Demonstration Marsh project is located in upper Galveston Bay within previously designated disposal areas known as Cells 15 and 16 (see Exhibit 8). The Demonstration Marsh is approximately 220 acres in size, including approximately 180 acres of emergent fill material and 40 acres of shallow open water. A 6,800 LF confinement levee encloses 220 acres of open water and fill material. Levee material was hydraulically dredged from the HSC, and fill material was obtained from maintenance dredging of the Bayport Ship Channel Flare and a portion of the HSC.

3.c. *Project Design*

The HSC Modernization Project Beneficial Use Disposal Plan for the bay reach of the HSC will use approximately 88.2 MCY of dredged material over the 50-year life of the project in a manner that provides environmental benefits to Galveston Bay. Approximately 4,250 acres of marsh habitat will be created from the dredged material. To evaluate the technical feasibility of the plan, the BUG recommended that a large scale demonstration project be constructed using materials, equipment and techniques that would replicate those that are envisioned for the BUG Plan.

To this end, the PHA and the Corps constructed a 220-acre site in upper Galveston Bay utilizing design criteria developed by the BUG. Some of the design work carried out is summarized below.

- Detailed hydrographic surveys of the HSC borrow and fill areas were performed.

- Bioengineering studies by the NMFS to determine the physical characteristics of functioning, natural marshes were conducted. These studies were used as references for the Demonstration Marsh to determine the open water to marsh ratios, length, width and depth of intertidal channels, in addition to the elevation of the substrate required to establish and sustain a variety of marsh vegetation.

- Geotechnical investigations entailing eighteen (18) soil borings spaced at 1,000-feet intervals along the channel borrow area, thirty-five (35) probings of the sub-bottom foundation along the proposed levee alignment, along with seven (7) undisturbed samples for comparison to future levee samples to analyze bay bottom foundation behavior were completed. Six (6) drop cores of the maintenance dredging material were obtained to determine the shrinkage and consolidation characteristics using lab test results and the Corps' Primary Consolidation and Desiccation of Dredged Fill (PCDDF) model.

3.d. Design Features

Some of the features of the Demonstration Marsh construction are:

(1) A 6,800 feet hydraulically placed levee was constructed utilizing 840,000 cy of new work clays and sands in forty (40) days. The plans called for a 20-feet wide crown to an elevation of 8-feet mean low tide (mlt) with a slope no steeper than 1 foot vertical: 3 feet horizontal (Exhibit 9). Two temporary spillboxes were installed to remove decanted water and control material distribution during the fill placement phase.

(2) Approximately 1,600,000 cy of fine-grained maintenance material was dredged and pumped as far as 20,000 feet to fill the site to an elevation of 6.5 feet in 16 days.

3.e. Benefits

To date, the construction of the demonstration marsh site has proceeded well. Construction of the site has fulfilled its purpose many times over as several key operational, engineering and environmental design parameters are being refined and/or developed from construction and monitoring of the site.

The benefits derived from construction of the demonstration marsh are many; some of these are discussed below.

- Construction of a 220-acre Demonstration Marsh provided the BUG with the opportunity to observe construction, planting, and biological utilization of a created marsh on a scale equivalent to the individual marsh cells proposed in the Beneficial Use Disposal Plan.

- Refinement of techniques for marsh creation, both for levee construction and fill placement, were achieved.

- Direct observation, evaluation and collection of field data for levee and fill material behavior studies from the following activities were initiated due to the construction of the marsh:

(1) Refinement of shrinkage factor for fill material using results of ongoing surveys of the Demonstration Marsh site as input to the Corps' self-weight and conventional consolidation computer program PCDDF; and

(2) Evaluation of bay bottom foundation material behavior after levee construction; to be obtained from future levee borings by the Corps.

- The material used to construct the levees is an erodible surface. Cost-effective alternatives to conventional stone rip-rap were explored by the BUG. The Demonstration Marsh provided the opportunity to evaluate possible cost-effective alternatives for levee protection, and thus potentially lower the costs of maintaining beneficial use sites. After evaluation and screening of approximately thirteen different shoreline protection measures by the BUG, three structural shoreline protection that were less costly than stone rip-rap were installed along approximately 3,300 LF of levee.

An additional shoreline protection measure was created by planting approximately 2,200 LF of the bayward side of the levee with smooth cordgrass (*S. alterniflora*). To date, this transplanting effort has resulted in a vigorous fringe marsh along approximately 2,000 LF of levee. This method of shoreline protection is also being evaluated as a possible shoreline protection measure for the BUG sites.

The construction of these alternative shoreline protection measures has allowed the BUG to evaluate both the construction and operational characteristics of each alternative. The BUG will continue to monitor and evaluate the shoreline protection measures throughout the life of the Demonstration Marsh.

- Construction of the Demonstration Marsh provided the opportunity to develop a partnership mechanism among the Corps, the PHA, and the BUG, for placement of maintenance dredged material within the Demonstration Marsh. The partnership meeting resulted in the enhanced coordination among the Corps, the PHA, and the BUG for implementing beneficial uses of dredged material and maintaining navigation of the HSC.

- Utilization of data obtained from the NMFS survey of natural reference marshes enabled the BUG to develop and implement bioengineering parameters to create a marsh that is functionally equivalent to natural marshes in Galveston Bay. For example, a planting plan for the Demonstration Marsh is currently being developed that incorporates design criteria including physical (i.e., slope, elevation, dimensions of constructed coves and creeks, other) and biological features (plant species establishment and zonation, species utilization by fauna, other) obtained by the NMFS survey of existing natural marshes.

- New habitats created by the construction of the clay and sand levee and by de-watering and consolidation of the fill material have been heavily used by both shorebirds and colonial waterbirds for nesting, resting and feeding.

  Construction of the levee resulted in significant nesting by black skimmers and coastal least terns on both the slope and crown of the levee in 1993 and 1994. In 1994, one of the largest colony of coastal least terns in Galveston Bay could be found at the Demonstration Marsh (P. Glass, USFWS).

Consolidation of the fill material has resulted in significant numbers of shorebirds feeding on benthos in the fill material. Large numbers of black-necked stilt, American avocet, Forester's tern, roseate spoonbills and tri-colored heron have been observed feeding within the levee interior.

3.f. Future Work Items

To complete development of the Demonstration Marsh, ditching of the site will be carried out to assist the natural shrinkage and consolidation of the fill material to the desired elevation range established by the NMFS survey of natural marshes in the local area. Once the fill area reaches a favorable elevation range, the marsh area will be planted using a planting design developed by the BUG to assist in the development of final plans and specifications for marsh creation proposed in the BUG Plan. Monitoring and evaluation of marsh development will be continued.

4. Development of Bioengineering Criteria

4.a. Introduction

The Galveston Bay estuary supports valuable commercial and recreational fisheries by providing habitat for fishery species. One of the most important nursery habitats is the intertidal marsh surface. Past studies by the NMFS have shown that Galveston Bay marshes are used extensively by the young of several fishery species including brown shrimp, which are more valuable than any other Texas fishery species. Other economically important species using marshes as juveniles are white shrimp, blue crabs, striped mullet, spotted seatrout, southern flounder and red drum. In addition, marsh is critical for many resident species such as grass shrimps and killifishes, which are eaten by fishery species, and thus support fishery production through secondary production.

Although the technical knowledge for planting marsh vegetation on dredged material is well established, albeit not for large acreages of marsh planting, the technology for creating marsh characteristics and features that function similar to natural marshes is in its infancy. One approach to designing marshes with a functionality similar to natural marshes is to create marshes with physical attributes (i.e., elevation, geomorphology) that approximate those of existing marshes. There are at least two reasons for taking this approach. It is well established in the scientific literature that physical attributes of marshes influence the distribution of plants and animals. For example, marsh plants tolerate only a narrow elevation range in Galveston Bay. Therefore, to ensure that vegetation established in created marshes is similar to natural marshes, the dredged material must have the same elevation as nearby existing (reference) marshes.

Animals are also influenced by physical features. The presence of channels and open water ponds within marshes is extremely important to creating habitat diversity and increasing access for animals. The degree to which juvenile fishery species can use a marsh is dependent upon passageways into the marsh. Created marshes without creeks and tributaries may be judged a success from a vegetation standpoint, but the marsh will be poorly used as a nursery habitat by important commercial and resident species.

4.b. Study

Design criteria for creating marshes that are similar to natural marshes in Galveston Bay do not exist. Subsequent to the 1992 BUG Report, the NMFS under contract with PHA undertook a second study titled Development of Design Criteria and Parameters for Constructing Ecologically Functional Marshes in Galveston Bay, Texas, 1994. The objectives of the study were:

- To characterize existing (reference) marshes near the beneficial use sites by measuring a variety of habitat attributes from aerial photography and in field surveys.
- Measure and compare animal use patterns among different types of habitats in the reference marshes.
- Determine which habitat features of the reference marshes should be constructed and tested in the Demonstration Marsh for application to the design of beneficial use sites recommended in the Beneficial Use Disposal Plan.

4.c. Results

To date, the characterization of reference marshes in upper Galveston Bay has been completed. The survey of reference marshes in the lower bay is due to be completed late 1994. Preliminary results from this study identified eight major habitats in upper Galveston Bay. These included four marsh types (*S. alterniflora* edge, *S. alterniflora* inner, *S. patens*, and *Scirpus maritimus*) and four subtidal habitats (marsh pond, marsh channel, marsh cove, and unsheltered open bay).

4.d. Conclusions

The conclusions of the 1994 NMFS report can be summarized as follows.

None of the marsh or subtidal habitats was preferred by all species. However, the intertidal and subtidal habitats within the marsh system contained much higher densities of most nekton than the open bay. Therefore, if marshes that are functionally similar to natural marshes are constructed, the increased benefit of enlarging the habitat area for fishery and forage species that use marsh systems (90% of important commercial and recreational fishery species) will outweigh the loss of open water bay bottom habitat and will provide a net-positive environmental benefit to Galveston Bay.

4.e. Marsh Design Criteria

In addition to the development of generic criteria for marsh creation that was presented in the 1992 BUG Report, the BUG, based on recent studies, have now developed specific design principles for marsh creation. These include:

(1) Migratory species (marine fishes and invertebrates which migrate into marshes during favorable conditions or which utilize marshes as nursery habitat) use the marsh edge much more frequently than interior marshes. Therefore, greater emphasis should be given to constructing low marsh edge habitat by creating large areas of *Spartina alterniflora,* and perhaps *Scirpus maritimus,* marsh interspersed with a dense network of shallow channels and interconnected ponds.

(2) A diversity of marsh types is needed to provide habitat to the full range of fishery species. High marsh, for example, was found to provide a refuge for prey species. Therefore, other marsh habitats (besides low *Spartina alterniflora* and *Scirpus maritimus* marshes) should be incorporated into the constructed marshes.

(3) Marsh open water was an important habitat type. Providing open water in the form of ponds is preferred over coves due to the increased "edge."

(4) Feeding waterbirds (herons, egrets, waterfowl, spoonbill, and others) heavily utilize marsh ponds which are not freely connected with a tidal channel due to the ease of capture of fish and invertebrates stranded and concentrated in drying pools during low tide conditions. Therefore, some ponds should be constructed in these created marshes that are isolated from tidal channels.

5. *Development of Planting Plan*

Introduction

The BUG is presently developing a Planting Plan that incorporates design criteria for creating marshes that are functionally similar to natural marshes in Galveston Bay. This plan will use the physical features (i.e., slope, elevation, dimensions of coves and creeks, other), measured by the NMFS for the reference marshes adjacent to the Demonstration Marsh to determine the approximate zonation of suitable species of vegetation.

5.a. Planting List Development

A planting list has been developed from the NMFS survey of natural reference marshes. The planting list is composed of plants that grow well and reproduce at a given location in the particular climate with minimum care, and remain free of serious disease or insect pests. Considerations in regard to the means and methods to vegetate the site are availability and costs, collection and handling ease, storage ease, and planting ease.

The steps used to develop the plant list include:

(1) Use of the composition of the communities in natural reference marshes found from the NMFS survey;

(2) Determination of which of the commonly occurring species are commercially available and development of a list of sources;

(3) Determination of the availability of materials to be used for planting (seeds, sprigs, rhizomes, culms, other);

(4) Generation of a planting list from among the appropriate commercially available, selected species; and

(5) Development of unit costs for each species and propagule type.

5.b. Development of Planting Methods

The type of propagule to be used (seed versus transplants) and the method(s) of planting will be developed by the BUG for each species type. The uniqueness of planting large quantities of plant materials on maintenance dredged material will be a primary consideration of the planting method. Economically feasible mechanical and hand planting methods are to be developed.

Planting methods are to be developed for the following areas: (1) the interior and exterior of the constructed levee; (2) the intertidal portion of the fill area; and (3) the supratidal and upland areas of the fill area. Other considerations for selection of planting methods include the recommended spacing and random placement for diversity of plant types.

5.c. Demonstration Marsh Planting Plan

Using the recommended elevations determined for each plant type from the NMFS, a preliminary planting plan is to be developed for the fill area of the Demonstration Marsh. Conservative assumptions based upon the most recent survey of the fill area will be made regarding the final elevation of the fill material before planting. The size of area (acres) for the range of elevation required for each plant type will be determined.

Once the planting areas have been determined for each plant type, the areas will be divided into plots for comparison of various planting methods, i.e., plots varying from a spacing of 3′ - 12′ centers, to without planting for measurement of natural colonization and establishment. The design of planting areas will be coordinated with the proposed levee protection and hydrologic modifications (i.e., construction of interior channels and ponds, and location of levee opening(s) to avoid disturbance by these activities.

The Demonstration Marsh Planting Plan will include:

(1) Recommended plant types and sources of materials for intertidal and supratidal areas;

(2) Specifications for plant materials, transportation, handling, storage and harvesting;

(3) Recommended planting method(s) for intertidal and supratidal areas;

(4) Requirements for existing condition determination (soil testing, topographic surveys, other)

(5) Determination of proposed hydrologic modifications;

(6) Delineation of areas suitable for intertidal and supratidal species establishment;

(7) Determination of plot size and type for each of the areas delineated;

(8) Recommended planting dates; and

(9) Monitoring requirements for planting and post-planting efforts (coordinated with the BUG Monitoring & Management Plan).

6. *Marsh Sites*

Introduction

The Beneficial Use Disposal Plan achieves the required 50-year disposal capacity for the HSC Modernization Project while providing for the creation of 4,250 acres of intertidal brackish and salt marsh in Galveston Bay. Table 3 presents the construction sequence and acres for initial project construction and project years 20, 30 and 40 (Exhibit 4).

TABLE 3
BENEFICIAL USE CONSTRUCTION SEQUENCE

Site	Initial Cell Construction	Initial Marsh Cells	Total Marsh Year 20	Total Marsh Year 30	Total Marsh Year 40	Total Project Life
Atkinson Island	730	140	730	1050	1210	1530
Mid-Bay	770	310	770	1110	1450	1790
Bolivar	580	240	410	580	930	930
Total Marsh	na	690 acres	1,910 acres	2,740 acres	3,590 acres	4,250 acres

The Beneficial Use Site Plan for the 45′ x 530′ project for the bay reach consists of three marsh creation sites and construction of one bird island (Exhibit 3). The three marsh sites, known as Site 15 (Atkinson Island Marsh), Site 19 (Mid-Bay Marsh) and Site 3 (Bolivar Marsh), are located in upper, mid and lower Galveston Bay, respectively. Together, they comprise a total of 4,250 acres of marsh created over the 50-year project life.

6.a. Atkinson Island Marsh - Site 15

Four cells will be initially constructed creating capacity for 730 acres of marsh creation (Exhibit 5). Approximately 140 acres of new work marsh (fill material obtained during channel enlargement) will be created from the dredging of approximately 2.0 MCY of soft materials. The confining levees for the new work marsh, a 270-acre cell and two additional 160-acre cells will be constructed by dredging approximately 4.5 MCY of clay and sand from the deepened and widened channel.

The larger 270-acre cell is constructed to contain the off-year maintenance dredging expected to be required after initial construction and relaxation of the newly cut slopes. The remaining five cells, totaling 800 acres, will be built later in the project as needed, and will require 4.35 MCY of channel mining to construct the containment levees (Note: Channel mining is dredging in short reaches of the channel to a maximum depth of 60 feet to obtain stiff clays for future levee construction, not site capacity).

The Atkinson Island Marsh site provides for a 50-year disposal capacity for the HSC reach from Morgans Point to the south a distance of 50,000 feet and will contain 1,530 acres of marsh habitat and confine approximately 19.3 MCY of maintenance dredging plus a total of 10.9 MCY of new work dredging for either fill or levee construction. The remaining maintenance material for this reach will be contained in the existing island disposal areas as fully confined sites.

6.b. Mid-Bay Marsh - Site 19

Three cells will be initially constructed utilizing a 310-acre new work cell, a 290-acre maintenance cell, and a 170-acre maintenance cell (Exhibit 6). Initial site construction resulting from the new work dredging will utilize 6.9 MCY of clay to build the confining levees, and 4.68 MCY of soft material to fill the new work cell. The 290-acre cell will be constructed to contain the off-year maintenance dredging expected to be required after initial construction and relaxation of the newly cut slopes. The initial construction shape provides winter and summer boater anchorages.

Six additional cells (170 acres each) will be constructed in the future to provide maintenance dredging during the 50-year life of the project. These additional cells will be constructed two-at-a-time in project years 20, 30 and 40 based on current shoaling rate estimate. Approximately 7.56 MCY of clay material to construct the confining levees of the future cells will be obtained from mining in the adjacent ship channel. Upon completion of construction for these future cells, a 170-acre boater cove will also be provided.

The Mid-Bay Marsh site provides for the 50-year disposal capacity for the HSC reach beginning at channel station 50+000 for a distance of 30,000 feet and will ultimately contain 1,790 acres of marsh habitat and confine approximately 22.8 MCY of maintenance dredging plus a total of 19.1 MCY of new work dredging for either fill or levee construction.

6.c. Bolivar Marsh - Site 3

This site will initially have three cells constructed creating capacity for 580-acres of marsh habitat consisting of a 240-acre new work cell and two (2) cells of 170-acres each to contain future maintenance dredging (Exhibit 7). In addition to utilizing maintenance material from the HSC to create marsh habitat, maintenance material from the Gulf Intracoastal Waterway (GIWW) from channel stations 3007+00 to 3100+00 (approximately 9,300 feet) will be incorporated with the HSC material to create a third maintenance cell of 350-acres. Included in the construction of the site is a boater anchorage at the east end of the site (Exhibit 7)

Given the disparity in maintenance dredging cycles for the HSC and GIWW (13-years versus 3 years, respectively), the third maintenance cell will not be completed until project year 40. During this period, maintenance material from the GIWW will continue to be discharged into the open marsh cell (M3), with the exception that every third cycle is expected to be discharged to the bird island (Site 5) for vegetation control and maintenance of island elevation and beach habitat.

The Bolivar Marsh site provides for a 50-year disposal capacity for the HSC reach beginning at Redfish Reef to Bolivar Roads as well as capacity for the above described section of the GIWW. The Bolivar Marsh will ultimately contain 930 acres of marsh habitat and confine approximately 14.1 MCY of maintenance and new work dredging from the HSC and approximately 1.9 MCY of maintenance material from the GIWW.

7. *Construction of Bird Island Habitat*

Introduction

In addition to marsh creation, the Beneficial Use Disposal Plan for the HSC Modernization Project provides for the construction of a 12-acre bird island (Site 5) in lower Galveston Bay (Exhibit 3). Construction of the bird island is based on recommendations developed from the USFWS study Advisability of Creating New Waterbird Nesting Islands, 1994. The report concludes that a new nesting island could benefit desirable waterbird species in Galveston Bay if properly constructed and placed in a favorable location for colonization.

In the USFWS (1992) report, recommended size of the bird rookery island was 8 acres. However, engineering considerations require the minimum size to be approximately 12 acres to allow for sufficient slope to the important beach area and to make it as self-sustaining as possible between disposal cycles.

7.a. Design

The planning guidelines and recommendations presented in the 1992 BUG Report were used in the development of the design shown in Exhibits 11 and 12. The island is 12 acres emergent with a 20-acre submerged "footprint" (covered bay bottom area) at a depth of -6 to -7 feet mlt (Exhibit 11). The proposed island is approximately 4 miles east of the HSC and 1 mile north of the Bolivar Marsh site. This location provides a firm bottom substrate and is in a location suitably remote from existing colonies.

It is expected that this island will suffer less from human disturbance than other important rookery islands in the southern portion of the bay due to its remoteness. The proposed deposition of dredged material from every third maintenance dredging cycle from the GIWW will provide refurbishment of the bare sand/shell nesting habitat and management of vegetation. Structural shoreline protection will be necessary given the high-wave energy, open-bay environment. It has been shown that structural shoreline protection is compatible with nesting bird use in a similar Texas bay (Glass, 1986).

Construction of the island is expected to provide nesting habitat for the bare sand/shell nesting guild, the shrub/scrub nesting guild and the high brush and tree nesting guild. The planting of live oak and hackberry at the crown of the island (Exhibit 12) will provide potential nesting habitat for species such as the olivaceous cormorant, roseate spoonbill, great blue heron, and great egret. The establishment of invader scrub/shrub species is expected to provide nesting habitat for tri-colored heron and snowy egrets. The periodic deposition of maintenance dredged material will not only provide refurbishment of the bare sand/shell nesting habitat but will also play an important role in maintaining desirable brush/scrub species, shrub/scrub density and spacing. The lower portion of the island (above mean high tide) will provide the bare sand/shell nesting habitat for the black skimmer and several species of terns.

The construction of the bird island addresses the following trends observed in the USFWS report:

(1) Although the total amount of bare sand/shell nesting habitat has not decreased, several factors indicate that good nesting habitat for this guild in the bay has suffered loss and degradation since 1973. First, the two most important nesting colonies in 1974 (Tiki and Atkinson Island) had both disappeared by 1990. Secondly, Lange's (1992) analysis concludes that black skimmers Texas-wide are nesting on an increasing number of smaller colonies since 1973, with a concurrent population decline.

(2) The two most important nesting islands for the medium brush nesting guild in 1973, Pelican Island and Redfish Island, have experienced decreasing utilization due to human disturbance and erosion, respectively.

(3) Two of the four important Galveston Bay colonies for the high brush and tree nesting guild have diminished or disappeared.

The 1992 BUG Report also recommended that the Vingt-et-Uns islands be restored to maintain the availability of more than one nesting site in eastern Galveston Bay to allow nesting birds to shift locations from year to year in response to disturbance pressure, predation, vegetation change, and parasite infection. However, due to the long pumping distances and the associated high cost, use of material from the HSC Modernization Project is no longer considered for the restoration of Vingt-et-Uns.

7.b. Summary

The Bird Island will be constructed from new work materials from the channel. It will have an octagonal shape protected on all sides except the southeast where a beach will be constructed utilizing local borrow from the nearby Bolivar Peninsula (Exhibit 7). The island construction will use an estimated 1.3 MCY from the ship channel dredging and have an area of approximately 12 acres. Periodic deposition of a total of approximately 1.1 MCY material over the 50-year project life from the GIWW will be used to maintain the key features of this island.

8. Restoration of Goat Island

8.a. Introduction

The sole beneficial use site for the bayou reach of the HSC is Site 18, the restoration of Goat Island using new work materials from the channel widening and deepening. The restoration of Goat Island will closely approximate the shape of the island as it existed around 1944 (Exhibit 3).

8.b. Construction

The dredging and placement of an estimated 6.0 MCY of new work material from the bayou reach of the channel will restore approximately 320-acres of island and provide shore protection for the Brownwood area along with providing upland habitat.

The remaining new work material consisting of approximately 17.0 MCY will be discharged into PHA's confined disposal areas (Alexander Island, Lost Lake, Peggy Lake, and Spilman Island) under the Disposal Area Management Program (DAMP). In addition, the confined disposal areas will provide the 50-year disposal capacity for the bayou section of the HSC, approximately 64.3 MCY (Exhibit 3).

The Goat Island restoration will be completed during initial project construction. No maintenance material will be utilized for this restoration element.

8.c. Summary

The 1992 BUG Report proposed the construction of a 500-acre upland and marsh site for the restoration of Goat Island. The change in project dimensions from 50' x 600' to 45' x 530', the resulting reduction in available materials, and competing demands for new work material for levee refurbishment at existing confined disposal areas, has reduced the scope of the Goat Island element. The presently proposed restoration of Goat Island is the construction of a 320-acre upland site approximately to the dimensions of the island's 1944 configuration.

9. Restoration of Red Fish Island

The restoration of Red Fish Island is in response to agency and overwhelming public input. The BUG is presently examining the availability of fossil shell in the HSC widening and deepening area. If suitable quantities can be found, and a cost-effective placement method is available, Red Fish Island will be restored to its approximate 1970 configuration. The BUG objected to the use of stiff clays or other non-shell material alternatives due to potential impacts to surrounding oyster reef. Red Fish Island may provide additional nesting habitat for colonial nesting waterbirds. However, past observations show that Red Fish Island was a popular anchorage area for recreational boaters which may discourage the development of important nesting habitat at Red Fish Island.

The construction of additional boater anchorages at beneficial use sites Mid-Bay and Bolivar marshes may relieve the present human pressure on emergent islands in Galveston Bay and allow Red Fish Island to be used as nesting habitat. Regardless of the type, restoration of the island will provide a positive benefit to Galveston Bay if construction is determined to be feasible.

10. Beneficial Use Plan - Entrance Reach

The BUG has stated a preference that the new work material consisting of approximately 12.2 MCY from the entrance reach of the HSC be used to construct near shore berms about 1.5 - 2 miles off from Stewart Beach for storm protection and topographic relief, provided the material is suitable. Otherwise, new work and maintenance material will go to the existing offshore site for the 50-year life of the project (Exhibits 11 & 12). Maintenance material not suitable to re-nourish the offshore berm will be placed in the Corps' existing offshore disposal area.

11. Monitoring and Management Plan (M+M Plan)

11.a. Introduction

A Monitoring and Management plan (M+M) is being prepared by the BUG which outlines ongoing and long-term activities necessary to insure the continued benefits of the BUG disposal plan.

The Monitoring and Management Plan (M+M) is divided into three distinct phases of project life; 1) pre-construction; 2) construction; and 3) post-construction. The level of monitoring effort varies with each phase but is greatest during the post-construction phase.

11.b. Objectives

The development of a M+M plan is based on project objectives - to provide uninterrupted safe navigation of the deepened and widened HSC while using the new work and maintenance dredged materials for creation and maintenance of functional intertidal marsh, bird islands, and possibly oyster reefs.

This plan documents proposed management actions, assessment procedures, timing, and frequency of monitoring and management actions. The M+M Plan focuses on structural features such as water level and community diversity that, when monitored over time, provide indications of habitat function. The M+M Plan also allows modifications to subsequently constructed marsh sites and defines maintenance requirements within the scope of the scheduled maintenance dredging contracts.

11.c. Organization and Funding for Implementation

The designation of an organization and funding sources to monitor the implementation of the M+M Plan, in accordance with each member's mandated responsibilities, is included in the supporting documentation cited in the Limited Reevaluation Report and Supplemental Environmental Impact Statement (LRR/SEIS).

Funding for the implementation of the M+M Plan for the period of construction will be included as a line item in the authorization document for the construction period. The PHA, as the local sponsor, will be responsible for funding the monitoring, management, and maintenance of the sites after project construction in accordance with the terms of the Project Cooperation Agreement (PCA) and requirements under the Water Resources Development Act (WRDA).

The development of a beneficial use plan and identification of parameters for routine and comprehensive monitoring are not enough to ensure that the benefits of marsh creation are derived over the 50-year life of the project. An organization must be designated and recognized in the project authorization document that will provide both coordination and oversight by the designated organization.

The PHA as the local sponsor, the Corps as the principal federal agency of the HSC Modernization Project, and the BUG (as constituted or re-constituted) based on Memorandum of Agreements (MOA's) between entities, with the likely addition of the Texas Natural Resources Conservation Commission (TNRCC), and the Galveston Bay Program, form BUG-2. BUG-2 will provide oversight of the construction, management, and monitoring of the beneficial use sites.

It is perceived that the resource agencies currently participating as BUG members would continue both during construction and through the life of the project as BUG-2. Specific agency roles are to be established, either through MOA's or Memorandum of Understandings (MOU's), and agreement reached before authorization is achieved. The ability of the agencies (including the Corps and the PHA) to conduct the necessary work are inherent to the success of the M+M Plan.

11.d. Coordination

Changes in maintenance dredging requirements, identification of source(s)/reaches of maintenance dredging material over the 50-year project life, and coordination between PHA, the Corps and the BUG are some of the principal coordination activities required to satisfy the plan's objective - balancing disposal requirements with the need to construct and/or maintain beneficial use sites. Included is monitoring of the effect, if any, upon the shoaling rate within the HSC due to widening and deepening of the channel and confinement of maintenance material. Contingency planning for emergency dredging and related activities must be considered for each site with scenarios analyzed for feasibility.

Coordination for site re-nourishment, changes in maintenance dredging quantities or frequency, and emergency dredging requirements are critical to the success of the plan. The method/arrangement for coordination between the PHA, the BUG, and the Corps is to be established prior to initial construction since maintenance dredging may occur before completion of the deepening and widening of the entire HSC; or, unforeseen events such as storms and excessive erosion could require contingency or emergency repairs to beneficial use sites or the need to quickly restore the navigation function of the channel.

In addition to coordination for management and monitoring of the Beneficial Use Disposal Plan, BUG-2 will maintain coordination with the bay interests and user groups, and the general public by providing periodic reports and up-to-date public presentation materials.

It is foreseeable that the products of coordination carried out through the M+M Plan may result in the need to amend the plan itself. This may be required by technological changes, changing federal or state regulations, problems discovered with methodologies described herein and others. Proposed changes will be reviewed by BUG-2 and agreed to at a meeting called for that purpose. Changes will be documented in a formal addendum to the M+M Plan.

12. **Supporting Data and Activities**

12.a. Probing Study. One of the key criteria needed for locating any beneficial use site is knowledge about the sediment properties which govern the ability of the bay bottom to provide support for the proposed beneficial use. Data identifying the thickness and location of the soft mud overlying firmer materials were not available; therefore, the bay floor was probed over a grid pattern spaced at approximate five thousand feet intervals to estimate the weight bearing capacity of the bay bottom at various locations throughout the bay.

The resulting data assisted the BUG in locating beneficial use sites in areas where the amount of available dredged materials could be efficiently utilized while minimizing the risk of failure due to settlement and sinking. Additional foundation investigations will be conducted as sites undergo further refinement and into final design.

12.b. NMFS Study - Site Selection for Beneficial Use of Dredged Material through Marsh Creation in Galveston Bay, Texas, R.J. Zimmerman, T.J. Minello, E.F. Klima, T. Baumer, M. Pattillo, and M. Pattillo-Castiglione, NMFS,1993. This study, along with other considerations relevant to construction impacts (i.e, pumping distances, pipelines, other), allowed the BUG to select locations within Galveston Bay for marsh creation. Results of this study indicated that marshes in the lower and eastern sides of Galveston Bay have the best chance of achieving significant gains in abundance and biomass of fish and decapod crustacean fauna. More importantly, this study showed that replacing some bay bottom with marsh would provide a significant net-positive impact upon the environment of Galveston Bay.

12.c. USFWS Study - An Analysis of the Advisability and Need of Creating New Colonial Waterbird Nesting Islands in Galveston Bay, Texas, P. Glass, 1994. Study results showed that a new nesting island could benefit desirable waterbird species in Galveston Bay if placed in an optimal location (Site 5 of the BUG Plan). This study also recommended that a continuing and adequately funded management and protection program must be instituted in conjunction with any structural measures to plan and coordinate necessary maintenance, management, and protection measures.

12.d. Demonstration Marsh. The PHA and the Corps constructed a Demonstration Marsh, approximately 220 acres in size, to identify key engineering and environmental design parameters and management requirements most critical for the establishment, growth and long-term survival of created marsh. Monitoring of construction as well as levee protection, development of a planting plan, and incorporation of bioengineering parameters developed from the NMFS study are presently ongoing.

In addition to providing key engineering and environmental design parameters, a joint-decision making process (formal pre-construction meeting) was developed and executed involving the Corps, the PHA, the dredging contractor and the BUG. This process proved to be successful in defining mutually-agreed upon goals and lines of communication.

12.e. Galveston Bay National Estuary Program Oyster Maps for Galveston Bay. For the 1992 BUG Report, the BUG utilized TPWD 1979 maps to delineate oyster reef locations within Galveston Bay. Subsequent to that report, GBNEP published the results of the recent oyster reef mapping effort by Dr. Powell. Reef and unconsolidated shell-on-mud complexes comprised a total of 36.8 square miles of the surveyed bay area (including West Bay, East Bay, Trinity Bay, and Galveston Bay).

The results of this mapping effort led the BUG to perform a survey of existing oyster reef at the Dollar Point marsh site. Results of the survey showed that significant reef would be impacted by the proposed 1992 site configuration. In addition to oyster reef impacts, presently proposed shoreline development also posed a conflict with the Dollar Point Marsh site. Therefore, due to the BUG's stated objective that existing productive habitat would not be sacrificed to create new habitat, the Dollar Point site was dropped from further consideration and the new work and maintenance dredged material re-directed to the Bolivar and Mid-Bay marsh sites.

12.f NMFS Interim Report: Development of Design Criteria and Parameters for Constructing Ecologically Functional Equivalent Marshes in Galveston Bay, Texas, L.P. Rozas, R.J. Zimmerman, T.J. Baumer, M. Pattillo, R. Burditt, 1994. This study, by identifying the predominant habitats and quantifying the use of these habitats by fishery species, provided the baseline information necessary to develop design parameters for constructing ecologically functional marshes in upper Galveston Bay. Furthermore, the study provides a potential baseline against which the constructed marshes in upper Galveston Bay can be measured to judge how successfully the habitat features were incorporated.

12.g. Three Dimensional Hydrodynamics Model, Houston - Galveston Navigation Channels, Texas. U.S. Army Corps of Engineers Waterways Experiment Station (WES), 1994. The objectives of the study are: (1) Develop an accurate, verified three-dimensional hydrodynamic and salinity model of Galveston Bay for the conditions existing in the second half of 1990; (2) Using this model, to evaluate the effects of proposed bathymetry changes due to the widening and deepening on circulation and salinity within the bay; (3) To evaluate the cumulative effects of future changes in freshwater inflow together with the deepened bathymetry; and (4) To provide the output from these model runs as input to a comprehensive model for evaluating oyster population response to the changed conditions modeled.

In addition to modeling changes for circulation and salinity due to channel widening and deepening, the WES 3-D Hydrodynamic & Salinity Model has been used to measure the impact to circulation and salinity from the construction of beneficial use sites within the bay. The BUG submitted a list of eighteen (18) potential beneficial use sites considered for Galveston Bay. This list included the acreage and location for each site (approximately 8,000 acres total).

As noted in the 1992 BUG Report, the existing HSC dimensions were used for the two model runs. The total area of emergent marsh for the 18 alternative sites equaled 8,000 acres for the two initial model runs. In contrast, the current BUG Plan, proposed for the 45' x 530' project, comprises approximately 4,250 acres of emergent marsh. Presently, WES is performing a model run for evaluation of circulation and salinity impacts for the current Beneficial Use Plan (Exhibit 3). As discussed above, given the reduction in total plan area from 8,000 acres to 4,250 acres, the current BUG Plan is expected to have no significant impact upon circulation or salinity.

12.h. Trends and Status of Wetland and Aquatic Habitats in the Galveston Bay System, Texas. W.A. White, T.A. Tremblay, E.G. Wermund, Jr., Bureau of Economic Geology, The University of Texas at Austin. L.R. Handley, National Wetlands Research Center, USFWS. April 1993. Wetland and aquatic habitats are essential biological components of the Galveston Bay Estuarine System. Understanding the spatial and temporal distribution of these habitats is critical if they are to be effectively protected, restored, and managed. This report presented the results of an intensive investigation to determine the trends and status of wetland and aquatic habitats in the Galveston Bay system.

The area of mapped emergent wetlands (marshes) decreased from about 165,000 acres in the 1950's to about 130,400 acres in 1989, producing a total net marsh loss of approximately 35,100 acres, or 21% of the 1950's resource.

The causes of wetland loss include human-induced subsidence and relative sea level rise, and drainage and filling of wetlands for agricultural, transportational, industrial, residential, and commercial purposes. Major losses in estuarine emergent marshes (salt and brackish) occurred as they were converted to open water and barren flats. Conversion of emergent marshes to open water accounted for about 30% of the total loss.

In the State of the Bay Report, the Galveston Bay National Estuary Program (GBNEP) indicated that habitat loss is a priority problem. Specifically, GBNEP estimates a net loss of 33,400 acres of wetlands over the last 40 years - primarily due to man's activities. GBNEP's proposed Comprehensive Conservation and Management Plan (CCMP) recommends the creation or restoration of 8,600 acres of estuarine emergent marsh over the next 10 years.

The BUG Plan provides for approximately 1,910 acres of marsh creation in the first twenty years of the 45' x 530' Project, approximately 20% of the CCMP objective. Overall, the 45' x 530' BUG Plan provides for approximately 50% of the total acreage recommended by the CCMP for Galveston Bay at the completion of the project life.

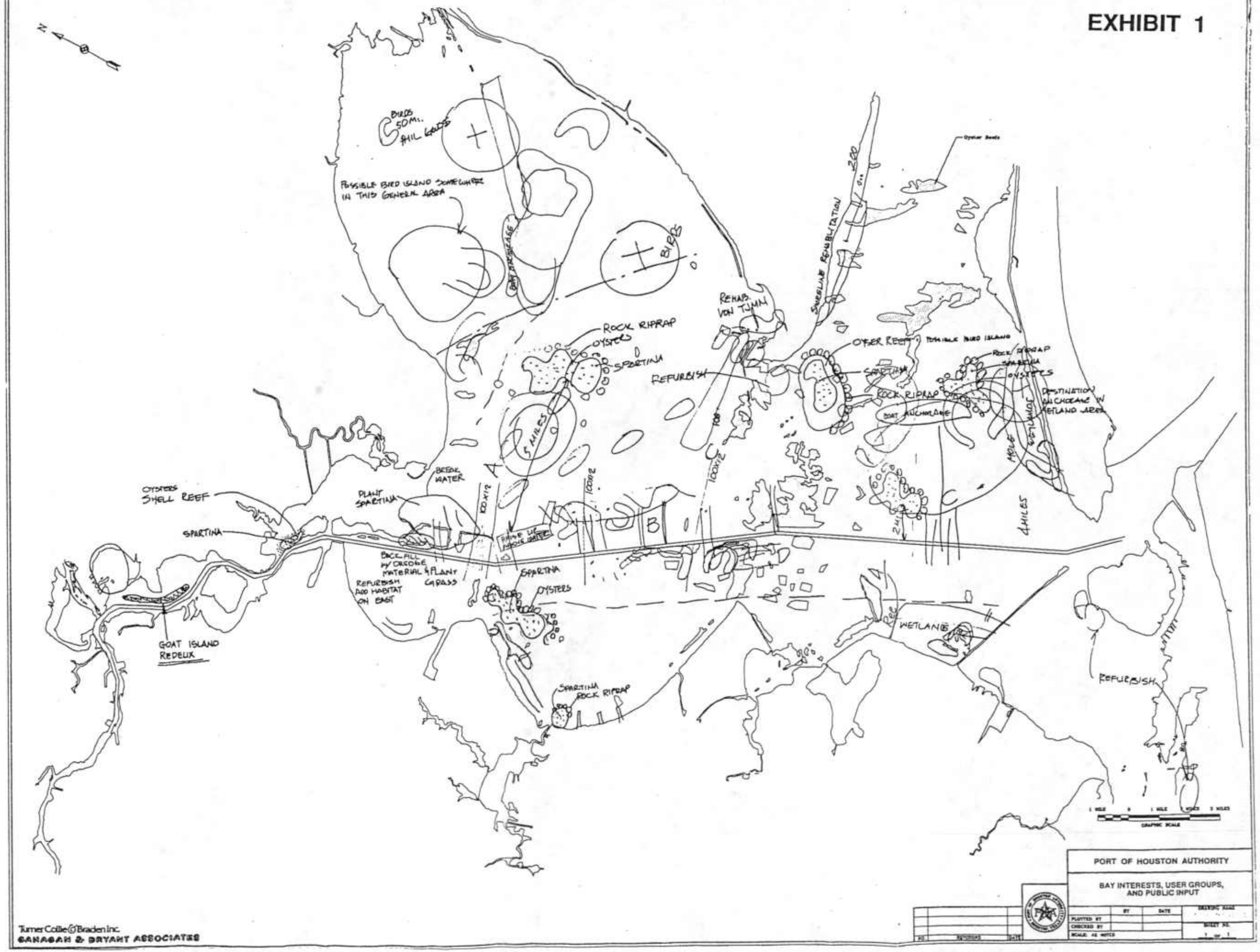
12.i. ICT Contaminant Subcommittee - Testing for Potential Contaminants of Maintenance Dredged Material for the Houston-Galveston Navigation Project, 1994. The contaminant subcommittee has evaluated the contaminant potential of maintenance material from the HSC for the bayou, bay, and entrance reaches of the HSC. Testing was performed on maintenance material from the existing project.

Based on evaluation of results from a variety of methodologies for contaminant testing, the contaminant subcommittee concluded that there are no contaminant concerns related to dredging and beneficial uses of maintenance dredged material for the bay and entrance reaches of the HSC. The maintenance dredged material for the bayou reach of the HSC has been approved for disposal to upland confined sites.

In addition to providing these conclusions, the contaminant subcommittee provided the ICT with recommendations for the bayou, bay, and entrance reaches of the HSC. A common theme of the recommendations for both the bay and entrance reaches of the HSC was that maintenance dredged material proposed for beneficial uses should be evaluated for compliance again at the time the material is proposed for disposal.

EXHIBITS

EXHIBIT 1



PORT OF HOUSTON AUTHORITY

BAY INTERESTS, USER GROUPS, AND PUBLIC INPUT

	BY	DATE
PLOTTED BY		
CHECKED BY		
SCALE: AS NOTED		

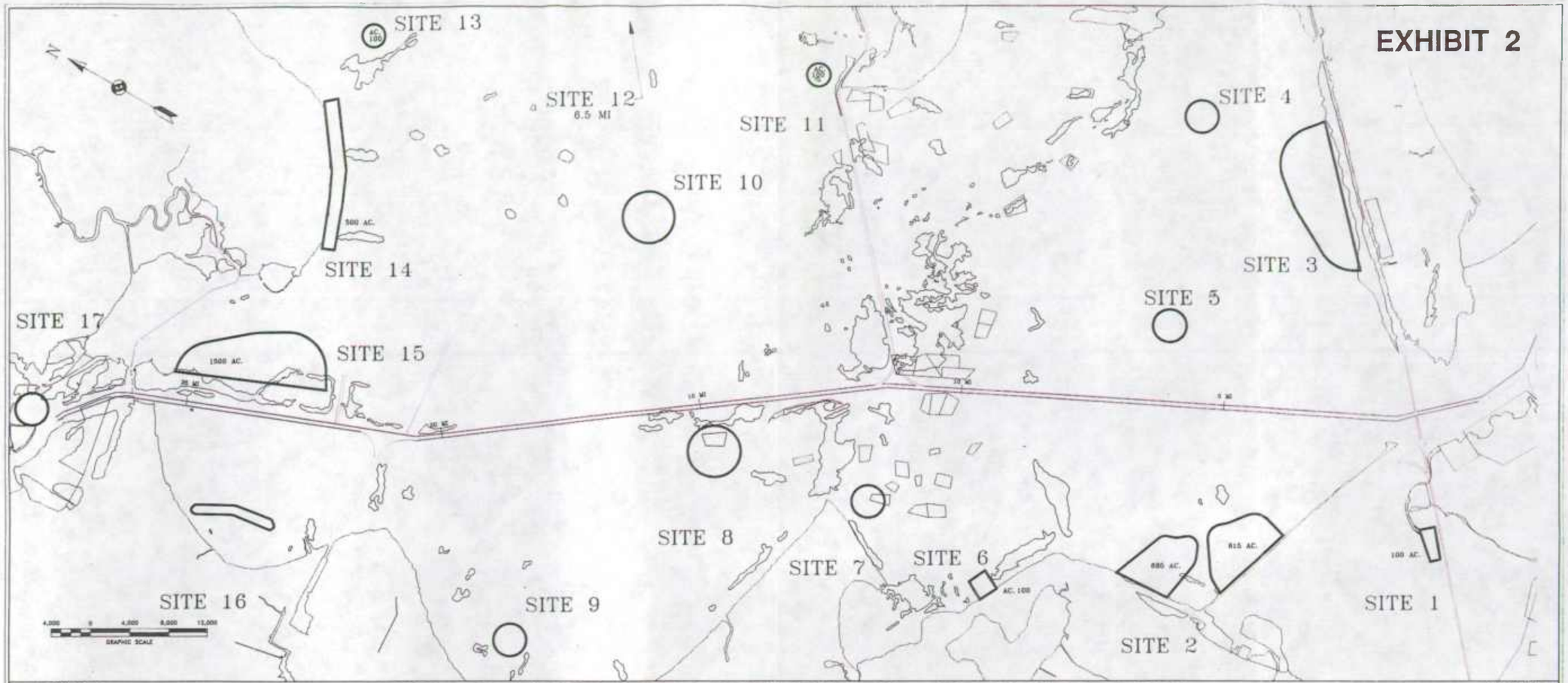
DRAWING NAME

SHEET NO. 1 OF 1

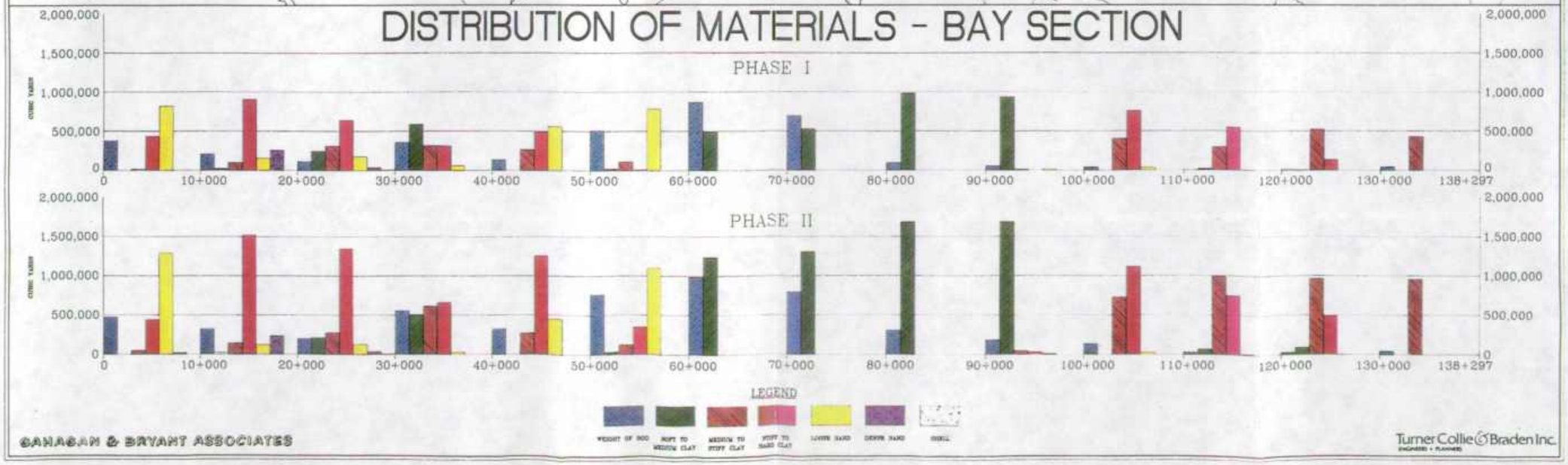
NO. REVISIONS DATE

Turner Collie & Braden Inc.
GANAGAN & BRYANT ASSOCIATES

EXHIBIT 2



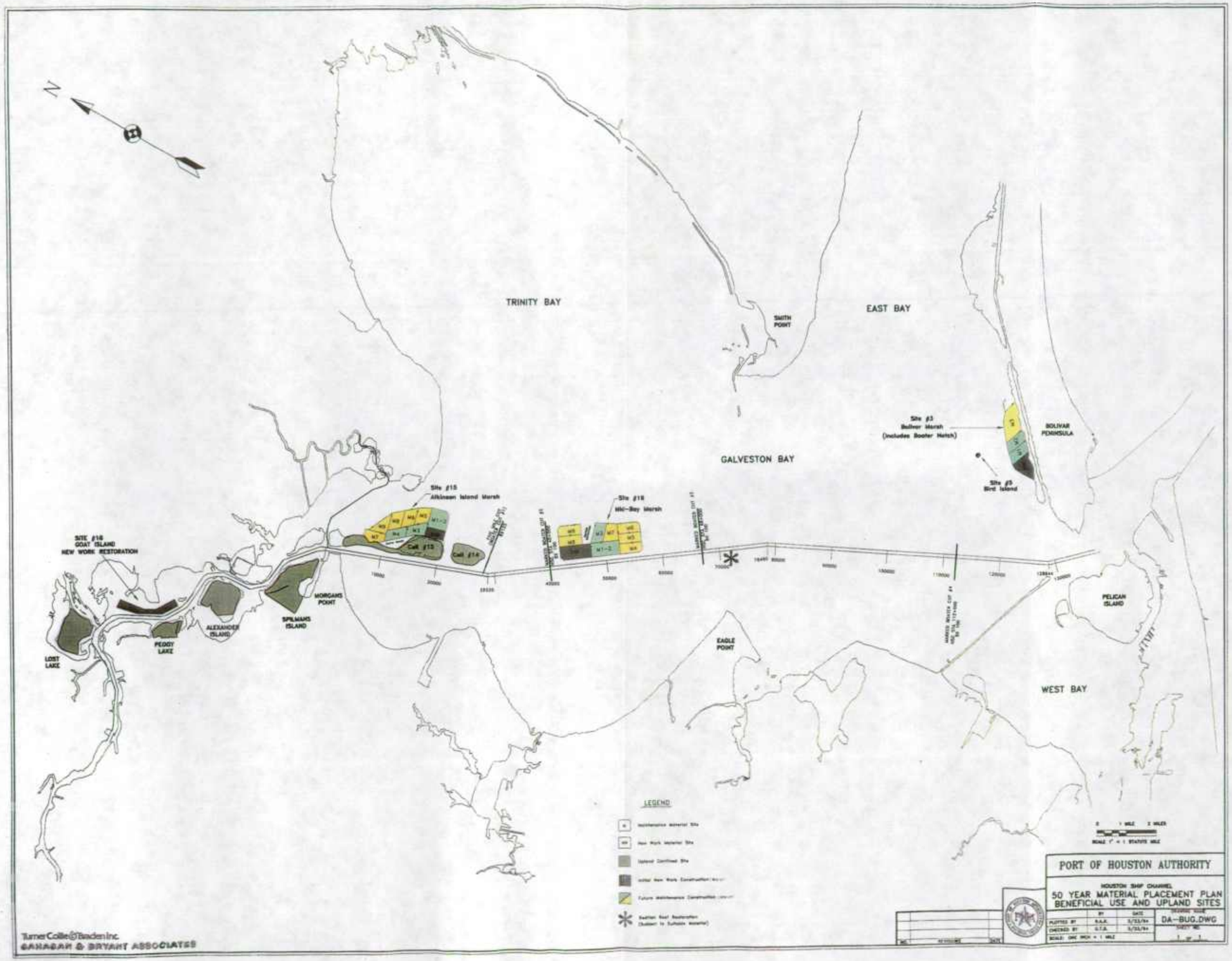
DISTRIBUTION OF MATERIALS - BAY SECTION



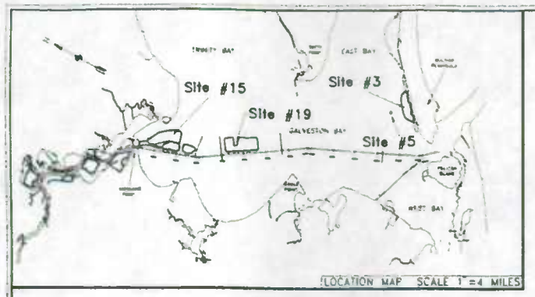
CANAGAN & BRYANT ASSOCIATES

Turner Collie & Braden Inc.
ENGINEERS + PLANNERS

EXHIBIT 3

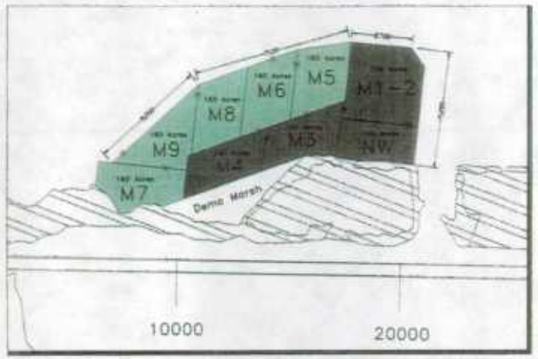

N
TRINITY BAY
SMITH POINT
EAST BAY
GALVESTON BAY
Site #3
Bolivar Marsh
(includes Booter Hatch)
BOLIVAR PENINSULA
Site #5
Bird Island
Site #15
Atkinson Island Marsh
Site #18
Mid-Bay Marsh
SITE #16
GOAT ISLAND
NEW WORK RESTORATION
MORGANS POINT
SPILMANS ISLAND
ALEXANDER ISLAND
PEGGY LAKE
LOST LAKE
EAGLE POINT
PELICAN ISLAND
WEST BAY
LEGEND
PORT OF HOUSTON AUTHORITY
HOUSTON SHIP CHANNEL
50 YEAR MATERIAL PLACEMENT PLAN
BENEFICIAL USE AND UPLAND SITES
DA-BUG.DWG
Turner Collie & Braden Inc.
CAMARGO & BRYANT ASSOCIATES

EXHIBT 4



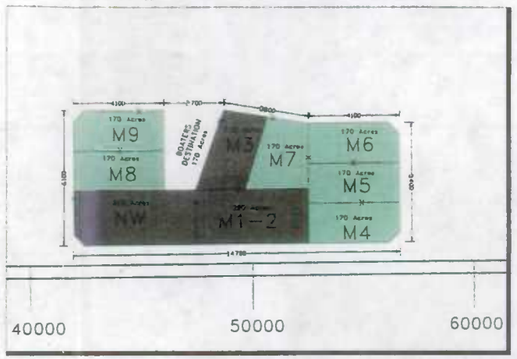
HOUSTON SHIP CHANNEL
BENEFICIAL USE PLAN

SITE #15 ATKINSON MARSH



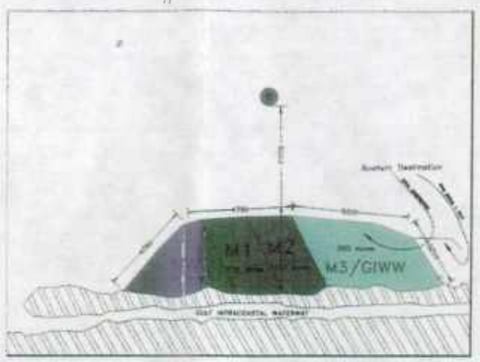
Initial Construction – 730 Acres
Future Construction – 800 Acres
Total – 1,530 Acres

SITE #19 MID-BAY MARSH

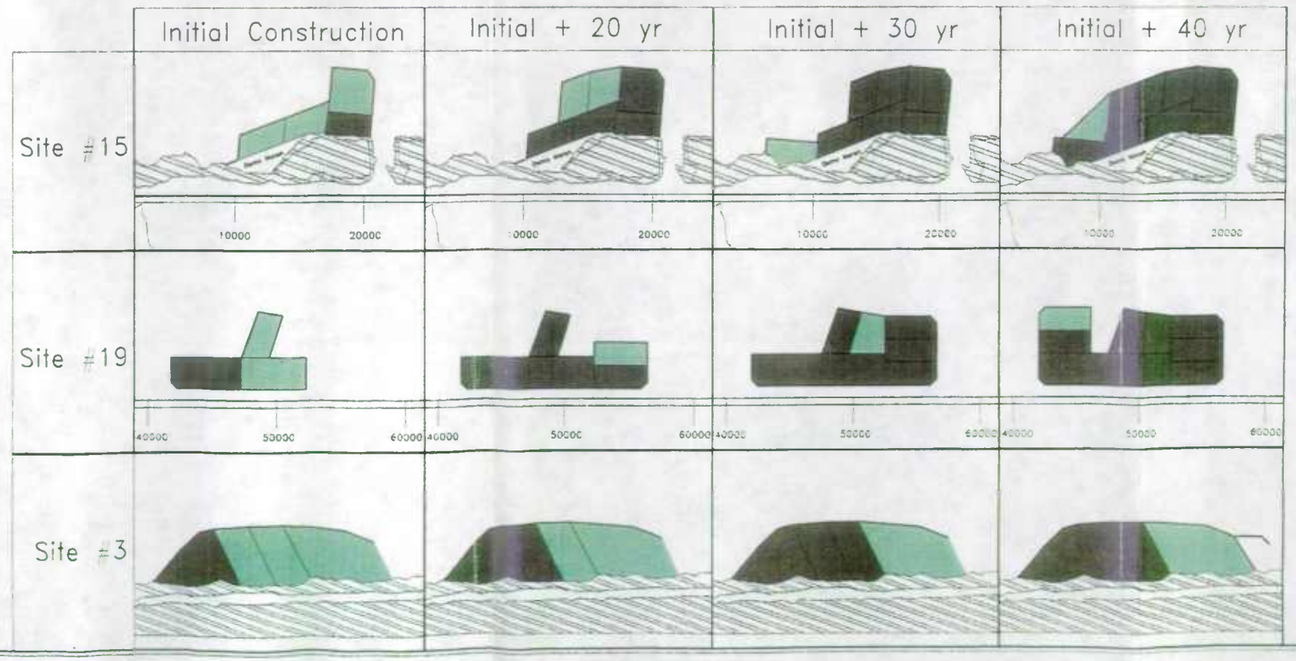


Initial Construction – 770 Acres
Future Construction – 1,020 Acres
Total – 1,790 Acres

SITE #3 BOLIVAR MARSH
SITE #5 BIRD ISLAND



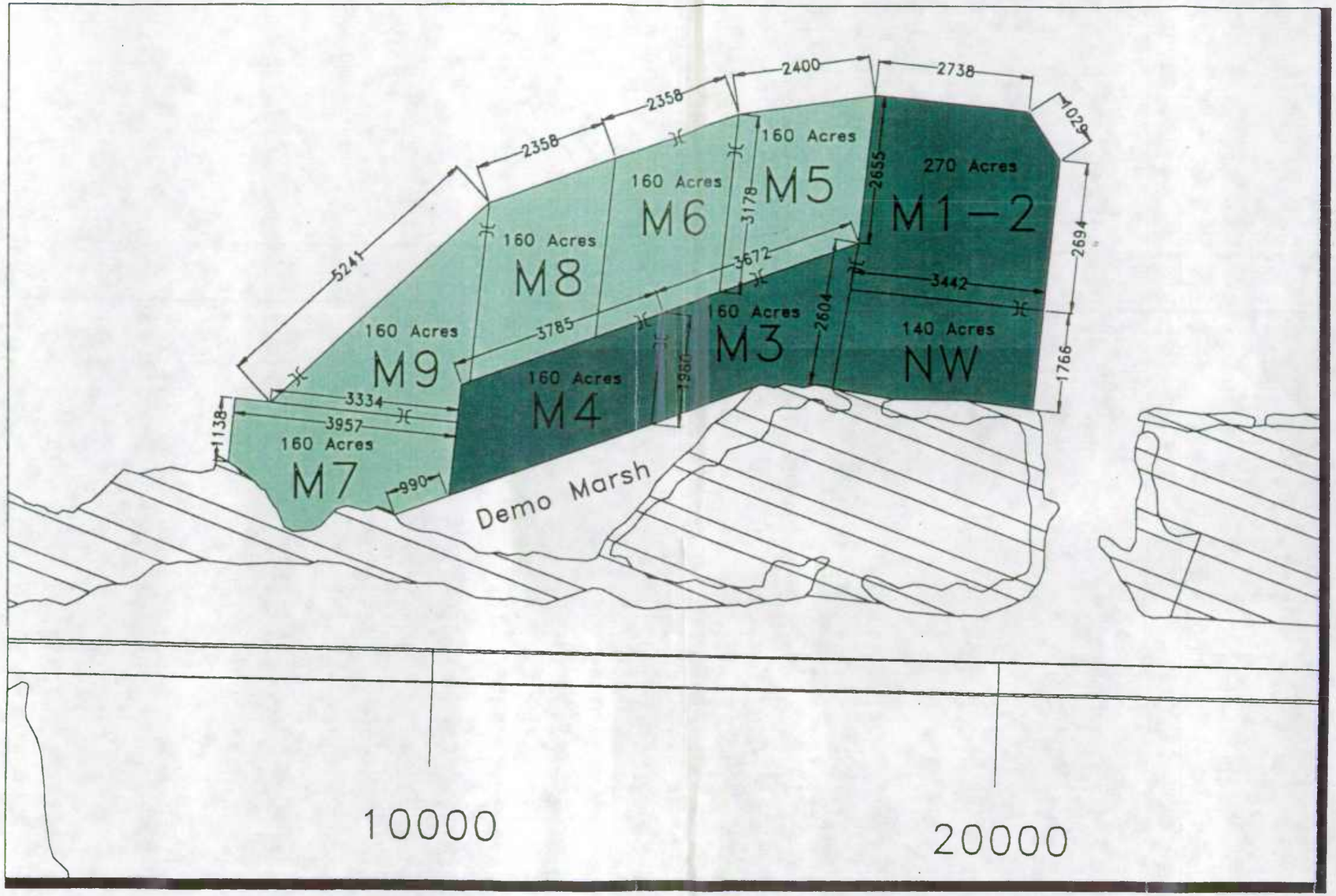
Initial Construction – 580 Acres
Future Construction – 350 Acres
Total – 930 Acres



Turner Collie & Braden Inc.
CAHAGAN & BRYANT ASSOCIATES

SITE #15 ATKINSON MARSH

EXHIBIT 5

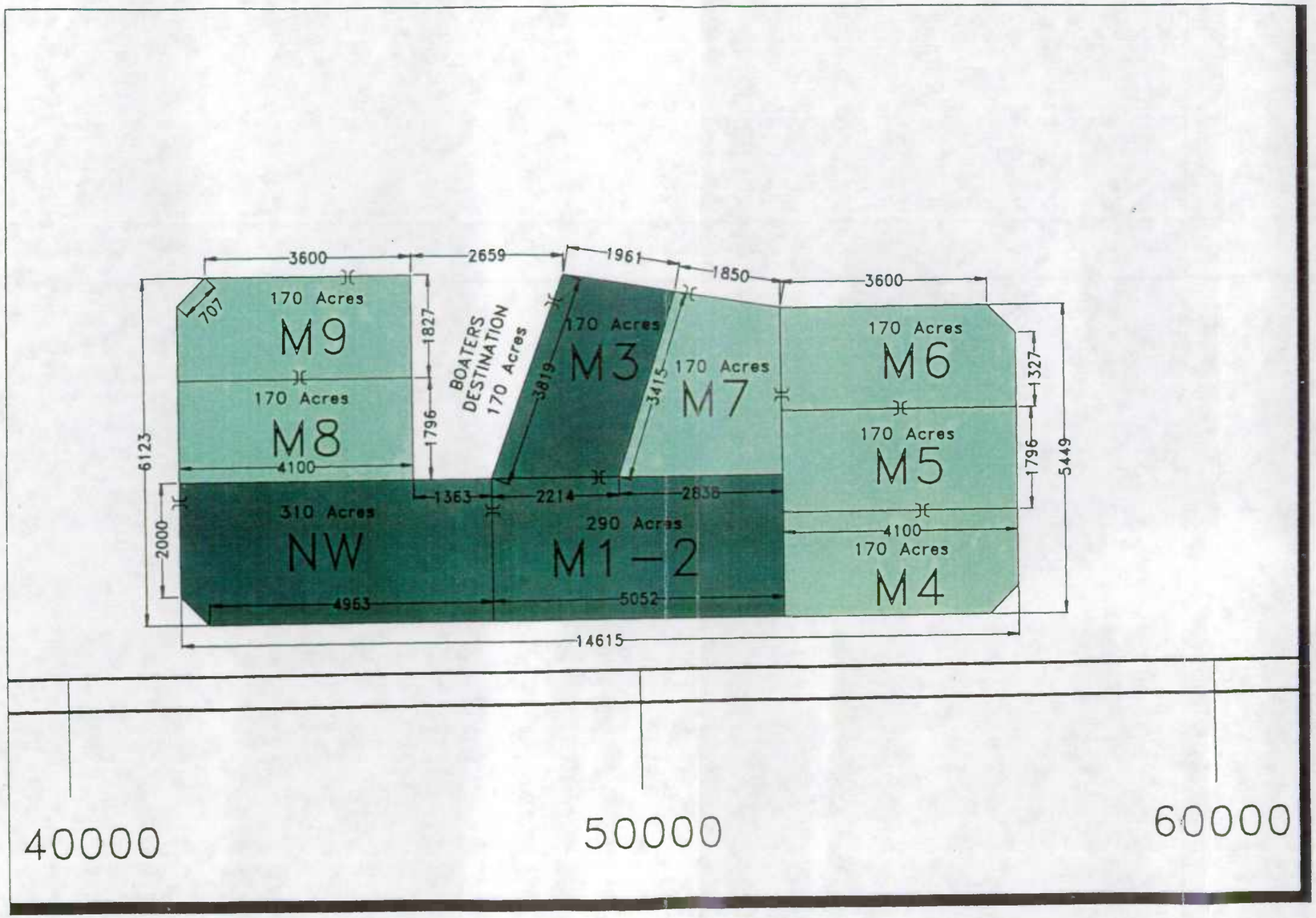


Initial Construction – 730 Acres
Future Construction – 800 Acres

Total – 1,530 Acres

EXHIBIT 6

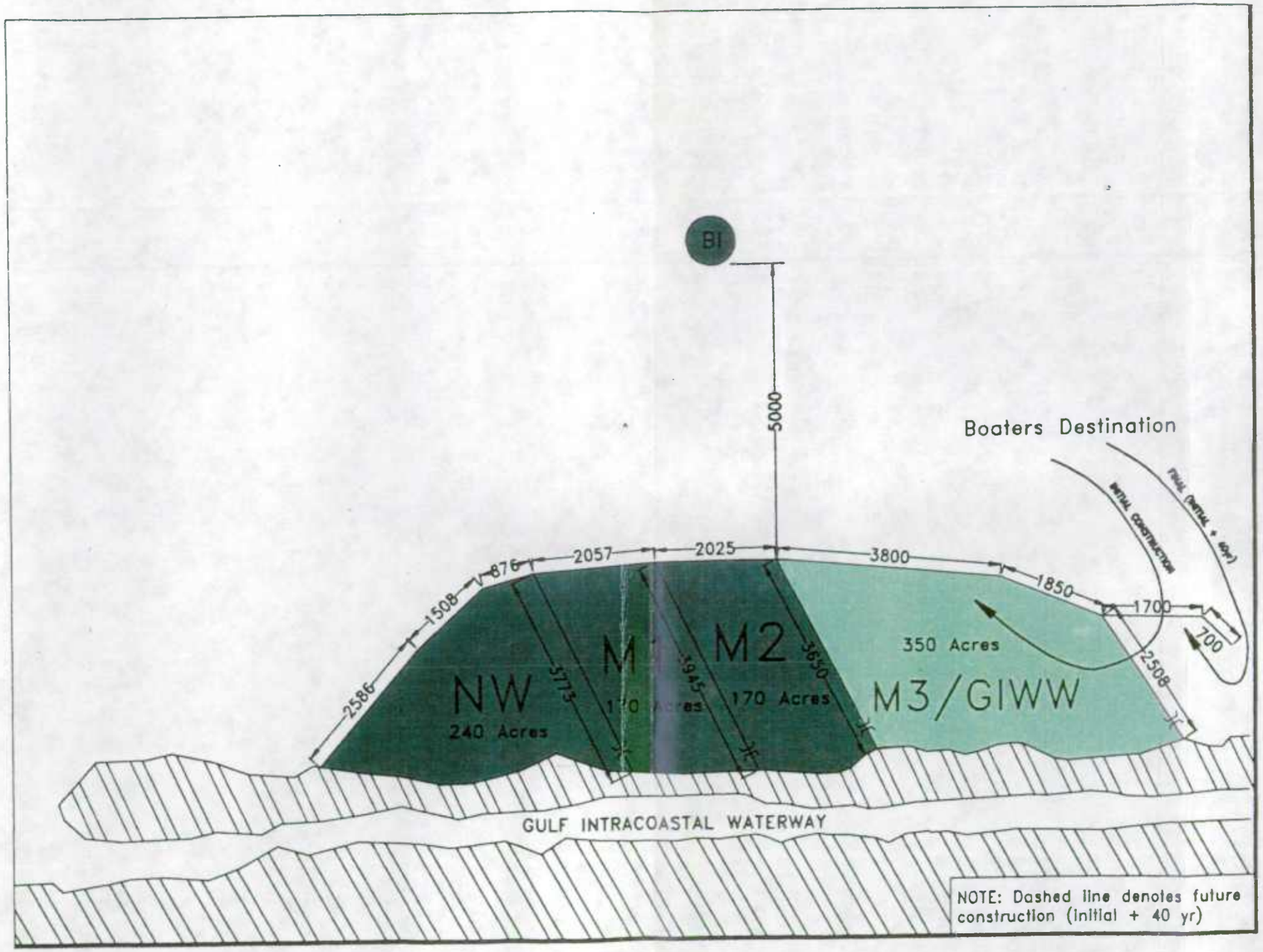
SITE #19 MID-BAY MARSH



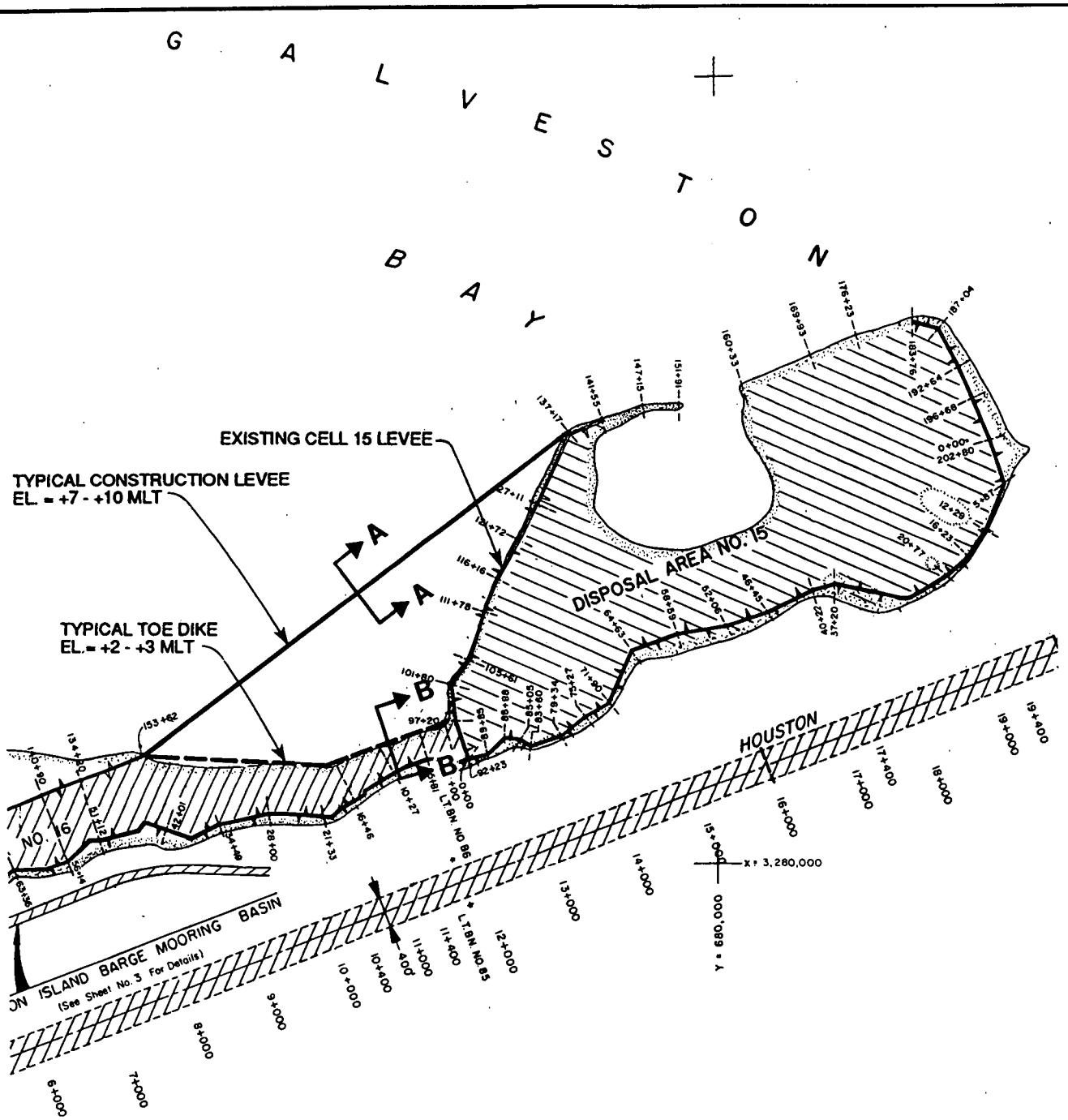
Initial Construction – 770 Acres
Future Construction – 1,020 Acres
Total – 1,790 Acres

SITE #3 BOLIVAR MARSH
SITE #5 BIRD ISLAND

EXHIBIT 7



Initial Construction – 580 Acres
Future Construction – 350 Acres
Total – 930 Acres



PURPOSE : MAINTENANCE DISPOSAL / DEMONSTRATION MARSH CREATION

DATUM : USACE
MEAN LOW TIDE (MLT)

MAP SOURCE : USACE, 1989

LOCATION OF PROPOSED ACTIVITIES

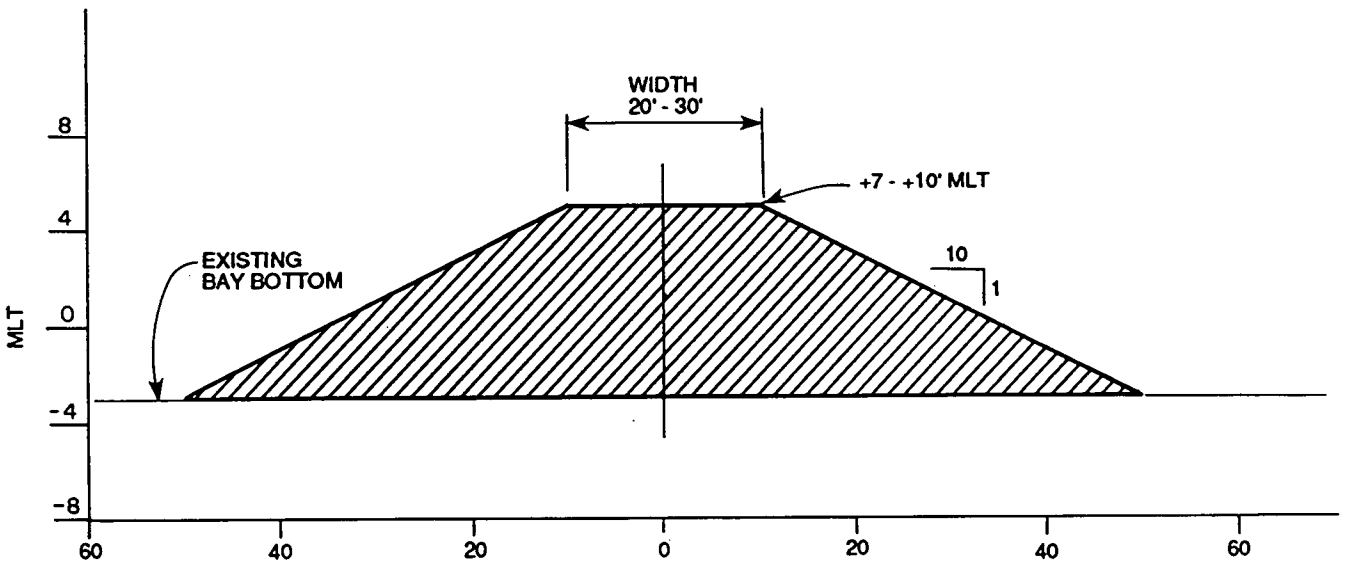
PROPOSED AND EXISTING CONSTRUCTION LEVEE AREAS

CONSTRUCTION OF DEMONSTRATION MARSH
DISPOSAL AREA 15
UPPER GALVESTON BAY, TEXAS
APPLICATION BY :
PORT OF HOUSTON AUTHORITY

DATE : OCTOBER 1992

EXHIBIT 8

Exhibit 9 Typical Containment Levee Cross-Section

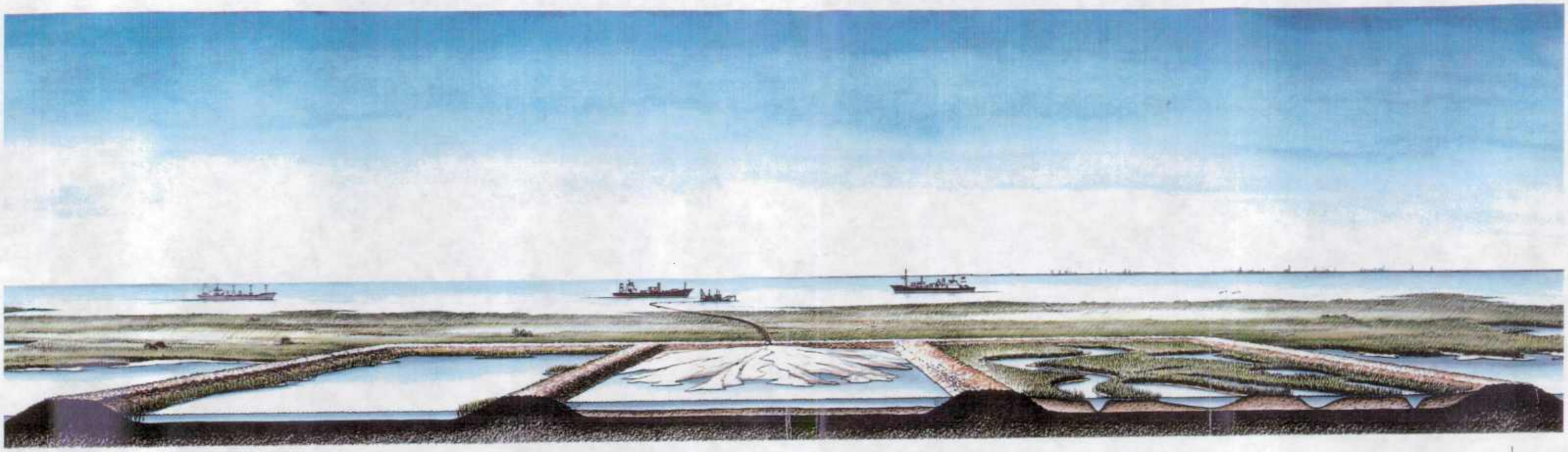


A - A

TYPICAL CONSTRUCTED LEVEE

SCALE : 1" = 20' (Horiz.)
1" = 8' (Vert.)

EXHIBIT 10

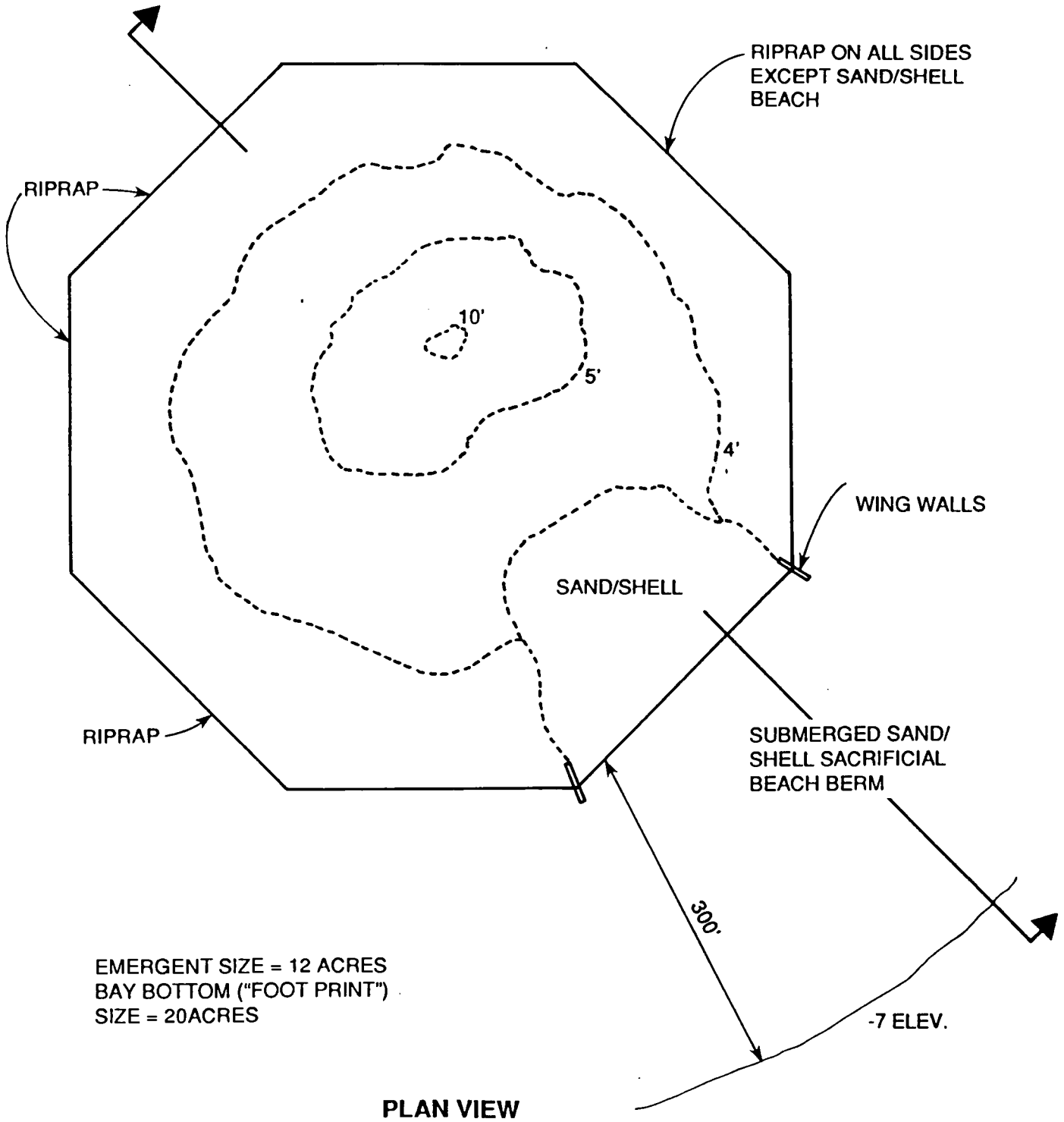


STAGE 1
LEVEE / OPEN WATER
1-7 YEARS

STAGE 2
LEVEE / FILL PLACEMENT
18-24 MONTHS

STAGE 3
LEVEE / CREATED MARSH
CONSTRUCTION COMPLETED
MONITORING AND MAINTENANCE IMPLEMENTED

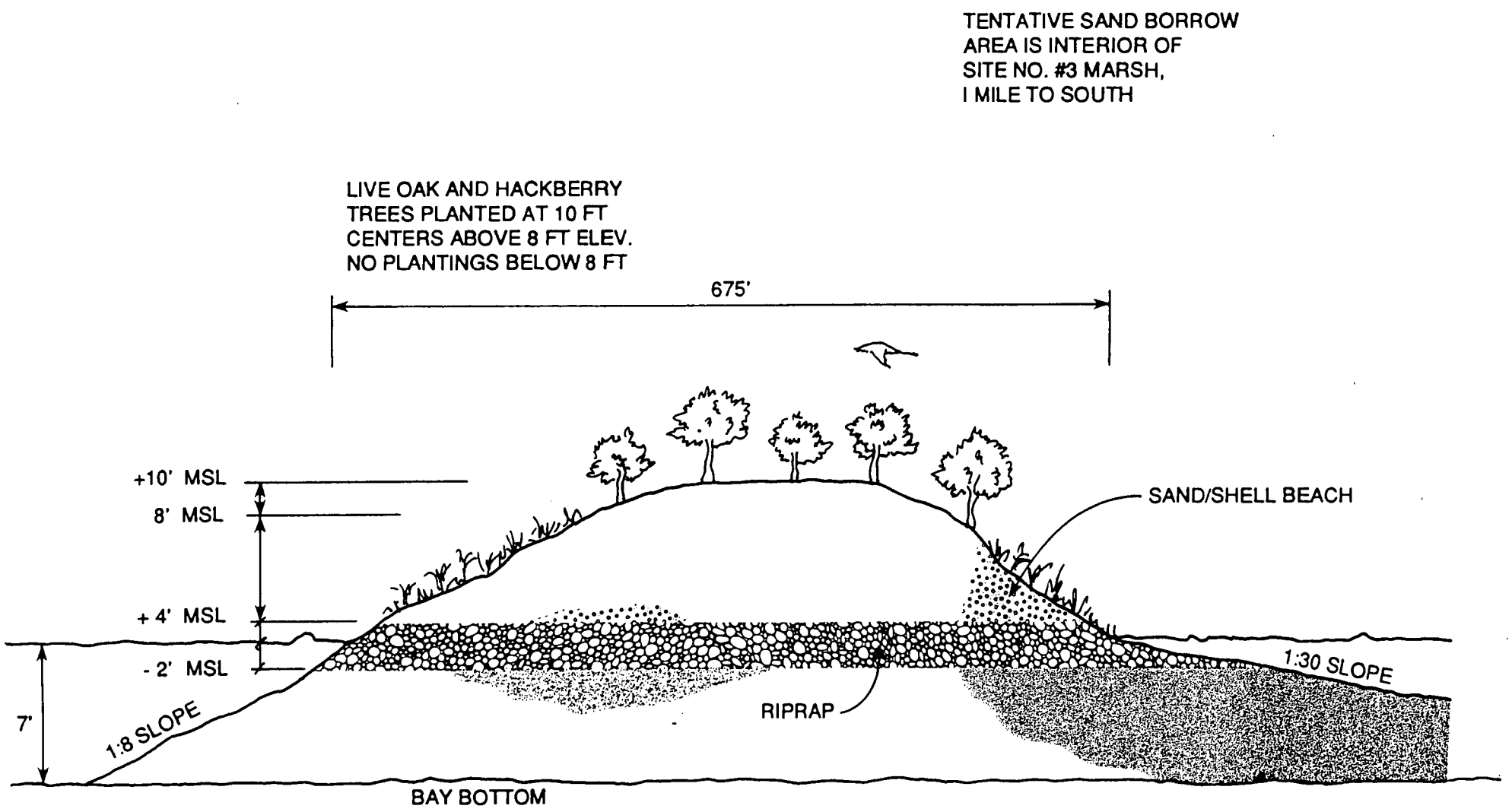
Exhibit 11 Bird Rookery Island Revised Plan



EMERGENT SIZE = 12 ACRES
BAY BOTTOM ("FOOT PRINT")
SIZE = 20ACRES

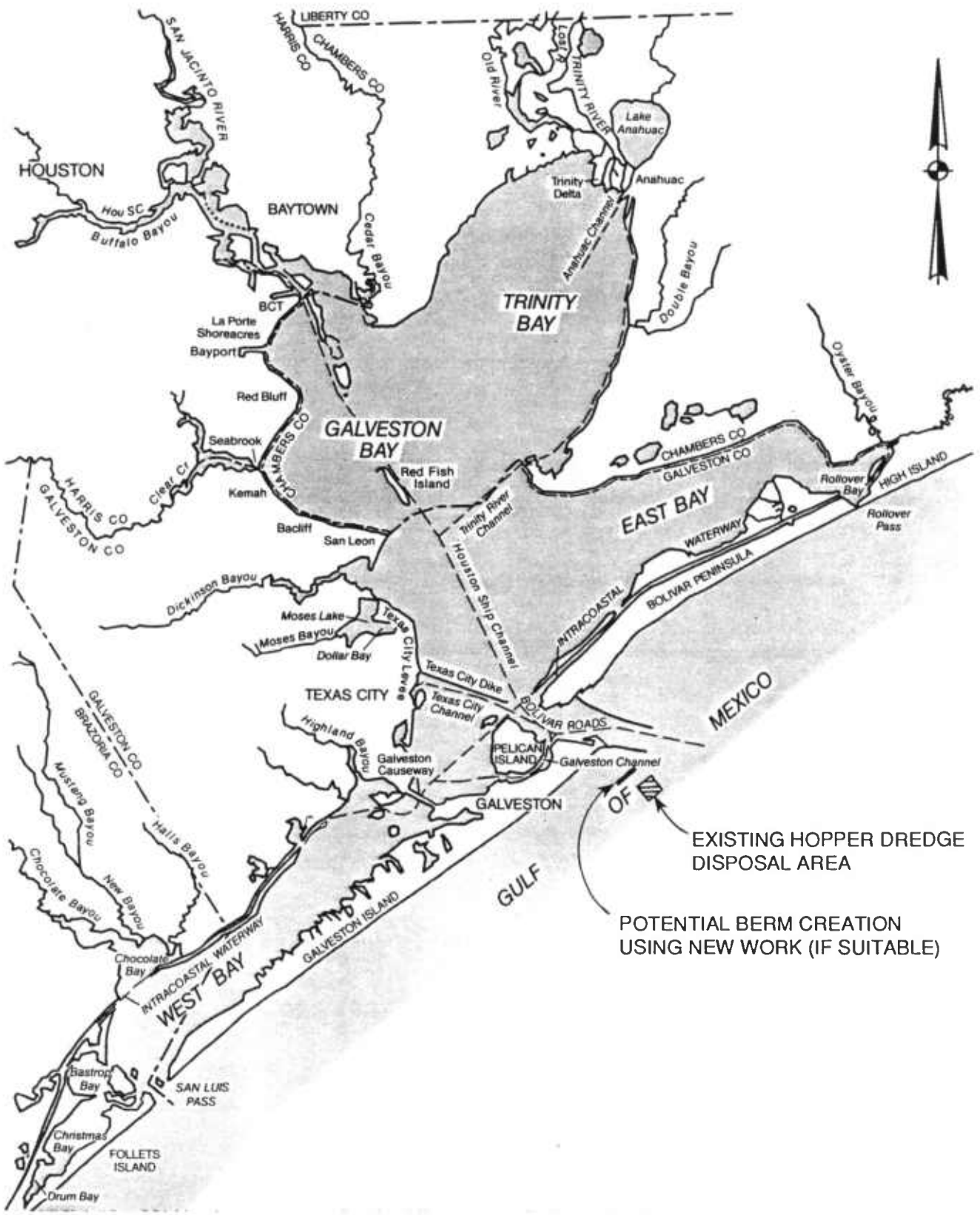
PLAN VIEW

Exhibit 12 Cross Section, Bird Rookery Island Revised Plan



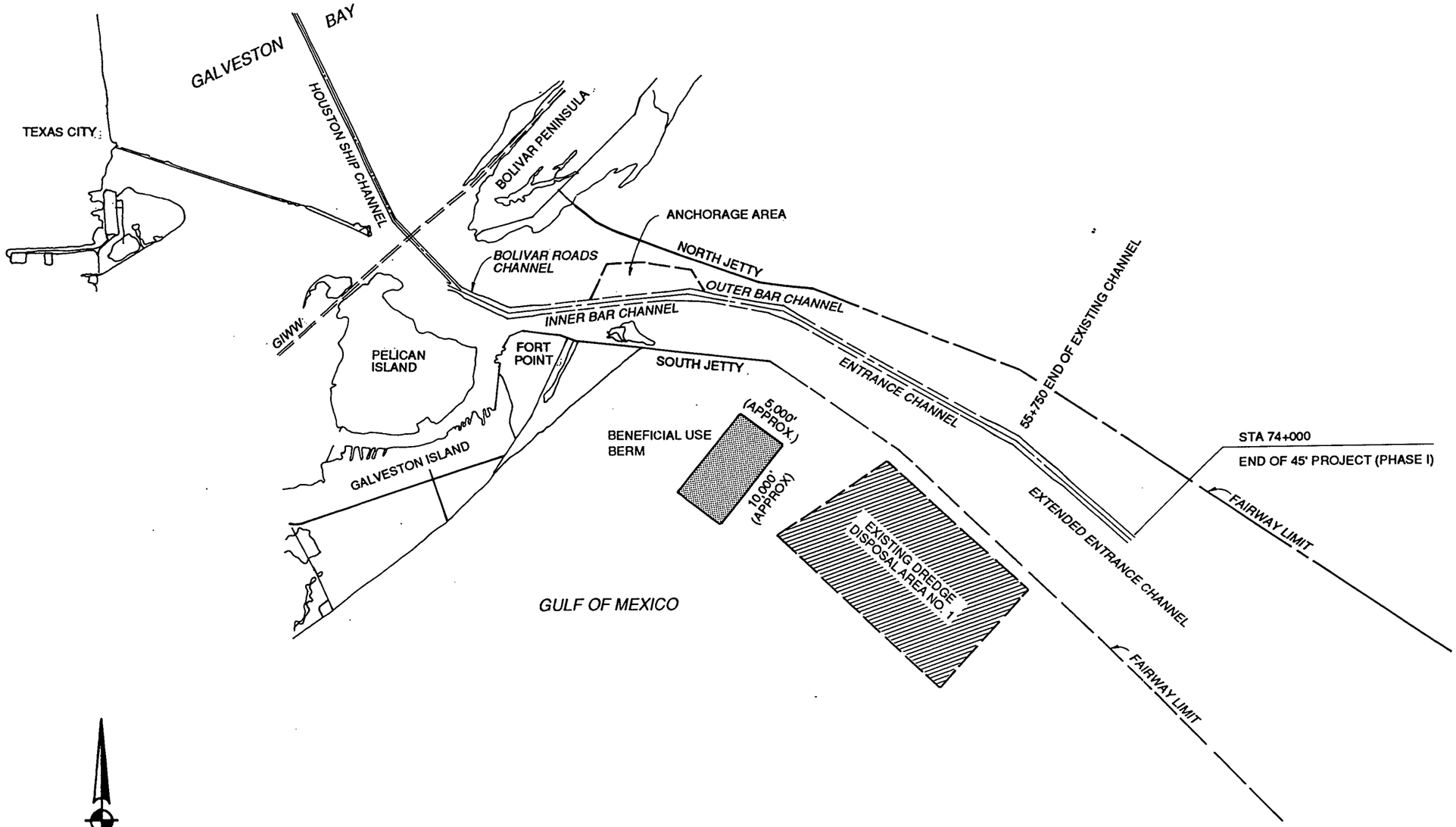
SECTION VIEW

Exhibit 13 Beneficial Use Plan - Entrance Reach



BENEFICIAL USES PLAN - ENTRANCE REACH

EXHIBIT 14



0 11,000

SCALE IN FEET
(APPROXIMATE)

LEGEND

EXISTING CHANNEL

PROPOSED CHANNEL

TYPICAL BERM CROSS-SECTION