U.S. Army Corps
of Engineers
Galveston District

Engineering Appendix
Houston-Galveston Navigation Channels, Texas
Galveston Harbor Channel Extension
Post Authorization Change Report

U.S. Army Corps of Engineers
Southwestern Division
Galveston District
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REFERENCES

1 Houston-Galveston Navigation Channels, Texas Limited Reevaluation Report and Final Supplemental Environmental Impact Statement, November 1995 (1995 LRR)

2 Houston-Galveston Navigation Channels, Texas Galveston Channel Project Final Limited Reevaluation Report, May 31,2007 (2007 LRR)

GALVESTON HARBOR CHANNEL EXTENSION

1.0 GENERAL

Engineering studies for the Galveston Harbor Channel (GHC) Extension included: preliminary geotechnical investigations (sampling and laboratory analysis); preparation of a preliminary dredged material management plan (DMMP); beneficial use concept studies; in-house hydrographic surveys of the channel; and land surveys. Other engineering and design features considered include surveying and mapping, environmental quality features, civil design, geotechnical design, structural design, access roads, operations and maintenance (O&M), cost estimates, data management and schedules for design and construction. Preliminary alternative designs and screening level cost estimates were developed in sufficient detail to substantiate the recommended plan and baseline cost estimate.

The Design Team assisted the Planning and Environmental Leads during the Plan Formulation process. Refer to the Post Authorization Change Report (PACR) for detailed discussion/analyses not covered here. This includes Planning Objectives, Preliminary Plan Formulation, including the No-Action Alternative and Structural Alternatives consisting of navigation channel improvements.

Preliminary Plan Formulation Phase – Several different channel depths (42, 43, 44, and 45-feet) were evaluated during initial plan formulation. The width considered for each depth alternative was kept constant at 1,075 feet and matches the new 45-foot channel.

Plan Formulation Phase – Alternatives Advanced for Further Screening:

1) No-Action Alternative;
2) 42-foot and 45-foot channel depth alternatives;
3) Alternatives for the Management of Dredged Material
   The following types of placement areas were evaluated:
   - Marsh creation
   - Existing Pelican Island Upland confined placement area (PA)
   - Proposed 81.76-acre Pelican Island Upland confined PA.

The considered plan alternatives are discussed in detail in this Appendix and the PACR.

1.1 Project Description

The study produced a National Economic Development (NED) Plan consisting of extending the 45-foot GHC to match the currently authorized 40-foot deep channel length resulting in a 2,571 foot extension of the new 45-foot channel. The plan includes keeping the width of the channel extension equal to the new 45-foot channel at 1,075 feet. The NED Plan includes using the existing Pelican Island upland confined PA for containment of the resulting dredged new work materials from the channel deepening and the future dredged maintenance material for the 50-year period of analysis.

2.0 CIVIL ENGINEERING

The plan of improvement described in this document pertains to the Galveston Harbor Channel, Texas. A study area map and pertinent channel design information are shown on Drawing Nos. C-0 through C-05 attached to this appendix.

2.1 Galveston Channels

The Galveston portion of the Houston-Galveston Navigation Channels, Texas Project (HGNC) consists of a series of channels as shown in Table 1.

TABLE 1 - CURRENTLY AUTHORIZED GALVESTON CHANNELS

Reach	Station	to	Station	Nominal Bottom Width (feet)	Authorized Project Depth (feet-MLT)	Channel Depth (feet-MLT)	Allowable Overdepth (feet)	Advanced Maintenance (included in Channel Depth)
Galveston Entrance Channel (aka Offshore Reach)								
Extended Entrance Channel	55+840		76+000	800	-47*	-49	2	2
Entrance Channel	30+515		55+840	800	-47*	-49	3	2
Outer Bar Channel	21+753		30+515	800	-47*	-49	2	2
Inner Bar Channel	4+490		21+753	800	-45	-47	1	2
Bolivar Roads Channel	0+000		4+490	800	-45	-47	1	2
Galveston Channel								
Galveston Harbor Channel	0+000		20+000	Varies	-45	-48	2	3
Galveston Harbor Channel	20+000		22+571	1085	-40	-43	2	3

*Note: Depths are increased 2 feet to allow for wave motion (pitch) in the entrance channel reaches.

2.2 Galveston Harbor Channel

The GHC is subdivided into two reaches: Station 0+000 to Station 20+000, and Station 20+000 to Station 22+571. The existing 45-foot deep GHC reach, part of the HGNC, intersects the Inner Bar Channel at Station 0+000, and extends to about Pier 38 at Station 20+000. The current 40-foot GHC reach extends from Station 20+000 to about 43rd Street at Station 22+571. The Extended Entrance, Entrance, Outer and Inner Bar Channels have been deepened to their new depths through the previous Houston-Galveston 45-foot Widening and Deepening Project for the Houston Ship Channel (HSC). Refer to Drawing C-01 for a plan view of the GHC.

The recently completed 45-foot GHC has a bottom width that varies from about 650 feet to 1,133 feet between Station 1+400 and Station 20+000. A widened transition begins at Station 1+400 and ends with the connection to the HGNC Bolivar Roads Channel. The 45-foot GHC footprint does not include the entire authorized 40-foot GHC footprint;

therefore, those sections of the 40-foot channel footprint that lie outside the 45-foot channel will continue to be maintained as per the HGNC authorization. Within the proposed GHC Extension reach the proposed 45-foot channel footprint supersedes the 40-foot depth footprint, and thus the 40-foot channel will not be maintained after construction of the proposed 45-ft channel. Drawing C-05 shows the authorized existing 40' channel footprint, the existing 45-foot channel, and the proposed 45-foot extension footprint. The proposed 45-foot extension, beginning at Station 20+000 and ending at Station 22+571, has a design width of 1,075 feet, matching the width of the newly constructed 45-foot GHC at Station 20+000.

2.3 Site Selection and Project Development

The feasibility study consisted of a three phase system: Initial Plan Formulation, Plan Formulation, and Detail phase.

2.3.1 Preliminary Plan Formulation Phase

Preliminary Plan Formulation Phase considered channel depths of: 41, 42, 43, 44, and 45-feet. All alternative plans considered a 1,075-foot wide channel, thus matching the existing 45-foot deep GHC width. Refer to the PACR for complete descriptions of the alternative plans studied. Several dredged material disposal options were also considered, including the existing upland confined Pelican Island PA, a new upland confined PA on Pelican Island, and a new beneficial use site (marsh) located off the west end of Pelican Island.

2.3.2 Plan Formulation Phase

The Plan Formulation phase re-focused on the 42-foot through 45-foot depths. The proposed 1,075-ft channel width is the same as the new 45-foot channel. This bottom width will be 10 feet less than the existing 40-foot channel width. Placement alternatives considered in this phase included the existing Pelican Island PA and the marsh described above.

2.3.3 Detail Phase

The Detail Phase of this study produced the selected plan. The selected plan was identified as the 45-foot deep channel extending 2,571 feet from the end of the currently authorized 45-foot channel to the current 40-foot channel limits to the west. The new

work dredging will be placed in the existing Pelican Island PA. Refer to the Geotechnical Design section of this appendix for details.

2.3.3.1 Proposed Extension Channel

The proposed channel centerline alignment extends westward from Station 20+000 to the end of the existing 40-foot channel at Station 22+571. The channel side slopes will be 1V:3H and bottom width will be 1,075 feet. See Table 2 for a summary of the proposed channel dimensions and Drawing No. C-03 for the proposed channel cross section.

TABLE 2 - PROPOSED GALVESTON HARBOR CHANNEL

Reach	Station	to	Station	Nominal Bottom Width (feet)	Authorized Project Depth (feet-MLT)	Channel Depth (feet-MLT)	Allowable Overdepth (feet)	Advanced Maintenance (included in Channel Depth)
Existing Galveston Harbor Channel	0+000		20+000	Varies	-45	-48	2	3
Proposed Galveston Harbor Channel Extension	20+000		22+571	1075	-45	-48	2	3

2.4 Real Estate

No additional land will be required for the selected plan.

2.5 Relocations and Removals

Removals associated with the project include aids to navigation, structures, pipelines and utilities.

2.5.1 Relocations and Removals

During the Detail Phase, the latest pipeline crossing information was incorporated and re-analyzed for the selected depth. A total of three pipelines were identified none of which require relocation. However, two of the three identified pipelines are inactive and need to be removed and disposed of. The cost to remove the two inactive pipelines is a non-Federal project cost. It is the responsibility of the sponsor to coordinate with the pipeline owner for removal. Table 3 summarizes the pipeline data for the project.

TABLE 3 - GALVESTON HARBOR CHANNEL EXTENSION PIPELINE LIST

Approximate Station	Description	Owner	Permit No.	Relocate	Remove
21+400	24" Water Main, -72' MLT	City of Galveston	14114(05)809	No	No
21+500	12" Waterline, ± -50' MLT	Pelican Island Development Corps	3427	No	Yes
21+550	12" Sewer Line, ± -50' MLT	Pelican Island Development Corps	3427	No	Yes

2.5.2 Aids to Navigation

The GHC Extension, beyond the channel improvements, will not require changes to the navigation aids.

2.5.3 Structures

2.5.3.1 Berthing Dock Areas

Docks and berthing areas which will utilize the new project depth had dredging volumes calculated. Port facility information was obtained through facility owners, and the local sponsor.

2.5.3.2 Structure Stability Analyses

Information was received from Texas International Terminals facility, located on the south side and at the west end of the proposed GHC Extension indicating that this bulk materials handling facility would take advantage of the proposed deeper draft channel. Texas International Terminals plans to dredge their berthing area and will retrofit their existing bulkhead facility to accommodate the deeper draft. This retrofit is a third-party portside facilities associated project cost and has been accounted for in the economics portion of this study. Design drawings were received for the existing Sulphur Terminal dock facility located on the south side of the GHC Extension at approximately Station 22+000. This facility lies about 170 feet south of the proposed channel bottom alignment and consists of a concrete dock supported on square precast concrete piles driven to an elevation of about -100.66 feet mean low tide (MLT). Upon review of the provided structural drawings, it was determined that the structure will not be impacted by the channel deepening. A stability analysis of the existing Edison-Chouest bulkhead, located on the north side of the GHC at approximately Station 21+300, was performed using the

CWALSHT computer program developed by the U.S. Army Corps of Engineers (USACE) Waterways Experiment Station (WES) Information Technology Laboratory currently known as the Engineer Research and Development Center (ERDC). The bulkhead lies approximately 100 feet north of the proposed channel bottom alignment and handles predominantly light draft vessel traffic. The analysis indicated the existing bulkhead will not be affected by the channel deepening. It was determined that other water-front structures along this project will not be affected because of their distance from the channel template.

2.6 Maintenance Dredging Frequency and Shoaling Rate

The dredging cycle of the channel would be defined by the average number of years between the O&M dredging operations for a historical period. Each channel or reach may or may not have its own dredging frequency. The Galveston District's Dredging History Database, a Microsoft Access-based computer program, was utilized to establish the existing shoaling rate and dredging frequency for the new 45-foot GHC for the 2007 Galveston Channel Limited Reevaluation Report (2007 LRR), Engineering Appendix. For that report, an analysis of 24 years of dredging history identified six maintenance dredging cycles with an estimated shoaling rate of 1,425,500 cubic yards per year for the complete 22,571-foot long channel. The new 45-foot deep channel shoaling rate will be assumed to remain the same as the existing channel, with 1,425,500 cubic yards per year, and a dredging frequency of four years. Shoaling will be assumed to be evenly distributed along the length and width of the channel; therefore, a linear interpolation of the channel dredging data produces a shoaling rate of approximately 162,000 cubic yards per year for the proposed GHC Extension reach. The dredging frequency will remain the same (four years) as the existing 45-foot channel.

2.7 Design Considerations

Several design assumptions were made in conjunction with this study. Hydrographic survey data provided by the area office were utilized in defining new work volumes. Maintenance materials identified in the surveys were discounted and new work volumes were calculated as material below the existing template, including advance maintenance and allowable overdepth. The proposed 45-foot channel would be narrower than the existing 40-foot channel.

2.8 New Work Dredging

The term "new work" refers to the material below the existing channel template which will be removed to increase the channel depth to the new project depth. The new work material quantities were calculated using a 3-dimensional surface (*.dtm) generated by the InRoads software program. The surface is a 3-D representation of the existing channel geometry. The channel has existing and proposed templates which are trapezoidal shapes, defined by bottom width and side slopes. Those templates were used to model the channel and calculate new work volumes. The existing template included the current advance maintenance and allowable overdepth values of three feet and two feet, respectively. The proposed new channel template also included an advance maintenance depth of three feet and a constant two feet of allowable overdepth for calculation of new work volumes. New work material volumes are shown in Table 4.

TABLE 4 - NEW WORK DREDGING VOLUMES FOR 45-FOOT PLAN

Reach	Station Nos.	FederalChannel Estimated New Work CY	Third-Party Facilities* Estimated New Work CY	Total Estimated New Work CY
Galveston Harbor Channel Extension	20+000 to 22+571	513,800	95,700	609,500

* Third-party portside facilities.

2.8.1 Non-Pay Dredging

Non-pay dredging would be defined as dredging outside the paid allowable overdepth that may occur due to such factors as unanticipated variations in substrate, incidental removal of submerged obstructions, or unusual wind and wave conditions. An estimated volume of 102,400 cubic yards of non-pay dredging is assumed for new work in the federal channel. This estimate is based on non-pay depth of 1 foot below the bottom of the allowable overdepth and within the channel toe width of 1075 feet. Non-pay dredging is not assumed on the sideslopes because it is anticipated that no new work will be performed on the sideslopes based on the geometry of the new verses old channel templates. Non-pay dredging within the private facility is estimated at 15,000 cubic yards. Non-pay volumes are included in the maintenance dredging volumes presented in Section *2.6 Maintenance Dredging Frequency and Shoaling Rate.*

2.8.2 Third-Party Portside Facilities Dredging

Third-party portside facilities new work dredging volume is calculated using the square footage of the third-party facilities and multiplying by the depth of new work dredging. The third-party maintenance volume would be based on the GHC shoaling rate and dredging frequency determined as described in Section 2.6. Using the GHC shoaling rate and the area of third-party maintenance dredging, a shoaling rate of 85,700 cubic yards per four-year dredging cycle would be assumed. The third-party maintenance dredging volume described above is not an incremental increase over and above the third-party maintenance volume for the existing project. The third-party new work and maintenance material would be placed within the Pelican Island PA. An existing tipping fee charged to third-party users for use of the Pelican Island PA covers the cost of lost capacity as a result of third-party dredging volumes placed in the PA. This work is considered an associated cost used in the benefit-cost ratio calculation and PA capacity analysis.

2.8.3 Allowable Overdepth

Additional depth outside the required channel template would be permitted to allow for inaccuracies in the dredging process. Per Engineering Regulation (ER) 1130-2-520, *Navigation and Dredging Operations and Maintenance Policies*, "District Commanders may dredge a maximum of two feet of allowable overdepth in coastal regions…, and inland navigation channels." This additional dredging allowance would be referred to as a dredging tolerance, or allowable overdepth. The existing channel has a two-foot allowable overdepth. It is anticipated that large pipeline dredges, similar in size used for maintenance dredging of the existing channel, will be utilized to construct the proposed 45-foot channel extension. District policy recommends a two-foot allowable overdepth in reaches where these large dredges operate.

2.8.4 Advance Maintenance

Advance maintenance consists of dredging deeper than the authorized channel template to provide for the accumulation and storage of sediment. In critical and fast-shoaling areas advance maintenance would be required to avoid frequent re-dredging and to ensure the most reliability for navigation within the channel and the least overall cost for operating and maintaining the project authorized dimensions. ER 1130-2-520 authorizes Major Subordinate Command (MSC) Commanders to approve advance maintenance. The existing 40-foot channel has an authorized three-foot advance maintenance depth. The three-foot advance maintenance depth would be assumed to remain the same for the

proposed 45-foot extension as authorized for the adjacent existing 45-foot channel.*2.9 Beneficial Use of Dredged Material*

Conceptual designs for beneficial use of dredged material were performed during the Plan Formulation Phase. Four beneficial use alternatives were evaluated for this project. General assumptions were used. The least cost methods were generally used in developing designs. It was assumed that no relocations would be necessary, and that right-of-ways (ROWs) and right-of-entries (ROEs) would be available. Specific field and design data was provided by the Environmental Section. During the Detail Phase, the selected marsh creation features were individually evaluated and updated. The evaluated marsh creation site adjoins Pelican Island near the southwest corner with most of the site currently under water. The following design and construction assumptions were developed based on the proposed site existing conditions and on typical sections proven successful in the Galveston Bay area for similar projects. Swamp accessible machinery would be required during marsh construction. Hydraulic levees would be built with the new work dredged material and the dredge pipeline routes are assumed to be the shortest distance to the middle of the site. Levee side slopes were designed to have slope protection such as rip-rap and concrete cellular mats. Marsh fill would occur with selective placement of dredged material within the marsh site boundary. Marsh fill could be new work or maintenance material, depending on the requirements of the marsh design. Where plantings would occur, it was assumed that abundant local species are available. Marsh creation was not selected as part of the NED Plan. The evaluated Marsh site location and conceptual plan are shown on Drawing No. B-02.

3.0 SURVEYING, MAPPING, AND OTHER GEOSPATIAL DATA REQUIREMENTS

3.1 Surveys

Extensive land surveys were not performed for this study. The district utilized color orthodigital aerial maps taken in 2004 to identify existing topographical features such as shoreline, docks, creeks, open or wooded areas, etc. Hydrographic surveys provided by the Galveston Area Office provided after-dredged surveys at 200-foot intervals for the channel, and represent ground surface ranging from elevation -30 feet to the bottom of the channel. Additional land elevations were implied from the ortho maps. Interpolation between hydrographic surveys and land surveys were performed using the InRoads software program. An overall 3-D surface (*.dtm) was generated, providing a representation of the existing conditions along the channel.

3.1.1 Additional Surveys

During the preconstruction, engineering and design (PED) phase of this project, a complete land survey of the PA site will be required. Hydrographic condition surveys of the channel will be performed by the area office and will be utilized and coordinated during PED to the extent practical.

3.2 Mapping

For this study, existing maps of the project area available at Galveston District (SWG) were used during the initial and plan formulation phases. Updated mapping was developed for the Detail phase, to include current conditions.

3.2.1 Additional Mapping

It will be assumed the existing maps of the project area will require only minor updating as time progresses. It is not anticipated that major changes will occur related to the mapping presented in the Engineering Appendix.

3.3 Datums

3.3.1 Horizontal Datum

Horizontal Datum will be Texas State Plane Coordinate System, South Central Zone, North American Datum (NAD) of 1983.

3.3.2 Vertical Datum

All elevations referred to in this report, unless specifically noted otherwise, are based on MLT datum. MLT datum is defined as 1.41 feet below National Geodetic Vertical Datum of 1929 (NGVD) for the reach of channel from point of origin (offshore) to Morgans Point, Texas.

Existing after-dredging hydrographic surveys in the local vertical datum of MLT were used in calculating new work volumes. Existing land survey data for the Pelican Island PA used North American Vertical Datum of 1988 (NAVD 88).

4.0 PROJECT SITE ACCESS

The Pelican Island PA has existing access roads available. No public roads require improvement for access to the project site.

5.0 ENVIRONMENTAL ENGINEERING

5.1 Environmental Objectives and Requirements

Environmental objectives and requirements described herein will be fulfilled by compliance with plans for the management of dredged material in the Pelican Island upland confined PA and by adopting and enforcing prudent and reasonable measures to avoid impacts and by the completion of measures described in the Environmental Assessment (EA) performed for this study.

5.2 Environmental Considerations

5.2.1 Energy Savings Features of the Design

Energy saving features of the design includes minimizing pumping distances between dredge vessels and the PA thereby reducing the load on the pump and minimizing the amount of diesel fuel and other commodities required to execute the planned project goals.

5.2.2 Environmental Effects of the Project

a. Emissions from the dredging vessel and other heavy equipment will locally degrade air quality during channel dredging and dredged material pumping operations.

b. Water clarity and quality at the dredging sites and the PAs will be temporarily affected by the dredging process. Some soil particles are temporarily lost in the water column during the dredging process. With time, the sediments are winnowed out, and settle back down on the channel and bay bottom thus re-establishing water clarity and quality as it existed prior to the dredging.

c. On a microorganism level, the dredged channel bottom will temporarily be affected while the area adjusts to the new environment the project created.

5.2.3 Integration of Environmental Sensitivity into All Aspects of the Project

Water and sediment quality of new work and maintenance dredging will be monitored to manage any impacts from dredging in the channel and dredged material pumping, placement, and decanting operations in the Pelican Island upland PA.

5.2.4 Lessons Learned During Past Project

The Environmental Review Guide for Operations (ERGO) was reviewed to identify environmental lessons learned on past projects. The identified lessons learned were applied to the design concepts considered for this project.

For some time now, the SWG geotechnical section has been refining the science and art of PA design and utilization. Included in the design concepts for this project is the use of improved drop-outlet structures that provide more effective sediment control to minimize turbidity of the effluent in the surrounding water column. Innovative levee construction techniques have been incorporated into the conceptual design. These techniques include placing selected soil types desirable for building levees directly into berms alongside the interior of existing levees during dredging operations to provide levee building materials for more efficient access during levee raising construction. Desirable dredged material would also be placed directly within proposed marsh levee templates to minimize later manipulation and therefore less turbidity in the surrounding water column.

5.2.5 Incorporation of Environmental Compliance Measures into the Project Design

There are numerous environmental drivers which govern protection of the public and environment during the construction phase of a project that were incorporated into the feasibility design for this project. Local, State and Federal environmental compliance measures incorporated into the project include:

- The Texas Pollutant Discharge Elimination System (TPDES) administered by the Texas Commission on Environmental Quality (TCEQ)
- Protection of Environmental Resources
- Preservation and Recovery of Historical, and Cultural Resources
- Protection of Water Resources
- Protection of Fish and Wildlife Resources
- Protection of Air Resources

- Protection from Sound Intrusions
- Pollution Prevention

5.3 Hazardous Toxic Radioactive Waste (HTRW)

Historic dredging events within the channel have not encountered HTRW. Therefore, based upon the HTRW assessment performed as described in the EA and additional in-house research, it has been determined that there would be a low probability of encountering contaminated sites or toxic substances during project construction.

6.0 GEOTECHNICAL ENGINEERING

6.1 Terminology

A variety of special terms used in this document shall be defined as follows:

Hydraulic placement referred to in this document shall be defined as discharging a slurry of water and soil from a dredge pipe.

Mechanical construction referred to in this document shall be defined as construction operations performed on land with conventional construction equipment (bulldozers, draglines, tractors, etc.).

Shaping referred to in this document shall be defined as the construction operations in connection with forming and constructing materials to a specified levee template.

New Work referred to in this document would be defined as new and currently undisturbed soils obtained from the deepening portion of the GHC.

Ponding shall be defined as the accumulation of water and or dredge fluid to some elevation behind levees within a PA.

Pure New Work refers to new work materials which are dredged separately from maintenance materials.

Mixed New Work refers to new work materials which are dredged with maintenance material mixed in with the new work material. For clarification however, whenever quantities of mixed new work are referred to in the design or cost estimates, these mixed quantities only represent the quantity of the new work material, and exclude the quantity of maintenance material allowed to mix with the new work material.

6.2 Existing Soils Data and Foundation Conditions

6.2.1 Galveston Harbor Channel Extension

Soil borings drilled within and near the channel extension in 1965 and 1980 were reviewed to identify the existing channel bottom soil conditions. Additional soil borings were not performed for this study. A boring layout and plotted boring logs are shown on Drawing Nos. B-08 and B-09. As shown by the boring logs the new work materials that will be dredged to deepen the channel will consist primarily of stiff to hard high-plasticity clays classified as CH soils. According to the Houston-Galveston Navigation Channels, Texas Limited Reevaluation Report and Final Supplemental Environmental Impact Statement, November 1995 (1995 LRR), previous estimates made near or prior to 1995 indicate that the make-up of dredged maintenance material from the channel has consisted in the past of approximately 80 percent fine grained materials and approximately 20 percent coarse grained or sandy materials.

6.2.2 Pelican Island PA

A boring location layout along with the plotted boring logs, for borings drilled at the site in 1972, 1977, 1979, and 1993 can be found in the 2007 LRR, Engineering Appendix**.** A brief description of the soils conditions within the Pelican Island PA is also included in the referenced Engineering Appendix. Since the preparation of the above referenced report, new work and maintenance materials have been dredged from the GHC from Station 0+000 to Station 20+000 and pumped to the Pelican Island PA during the time period from late-2009 through mid-2010. Maintenance materials have been dredged from the GHC from Station 20+000 to Station 22+571 and placed in the Pelican Island PA during the same time period. New work materials were placed in interior berms and on levees within Cells A, B, and C. In addition, perimeter levees at Cell C that had been damaged during Hurricane Ike were repaired and incrementally raised. Graded stone riprap shoreline protection was constructed along two sections of the Cell C perimeter levee at the northeast end of the PA. A new weir was constructed to replace the existing weir at the northwest end of Cell B to control dredge ponding levels and flow into Cell C. The new weir is 40-feet wide and is constructed using structural steel members, timber

bulkheads, and has a cast-in-place concrete base. The design elevation of top of the concrete base is +18.0 feet (NAVD88). The weir is capable of restricting flow using stop log timbers up to elevation +30.0 feet; therefore, this flow control elevation adjustment is available from elevation +18.0 to +30.0 feet (NAVD88). A new five-bay drop-outlet structure was constructed near the southeast corner of Cell C and replaced the old structure and provides the only discharge of effluent into the bay from the PA. The effluent is discharged through two 48-inch diameter steel pipes to the south. Flow of effluent is controlled using stop-log timbers at elevations ranging from about +12.0 feet to +30.0 feet (NAVD88). The drop-outlet structure will be periodically raised and moved laterally in the future as required to accommodate levee raisings and/or realignments.

The current estimated dredged material capacity in the Pelican Island PA is 40 MCY and is based on an ultimate levee height of +50 feet MLT as discussed in the 1995 LRR. Per the 50-Year Disposal Plan presented in the 1995 LRR, in order to have enough capacity for maintenance material over the 50-year period of analysis, the final projected elevation of the PA, after a series of levee lifts in the O&M phase, would be approximately +50 feet MLT. The projected required levee elevation is based on an estimated maintenance dredging volume of 5.7 million cubic yards every four years for the entire GHC reach and an assumed maintenance material shrinkage factor of 0.65, as discussed in the section of the 2007 LRR Engineering Appendix entitled CONSTRUCTION PROCEDURE. The required PA capacity for dredged maintenance material, for the remainder of the 50-year project life, is 29.64 MCY cubic yards, leaving about 10.36 million cubic yards of available capacity. The total new work volume anticipated for placement in the PA from construction of this channel extension, 726,900 cubic yards (581,520 cubic yards after shrinkage), includes 513,800 CY of estimated new work from construction of the extension, 95,700 CY of new work from third-party facilities, plus 102,400 CY and 15,000 CY of non-pay dredging for the extension and third-party facilities respectively. No incremental increase in shoaling within the Federal channel or private facilities is anticipated as result of this project. Therefore, Pelican Island PA has more than sufficient remaining capacity to accommodate the new work volume generated by this channel extension.

6.2.3 Proposed Upland PA on Pelican Island

At the request of the Port of Galveston, an 81.76-acre tract located on the north edge of the GHC and between the Halliburton Energy Services Galveston Terminal Slip and the Pennzoil/Oxy USA Slip was explored for consideration as a new dredged material upland confined PA. A total of eight soil borings were performed within the proposed PA to characterize the soil conditions. As described in the 1995 LRR, the soils at emergent

areas of Pelican Island are the result of dredged material discharges over the past 70 or so years. The soil borings taken within this tract of land on Pelican Island indicate the soils in this area are a mixture of fill materials, consisting of medium to high plasticity clays, sands, silty sands, and clayey sands. A review of the soil types encountered indicate that approximately 70 percent (or-that the majority) of the encountered soils consist of sands, silty sands, and clayey sands with the remainder being fine-grained sandy clays to clays, and are typical of the fill soils encountered on Pelican Island in previous borings. Consideration of this tract for upland disposal for inclusion in the NED Plan was abandoned during the Detail Phase of this study because of the high cost to develop the site compared to the relative small placement capacity of the completed PA. A conceptual PA plan, soil boring layout, and boring logs are shown on Drawing Nos. B-03 through B-07.

6.3 Beneficial Use Site Alternatives

A beneficial use site (hereinafter referred to as the Marsh Site) was considered during the Preliminary Plan Formulation and Plan Formulation Phases of this study. The Marsh Site considered would be located just off and west of the southwest corner of Pelican Island. The studied Marsh Site ranged in area from about 48 acres to 103 acres to accommodate the volume of new work material for the various proposed channel depth alternatives studied. Preliminary levee construction design and levee erosion and wave protection systems were developed and construction quantities were estimated for preliminary construction cost determinations. The conceptual levee and wave protection designs are based on designs used successfully in the Galveston Bay area having similar fetch lengths. The Marsh Site alternatives were not selected for inclusion in the NED plan because of the high cost to construct and develop compared to placement of the dredged materials into the existing Pelican Island PA and the lack of a cost share partner to offset those costs. A conceptual beneficial use site plan and levee cross sections are shown on Drawing No. B-02 attached to this appendix.

6.4 Levee Work

6.4.1 Initial Mechanical Levee Work

The proposed plan involves mechanically raising the levees at Pelican Island PA, prior to deepening the channel, to sufficient height to: 1) allow for the containment of the new work material; and 2) account for any initial maintenance material that may be encountered above the new work material during the channel deepening. Neither the existing weir structure located at the northwest corner of Cell B, nor the existing drop-

outlet structure located in Cell C, will be required to be raised as a result of the proposed levee raising.

6.4.2 Hydraulically Placed Levee Foundation

Using the proposed channel extension configuration (45-foot channel), the most current estimate of new work material from the channel deepening (not including maintenance material) would be around 609,500 cubic yards, including Federal and third-party portions. It would be proposed that the new work materials from the channel be stacked hydraulically along the perimeter levees, to the inside of the PA in Cell B, serving the dual purpose of providing usable levee building material following the channel deepening, and providing added foundational strength by displacing and consolidating some of the softer materials from beneath the hydraulically placed new work materials. During hydraulic placement of the new work material along the levee perimeter, it would be expected that up to half of the new work material pumped in from the channel may displace softer soils within the PAs. By replacing some of the softer soils with stronger new work materials through displacement, the goal will be to create a stronger counteractive shear surface within the levee embankment to help prevent or reduce the chance of deep levee failures as the levees are raised in the future. The discharge point of the dredge pipe will be moved along the levee as the hydraulic fill is placed; therefore, incurring additional cost to the dredging contract. The additional cost for moving the dredge discharge has been considered in the economic analysis.

After hydraulic placement, but prior to the next dredge cycle, it is proposed that the remaining available mounded new work then be shaped to a selected slope, crown width, and levee elevation as directed by USACE. In addition, during the shaping process of the new hydraulically placed foundation, it is proposed that the new shaped levee be slightly offset inward from the current levee configuration which will increase the overall length of the counteractive shear surface in the levee embankment, allowing for an increased counteracting force against the driving weight of the levee embankment. The hydraulically placed new work levee foundation will serve as the base for all future levee lifts, and be shaped to a uniform elevation. A typical conceptual levee cross section for Pelican Island levee construction is shown on Drawing No. B-01.

During future O&M levee construction on top of the hydraulically placed new work foundation, it is recommended that periodic checks of the foundation and embankment be made. Additional core borings, soils sampling, soils testing, and follow up stability analyses, should be performed periodically as conditions require. The additional soils data will be used to verify to what extent consolidation and foundation strength gain has

occurred over time, and determine if additional stability measures should be taken (such as offsetting the levees further into the PA if necessary or other measures). Per the 50-Year Disposal Plan presented in the 1995 LRR, in order to have enough capacity for maintenance material over the 50 year period of analysis, the final projected elevation of the PA, after a series of levee lifts in the O&M phase, would be approximately +50 feet MLT.

The assumption that levees may be built to at least elevation +50 feet is based on "a report submitted to the Port of Houston Authority by a private consultant, *Geotechnical Memorandum Disposal Area Management Plan, Spilmans Island, Alexander Island, Lost Lake, Houston Ship Channel, Harris County, Texas (1994)*…that shows that a levee could be built to +60.0 feet at Alexander Island, without failure." The 1995 LRR goes on to state that, "The District believes that Alexander Island has the weakest foundation conditions." Note the 1995 LRR disposal plan included Pelican Island. The District will perform additional geotechnical exploration and stability analysis over the course of the project life during the PED phase of future levee-raising projects to confirm levee stability and allowable ultimate height.

6.5 Proposed Order of Work

The proposed order of work includes first mechanically raising the Pelican Island PA, Cell B west levee and mechanically constructing retention levees within the interior of the Cell. Then dredging of the GHC Extension will begin with placement of maintenance and new work materials hydraulically within Cell B. The new work material will be placed in berms along the interior of the Cell B west perimeter levee. The dredge pipe shall have a "Y" valve installed such that when maintenance or "mixed new work" materials are encountered that contain materials unsuitable for levee construction, it can be directed toward the interior of Cell B and not in the proposed interior berms (see paragraph above entitled Terminology).

6.6 Levee and Channel Templates

Typical levee slope templates proposed for the Pelican Island upland PA were developed for the 1995 Engineering Supplement to LRR and the 2007 LRR Engineering Appendix referenced herein. The proposed channel slopes for the deepening project construction are 1V on 3H. The channel slopes will be maintained at a 1V on 2H slope during O&M as per existing practices for the GHC.

6.7 Proposed Additional Soils Investigations

As discussed in the above paragraph entitled "Hydraulically Placed Levee Foundation", it would be recommended that future periodic checks of the levee foundation and embankment be made by additional exploratory soil borings, sampling, and testing. The data obtained from the additional investigations will be used to verify consolidation and foundation strength gain over time, and the stability of the levee embankments. The resulting analyses will be used during future O&M levee raising design and construction on top of the hydraulically placed new work foundations. Additional geotechnical data will be obtained for the PED phase of the project by drilling soil borings within the proposed channel extension template in accordance with the guidance outlined in Engineer Manual (EM) 1110-1-1804, *Geotechnical Investigations*. Samples of the channel foundation soils will be obtained for classification and strength measurement. The data will be analyzed to develop estimated quantities of acceptable materials available for levee building and to verify channel side slopes will be stable after the deepening project.

7.0 OPERATION AND MAINTENANCE

The O&M phase of the project will be accomplished using the existing procedure for all the navigation channels in the Galveston District. The procedure would be composed of the following steps:

1) Historical records are kept for shoaling rates in various reaches of the navigation channel. The data in the historical records are continually updated based on actual dredging volumes for the various reaches.

2) Condition Surveys are conducted twice a year to determine the actual cross-sections at several stations along the navigation channel. The cross-sections are used to compute the actual shoaling rate in the various reaches. The actual shoaling rates are compared with the expected rates obtained from the historical data. Historical data are also updated to reflect the actual shoaling rates.

3) Dredging contracts are prepared to restore the channel to its design template as required for the various reaches of the channel.

4) The Corps of Engineers performs all the activities indicated above. The Local Sponsors provide the land for dredged materials placement and the containment levees required.

5) The structural components in this project are limited to the interior weir and drop-outlet structure used to drain the excess water from the PAs. The structures are composed of structural steel members and access/working platforms. Water drainage would be controlled by the use of timber planks. As part of the O&M of the project, these structures will be periodically painted as needed, and the timber planks replaced. As the levee heights are raised to accommodate future dredged material, the drop-outlet structure will also be raised and repositioned laterally as required depending on the new levee configuration.

6) Other structures impacted by the project may be industrial wharfs and docks. The maintenance of these structures would be the responsibility of their owners.

7) The anticipated dredged maintenance material quantities for future O&M are not anticipated to change from those previously calculated for the existing 40-foot project. The existing shoaling rate has been determined as approximately 162,000 cubic yards per year for the proposed 45-foot channel extension with the required maintenance dredging frequency as once every four years. The cost estimates for maintenance dredging over the 50-year period of analysis can be found in Section 9.0 COST ENGINEERING of this Appendix.

8.0 HYDROLOGY AND HYDRAULICS

Studies performed for the Galveston Bay Area Navigation Study (GBANS), Feasibility Report and Environmental Impact Statement (EIS) for improving the Houston and Galveston channel (GBANS 1987) and sequential studies to support the 1995 and 2007 LRR's are viable for this PACR. Below is a summary of hydraulic and hydrology studies that have been completed and their applications.

8.1 Hydrodynamic and Salinity Model Study

A number of hydrodynamic and salinity models have been developed as part of the GBANS study. These models assist in refining estimates of project induced changes to the circulation patterns and salinity regime of Galveston Bay. Studies of freshwater inflows were conducted for the GBANS, 1987. For the 1995 LRR the Texas Water

Development Board (TWDB)-Soil Conservation Service Model was applied to obtain existing condition runoff for gaged and ungaged basins. The future hydrology described in the GBANS report was updated and revised to incorporate new data.

As part of the GBANS, 1987 report, a two dimensional model utilized by the State of Texas was used to evaluate the hydrodynamics of all the bay systems along the Gulf Coast. The model, however, was limited in its abilities to account for the various forces acting on the bay. Therefore, a detailed RMA-10-WES three dimensional model was developed as part of the 1995 LRR. Two new data collection efforts were used to acquire the boundary conditions, initial conditions, and verification data for the model: an intensive 25-hour survey for vertical current and salinity data and a long-term (180 days) monitoring program to obtain water level, salinity, and currents. The results from the hydro-salinity study were coordinated with an oyster model study directed by Dr. Eric Powell of Texas A&M University used to assess project-induced impacts on oysters for the EIS in the 1995 LLR. The currents produced by the hydro-salinity model were also used as a key input parameter for the ship simulation study. A discussion and analysis of model results is found in "*Houston-Galveston Navigation Channels, Texas Project, Report 4, Three-Dimensional Numerical Modeling of Hydrodynamics and Salinity*, TR HL-92-7." Figures and a summary from this report can be found in the 1995 LRR. A brief discussion of modeled parameters is described below.

The model was run for existing condition (40 feet), 45 feet and 50 feet for low, medium, and high freshwater inflows for tidal, meteorological, and hydrologic conditions. The resulting time series, isohaline charts, and cross sections plots can be viewed in the WES Technical Report TR-HL-92-7. The isohaline charts can also be viewed in the Appendices of the 1995 LRR. According to the WES report, "The typical Galveston Bay trend is for low salinity values through early summer. The large drop in freshwater inflow beginning in July along with the higher Gulf salinity causes a rise in salinity, usually, reaching a maximum around October. The simulated Gulf salinity drops quickly in September and the Bay salinities follow later. The overall increase in salinity of the 45' deepening in comparison to the existing conditions was regionally most noticeable in the upper bay; and time-wise in the fall (for all regions). During freshwater flow periods this region and Trinity Bay were practically fresh for both existing and 45' deepening. Generally, the maximum increase in salinity was greater during the high flow scenario than in the low."

In summary, for this GHCE LRR study, the conclusions from the 1995 LRR RMA report are applicable – channel deepening resulted in a larger salinity gradient from the channel to the bay. The salinity increase in the lower bay was much less significant than in other

areas, typically about 1 part per thousand (ppt). Salinity values are lower in the summer months and highest in October.

8.2 Ship-Handling Simulation Model Study

This study was conducted as part of the 1995 LRR. Results are applicable to the channel extension. The study tested both the proposed 45-foot and 50-foot channels for safe two-way navigation, efficient design, and recommended design changes where needed. The ship simulation provided a template design for the GHC that provided for safe ship maneuverability for a design vessel 990 feet long, 160 feet wide, and a draft of 44 feet. The simulation resulted in a recommendation for a minimum 4,500-foot long turning area extending past Pier 36 or approximately Station 19+300. The 1995 LRR adopted a turning area of 4,700 feet long by 1,075 feet wide which ends at Station 20+000 or the end of the existing 45-foot channel. The GHC Extension further extends the turning area to the end of the proposed Extension, resulting in a 1,075-foot wide by 7,271-foot long turning area. The extended turning area would allow pilots additional leeway in selecting appropriate vessel turning locations within the channel to account for variable factors such as current and location of docked vessels. Refer to the 1995 LRR, Section 4.3 "Ship Simulation Study" for a detailed analysis of the ship simulation study.

8.3 Shoaling Rate Investigation

During the re-evaluation study, annual maintenance rates for the existing 45-foot GHC were derived by observing the results for detailed investigations of the bayou and bay reaches for the HSC and taking into account the quadratic equation in WES Technical Report TR H-78-5, "*Methods of Estuarine Shoaling Analysis*", Trawle, 1981. The predictions were verified in analysis of the historical shoaling rates. Based on observations, predicted rates for the proposed project were the same as the existing channel. The results from this investigation combined with additional analysis of shoaling rates in the District's Dredging History Database were used to develop the shoaling estimates for the GHC Extension. Estimated shoaling is 162,000 cubic yards per year.

8.4 Dredging Frequency Study

The proposed maintenance cycle of four years for the existing GHC will be used for the extension. This value was derived during the shoaling rate investigation. Historically the channel had been dredged every four years during the prior 24 years for a total of six

cycles. Because the shoaling rates were not predicted to increase the same dredging frequency is applicable.

8.5 Advance Maintenance Study

This was conducted to ascertain the effectiveness of the advance maintenance depths. Existing O&M practices since the year the channel was initially dredged to the 40-foot project have yielded an advance maintenance depth of three feet as being adequate in maintaining the project depth between dredging contracts. This existing depth of three feet will be used for the channel extension in this PACR. The allowable overdepth will be two feet.

9.0 COST ENGINEERING

The plan presented in the 1995 LRR consisted of deepening and widening the HSC and the Galveston Harbor and Channel, Texas. The Galveston portion was subdivided into two reaches designated as the Offshore Reach and the Galveston Channel Reach. The Galveston Channel Reach, referred to as the GHC in this document, is authorized to 45 feet deep from Station 0+000 to Station 20+000. From Station 20+000 to Station 22+571 the channel is only authorized to a depth of 40-feet. As such, the local sponsor and facilities at the far end of the 40-foot GHC (last 0.5 mile) are not able to receive deeper draft vessels at their facilities without practices such as light-loading. In order to take full advantage of the 45 foot deepening of the GHC, the local sponsor and facilities propose deepening the remaining 0.5 miles of 40-foot channel to 45 feet.

A Mii estimate was prepared for this PACR which proposes deepening the existing last 2,571 feet of authorized channel in the GHC from 40 to 45 foot deep. This would be accomplished by pipeline dredging the channel and placing the material into the existing Pelican Island (Cell B) PA. Pelican Island PA is located north of the GHC, approximately 1,100 acres in size and currently divided into a three cell disposal system. The Mii estimate is presented on Plate No. 1 attached to this appendix.

The PA would be conventional earthen levee constructed with the material excavated from the site. Quantities and design features were developed by the SWG Engineering Branch.

This estimate was prepared using the latest Unit Price Books and labor rates for fiscal year (FY) 2011. The estimate was set-up as one contract, being subdivided into non-

Federal and Federal Costs. The costs were further organized in accordance with the work breakdown structure. The midpoint date of each account code was provided by the project manager for developing the fully funded costs. The estimate was prepared in accordance with ER 1110-2-1302, dated 15 September 2008. The costs were escalated in accordance with the above ER and EM 1110-2-1304, dated 31 March 2009. All this data was input into the Total Project Cost Summary Sheet (TPCS). The TPCS is shown on Plate No. 2. The baseline estimate provides for all pertinent elements for a complete project ready for operations.

Since the project is under 40 million dollars, a formal cost risk analysis using Crystal Ball software was not needed. Instead an Informal Risk Analysis developed by the Cost Engineering Branch, Walla Walla District was used to develop the project contingences. The results of the Informal Risk Analysis are presented on Plate No. 3. The results of the Mii and contingencies are presented in the TPCS attached to this appendix.

The O&M estimate was prepared using October 2011 Price Level. This estimate is shown on Plate No. 4 of this appendix.

ACCOUNT CODE 01 – LANDS AND DAMAGES: Cost for this Account Code was provided by SWG, Real Estate Division.

ACCOUNT CODE 02 – RELOCATIONS: Two inactive utility pipelines have been identified as being required to be removed due to the recommended channel template. The sizes and linear feet of pipe to be removed were provided by the design engineer.

ACCOUNT CODE 12 -- NAVIGATION PORTS AND HARBORS: Dredge quantities were developed by the design engineer. The channel was assumed to be dredged using traditional dredging methods for the area, and using a 30-inch pipeline to pump the material into existing PA (Pelican Island Cell B) located north of the waterway. The dredging cost was developed using the Cost Engineering Dredge Estimating Programs (CEDEP) developed by the Walla Walla District. The dredge production rates were reduced to account for the stiffer “new work” material to be encountered. The cost for mobilization and demobilization was developed using CEDEP, assuming the pipeline dredge was based in New Orleans, LA. The dredging estimates were based on standard operating practices for the Galveston area and considering the dredge pipe discharge will be moved along the Cell B west perimeter levee during dredging operations to construct a hydraulic fill berm.

The cost for preparing the Cell B levees for receiving the dredged material was included under this code of accounts. Part of the cost for creating the Cell B included clearing, grubbing, and stripping the area; as well as turfing the outside of the levee. Labor rates and overhead costs were adjusted to reflect Region 6. Soil characteristics were provided by SWG, Engineering Division, Geotechnical and Structures Section.

ACCOUNT CODE 30 -- ENGINEERING AND DESIGN: The cost for this account was developed using the guidelines provided in the TPCS, with the agreement of the cost engineer and the project manager.

ACCOUNT CODE 31 -- CONSTRUCTION MANAGEMENT: The cost for this account was developed using the guidelines provided in the TPCS, with the agreement of the cost engineer and the project manager.

10.0 CHANNEL CONSTRUCTION

10.1 General

The project will be dredged in one contract. All material will be excavated with a hydraulic pipeline dredge, and placed into confined disposal site at Pelican Island PA.

10.2 Construction Method

The construction will utilize traditional dredging techniques, such as the hydraulic pipeline dredge. Placement of the material for the GHC Extension will also be traditional, in that the material will be contained in a confined, upland site. The Pelican Island PA will be decanted during and following dredging to reduce hydraulic material volume and with the intent to minimize dispersal of sediments into the bay through the effluent. The PA construction is such that flow will be directed from Cell B through the weir into Cell C, then around training levees in Cell C toward the drop-outlet box and finally discharging into the bay. This labyrinth of weir and training levees maximizes the distance that the dredge pipe discharge must travel. In addition, elevations of the weir and drop-outlet box would be controlled using adjustable stop-log timbers to control flow velocities within the PA, thus allowing the maximum amount of sediment to settle prior to discharge into the bay.

11.0 PROJECT SECURITY

Security measures for protecting the project against attacks, such as terrorism attacks, are not considered necessary because of the nature of the project. The only likely attack would be attempts to sink a vessel in order to block navigation. The sunken vessel can usually be removed within a few days to allow navigation to resume. The only vertical structures in this project are the existing drop-outlet and weir structures in the Pelican Island PA, but they are not considered likely attack targets because of the unimportant consequences of failure, and because they can be repaired fairly quickly to restore their function.

12.0 DATA MANAGEMENT

The electronic version of the Engineering Appendix is located on the Districts "W" drive. Location of the folder can be accessed through: W:\Cadd\Projects\Galv\Galveston Harbor PACR\Gal Har 45' Ext PACR.

Civil design related data is documented within the Design Documentation Report (DDR) folder located on the Districts "W" drive. Location of the folder can be accessed through: W:\Cadd\Projects\Galv\Galveston Harbor PACR\Gal Har 45' Ext PACR.

The Geotechnical Engineering data and supporting documentation for the geotechnical portion of the Engineering Appendix is located in the DDR folder located on the Districts "W" drive. Location of the folder can be accessed through: W:\Cadd\Projects\Galv\Galveston Harbor PACR\Gal Har 45' Ext PACR/Geotechnical Engineering.

The Mii Cost Estimate is located within the Cost Engineering folder located on the Districts "W" drive: W:\Cadd\Projects\Galv\Galveston Harbor PACR\Gal Har 45' Ext PACR/Cost Engineering.

13.0 USE OF METRIC SYSTEM MEASUREMENTS

The existing GHC, Texas is established in English units. The navigation industry exclusively uses English units. In the District, water depths are typically expressed in feet and accuracy standards are expressed in feet. Distances are measured in feet, or miles. Engineering project coordinates are normally in English units (feet). Construction

measurement quantities are normally measured in linear feet, square feet, or cubic yards. The Districts' Dredging History Database uses English units.

14.0 ENVIRONMENTAL OPERATING PRINCIPLES (EOP)

The purpose of this section is to provide examples of how the Engineering Appendix integrates EOPs as applicable to engineering and design as required for sustainability, preservation, stewardship, and restoration of the project area's natural resources.

Various project planning and design processes were carried out to achieve practical balance between environmental and economic considerations. The following paragraphs discuss various planning and design considerations that incorporate ways and means to minimize the environmental impact of the project.

14.1 Dredging

In order to minimize water quality degradation, the most efficient dredging techniques and equipment would be utilized for new work and maintenance dredging. Sediment sampling and soil core borings would be performed during the PED phase of the project to classify the new work and maintenance material proposed to be dredged and to identify existing contaminants for appropriate disposal during dredging operations.

14.2 Dredged Material Disposal

Selection of the existing Pelican Island PA site and placement of dredged material within the PA was optimized for proximity to the project. Thus, the need for construction of additional upland disposal sites was eliminated and the distance required to pump the dredged material was minimized. This will result in saving energy and reducing equipment exhaust emissions.

14.3 Design

The project is designed to provide increased navigational safety and efficiency along the channel.

14.4 Effluent Water and Sediment Quality

The effluent water and sediment quality will be monitored during dredging operations to insure it meets state and national quality requirements.

14.5 Relative Mean Sea Level Rise

In accordance with USACE guidance, the projected future relative mean sea level (RMSL) change over the 50-year period of analysis (2012-2062), for the three future (low, medium and high) scenarios may be estimated from subsidence rates. Table 5 provides the estimated RMSL change for the project area from 2012-2062 using both tidal gauge records and basal peat layer data. For more detailed information concerning RMSL see the EA discussion on Local (Relative) Sea Level.

TABLE 5 - ESTIMATED CHANGE IN RMSL

	Subsidence Rate (ft/yr)	
Scenario	**Basal Peat (0.0016 ft/yr)**	**Tide gage (0.0154 ft/yr)**
	RMSL change 2012-2062, (ft)	
Low (Historic) Rate	0.36	1.04
Medium (Modified NRC I Curve) Rate	0.76	1.44
High (Modified NRC III Curve) Rate	2.00	2.73

14.6 Geotechnical Engineering

In an effort to "proactively consider environmental consequences of Corp programs" as part of the EOP's, PA containment levee design practices have been focused on providing a levee layout design with sufficient freeboard, to provide the needed settling time for soil particles within the effluent discharge material, to promote lower levels of turbidity in the drop-outlet structure effluent. Other factors may influence settling time including the discharge flow rate implemented by the dredging contractor. Specification language is added at the time plans and specifications are produced. This language provides additional restrictions on contractor dredging operations such that effluent concentrations at drop-outlet structure are within legal and allowable limits.

14.7 Environmental Engineering

During this feasibility study, the design team consulted the EOP's outlined in the ER 200-1-5 "*Environmental Quality - Policy for Implementation and Integrated Application of the U.S. Army Corps of Engineers (USACE) Environmental Operating Principles (EOP) and Doctrine*," dated 30 October 2003. The text in Section 5.0 ENVIRONMENTAL ENGINEERING of this document discusses the application of these principles.

15.0 RISK AND UNCERTAINTY

This section provides detail as applicable for addressing USACE policy concerning risk and uncertainty with regard to estimated construction quantities. Typical changes in channel shoaling rates are attributed to several major factors including: increase in bottom width; decreased flow velocity due to enlarged cross-section; modified salinity regime; increased vessel traffic; channel bank failure; and, sediment brought down by rivers, etc.

The only change in the channel dimensions for this project is an increase in depth and a slight decrease in bottom width. Based on the hydrodynamic and salinity model study performed for the 1995 LRR, the salinity in the Lower Bay area will remain the same or change very little with channel deepening. The channel bank in the area has a proven history of stability and there is no river to increase sediment load. The cross section is enlarged because of the increased depth thereby providing a possible decrease in current velocities.

Navigable vessels and docks are predicted to experience insignificant impacts of higher water elevation resulting from RMSL rise.

Because of the uncertainty involved in the assumptions and calculations of velocity data and channel side slope stability, the estimated shoaling quantities for the proposed project may not match the actual shoaling rates and are therefore subject to a certain degree of uncertainty.

Since the project is under 40 million dollars, a formal cost risk analysis using the Crystal Ball software was not required. Therefore, cost contingencies were developed using the Informal Risk Analysis method developed by the Walla Walla District. Refer to Section 9.0 COST ENGINEERING of this appendix.

DRAWINGS AND PLATES

Houston-Galveston Navigation Channel, TX
Galveston Harbor Channel Extension Project
Limited Re-Evaluation Report

Estimated by	J. Lockhart
Designed by	CESWG-EC-PS
Prepared by	U.S. Army Corps of Engineers - Galveston District
Preparation Date	5/31/2012
Effective Date of Pricing	5/31/2012
Estimated Construction Time	224 Days

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Description	UOM	Quantity	DirectCost	ContractCost	ProjectCost
Project Cost Summary Report			**7,293,945**	**7,741,066**	**7,741,066**
02 Contract 1 - 45' - NED, Ch to Peican Island Cell B	**LS**	**1.00**	**7,293,945**	**7,741,066**	**7,741,066**
0201 Non-Federal Costs	**LS**	**1.00**	**272,250**	**349,851**	**349,851**
020102 Relocations	**EA**	**1.00**	**272,250**	**349,851**	**349,851**
0202 Federal Costs	**LS**	**1.00**	**7,021,695**	**7,391,215**	**7,391,215**
020212 Navigation Ports and Harbors	**LS**	**1.00**	**7,021,695**	**7,391,215**	**7,391,215**

Description	Page
Project Cost Summary Report	**1**
02 Contract 1 - 45' - NED, Ch to Peican Island Cell B	1
0201 Non-Federal Costs	1
020102 Relocations	1
0202 Federal Costs	1
020212 Navigation Ports and Harbors	1

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For

SWG Houston-Galveston Ship Channel Extension
45' Depth

The Houston Galveston Ship Channel Extension as presented by Galveston District has undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of July 23, 2012, the Cost MCX certifies the estimated total project cost of:

FY 2014 Price Level: $11,897,000
Fully Funded Amount: $12,003,000

It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management throughout the life of the project.

Glenn R. Matlock

Glenn R. Matlock, PE, CCE, PM1
Chief, Cost Engineering
Walla Walla District

US Army Corps of Engineers®

Date 23 July 2012

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Houston-Galveston Channel Extention, 45' - NED
LOCATION: Galveston, Texas

DISTRICT: Galveston, Texas
PREPARED: 6/19/2012
POC: CHIEF, PROFESSIONAL SERVICES, Willie Jeo Honza

This Estimate reflects the scope and schedule in report; Houston-Galveston Navigation Channels, Texas, Galveston Channel Extension, Limited Reevaluation Report (LRR)

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Doller Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
						Program Year (Budget EC): 2014 Effective Price Level Date: 1 OCT 13								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 1-Oct-11 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
02	RELOCATIONS	$350	$70	20%	$420	3.5%	$362	$72	$435			$365	$73	$438
12	NAVIGATION PORTS & HARBORS	$7,391	$1,478	20%	$8,869	3.5%	$7,647	$1,529	$9,176			$7,708	$1,542	$9,250
	CONSTRUCTION ESTIMATE TOTALS:	$7,741	$1,548		$9,289	3.5%	$8,009	$1,602	$9,611			$8,073	$1,615	$9,688
01	LANDS AND DAMAGES		-			-								
30	PLANNING, ENGINEERING & DESIGN	$1,090	$219	20%	$1,309	4.4%	$1,138	$228	$1,366			$1,147	$230	$1,378
31	CONSTRUCTION MANAGEMENT	$735	$147	20%	$882	4.4%	$767	$153	$920			$781	$156	$937
	PROJECT COST TOTALS:	$9,566	$1,914	20%	$11,480		$9,914	$1,983	**$11,897**			$10,002	$2,001	$12,003

CHIEF, PROFESSIONAL SERVICES, Willie Jeo Honza

PROJECT MANAGER, James Worthington

CHIEF, REAL ESTATE, Orlando Rosa

CHIEF, PLANNING,Dolan Dunn

CHIEF, ENGINEERING, Robert Howell

CHIEF, OPERATIONS, Joe Hramez

CHIEF, CONSTRUCTION, Don Carelock

CHIEF, CONTRACTING,xxx

CHIEF, PM-PB,William Wise

CHIEF, DPM, Pete Perez

ESTIMATED FEDERAL COST:	**$11,565**
ESTIMATED NON-FEDERAL COST:	**$438**
ESTIMATED TOTAL PROJECT COST:	**$12,003**

PLATE 2
Page 2 of 3

Filename: Galveston NED- 45_TPCS_June2012_r2 by JFL.xlsx
TPCS

PLATE 2
Page 2 of 3

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Houston-Galveston Channel Extention, 45' - NED
LOCATION: Galveston, Texas
DISTRICT: Galveston, Texas
PREPARED: 6/19/2012
POC: CHIEF, PROFESSIONAL SERVICES, Willie Jeo Honza
This Estimate reflects the scope and schedule in report; Houston-Galveston Navigation Channels, Texas, Galveston Channel Extension, Limited Reevaluation Report (LRR)

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Doller Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 31-May-12 Effective Price Level: 1-Oct-11				Program Year (Budget EC): 2014 Effective Price Level Date: 1 OCT 13								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1 or CONTRACT 1													
02	RELOCATIONS	$350	$70	20%	$420	3.5%	$362	$72	$435	2014Q3	0.8%	$365	$73	$438
12	NAVIGATION PORTS & HARBORS	$7,391	$1,478	20%	$8,869	3.5%	$7,647	$1,529	$9,176	2014Q3	0.8%	$7,708	$1,542	$9,250
	CONSTRUCTION ESTIMATE TOTALS:	$7,741	$1,548	20%	**$9,289**		$8,009	$1,602	$9,611			$8,073	$1,615	$9,688
01	LANDS AND DAMAGES													
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$77	$15	20%	$92	4.4%	$80	$16	$96	2014Q2	0.8%	$81	$16	$97
2.0%	Planning & Environmental Compliance	$155	$31	20%	$186	4.4%	$162	$32	$194	2014Q2	0.8%	$163	$33	$196
7.0%	Engineering & Design	$542	$108	20%	$650	4.4%	$566	$113	$679	2014Q2	0.8%	$570	$114	$684
1.0%	Engineering Tech Review ITR & VE	$77	$15	20%	$92	4.4%	$80	$16	$96	2014Q2	0.8%	$81	$16	$97
1.5%	Contracting & Reprographics	$116	$23	20%	$139	4.4%	$121	$24	$145	2014Q2	0.8%	$122	$24	$146
	Real Estate In-house Labor	$7	$2	25%	$9	4.4%	$7	$2	$9	2014Q2	0.8%	$7	$2	$9
0.5%	Engineering During Construction	$39	$8	20%	$47	4.4%	$41	$8	$49	2014Q3	1.8%	$41	$8	$50
	Planning During Construction			20%										
1.0%	Project Operations	$77	$15	20%	$92	4.4%	$80	$16	$96	2014Q2	0.8%	$81	$16	$97
31	CONSTRUCTION MANAGEMENT													
7.5%	Construction Management	$581	$116	20%	$697	4.4%	$606	$121	$728	2014Q3	1.8%	$617	$123	$741
1.0%	Project Operation:	$77	$15	20%	$92	4.4%	$80	$16	$96	2014Q3	1.8%	$82	$16	$98
1.0%	Project Management	$77	$15	20%	$92	4.4%	$80	$16	$96	2014Q3	1.8%	$82	$16	$98
	CONTRACT COST TOTALS:	$9,566	$1,914		**$11,480**		$9,914	$1,983	$11,897			$10,002	$2,001	**$12,003**

Abbreviated Risk Analysis

Houston-Galveston Navigation Chl Extention LPP- 45'
35% CWE

Meeting Date: 1-Jun-12

PDT Members (Typical Recommended)

Project Management:	James Worthington
Study Manager:	Cheryl Jaynes
Relocations:	Nancy Young
Engineering & Design:	Nancy Young/David Boothby
Cost Engineering:	Jackie Lockhart

Abbreviated Risk Analysis

Project (less than $40M): **Houston-Galveston Navigation Chl Extention LPP- 45'**
Project Development Stage: 35% CWE

Total Construction Contract Cost = $ 7,751,951

	WBS	Potential Risk Areas	Contract Cost		% Contingency	$ Contingency	Total
1	02 RELOCATIONS	Pipeline Removal	$ 349,851		10.42%	$ 36,443	$ 386,294
2	12 NAVIGATION, PORTS AND HARBORS	Mob & Demob of Dredge	$ 920,000		18.75%	$ 172,500	$ 1,092,500
3		Dredging	$ 4,999,274		22.92%	$ 1,145,667	$ 6,144,941
4		Placement Area (PA)	$ 1,482,825		12.50%	$ 185,353	$ 1,668,178
5			$ -		0.00%	$ -	$ -
6			$ -		0.00%	$ -	$ -
7			$ -		0.00%	$ -	$ -
8			$ -		0.00%	$ -	$ -
9			$ -		0.00%	$ -	$ -
10			$ -		0.00%	$ -	$ -
11			$ -		0.00%	$ -	$ -
12			$ -	0.0%	0.00%	$ -	$ -
13			$ -		0.00%	$ -	$ -
14			$ -		0.00%	$ -	$ -

Totals					
Total Construction Estimate	$ 7,751,950	19.87%	$ 1,539,963	$ 9,291,913
Total Planning, Engineering & Design	$ -	0.00%	$ -	$ -
Total Construction Management	$ -	0.00%	$ -	$ -
Total	$ 7,751,950		$ 1,539,963	$ 9,291,913

Houston-Galveston Navigation Chl Extention LPP- 45'
35% CWE
Abbreviated Risk Analysis

Meeting Date: 1-Jun-12

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

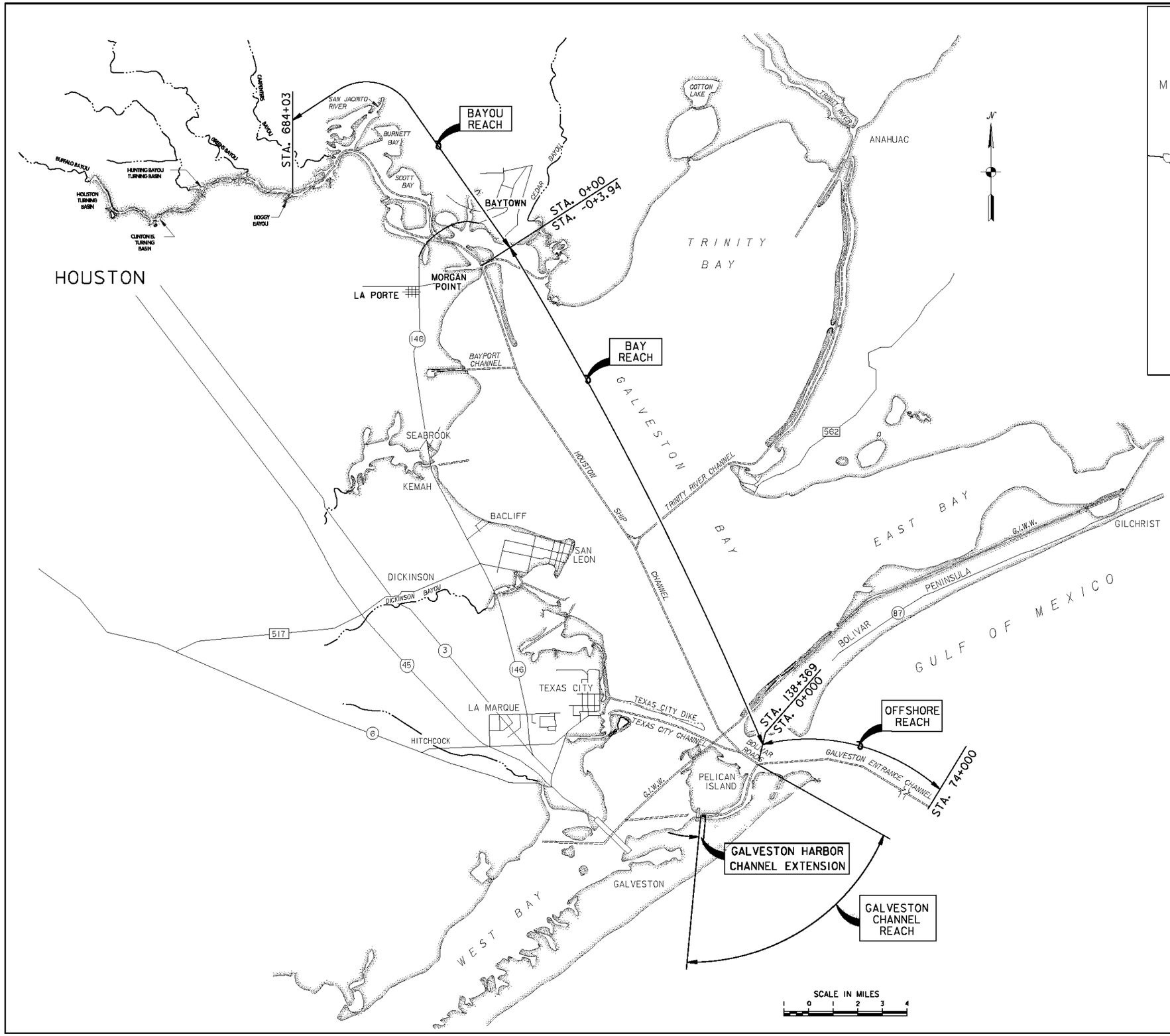
Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Project Scope						
PS-1	Pipeline Removal	Unknowns always exist with dealing with underground utilities.	No Issue	Very LIKELY	Marginal	3
PS-2	Mob & Demob of Dredge		No Issue	Unlikely	Negligible	0
PS-3	Dredging	Potential for scope changes before and after construcion contract award	As design are further developed, there is a potential that the location in the PA may change	LIKELY	Marginal	2
PS-4	Placement Area (PA)	Potential for scope changes before and after construcion contract award	As design are further developed, there is a potential that the location in the PA may change	LIKELY	Negligible	1
Acquisition Strategy						
AS-1	Pipeline Removal	None	No Issue	Very Unlikely	Negligible	0
AS-2	Mob & Demob of Dredge	Bidding Climate	Availability of dredg at time needed	Very LIKELY	Significant	4
AS-3	Dredging	Bidding Climate	Availability of dredg at time needed	Very LIKELY	Significant	4
AS-4	Placement Area (PA)	None	No Issue	Very Unlikely	Negligible	0
Construction Complexity						
CC-1	Pipeline Removal	None	No Issue	Very Unlikely	Significant	1
CC-2	Mob & Demob of Dredge	None	No Issue	Unlikely	Negligible	0
CC-3	Dredging	None	No Issue	Unlikely	Negligible	0
CC-4	Placement Area (PA)	None	potential modification	LIKELY	Marginal	2
Volatile Commodities						
VC-1	Pipeline Removal	None	No Issue	Very Unlikely	Negligible	0
VC-2	Mob & Demob of Dredge	Fuel price fluctuation	Fuel price fluctuations continue. Fuel has a great impact on dredging cost.	Very LIKELY	Marginal	3
VC-3	Dredging	Fuel price fluctuation	Fuel price fluctuations continue. Fuel has a great impact on dredging cost.	Very LIKELY	Marginal	3
VC-4	Placement Area (PA)	None	No Issue	Very Unlikely	Negligible	0

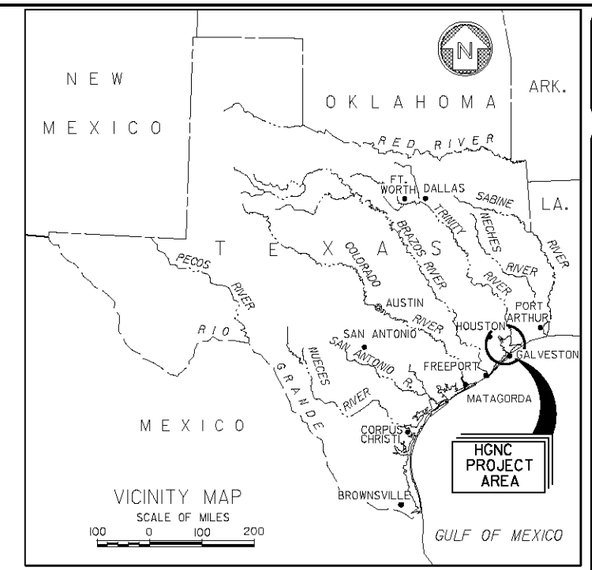
Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Quantities						
Q-1	Pipeline Removal	Unknowns always exist with dealing with underground utilities.	LF of pipe to be remove may increase or decrease	LIKELY	Negligible	1
Q-2	Mob & Demob of Dredge	None	No Issue	Very Unlikely	Negligible	0
Q-3	Dredging	None	No Issue	Very Unlikely	Negligible	0
Q-4	Placement Area (PA)	Design has not been finalized.	Quantities may increase or decrease	LIKELY	Marginal	2
Fabrication & Project Installed Equipment						
FI-1	Pipeline Removal	None	No Issue	Very Unlikely	Negligible	0
FI-2	Mob & Demob of Dredge	None	No Issue	Very Unlikely	Negligible	0
FI-3	Dredging	None	No Issue	Very Unlikely	Negligible	0
FI-4	Placement Area (PA)	None	No Issue	Very Unlikely	Negligible	0
Cost Estimating Method						
CE-1	Pipeline Removal	None	No Issue	Very Unlikely	Negligible	0
CE-2	Mob & Demob of Dredge	Don't know what the bid climate at time of bid opening	Depending on the bidding climate the estimate could go up	LIKELY	Marginal	2
CE-3	Dredging	Don't know what the bid climate at time of bid opening	Depending on the bidding climate the estimate could go up	LIKELY	Marginal	2
CE-4	Placement Area (PA)	Don't know what the bid climate at time of bid opening	Depending on the bidding climate the estimate could go up	Unlikely	Marginal	1
External Project Risks						
EX-1	Pipeline Removal	None	No Issue	Very Unlikely	Negligible	0
EX-2	Mob & Demob of Dredge	None	No Issue	Very Unlikely	Negligible	0
EX-3	Dredging	Potential for political influence	Political pressure to use another PA. This could increase the unit cost, if the pipeline lengths need to increase	Very Unlikely	Marginal	0
EX-4	Placement Area (PA)	Potential for political influence	Political pressure to use another PA . Might required more work to be done for the PA to be ready.	Very Unlikely	Marginal	0

GALVESTON NAVIGATION CHANNEL, TEXAS
50 YEAR O&M COST
PELICAN ISLAND DISPOSAL
OCTOBER 2011 PRICE LEVEL

19-Jun-12

	Cycle	50 Year O&M With Project	50 Year O&M With Out Project
O&M Costs			
Year 1			
Year 2			
Year 3			
Year 4	1	4,931,725	4,931,725
Year 5			
Year 6			
Year 7			
Year 8	2	4,931,725	4,931,725
Year 9			
Year 10			
Year 11			
Year 12	3	4,931,725	4,931,725
Year 13			
Year 14			
Year 15			
Year 16	4	4,931,725	4,931,725
Year 17			
Year 18			
Year 19			
Year 20	5	4,931,725	4,931,725
Year 21			
Year 22			
Year 23			
Year 24	6	4,931,725	4,931,725
Year 25			
Year 26			
Year 27			
Year 28	7	4,931,725	4,931,725
Year 29			
Year 30			
Year 31			
Year 32	8	4,931,725	4,931,725
Year 33			
Year 34			
Year 35			
Year 36	9	6,040,855	6,040,855
Year 37			
Year 38			
Year 39			
Year 40	10	4,931,725	4,931,725
Year 41			
Year 42			
Year 43			
Year 44	11	4,931,725	4,931,725
Year 45			
Year 46			
Year 47			
Year 48	12	4,931,725	4,931,725
Year 49			
Year 50			
TOTAL :		**$ 60,289,830**	**$ 60,289,830**





U.S. Army Corps of Engineers
Galveston District

Rev.	Description	Date	By

BY:HJECONCY DATE:2/28/2013 TIME:12:01:30 PM

Drawn by: NCY	Date: MARCH 2013	Rev.	
Designed by: NCY	Scale: AS SHOWN		
Checked by: BS	Approval Recommended:		
Submitted by: DAVID R. BROWN, P.E., Chief, Galveston Engineering	JOSEPH L. KING, R.A., Chief, Engineering Branch		
Approved by: ROBERT L. WEEL P.E., Deputy Chief, Engineering and Construction Division			

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
CHRISTOPHER W. SALLESE
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER

HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

STUDY AREA MAP

Drawing No.:
C-0

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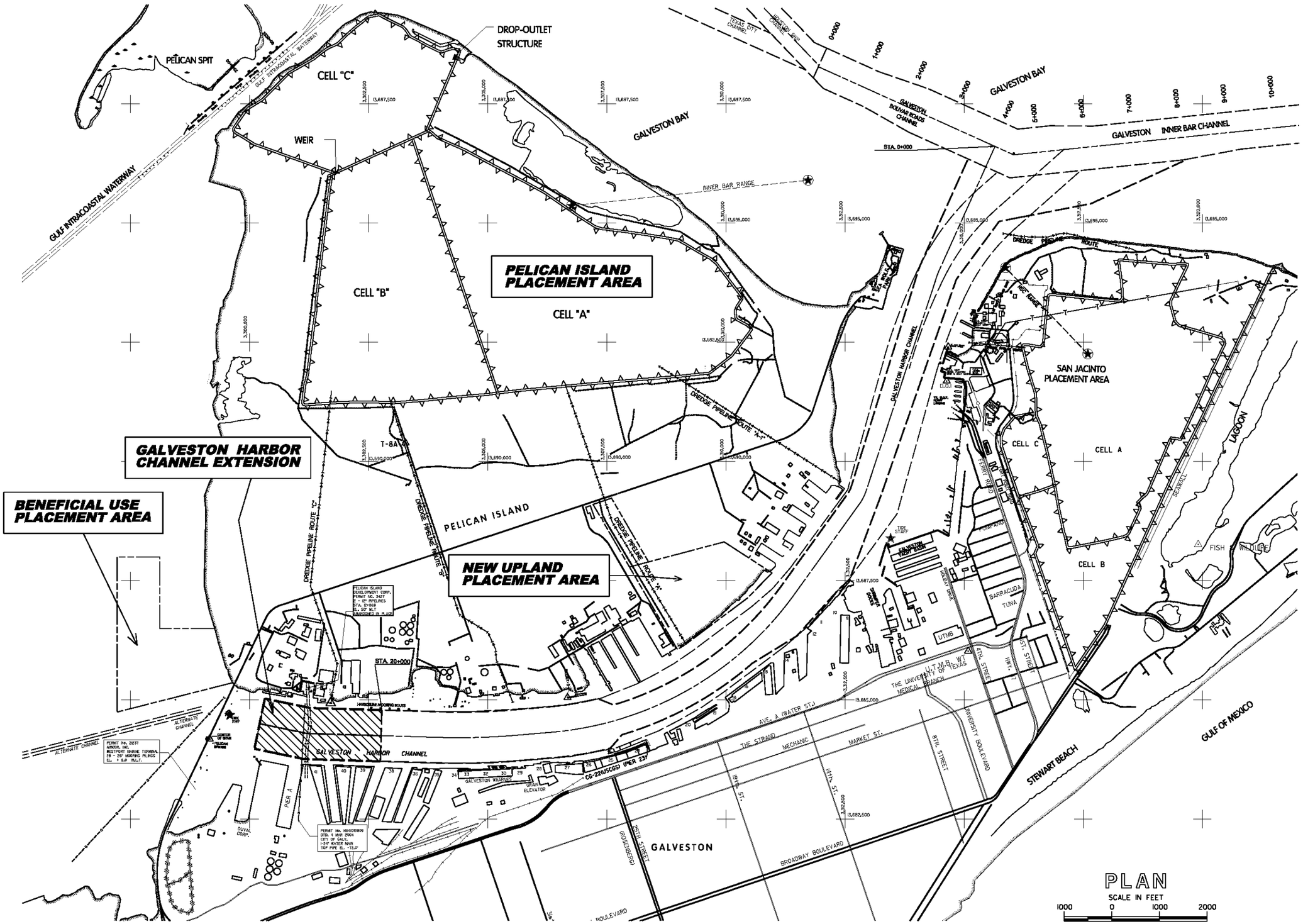

U.S. Army Corps of Engineers
Galveston District

Rev.	Description	Date	By

BY:M3ECONCY DATE:2/28/2013 TIME:12:02:32 PM

Drawn by: NCY	Date: MARCH 2013	Rev.	
Designed by: NCY	Scale: AS SHOWN		
Checked by: MD	Approval Recommended:		
Submitted by: DAVID R. BROWN, P.E., Chief, General Engineering	JOSEPH L. KING, R.A. Chief, Engineering Branch		
Approved by: ROBERT BALLWEIL P.E. Deputy Chief, Engineering and Construction Division			

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
CHRISTOPHER W. SALLESE
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER

HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

GALVESTON HARBOR CHANNEL EXTENSION LOCATION PLAN

Drawing No.:
C-01

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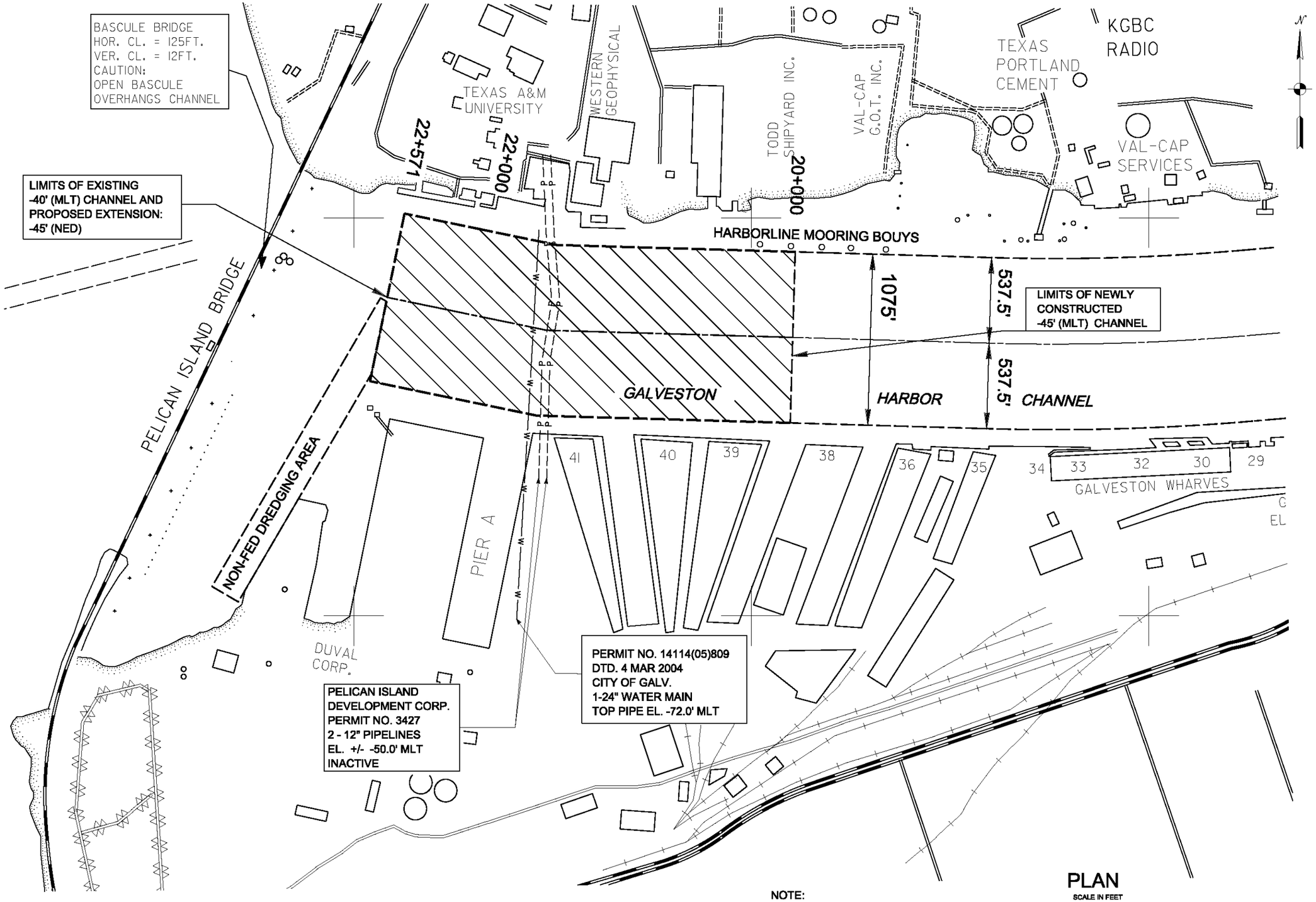

NOTE:
REFER TO DWG C-04 FOR
CHANNEL ALIGNMENT.

PLAN
SCALE IN FEET
300 0 300 600

DRAFT

U.S. Army Corps of Engineers
Galveston District

Rev.	Description	By	Date

BY:MSECEDBB DATE:3/4/2013 TIME:12:52:31 PM

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
CHRISTOPHER W. SALLESE
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER

Drawn by: NCY
Designed by: NCY
Checked by: MD
Submitted by: DAVID R. BROWN, P.E., Chief, General Engineering
Approved by: ROBERT A. VANELL P.E., Deputy Chief, Engineering and Construction Division
Rev:
Date: MARCH 2013
Scale: AS SHOWN
Approval Recommended: JOSEPH L. KING, P.A., Chief, Engineering Branch

HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

PROPOSED GHC EXTENSION
-45' NED PLAN

Drawing No.:
C-02

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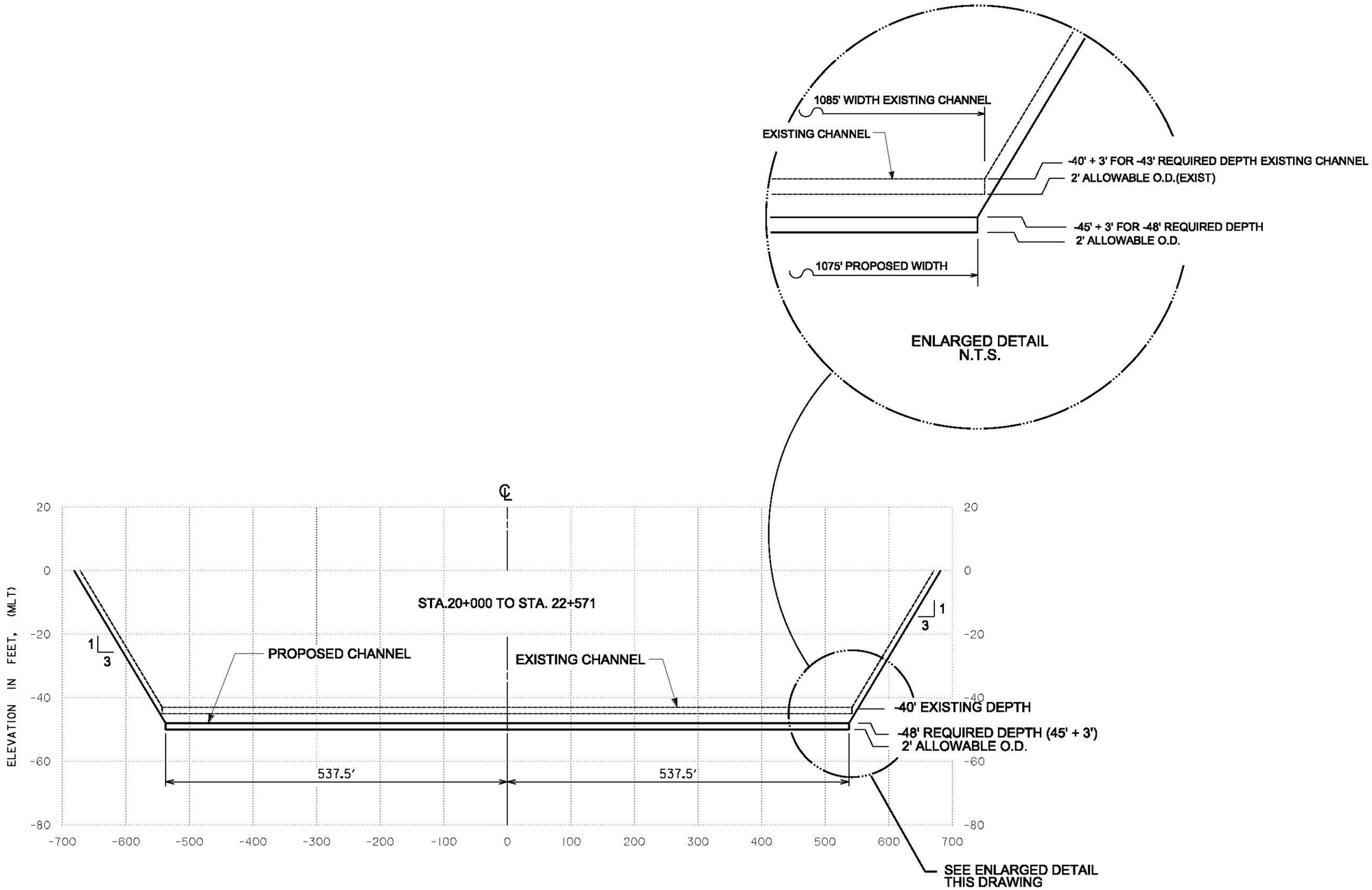


TYPICAL CROSS SECTION
N.T.S.

NOTES:

1. THE CHANNEL TEMPLATE INCLUDES 3' ADVANCE MAINTENANCE FOR EXISTING AND NED DEPTHS.
2. DISTANCES ARE IN FEET.
3. VERTICAL DATUM IS MEAN LOW TIDE (MLT).

U.S. Army Corps of Engineers
Galveston District

Rev.	Description	Date	By

BY: M3ECEDBB DATE: 3/4/2013 TIME: 1:58:23 PM

Drawn by:	NCY	Date:	MARCH 2013
Designed by:	NCY		Rev.
Checked by:	MG	Scale:	AS SHOWN
Submitted by:	DAVID R. BROWN, P.E., Chief, General Engineering	Approval Recommended:	JOSEPH L. KING, R.A., Chief, Engineering Branch
Approved by:	ROBERT A. WEBELL P.E., Deputy Chief, Engineering and Construction Division		

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
CHRISTOPHER W. SALLESE
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER

HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

TYPICAL CHANNEL
CROSS SECTION

Drawing No.:
C-03

File: W:\Cadd\Projects\Gal\Galveston Harbor PACR\Gal Har 45' Ext PACR\Civil Design\04 C03.dgn

GALVESTON HARBOR CHANNEL– 45′ PROJECT

CENTERLINE ALIGNMENT										LEFT TOE			RIGHT TOE		
POINT TYPE	STATION	NORTHING (Y)	EASTING (X)	DISTANCE (FEET)	DEGREE OF CURVE	DELTA	RADIUS (FEET)	TANGENT (FEET)	LENTGH (FEET)	NORTHING (Y)	EASTING (X)	DISTANCE (FEET)	NORTHING (Y)	EASTING (X)	DISTANCE (FEET)
POB	0+000.00	13,696,609.10	3,315,647.34												
	0+500.00	13,696,153.27	3,315,441.87							13,695,858.20	3,316,096.47	718.03	13,696,320.93	3,315,069.91	408.00
	1+140.34	13,695,569.51	3,315,178.73							13,695,121.47	3,316,172.68	1,090.26	13,695,737.16	3,314,806.77	408.00
	1+400.00	13,695,332.78	3,315,072.02							13,695,034.70	3,315,733.31	725.36	13,695,500.44	3,314,700.07	408.00
CURVE 1				2,869.56											
PC	2+869.56	13,693,993.03	3,314,468.12							13,693,825.36	3,314,840.08	408.08	13,694,160.69	3,314,096.16	408.00
									52.53						
PI	2+922.09	13,693,945.14	3,314,446.53		5°43′46″	6°00′50″	1,000.00	104.96							
									52.53						
PT	2+974.53	13,693,895.25	3,314,430.08							13,693,767.48	3,314,817.56	408.00	13,694,023.02	3,314,042.61	408.00
CURVE 2				4,750.57											
PC	7+725.10	13,689,383.64	3,312,942.38							13,689,281.86	3,313,251.03	325.00	13,689,485.41	3,312,633.72	325.00
									154.43						
PI	7+879.53	13,689,236.98	3,312,894.01		5°43′46″	17°33′26″	1,000.00	306.43							
									154.43						
PT	8+031.53	13,689,111.74	3,312,803.67							13,688,893.73	3,313,105.87	372.64	13,689,301.89	3,312,540.09	325.00
	9+435.15	13,687,973.42	3,311,982.47							13,687,530.72	3,312,596.12	756.67	13,688,163.56	3,311,718.89	325.00
	9+751.99	13,687,716.46	3,311,797.10							13,687,310.34	3,312,360.06	694.16	13,687,906.61	3,311,533.53	325.00
CURVE 3				2,354.94											
PC	10+386.47	13,687,201.91	3,311,425.89							13,686,835.98	3,311,933.12	625.45	13,687,392.05	3,311,162.31	325.00
	11+000.00	13,686,720.70	3,311,045.61							13,686,339.74	3,311,486.49	582.68	13,686,933.19	3,310,799.69	325.00
	12+000.00	13,686,013.23	3,310,340.07							13,685,767.89	3,310,553.22	325.00	13,686,258.56	3,310,126.91	325.00
									3,208.89						
PI	13+359.27	13,684,599.53	3,309,548.50		0°49′07″	49°15′17″	7,000.00	6,017.59							
									3,208.89						
	15+000.00	13,684,583.18	3,307,728.93							13,684,271.45	3,307,820.85	325.00	13,684,894.91	3,307,637.00	325.00
	15+300.00	13,684,504.52	3,307,439.45							13,683,982.93	3,307,569.25	537.50	13,685,026.11	3,307,309.64	537.50
PT	16+404.06	13,684,323.31	3,306,351.52							13,683,787.80	3,306,397.78	537.50	13,684,858.81	3,306,305.25	537.50
CURVE 4				743.01											
PC	17+147.07	13,684,259.35	3,305,611.27							13,683,723.84	3,305,657.53	537.50	13,684,794.85	3,305,565.00	537.50
									809.63						
PI	17+956.70	13,684,189.66	3,304,804.64		0°24′33″	6°37′10″	14,000.00	1,617.46							
									809.63						
PT	18+764.53	13,684,213.41	3,303,995.36							13,683,676.14	3,303,979.58	537.50	13,684,750.68	3,304,011.13	537.50
				1,235.46											
POE	20+000.00	13,684,249.66	3,302,760.42							13,683,712.39	3,302,744.65	537.50	13,684,786.93	3,302,776.19	537.50

PROPOSED GALVESTON HARBOR CHANNEL EXTENSION– 45′ PROJECT

POB	20+000.00	13,684,249.66	3,302,760.42							13,683,712.39	3,302,744.65	537.50	13,684,786.93	3,302,776.19	537.50
				1,548.78											
	21+548.77	13,684,295.11	3,301,212.31							13,683,759.24	3,301,148.62	537.50	13,684,830.97	3,301,276.00	537.50
				1,022.59											
POE	22+571.36	13,684,505.53	3,300,211.61							13,683,979.02	3,300,103.45	537.50	13,685,031.01	3,300,324.66	537.50

NOTES:

1. HORIZONTAL DATUM: NAD 83, TEXAS STATE PLANE SOUTH CENTRAL ZONE
2. VERTICAL DATUM: MEAN LOW TIDE (MLT) FOR NAVIGATION CHANNEL
   NAVD 88 FOR LAND BASED CONSTRUCTION

U.S. Army Corps of Engineers
Galveston District

Rev.	Description	Date	By

BY:M3ECXANCY DATE:2/28/2013 TIME:3:12:49 PM

Drawn by: NCY
Designed by: NCY
Checked by: MD
Submitted by: DAVID R. BROWN, P.E., Chief, General Engineering
Approved by: ROBERT D. WEBEL P.E., Deputy Chief, Engineering and Construction Division
Date: MARCH 2013
Rev.
Scale: AS SHOWN
Approval Recommended: JOSEPH L. KING, R.A., Chief, Engineering Branch

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

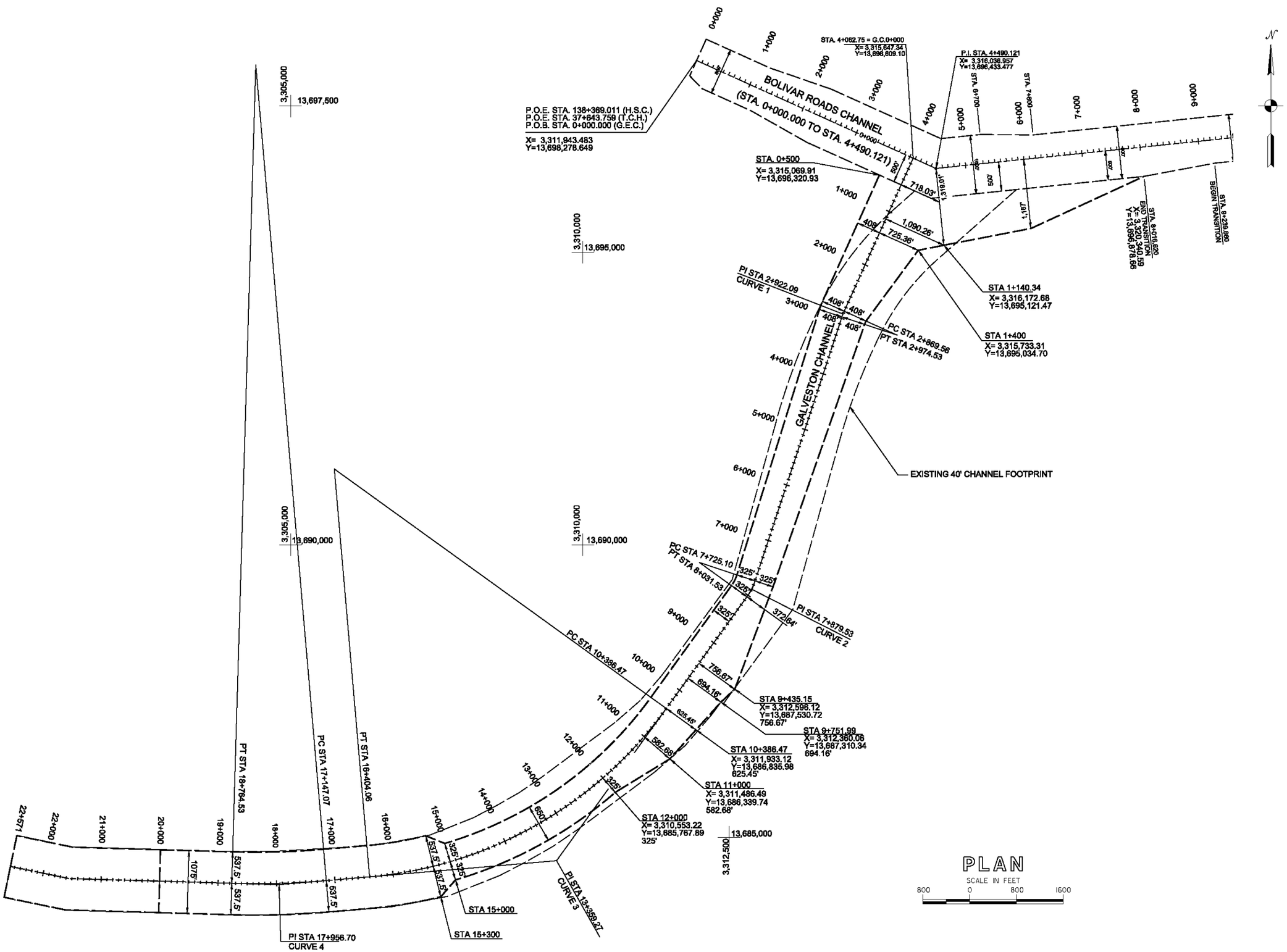
PREPARED UNDER THE DIRECTION OF
CHRISTOPHER W. SALLESE
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER

HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

GALVESTON HARBOR CHANNEL
ALIGNMENT

Drawing No.:
C-04

File: W:\Cadd\Projects\Galv\Galveston Harbor PACR\Gal Har 45' Ext PACR\Civil Design\05 C04.dgn



U.S. Army Corps of Engineers
Galveston District

TIME:12:04:43 PM
DATE:2/28/2013
BY:M:\REDONCY

Rev.	Description	Date	By

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

Drawn by: NCY
Designed by: NCY
Checked by: MD
Date: MARCH 2013
Scale: AS SHOWN
Rev.

Submitted by: DAVID R. BROWN, P.E., Chief, General Engineering
Approval Recommended: JOSEPH L. KING, R.A., Chief, Engineering Branch
Approved by: ROBERT D. MOWELL P.E., Deputy Chief, Engineering and Construction Division

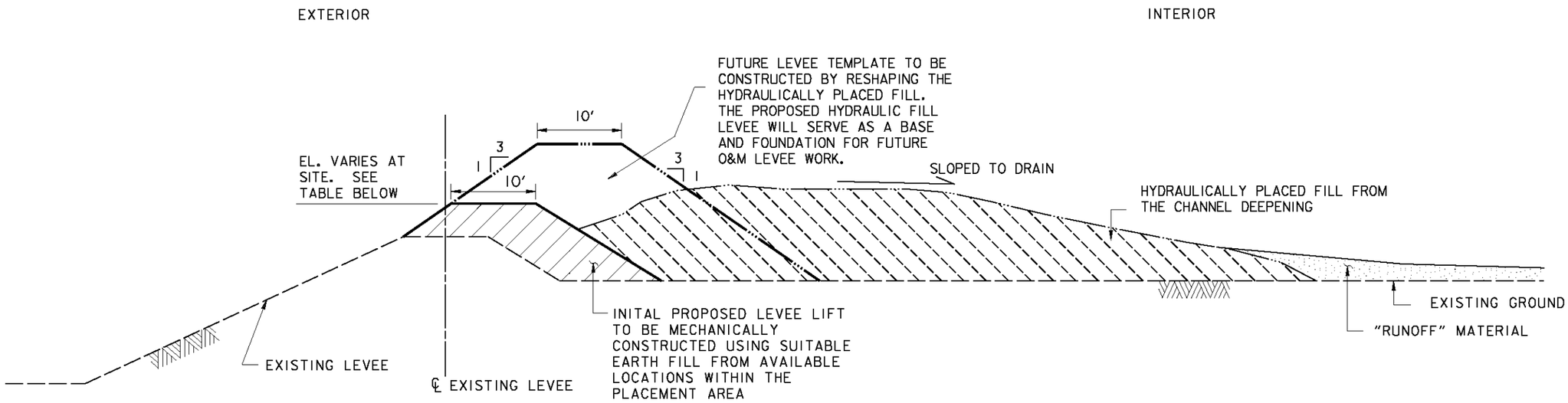
PREPARED UNDER THE DIRECTION OF
CHRISTOPHER W. SALLESE
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER

HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

GALVESTON HARBOR CHANNEL ALIGNMENT PLAN

Drawing No.:
C-05

File: W:\Cadd\Projects\Galv\Galveston Harbor PACR\Gal Har 45' Ext PACR\Civil Design\05 C05.dgn



TYPICAL SECTION
INITIAL LIFT & FUTURE HYDRAULIC FILL LEVEE
AT PELICAN ISLAND PLACEMENT AREA

N.T.S.

NOTES:

1. THE PROPOSED ELEVATIONS FOR LEVEE LIFTS, AS SHOWN IN THE TABLE, ARE BASED ON ESTIMATED INITIAL CAPACITY REQUIREMENTS FOR BOTH NEW WORK DREDGE MATERIALS FROM THE CHANNEL DEEPENING AND ANTICIPATED MAINTENANCE MATERIALS THAT MAY BE ENCOUNTERED ABOVE THE NEW WORK MATERIALS. THE EXISTING INTERIOR AND LEVEE ELEVATIONS, USED TO DETERMINE THE APPROPRIATE INITIAL LEVEE LIFT ELEVATIONS FOR SUFFICIENT INITIAL CAPACITY, ARE GENERALLY BASED ON SURVEY ELEVATIONS SHOWN ON PREVIOUS PLANS OR ESTIMATED. DURING THE PRODUCTION OF PLANS AND SPECIFICATIONS ASSOCIATED WITH THE GALVESTON CHANNEL EXTENSION, THE LEVEE LIFT ELEVATIONS AND REACHES PROPOSED ON THIS DRAWING MAY BE SUBJECT TO CHANGE, TO REFLECT FACTORS WHICH INCLUDE BUT MAY NOT BE LIMITED TO:
   1) MORE RECENT SURVEY DATA MADE AVAILABLE,
   2) CHANGES TO THE INTERIOR ELEVATIONS DUE TO ADDTIONAL DREDGE MAINTENANCE MATERIALS PLACED AT THE SITES PRIOR TO THE ISSUANCE OF PLAN AND SPECIFICATIONS FOR THIS PROJECT,
   3) CHANGES TO THE AMOUNT OF INITIAL ANTICIPATED MAINTENANCE MATERIAL TO BE DREDGED ALONG WITH NEW WORK MATERIALS FROM THE CHANNEL EXTENSION, DUE TO ADDITIONAL MAINTENANCE DREDGING PERFORMED PRIOR TO THE ISSUANCE OF PLANS AND SPECIFICATIONS FOR THIS PROJECT, OR
   4) CHANGES TO THE AMOUNT OF INITIAL ANTICIPATED MAINTENANCE MATERIAL AS A RESULT OF ADDITIONAL SEDIMENTATION ACCUMULATION PRIOR TO THE ISSUANCE OF PLANS AND SPECIFICATIONS.
2. THE INITIAL LEVEE LIFTS TO BE CONSTRUCTED PRIOR TO PLACEMENT OF HYDRUALIC FILL MATERIALS FROM THE CHANNEL, WILL BE CONSTRUCTED ALONG THE EXTERIOR LEVEES AT THE PLACEMENT AREA.
3. THE NEW WORK MATERIALS FROM THE CHANNEL WILL ONLY BE PLACED AND SHAPED ALONG THE INTERIOR OF THE EXTERIOR PERIMETER LEVEES.

INITIAL LEVEE LIFT ELEVATIONS (NAVD 88)

PLACEMENT AREA	CELL	LEVEE REACH	ESTIMATED APPROX. EXISTING LEVEE ELEVATION	PROPOSED INITIAL LEVEE LIFT ELEVATION
PELICAN ISLAND	B	ENTIRE PERIMETER LEVEE	28'	30'

U.S. Army Corps of Engineers
Galveston District

Rev.	Description	Date	By

BY:M3ECOANCY DATE:2/28/2013 TIME:1:55:04 PM

Drawn by: CM
Designed by: BB
Checked by: BB
Submitted by: LORI K. THOMAS, P.E., Chief, Geotech/Structure Section
Approved by: ROBERT G. WAGELL P.E., Deputy Chief, Engineering and Construction Division
Date: MARCH 2013
Rev.
Scale: AS SHOWN
Approval Recommended: JOSEPH L. KING, R.A., Chief, Engineering Branch

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

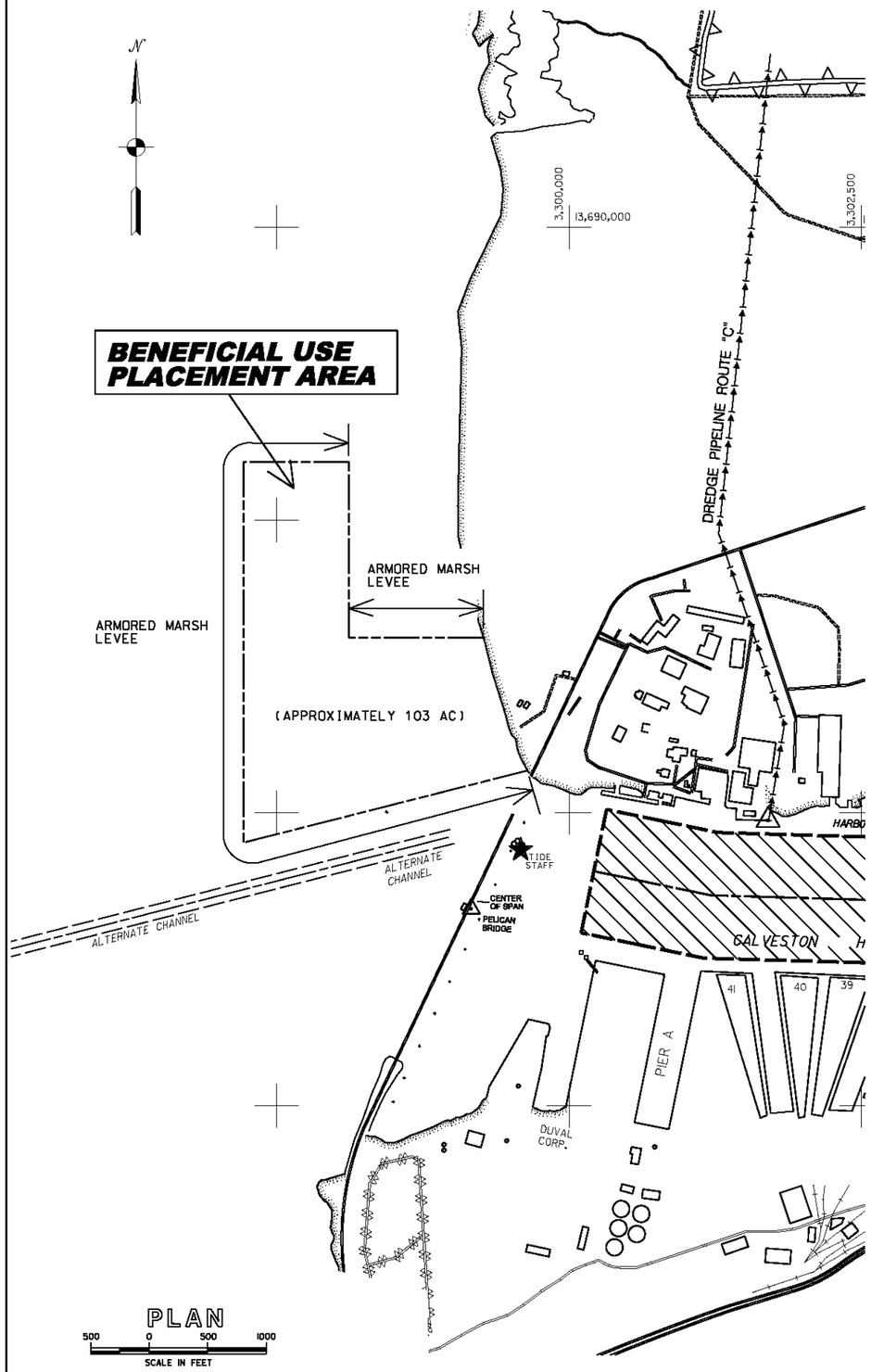
PREPARED UNDER THE DIRECTION OF
CHRISTOPHER W. SALLESE
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER

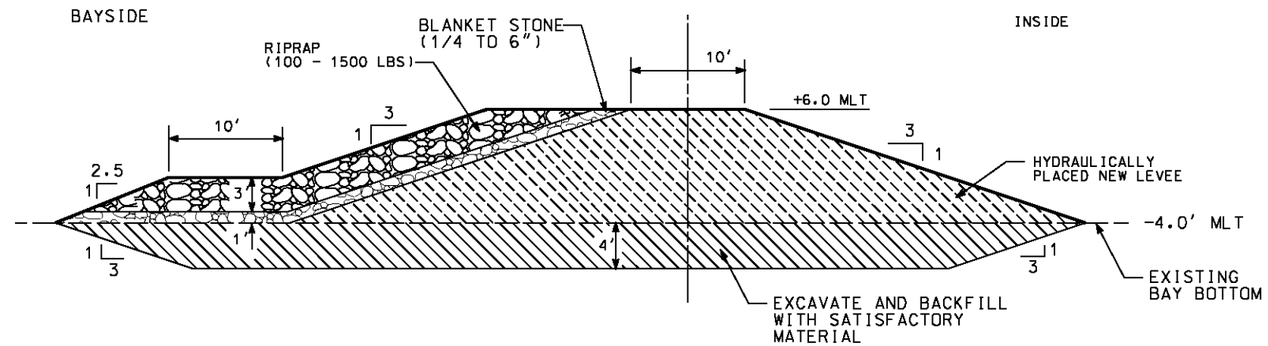
HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

TYPICAL SECTION
PROPOSED LEVEE ENLARGEMENT AT
PELICAN ISLAND

Drawing No.:
B-01

File: W:\Cadd\Projects\Galv\Galveston Harbor PACR\Gal Har 45' Ext PACR\Civil Design\07 B01 TYP LEVEE.DGN





TYPICAL CROSS SECTION – ARMORED MARSH LEVEE

N.T.S.

NOTES:

1. THE LEVEE SOIL TEMPLATE REMAINS THE SAME FOR LEVEE WITH AND WITHOUT STONE PROTECTION.
2. THE TOP 4' OF EXISTING LEVEE FOUNDATION MATERIAL SHALL BE EXCAVATED AS SHOWN AND BACKFILLED WITH SATISFACTORY MATERIAL FROM ADJACENT BORROW PITS.
3. THE NEW LEVEE SHALL BE FILLED USING HYDRAULICALLY PLACED NEW WORK MATERIAL FROM THE CHANNEL DREDGING OPERATIONS.

U.S. Army Corps of Engineers
Galveston District

Rev.	Description	Date	By

BY:MBECKNACY DATE:2/28/2013 TIME:1:56:52 PM

Drawn by: CM
Designed by: BB
Checked by: BB
Date: MARCH 2013
Scale: AS SHOWN
Submitted by: LORI K. THOMAS, P.E., Chief, Geotech/Structure Section
Approval Recommended: JOSEPH L. KING, R.A., Chief, Engineering Branch
Approved by: ROBERT SALVEMINI, P.E., Deputy Chief, Engineering and Construction Division

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

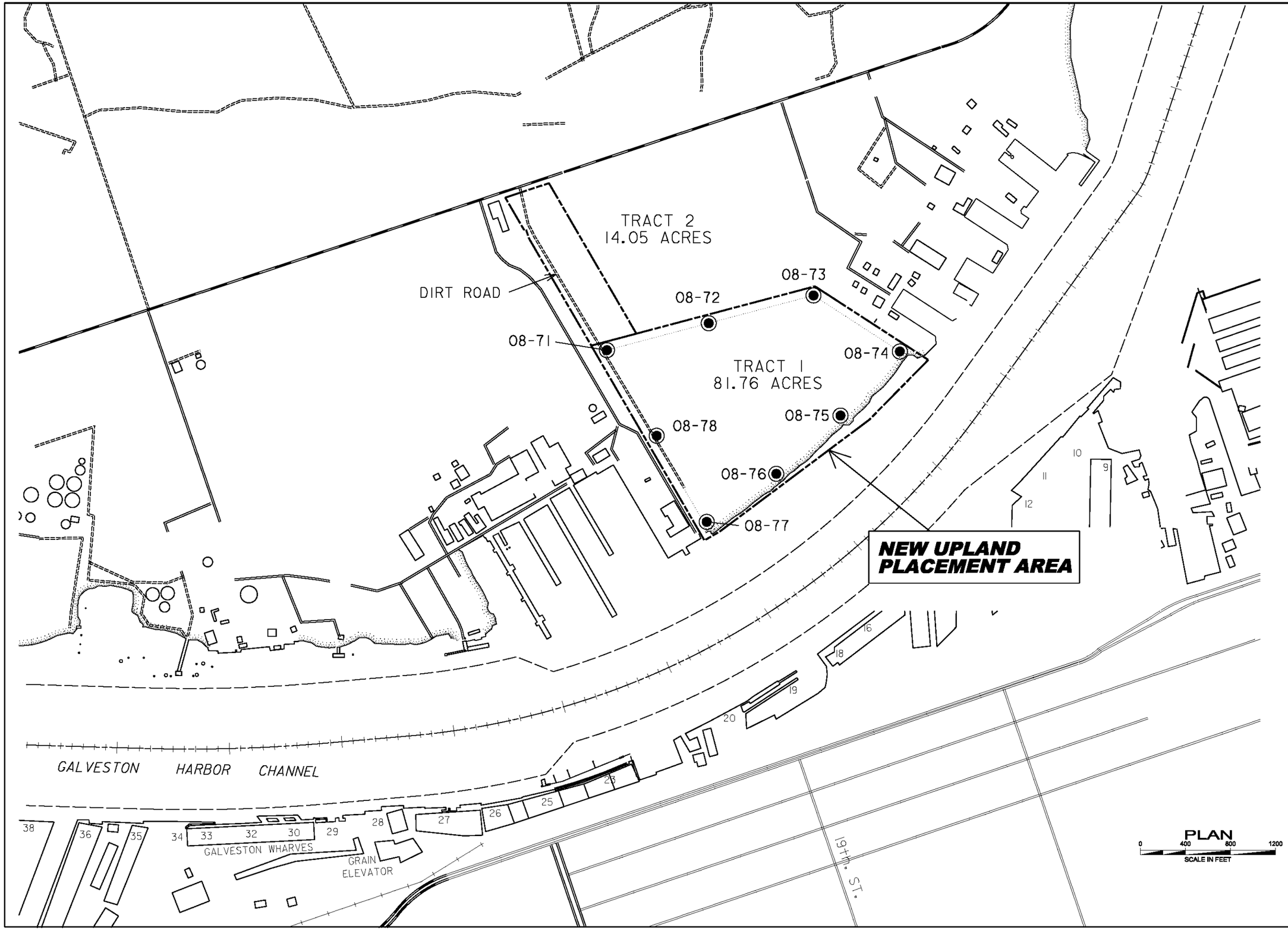
PREPARED UNDER THE DIRECTION OF
CHRISTOPHER W. SALLESE
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER

HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

BENEFICIAL USE
PLACEMENT AREA
CONCEPTUAL PLAN

Drawing No.:
B-02

File: W:\Cadd\Projects\Galv\Galveston Harbor PACR\Civil Design\08 B02.dgn



U.S. Army Corps of Engineers
Galveston District

Rev.	Description	Date	By

BY:M3ECOANCY DATE:2/28/2013 TIME:2:01:18 PM

Drawn by: NCY	Date: MARCH 2013	Rev.
Designed by: NCY	Scale: AS SHOWN	
Checked by: BS	Approval Recommended:	
Submitted by: LORI K. THOMAS, P.E. Chief, Geotech/Structure Section	JOSEPH L. KING, R.A. Chief, Engineering Branch	
Approved by: ROBERT M. WEBEL P.E. Deputy Chief, Engineering and Construction Division		

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
CHRISTOPHER W. SALLESE
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER

HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

NEW UPLAND PLACEMENT AREA BORING PLAN

Drawing No.:
B-03

File: W:\Cadd\Projects\Gal\Galveston Harbor PACR\Gal Har 45' Ext PACR\Civil Design\09 B03 New PA Boring Layout.dgn

Hole No. 08-71

BORING LOG | DISTRICT | INSTALLATION | SHEET 1 OF 1 SHEETS

1. PROJECT: Galveston Channel Extension - New Pelican Island PA
2. LOCATION (Coordinates or Station): N=13687753 E=3308107
3. DRILLING AGENCY: Dempsey (Geotest Engineering, Inc.)
4. LABORATORY TESTING AGENCY: Tolunay-Wong Engineers, Inc.
5. DEPTH OF WATER: ▽ TOD: ▼ 24-HR:
6. DEPTH OF HOLE: 25 ft
7. ELEVATION OF HOLE:
8. DATUM FOR ELEVATION:
9. ELEVATION OF GROUNDWATER: ▽ TOD: ▼ 24-HR:
10. DRILLING DATE and TIME: STARTED: COMPLETED:
11. CLASSIFICATION REFERENCE:
12. ENGINEER:

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			POORLY GRADED SAND WITH SILT (SP-SM), brown & gray, w/ roots & shell fragments		1									11.6
			SILTY SAND (SM), gray, w/ clay seams -w/ sand seams & calcareous nodules @ 2' - 4'		2			0.75	96.6	12.1				24.1
5			-brown & gray, w/ shell fragments @ 4' - 6'		3									
			-medium dense @ 6' - 7.5'		4		17							24.5
10			**FAT CLAY (CH)**, very soft, gray, w/ sand seams -w/ sand pockets @ 10' - 12'		5			0.0	64.5	58.3				
					6			0.0	68.2	55.0	69	22	47	92.2
15			-soft @ 14' - 16'		7			0.0	69.0	52.4				
			SILTY SAND (SM), very loose, gray, w/ clay seams		8		3							31.1
20			**FAT CLAY (CH)**, soft, gray, w/ sand seams		9			0.0	62.8	55.5	101	32	69	98.5
			SANDY LEAN CLAY (CL), very soft, gray, w/ sand seams		10			0.0	72.4	48.8				
					11			0.0	95.2	25.6				
25														
30														

SWG 1836 BOR 08.18.919.GPJ TOLUNAY-WONG ENGINEERS.GDT 12/5/08

ENG FORM: SWG 1836 BOR

Hole No. 08-72

BORING LOG | DISTRICT | INSTALLATION | SHEET 1 OF 1 SHEETS

1. PROJECT: Galveston Channel Extension - New Pelican Island PA
2. LOCATION (Coordinates or Station): N=13687954 E=3308830
3. DRILLING AGENCY: Dempsey (Geotest Engineering, Inc.)
4. LABORATORY TESTING AGENCY: Tolunay-Wong Engineers, Inc.
5. DEPTH OF WATER: ▽ TOD: ▼ 24-HR:
6. DEPTH OF HOLE: 25 ft
7. ELEVATION OF HOLE:
8. DATUM FOR ELEVATION:
9. ELEVATION OF GROUNDWATER: ▽ TOD: ▼ 24-HR:
10. DRILLING DATE and TIME: STARTED: COMPLETED:
11. CLASSIFICATION REFERENCE:
12. ENGINEER:

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			FAT CLAY (CH), firm, gray & brown -w/ roots & ferrous nodules @ 0' - 2'		1			0.75	75.3	42.3				
			-firm, w/ slickensides @ 2' - 4'		2			0.50	73.8	40.6	101	32	69	95
5			-very soft, w/ sand seams @ 4' - 6'		3			0.25	66.4	55.6				
			SILTY SAND (SM), medium dense, brown		4		4							13.2
10			**SANDY LEAN CLAY (CL)**, very soft to soft, gray, w/ sand seams		5			0.0	88.7	15.4				
					6			0.5		35.9				
15			**SILTY SAND (SM)**, gray -medium dense, w/ sand & clay seams @ 14' - 16'		7			0.0						19.8
					8		11							
			LEAN CLAY (CL), firm, gray		9		7			35.2				
20			**FAT CLAY (CH)**, very soft, gray, w/ sand seams & shell fragments		10			0.0	62.4	63.0	92	31	61	91.7
			SILTY SAND (SM), very loose, gray, w/ clay seams		11		2							
					12		3							
25														
30														

SWG 1836 BOR 08.18.919.GPJ TOLUNAY-WONG ENGINEERS.GDT 12/5/08

ENG FORM: SWG 1836 BOR

U.S. Army Corps of Engineers
Galveston District

Rev.	Description	Date	By

BY:MSECONCY DATE:2/28/2013 TIME:12:26:54 PM

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

Drawn by: GM
Designed by: BS
Checked by: BS
Submitted by:
Date: MARCH 2013
Scale: As shown
Approved/Recommended:
JOSEPH L. KING, P.A.
Chief, Engineering Division

PREPARED UNDER THE DIRECTION OF
CHRISTOPHER W. SALLESE
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER

HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

BORING LOGS

Drawing No.:
B-04

File: W:\Cadd\Projects\Galv\Galveston Harbor PACR\Geo\Har 46' Ext PACR\Geo\Design\10 B04.dgn

Hole No. 08-73

BORING LOG | DISTRICT | INSTALLATION | SHEET 1 OF 1 SHEETS

1. PROJECT: Galveston Channel Extension - New Pelican Island PA
2. LOCATION (Coordinates or Station): N=13688308 E=3309991
3. DRILLING AGENCY: Dempsey (Geotest Engineering, Inc.)
4. LABORATORY TESTING AGENCY: Tolunay-Wong Engineers, Inc.
5. DEPTH OF WATER: ▽ TOD: ▼ 24-HR:
6. DEPTH OF HOLE: 25 ft
7. ELEVATION OF HOLE:
8. DATUM FOR ELEVATION:
9. ELEVATION OF GROUNDWATER: ▽ TOD: ▼ 24-HR:
10. DRILLING DATE and TIME: STARTED: COMPLETED:
11. CLASSIFICATION REFERENCE:
12. ENGINEER:

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			POORLY GRADED SAND WITH SILT (SP-SM), brown, w/ roots & shell fragments		1									9
			SILTY SAND (SM), brown & gray, w/ shell & clay seams		2									26.8
5					3									
			FAT CLAY (CH), soft, brown & gray, w/ shell fragments -w/ calcareous & ferrous nodules @ 6' - 8' -very stiff, gray below 8'		4			0.50	77.5	42.5				
					5			0.25	56.3	74.0	95	30	65	94.7
10			-w/ sand pockets @ 10' - 12'		6			0.25	77.5	46.0				
			SILTY SAND (SM), medium dense, gray -w/ shell fragments @ 12' - 18.5' -w/ clay seams @ 12' - 13.5'		7		16							
15			-loose below 17'		8		10							31.7
20					9		9							
			FAT CLAY (CH), firm, gray, w/ sand seams & pockets		10		6			66.4				
25														
30														

SWG 1836 BOR 08.18.919.GPJ TOLUNAY-WONG ENGINEERS.GDT 12/5/08

ENG FORM: SWG 1836 BOR

Hole No. 08-74

BORING LOG | DISTRICT | INSTALLATION | SHEET 1 OF 1 SHEETS

1. PROJECT: Galveston Channel Extension - New Pelican Island PA
2. LOCATION (Coordinates or Station): N=13687730 E=3310707
3. DRILLING AGENCY: Dempsey (Geotest Engineering, Inc.)
4. LABORATORY TESTING AGENCY: Tolunay-Wong Engineers, Inc.
5. DEPTH OF WATER: ▽ TOD: ▼ 24-HR:
6. DEPTH OF HOLE: 25 ft
7. ELEVATION OF HOLE:
8. DATUM FOR ELEVATION:
9. ELEVATION OF GROUNDWATER: ▽ TOD: ▼ 24-HR:
10. DRILLING DATE and TIME: STARTED: COMPLETED:
11. CLASSIFICATION REFERENCE:
12. ENGINEER:

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLAST C LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			FAT CLAY (CH), very stiff-hard, brown & gray, w/ roots & shell fragments		1			4.50	95.8	23.7				
			SANDY LEAN CLAY (CL), very stiff, brown & gray, w/ shell fragments & sand seams		2			4.50	105.0	16.3	48	19	29	61.9
5			**POORLY GRADED GRAVEL (GP)**, gray, w/ sand seams		3					3.8				
			FAT CLAY (CH), very soft, gray		4			0.0		34.4				
			-w/ sand seams @ 8' - 10'		5			0.0	52.3	83.2	90	31	59	94.9
10			**SILTY SAND (SM)**, loose, gray, w/ clay seams -w/ shell fragments @ 10' - 22'		6		10							20.1
15			-medium dense below 15'		7		21							
20					8		16							18
25					9		17							
30														

SWG 1836 BOR 08.18.919.GPJ TOLUNAY-WONG ENGINEERS.GDT 12/5/08

ENG FORM: SWG 1836 BOR

U.S. Army Corps of Engineers
Galveston District

Rev.	Description	Date	By

BY: MCBEDONCY DATE: 2/28/2013 TIME: 12:37:28 PM

Drawn by: Date: MARCH 2013 Rev.
Designed by: CAA Scale:
Checked by: Approved Recommended:
Submitted by: JOSEPH L. KING, R.A.
LORI K. THOMAS, P.E. Geotech/Structures Section Chief, Engineering Branch
Approved by: CHRISTOPHER W. SALLESE, P.E. Chief, Engineering and Construction Division
Approved by: PREPARED UNDER THE DIRECTION OF CHRISTOPHER W. SALLESE COLONEL, CORPS OF ENGINEERS DISTRICT COMMANDER

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

BORING LOGS

Drawing No.: B-05

File: W:\Cad\Projects\Gal\Galveston Harbor PACR\Dist Her 45 Ext PACR\Civil Design\11 B05.dgn

Hole No. 08-75

BORING LOG

DISTRICT	
INSTALLATION	
SHEET 1 OF 1 SHEETS	
1. PROJECT	Galveston Channel Extension - New Pelican Island PA
2. LOCATION (Coordinates or Station)	N=13687180 E=3310181
3. DRILLING AGENCY	Dempsey (Geotest Engineering, Inc.)
4. LABORATORY TESTING AGENCY	Tolunay-Wong Engineers, Inc.
5. DEPTH OF WATER	▽ TOD: ▼ 24-HR:
6. DEPTH OF HOLE	25 ft
7. ELEVATION OF HOLE	
8. DATUM FOR ELEVATION	
9. ELEVATION OF GROUNDWATER	▽ TOD: ▼ 24-HR:
10. DRILLING DATE and TIME	STARTED: COMPLETED:
11. CLASSIFICATION REFERENCE	
12. ENGINEER	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			FAT CLAY (CH), stiff, brown & gray, w/ roots & sand seams		1			2.50	94.8	21.4				
			LEAN CLAY (CL), soft, brown & gray, w/ roots, sand pockets & seams		2			0.50	88.1	30.2				
5			**SANDY FAT CLAY (CH)**, firm, brown & gray, w/ roots & sand seams		3			0.50	87.8	32.5	58	21	37	57.7
			LEAN CLAY (CL), soft, gray, w/ shell fragments, sand pockets & seams		4			0.50	69.3	50.6				
			SILTY SAND (SM), medium dense, gray, w/ shell fragments		5		17							12.3
10			-w/ clay seams @ 13' - 14.5'		6		23							
15			-dense @ 18' - 22.5'		7		39							13.1
20			-w/ clay seams below 21'		8		49							
					9		14							
25														
30														

SWG 1836 BOR 08.18.919.GPJ TOLUNAY-WONG ENGINEERS.GDT 12/5/08

ENG FORM: SWG 1836 BOR

Hole No. 08-76

BORING LOG

DISTRICT	
INSTALLATION	
SHEET 1 OF 1 SHEETS	
1. PROJECT	Galveston Channel Extension - New Pelican Island PA
2. LOCATION (Coordinates or Station)	N=13686640 E=3309627
3. DRILLING AGENCY	Dempsey (Geotest Engineering, Inc.)
4. LABORATORY TESTING AGENCY	Tolunay-Wong Engineers, Inc.
5. DEPTH OF WATER	▽ TOD: ▼ 24-HR:
6. DEPTH OF HOLE	25 ft
7. ELEVATION OF HOLE	
8. DATUM FOR ELEVATION	
9. ELEVATION OF GROUNDWATER	▽ TOD: ▼ 24-HR:
10. DRILLING DATE and TIME	STARTED: COMPLETED:
11. CLASSIFICATION REFERENCE	
12. ENGINEER	

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			SILTY SAND (SM), brown & gray -w/ roots & shell fragments @ 0' - 2'		1									12.7
			-w/ sand seams @ 2' - 4'		2			0.75		11.9				
5			**SANDY FAT CLAY (CH)**, firm, brown & gray, w/ sand seams		3			0.75	90.7	29.4	50	19	31	64.7
			POORLY GRADED SAND WITH SILT (SP-SM), firm, gray, w/ clay seams		4		8							10.7
10			**FAT CLAY (CH)**, stiff, gray, w/ sand seams & shell fragments		5		18							
15			**SILTY SAND (SM)**, medium dense, gray, w/ clay seams & shell fragments		6		11							22.8
20			-loose @ 21' - 22.5'		7		10							
					8		19							
25														
30														

SWG 1836 BOR 08.18.919.GPJ TOLUNAY-WONG ENGINEERS.GDT 12/5/08

ENG FORM: SWG 1836 BOR

U.S. Army Corps of Engineers
Galveston District

Rev.	Description	Date	By

BY:M9ECONCY DATE:2/28/2013 TIME:12:31:22 PM

Drawn by: GM
Designed by: RS
Checked by: BS
Date: MARCH 2013
Scale: As shown
Submitted by: LORI K. HUMAN, P.E., Project Manager/Hydraulic Engineer
Approved by: JOSEPH L. KING, R.A., Chief, Engineering Division
Approved by: ROBERT B. SYRELL, P.E., Deputy Chief, Engineering and Construction Division

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
CHRISTOPHER W. SALLESE
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER

HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

BORING LOGS

Drawing No.:
B-06

File: W:\Cadd\Projects\Gal\Galveston Harbor PACR\Gal Her 45' Ext PACR\Cmll Design\12 B06.dgn

Hole No. 08-77

BORING LOG | DISTRICT | INSTALLATION | SHEET 1 OF 1 SHEETS

1. PROJECT: Galveston Channel Extension - New Pelican Island PA
2. LOCATION (Coordinates or Station): N=13686202 E=3308998
3. DRILLING AGENCY: Dempsey (Geotest Engineering, Inc.)
4. LABORATORY TESTING AGENCY: Tolunay-Wong Engineers, Inc.
5. DEPTH OF WATER: ▽ TOD: ▼ 24-HR:
6. DEPTH OF HOLE: 25 ft
7. ELEVATION OF HOLE:
8. DATUM FOR ELEVATION:
9. ELEVATION OF GROUNDWATER: ▽ TOD: ▼ 24-HR:
10. DRILLING DATE and TIME: STARTED: COMPLETED:
11. CLASSIFICATION REFERENCE:
12. ENGINEER:

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			LEAN CLAY WITH SAND (CL), very stiff-hard, gray & brown, w/ roots, shell fragments & sand seams		1			4.50	104.0	13.0				
			SILTY SAND (SM), gray -w/ plastic @ 2' - 3' -w/ clay balls @ 2' - 4'		2									31.3
5			-w/ plastic @ 4' - 5' -w/ slickensides, sand seams & roots @ 4' - 6'		3			0.25						19.7
			FAT CLAY (CH), very soft, gray, w/ sand seams & shell fragments		4			0.25	76.3	46.1				
			SILTY SAND (SM), dense, gray		5		35							
10														
			POORLY GRADED SAND WITH SILT (SP-SM), dense, gray, w/ shell fragments		6		32							7
15														
			SILTY SAND (SM), dense, gray, w/ shell fragments		7		49							
20			**CLAYEY SAND (SC)**, gray, w/ sand seams		8			0.25	81.5	38.5	39	20	19	47.7
			LEAN CLAY WITH SAND (CL), very soft, gray, w/ shell fragments & sand seams		9			0.0		32.9				
25														
30														

SWG 1836 BOR 08.18.919.GPJ TOLUNAY-WONG ENGINEERS.GDT 12/5/08

ENG FORM: SWG 1836 BOR

Hole No. 08-78

BORING LOG | DISTRICT | INSTALLATION | SHEET 1 OF 1 SHEETS

1. PROJECT: Galveston Channel Extension - New Pelican Island PA
2. LOCATION (Coordinates or Station): N=13686997 E=3308543
3. DRILLING AGENCY: Dempsey (Geotest Engineering, Inc.)
4. LABORATORY TESTING AGENCY: Tolunay-Wong Engineers, Inc.
5. DEPTH OF WATER: ▽ TOD: ▼ 24-HR:
6. DEPTH OF HOLE: 25 ft
7. ELEVATION OF HOLE:
8. DATUM FOR ELEVATION:
9. ELEVATION OF GROUNDWATER: ▽ TOD: ▼ 24-HR:
10. DRILLING DATE and TIME: STARTED: COMPLETED:
11. CLASSIFICATION REFERENCE:
12. ENGINEER:

DEPTH (ft)	ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	NUMBER	RECOVERY (%)	SPT (N)	PENETROMETER (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (% <200)
			FAT CLAY (CH), firm, brown -w/ roots & shell fragments @ 0' - 2'		1			1.25	88.5	34.2				
			-soft @ 2' - 4' -brown & gray @ 2' - 6'		2			0.50	70.8	48.3	72	23	49	97.9
5			-w/ ferrous nodules @ 4' - 6'		3			0.75	63.6	61.0				
			-soft @ 6' - 10'		4			0.50	64.4	59.5	116	30	86	
			-brown & gray @ 8' - 14'		5			0.50	72.1	50.2				
10			-w/ shell fragments @ 10' - 12' -w/ sand seams below 10'		6			0.75	72.2	54.3				
			-w/ ferrous & calcareous nodules @ 12' - 14'		7			0.75	84.5	34.8				
15			-very soft, w/ sand partings & pockets @ 14' - 16'		8			0.0		62.4				
			CLAYEY SAND (SC), dense, gray		9			0.0	89.7	33.8	44	20	24	47.4
			SILTY SAND (SM), dense, gray -w/ clay seams @ 18' - 19.5'		10		37							
20					11		40							12.7
			-w/ clay seams @ 23.5' - 25'		12		39							
25														
30														

SWG 1836 BOR 08.18.919.GPJ TOLUNAY-WONG ENGINEERS.GDT 12/5/08

ENG FORM: SWG 1836 BOR

U.S. Army Corps of Engineers
Galveston District

Rev.	Description	Date	By

BY:149ECONCY DATE:2/28/2013 TIME:12:26:25 PM

Drawn by: GM
Designed by: NS
Checked by: NS
Scale: As shown
Date: March 2013
Approved: JOSEPH L. KING, P.A.
Chief, Engineering Division

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

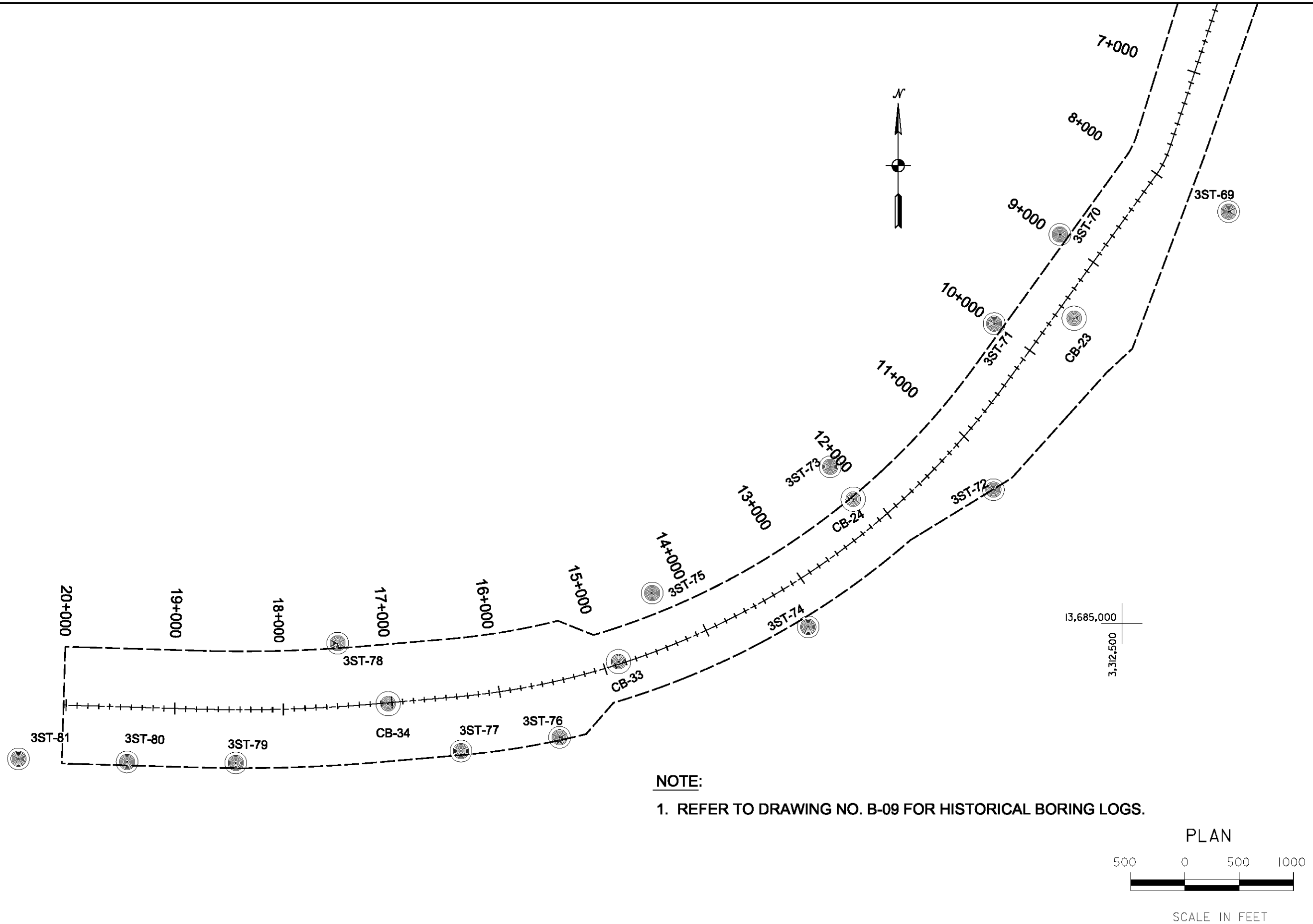
PREPARED UNDER THE DIRECTION OF
CHRISTOPHER W. SALLESE
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER

HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

BORING LOGS

Drawing No.:
B-07

File: W:\Cadd\Projects\Gal\Galveston Harbor PACR\Gal Her 45' Ext PACR\Cfd Designs\B07.dgn



NOTE:

1. REFER TO DRAWING NO. B-09 FOR HISTORICAL BORING LOGS.

U.S. Army Corps of Engineers
Galveston District

Rev.	Description	Date	By

BY:M3ECOANCY DATE:2/28/2013 TIME:12:38:31 PM

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
CHRISTOPHER W. SALLESE
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER

Drawn by:	HCY	Date:	MARCH 2013
Designed by:	HCY	Rev.	
Checked by:	BB	Scale:	AS SHOWN

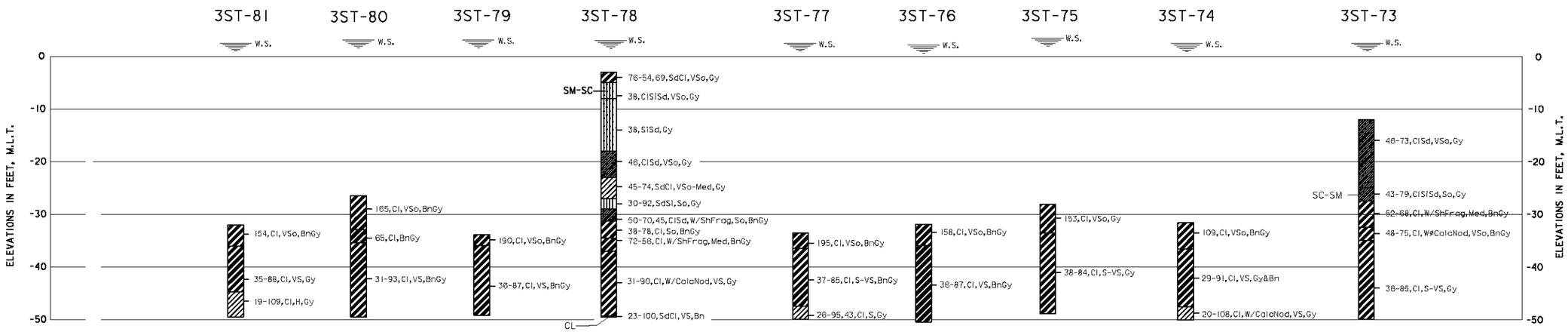
Submitted by: DAVID R. BROWN, P.E., Chief, General Engineering
Approved by: ROBERT A. WAGELI, P.E., Deputy Chief, Engineering and Construction Division
Approval Recommended: JOSEPH L. KING, R.A., Chief, Engineering Branch

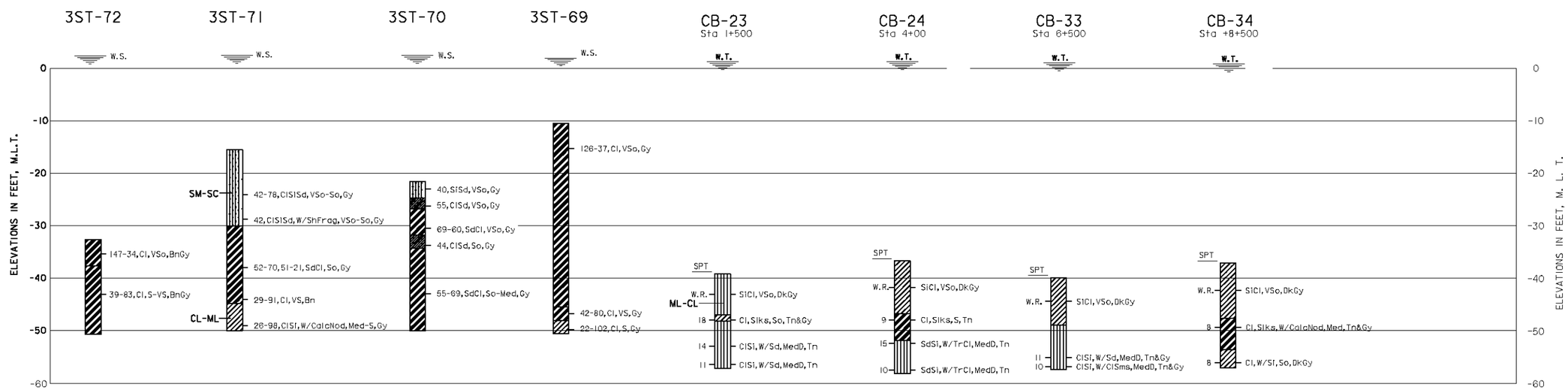
HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

HISTORICAL BORINGS
LOCATION PLAN

Drawing No.:
B-08

File: W:\Cadd\Projects\Galv\Galveston Harbor PACR\Gal Har 45' Ext PACR\Civil Design\14 B08 GALV CH BORING PLAN.dgn





U.S. Army Corps of Engineers
Galveston District

Rev.	Description	Date	By

BY:M3EDANCY DATE:2/28/2013 TIME:12:36:05 PM

Drawn by:	PR	Date:	MARCH 2013
Designed by:	BB		
Checked by:	BB	Scale:	AS SHOWN
Submitted by:		Approval Recommended:	
LORI K. THOMAS, P.E., Chief, Geotech/Structure Section		JOSEPH L. KING, R.A. Chief, Engineering Branch	
Approved by: ROBERT A. MORELL P.E. Deputy Chief, Engineering and Construction Division			

U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS

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CHRISTOPHER W. SALLESE
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER

HOUSTON-GALVESTON
NAVIGATION CHANNEL, TEXAS
POST AUTHORIZATION CHANGE REPORT
GALVESTON HARBOR CHANNEL EXTENSION

BORING LOGS

Drawing No.:
B-09

File: W:\Cadd\Projects\Geo\Galveston Harbor PACR\Gal Har 45' Ext PACR\Civil Design\15 B09 BRG LOGS.dgn