# FINAL REPORT FREEPORT HARBOR, TEXAS CHANNEL IMPROVEMENT PROJECT

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## COMMUNICATION

FROM

## THE ASSISTANT SECRETARY, ARMY, CIVIL WORKS, THE DEPARTMENT OF DEFENSE

TRANSMITTING

THE FREEPORT HARBOR CHANNEL IMPROVEMENT PROJECT, BRAZORIA COUNTY, TEXAS FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT

## PART 1 OF 2

JULY 8, 2013.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

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DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

MAY 31 2013

Honorable John Boehner
Speaker of the House
of Representatives
U.S. Capitol Building, Room H-232
Washington, D.C. 20515-0001

Dear Mr. Speaker:

In response to a study conducted under the authority of Section 216 of the Flood Control Act of 1970, the Secretary of the Army supports the authorization and construction of the Freeport Harbor Channel Improvement Project (FHCIP), Brazoria County, Texas. The proposal is described in the report of the Chief of Engineers, dated January 7, 2013, which includes other pertinent reports and comments. The Secretary of the Army plans to implement the project at the appropriate time, considering National priorities and the availability of funds.

The recommended plan would contribute to the economic efficiency of commercial navigation in Freeport Channel by allowing the current fleet of ships to load approximately 17 to 24 percent more cargo, thereby reducing lightering costs. The proposed improvements would also accommodate a shift to larger, more efficient, vessels and would ensure the safety of vessels transiting the channel under difficult wind and wave conditions. The proposed project consists of the following improvements: 1) Deepen the Outer Bar Channel into the Gulf of Mexico to -58 feet mean lower low water (MLLW); 2) Deepen from the end of the jetties in the Gulf of Mexico to the Lower Turning Basin to -56 feet MLLW; 3) Deepen from the Lower Turning Basin to Station 132+66 near the Brazosport Turning Basin to -56 feet MLLW; 4) Deepen from the Brazosport Turning Basin, through the Upper Turning Basin to -51 feet MLLW; 5) Deepen and widen the lower 3,700 feet of the Stauffer Channel to -51 feet MLLW with a width of 300 feet; and 6) Dredge the remainder of the Stauffer Channel to -26 feet MLLW.

Material from the inland Freeport Harbor channels and basins would be placed in one existing confined upland Placement Area (PA 1), and two new Placement Areas (PA 8 and PA 9). Mitigation features would consist of the preservation of approximately 131 acres of riparian forest under a permanent conservation easement and the improvement of its habitat value by establishing 11 acres of riparian forest in place of 11 acres of invasive tree species; the creation of 3 acres of wetlands and an associated 1 acre of riparian forest; and required monitoring of mitigation performance and impacts to wetlands and riparian forest for corrective action, if needed.

The recommended navigation plan is the Locally Preferred Plan (LPP), rather than the National Economic Development (NED) plan. All the features of the recommended LPP would be shallower and less costly than the NED plan, except for the recommendation of a dredging depth in the Lower Stauffer channel of -51 feet, which is also part of the NED plan. The additional depth would accommodate current and future containership traffic that is constrained because of a lack of workable tide. A request to grant an exception to the NED plan was submitted to our office for review and was approved on November 30, 2010.

Based on October 2012 (FY13) price levels, the estimated project first cost for the LPP is $237,474,000, which includes constructing the General Navigation Features (GNFs) and the value of lands, easements, rights of-way and relocations (LERRs). The estimated costs are as follows: $208,079,000 for channel modification and dredged material placement; $165,000 for fish and wildlife mitigation; $18,135,000 for preconstruction, engineering and design efforts; $9,404,000 for construction management; and $1,691,000 for LERRs (except utility relocations) provided by the non-federal sponsor. Associated costs include aids to navigation at an estimated $1,383,000 and $58,497,000 for local service facilities (berth deepening and related improvements), for which the non-federal sponsor would be 100 percent responsible and are excluded from the project first cost.

For the purpose of annualization and economic comparison, the total of the project first cost for the LPP and the associated costs are estimated at $297,354,000. At a discount rate of 3.75 percent and a 50-year period of economic analysis, the average annual benefits are estimated at $48,042,000 and the average annual costs are estimated at $25,449,000. The net benefits are $22,593,000 and the benefit cost ratio is 1.9 to 1. The incremental annual cost of operation and maintenance (O&M) for the recommended plan is estimated at $11,371,000 and is included in the average annual cost calculation. Cost sharing for O&M is in accordance with Section 101(b) of WRDA 1986, as amended. It would be 100 percent federal for depths under 45 feet and 50 percent federal and 50 percent non-federal for depths over 45 feet. The annual costs are estimated at $6,254,000 federal and $5,117,000 non-federal for O&M.

By comparison, the project first cost of the NED plan is estimated to be $341,157,000. Annual costs and benefits for the NED plan are estimated at $32,389,000 and $76,858,000, respectively, with net benefits of $44,469,000 and a benefit cost ratio of 2.4 to 1.

The Port of Freeport fully supports the LPP and is legally capable of fulfilling the requirements to be the non-federal sponsor for construction. Based on a GNF cost of $235,783,000, cost sharing is applied in accordance with the provisions of Section 101(a) of WRDA 1986, as amended. The federal cost would be about $121,132,000 and the non-federal cost would be about $116,342,000. The specific cost sharing for each component is as follows: for the Upper and Lower Stauffer Channels, 90 percent federal and 10 percent non-federal for the zone between -18 and -20 feet at a cost of $769,000 and $85,000, respectively; 75 percent federal and 25 percent

non-federal for the zone between -20 and -45 feet, at a cost of $8,686,000 and $2,897,000, respectively; and 50 percent federal and 50 percent non-federal for the depths greater than -45 feet in the Lower Stauffer channel only, at a cost of $1,019,000 each. For the deepening of the main Freeport Harbor channels from the existing -46-foot depth to -56 feet (-58 feet offshore), cost sharing is 50 percent federal and 50 percent non-federal, for a cost of $110,520,000 each in this zone.

In addition to the GNF costs, the non-federal sponsor must pay an additional 10 percent of the GNF in cash over a period not to exceed 30 years, with interest, minus the value of LERRs. The additional 10 percent payment without interest is estimated to be $23,578,000, with credit for LERRs of $1,691,000, yielding an estimated non-federal cash contribution of $21,887,000. Finally, the cost for environmental mitigation would be shared at a rate of 51.4 percent by the federal government and 48.6 percent by the non-federal sponsor or $137,000, federal and $130,000 non-federal.

The Corps has responded to all resource agency and interested party comments and there are no outstanding environmental concerns. An Independent External Peer Review (IEPR) was conducted before finalization of the feasibility report and the Corps satisfactorily addressed all critical issues raised by the IEPR panel.

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress and concludes that the report recommendation is consistent with the policy and programs of the President. However, OMB also noted that should the Congress authorize this project for construction, it would need to compete with other proposed investments for funding in future budgets. A copy of OMB's letter, dated May 22, 2013, is enclosed. I am providing a copy of this transmittal and the OMB letter to the Subcommittee on Water Resources and Environment of the House Committee on Transportation and Infrastructure, and the Subcommittee on Energy and Water Development of the House Committee on Appropriations. I am also sending an identical letter to the President of the Senate.

Very truly yours,

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

Enclosures

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9 Enclosures

1. Record of Decision May 2013
2. OMB clearance letter, May, 22, 2013
3. Report of the Chief of Engineers, Jan 7, 2013
4. Letter from Dept of Agriculture (NRCS), Sep 5, 2012
5. Letter from USDOT Nov 9, 2012
6. Letter from EPA, Oct 5, 2012
7. Letter of support from Port Freeport, Jul 12, 2012
8. Summary for Office of the Parliamentarian
9. Freeport Harbor TX Harbor Channel Improvement Project Feasibility Report and Environmental Impact Statement, September 2012 (w Dec 2012 Addendum) (DVD)

RECORD OF DECISION

FREEPORT HARBOR CHANNEL IMPROVEMENT PROJECT
BRAZORIA COUNTY, TEXAS

The Feasibility Report (FR) and the Final Environmental Impact Statement (FEIS), each dated September 2012, and the report of the Chief of Engineers, dated January 7, 2013, for the Freeport Harbor Channel Improvement Project (FHCIP), Brazoria County, Texas, address navigation improvement opportunities at Freeport, Texas. Based on these reports, the reviews of other federal, state and local agencies, input from the public, and the review by my staff, I find the plan recommended by the Chief of Engineers to be technically feasible, economically justified, environmentally acceptable and in the public interest. Thus, I approve the FHCIP for construction.

The FR and the FEIS document the evaluation of both structural and non-structural alternatives for Freeport Harbor. The recommended plan is the -56 feet mean lower low water (MLLW) x 600-foot plan, which is also the environmentally preferable alternative and the plan preferred by the local sponsor. The recommended plan consists of the following modifications to the existing Freeport Harbor project:

a. Deepening and extending the Outer Bar Channel 1.3 miles farther into the Gulf of Mexico at a depth of -58 feet (MLLW) and a width of 600 feet;
b. Deepening the Jetty Channel, the Lower Turning Basin and the Main Channel through Station 132+66 to -56 feet MLLW;
c. Widening the Brazosport Turning Basin to 1,200 feet;
d. Deepening from Station 132+66 through the Upper Turning Basin to -51 feet MLLW;
e. Deepening and widening the lower 3,700 feet of the Stauffer Channel to -51 feet MLLW and 300 feet in width;
f. Dredging the remainder of the Stauffer Channel to -26 feet MLLW (its previously authorized depth was -30 feet) at the existing 200 feet in width;
g. Compensatory mitigation consisting of:
    - Preservation of approximately 131 acres of riparian forest and improvement of its habitat value by replacement of 11 acres of invasive tree species;
    - Creation of 3 acres of wetlands and an associated 1 acre of riparian forest;
    - Monitoring of mitigation performance for corrective action, if needed.

The "no action" alternative assumed that the non-federal sponsor (Port Freeport) would accomplish construction to widen specific channel reaches before construction of the FHCIP. This was the expected future condition against which all other project alternatives and impacts were compared. In addition to this "no action" plan, eight structural alternatives and two non-structural alternatives were evaluated as described in the FR and the FEIS, which are incorporated herein by reference. The structural alternatives included various increases to the existing channel depths and widths as outlined in the FEIS. The non-structural alternatives included pilot rules and lightering.

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The Draft Feasibility Report and Draft Environmental Impact Statement were circulated for public review for 45 days starting on December 23, 2010. A public meeting was held on January 13, 2011 in Freeport, Texas. All comments submitted on the draft report were responded to in the FEIS. Additional comment letters were received on the FEIS. No objections to the project were expressed.

All practicable means to avoid or minimize environmental effects have been incorporated into the recommended plan. The primary project impacts would be the loss of 21 acres of riparian forest and 39 acres of ephemeral wetlands which result from construction of new dredged material placement areas. The compensatory mitigation plan would fully address all unavoidable significant impacts. Port Freeport has agreed to grant a conservation easement to an appropriate state agency or organization for the mitigation lands.

Technical and economic criteria used in the formulation of alternative plans were those specified in the Water Resource Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. All applicable laws, executive orders, regulations and guidelines were considered in the evaluation of alternatives and the selection of the recommended plan. The U.S. Army Corps of Engineers has determined that the recommended plan is fully consistent to the maximum extent practicable with the Texas Coastal Management Plan. Water Quality Certification under Section 401 of the Clean Water Act has been received from the State of Texas. Based on review of these evaluations, I find that the public interest would best be served by implementing the recommended plan. This Record of Decision completes the National Environmental Policy Act process.

May 31, 2013
Date

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

May 22, 2013

The Honorable Jo-Ellen Darcy
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon
Washington, DC 20310-0108

Dear Ms. Darcy:

As required by Executive Order 12322, the Office of Management and Budget has reviewed a March 2012 Army Corps of Engineers (Corps) feasibility study (report) that proposes construction of a set of channel improvements at the Port of Freeport, Brazoria County, Texas, at a first cost of $237.5 million (October 2012 prices).

Based on the Corps estimate of the benefits and costs of the project in this report, OMB has concluded that this project would be consistent with the policy and programs of the President. More specifically, the report estimates that the benefit-cost ratio for the project is 1.9 to 1 at the Federal Water Resources discount rate of 3.75 percent. However the BCR is 1.3 to 1 at a discount rate of seven percent. Seven percent rate is the discount rate that the Administration uses for budgeting to measure the performance of Corps construction projects whose primary purpose is to provide an economic return to the Nation.

However, the underlying analysis supporting the report's economic conclusions contains a significant amount of uncertainty about future traffic and this uncertainty could result in a lower return to the Nation than reported. Analysis results are highly dependent on future traffic levels, particularly for imports of crude petroleum. Reduced transportation costs for imports of crude petroleum to this port account for 72 percent of the total estimated benefits and the report assumes that after the channel deepening, imports of this commodity to this port will grow by 2.2 percent per year on average over the next 20 to 30 years. By comparison, crude petroleum imports to this port have been relatively flat or seen only modest gains over the past 10 years. At an assumed "no growth" traffic level, the project would not be economically justified at a seven percent discount rate. Also, the Corps used commodity forecasts from an international consulting firm that regularly updates to its forecasts according to the latest business conditions, nationally as well as regionally (in this case, all U.S. ports in the Gulf of Mexico considered together). The report used commodity forecasts from about 2010. The consultant's most recent forecasts for U.S. crude petroleum imports, both nationally and in the Gulf region predict that crude petroleum imports will only grow by an average of about one percent per year over the next 20 years. In addition, Energy Information Administration expects a modest drop in crude petroleum imports nationwide over the same period. At an assumed one percent rate of growth

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for crude oil imports the project is marginally justified with a BCR of 1.4 at a 3.75 percent discount rate and a BCR of 1.0 at a seven percent discount rate.

The Office of Management and Budget does not object to your submitting this report to Congress. However, when you do so, please advise the Congress that the Administration will be requesting the Corps, after it completes all pre-construction design and engineering work on this project, to update and refine its estimates of the benefits and costs, before determining whether to recommend funding to construct this project. Furthermore, as with all civil works projects, this project will need to compete with other proposed investments for funding in future budgets.

Thank you for your assistance and for the assistance of your staff during our review of this project.

Sincerely,

John C. Pasquantino
Deputy Associate Director
Energy, Science, and Water

DEPARTMENT OF THE ARMY
CHIEF OF ENGINEERS
2600 ARMY PENTAGON
WASHINGTON, DC 20310-2600

JAN 7 2013

DAEN

SUBJECT: Freeport Harbor Channel Improvement Project, Brazoria County, Texas

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on navigation improvements for the Freeport Harbor Channel Improvement Project (FHCIP). It is accompanied by the report of the Galveston District Engineer and the Southwestern Division Engineer. The feasibility study was conducted under the authority of Section 216 of the Flood Control Act of 1970, which authorizes review of completed Corps of Engineers navigation projects when significant changes in physical or economic conditions have occurred, and the submission of a report to Congress on the advisability of modifying the project in the overall public interest. Pre-construction engineering and design activities for this proposed project, if funded, would be continued under the authority provided by the section cited above. The existing Freeport Harbor Channel was authorized by the River and Harbor Acts of May 1950 and July 1958.

2. The report recommends a project that will contribute significantly to the economic efficiency of commercial navigation in the region. The FHCIP is an improvement of the existing Freeport Harbor Channel that provides for a deep-draft waterway from the Gulf of Mexico to the City of Freeport through the original mouth of the Brazos River. A diversion dam about 7.5 miles above the original river mouth, and a diversion channel rerouting the Brazos River from the dam to an outlet into the Gulf about 6.5 miles southwest of the original mouth, now separate the Freeport Harbor Channel from the river system and make the harbor and channels an entirely tidal system. The study evaluated navigation and environmental problems and opportunities for a 70-square mile study area. The study area includes the cities of Freeport, Surfside Beach and Quintana, the Freeport Harbor Channel, the Brazos River Diversion Channel, a portion of the Gulf Intracoastal Waterway, the Gulf of Mexico shoreline on both sides of the Freeport Harbor Channel, and the offshore channel and placement areas 10 miles into the Gulf of Mexico. The entire study area is located within Brazoria County, Texas and adjacent state waters in the Gulf of Mexico.

3. The reporting officers recommend the Locally Preferred Plan (LPP) to modify the existing Freeport Harbor Channel. The LPP consists of the following improvements:

a. Deepen the Outer Bar Channel into the Gulf of Mexico to -58 feet mean lower low water (MLLW);

b. Deepen from the end of the jetties in the Gulf of Mexico to the Lower Turning Basin to -56 feet MLLW;

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DAEN
SUBJECT: Freeport Harbor Channel Improvement Project, Brazoria County, Texas

c. Deepen from the Lower Turning Basin to Station 132+66 near the Brazosport Turning Basin to -56 feet MLLW;

d. Deepen from Station 132+66, above the Brazosport Turning Basin, through the Upper Turning Basin to -51 feet MLLW;

e. Deepen and widen the lower 3,700 feet of the Stauffer Channel to -51 feet MLLW and 300 feet wide;

f. Dredge the remainder of the Stauffer Channel to -26 feet MLLW (its previously authorized depth was -30 feet).

Dredged material placement for this project will be provided in accordance with the Dredged Material Management Plan developed during the study. Deepening of the Freeport Harbor Channel would generate approximately 17.3 million cubic yards of new work material and approximately 176 million cubic yards of maintenance over the 50-year period of economic evaluation. Material from the Channel Extension, Outer Bar Channel, and Jetty Channel would be placed offshore in the existing New Work and Maintenance Material Ocean Dredged Material Disposal Sites (ODMDSs). Material from the inland Freeport Harbor channels and basins would be placed in one existing confined upland Placement Area (PA 1), and two new Placement Areas (PA 8 and PA 9).

Mitigation features will consist of the preservation of approximately 131 acres of riparian forest under a permanent conservation easement and the improvement of its habitat value by establishing 11 acres of riparian forest in place of 11 acres of invasive tree species; the creation of three acres of wetlands and an associated one acre of riparian forest; and required monitoring of mitigation performance and impacts to wetlands and riparian forest for corrective action, if needed.

4. The recommended navigation plan is not the National Economic Development (NED) plan. The recommended LPP is shallower and will be less costly than the NED plan in the main channel portion of the FHCIP. The LPP is supported by the non-Federal, cost sharing sponsor (Port Freeport).

5. Project Cost Breakdown based on October 2012 prices.

a. Project First Cost. The estimated project first cost of constructing the FHCIP is $237,474,000 which includes the cost of constructing General Navigation Featrures (GNF) and the value of lands, easements, rights-of-way and relocations estimated as follows: $208,079,000 for channel modification and dredged material placement; $165,000 for fish and wildlife mitigation; $1,691,000 for lands, easements, and rights-of-way provided by the

non-Federal sponsor; $18,135,000 for planning, engineering and design efforts; and $9,404,000 for construction management.

b. Estimated Federal and Non-Federal Shares: The estimated Federal and non-Federal shares of the project first cost are $121,132,000 and $116,342,000, respectively, as apportioned in accordance with the cost sharing provisions of Section 101(a) of the Water Resources Development Act (WRDA) of 1986, as amended (33 U.S.C. 2211(a)), as follows:

(1) The costs for deepening the Upper Stauffer Channel will be shared at the rate of 90 percent by the Government and 10 percent by the non-Federal sponsor for dredging depths between 18 and 20 feet and 75 percent by the Government and 25 percent by the non-Federal Sponsor for dredging between 20 and 26 feet. The total cost for this reach is $3,607,000 with $2,782,000 in Federal costs and $825,000 in non-Federal costs.

(2) The cost for deepening the Lower Stauffer Channel will be shared at the rate of 90 percent by the Government and 10 percent by the non-Federal sponsor for dredging depths between 18 and 20 feet and 75 percent by the Government and 25 percent by the non-Federal sponsor for dredging depths between 20 and 45 feet. Dredging depths deeper than 45 feet will be shared at the rate of 50 percent by the Government and 50 percent by the non-Federal sponsor. Costs for deepening this reach total $10,869,000 with $7,693,000 being paid by the Government and $3,176,000 being paid by the non-Federal sponsor.

(3) The costs for the deepening of the Freeport Harbor channels from the existing 46-foot depth to 56 feet (58 feet offshore) will be shared at the rate of 50 percent by the Government and 50 percent by the non-Federal sponsor. Accordingly, the Federal and non-Federal shares of the estimated $221,040,000 cost in this zone will be approximately $110,520,000 being paid by the Government and $110,520,000 being paid by the non-Federal sponsor.

(4) The costs for environmental mitigation will be shared at the prorated share rate of 51.4% by the Government and 48.6% by the non-Federal sponsor. Costs for mitigation total $267,000 with $137,000 being paid by the Government and $130,000 being paid by the non-Federal sponsor.

(5) In addition to payment by the non-Federal sponsor of its share of costs as estimated and described in sub-paragraphs b(1), b(2), b(3) and b(4) above, the estimated non-Federal share of $116,342,000 includes $1,691,000 for the estimated value of lands, easement, and rights-of-way that it must provide pursuant to Section 101(a)(3) of WRDA 1986, as amended (33 U.S.C.2211(a)(3)).

c. Additional 10 Percent Payment. In addition to payment by the non-Federal sponsor of its share of the project first costs determined in sub-paragraphs b(1), b(2) and b(3) above, pursuant to Section 101(a)(2) of WRDA 1986, as amended (33 U.S.C. 2211(a)(2)), the non-Federal sponsor must pay an additional 10 percent of the cost of the general navigation features of the project in cash over a period not to exceed 30 years, with interest. The additional 10% payment without interest is estimated to be $23,578,000. The value of lands, easements, rights-of-way, and relocations, estimated as $1,691,000, provided by the non-Federal sponsor under Section 101(a)(3) of WRDA 1986, as amended, will be credited toward payment of this amount.

d. Operations and Maintenance Costs. The additional annual cost of operation and maintenance for this recommended plan is estimated at $11,371,000. In accordance with Section 101(b) of WRDA 1986, as amended (33 U.S.C. 2211(b)), the non-Federal sponsor will be responsible for an amount equal to 50 percent of the excess of the cost of the operation and maintenance of the project over the cost which would be incurred for operation and maintenance of the project if the project had a depth of 45 feet. The Federal Government would be responsible for $6,254,000 of the incremental operations and maintenance costs and the non-Federal sponsor would be responsible for the remaining $5,117,000.

e. Associated Costs. Estimated associated costs of $58,881,000 include $39,695,000 in non-Federal costs associated with bulkhead modifications, $18,803,000 for dredging of non-Federal berthing areas adjacent to the Federal channel and $1,383,000 for aids to navigation (a U.S. Coast Guard expense).

f. Authorized Project Cost and Section 902 Calculation. The project first cost for the purpose of calculating the maximum cost of the project pursuant to Section 902 of WRDA 1986, as amended, includes the cost of constructing the GNFs and the value of lands, easements, and rights-of-way. Accordingly, as set forth in paragraph 5.a, above,based on October 2012 prices, the total estimated project first cost for these purposes is $237,474,000 with an estimated federal share of $121,132,000 and an estimated non-Federal share of $116,342,000. Based on October 2012 price levels, a discount rate of 3.75 percent, and a 50-year period of economic analysis, the project average annual benefits and costs for the FHCIP are estimated at $48,042,000 and $25,449,000, respectively, with resulting net excess benefits of $22,593,000 and a benefit-to-cost ratio of 1.9 to 1.

7. The goals and objectives included in the Campaign Plan of the Corps have been fully integrated into the Freeport Harbor Channel study process. The recommended plan was

developed in coordination and consultation with various Federal, State and local agencies using a systematic and regional approach to formulating solutions and evaluating the benefits and impacts that would result. The feasibility study evaluated navigation and environmental problems and opportunities for the entire study area of about 70 square-miles. Risk and uncertainty were addressed during the study by sensitivity analyses that evaluated the potential impacts of sea level change and economic assumptions as well as cost risk analysis.

8. In accordance with the Corps Engineering Circular on review of decision documents, all technical, engineering, and scientific work underwent an open, dynamic, and vigorous review process to ensure technical quality. This included an Agency Technical Review (ATR), an Independent External Peer Review (IEPR), and a Corps Headquarters policy and legal review. All concerns of the ATR have been addressed and incorporated into the final report. An IEPR was completed by Battelle Memorial Institute in August 2008. A total of 22 comments were documented. The comments were related to plan formulation, vessel fleet analysis, benefits, water quality, and sensitivity analyses. An IEPR back-check was completed in June 2011, which resulted in follow-up comments related to the original 22 comments. In response, sections in the main report and EIS were expanded to include additional information. The IEPR responses were reviewed by the Deep Draft Navigation Planning Center of Expertise in June 2011 with all comments satisfactorily addressed.

9. Washington level review indicates that the plan recommended by the reporting officers is technically sound, environmentally and socially acceptable, and economically justified. The plan complies with all essential elements of the U.S. Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Land Related Resources Implementation Studies. The recommended plan complies with other administration and legislative policies and guidelines. The views of interested parties, including Federal, State and local agencies, have been considered. A Biological Opinion has been received from the National Marine Fisheries Service (NMFS) for potential incidental take of sea turtles during construction. The Biological Opinion has been reviewed and found acceptable.

State and agency comments received during review of the final report/environmental impact statement included comments by the U.S. Coast Guard (USCG) and the U.S. Environmental Protection Agency (USEPA). The USCG requested Corps assistance in obtaining funds for the necessary navigation aid modifications and the Corps response stated that the district would coordinate to request the necessary USCG funding in conjunction with project construction funds. The USEPA expressed concerns on a variety of topics in a letter dated October 5, 2012. The Corps response stated that expanded explanations were provided in the

report and FEIS on the rationale for plan formulation and selection, planned air pollution prevention/reduction measures during construction, dredged material placement procedures at ocean sites, and analyses of socio-economic/health and safety effects based on additional modeling and analyses. The Corps also committed to further USEPA review of sediment data collected during the pre-construction engineering and design phase and continued coordination as needed, depending upon the testing results.

10. I concur in the findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend that navigation improvements for the Freeport Harbor Channel be authorized in accordance with the reporting officer's recommended plan at an estimated cost of $237,474,000 with such modifications as in the discretion of the Chief of Engineers may be advisable. My recommendation is subject to cost sharing, financing, and other applicable requirements of Federal and State laws and policies, including Section 101 of WRDA 1986, as amended. This recommendation is subject to the non-Federal sponsor agreeing to comply with all applicable Federal laws and policies including that the non-Federal sponsor must agree with the following requirements prior to project implementation.

a. Provide 10 percent of the total cost of construction of the general navigation features (GNF) attributable to dredging to a depth not in excess of 20 feet; plus 25 percent of the total cost of construction of the GNFs attributable to dredging to a depth in excess of 20 feet but not in excess of 45 feet; plus 50 percent of the total cost of construction of the GNFs attributable to dredging to a depth in excess of 45 feet as further specified below:

(1) Provide 25 percent of design costs allocated by the Government to commercial navigation in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

(2) Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs allocated by the Government to commercial navigation;

(3) Provide, during construction, any additional funds necessary to make its total contribution for commercial navigation equal to 10 percent of the total cost of construction of the GNFs attributable to dredging to a depth not in excess of 20 feet; plus 25 percent of the total cost of construction of the GNFs attributable to dredging to a depth in excess of 20 feet but not in excess of 45 feet; plus 50 percent of the total cost of construction of the GNFs attributable to dredging to a depth in excess of 45 feet;

b. Provide all lands, easement, and rights-of-way (LER), including those necessary for the borrowing of material and placement of dredged or excavated material, and perform or assure performance of all relocations, including utility relocations, all as determined by the Government to be necessary for the construction or operation and maintenance of the GNFs;

c. Pay with interest, over a period not to exceed 30 years following completion of the period of construction of the GNFs, an additional amount equal to 10 percent of the total cost of construction of GNFs less the amount of credit afforded by the Government for the value of the LER and relocations, including utility relocations, provided by the non-Federal sponsor for the GNFs. If the amount of credit afforded by the Government for the value of LER, and relocations, including utility relocations, provided by the non-Federal sponsor equals or exceeds 10 percent of the total cost of construction of the GNFs, the non-Federal sponsor shall not be required to make any contribution under this paragraph, nor shall it be entitled to any refund for the value of LER and relocations, including utility relocations, in excess of 10 percent of the total costs of construction of the GNFs;

d. Provide, operate, and maintain, at no cost to the Government, the local service facilities in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Government;

e. Provide 50 percent of the excess cost of operation and maintenance of the project over that cost which the Government determines would be incurred for operation and maintenance if the project had a depth of 45 feet;

f. Give the Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating and maintaining the GNFs;

g. Hold and save the United States free from all damages arising from the construction or operation and maintenance of the project, any betterments, and the local service facilities, except for damages due to the fault or negligence of the United States or its contractors;

h. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence is required, to the extent and in such detail as will properly reflect total cost of construction of the project, and in accordance with the standards for financial management systems set forth in the

DAEN
SUBJECT: Freeport Harbor Channel Improvement Project, Brazoria County, Texas

Uniform Administrative Requirements for Grants and Cooperative Agreements to State and local governments at 32 CFR, Section 33.20;

i. Perform, or ensure performance of, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601–9675, that may exist in, on, or under LER that the Government determines to be necessary for the construction or operation and maintenance of the GNFs. However, for lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude, only the Government shall perform such investigation unless the Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

j. Assume complete financial responsibility, as between the Government and the non-Federal sponsor, for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under LER that the Government determines to be necessary for the construction or operation and maintenance of the project;

k. To the maximum extent practicable, perform its obligations in a manner that will not cause liability to arise under CERCLA;

l. Comply with Section 221 of PL 91-611, Flood Control Act of 1970, as amended, (42 U.S.C. 1962d-5b) and Section 101(e) of the WRDA 86, Public Law99-662, as amended, (33 U.S.C. 2211(e)) which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

m. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, PL 91-646, as amended, (42 U.S.C. 4601-4655) and the Uniform Regulations contained in 49 CFR 24, in acquiring lands, easements, and rights-of-way, necessary for construction, operation and maintenance of the project including those necessary for relocations, the borrowing of material, or the placement of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

n. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, PL 88-352 (42 USC 2000d), and

DAEN
SUBJECT: Freeport Harbor Channel Improvement Project, Brazoria County, Texas

Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive changes the provision of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c);

o. Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation that are in excess of 1 percent of the total amount authorized to be appropriated for the project;

p. Not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefore, to meet any of the non-Federal sponsor's obligations for the project costs unless the Federal agency providing the Federal portion of such funds verifies in writing that such funds are authorized to be used to carry out the project; and

q. Complete the first phase of the Velasco Container Terminal (800-foot berth and 35 acres of supporting backland) on the Stauffer Channel prior to the initiation of construction of the Stauffer Channel portion of the project.

11. The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program or the perspective of higher review levels within the Executive Branch. Consequently, the recommendation may be modified before it is transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to the Congress, the State of Texas, Port Freeport (the non-Federal sponsor), interested Federal agencies, and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

THOMAS P. BOSTICK
Lieutenant General, USA
Chief of Engineers

**United States Department of Agriculture**

NRCS

Natural Resources Conservation Service
101 South Main
Temple, TX 76501-7602

September 5, 2012

Mr. Theodore A. Brown, P.E.
Chief, Planning and Policy Division
Headquarters
U. S. Army Corps of Engineers
CECW-P (SA)
7701 Telegraph Road
Alexandria, VA 22315-3860

Dear Mr. Brown:

We have reviewed the information pertaining to the proposed report of the Chief of Engineers and the report of the district engineer on the Freeport Harbor, Texas, Channel Improvement Project.

This project should have no significant impact on the environment or natural resources in the area.

Thank you for the opportunity to review this proposed project.

Sincerely,

Salvador Salinas

SALVADOR SALINAS
State Conservationist



Encl 4

U.S. Department of Transportation
United States Coast Guard

Captain of the Port
United States Coast Guard
Sector Houston-Galveston

9640 Clinton Drive
Houston, TX 77029
Phone: (713) 671-5164
FAX: (713) 671-5177

11460
NOV 9 2012

U.S. Army Corps of Engineers
Attn: Lee Ware
CECW-P (SW)
7701 Telegraph Road
Alexandria, VA 22315-3860

Dear Mr. Ware,

Thank you for the opportunity to comment on the Freeport Improvement Project. I've enclosed my response and concerns relevant to the Public Notice for Army Corps of Engineers (USACE) Feasibility study: Freeport Harbor Channel Improvement Project. If you have any questions, please contact LCDR Xochitl Castañeda at (713) 671-5164 or Xochitl.L.Castaneda@uscg.mil.

Sincerely,

J. H. Whitehead
Captain, U.S. Coast Guard
Captain of the Port
Houston-Galveston, Texas

Enclosure: Coast Guard Evaluation
Copy: USACOE Galveston District

Encl 5

## Report of USACE Permit Application Risk Assessment

USCG COTP Zone: Sector Houston-Galveston
USACE District Engineer Office: Galveston District

Structure or Project: Freeport Harbor Channel Improvement Project
Location: Freeport Harbor Channel

**New Structure or Project**
Application Number: CECW-PC (1105-2-10a)
Date of Public Notice: 38001

**Existing Structure or Project**
Date USACE Permit Issued:

**Recommended Action:** Issue permit with conditions

**Comments (must be included when it is recommended that a permit be issued with conditions or that the permit be denied as well as whenever it is recommended that an existing permit be modified, suspeneded or revoked)**

The obstacle to this project is the relocation of the Freeport Jetty Inbound Range Front (LLNR 26965) and Rear (LLNR 26975). Our staff consulted with the Brazos Pilots concerning this project, the centerline of the channel will be shifted North, which would require the range line to shift. The rear range is currently located on a levee in the Dow facility that will create a major issue to relocate and will cost upward of $1M. The Coast Guard does not have funding to support this update. Request ACOE support to facilitate funding support directly or indirectly.

**Summary of Completed Risk Assessment**

| | RIN | Percent Cumulative Risk |
|---|---|---|
| **Project Location** | **124.784** | **55.58%** |
| Public Safety Impact | 15.595 | 6.95% |
| Environmental Impact | 50.541 | 22.51% |
| Economic Impact | 58.649 | 26.12% |
| **Vessel Traffic / Port Operations** | **99.730** | **44.42%** |
| Public Safety Impact | 25.405 | 11.32% |
| Environmental Impact | 33.514 | 14.93% |
| Economic Impact | 40.811 | 18.18% |

Approved by: J. H. Whitehead, Capt USCG
Captain of the Port

| For each area of concern, assess the risk to the structure or project based on where it is located on a waterway. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Area of concern | Mishap | | Risk Factors | Category related risk estimates | | | | |
| | | | | Likelihood Score | | | RIN | Percent Cumulative Risk |
| | | | | Cat I | Cat II | Cat III | | |
| Public Safety Impact | A. | HAZMAT Exposure | | 2 | 1 | 0 | 2.7027 | 1.20% |
| | B. | Collision | | 1 | 1 | 0 | 1.8919 | 0.84% |
| | C. | Grounding | | 0 | 0 | 0 | 1.0000 | 0.45% |
| | D. | Fire / Explosion | | 1 | 2 | 0 | 10.0000 | 4.45% |
| Total estimate of risk to public safety associated with project location | | | | | | | *15.595* | *6.95%* |
| Environmental Impact | A. | Fire / Explosion | | 1 | 1 | 1 | 10.0000 | 4.45% |
| | B. | Oil Spill | | 2 | 2 | 1 | 18.9189 | 8.43% |
| | C. | Barge breakaway | | 2 | 1 | 0 | 2.7027 | 1.20% |
| | D. | HAZMAT Exposure | | 2 | 2 | 1 | 18.9189 | 8.43% |
| Total estimate of risk to the marine environment associated with project location | | | | | | | *50.541* | *22.51%* |
| Economic Impact | A. | Barge breakaway | | 2 | 1 | 1 | 10.8108 | 4.82% |
| | B. | Cargo mishandling | | 3 | 2 | 0 | 18.9189 | 8.43% |
| | C. | Fire / Explosion | | 1 | 1 | 1 | 10.0000 | 4.45% |
| | D. | HAZMAT Exposure | | 2 | 2 | 1 | 18.9189 | 8.43% |
| Total estimate of risk to economic loss associated with project location | | | | | | | *58.649* | *26.12%* |
| **TOTAL RISK ESTIMATE FOR PROJECT LOCATION** | | | | | | | **124.784** | **55.58%** |

For each area of concern, assess the risk to the port or waterway based on the structure or project's impact on vessel traffic or port operations.

| Area of concern | Mishap | Risk Factors | Category related risk estimates | | | | |
|---|---|---|---|---|---|---|---|
| | | | Likelihood Score | | | RIN | Percent Cumulative Risk |
| | | | Cat I | Cat II | Cat III | | |
| Public Safety Impact | A. HAZMAT Exposure | | 2 | 1 | 0 | 2.7027 | 1.20% |
| | B. Collision | | 1 | 1 | 0 | 1.8919 | 0.84% |
| | C. Cargo mishandling | | 2 | 2 | 0 | 10.8108 | 4.82% |
| | D. Fire / Explosion | | 1 | 2 | 0 | 10.0000 | 4.45% |
| Estimate of risk to public safety associated with impact on vessel traffic / port operations | | | | | | *25.405* | *11.32%* |
| Environmental Impact | A. Fire / Explosion | | 1 | 1 | 1 | 10.0000 | 4.45% |
| | B. HAZMAT Exposure | | 2 | 1 | 0 | 2.7027 | 1.20% |
| | C. Collision | | 2 | 2 | 1 | 18.9189 | 8.43% |
| | D. Cargo mishandling | | 2 | 0 | 0 | 1.8919 | 0.84% |
| Estimate of risk to marine environment associated with impact on vessel traffic / port operations | | | | | | *33.514* | *14.93%* |
| Economic Impact | A. Fire / Explosion | | 1 | 1 | 1 | 10.0000 | 4.45% |
| | B. Collision | | 1 | 1 | 1 | 10.0000 | 4.45% |
| | C. HAZMAT Exposure | | 1 | 1 | 1 | 10.0000 | 4.45% |
| | D. Oil Spill | | 2 | 1 | 1 | 10.8108 | 4.82% |
| Estimate of risk to economic loss associated with impact on vessel traffic / port operations | | | | | | *40.811* | *18.18%* |
| **TOTAL RISK ESTIMATE FOR PROJECT IMPACT ON VESSEL TRAFFIC / PORT OPERATIONS** | | | | | | 99.730 | 44.42% |

**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY**
**Region 6**
**1445 Ross Avenue, Suite 1200**
**Dallas, TX 75202-2733**

October 5, 2012

Janelle Stokes
U.S. Army Corps of Engineers
Galveston District
P.O. Box 1229
Galveston, Texas 77553-1229

Dear Ms. Stokes:

In accordance with our responsibilities under Section 309 of the Clean Air Act (CAA), the National Environmental Policy Act (NEPA), and the Council on Environmental Quality (CEQ) regulations for implementing NEPA, the U.S. Environmental Protection Agency (EPA) Region 6 office in Dallas, Texas, has completed its review of the Final Environmental Impact Statement (FEIS) prepared by the Galveston District, U.S. Army Corps of Engineers (USACE) for the Freeport Harbor Channel Improvement Project, Brazoria County, Texas. The Brazos River Harbor Navigation District (also known as Port Freeport) proposes to deepen and widen the Freeport Harbor Channel and associated turning basins (except Brazos Harbor), up to and including the Stauffer Turning Basin to eliminate existing operational constraints.

In our letter dated February 11, 2011, EPA rated the Draft EIS as Environmental Concerns - Insufficient Information (EC-2), primarily due to concerns with air quality, the ocean dredged material disposal site, children's health, cumulative impacts, and greenhouse gas emissions. EPA believes that the USACE has sufficiently and adequately addressed the concerns in the comment letter. However, we have additional comments below:

ES.5 Vegetation and Wetlands, page ES-7

This section states "Construction of two new upland confined Placement Areas (PA), PAs 8 and 9, would convert approximately 418 acres of land, including 21 acres of forest and 39 acres of ephemeral wetlands, to a dredged material placement area. Coordination with U.S. Fish and Wildlife Service (USFWS) and Texas Parks and Wildlife Department (TPWD) regarding these impacts has resulted in proposed mitigation that includes creation and maintenance of forested habitat and creation of wetland areas adjacent to impact areas".

- It appears that much of the area designated as pasture (358 acres) could be wetlands that would need to be mitigated in-kind.

- EPA recommends that the USACE provide field verified wetland delineations using a combination of the 1987 U.S. Army Corps of Engineers Wetland Delineation Manual and the Atlantic and Gulf Coastal Plain Regional Supplement (Version 2.0) for the proposed inland PAs 8 and 9. EPA requests a review of the field delineations.

Encl 6

3.6.1.3 Greenhouse Gas Emissions and Climate Change (GHG), page 3-46

This section contains the statement "To date, specific thresholds to evaluate adverse impacts pertaining to GHG emissions have not been established by local decision-making agencies, the State, or the Federal government". From a perspective of specific thresholds (Significant Impact Levels, National Ambient Air Quality Standards) applicable to GHG emissions, this statement is correct. However, GHG emissions are typically associated with other air pollutants. Please clarify this statement to indicate that associated air pollutants have been evaluated for project-related impacts.

6.4.1.1 Wetlands, page 6-19

This section states "The Locally Preferred Plan Alternative would impact 39 acres of ephemeral wetlands, mitigated by one 3-acre pond planted with appropriate vegetation to fully compensate for lost average annual habitat units".

- EPA recommends the USACE use the approved wetland functional assessment model, iHGM, required by the Galveston District for permits, to determine the wetland types that would be impacted and the extent of functional loss and appropriate compensatory mitigation that would be required to fully restore the unavoidable adverse impacts to waters of the U.S., including special aquatic sites as identified in 40 CFR Part 230 Section 404(b)(1). EPA requests a review of the iHGM assessment and mitigation plan.

EPA asks that the USACE address these concerns and any mitigation in a Supplemental Information Report and/or the Record of Decision (ROD) document to complete the NEPA process. EPA appreciates the opportunity to review the FEIS. If you have any questions or concerns, please contact John MacFarlane of my staff at macfarlane.john@epa.gov or 214-665-7491 for assistance.

Sincerely,

Rhonda Smith
Chief, Office of Planning
and Coordination

PORT FREEPORT℠
THE COAST IS CLEAR
200 W. SECOND ST., 3rd FL. • FREEPORT, TX 77541
(979) 233-2667 • 1 (800) 362-5743 • FAX: (979) 233-5625

July 12, 2012

Col. Christopher W. Sallese, Commander
USACE, Galveston District
P.O. Box 1229
Galveston, TX 77550-1229

Re: Freeport Harbor, Texas Channel Improvement Project

Dear Col. Sallese,

Port Freeport extends its full support for the deepening and widening of the Freeport Harbor Channel. We understand that approval of the decision document by the U.S. Army Corps of Engineers will allow the project to move into the implementation phase.

Port Freeport feels that the Locally Preferred Plan (LPP), contained in the Draft Feasibility Report, is the best alternative to address the requirements for navigation in the deep draft navigation channel, and is consistent with our goals of providing for the safe and efficient transport of vessels into and out of the area, and enhancing economic development for our region.

We are prepared to enter into the next phase of this project and look forward to executing a Project Partnership Agreement (PPA) at the earliest opportunity. We understand the provisions of the PPA include the requirements for operation and maintenance of the project. Our Non-Federal Sponsor's Self-Certification of Financial Capability for Decision Documents is attached. Thank you for your assistance with this much needed project. Please contact me if you need any additional information.

Sincerely,

Bill Terry, Chairman
Port Commission of Port Freeport

Cc: Phyllis Saathoff, Interim Executive Port Director

PORT COMMISSION

BILL TERRY, CHAIRMAN; RAVI K. SINGHANIA, VICE CHAIRMAN; JOHN HOSS, SECRETARY; SHANE PIRTLE, ASSISTANT SECRETARY; PAUL KRESTA, COMMISSIONER; THOMAS S. PERRYMAN, COMMISSIONER; PHYLLIS SAATHOFF, INTERIM EXECUTIVE PORT DIRECTOR/CEO

Encl 7

**NON FEDERAL SPONSOR'S**
**SELF-CERTIFICATION OF FINANCIAL CAPABILITY**
**FOR DECISION DOCUMENTS**

I, Bill Terry, do hereby certify that I am the Chairman of the Port Commission of Port Freeport (the Non-Federal Sponsor); that I am aware of the financial obligations of the Non-Federal Sponsor for the Freeport Harbor, Texas Channel Improvement Project; and that the Non-Federal Sponsor will have the financial capability to satisfy the Non-Federal Sponsor's obligations for that project. I understand the Government acceptance of this self-certification shall not be construed as obligating either the Government or the Non-Federal Sponsor to implement the project.

IN WITNESS WHEREOF, I have made and executed this certification the 12th day of July, 2012

BY: _____

TITLE: Chairman

DATE: July 12, 2012

Certification Regarding Lobbying.

The undersigned certifies, to the best of its knowledge and belief, that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the entering into of this cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this cooperative agreement, the undersigned shall complete and submit Standard Form LLL "Disclosure of Lobbying Activities," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all contracts and awards for work described in Article 2 and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance is placed when this transaction is made or entered into. This certification is a prerequisite for making or entering into this transaction imposed by Section 1352, Title 31, U.S. Code. The prohibition does not apply to the following activities:

(1) Providing information specifically requested by the Secretary of the Army and U.S. Army Corps of Engineers or information not specifically requested but necessary for the Secretary to make an informed decision, or

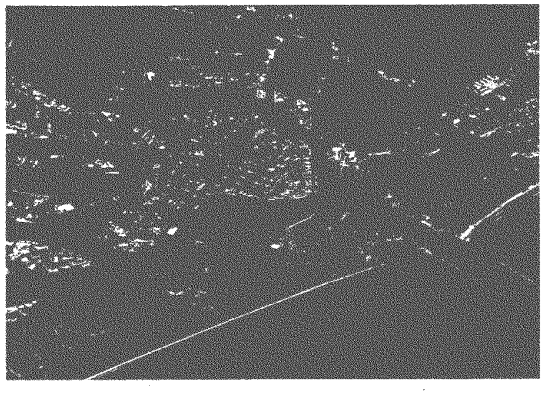
(2) Professional or technical services applying a professional or technical discipline rendered directly in the preparation and submission of the application, or

(3) Technical discussion regarding the application features and adaption of the proposal to meet eligibility requirements.

Bill Terry, Chairman,
Port Commission
Port Freeport

US Army Corps
of Engineers
Galveston District

# VOLUME I
# FINAL
# FREEPORT HARBOR, TEXAS
# CHANNEL IMPROVEMENT PROJECT
# FEASIBILITY REPORT



September 2012

## EXECUTIVE SUMMARY

The purpose of this feasibility study is to develop and evaluate alternatives for navigation problems that directly affect the Freeport Harbor Channel. To allow for a more effective, safe, and efficient waterway, the study focused on eliminating the major problems contributing to inefficiencies on the waterway, such as insufficient depth and width, as determined by fleet forecasts and the requirement for one-way and daylight-only traffic in the channel. The study evaluated project benefits based on reductions in transportation costs generated from more-efficient loading of the existing fleet, from reductions in vessel delays, and the introduction of larger vessels. The study was conducted to determine whether navigation problems currently being experienced at Freeport Harbor could be alleviated and are in the Federal interest and to provide documentation needed to recommend Congressional authorization and funding for construction of that project. The Freeport Harbor study area is shown on Figure ES-1.

The original project for Federal channel improvement at Freeport was authorized by the River and Harbor Act (RHA), approved June 14, 1880, which provided for construction of jetties for controlling and improving the channel over the bar at the mouth of the Brazos River. Work was started in 1881 and continued to 1886 when operations were suspended due to lack of funds. In March 1899, the Brazos River Channel and Dock Company, under authority granted by the RHA of August 21, 1888, began rework on the navigation channel. The company was unable to finance completion of the work, and in April, the works, rights, and privileges were transferred to the United States. This constituted the initial authorization for the existing project for Freeport Harbor.

The existing Freeport Harbor Project was authorized by the RHAs of May 1950 and July 1958. The acts provided for an Outer Bar Channel 38 feet deep and 300 feet wide from the Gulf of Mexico to a point inside the jetties and for inside channels 36 feet deep and 200 feet wide to and including the Upper Turning Basin. Greater depth and width were authorized by Congress in 1970 (Section 101 of RHA of 1970, PL 91-611; House Document 289, 93rd Congress – 2nd Session, 31 Dec 1975) and by the President in 1974. These authorizations were for the Jetty Channel to be relocated and deepened to 45 feet, widened to 400 feet, and the North Jetty relocated northward. The relocated Entrance Channel (Outer Bar) was authorized to a 400-foot width, to a 47-foot depth, and to extend approximately 4.6 miles into the Gulf of Mexico. A Final Environmental Impact Statement for the project was prepared by the U.S. Army Corps of Engineers (USACE) in 1978. In 1978, Seaway Pipeline, Inc., under a Department of Army permit, was authorized to widen the Entrance (Outer Bar) Channel to 400 feet and the Jetty Channel to 230 feet. Seaway Pipeline was formed as a consortium in the 1970s to construct the Seaway Terminal, storage tankage at the Jones Creek Tank Farm, and the pipeline from Jones Creek Tank Farm to Cushing, Oklahoma, to transport foreign crude into the Heartland. The Outer Bar Channel was widened under the permit.

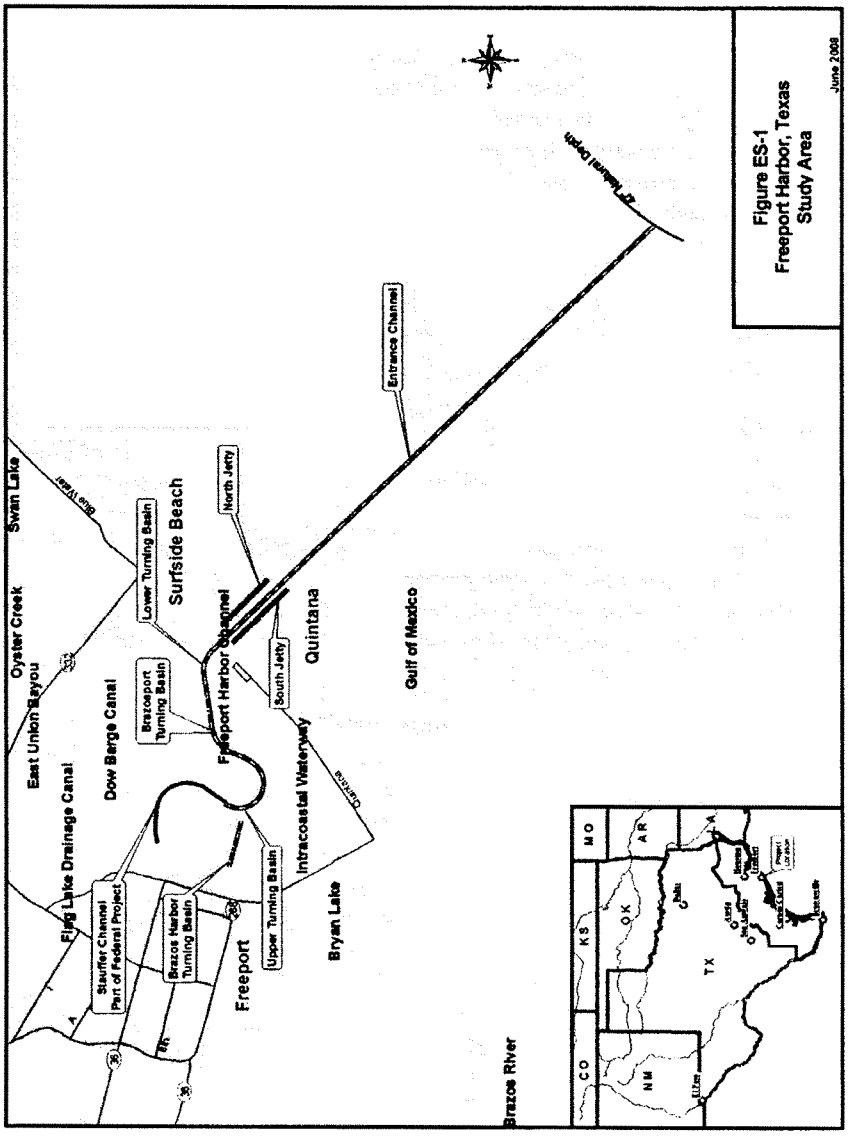



**Figure ES-1**
**Freeport Harbor Texas**
**Study Area**

Port Freeport (formerly the Brazos River Harbor Navigation District) is the non-Federal sponsor for the study. The study has been coordinated with interested Federal, State, and local agencies, and interested public. In October 2002, a Reconnaissance Report Section 905(b) Analysis was completed for Freeport Harbor. The Section 905(b) analysis was conducted under authority of Section 216 of the Flood Control Act of 1970. The reconnaissance evaluation recommended proceeding with a cost-shared feasibility study with the Brazos River Harbor Navigation District as the lead cost-sharing Sponsor. The Feasibility Cost Sharing Agreement was signed July 7, 2003.

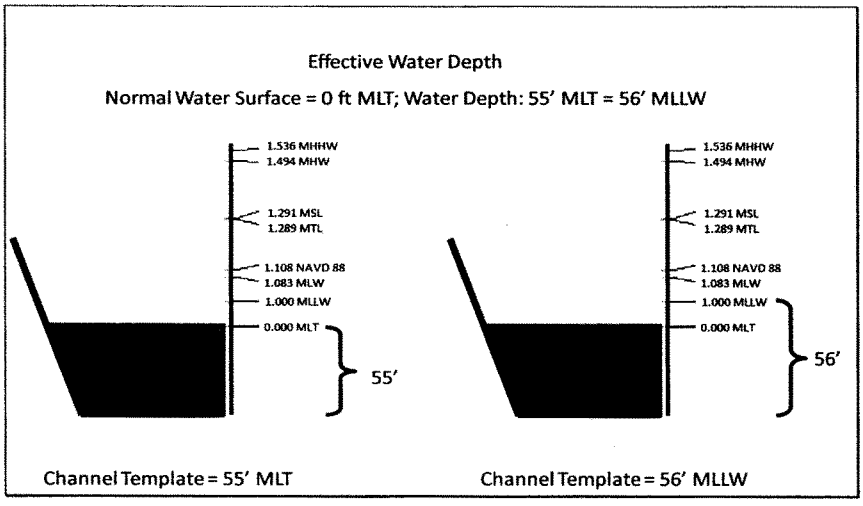
All elevations referred to in this report, unless specifically noted otherwise, are based on USACE Galveston District's local Mean Low Tide (MLT) datum. This project is a compilation of National Geodetic Vertical Datum of 1929 (NGVD 29) and the newer North American Vertical Datum of 1988 (NAVD 88). Existing after-dredged hydro surveys in the local vertical datum of MLT were used in calculating new work volumes. These vertical datum are presented in the studies performed by the Engineer Research and Development Center, and can be referenced for more clarification.

The North American Datum of 1927 (NAD 27) was used during the initial screening of alternatives. After the Feasibility Scoping Meeting, the study was converted to the newer North American Datum of 1983 (NAD 83). Final Plates are shown in NAD 83, Texas State Plane Coordinate System, South Central Zone.

Army regulations and USACE Headquarters guidance on tidal datum, provided in Engineer Technical Letter (ETL) 1110-2-349 *REQUIREMENTS AND PROCEDURES FOR REFERENCING COASTAL NAVIGATION PROJECTS TO MEAN LOWER LOW WATER DATUM*, dated April 1, 1993, and Engineer Manual (EM) 1110-2-1003, April 1, 2002, stress the necessity of converting local datum, such as MLT to Mean Lower Low Water (MLLW). EM 1110-2-1003 further states that MLLW should be tied to the NAVD 88. The predominant reasons for conversion to MLLW are the need for consistency throughout the ports of the U.S., to enhance the continuity of National Oceanic and Atmospheric Administration and U.S. Coast Guard (USCG) navigation charts, and to avoid misconceptions within the shipping and dredging industries with regard to channel depths.

The USACE Galveston District has an established survey control network along the Freeport Harbor Channel. To comply with the above-referenced guidance on referencing tidal datums using MLLW, the Galveston District took vertical survey measurements at tide gages and benchmarks to estimate the relative difference between MLT and MLLW datums along the Freeport Channel. The objective was to maintain an effective water depth of 55 feet while correctly referencing resulting water surface level in MLLW as shown in the following Figure ES-2.

**Figure ES-2**
**Effective Water Depth**
**Freeport Harbor Channel**
**Mean Low Tide – Mean Lower Low Water**




At Freeport Channel, datum values for MLLW are +1 foot above MLT. However, this does not result in increased water depth, as the additional +1 foot of nominal depth is actually +1 foot above the normal surface water level. Therefore, the actual water depths are equivalent between a 55-foot MLT channel template and a 56-foot MLLW channel template.

As the study and its documentation were completed using MLT, references to MLT have been maintained throughout this document, though numbers are also referenced in MLLW depths at some locations in the report. These references are in parentheses and the datum is referenced at each reference point.

The Recommended Plan addresses the problems and opportunities identified during the study and satisfies the planning objectives of increasing navigation efficiency and safety along the Freeport Harbor Channel while maintaining the coastal and estuarine resources within the project area. This Recommended Plan is the Locally Preferred Plan (LPP), the plan preferred by the Sponsor. The LPP is recommended in lieu of the National Economic Development (NED) Plan. The NED Plan and the LPP were fully developed. The LPP is less costly than the NED Plan for the Entrance and Main channels and the net excess benefits are less.

Based on the economic, engineering, and environmental factors considered, the LPP includes deepening of the Outer Bar Channel from the jetties into the Gulf of Mexico to –57 feet MLT (–58 feet MLLW); deepening from the end of the jetties in the Gulf of Mexico to the Lower

Turning Basin to –55 feet MLT (–56 MLLW); deepening the Main Channel from the Lower Turning Basin to Sta. 132+66 (ConocoPhillips dock area, above 1,200-foot Brazosport Turning Basin) to –55 feet MLT (–56 feet MLLW); deepening of Freeport Harbor from Sta. 132+66 through the Upper Turning Basin to –50 feet MLT (–51 feet MLLW); deepening and widening the lower 3,700 feet of the Stauffer Channel at a depth of –50 feet MLT (–51 feet MLLW) and 300 feet wide; and dredging the remainder of the Stauffer Channel to a depth of –25 feet MLT (–26 feet MLLW), in lieu of restoring it to its previously authorized dimensions of 30 feet by 200 feet. Depths shown exclude advance maintenance and allowable overdepth. It is estimated that the approximately 17.3 million cubic yards of new work material (including advance maintenance and allowable overdepth) would require eight separate dredging contracts to complete. The work is estimated to begin in 2015 and be complete by 2021. Dredged material management will be performed according to the Dredged Material Management Plan.

The project benefits were calculated for a 2017–2067 period of analysis using the Fiscal Year (FY) 12 Federal discount rate of 4.0 percent and the deep-draft vessel operating costs contained in Economic Guidance Memorandum 08-04. The proposed channel improvements are in response to the need for deeper access required by liquid bulk vessels, the introduction of larger vessels, and the reauthorization of the upper reaches of the harbor. The deepening and widening of the Freeport Harbor Channel will generate annual benefits of $41,814,000 with total annual costs of $25,068,000, producing a benefit-cost ratio of 1.7. At a discount rate of 7 percent, annual benefits of $38,082,000 and total annual costs of $26,333,000 produce a benefit-cost ratio of 1.4.

The project first cost of all project components totals $232,121,400. The fully funded project cost of all components totals $247,485,000.

The total cost for the Recommended Plan is $290,652,000, as shown in Table ES-1. Costs include implementation costs and associated costs. Implementation costs include post-authorization planning and design costs, construction costs, construction contingency costs, and Operation and Maintenance (O&M) costs. Construction costs include costs for dredging and placement area construction. Costs for fish and wildlife mitigation are also included. No cultural resource mitigation costs are expected at this time. A programmatic agreement is in effect for any cultural resource mitigation, if required at a later date. Aids to navigation (estimated at $1,352,000) are provided by the USCG, and are a Federal cost included in the economic justification, but are not subject to project cost sharing. Construction General funding will fund Federal share of all project construction.

**Table ES-1**
**Recommended Plan Cost**
**Comparison of Costs (rounded) October 11**

| Cost Account | Item Description | First Cost (Oct 11 Price Level) | Fully Funded Cost (Oct11 Price Level) |
|---|---|---|---|
| **Federal Construction Cost** | | | |
| 01 | Lands & Damages | -0- | -0- |
| 06 | Fish & Wildlife Facilities | 61,000 | 180,000 |
| 12 | Navigation Ports & Harbors | 203,389,000 | 219,370,000 |
| 30 | Planning, Engineering & Design | 17,726,000 | 19,606,000 |
| 31 | Construction Management | 9,192,000 | 10,595,000 |
| **Federal Construction** | | **230,468,000** | **249,751,000** |
| **Non-Federal (LERRs/ Associated) Cost** | | | |
| 01 | Lands & Damages | 1,653,000 | 1,753,000 |
| 02 | Relocations | -0- | -0- |
| 12 | Navigation Ports & Harbors (1) | 57,179,000 | 61,829,000 |
| **Non-Federal Construction** | | **58,832,000** | **63,582,000** |
| **Aids to Navigation** | | **1,352,000** | **1,456,000** |
| **Total Navigation Costs** | | **290,652,000** | **314,788,000** |

(1) Costs include $38,800,000 in non-Federal bulkhead modifications and 18,379,000 in dredging costs for berthing areas adjacent to the Federal channel.

Project costs and price escalation (calculated by estimating the midpoint of the proposed contracts) are combined to create the Fully Funded Cost. The Project First Cost for all project components is separated into expected non-Federal and Federal cost shares and detailed in Table ES-2. These costs are accurately apportioned at different cost share rates based on the work being done at different depths. For a majority of the work where the existing channel is currently at 45-foot MLT (46-foot MLLW), the work will be cost shared 50 percent Federal/50 percent non-Federal. On the Stauffer Channel where the existing depths are less than 20 feet and depths are proposed to go to 50 feet MLT (51 feet MLLW), cost share will cover all levels including 90/10 Federal/non-Federal, 75/25, and 50/50. Where Stauffer Channel is proposed to go to 25 feet MLT (26 feet MLLW), cost share will be both the 90/10 and 75/25 cost shares.

**Table ES-2**
**Cost Apportionment**

| Cost Apportionment Navigation* | First Cost ($) | Fully Funded Cost ($) |
|---|---|---|
| Federal Navigation: | | |
| Freeport Channel | 108,029,000 | 115,262,000 |
| Lower Stauffer Channel | 7,520,000 | 7,958,000 |
| Upper Stauffer Channel | 2,719,000 | 2,876,000 |
| Lands & Damages | -0- | -0- |
| Mitigation | 134,000 | 142,000 |
| **Total Federal Navigation** | **118,402,000** | **126,238,000** |
| non-Federal Navigation: | | |
| Freeport Channel | 108,029,000 | 115,262,000 |
| Lower Stauffer Channel | 3,104,000 | 3,284,000 |
| Upper Stauffer Channel | 806,000 | 852,000 |
| Land & Damages | 1,653,000 | 1,713,000 |
| Mitigation | 127,000 | 136,000 |
| **Total non-Federal Navigation** | **113,719,000** | **121,247,000** |
| **Total Navigation** | **232,121,000** | **247,485,000** |

*Costs include Preconstruction Engineering & Design and Construction Management totals.

The USACE prepared a Final Environmental Impact Statement (FEIS) as required by the National Environmental Policy Act (NEPA) to present an evaluation of potential impacts associated with the proposed Freeport Harbor project. The FEIS has been properly prepared and coordinated as required by NEPA. All factors that may be relevant to the proposed project were considered, including dredged material management, air quality, shoreline erosion, historic resources, protected species, recreation, water and sediment quality, energy needs, safety, hazardous materials, and, in general, the welfare of the people. Areas of potential impact identified include water and sediment quality, air quality, noise, riparian forest and wetlands, terrestrial and aquatic wildlife (including Essential Fish Habitat), protected species, cultural resources, land use, and socioeconomics. For the proposed project, the majority of potential project-related impacts were avoided. Mitigation was proposed only for impacts to riparian forest and wetland habitats. Public involvement occurred through public meetings and other outreach efforts throughout the history of the project. The public, State and Federal resource agencies, industry, local government, and other interested parties have been proactively informed about the project.

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## Acronyms and Abbreviations

| | |
|---|---|
| 3D | three dimensional |
| AAHU | Average Annual Habitat Unit |
| AEO | Annual Energy Outlook |
| ASA(CW) | Assistant Secretary of the Army (Civil Works) |
| BA | Biological Assessment |
| BCR | Benefits-to-Cost Ratio |
| BO | Biological Opinion |
| BOEM | Bureau of Ocean Energy Management, Regulation and Enforcement, formerly the Minerals Management Service (MMS) |
| BPD | Barrels per Day |
| BRPA | Brazos River Pilots Association |
| CBRA | Coastal Barrier Improvement Act |
| CE/ICA | Cost Effectiveness and Incremental Cost Analysis |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act (80) |
| CFR | Code of Federal Regulations |
| CHL | Coastal Hydraulics Laboratory |
| cm | centimeter |
| cm/sec | centimeters per second |
| CWA | Clean Water Act |
| cy | cubic yards |
| dB | Decibel |
| dBA | sound levels measured using A-weighting |
| DMMP | Dredged Material Management Plan |
| DOE | U.S. Department of Energy |
| DWT | Deadweight Tonnage |
| DX | Directorate of Expertise |
| EC | Engineering Circular |
| EFH | Essential Fish Habitat |
| EGM | Economic Guidance Memorandum |
| EIA | Energy Information Administration |
| EIS | Environmental Impact Statement |
| EJ | Environmental Justice |
| EM | Engineer Manual |
| EO | Executive Order |
| EOP | Environmental Operating Principles |
| EPA | U.S. Environmental Protection Agency |
| EQ | Environmental Quality |

| | |
|---|---|
| ER | Engineer Regulation |
| ERDC | Engineer Research and Development Center |
| ESA | Endangered Species Act (73) |
| ETL | Engineer Technical Letter |
| FEIS | Final Environmental Impact Statement |
| FPPA | Farmland Protection Policy Act |
| ft/sec | feet per second |
| ft/yr | feet per year |
| FTZ | Foreign Trade Zone |
| FWOP | Future Without-Project |
| FWP | Future With-Project |
| FY | Fiscal Year |
| GIWW | Gulf Intracoastal Waterway |
| GLO | Texas General Land Office |
| GNF | General Navigation Feature |
| GDP | gross domestic product |
| H&H | Hydrology and Hydraulics |
| HEP | Habitat Evaluation Procedures (Ecosystem Evaluation) |
| HGB | Houston-Galveston-Brazoria |
| HQ | USACE Headquarters |
| HSI | Habitat Suitability Index |
| HTRW | Hazardous, Toxic, and Radioactive Waste |
| HU | habitat unit |
| IPCC | Intergovernmental Panel on Climate Change |
| IWR | Institute of Water Resources |
| LER | lands, easement, and rights-of-way |
| LERR | lands, easements, rights-of-way, and relocations |
| LNG | Liquefied Natural Gas |
| LOA | (Ship) Length Overall |
| LPP | Locally Preferred Plan |
| $m^3$ | cubic meter |
| mcy | million cubic yards |
| mcy/yr | million cubic yards per year |
| MDFATE | Multiple Disposal Fate model |
| MLLW | Mean Lower Low Water |
| MLT | Mean Low Tide |
| mm/yr | millimeters per year |
| MMS | Mineral Management Service, now the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEM) |

| | |
|---|---|
| NAD 27 (or 83) | North American Datum of 1927 (or 1983) |
| NAVD 88 | North American Vertical Datum of 1988 |
| NDC | Navigation Data Center |
| NED | National Economic Development |
| NEPA | National Environmental Policy Act (69) |
| NGVD 29 | National Geodetic Vertical Datum of 1929 |
| NMFS | National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| $NO_x$ | Nitrogen oxides |
| NRC | National Research Council |
| NRCS | Natural Resources Conservation Service |
| O&M | Operation and Maintenance |
| ODMDS | Ocean Dredged Material Disposal Site |
| OSE | other social effects |
| OSV | offshore supply vessels |
| PA | Placement Area |
| PADD | Petroleum Administration Defense District |
| PAg | Programmatic Agreement |
| PED | Preconstruction Engineering and Design |
| PGL | Planning Guidance Letter |
| PL | Public Law |
| PSV | platform supply vessel |
| RED | Regional Economic Development |
| RHA | River and Harbor Act |
| RRC | Railroad Commission of Texas |
| RSLR | Relative Sea Level Rise |
| SAV | submerged aquatic vegetation |
| SH | State Highway |
| SHPO | State Historic Preservation Officer |
| SIP | State Implementation Plan (CAA) |
| SMMP | Site Monitoring and Management Plan |
| SOC | species of concern |
| SPR | Strategic Petroleum Reserve |
| SPT | Standard Penetration Tests |
| TCEQ | Texas Commission on Environmental Quality (formerly Texas Natural Resources Conservation Commission [TNRCC]) |
| TEPPCO | Texas Eastern Petroleum Pipeline Company |
| TEU | Total Equivalent Units (Container – 20 x 8 x 8) (7.5 metric tons) |
| TPCS | Total Project Cost Summary |

| | |
|---|---|
| TPWD | Texas Parks and Wildlife Department |
| TWDB | Texas Water Development Board |
| TxDOT | Texas Department of Transportation |
| TY | target year |
| UC | Unconfined Compression Tests |
| USACE | U.S. Army Corps of Engineers |
| USC | United States Code |
| USCG | U.S. Coast Guard |
| USFWS | U.S. Fish and Wildlife Service |
| UU or Q-tests | Unconsolidated Undrained Triaxial Compression Tests |
| VE | Value Engineering |
| VLCC | Very Large Crude Carrier |
| WCSC | Waterborne Commerce Statistics Center |
| WRDA | Water Resources Development Act |

# ADDENDUM

## FREEPORT HARBOR, TEXAS

## CHANNEL IMPROVEMENT PROJECT

### 1.A PURPOSE

The purpose of this Addendum is to document changes to the project costs as presented in the Final Feasibility Report of June 2012, based on revision of the final project costs to reflect October 2012 price levels and the current interest rate of 3.75 percent. The June 2012 report presented cost levels in October 2011 price levels with the interest rate of 4.0 percent. The costs have been inflated to October 2012 cost levels using factors developed by price leveling the labor and contracts using the Cost Estimate Updating Rates from Budget EC 11-2-202 dated 31 Mar 2012.

### 1.B PROJECT COSTS

The project cost for the Recommended Plan is $297,354,000, as shown in Table 1. Costs include implementation costs and associated costs. Implementation costs include postauthorization planning and design costs, construction costs, construction contingency costs, and O&M costs. Construction costs include costs for dredging and placement area construction. Costs for fish and wildlife mitigation are also included. No cultural resource mitigation costs are expected at this time. A programmatic agreement is in effect for any cultural resource mitigation, if required at a later date. Aids to navigation (estimated at $1,383,000) are provided by the USCG, and are a Federal cost included in the economic justification, but are not subject to project cost sharing. Construction General funding will fund Federal share of all project construction.

Project costs and price escalation (calculated by estimating the midpoint of the proposed contracts) are combined to create the Fully Funded Cost. The Project First Cost for all project components is separated into expected non-Federal and Federal cost shares and detailed in Table 2. These costs differ from those in Table 1 due to the inclusion of Planning, Engineering & Design and Construction Management costs across the different channel segments. These costs are accurately at different cost share rates based on the work being done at different depths. For a majority of the work where the existing channel is currently at -45-foot MLT (-46-foot MLLW), the work will be cost shared 50 percent Federal/50 percent non-Federal. On the Stauffer Channel where the existing depths are less than 20 feet and depths are proposed to go to -50-foot MLT (-51-foot MLLW), cost share will cover all levels including 90/10 Federal/non-

Federal, 75/25, and 50/50. Where Stauffer Channel is proposed to go to -25-foot MLT (-26-foot MLLW), cost share will cover both the 90/10 and 75/25.

**Table 1**
**Recommended Plan Cost**
**Comparison of Costs (rounded)**

| Cost Account | Item Description | First Cost (Oct 12 Price Level) | Fully Funded Cost (Oct12 Price Level) |
|---|---|---|---|
| **Federal Construction Cost** | | | |
| 01 | Lands & Damages | -0- | -0- |
| 06 | Fish & Wildlife Facilities | $165,000 | $197,000 |
| 12 | Navigation Ports & Harbors | $208,079,000 | $224,427,000 |
| 30 | Planning, Engineering & Design | $18,135,000 | $20,044,000 |
| 31 | Construction Management | $9,404,000 | $10,840,000 |
| **Federal Construction** | | **$ 235,783,000** | **$255,508,000** |
| **Non-Federal (LERs/ Facilities) Cost** | | | |
| 01 | Lands & Damages | $1,691,000 | $1,793,000 |
| 02 | Relocations | -0- | -0- |
| 12 | Navigation Ports & Harbors (1) | $58,497,000 | $63,254,000 |
| **Non-Federal Construction** | | **$60,188,000** | **$65,047,000** |
| | USCG Navigation Aids | 1,383,000 | 1,490,000 |
| **Total Navigation Costs** | | **297,354,000** | **$322,045,000** |

(1) Costs include $39,695,000 in non-Federal bulkhead modifications and 18,803,000 in dredging costs for berthing areas adjacent to the Federal channel.

The maintenance of project features will be funded through annual appropriations of the O&M program. The actual amounts will vary on a year-to-year basis because of variability in the volume of material removed during each dredging cycle and the variability of the cycles. Costs for maintenance of the Freeport Harbor Project will be in accordance with Section 101(b) of

WRDA 86 (Planning Guidance Letter [PGL] 47, Cost Sharing for Dredged Material Disposal Facilities and Dredged Material Disposal Facility Partnerships), which allocates the increment of costs for maintenance of channel depths less than 45 feet as 100 percent Federal and the increment of costs for channel depths greater than 45 feet as 50 percent non-Federal and 50 percent Federal.

**Table 2**
**Cost Apportionment**

| Cost Apportionment Navigation | First Cost | Fully Funded Cost |
|---|---|---|
| Federal Navigation: | | |
| Freeport Channel | $110,520,000 | $117,919,000 |
| Lower Stauffer Channel | $7,693,000 | $8,141,000 |
| Upper Stauffer Channel | $2,782,000 | $2,942,000 |
| Lands & Damages | -0- | -0- |
| Mitigation | $137,000 | $145,000 |
| **Total Federal Navigation** | **$121,132,000** | **$129,147,000** |
| Non-Federal Navigation: | | |
| Freeport Channel | $110,520,000 | $117,919,000 |
| Lower Stauffer Channel | $3,176,000 | $3,360,000 |
| Upper Stauffer Channel | $825,000 | $872,000 |
| Land & Damages | $1,691,000 | $1,752,000 |
| Mitigation | $130,000 | $139,000 |
| **Total non-Federal Navigation** | **$116,342,000** | **$124,042,000** |
| **Total Navigation** | **$237,474,000** | **$253,189,000** |

Additional PA capacity for the Recommended Plan will be constructed regularly over the 50-year period of analysis in conjunction with maintenance dredging cycles. Costs for disposal facility maintenance associated with the project will be allocated as 50 percent non-Federal and 50 percent Federal for the incremental cost associated with depths over 45 feet and 100 percent Federal for depths less than 45 feet.

The USCG is responsible for aids to navigation, and the cost is allocated as a Federal expense because the installation of new navigation aids on the Outer Bar Channel Extension and the Outer Bar Channel is related to deepening and widening and the replacement of navigation aids on the channel.

## 1.C COST-SHARING APPORTIONMENT

The project cost for determining the cost-sharing requirements is based on the Project First Cost. This differs from the cost estimate that was utilized for the economic analysis that determined project benefits and the BCR.

General navigation features (GNF) costs for deepening greater than 45 feet are cost shared at 50 percent non-Federal and 50 percent Federal. GNF costs for deepening between 25 and 45 feet are cost shared at 75 percent non-Federal and 25 percent Federal and costs for deepening in depths less than 20 feet are cost shared at 90 percent Federal and 10 percent non-Federal. A majority of the dredging is in areas where the current channel is already at 45 feet MLT (46 feet MLLW) so a majority of costs will be shared 50/50. Stauffer Channel, however, is currently at 18 feet MLT (19 feet MLLW) and these costs will be cost shared across all the cost share ratios. The costs are separated into expected Federal and non-Federal shares and detailed in Table 2. Fish and wildlife mitigation is considered a GNF and is cost shared in the same manner as other GNF costs. Mitigation is necessary due to the construction of new PAs. Mitigation costs have been apportioned according to the reaches that will utilize these new PAs and the cost share has been designated appropriately. Should cultural resources data recovery be needed at a later date, it would be handled in accordance with PL 93-291 (Section 7), e.g., data recovery costs would be 100 percent Federal up to 1 percent of the total amount appropriated for the project.

Non-Federal costs include Sponsor and berthing/dock owner costs. The Sponsor is responsible for 100 percent of LERRs. All project construction is on lands that are currently owned by the non-Federal sponsor. Pipeline relocations are defined as "deep-draft utility relocations" pursuant to PGL 44. No pipeline relocations are anticipated. Owners of berth and dock facilities that require modification in conjunction with the project would be responsible for 100 percent of those associated costs. Berth deepening and structural modifications will be incurred and are included in the project cost (Table 1). The USCG is responsible for 100 percent of the cost of aids to navigation.

## 1.D ADDITIONAL NON-FEDERAL SPONSOR CASH CONTRIBUTION

Section 101 of PL 99-662 requires for all navigation channel depths that the non-Federal sponsor must provide an additional cash contribution equal to 10 percent of fully funded GNF costs (minus costs for LERRs). This total is detailed in Table 3 below. These costs may be paid over a period not to exceed 30 years.

**Table 3**
**Total General Navigation Features Costs and Credits**
**(October 2012 Price Level)**

| | | |
|---|---|---|
| Cost-Shared GNF | | $235,783,000 |
| 10% of GNF | | $23,578,000 |
| | | |
| Creditable Land Costs | | $1,691,000 |
| | | |
| Creditable Difference | | ($21,887,000) |
| | | |

## 1.E EQUIVALENT ANNUAL BENEFITS

To determine whether Federal interest in the proposed improvements is warranted, the project has been evaluated for its environmental impacts, social effects, and economic justification. Project benefits were developed based on October 2012 price levels using a project base year of 2017. Economic justification is expressed in terms of a Benefit-Cost analysis. Project costs are discounted to present value and amortized over the period of analysis. They are then compared to average annual economic benefits that would be produced by the project. To be recommended a project must have a Benefit to Cost Ratio (BCR) of greater than one-to-one. In addition, alternative plans for different channel depths are compared to determine and recommend the plan which has the highest annual net benefits. Net benefits are total annual benefits minus total annual costs. The project was examined incrementally foot-by-foot to determine the channel depth yielding the highest net benefit. The annual costs, annual benefits, and benefit cost analysis for the project are shown in Table 4.

**Table 4**
**Freeport Channel and Stauffer Modifications**
**LPP Economic Summary**
**Average Annual Values at 3.75% and $1,000s**

| | Freeport Channel 56/51 feet | Lower Stauffer 51 feet | Upper Stauffer 26 feet | Totals |
|---|---|---|---|---|
| First Cost of Construction | $281,330 | $12,113 | $3,911 | $297,354 |
| Interest During Construction | $18,319 | $133 | $6 | $18,458 |
| Total Investment | $299,649 | $12,246 | $3,917 | $315,812 |
| Average Annual Cost | $13,357 | $546 | $175 | $14,078 |
| Average Annual O&M | $10,328 | $1,001 | $42 | $11,371 |
| Total Annual Cost | $23,685 | $1,547 | $217 | $25,449 |
| Average Annual Benefits | $38,823 | $7,789 | $1,430 | $48,042 |
| Net Excess Benefits | $15,138 | $6,242 | $1,213 | $22,593 |
| B/C Ratios | 1.6 | 5.0 | 6.6 | 1.9 |

US Army Corps
of Engineers
Galveston District

# VOLUME I
# FINAL
# FREEPORT HARBOR, TEXAS
# CHANNEL IMPROVEMENT PROJECT
# FEASIBILITY REPORT

September 2012

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## EXECUTIVE SUMMARY

The purpose of this feasibility study is to develop and evaluate alternatives for navigation problems that directly affect the Freeport Harbor Channel. To allow for a more effective, safe, and efficient waterway, the study focused on eliminating the major problems contributing to inefficiencies on the waterway, such as insufficient depth and width, as determined by fleet forecasts and the requirement for one-way and daylight-only traffic in the channel. The study evaluated project benefits based on reductions in transportation costs generated from more-efficient loading of the existing fleet, from reductions in vessel delays, and the introduction of larger vessels. The study was conducted to determine whether navigation problems currently being experienced at Freeport Harbor could be alleviated and are in the Federal interest and to provide documentation needed to recommend Congressional authorization and funding for construction of that project. The Freeport Harbor study area is shown on Figure ES-1.

The original project for Federal channel improvement at Freeport was authorized by the River and Harbor Act (RHA), approved June 14, 1880, which provided for construction of jetties for controlling and improving the channel over the bar at the mouth of the Brazos River. Work was started in 1881 and continued to 1886 when operations were suspended due to lack of funds. In March 1899, the Brazos River Channel and Dock Company, under authority granted by the RHA of August 21, 1888, began rework on the navigation channel. The company was unable to finance completion of the work, and in April, the works, rights, and privileges were transferred to the United States. This constituted the initial authorization for the existing project for Freeport Harbor.

The existing Freeport Harbor Project was authorized by the RHAs of May 1950 and July 1958. The acts provided for an Outer Bar Channel 38 feet deep and 300 feet wide from the Gulf of Mexico to a point inside the jetties and for inside channels 36 feet deep and 200 feet wide to and including the Upper Turning Basin. Greater depth and width were authorized by Congress in 1970 (Section 101 of RHA of 1970, PL 91-611; House Document 289, 93rd Congress – 2nd Session, 31 Dec 1975) and by the President in 1974. These authorizations were for the Jetty Channel to be relocated and deepened to 45 feet, widened to 400 feet, and the North Jetty relocated northward. The relocated Entrance Channel (Outer Bar) was authorized to a 400-foot width, to a 47-foot depth, and to extend approximately 4.6 miles into the Gulf of Mexico. A Final Environmental Impact Statement for the project was prepared by the U.S. Army Corps of Engineers (USACE) in 1978. In 1978, Seaway Pipeline, Inc., under a Department of Army permit, was authorized to widen the Entrance (Outer Bar) Channel to 400 feet and the Jetty Channel to 230 feet. Seaway Pipeline was formed as a consortium in the 1970s to construct the Seaway Terminal, storage tankage at the Jones Creek Tank Farm, and the pipeline from Jones Creek Tank Farm to Cushing, Oklahoma, to transport foreign crude into the Heartland. The Outer Bar Channel was widened under the permit.

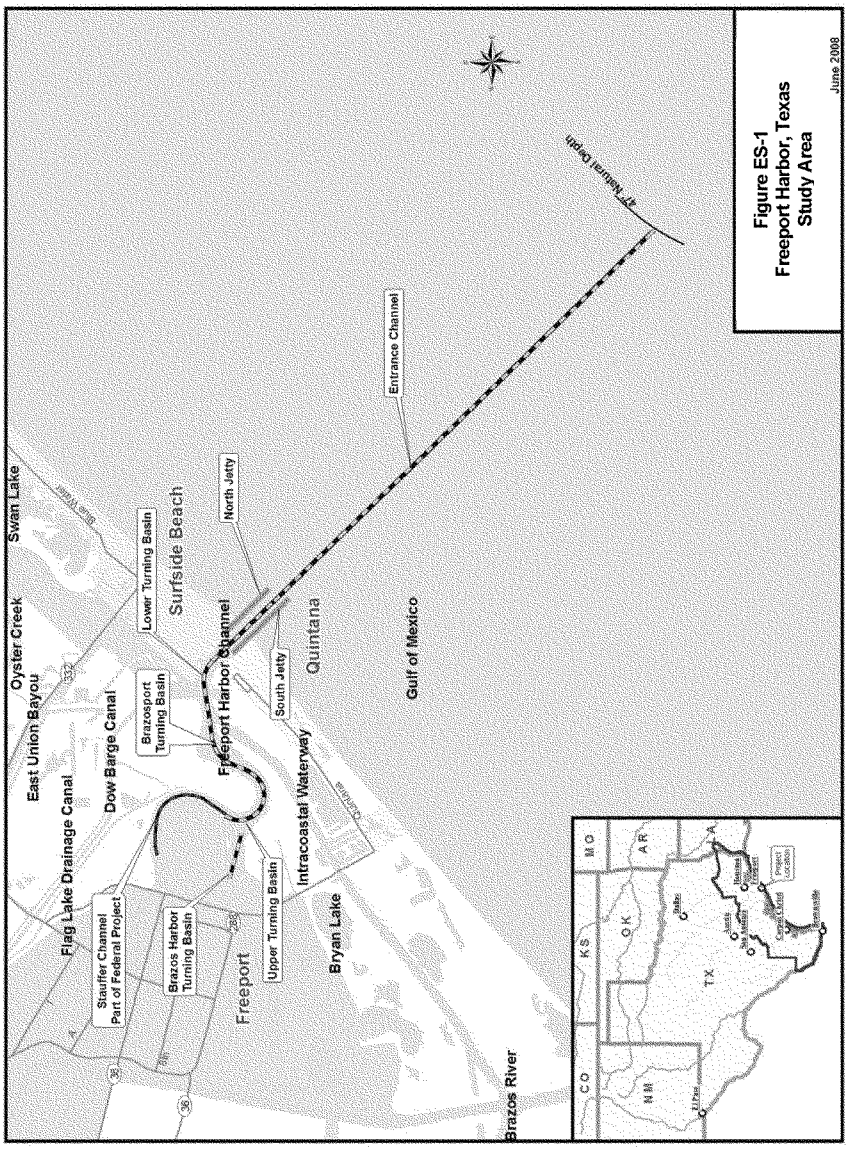



**Figure ES-1**
**Freeport Harbor Texas**
**Study Area**

Port Freeport (formerly the Brazos River Harbor Navigation District) is the non-Federal sponsor for the study. The study has been coordinated with interested Federal, State, and local agencies, and interested public. In October 2002, a Reconnaissance Report Section 905(b) Analysis was completed for Freeport Harbor. The Section 905(b) analysis was conducted under authority of Section 216 of the Flood Control Act of 1970. The reconnaissance evaluation recommended proceeding with a cost-shared feasibility study with the Brazos River Harbor Navigation District as the lead cost-sharing Sponsor. The Feasibility Cost Sharing Agreement was signed July 7, 2003.

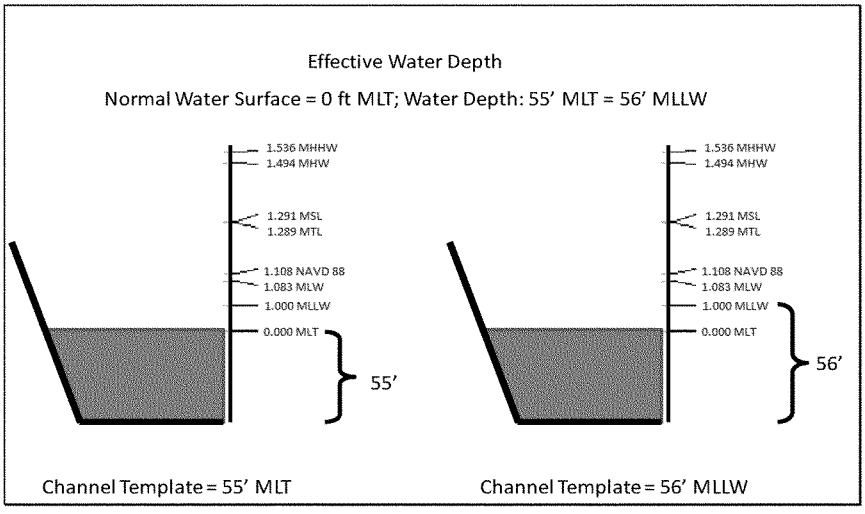
All elevations referred to in this report, unless specifically noted otherwise, are based on USACE Galveston District's local Mean Low Tide (MLT) datum. This project is a compilation of National Geodetic Vertical Datum of 1929 (NGVD 29) and the newer North American Vertical Datum of 1988 (NAVD 88). Existing after-dredged hydro surveys in the local vertical datum of MLT were used in calculating new work volumes. These vertical datum are presented in the studies performed by the Engineer Research and Development Center, and can be referenced for more clarification.

The North American Datum of 1927 (NAD 27) was used during the initial screening of alternatives. After the Feasibility Scoping Meeting, the study was converted to the newer North American Datum of 1983 (NAD 83). Final Plates are shown in NAD 83, Texas State Plane Coordinate System, South Central Zone.

Army regulations and USACE Headquarters guidance on tidal datum, provided in Engineer Technical Letter (ETL) 1110-2-349 *REQUIREMENTS AND PROCEDURES FOR REFERENCING COASTAL NAVIGATION PROJECTS TO MEAN LOWER LOW WATER DATUM*, dated April 1, 1993, and Engineer Manual (EM) 1110-2-1003, April 1, 2002, stress the necessity of converting local datum, such as MLT to Mean Lower Low Water (MLLW). EM 1110-2-1003 further states that MLLW should be tied to the NAVD 88. The predominant reasons for conversion to MLLW are the need for consistency throughout the ports of the U.S., to enhance the continuity of National Oceanic and Atmospheric Administration and U.S. Coast Guard (USCG) navigation charts, and to avoid misconceptions within the shipping and dredging industries with regard to channel depths.

The USACE Galveston District has an established survey control network along the Freeport Harbor Channel. To comply with the above-referenced guidance on referencing tidal datums using MLLW, the Galveston District took vertical survey measurements at tide gages and benchmarks to estimate the relative difference between MLT and MLLW datums along the Freeport Channel. The objective was to maintain an effective water depth of 55 feet while correctly referencing resulting water surface level in MLLW as shown in the following Figure ES-2.

**Figure ES-2**
**Effective Water Depth**
**Freeport Harbor Channel**
**Mean Low Tide – Mean Lower Low Water**




At Freeport Channel, datum values for MLLW are +1 foot above MLT. However, this does not result in increased water depth, as the additional +1 foot of nominal depth is actually +1 foot above the normal surface water level. Therefore, the actual water depths are equivalent between a 55-foot MLT channel template and a 56-foot MLLW channel template.

As the study and its documentation were completed using MLT, references to MLT have been maintained throughout this document, though numbers are also referenced in MLLW depths at some locations in the report. These references are in parentheses and the datum is referenced at each reference point.

The Recommended Plan addresses the problems and opportunities identified during the study and satisfies the planning objectives of increasing navigation efficiency and safety along the Freeport Harbor Channel while maintaining the coastal and estuarine resources within the project area. This Recommended Plan is the Locally Preferred Plan (LPP), the plan preferred by the Sponsor. The LPP is recommended in lieu of the National Economic Development (NED) Plan. The NED Plan and the LPP were fully developed. The LPP is less costly than the NED Plan for the Entrance and Main channels and the net excess benefits are less.

Based on the economic, engineering, and environmental factors considered, the LPP includes deepening of the Outer Bar Channel from the jetties into the Gulf of Mexico to –57 feet MLT (–58 feet MLLW); deepening from the end of the jetties in the Gulf of Mexico to the Lower

Turning Basin to –55 feet MLT (–56 MLLW); deepening the Main Channel from the Lower Turning Basin to Sta. 132+66 (ConocoPhillips dock area, above 1,200-foot Brazosport Turning Basin) to –55 feet MLT (–56 feet MLLW); deepening of Freeport Harbor from Sta. 132+66 through the Upper Turning Basin to –50 feet MLT (–51 feet MLLW); deepening and widening the lower 3,700 feet of the Stauffer Channel at a depth of –50 feet MLT (–51 feet MLLW) and 300 feet wide; and dredging the remainder of the Stauffer Channel to a depth of –25 feet MLT (–26 feet MLLW), in lieu of restoring it to its previously authorized dimensions of 30 feet by 200 feet. Depths shown exclude advance maintenance and allowable overdepth. It is estimated that the approximately 17.3 million cubic yards of new work material (including advance maintenance and allowable overdepth) would require eight separate dredging contracts to complete. The work is estimated to begin in 2015 and be complete by 2021. Dredged material management will be performed according to the Dredged Material Management Plan.

The project benefits were calculated for a 2017–2067 period of analysis using the Fiscal Year (FY) 12 Federal discount rate of 4.0 percent and the deep-draft vessel operating costs contained in Economic Guidance Memorandum 08-04. The proposed channel improvements are in response to the need for deeper access required by liquid bulk vessels, the introduction of larger vessels, and the reauthorization of the upper reaches of the harbor. The deepening and widening of the Freeport Harbor Channel will generate annual benefits of $41,814,000 with total annual costs of $25,068,000, producing a benefit-cost ratio of 1.7. At a discount rate of 7 percent, annual benefits of $38,082,000 and total annual costs of $26,333,000 produce a benefit-cost ratio of 1.4.

The project first cost of all project components totals $232,121,400. The fully funded project cost of all components totals $247,485,000.

The total cost for the Recommended Plan is $290,652,000, as shown in Table ES-1. Costs include implementation costs and associated costs. Implementation costs include post-authorization planning and design costs, construction costs, construction contingency costs, and Operation and Maintenance (O&M) costs. Construction costs include costs for dredging and placement area construction. Costs for fish and wildlife mitigation are also included. No cultural resource mitigation costs are expected at this time. A programmatic agreement is in effect for any cultural resource mitigation, if required at a later date. Aids to navigation (estimated at $1,352,000) are provided by the USCG, and are a Federal cost included in the economic justification, but are not subject to project cost sharing. Construction General funding will fund Federal share of all project construction.

**Table ES-1**
**Recommended Plan Cost**
**Comparison of Costs (rounded) October 11**

| Cost Account | Item Description | First Cost (Oct 11 Price Level) | Fully Funded Cost (Oct11 Price Level) |
|---|---|---|---|
| **Federal Construction Cost** | | | |
| 01 | Lands & Damages | -0- | -0- |
| 06 | Fish & Wildlife Facilities | 61,000 | 180,000 |
| 12 | Navigation Ports & Harbors | 203,389,000 | 219,370,000 |
| 30 | Planning, Engineering & Design | 17,726,000 | 19,606,000 |
| 31 | Construction Management | 9,192,000 | 10,595,000 |
| **Federal Construction** | | **230,468,000** | **249,751,000** |
| **Non-Federal (LERRs/ Associated) Cost** | | | |
| 01 | Lands & Damages | 1,653,000 | 1,753,000 |
| 02 | Relocations | -0- | -0- |
| 12 | Navigation Ports & Harbors (1) | 57,179,000 | 61,829,000 |
| **Non-Federal Construction** | | **58,832,000** | **63,582,000** |
| **Aids to Navigation** | | **1,352,000** | **1,456,000** |
| **Total Navigation Costs** | | **290,652,000** | **314,788,000** |

(1) Costs include $38,800,000 in non-Federal bulkhead modifications and 18,379,000 in dredging costs for berthing areas adjacent to the Federal channel.

Project costs and price escalation (calculated by estimating the midpoint of the proposed contracts) are combined to create the Fully Funded Cost. The Project First Cost for all project components is separated into expected non-Federal and Federal cost shares and detailed in Table ES-2. These costs are accurately apportioned at different cost share rates based on the work being done at different depths. For a majority of the work where the existing channel is currently at 45-foot MLT (46-foot MLLW), the work will be cost shared 50 percent Federal/50 percent non-Federal. On the Stauffer Channel where the existing depths are less than 20 feet and depths are proposed to go to 50 feet MLT (51 feet MLLW), cost share will cover all levels including 90/10 Federal/non-Federal, 75/25, and 50/50. Where Stauffer Channel is proposed to go to 25 feet MLT (26 feet MLLW), cost share will be both the 90/10 and 75/25 cost shares.

**Table ES-2**
**Cost Apportionment**

| Cost Apportionment Navigation* | First Cost ($) | Fully Funded Cost ($) |
|---|---|---|
| Federal Navigation: | | |
| Freeport Channel | 108,029,000 | 115,262,000 |
| Lower Stauffer Channel | 7,520,000 | 7,958,000 |
| Upper Stauffer Channel | 2,719,000 | 2,876,000 |
| Lands & Damages | -0- | -0- |
| Mitigation | 134,000 | 142,000 |
| **Total Federal Navigation** | **118,402,000** | **126,238,000** |
| non-Federal Navigation: | | |
| Freeport Channel | 108,029,000 | 115,262,000 |
| Lower Stauffer Channel | 3,104,000 | 3,284,000 |
| Upper Stauffer Channel | 806,000 | 852,000 |
| Land & Damages | 1,653,000 | 1,713,000 |
| Mitigation | 127,000 | 136,000 |
| **Total non-Federal Navigation** | **113,719,000** | **121,247,000** |
| **Total Navigation** | **232,121,000** | **247,485,000** |

*Costs include Preconstruction Engineering & Design and Construction Management totals.

The USACE prepared a Final Environmental Impact Statement (FEIS) as required by the National Environmental Policy Act (NEPA) to present an evaluation of potential impacts associated with the proposed Freeport Harbor project. The FEIS has been properly prepared and coordinated as required by NEPA. All factors that may be relevant to the proposed project were considered, including dredged material management, air quality, shoreline erosion, historic resources, protected species, recreation, water and sediment quality, energy needs, safety, hazardous materials, and, in general, the welfare of the people. Areas of potential impact identified include water and sediment quality, air quality, noise, riparian forest and wetlands, terrestrial and aquatic wildlife (including Essential Fish Habitat), protected species, cultural resources, land use, and socioeconomics. For the proposed project, the majority of potential project-related impacts were avoided. Mitigation was proposed only for impacts to riparian forest and wetland habitats. Public involvement occurred through public meetings and other outreach efforts throughout the history of the project. The public, State and Federal resource agencies, industry, local government, and other interested parties have been proactively informed about the project.

## Acronyms and Abbreviations

| | |
|---|---|
| 3D | three dimensional |
| AAHU | Average Annual Habitat Unit |
| AEO | Annual Energy Outlook |
| ASA(CW) | Assistant Secretary of the Army (Civil Works) |
| BA | Biological Assessment |
| BCR | Benefits-to-Cost Ratio |
| BO | Biological Opinion |
| BOEM | Bureau of Ocean Energy Management, Regulation and Enforcement, formerly the Minerals Management Service (MMS) |
| BPD | Barrels per Day |
| BRPA | Brazos River Pilots Association |
| CBRA | Coastal Barrier Improvement Act |
| CE/ICA | Cost Effectiveness and Incremental Cost Analysis |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act (80) |
| CFR | Code of Federal Regulations |
| CHL | Coastal Hydraulics Laboratory |
| cm | centimeter |
| cm/sec | centimeters per second |
| CWA | Clean Water Act |
| cy | cubic yards |
| dB | Decibel |
| dBA | sound levels measured using A-weighting |
| DMMP | Dredged Material Management Plan |
| DOE | U.S. Department of Energy |
| DWT | Deadweight Tonnage |
| DX | Directorate of Expertise |
| EC | Engineering Circular |
| EFH | Essential Fish Habitat |
| EGM | Economic Guidance Memorandum |
| EIA | Energy Information Administration |
| EIS | Environmental Impact Statement |
| EJ | Environmental Justice |
| EM | Engineer Manual |
| EO | Executive Order |
| EOP | Environmental Operating Principles |
| EPA | U.S. Environmental Protection Agency |
| EQ | Environmental Quality |

| | |
|---|---|
| ER | Engineer Regulation |
| ERDC | Engineer Research and Development Center |
| ESA | Endangered Species Act (73) |
| ETL | Engineer Technical Letter |
| FEIS | Final Environmental Impact Statement |
| FPPA | Farmland Protection Policy Act |
| ft/sec | feet per second |
| ft/yr | feet per year |
| FTZ | Foreign Trade Zone |
| FWOP | Future Without-Project |
| FWP | Future With-Project |
| FY | Fiscal Year |
| GIWW | Gulf Intracoastal Waterway |
| GLO | Texas General Land Office |
| GNF | General Navigation Feature |
| GDP | gross domestic product |
| H&H | Hydrology and Hydraulics |
| HEP | Habitat Evaluation Procedures (Ecosystem Evaluation) |
| HGB | Houston-Galveston-Brazoria |
| HQ | USACE Headquarters |
| HSI | Habitat Suitability Index |
| HTRW | Hazardous, Toxic, and Radioactive Waste |
| HU | habitat unit |
| IPCC | Intergovernmental Panel on Climate Change |
| IWR | Institute of Water Resources |
| LER | lands, easement, and rights-of-way |
| LERR | lands, easements, rights-of-way, and relocations |
| LNG | Liquefied Natural Gas |
| LOA | (Ship) Length Overall |
| LPP | Locally Preferred Plan |
| $m^3$ | cubic meter |
| mcy | million cubic yards |
| mcy/yr | million cubic yards per year |
| MDFATE | Multiple Disposal Fate model |
| MLLW | Mean Lower Low Water |
| MLT | Mean Low Tide |
| mm/yr | millimeters per year |
| MMS | Mineral Management Service, now the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEM) |

| | |
|---|---|
| NAD 27 (or 83) | North American Datum of 1927 (or 1983) |
| NAVD 88 | North American Vertical Datum of 1988 |
| NDC | Navigation Data Center |
| NED | National Economic Development |
| NEPA | National Environmental Policy Act (69) |
| NGVD 29 | National Geodetic Vertical Datum of 1929 |
| NMFS | National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| $NO_x$ | Nitrogen oxides |
| NRC | National Research Council |
| NRCS | Natural Resources Conservation Service |
| O&M | Operation and Maintenance |
| ODMDS | Ocean Dredged Material Disposal Site |
| OSE | other social effects |
| OSV | offshore supply vessels |
| PA | Placement Area |
| PADD | Petroleum Administration Defense District |
| PAg | Programmatic Agreement |
| PED | Preconstruction Engineering and Design |
| PGL | Planning Guidance Letter |
| PL | Public Law |
| PSV | platform supply vessel |
| RED | Regional Economic Development |
| RHA | River and Harbor Act |
| RRC | Railroad Commission of Texas |
| RSLR | Relative Sea Level Rise |
| SAV | submerged aquatic vegetation |
| SH | State Highway |
| SHPO | State Historic Preservation Officer |
| SIP | State Implementation Plan (CAA) |
| SMMP | Site Monitoring and Management Plan |
| SOC | species of concern |
| SPR | Strategic Petroleum Reserve |
| SPT | Standard Penetration Tests |
| TCEQ | Texas Commission on Environmental Quality (formerly Texas Natural Resources Conservation Commission [TNRCC]) |
| TEPPCO | Texas Eastern Petroleum Pipeline Company |
| TEU | Total Equivalent Units (Container – 20 x 8 x 8) (7.5 metric tons) |
| TPCS | Total Project Cost Summary |

| | |
|---|---|
| TPWD | Texas Parks and Wildlife Department |
| TWDB | Texas Water Development Board |
| TxDOT | Texas Department of Transportation |
| TY | target year |
| UC | Unconfined Compression Tests |
| USACE | U.S. Army Corps of Engineers |
| USC | United States Code |
| USCG | U.S. Coast Guard |
| USFWS | U.S. Fish and Wildlife Service |
| UU or Q-tests | Unconsolidated Undrained Triaxial Compression Tests |
| VE | Value Engineering |
| VLCC | Very Large Crude Carrier |
| WCSC | Waterborne Commerce Statistics Center |
| WRDA | Water Resources Development Act |

# 1.0 INTRODUCTION

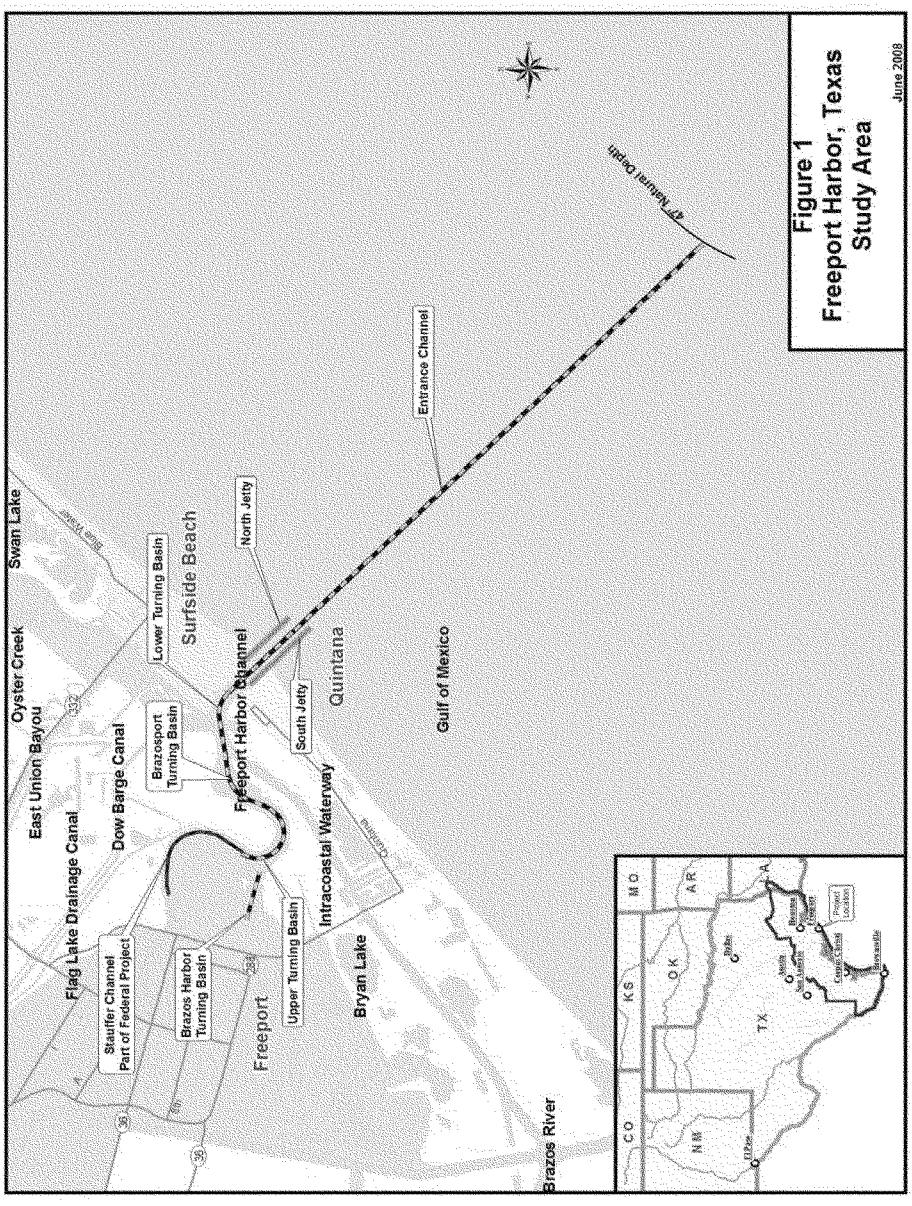
Freeport Harbor provides deepwater access from the Gulf of Mexico to Port Freeport. The waterway extends from deep water in the Gulf through a 0.83-mile jettied channel to the Lower Turning Basin, then westerly approximately 1.5 miles to and including the Brazosport Turning Basin, then westerly approximately 2.2 miles through the Upper Turning Basin to and including a turning basin at Brazos Harbor. The Stauffer Channel extends 1.15 miles from the Upper Turning Basin to the Stauffer Turning Basin. The study area is shown on Figure 1.

The existing authorized depth for the Freeport Harbor Channel is 45 feet mean low tide (MLT). All elevations referred to in this report, unless specifically noted otherwise, are based on the U.S. Army Corps of Engineers (USACE) Galveston District's local MLT datum. This project is a compilation of National Geodetic Vertical Datum of 1929 (NGVD 29) and the newer North American Vertical Datum of 1988 (NAVD 88). Existing after-dredged hydro surveys in the local vertical datum of MLT were used in calculating new work volumes. These vertical datum are presented in the studies performed by the Engineer Research and Development Center (ERDC), and can be referenced for more clarification.

An evaluation was performed comparing the elevation data to Mean Lower Low Water (MLLW) and addressing data conversion. This is addressed in further detail in Section 8, Engineering Studies, of this report.

At Freeport Channel, datum values for MLLW are +1 foot above MLT. However, this does not result in increased water depth, as the additional +1 foot of nominal depth is actually +1 foot above the normal surface water level. Therefore, the actual water depths are equivalent between a 55-foot MLT channel template and a 56-foot MLLW channel template.

As the study and its documentation were completed using MLT, references to MLT have been maintained throughout this document, though numbers are also referenced in MLLW depths at some locations in the report. These references are in parentheses and the datum is referenced at each reference point. Authorized project widths of the channel range from 400 feet from the Gulf to the Brazosport Turning Basin to 200 feet for the Brazos Harbor Channel. Brazos Harbor Channel and Turning Basin are 36 feet MLT (37 feet MLLW). The deauthorized Stauffer Channel measures 200 feet wide with a depth of approximately 18 feet (authorized at 30 feet) MLT (19 feet MLLW). The tidal range for Freeport Harbor is typically 2 feet. Construction of the existing 45-foot Freeport Harbor Project was completed in 1993.


Swan Lake
Oyster Creek
East Union Bayou
Flag Lake Drainage Canal
Dow Barge Canal
Stauffer Channel
Part of Federal Project
Brazos Harbor
Turning Basin
Freeport
Upper Turning Basin
Intracoastal Waterway
Bryan Lake
Brazos River
Lower Turning Basin
Brazosport
Turning Basin
Surfside Beach
Freeport Harbor Channel
North Jetty
South Jetty
Quintana
Gulf of Mexico
Entrance Channel
Figure 1
Freeport Harbor, Texas
Study Area
June 2008

The size of ships has steadily increased such that vessels have to be light-loaded to traverse the waterway. The current channel depth requires that large crude carriers remain offshore and transfer their cargo into smaller crude tankers for the remainder of the voyage.

This comprehensive navigation study investigates the feasibility of improving the Freeport Harbor Channel. This section of the report identifies the study authority, scope, participants and coordination, related studies, and study process.

## 1.1 PURPOSE AND AUTHORITY

The purpose of this study is to develop and evaluate alternatives for navigation problems that directly affect the Freeport Harbor Channel. To allow for a more effective, safe, and efficient waterway, the study is focused on eliminating the major problems contributing to inefficiencies on the waterway, such as insufficient channel depth and width, as determined by fleet forecasts and the requirement for one-way and daylight-only traffic in the channel. The study also identifies economic benefits associated with sponsor-proposed channel modifications and recommends alternatives that maximize these benefits. Authority for the study is contained in Section 216 of the 1970 Flood Control Act:

> *Section 216. The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest.*

This feasibility study is being conducted to determine whether navigation problems currently being experienced at Freeport Harbor are in the Federal interest and to provide the documentation needed to recommend Congressional authorization and funding for construction of that project.

## 1.2 DESCRIPTION OF THE FREEPORT AREA

Freeport Harbor is located immediately south of the city of Freeport in Brazoria County, Texas, on the middle Texas coast. One of the earliest ports on the Texas coast, a harbor was developed at the mouth of the Brazos River, which was subsequently diverted to the west to an outlet into the Gulf about 6.5 miles southwest of the original mouth, resulting in a ship channel that receives no natural freshwater inflow from the river. The channel and harbor are heavily developed with industrial and commercial properties. Freeport is about 50 miles southwest of Houston. The cities of Surfside Beach and Quintana, Texas, are found on the Gulf shore east and west of the

jettied Entrance Channel, respectively. Although extensive coastal marshes are found along this part of the Texas coast, the immediate project area is heavily developed, with limited natural resources remaining.

For purposes of Final Environmental Impact Statement (FEIS) development and analysis, the term "project area" is used to refer to the project footprint and area of direct project impact, defined as the ship channel and dredge disposal sites, including a 1-mile radius around these project features. A broader "study area" incorporates the area of indirect impacts and areas defined by regulation or individual resource. For example, for air conformity purposes, the study area includes the seven counties of the Harris-Galveston-Brazoria (HGB) Ozone Nonattainment Area, while for endangered species purposes, the study area is defined as Brazoria County and the Gulf of Mexico. The study area includes the extensive and rich marsh and estuarine resources of the Texas midcoast, largely lacking from the ship channel project area. The following discussion provides information first on the broader midcoastal study area, then focuses in on the ship channel project area and addresses the resources directly impacted by the project and project mitigation.

## 1.3 STUDY AREA DESCRIPTION: THE GENERAL FREEPORT AREA ENVIRONMENTAL SETTING

Freeport is located on the Gulf Coastal Plain, which is extremely flat, rising from about 3 feet above sea level behind the beaches to about 15 feet 15 miles inland. The primary physiographic environments of the study area include fluvial deltaic systems, barrier island strandplain systems, and aeolian (wind) systems. The coastal zone within the study area is underlain by sedimentary deposits that originated in ancient, but similar, physiographic environments. These ancient sediments were deposited by the same natural processes that are currently active in shaping the present coastline, such as longshore drift, beach wash, wind deflation and deposition, tidal currents, wind-generated waves and currents, delta outbuilding, and river point bar and flood deposition.

Tidal circulation and mixing in the Gulf of Mexico near Freeport is the result of a complex interaction of tides, meteorological driving forces, freshwater inflows, and Coriolis acceleration. The generally westerly longshore current in the northwestern Gulf of Mexico dominates the hydrodynamic regime near Freeport, resulting in sediment transport to the southwest, which causes shoaling into the Freeport Harbor Entrance (Outer Bar and Jetty) Channel.

The climate of the Freeport area is humid subtropical with warm to hot summers and mild winters. The dominant air mass in summer is marine tropical in which sea breezes moderate afternoon heat. Occasional showers or thunderstorms are common during this season. Winters are mild with considerable day-to-day variation between the marine tropical air mass and

modified continental polar and marine polar air masses. Periods of freezing temperatures are infrequent and usually last no longer than 2 or 3 days.

Rainfall averages about 43 inches annually at Freeport. The annual rainfall distribution is greater for the early summer and fall periods and least for the winter and late summer. Two principal wind regimes dominate the area and include persistent southeasterly winds occurring from March through November and strong, short-lived northerly winds from December through February. Severe weather occurs periodically in the area in the form of thunderstorms, tornadoes, and tropical storms or hurricanes.

The study area is characterized as Quaternary (Recent and Holocene) Alluvium containing thick deposits of clay, silt, sand, and gravel, overlying the Pleistocene-aged Beaumont Formation. These formations consist mainly of stream channel, point bar, natural levee, and backswamp deposits associated with former and current river channels and bayous. The Alluvium outcrops in a belt approximately 70 to 90 miles wide paralleling the Texas coastline. The underlying Beaumont Formation is estimated to be less than 1,000 feet thick and consists mostly of clay, silt, sand, and gravel. Subsidence is estimated to be 2.65 millimeters per year (mm/yr), and relative sea level rise (RSLR) is projected to be between 0.5 mm/yr and 2.65 mm/yr (FEIS Appendix L).

The Gulf Coast Aquifer system is the principal source of groundwater for public, agricultural, and industrial needs in the Freeport area. Within the aquifer system, the Chicot Aquifer is the uppermost aquifer, and all public and private water-supply wells in the area are supplied by this aquifer (Texas Water Development Board [TWDB], 2007). The Evangeline Aquifer underlies the Chicot and is noted for its abundance of good-quality groundwater and is considered one of the most prolific aquifers in the Texas Coastal Plain (Baker, 1979), but is not used in the Freeport area.

### 1.3.1 Air Quality

Freeport is included in the eight-county HGB Ozone Nonattainment Area, which is in attainment or unclassified for all criteria pollutants except ozone and is classified as having "severe" nonattainment with the 1-hour and the 8-hour National Ambient Air Quality Standards for ozone. Under the "severe" attainment designation, the HGB has a deadline of June 15, 2019, for attainment of the 8-hour ozone standard. The 1-hour attainment is still pending (40 *Code of Federal Regulations* [CFR], Part 81) (*Federal Register*, Vol. 73, No. 191). Because the proposed project is located in the HGB nonattainment area for ozone, a General Conformity Determination was prepared and the Recommended Plan was found to be in conformity with the current State Implementation Plan (SIP) (Texas Commission on Environmental Quality [TCEQ], 2007).

### 1.3.2 Fish and Wildlife Resources

The study area contains estuarine, wetland, and upland habitats that support a variety of fish and wildlife resources. Since the study area has tidal and freshwater habitats, wildlife species are diverse. The area also supports productive sport and commercial fishing. Due to the diversity of bird life, bird watching is an important recreational activity.

**Upland Resources**. The study area supports a diverse population of upland wildlife species. Uplands include developed areas, dunes and relict beach ridges, grassland/pastures, scrub/shrub vegetation, and woodlands. An important ecosystem that occurs within the study area is the Columbia Bottomlands, which is located in the floodplains of the Brazos, San Bernard, and Colorado rivers north and west of Freeport. The Columbia Bottomlands support uplands and wetlands including marshes, forested wetlands, small-scattered prairies, and bottomland hardwood forests that are important stopping points for migratory birds of the Central and Mississippi flyways.

The immediate study area and vicinity support an abundant and diverse avifauna. Common species of potential occurrence in the study area include great blue heron, great egret, snowy egret, little blue heron, white ibis, roseate spoonbill, clapper rail, grebes, pelicans, cormorants, ducks, geese, hawks, rails, plovers, sandpipers, gulls, doves, owls, hummingbirds, swallows, purple martins, wrens, thrushes, mockingbirds, blackbirds, grackles, cowbirds, and others.

Common terrestrial mammals include the Virginia opossum, various rodents, eastern cottontail, raccoon, striped skunk, coyote, bobcat, and white-tailed deer. Terrestrial amphibian and reptile species of potential occurrence in the study area include Blanchard's cricket frog, Gulf Coast toad, green treefrog, American bullfrog, small-mouthed salamander, western diamond-backed rattlesnake, cotton-mouthed moccasin, American alligator, diamondback terrapin, and other species.

National wildlife refuges within the study area include the Brazoria and San Bernard. In addition to the two Federal refuges, there is a state wildlife management area (Justin Hurst) located about 5 miles west of Freeport. Local sanctuaries include the Neotropical Bird Sanctuary and the Xeriscape Park administered by the town of Quintana.

**Aquatic Resources**. The study area consists of both marine and freshwater ecosystems that support ecological diversity and abundance. A general overview of the marine and freshwater resources present within the study area is described below.

**Marine Resources**. The entire food chain of open-water areas is dependent on the microscopic plankton that provides an abundant food source for fish and other marine life. The open-water bottom is dominated by benthic organisms, including epifauna, such as crabs and smaller crustaceans, and infauna, such as mollusks and polychaetes. These organisms support other

important resources including Essential Fish Habitat (EFH), which is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. The study area is located in an area that has been identified as EFH for juvenile and adult brown, pink, and white shrimp and juvenile and adult gray snapper, red drum, Spanish mackerel, and others. EFH for the species known to occur in the study area includes estuarine emergent wetlands, estuarine mud, sand, and shell substrates, estuarine water column, and nonvegetated bottom.

**Coastal Wetland Resources**. Study area coastal wetlands (saline to freshwater) provide essential habitat for fish, shellfish, and other wildlife. Coastal wetlands also serve to filter and process agricultural and urban runoff and buffer coastal areas against storm and wave damage. Wetland plant communities that occur in the study area include submerged aquatic vegetation (SAV) including shoalgrass and widgeongrass; estuarine salt and brackish marshes of smooth cordgrass, saltgrass, bulrush, and glasswort; estuarine tidal flats with less than 30 percent vegetative cover of glasswort, saltwort, and shoregrass; freshwater aquatic vegetation including invasives like water hyacinth and natives like arrowhead; and freshwater marshes including spikerush, flat-sedge, rushes, smartweed, coastal water-hyssop, seashore paspalum, bulrush, and cattails.

### 1.3.3 Threatened, Endangered, and Protected Species

A number of threatened, endangered, or protected species may occur in the study area including the whooping crane, piping plover, bald eagle, peregrine falcon, reddish egret, white-faced ibis, wood stork, white-tailed hawk, and possibly the sooty tern. The green, loggerhead, Kemp's ridley, and hawksbill sea turtles may occur in the study area and could be negatively impacted by dredging. A Biological Assessment (BA) addressing these species and potential impacts is included as Appendix I in the FEIS.

### 1.3.4 Cultural Resources

Numerous cultural resource investigations, both terrestrial and marine, have been performed in the project area resulting in a well-developed cultural history for this portion of the Texas coast. The aboriginal inhabitants of this region seasonally exploited the Brazos River for its maritime and mainland resources; early European mariners utilized the mouth of the Brazos as a riverine passage to mercantile trade; and the nineteenth-century Austin colonists developed the mouth of the Brazos into commercial and social centers. Therefore, cultural resources characteristic of this area range from prehistoric shell middens to early European shipwrecks to historic period sites such as Fort Velasco and the towns of Quintana and Velasco.

### 1.3.5 Socioeconomic Considerations

The study area lies within the HGB Metropolitan Statistical Area. The economy of the Freeport area is broadly based in manufacturing, agriculture, and fishing. The development of improved

port transportation facilities along the ship channel has allowed greater export of agricultural products and handling of petroleum products. Port Freeport ranked as the 26th largest port in the United States in terms of total tonnage in 2008. Approximately 900 deep-draft vessels call at Port Freeport annually. Most large ship traffic consists of crude or chemical tankers. Containerships also call at Port Freeport. Based on the American Association of Port Authorities, the port handled approximately 72,000 Total Equivalent Units (TEUs) in 2008.

The discovery of oil and natural gas in the area promoted a broad industrial base. Consequently, Freeport has one of the largest petrochemical complexes in the world. Industrial development in the area consists of plants devoted to producing and refining petroleum and petroleum products, petrochemicals, chemical derivatives, and primary metals. Related industries include offshore service vessels, drilling rigs, offshore producing platforms, and offshore service equipment.

Commercial and recreational fishing is also important to the regional economy. The fisheries found in the study area are generally classified as estuarine or marine. The most important commercially harvested species that inhabit estuarine and coastal waters in the study area are brown and white shrimp, southern flounder, and blue crabs. Recreational fish catches include speckled trout, redfish, sand trout, southern flounder, black drum, and shrimp and crabs in the inshore area. Offshore catches include ling, red snapper, amberjack, king mackerel, and Spanish mackerel. Scattered reefs of Eastern oysters are present in areas east of Freeport surrounding Oyster Creek, and scattered oysters are found in many of the nearby open-water areas including Swan and Bryan lakes; however, oysters are not commercially harvested.

The Freeport area is a popular recreational area, and tourism is an important aspect of the local economy. Recreational fishing, hunting, and birding have emerged as important factors in the area economy since the 1960s. The diversity of coastal habitats in the Freeport area supports a large diversity of shore birds, while the large number of adjacent shallow lakes and grain fields create an ideal habitat for waterfowl and migratory birds.

Brazoria County's population increased from 191,707 in 1990 to 304,844 in 2009, with a rate of increase higher than the state. The county's population was estimated at 249,832 in 2001. Freeport increased from 11,845 in 1990 to 13,477 in 2009. These population increases have been driven primarily by the development of the petrochemical industry since 1940, with recent contributions by tourism. Projections by the Texas State Data Center indicate that the county will reach a population of 416,157 in 2040.

## 1.4 PROJECT AREA DESCRIPTION

The project area for the Freeport Harbor Channel Improvement Project is the existing Freeport Harbor 45-foot MLT (46-foot MLLW) navigation project, including the construction footprint of the Recommended Plan, the existing New Work and Maintenance Ocean Dredged Material Disposal Sites (ODMDSs), and the three upland confined Placement Areas (PAs) (existing PA 1

and newly designated PAs 8 and 9), plus a 1-mile radius around all of these project features (Figures 2 and 17). The existing and proposed project is geographically divided into four main channel segments and associated reaches: the Outer Bar Channel and reaches, Main Channel and reaches, Brazos Harbor Channel, and Stauffer Channel. Figure 2 shows the Freeport Harbor main channels and existing PAs. The existing authorized project dimensions are shown in Table 1.

**Table 1**
**Authorized Freeport Harbor Dimensions**

| Channel Segment | Depth in feet MLT (MLLW) | Width (feet) | Length (miles) |
|---|---|---|---|
| Outer Bar Channel | | | |
| Outer Bar Channel | 47(48) | 400 | 5.68 |
| Jetty Channel | 45(46) | 400 | 1.35 |
| Lower Turning Basin | 45(46) | 750 | 0.14 |
| Main Channel | | | |
| Channel to Brazosport Turning Basin | 45(46) | 400 | 0.50 |
| Brazosport Turning Basin | 45(46) | 1,000 | 0.19 |
| Channel to Upper Turning Basin | 45(46) | 350–375 | 1.08 |
| Upper Turning Basin | 45(46) | 1,200 | 0.23 |
| Brazos Harbor | | | |
| Channel to Brazos Harbor | 36(37) | 200 | 0.51 |
| Brazos Harbor Turning Basin | 36(37) | 750 | 0.13 |
| Stauffer Channel (Deauthorized) | | | |
| Channel to Stauffer Turning Basin | 30(31) | 200 | 1.34 |
| Stauffer Turning Basin | 30(31) | 500 | 0.09 |

## 1.5 ENVIRONMENTAL SETTING

The Gulf of Mexico and the Lower Turning Basin bound the Outer Bar Channel. The North and South jetties that protect a portion of the Outer Bar Channel are 7,700 and 6,640 feet long, respectively, and extend into the Gulf from the beachfront communities of Surfside Beach and Quintana, stabilizing the original river mouth at Freeport. The Main Channel reaches extend westerly and then northerly, connecting a series of turning basins beginning downstream at the Lower Turning Basin, then proceeding upstream to the Brazosport and Upper turning basins.

In general, the landward portion of the project area encompasses areas dominated by industrial, commercial, and residential development with some recreation areas, as well as scattered agricultural land and some remnant marshes, all of which are centered around the Freeport Harbor Channel. Prior to the diversion of the Brazos River, the channel was the mouth of the Brazos River. Currently, the Freeport Harbor Channel extends into the Gulf, with no associated bay or estuary, and dead-ends upstream just before reaching State Highway (SH) 288, after

passing through the city of Freeport. The community of Surfside Beach is located immediately northeast of the Freeport Harbor Jetty Channel, and Quintana is located immediately to the southwest. Both communities are small beachfront residential areas along public-access beaches. Surfside Beach has been affected by erosion, with homes currently being removed from the beach in efforts to proceed with beach nourishment and shoreline stabilization projects. Quintana is located adjacent to the Seaway upland confined dredged material disposal area and the Freeport Liquefied Natural Gas (LNG) facility. Just past that facility, the Gulf Intracoastal Waterway (GIWW) crosses Freeport Harbor Channel. From that point, industrial complexes, such as Dow Chemical Company and ConocoPhillips Petroleum facilities, line the banks of the channel until the transition into the city of Freeport. Brazos Harbor, located west of the Upper Turning Basin, contains the majority of port facilities.

The Stauffer Channel extends from the Upper Turning Basin upstream to the Stauffer Turning Basin (see Figure 2). The Stauffer Channel was authorized as a 30-x-200-foot channel. However, it was never federally constructed. The channel currently has a depth of approximately –18.0. This channel was deauthorized in 1974 under Section 12 of the Water Resources Development Act (WRDA) of 1974 (Public Law [PL] 93-251). No objections to deauthorization were raised at the time. Various commercial fishery, marine businesses, and recreational facilities are located along the Stauffer Channel. Several pipelines also cross the existing navigation project channel, but all are of sufficient depth and will not be impacted by proposed channel improvements.

The shoreline on both the Surfside Beach (northern) and Quintana Beach (southern) areas has changed substantially over the last 150 years. Most of the Texas shoreline is now in retreat because of RSLR and a reduced supply of sand from changes to the Mississippi and Atchafalaya river systems and from reservoirs built on Texas rivers. A major shoreline change factor for the Freeport area was the Brazos River diversion in 1929 to control excessive dredging requirements in Port Freeport. The relocation had the unanticipated side effect of moving the main source of sediment away from the immediate project area beaches. Another factor has been reservoir development in the Brazos River watershed that, while essential for water supply and flood control, has greatly reduced the sand supply at the relocated Brazos River mouth. The biggest rate of shoreline change occurs with severe storms.

Other major factors are RSLR that moves the shoreline inland and a movement of sand from the beach inland by aeolian drift (wind) aggravated by beach vehicle traffic. Finally, there has been the interception of sand from the longshore system by the navigation channel and jetties. The jetties act as groins to block longshore sediment movement, but some material gets around and through the jetties and must be periodically dredged from the Freeport Harbor Outer Bar and Jetty channels.

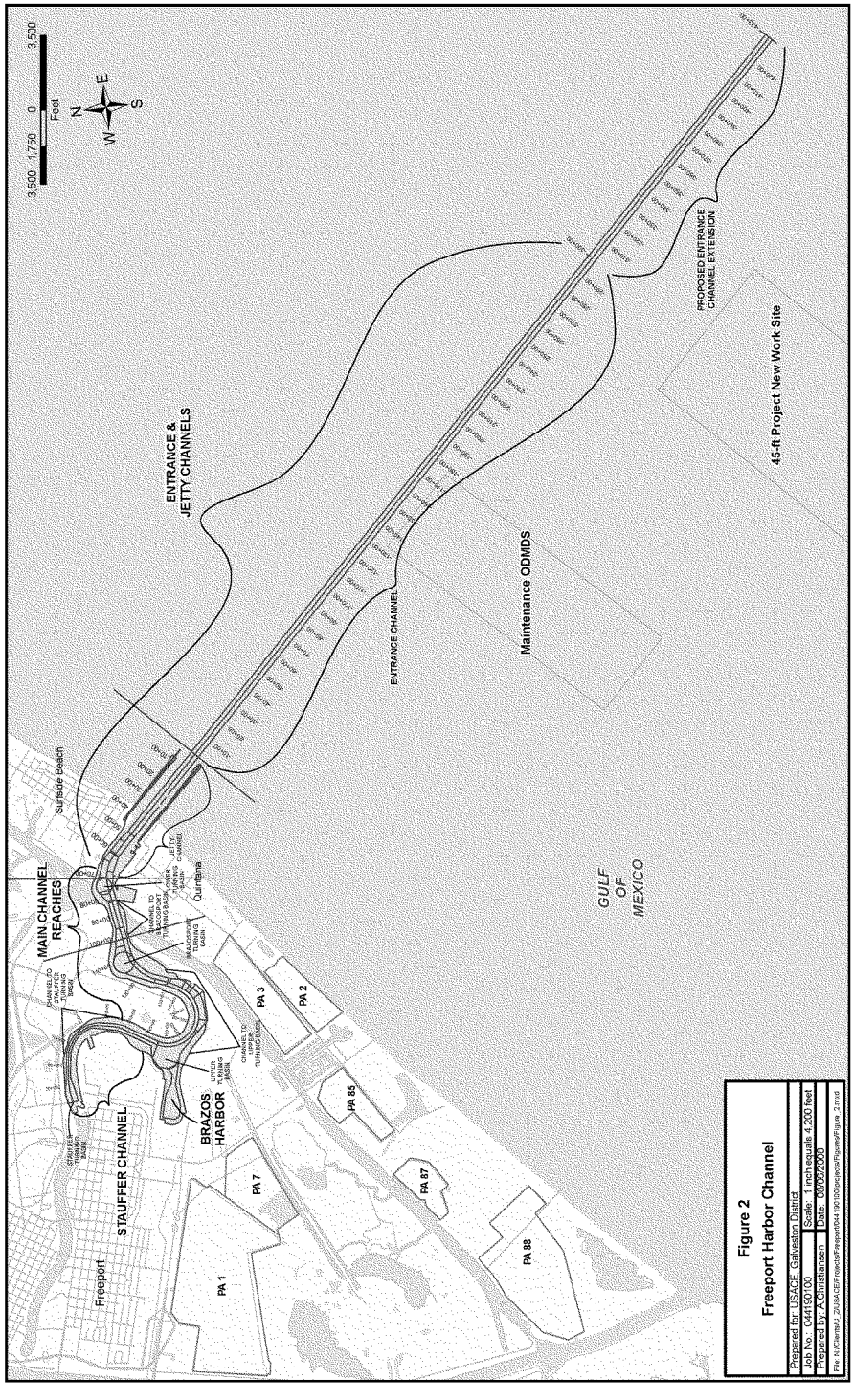



**Figure 2**
**Freeport Harbor Channel**

Prepared for: USACE, Galveston District
Job No.: 04419010 | Scale: 1 inch equals 4,200 feet
Prepared by: AChristiansen | Date: 06/05/2006
File: N:\Clients\USACE\Projects\Freeport\04419010\projects\Figures\Figure_2.mxd

### 1.5.1 Fish and Wildlife Resources

It should be noted that because of urban and industrial development over many decades, habitat types in much of the project area have been disturbed to the point where original species composition and diversity found prior to major development no longer exist. Consequently, much of the project area and the project footprint is devoid of significant biological resources and sensitive habitats, and has low ecological value.

**Upland Resources.** Natural habitats within the project footprint are highly fragmented due to human disturbance. Upland areas immediately along the ship channel contain broadly scattered grasses, sparse stands of shrub vegetation including invasive salt cedar and big leaf sumpweed, as well as small fringes of giant reed. Grasslands that may occur within the project area include pastures dominated by introduced species including bermudagrass and bahiagrass. Remnant coastal prairie plant species including little bluestem, brownseed paspalum, indiangrass, rosettegrass, and thin paspalum may still be found on the converted pasturelands used for grazing and haying. There are also fragmented and often isolated wetlands, flooded borrow pits, ditches, and other open-water areas in the project area.

Two proposed upland PAs (PAs 8 and 9) would be required for both new work and maintenance material from the Recommended Plan. These proposed new PAs are located northwest of the ship channel, west of the Brazos River Diversion Channel, and north of SH 36, and are currently used as pasture. Construction of PA 9 would impact 39 acres of ephemeral freshwater wetlands in the pasture, and 21 acres of riparian forest adjacent to the Brazos River Diversion Channel.

**Marine Resources.** The project area is located in an area that has been identified as EFH for juvenile and adult brown, pink, and white shrimp and juvenile and adult gray snapper, red drum, Spanish mackerel, and others. EFH that occurs within the project footprint include marine water column and marine nonvegetated bottoms. Although there are a few areas of quality EFH within the project area, the habitat within the project footprint in the Freeport Harbor Channel and areas immediately adjacent to the project footprint is dominated by industrial, commercial, and residential development, which does not represent high-quality EFH. Additionally, marine water column and marine nonvegetated bottoms occur in abundance within the project area and are, therefore, not unique to the area.

**Coastal Wetland Resources.** The majority of marsh habitat found in the project area does not have a direct hydrologic connection to the Freeport Harbor Channel. Within the project footprint, there are no estuarine or forested wetlands, estuarine tidal flats, freshwater flats, beach or dune habitat, and no SAV.

### 1.5.2 Threatened and Endangered Species

There are 32 federally and/or state-listed threatened and endangered wildlife species and 9 National Marine Fisheries Service (NMFS)–designated wildlife species of concern (SOC) of potential occurrence in Brazoria County, Texas, and adjacent Gulf waters. Of these, 13 are of possible occurrence in the study area and include the smalltooth sawfish, green sea turtle, hawksbill sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, loggerhead sea turtle, piping plover, whooping crane, blue whale, fin (or finback) whale, humpback whale, Sei whale, and the sperm whale.

A BA has been prepared to coordinate potential impacts to all federally listed species in the project area. This document, presented in FEIS Appendix I, concludes that construction of the proposed project may affect, but is not likely to adversely affect, four sea turtle species (green, hawksbill, Kemp's ridley, and loggerhead). No other impacts to federally listed species are anticipated.

### 1.5.3 Water and Sediment Quality

TCEQ has designated the old Brazos River Channel Tidal (Freeport Harbor) as Segment 1111. This segment covers a portion of the project area. The designated uses for Segment 1111 are contact recreation (swimming) and high-quality aquatic habitat. Historical sediment analyses reveal no contaminant issues regarding sediment quality in the project area. Analyses indicate that both maintenance and new work dredged material are safe for potential beneficial uses if beneficial uses were feasible, and safe for upland and ocean placement.

### 1.5.4 Noise

Noise levels in the project area are elevated compared to undeveloped areas along the coast and are affected by petrochemical industry operations, vessel navigation, and vehicular traffic in the Freeport Harbor area.

The magnitude of noise is usually described by its sound pressure, usually in decibels (dB), and dB values are further defined in terms of frequency-weighted scales (A, B, C, or D). The A-weighted scale is most commonly used in environmental noise measurements because it places most emphasis on the frequency range detected by the human ear (1,000–6,000 hertz). Sound levels measured using A-weighting are often expressed as dBA.

Although the vast majority of land use along the ship channel is dominated by commercial and industrial uses, noise-sensitive receivers such as single-family residences, recreational vehicle parks, and recreational areas do occur on both sides of the channel in the communities of Quintana, Surfside Beach, and Freeport.

At a distance of 0.5 mile from the channel, noise levels measured at noise-sensitive receivers within Quintana were found to range from approximately 49 to 61 dBA. The average, ambient outside noise level recorded within Quintana was 55 dBA, which is similar to the goal set by agencies for the outdoor noise environment in residential areas. Maintenance dredging currently occurs on the Freeport Harbor Channel approximately every 10 months and generally includes use of a hopper dredge, which typically produces 87 dBA at 50 feet. The nearest noise-sensitive receivers affected by existing channel maintenance activities are located within Surfside Beach Jetty Park, which is approximately 220 feet from the channel centerline, and the nearest residences at Surfside Beach are located approximately 880 feet from the channel centerline. Worst-case noise levels related to maintenance dredging operations were calculated to be approximately 75 dBA at the Surfside Beach Jetty Park and 63 dBA at Surfside Beach's nearest residences.

### 1.5.5 Hazardous, Toxic, and Radioactive Waste

A Hazardous, Toxic, and Radioactive Waste (HTRW) assessment was conducted for the project area, in accordance with USACE document Engineering Regulation (ER) 1165-2-132, Water Resource Policies and Authorities–Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works Projects. The purpose of the assessment was to identify "the existence of, and potential for HTRW contamination on lands in the project area, or external contamination which could impact, or be impacted by the proposed project." The findings and recommendations presented in the HTRW assessment are based on information derived from a review of historic aerial photographs, interviews with persons knowledgeable of the area, a review of regulatory agency databases, and a site visit. The assessment revealed that several HTRW sources exist at upland industries that line the banks of the Freeport Harbor Channel. Although these sources exist upland, no active enforcement actions were under way and no HTRW sites were located within the project area footprint. More-detailed information regarding the HTRW assessment can be found in Appendix D-1 of the FEIS that accompanies this document.

### 1.5.6 Prime and Unique Farmland

A total of six soil series are located within existing PA 1 and proposed PAs 8 and 9. These series include Surfside clay, Velasco clay, Brazoria clay, Clemville silty clay loam, Norwood silt loam, and Pledger clay. Of these series, PA 9 is composed primarily of Brazoria clay, with lesser amounts of Clemville silty clay loam (northeast), Norwood silt loam (east), and Pledger clay (south). All these soils are nearly level nonsaline soils used primarily as pastureland and cropland.

Prime farmland soils are defined by the Secretary of Agriculture as those soils that have the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops. The soil quality, growing season, and moisture supply are available to

economically produce sustained high yield of crops when treated and managed, including water management, according to acceptable farming methods. Some soils are considered prime farmland in their native state, and others are considered prime farmland only if they are drained or watered well enough to grow the main crops in the area. There are no designated "unique farmlands" in the State of Texas.

The soils located in PA 9 are classified as prime farmlands, while those in PA 8 are not. Construction of PA 9 will impact approximately 250 acres of prime farmland. According to the Natural Resources Conservation Service (NRCS), PA 9 and the mitigation area do contain soils classified as Important Farmland and are subject to the Farmland Protection Policy Act (FPPA).

### 1.5.7 Cultural Resources

Both marine and terrestrial archeological surveys were conducted for areas of new construction in the project area. Archival research and field surveys identified potential remains of a Civil War Confederate gun battery at proposed PA 9. No cultural resources were identified at proposed PA 8. A Programmatic Agreement (PAg) was executed among the USACE, Port Freeport, and the Texas State Historic Preservation Officer (SHPO) to ensure compliance with Section 106 of the National Historic Preservation Act for these resources. Further investigation of the potential Civil War gun battery would be undertaken during development of plans and specifications for this project.

## 1.6 NON-FEDERAL SPONSOR AND COORDINATION

The District Engineer, Galveston District, USACE, is responsible for the overall management of the study and report preparation. Port Freeport (formerly Brazos River Harbor Navigation District) is the non-Federal sponsor for the study. The Brazos River Harbor Navigation District was created in 1925 by the Texas State Legislature. It was created to make improvements for the navigation of inland and coastal waters, for the preservation and conservation of inland and coastal waters for navigation, and for control and distribution of storm and flood waters of rivers and streams in aid of navigation. It was organized and incorporated under the laws of the State of Texas, but is not a State agency. The study is being coordinated with interested Federal, State, and local agencies and the public. The following are some of the agencies and groups that provided input during preparation of the report:

### 1.6.1 Federal Agencies

- U.S. Fish and Wildlife Service (USFWS)
- U.S. National Marine Fisheries Service (NMFS)
- U.S. Environmental Protection Agency (EPA)
- U.S. Coast Guard (USCG)

### 1.6.2 State Agencies

- Texas Commission on Environmental Quality (TCEQ)
- Texas General Land Office (GLO)
- Texas Parks and Wildlife Department (TPWD)
- State Historic Preservation Officer (SHPO)
- Texas Department of Transportation (TxDOT)
- Texas Railroad Commission (RRC)

### 1.6.3 Regional, County, and Local Agencies

- Port Freeport

### 1.6.4 Other Interests

- Brazos River Pilots Association (BRPA)

In addition, representatives of numerous firms involved in navigation as well as special-interest groups and individuals provided input to the study.

## 1.7 PRIOR AUTHORIZATIONS

The original project for Federal improvement at Freeport was authorized by the River and Harbor Act (RHA) of June 14, 1880, which provided for construction of jetties for controlling and improving the channel over the bar at the mouth of the Brazos River. The work was started in 1881 and continued until 1886 when operations were suspended for lack of funds. Partial construction of the jetties was accomplished, but the work was not successful in obtaining an adequate depth over the bar. On March 28, 1899, the Brazos River Channel and Dock Company, under authority granted by the RHA of August 21, 1888, started work to provide a navigation channel at the mouth of the Brazos River and thence inland between the banks of the river. The company was unable to finance completion of the work, and on April 25, 1899, in accordance with requirements of the RHA of March 3, 1899, transferred all its works, rights, and privileges to the United States. This constituted the initial authorization for the existing project for Freeport Harbor.

The Federal project known as Freeport Harbor, Texas, is an improvement of the original mouth of the Brazos River that provides for a deep-draft waterway from the Gulf of Mexico to the city of Freeport. A diversion dam about 7.5 miles above the original river mouth and a diversion channel rerouting the Brazos River from the dam to an outlet in the Gulf about 6.5 miles southwest of the original mouth now make Freeport Harbor solely tidal.

The Freeport Harbor waterway has an overall length of about 7.6 miles from deep water in the Gulf of Mexico to the Brazos Harbor Turning Basin. The Stauffer Channel was dredged originally by local interests to a depth of 25 feet over a bottom width of 300 feet, with a 500-foot-square basin area. The RHA of 1935 incorporated the channel into the Federal project and authorized its deepening to 30 feet over a bottom width of 200 feet, and deepening the basin to 30 feet. Prior to deauthorization in 1974, available depths were considered adequate for the using traffic, and the authorized 30-foot depth was not dredged.

The project also provides for construction of a navigation lock in the diversion dam by local interests, when required in the interest of commerce and navigation. The lock has not been required and at present is classified as an inactive element of the project.

The Freeport Harbor Project was authorized by the RHAs of May 1950 and July 1958. The RHAs provided for an Entrance Channel 38 feet deep and 300 feet wide from the Gulf of Mexico to a point inside the jetties and for inside channels 36 feet deep and 200 feet wide to and including the Upper Turning Basin. The 38/36-foot project was completed in 1962. Greater depth and width were authorized by Congress in 1970 (Section 101 of RHA of 1970, PL 91-611; House Document 289, 93rd Congress – 2nd Session, December 31, 1975) and by the president in 1974. These authorizations were for the Jetty Channel to be relocated and deepened to 45 feet, widened to 400 feet, and the North Jetty relocated northward. The relocated Outer Bar Channel was authorized to a 400-foot width, to a 47-foot depth, and to extend approximately 4.6 miles into the Gulf. An FEIS for the project was prepared by the USACE in 1978 (USACE, 1978). In 1978, prior to Federal construction, Seaway Pipeline, Inc., under a Department of Army permit, widened the Outer Bar Channel to 400 feet and the Jetty Channel to 230 feet.

The 45-foot MLT (46-foot MLLW) channel was completed in 1993, including channel and turning basins dredging, relocation of the USCG station, construction of the 3,700-foot North Jetty, construction of public use facilities, rehabilitation of the South Jetty and addition of 500 feet to the North Jetty, and adjustments to a bend near the project's Upper Turning Basin.

There are no bridges across the various channels of the Federal navigation project.

## 1.8 STUDY AND REPORT PROCESS

In October 2002, USACE completed a Reconnaissance Report Section 905(b) Analysis for Freeport Harbor. This report concluded that channel modifications that would improve the efficiency and safety of the channels appeared feasible. The report recommended detailed studies to quantify the magnitude of the costs and benefits associated with several types of improvements.

This feasibility study follows the recommendations given in the Reconnaissance Report. It includes detailed analyses of a range of improvements and their effectiveness at improving

efficiency and safety by allowing the use of larger, more-efficient vessels and reducing delays and vessel casualties. It also includes detailed assessments of environmental, social, and local economic effects of those improvements determined to be most viable from a national economic perspective. Results of this study form the basis for a decision on project implementation, including preconstruction design studies.

The study process provided for a systematic preparation and evaluation of alternate plans that address study area problems and opportunities. The process involved all of the six functional planning steps:

1. Specify Problems and Opportunities
2. Inventory and Forecast Conditions
3. Formulate Alternative Plans
4. Evaluate Effects of Alternative Plans
5. Compare Alternative Plans
6. Select Recommended Plan

The earlier Reconnaissance Report emphasized problem identification and formulation of alternatives. Emphasis in this Feasibility Report is on evaluation of alternatives, assessment of impacts, and selection of a recommended plan.

# 2.0 PROBLEM IDENTIFICATION

Existing water resources problems and needs for Freeport Harbor were identified through coordination with Federal and State agencies, area residents, waterway users, and the non-Federal sponsor. Most of the identified problems are not unique to Freeport but are common to many of the areas along the coast of Texas.

## 2.1 NAVIGATION AND COMMERCE

Since the completion of the 45-foot project, the size of ships using the waterway has steadily increased so that many vessels currently have to be light-loaded to traverse the waterway. The current channel depth requires that large crude carriers remain offshore and transfer their cargo into smaller crude tankers for the remainder of the voyage. This lightering operation takes place in the Gulf of Mexico where the two ships, the mother ship and the lightering ship, come together so that the cargo transfer can take place. Although this operation has been going on for years, the possibility for a collision, oil spill, fire, or other adverse environmental consequences is always present. Deepening the channel will reduce the number of lightering and lightening operations and provide more opportunity for direct shipments. Current projections suggest that crude imports will increase throughout the period of evaluation. As these imports increase, the number of lightering vessels and product carriers will also increase, adding to the shipping delays and congestion.

### 2.1.1 Historical Traffic Overview

This provides an overview of recent historical traffic for the existing commodity base. The discussion is limited to crude petroleum, petroleum and chemical products, general and container cargo, and LNG.

Freeport experienced strong growth over the past decade, with total tonnage increasing from an average of 16.1 million short tons for 1994–1995 to 28.5 million for 2004–2006. In 2008, Freeport ranked 26th in the Nation in terms of total tonnage, up from 38th in the early 1990s. In terms of foreign imports and exports, Freeport ranked 12th among U.S. ports in 2007, up from 25th in the early 1990s.[1] Approximately 85 percent of Freeport's current tonnage consists of deep-draft movements. The remaining 15 percent consists of shallow-draft GIWW traffic.

Table 2 presents Freeport's tonnage by major commodity groups through 2009. As indicated, petroleum, specifically crude petroleum, dominates total tonnage. Crude petroleum presently represents 75 percent of 2004–2009 ocean-going tonnage. Freeport's crude petroleum imports represented an average of 3.9 percent of the U.S. total and 6.9 percent of Petroleum

[1] USACE, Waterborne Commerce of the U.S., Part 5, National Summary, Institute of Water Resources (IWR)-Waterborne Commerce Statistics Center (WCSC)-09, 2006-2007 and 1991-1993. Commodity-specific tonnages were not available for 2007 as of May 23, 2009.

Administration Defense District (PADD) III. The combination of the channel-deepening project from 40 to 45 feet in the early 1990s and refinery expansions fostered a 178 percent increase in Freeport's crude imports from 1993 to 1998. Over the same period, PADD III imports increased 31 percent and U.S. imports increased by 28 percent. Since 1998, Freeport's growth has leveled and is more comparable to national and regional growth. Statistics published in Institute of Water Resources (IWR)-Waterborne Commerce Statistical Center (WCSC)-09 show Freeport's 2007 total tonnage at approximately 30 million short tons, down from 32 million in 2006. Preliminary data from the U.S. Department of Energy (DOE) show that Freeport's crude oil imports were down in both 2007 and 2008 over 2006; however, review of the 2008 monthly data showed that Freeport crude oil imports were generally higher in 2008 than 2007 for all months except September when Hurricane Ike hit the region.

**Table 2**
**Freeport Harbor Deep-Draft Tonnage (1,000s of short tons)**
**(1970–2009)**

| | Major Deep-draft Commodities | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Petroleum Products | | Chemical Products | | | | | |
| Year | Crude Oil Imports | Imports | Exports | Imports | Exports | Other | Total Ocean-going | Inland Waterway Barge Cargo | Total Tonnage |
| 1970 | 0 | 0 | 0 | 0 | 1,082 | 1,209 | 2,291 | 2,992 | 5,283 |
| 1980 | 12,498 | 221 | 0 | 301 | 1,162 | 3,117 | 17,299 | 2,832 | 20,131 |
| 1990 | 5,472 | 17 | 26 | 149 | 1,093 | 3,407 | 10,164 | 4,330 | 14,494 |
| 1991 | 6,175 | 38 | 10 | 183 | 967 | 1,895 | 9,268 | 6,398 | 15,666 |
| 1992 | 5,891 | 53 | 14 | 163 | 871 | 2,761 | 9,753 | 5,200 | 14,953 |
| 1993 | 7,025 | 18 | 25 | 176 | 931 | 1,564 | 9,739 | 4,286 | 14,025 |
| 1994 | 10,073 | 259 | 17 | 187 | 1,431 | 1,483 | 13,450 | 4,000 | 17,450 |
| 1995 | 10,378 | 1,345 | 73 | 344 | 1,425 | 1,357 | 14,922 | 4,740 | 19,662 |
| 1996 | 15,074 | 1,887 | 27 | 275 | 1,418 | 1,199 | 19,880 | 4,691 | 24,571 |
| 1997 | 16,742 | 1,863 | 117 | 333 | 1,522 | 1,272 | 21,849 | 4,432 | 26,281 |
| 1998 | 19,527 | 1,825 | 46 | 255 | 1,724 | 1,175 | 24,552 | 4,462 | 29,014 |
| 1999 | 18,321 | 1,644 | 39 | 341 | 1,633 | 1,247 | 23,225 | 4,851 | 28,076 |
| 2000 | 19,770 | 2,054 | 45 | 379 | 2,217 | 1,685 | 26,150 | 4,835 | 30,985 |
| 2001 | 19,307 | 2,413 | 40 | 583 | 1,748 | 1,407 | 25,498 | 4,645 | 30,143 |
| 2002 | 18,019 | 736 | 119 | 663 | 1,907 | 1,119 | 22,563 | 4,601 | 27,164 |
| 2003 | 19,672 | 1,857 | 87 | 778 | 2,104 | 1,114 | 25,612 | 4,925 | 30,537 |
| 2004 | 20,602 | 2,873 | 91 | 835 | 2,622 | 2,093 | 29,116 | 4,792 | 33,908 |
| 2005 | 22,000 | 1,779 | 91 | 691 | 2,509 | 1,553 | 28,623 | 4,672 | 33,295 |
| 2006 | 21,706 | 1,080 | 109 | 705 | 2,551 | 1,420 | 27,571 | 4,576 | 32,147 |
| 2007 | 18,523 | 1,046 | 90 | 710 | 2,691 | 1,005 | 24,065 | 5,151 | 29,216 |
| 2008 | 20,607 | 955 | 81 | 602 | 2,406 | 1,347 | 25,998 | 3,844 | 29,842 |
| 2009 | 19,418 | 220 | 200 | 573 | 1,864 | 1,063 | 23,398 | 4,025 | 27,363 |

Source: USACE, Waterborne Commerce of the U.S., Part 2, 1970–2009

The Port of Freeport is contained in a relatively large foreign trade zone (FTZ). The purpose of an FTZ is to attract and promote U.S. participation in international trade and commerce. Merchandise in an FTZ is considered to be outside the U.S. Customs territory. Therefore, the merchandise is subject to duty only when it leaves the FTZ for consumption in the U.S. market. If FTZ merchandise is exported, there is no duty liability. While in the FTZ, foreign merchandise and domestic merchandise may be stored, sold, exhibited, assembled, disassembled, repackaged, distributed, sorted, tested, graded, cleaned, mixed with other merchandise, otherwise manipulated, or destroyed. The merchandise may also undergo manufacturing operations. Merchandise subject to quota may be stored in an FTZ until a closed quota reopens.

Expansion of the Panama Canal is expected to have significant impacts on shipping routes, port development, cargo distribution, and a host of others to the U.S. maritime system. One of its greatest impacts will be felt in the fast-growing container trade where expansion will enable larger vessels to transit the canal. Vessel calls on the East and Gulf coasts are also expected to increase significantly as cargo shifts away from the congested West Coast. Expansion of the canal project is expected to be completed in 2014 and will coincide with the 2017–2067 period of analysis used for the Freeport Harbor evaluation.

### 2.1.2 Crude Petroleum Import Overview

Table 3 displays Freeport's crude petroleum imports and shows the port's share of the national and regional totals. Freeport's import growth relates to the pipeline distribution network with national links and regional connections from the channel's Seaway and ConocoPhillips terminals. The Seaway pipeline system provides a critical link in the crude oil supply chain for Central and Midwest refining centers.

During the 1990s, partnerships between ConocoPhillips, Texas Eastern Petroleum Pipeline Company (TEPPCO), Seaway, and ARCO authorized the construction of two new storage tanks at Phillips's Sweeny Tank Farm. The two new tanks expanded the shell tank storage capacity at Sweeny from 1.6 million barrels to 2.6 million barrels. The expansion increased the capacity of the Seaway crude system from approximately 223,000 barrels per day (BPD) to the current volume of 260,000 BPD. As indicated, these changes coincided with the completion of the 45-foot project depth and offshore jetty expansion in the mid-1990s.

Approximately 25 percent of the crude oil imported to Freeport is sent from PADD III to PADD II.

While the Energy Information Administration (EIA) shows all of Freeport's crude oil imports being tied to ConocoPhillips's Sweeny refinery, the point of demarcation is one of two docks on the Freeport Harbor Channel. The Sweeny refinery receives crude oil through the Seaway and the ConocoPhillips docks on the Freeport Channel. Approximately 90 percent of Freeport's total crude oil ship tonnage is discharged at Seaway, the remaining 10 percent at the ConocoPhillips

dock. Both the Seaway and ConocoPhillips terminals provide access to the regional and national pipeline network. The Sweeny refinery is 28 miles to the northwest of Freeport.

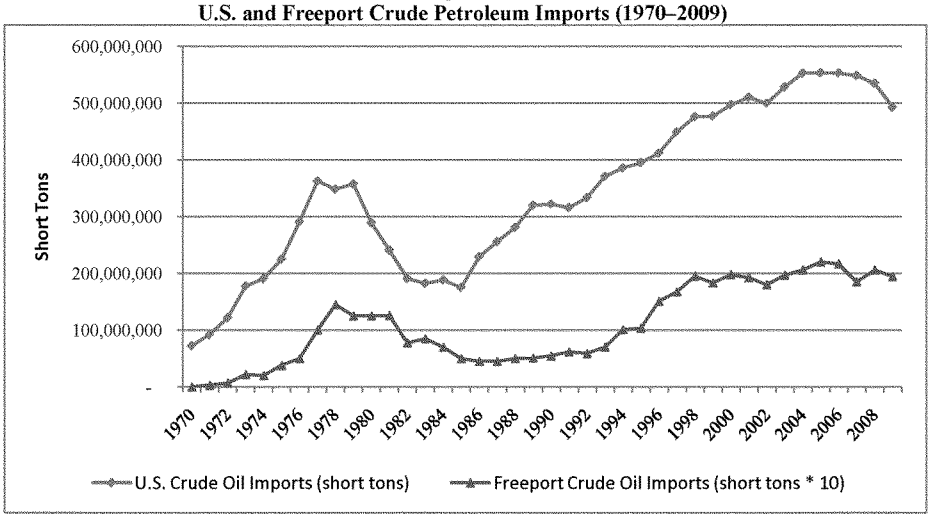
**Table 3**
**Comparison of Freeport and Regional and National Totals**
**Crude Petroleum Imports (1,000s of short tons)**

| Year | Freeport Imports | PADD III Imports | U.S. Total Imports | Freeport % of | |
|---|---|---|---|---|---|
| | | | | PADD III | U.S. Total |
| 1990 | 5,472 | 178,052 | 322,433 | 3.1 | 1.7 |
| 1991 | 6,175 | 174,852 | 316,310 | 3.5 | 2.0 |
| 1992 | 5,891 | 184,871 | 333,666 | 3.2 | 1.8 |
| 1993 | 7,025 | 204,356 | 371,267 | 3.4 | 1.9 |
| 1994 | 10,073 | 221,020 | 386,381 | 4.6 | 2.6 |
| 1995 | 10,378 | 222,164 | 395,484 | 4.7 | 2.6 |
| 1996 | 15,074 | 237,708 | 411,824 | 6.3 | 3.7 |
| 1997 | 16,742 | 252,270 | 449,961 | 6.6 | 3.7 |
| 1998 | 19,527 | 267,175 | 476,231 | 7.3 | 4.1 |
| 1999 | 18,321 | 270,491 | 477,592 | 6.8 | 3.8 |
| 2000 | 19,770 | 281,170 | 497,547 | 7.0 | 4.0 |
| 2001 | 19,307 | 292,859 | 510,298 | 6.6 | 3.8 |
| 2002 | 18,019 | 282,226 | 499,999 | 6.4 | 3.6 |
| 2003 | 19,672 | 300,325 | 528,703 | 6.6 | 3.7 |
| 2004 | 20,602 | 316,402 | 553,337 | 6.5 | 3.7 |
| 2005 | 22,000 | 310,493 | 553,923 | 7.1 | 4.0 |
| 2006 | 21,706 | 309,399 | 553,489 | 7.0 | 3.9 |
| 2007 | 18,523 | 306,956 | 521,948 | 6.0 | 3.6 |
| 2008 | 20,607 | 294,045 | 535,170 | 7.0 | 3.9 |

Source: USACE and Energy Information Administration (EIA), 1990–2009.

Expectations are that Freeport's imports will grow at rates generally comparable to the regional and national trends. This expectation is based on the study area's established infrastructure of regional and national pipeline distribution links. Comparison of the Freeport and U.S. 1970–2008 period relationship is illustrated on Figure 3.

**Figure 3**
**U.S. and Freeport Crude Petroleum Imports (1970–2009)**




Source: USACE, Waterborne Commerce of the U.S., Part 2, 1970–2009 and EIA.

### 2.1.3 Petroleum and Chemical Product Overview

Regional production includes petroleum products such as transportation fuels, such as gasoline, diesel fuel, and jet fuel, and chemical products such as sodium hydroxide, complex hydrocarbons, and ammonia. For 2004–2006, petroleum and chemical imports and exports totaled 5.3 million short tons. Freeport's products consist primarily of petroleum product imports and chemical exports. Petroleum products are distributed throughout the Midwest and southeastern United States by pipeline, barge, and railcar. Chemicals are primarily distributed by inland waterway barge.

As shown in Table 2, petroleum product imports experienced high growth after 1994. Imports totaled 259 thousand short tons in 1994 and increased to 1.3 million in 1995. The increases experienced in the mid-1990s were associated with lube oil imports, which represented an average of nearly 70 percent of 1995–2000 petroleum product imports. While experiencing tremendous growth from 1994 to 1995, petroleum product imports are variable (see Table 2). In spite of fluctuating volumes, Freeport's share of U.S. petroleum product imports has remained between 1 and 2 percent since the mid-1990s. Freeport's petroleum product exports are much lower than imports and are also variable. Freeport's product exports averaged 97 thousand short tons for 2004–2009. Freeport's petroleum product exports represent less than 1 percent of the U.S. total product export. Table 4 shows Freeport's 1992–2007 percent of the U.S. totals. As

shown in Table 4, Freeport exports 4.6 percent of U.S. chemicals. Chemical export volumes for 2004–2007 averaged 2.6 million short tons and represent record highs.

**Table 4**
**Freeport Harbor**
**Petroleum and Chemical Product Imports and Exports**
**Freeport Percentages of U.S. Totals**

| Year | Petroleum Products | | Chemical Products | |
|---|---|---|---|---|
| | Imports | Exports | Imports | Exports |
| 1992 | 0.1 | 0.0 | 1.0 | 2.1 |
| 1993 | 0.0 | 0.0 | 0.9 | 2.3 |
| 1994 | 0.3 | 0.0 | 0.8 | 3.2 |
| 1995 | 1.7 | 0.1 | 1.4 | 2.9 |
| 1996 | 1.9 | 0.1 | 1.1 | 3.0 |
| 1997 | 1.8 | 0.2 | 1.3 | 3.0 |
| 1998 | 1.5 | 0.1 | 0.9 | 3.4 |
| 1999 | 1.3 | 0.1 | 1.2 | 3.1 |
| 2000 | 1.6 | 0.1 | 1.0 | 3.8 |
| 2001 | 1.8 | 0.1 | 1.3 | 3.2 |
| 2002 | 0.6 | 0.2 | 1.7 | 3.5 |
| 2003 | 1.3 | 0.2 | 1.9 | 3.9 |
| 2004 | 1.7 | 0.1 | 1.9 | 4.3 |
| 2005 | 1.1 | 0.1 | 1.5 | 4.2 |
| 2006 | 1.1 | 0.1 | 1.5 | 4.4 |
| 2007 | 0.6 | 0.1 | 1.5 | 4.6 |

Source: USACE, Waterborne Commerce of the U.S., Part 2, 1992–2007.

Freeport exports 30.2 percent of U.S. sodium hydroxide; 9.4 percent of U.S. organic chemicals; 9.2 percent of U.S. chemical hydrocarbon; and 7.1 percent of alcohols. In comparison to exports, chemical imports are lower and averaged 768 thousand short tons for 2003–2005, which is three times less than exports. While lower in volume than exports, Freeport imports nearly 15 percent of U.S. chemical hydrocarbons and nearly 8 percent of ammonia.

### 2.1.4 General and Container Cargo Overview

Freeport's remaining cargo primarily consists of banana imports, rice exports, and outbound coastwise chemical shipments. Distribution of these commodities by major group is displayed in Table 5 and Figure 4. Freeport imports 6 percent of the U.S. banana imports and exports 6 percent of rice exports. Bananas and rice are transported through docks located within the Brazos Harbor Turning Basin where the project depth is 36 feet. Bananas are transported in

**Table 5**
**Freeport Harbor Other Ocean-going Cargo Major Commodities, 1970–2007**
**(1,000s of short tons)**

| Year | Banana Imports | Rice Exports | Bulk Materials & Manufactured Goods | Coastwise Chemicals | | Group Total | Total Ocean-going Tonnage | % of Total Ocean-going Tonnage |
|---|---|---|---|---|---|---|---|---|
| | | | | Receipts | Shipments* | | | |
| 1970 | 0 | 0 | 1 | 118 | 563 | 682 | 2,291 | 30 |
| 1975 | 0 | 100 | 18 | 130 | 537 | 784 | 5,482 | 14 |
| 1980 | 0 | 32 | 1 | 154 | 614 | 801 | 17,299 | 5 |
| 1985 | 203 | 24 | 1 | 158 | 217 | 602 | 10,319 | 6 |
| 1990 | 133 | 195 | 4 | 109 | 284 | 725 | 10,164 | 7 |
| 1995 | 174 | 287 | 8 | 62 | 380 | 911 | 14,922 | 6 |
| 1996 | 202 | 247 | 12 | 41 | 344 | 846 | 19,880 | 4 |
| 1997 | 133 | 212 | 8 | 71 | 527 | 951 | 21,849 | 4 |
| 1998 | 320 | 175 | 5 | 86 | 426 | 1,012 | 24,552 | 4 |
| 1999 | 301 | 174 | 11 | 82 | 428 | 996 | 23,225 | 4 |
| 2000 | 255 | 310 | 76 | 6 | 555 | 1,202 | 26,150 | 5 |
| 2001 | 173 | 210 | 160 | 10 | 533 | 1,086 | 25,498 | 4 |
| 2002 | 293 | 226 | 47 | 0 | 419 | 985 | 22,563 | 4 |
| 2003 | 233 | 210 | 89 | 0 | 443 | 975 | 25,612 | 4 |
| 2004 | 237 | 203 | 504 | 0 | 712 | 1,656 | 29,116 | 6 |
| 2005 | 300 | 245 | 591 | 1 | 445 | 1,582 | 28,930 | 5 |
| 2006 | 315 | 215 | 240 | 0 | 350 | 1,120 | 27,571 | 4 |
| 2007 | 354 | 101 | 405 | 0 | 281 | 1,141 | 24,065 | 5 |

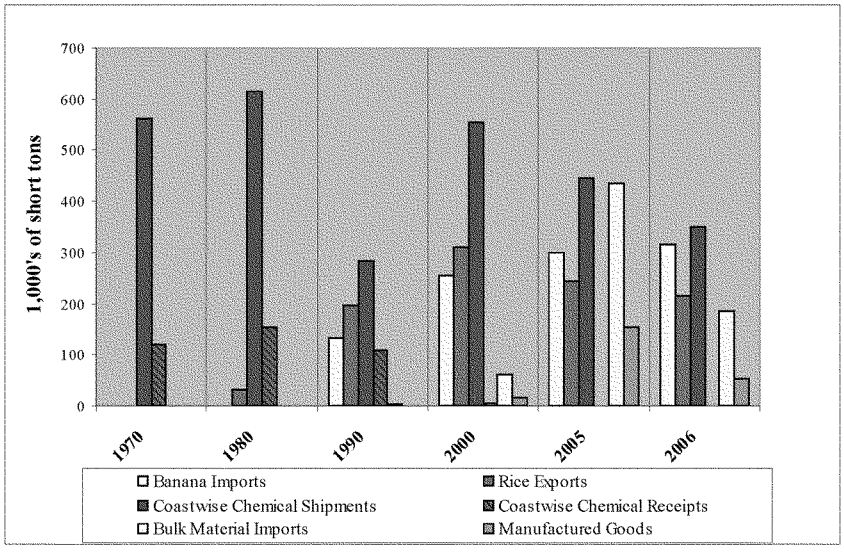
Source: USACE, Waterborne Commerce of the U.S., Part 2, 1970–2007.

*Primarily consists of shipments of hydrocarbons.

refrigerated cargo vessels. Future use of larger vessels for banana imports is not anticipated. The deadweight tonnage (DWT) range for refrigerated cargo vessels is 11,000 to 16,000. Analysis for the fleet showed that the median beam width of the future is not expected to increase.

While it does not appear that refrigerated cargo vessel sizes are increasing, significant increases are occurring for other vessel groups, and completion of the Panama Canal expansion by the year 2014 will allow for more-fully loaded vessel movements from deepwater ports in the Far East and the western coasts of Mexico and South America. The canal expansion will accommodate maximum loaded drafts of 15 meters, or approximately 49 feet. Freeport's increasing traffic volumes and vessel size limitations within Brazos Harbor Turning Basin for general and container cargo facilities (Figure 5) prompted construction of landside facilities adjacent to the Upper Turning Basin and lower reach of the Stauffer Channel.

**Figure 4**
**Freeport Harbor 1970–2006**
**Other Ocean-going Cargo**
**(1,000s of Short Tons)**




Source: USACE, Waterborne Commerce of the U.S., Part 2, 1970–2006.

Freeport's other general cargo base consists of rice exports and bulk materials. Rice is transported in general cargo vessels, and the size of these vessels has increased over the last decade. The largest general cargo vessels using the public terminal range from 40,000 to 46,000 DWT. The larger carriers are used for meat, sugar, cereal, and vegetable imports from Brazil and Europe. There are some indications of transitions to larger vessels for bulk materials, chemicals, and general cargo. While more deeply loaded vessels are not anticipated for the turning basin reach, the port is expanding general and container cargo facilities just outside the turning basin reach due to capacity constraints within the basin and the introduction of larger container vessels for a wider range of commodities. The Port is constructing a new container facility, Velasco Terminal.

Large bulk carriers are used in the import of Freeport's limestone and building materials. Maximum vessel size is presently 67,000 DWT. Design drafts range from 40 to 44 feet, and loaded drafts range from 35 to 39 feet. Total limestone imports for 2005 were 433,000 tons. Limestone imports represented 40 percent of 2003–2005's general cargo tonnage. Rock and limestone are used in residential and commercial building construction and have increased at all

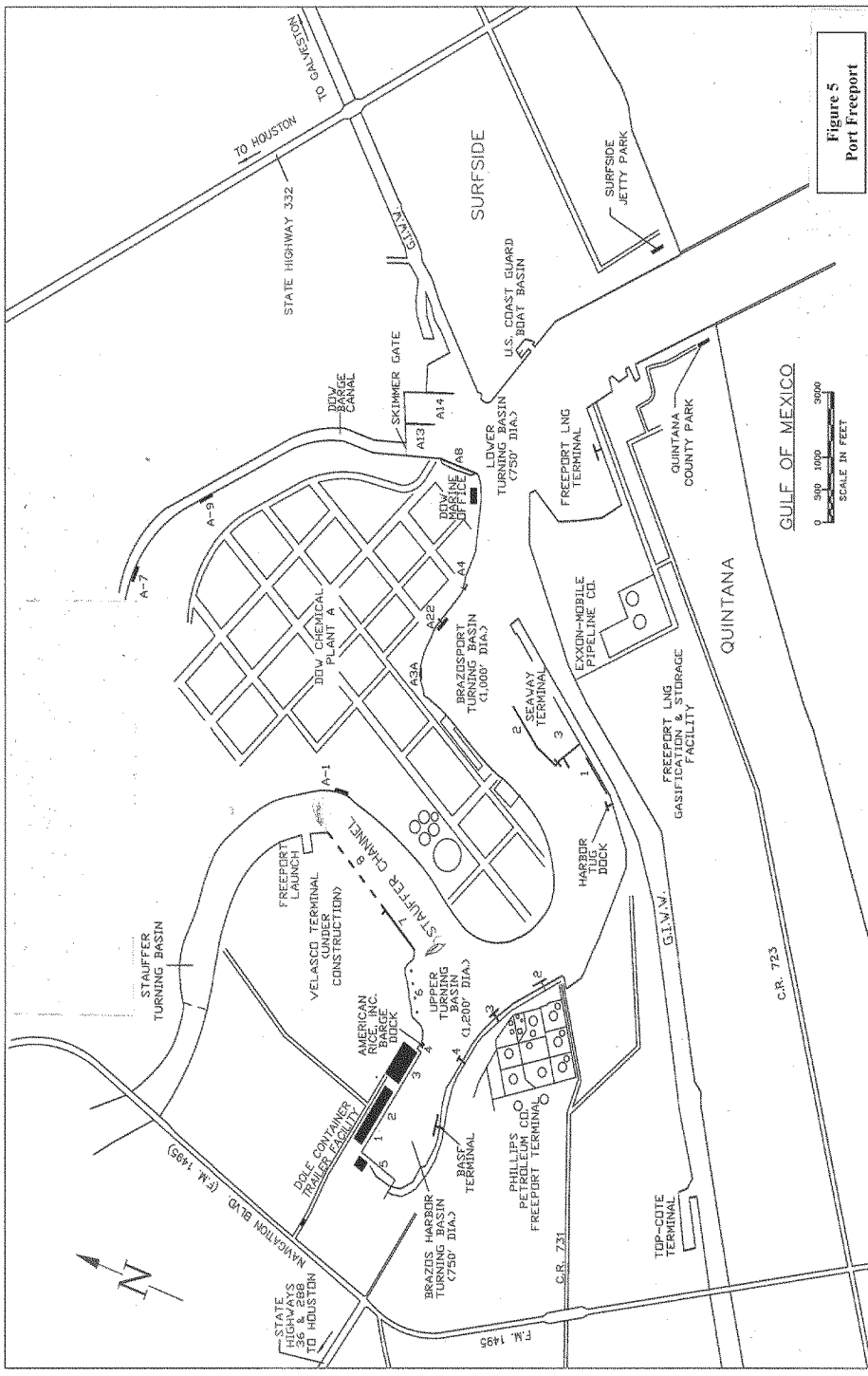



**Figure 5**
**Port Freeport**

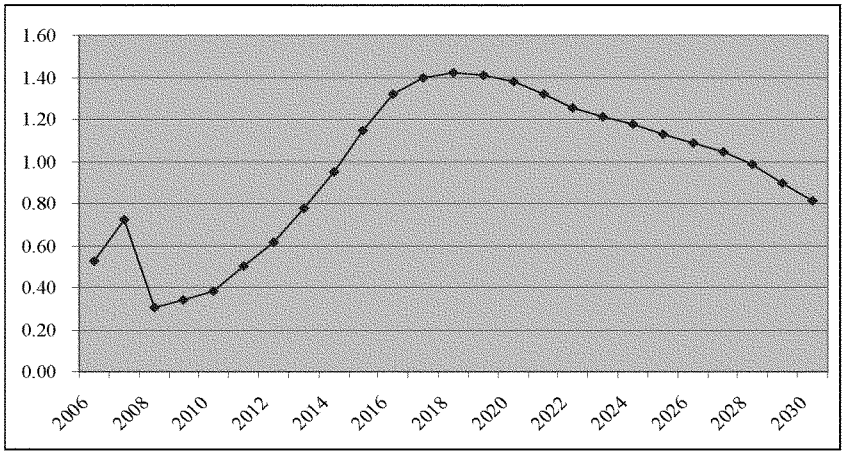
Texas ports. These cargoes are presently transported through the facilities in the Brazos Harbor Basin. A portion of future bulk traffic is anticipated to move to the Velasco Terminal dock. This move will allow for the use of larger and more-fully loaded bulk carriers.

### 2.1.5 Liquefied Natural Gas Overview

Freeport's LNG terminal became operational in April 2008. The terminal is located along the southern edge of the Freeport Harbor Jetty Channel near Station 65+00 and adjacent to the intersection of the Freeport Harbor Channel and the GIWW. The docks at the LNG terminal were built to accommodate vessels 1,099 feet long by 177 feet wide.

Total U.S. LNG imports were down in 2008 by 54 percent from the 2007 record high of 771 billion cubic feet. While LNG traffic through Freeport is also presently low, the DOE's April 2009 forecast shows U.S. LNG imports reaching 2007 levels again in 2017 and peaking at 1,380 billion cubic feet in 2020. Between 2020 and 2030, imports are forecasted to turn down once again. Figure 6 shows the DOE's 2006–2030 U.S. LNG import forecast. Freeport's existing LNG facility includes two 160,000-cubic-meter ($m^3$) storage tanks and one piled dock capable of handling LNG vessels in excess of 200,000 $m^3$, in order to accommodate the largest LNG tankers under construction today. The first phase of the project allows the facility to have a send-out capacity of 1.75 billion cubic feet per day.

**Figure 6**
**U.S. LNG Imports 2006–2030**
**Trillions of Cubic Feet**




Source: U.S. Department of Energy, Updated Annual Energy Outlook 2009 Reference Case Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in the Economic Outlook, Table 13, SR/OIAF/2009-03.Container Overview

Natural gas will be transported from Freeport through a 9.4-mile pipeline to Stratton Ridge, Texas, which is a major point of interconnection with the Texas intrastate gas pipeline system. The Freeport Section 204 widening analysis includes detailed analysis of Freeport's LNG market. Import volumes of 84.2 billion cubic feet per day are forecasted for 2010, with volumes increasing to 712 billion cubic feet by 2018 as shown in the Section 204 report. The vessel sizes and expected throughput prompted the non-Federal sponsor to pursue widening of the Outer Bar and Jetty channels from 400 to 600 feet under the Section 204 authority of WRDA of 1986, as amended in 1990. Phase I of the terminal is presently in operation, and vessel traffic commenced in April 2008. While LNG provided the impetus for the Section 204 study, channel widening would also benefit existing and future traffic. The base analysis used for the feasibility study assumes that the channel is widened.

### 2.1.6 Container Overview

The Stauffer Channel (upstream of the Upper Turning Basin) presently has an operating depth of approximately 18 feet. The channel was authorized to 30 feet and had an operating depth of 25 feet in the mid-1950s. In 1955, the channel was placed in an inactive status and subsequently deauthorized in 1974 under Section 12, Appendix C, PL 93-251. Since its deauthorization, the channel depth has deteriorated from its previously constructed 25 feet to an approximate 18-foot water depth. The depth limitations and impediments associated with silting generate safety concerns and contribute to declining utilization patterns.

#### 2.1.6.1 Stauffer Channel Modification

In order to accommodate a container facility, the port initially wished to extend the terminus of the Federal channel to include a portion of the Stauffer Channel. The length of the proposed channel was to be approximately 1,200 feet from the federally authorized 45-foot-deep Upper Turning Basin. The port presently ships and receives general cargo through the Brazos Harbor Turning Basin docks. As part of the feasibility study, optimization of the depth for the channel modification would need to be determined. Depth alternatives of 35, 40, 45, and 50 feet were initially evaluated for the 1,200-foot reach. The results of the initial screening resulted in a more-focused evaluation of a smaller range of depths, as discussed in Section 5. Analysis was conducted to determine the competitive advantage that Freeport might potentially have over competing ports. For instance, there is considerable overlap between the Houston and Freeport population centers, and a Freeport container terminal has the potential of capturing associated savings.

#### 2.1.6.2 Stauffer Channel Container Cargo

The proposed Freeport container facility would be in competition with the Port of Houston facilities, specifically Barbours Cut, as well as the facilities at Bayport (Houston) and at the planned facility at Shoal Point in Texas City. Barbours Cut is the Gulf Coast's largest container

facility and is the third largest in the Nation. Therefore, the Houston fleet was reviewed as a potential indicator of vessel size expectations.

### 2.1.7 Offshore Vessel Overview

Presently the upper reach of the Stauffer Channel from Station 223+00 through Station 256+00 has a water depth of approximately 18 feet. In spite of its deauthorization, the Stauffer Channel is used to a limited extent. Prior to its deauthorization in 1974, the project operating depth was 25 feet. Channel user traffic consists of seismic and crew vessels. Discussions with channel users and company officials indicated that maneuvering between the silted channels and maintaining a proper alignment for safe passage is difficult. The difficulty results from under-hull clearance that the pilots need for safety. Clearance needs to be approximately 10 percent of the channel depth.

## 2.2 SAFETY AND NATIONAL SECURITY

In light of recent world events, global concern regarding acts of international terrorism and organized crime has increased, leading to heightened domestic and international security at U.S. ports. Efforts led by the U.S. Customs Service, USCG, and World Customs Organization have increased port security by requiring more-stringent vessel inspections, deploying additional monitoring vessels, and increasing terminal owner/operator security measures. Programs such as Operation Noble Eagle, Operation Neptune Shield, and additional Homeland Security concepts and strategies have been integrated into the daily operations of ports through coordination of USCG resources and partnerships with the maritime community and local law enforcement agencies. These partnerships are working to increase the local network of and interaction among Federal, State, and local law enforcement and intelligence agencies. Port Freeport operates under very strict safety policies and measures, which are for the most part beyond the scope of this study.

Port Freeport is one of the Nation's most important ports for the petrochemical industry. Key national influences include TEPPCO Terminal, Dow Chemical, Freeport LNG, BASF Corporation, and the Strategic Petroleum Reserve (SPR). A deeper and wider channel that allows for safer and more-efficient movement of crude and petroleum products is not only an economic benefit to the U.S., but also makes the channel safer for ship traffic and brings the U.S. a step closer to being more self-sufficient in the refining of fossil fuels. This can ultimately contribute to our national security. Improvements to navigation and the continued cooperation between international and national agencies and the private business sector contribute to the security of our Nation and its ports.

## 2.3 ENVIRONMENTAL

The potential impacts of the proposed project on human and environmental resources were identified during the public interest review, including the placement of dredged material. All factors that may be relevant to the proposed project were considered, including the following: dredged material management, air quality, shoreline erosion, economics, historic resources, protected species, ecological resources, water and sediment quality, geology and soils, energy needs, hazardous materials, recreation, and, in general, the welfare of the people. Air quality impacts resulting in nitrogen oxides ($NO_x$) increases and displacement of ephemeral wetlands and riparian forest at proposed upland PAs have been addressed in the project FEIS.

## 2.4 PROBLEM SUMMARY

The depth and width of the existing channel system remain restrictive to a large portion of the current world fleet because of their size. Beam width restrictions continue to cause delays for larger ships wishing to enter Freeport's port facilities. Increased channel depths would reduce the need for lightering and lightening. Access to additional facilities would also allow the Port of Freeport to utilize facilities for future development. A project addressing current shipping delays while increasing safety for both the industry and the environment is needed.

# 3.0 FORMULATION OBJECTIVES, CONSTRAINTS, AND CRITERIA

## 3.1 NATIONAL OBJECTIVES

The fundamental national objective of Federal participation in water resources development projects is to assure that an optimum contribution is made to the welfare of all people. The Water Resources Council's *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* dated March 1983 and the National Environmental Policy Act of 1969 (NEPA), PL 91-190, as amended, provide the basis for Federal policy for planning Federal water resources projects. These authorities have established the procedures for formulation and evaluation of water resources projects. Additional policies and regulations, derived from executive and legislative authority, further define the criteria for assessment of plan impacts, risk analysis, review and coordination procedures, and project implementation.

Current Federal policy dictates that National Economic Development (NED) is the primary national objective in water resources planning. NED objectives stress increasing the value of the Nation's output of goods and services and improving economic efficiency on a national level. Planning objectives designed to improve NED are concerned with the value of increased output of goods and services resulting from external economics associated with a plan.

The Federal objective of water and related land resources planning is to contribute to NED in a manner that is consistent with protecting the Nation's environment. Consequently, the resource's condition should be more desirable with the recommended plan than under the without-project condition.

National objectives are designed to assure systematic interdisciplinary planning, assessment, and evaluation of plans addressing natural, cultural, and environmental concerns that will be responsive to Federal laws and regulations.

Four accounts are established to facilitate display of effects of alternative plans. The NED account is required. Other information that is required by law or that will have a material bearing on the decision-making process should be included in the other accounts, or in some other appropriate format used to organize information on effects:

1. The NED account displays changes in the economic value of the national output of goods and services;
2. The environmental quality (EQ) account displays nonmonetary effects on significant natural and cultural resources;

3. The regional economic development (RED) account registers changes in the distribution of regional economic activity that results from each alternative plan. Evaluation of regional effects are to be carried out using nationally consistent projections of income, employment, output, and population; and
4. The other social effects (OSE) account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

### 3.1.1 Regional Sediment Management

Regional sediment management was also a considered objective. Section 2037 of WRDA 07 amends Section 204 of WRDA 92. The objective was to investigate the opportunity to develop, at Federal expense, a regional sediment management plan, in cooperation with appropriate Federal, State, regional, and local agencies, for sediment obtained through construction, operation, or maintenance of an authorized Federal water resources project. The regional sediment management plan would identify projects for transportation and placement of sediment to reduce storm damages to property and protect, restore, and create aquatic and biologically related habitat including wetlands.

## 3.2 PLANNING OBJECTIVES

The primary objective of Federal navigation activities is to contribute to the Nation's economy while protecting the Nation's environmental resources in accordance with existing laws, regulation, and executive orders. More-specific planning objectives were identified by area residents and concerned State and Federal agencies or suggested by existing opportunities for improving the quality of life. Plans were formulated and evaluated with the following objectives in mind:

1. To improve the navigational efficiency and safety of the deep-draft navigation system at Freeport Harbor within the period of analysis, and
2. To maintain, protect, or restore the quality of the Freeport Harbor area's terrestrial, cultural, estuarine, and coastal resources within the period of analysis.

## 3.3 PLANNING CONSTRAINTS

Plans must be formulated with regard to addressing the problems and needs of the area, taking into consideration future without-project (FWOP) conditions. The plans should identify tangible and intangible benefits and costs from economic, environmental, social, and regional perspectives. Institutional implementation constraints should also be identified. The formulation framework requires the systematic preparation and evaluation of alternative solutions to the recognized water resource–related problems within the study area. The process also requires that impacts of the proposed action be measured and results displayed or accounted for in terms of contributions to NED, EQ, RED, and OSE.

Interaction with other interests must be maintained throughout the planning process to avoid duplication of effort, minimize conflicts, obtain consistency, and assure completeness. The following constraints apply to this feasibility study:

- Fish and wildlife habitat in the study area should be preserved, if possible;
- The study process and plans developed must comply with Federal laws and policies; and
- Alternative plans that resolve problems in one area should not create or amplify problems in other areas.

## 3.4 PHYSICAL CONSTRAINTS

Plans must be formulated with regard to addressing physical channel constraints in two areas. Widening in the Jetty Channel area will be limited to a top width based on the distance between the jetties. Relocation of the jetties could make the project economically infeasible. The second area with physical constraint issues is in the channel reach between the Brazosport Turning Basin and the Upper Turning Basin. Within this reach, there are dock facilities whose modifications could make channel widening economically infeasible.

## 3.5 GUIDANCE AND CRITERIA

Current guidance specifies that the Federal objective of planning is to contribute to NED consistent with protecting the Nation's environment. The following general criteria are applicable to all water resource studies. They have generally guided the formulation of this study. Technical, economic, environmental, and social criteria have been established to guide the project development process. These criteria are discussed below.

### 3.5.1 Technical Criteria

Technical criteria require the preservation of adequate project dimensions to provide safe passage of commercial navigation traffic through this waterway while minimizing environmental impacts. These criteria require plans to be compatible with navigation needs and consistent with the requirements of the navigational equipment using this portion of the waterway and to provide a long-term plan for the placement of dredged materials in order to continue maintenance of the waterway in the future. These plans must be consistent with specific environmental conditions of the area including soil conditions, topography, and terrestrial and aquatic ecosystems.

Formulation of alternative alignments and dredged material placement alternatives and their evaluation was accomplished by analysis of historical and projected shoaling rates, erosion causes and rates, and general structural and nonstructural alternatives applicable for conditions that are specific to this area. Technical information, both historical data and specific information prepared for this project, used during this study included, but was not limited to, ship simulation

results, aerial photography, historical dredging records, and previously published scientific reports related to this area.

### 3.5.2 Economic Criteria

The economic criteria require that tangible benefits attributable to projects exceed project costs. Project benefits and costs are reduced to average annual equivalent values and related in a ratio of benefits to costs (benefits-to-cost ratio, or BCR). This ratio must exceed unity to meet the NED objective. Selected plans, whether structural, nonstructural, or a combination of both, should maximize excess benefits over costs; however, unquantifiable features must be addressed subjectively. These criteria are used to develop plans that achieve the objective of NED and provide a base condition for consideration of economically unquantifiable factors that may impact on project proposals.

All structural and nonstructural measures for navigation projects should be evaluated using the appropriate period of analysis and the currently applicable interest rate. Total annual costs should include amounts for operation, maintenance, major replacements, and mitigation, as well as amortization and interest on the investment.

### 3.5.3 Environmental Criteria

The general environmental criteria for navigation projects are identified in Federal environmental statutes, executive orders, planning guidelines, and the Environmental Operating Principles (EOP). It is the national policy that fish and wildlife resource conservation be given equal consideration with other study purposes in the formulation and evaluation of alternative plans. The basic guidance during planning studies is to assure that care is taken to preserve and protect significant ecological and cultural values, and to conserve natural resources. These efforts also should provide the means to maintain and restore, as applicable, the desirable qualities of the human and natural environment. Alternative plans formulated to improve navigation should avoid damaging the environment to the extent practicable and contain measures to minimize or mitigate unavoidable environmental damages. Particular emphasis was placed on the following:

- Protection, preservation, and improvement of the existing fish and wildlife resources along with the protection and preservation of estuaries and wetland habitats and water quality;
- Consideration in the project design of the least-disruptive construction techniques and methods;
- Mitigation for project-related unavoidable impacts by minimizing, rectifying, reducing or eliminating, compensating, replacing, or substituting resources;
- Preservation of significant historical and archeological resources through avoidance of impacts. This is the preferable action to any other form of mitigation since these are finite, nonrenewable resources.

EOP have been established for evaluation of water resource projects. Throughout the study process, the EOP should be considered. The EOP ensure conservation, environmental preservation, and restorations are considered at the same level as economic issues. These principles are (1) strive to achieve environmental sustainability, (2) consider environmental consequences, (3) seek balance and synergy, (4) accept responsibility, (5) mitigate impacts, (6) understand the environment, and (7) respect other views.

### 3.5.4 Social and Other Criteria

Plans proposed for implementation should have an overall favorable impact on the social wellbeing of affected interests and have overall public acceptance. Structural and nonstructural alternatives must reflect close coordination with interested Federal and State agencies and the affected public. The effects of these measures on the environment must be carefully identified and compared with technical, economic, and social considerations and evaluated in light of public input.

### 3.5.5 Other USACE Initiatives

#### 3.5.5.1 USACE Campaign Plan

In August 2006, as a result of lessons learned from hurricanes Katrina and Rita, the USACE Chief of Engineers initiated the "Actions for Change" in an effort to transform the USACE planning, design, construction, and operation and maintenance (O&M) principles and decision-making processes. This program has been further developed into the Campaign Plan. The USACE is moving forward with this Campaign Plan to transform the way business is done. The USACE Campaign Plan is available on the internet at http://www.usace.army.mil/about/campaignplan/ Pages/Home.aspx.

The successful achievement of the goals and objectives contained in this Campaign Plan are dependent on actions implemented by the entire USACE team. The Campaign Plan included four goals for USACE. These goals are:

**Goal 1: Ready for all Contingencies** – Deliver USACE support to combat, stability, and disaster operations through forward deployed and reachback capabilities.

**Goal 2: Engineering Sustainable Water Resources** – Deliver enduring and essential water resource solutions through collaboration with partners and stakeholders.

**Goal 3: Delivering Effective, Resilient, Sustainable Solutions** – Deliver innovative, resilient, sustainable solutions to the Armed Forces and the Nation.

**Goal 4: Recruit and Retain Strong Teams** – Build and cultivate a competent, disciplined, and resilient team equipped to deliver high quality solutions.

Goals 1 and 4 do not apply directly to the USACE planning process and are not discussed in detail. Goals 2 and 3 pertain to water resources planning and directly to the Freeport Harbor study. These goals are described in more detail below.

***Goal 2: Engineering Sustainable Water Resources***

With Goal 2 USACE focuses on comprehensive, sustainable, and integrated solutions to the Nation's water resources challenges through collaboration with stakeholders. This goal refers to not only developing and delivering comprehensive and lasting solutions but also ensuring that these solutions are long lasting, integrated, and holistic to respond to today's and future challenges.

***Goal 3: Delivering Effective, Resilient, Sustainable Solutions***

Goal 3 emphasizes that USACE will provide innovative, resilient, and sustainable infrastructure solutions for the Nation today and in the future. USACE is the Nation's premier public service engineering and construction organization and can provide infrastructure support to serve both the military and national civilian arenas. This effort will improve resilience and lifecycle investment in critical infrastructure, deliver reliable infrastructure using a risk-informed asset management strategy, and develop and apply innovative approaches to delivering quality infrastructure.

The Campaign Plan results are discussed in Section 12.

# 4.0 PLAN FORMULATION

## 4.1 PLAN FORMULATION RATIONALE

The rationale for formulating and developing alternative solutions is discussed in the following paragraphs. The planning framework requires the systematic preparation and evaluation of alternative ways of addressing problems, needs, concerns, and opportunities while considering environmental factors. The criteria and broad planning objectives previously identified form the basis for subsequent plan formulation, screening, and ultimately plan selection.

The planning process for this study has been driven by the overall objective of developing a comprehensive plan that would allow reliable and efficient ship traffic at Freeport Harbor. Secondary objectives have been to address other related water resources problems in the study area. The first phase of this process was to establish the magnitude and extent of the problems and then to develop and evaluate an array of alternative solutions to meet the existing and long-range future needs of the area.

During the feasibility phase, lines of communication were opened with Federal, State, and local agencies, private groups, and the affected public. Through scoping and other coordination meetings, public involvement activities were continued throughout the planning process.

The expected FWOP scenario was first developed for comparison with other alternatives. Nonstructural and structural plans were developed to address the planning objectives. For the structural plans, an array of channel modifications and dredged material placement alternatives were developed, evaluated, and screened. The modifications were investigated as to possible means to satisfy the objectives of a more-reliable, more-efficient Freeport Harbor.

Through a two-phased screening process, a plan was ultimately selected. The first phase of plan formulation was the initial assessment of potential management measures with initial technical and environmental criteria. Rough cost and economic estimates were made for potential alternative plans, and the plans were screened. Further preliminary and detailed design refinements were accomplished for the screened alternatives and for the recommended plan prior to developing a baseline cost estimate for this plan.

Structural and nonstructural measures were examined for project applicability. The No Action/Without-Project conditions were established for the project. Preliminary alternatives were developed for various plans. Preliminary environmental considerations were evaluated for the various plans. From these evaluations in Phase 1, alternative plans were selected to carry forward into Phase 2, detailed plan formulation.

Benefits and costs, detailed in Table 6, were developed for preliminary channel alternatives up to the Upper Turning Basin. These numbers were used to reduce the number of alternatives to be considered during more-detailed evaluation. Mitigation was considered to be the same for all alternatives during the screening of alternative plans. Cost factors such as levee construction, dredging, and pipeline relocation/removal, engineering design, and construction management were included in this cost analysis. The evaluation was performed to put all the alternative plans on an equal basis without the mitigation costs. Although no ecological benefits and mitigation costs were calculated, all alternatives were reviewed for potential effects to the environment in a nonquantitative manner. Costs for O&M for each of the alternatives were not included in the initial evaluation but were considered in the later screening process. Costs were developed for all of the alternative plans; however, benefits were determined only for traffic associated with terminals on the authorized channel. Benefits for the Stauffer Channel were not calculated for the initial screening.

**Table 6**
**Initial Costs and Benefits for Considered Alternatives**

| Freeport Harbor Channel Widening and Deepening | | | | | |
|---|---|---|---|---|---|
| **Depth (feet)** | **Width (feet)** | **Benefits ($000)** | **Cost ($000)** | **BCR** | **Net Benefits ($000)** |
| 45 | 500 | 650 | 1,024 | 0.6 | –374 |
| 48 | 400 | 37,855 | 6,567 | 5.8 | 31,288 |
| 48 | 470 | – | 7,519 | – | * |
| 48 | 500 | 38,505 | 7,821 | 4.9 | 30,683 |
| 48 | 530 | – | 8,056 | – | * |
| 50 | 400 | 49,758 | 7,834 | 6.4 | 41,924 |
| 50 | 470 | – | 8,847 | – | * |
| 50 | 500 | 50,408 | 9,075 | 5.6 | 41,333 |
| 50 | 530 | – | 9,375 | – | * |
| 52 | 400 | 60,483 | 9,168 | 6.6 | 51,316 |
| 52 | 470 | – | 10,248 | – | * |
| 52 | 500 | 61,133 | 10,553 | 5.8 | 50,581 |
| 52 | 530 | – | 11,088 | – | * |
| 55 | 400 | 90,300 | 13,179 | 6.8 | 77,121 |
| 55 | 470 | – | 14,411 | – | * |
| 55 | 500 | 91300 | 15,424 | 5.9 | 75,876 |
| 55 | 530 | – | 16,121 | – | * |
| 60 | 400 | 140,000 | 20,280 | 6.9 | 119,720 |
| 60 | 470 | – | 21,778 | – | * |
| 60 | 500 | 141,474 | 23,591 | 6.0 | 117,883 |
| 60 | 530 | – | 24,340 | – | * |

*Benefits were not computed for these widths because the ship simulation study was used to determine the preferred width of the channel. It was not necessary to compute a BCR for each depth and width combination, but only to determine the best depth alternative for a common width.

Environmental concerns identified during the reconnaissance study in 2002 included the potential for environmental harm resulting from shipping accidents and associated oil/chemical spills, or other harmful releases to the environment. Safety issues and vessel casualties were reviewed. The results of these investigations indicated that differences between without- and with-project future casualty occurrences were generally not discernible. Vessel accident risks are presently minimized by the BRPA traffic rules. Minimization of accident probability through traffic rules will continue under the without- and with-project future conditions. The transit/traffic rules and associated restrictions are voluntary and agreed upon by the shipping industry, supported by the USCG Captain of the Port Orders under the Ports and Waterways Safety Act of 1976, as amended, and administered by the BRPA. The agreement dated January 12, 1981, will remain in force until the shipping industries, BRPA, and USCG agree to its revision or modification. Freeport Channel vessel traffic, particularly crude petroleum tankers and product tankers, are subject to vessel size limitations due to the existing 400-foot channel width. While traffic rules would be relaxed to some extent based on channel widening performed under the non-Federal sponsor's Section 204 study, the rules will be designed to limit risk. The Section 204 project will result in an increase in channel width from 400 to 600 feet.

Sediment quality in Freeport Harbor is not a concern for any alternative plan considered.

## 4.2 NO ACTION AND FUTURE WITHOUT-PROJECT CONDITION

To comply with the requirements of NEPA, a "No Action" Alternative must be included in the alternative array. The USACE planning guidance also requires analysis of a FWOP plan as one of the alternatives. The No Action Alternative describes existing conditions in the project area and is normally used for establishing FWOP conditions for an existing project. That is, FWOP conditions are those conditions that would normally occur due to natural or human-induced changes in the environment, changes in socioeconomic conditions, or other changes at some future point in time that would modify or influence an existing project, in the absence of a specific Federal action. As such, the No Action Alternative normally provides the basis for establishing the FWOP, and is used for comparative purposes when assessing impacts of other proposed alternatives. The No Action Plan consists of a 45-foot-deep by 400-foot-wide navigation channel with its periodic maintenance dredging program. Use of the channel by multiple vessels would be limited because of the current 400-foot width of the channel. As vessels increase in draft and beam, the restrictive depth and width of Freeport Harbor would prevent some vessels from entering with full loads, or would prevent the use of the channel complex altogether by large vessels. The need to lighter products and/or light load vessels would increase, thereby increasing overall user costs and decreasing the efficiency of the vessels using the waterway.

However, in the case of the proposed Federal project, the primary FWOP condition will not be based on the existing No Action Alternative. Instead, it will be based on proposed modifications of the existing channel under a permit widening application submitted to the USACE, Galveston District by the non-Federal sponsor (Port Freeport) subsequent to initial plan formulation. Under the permit widening action, the existing Outer Bar and Jetty channels would be widened, but not deepened. The FWOP condition would consist of the existing 45-foot-deep Outer Bar Channel, which would be widened from 400 to 600 feet. The permit action proposed by Port Freeport is within the footprint of the proposed Federal project. The permit site is located along the northern edge of the Outer Bar and Jetty channels. The permit was issued in March 2009, and the permit Widening Project would be constructed ahead of the proposed Federal project. Widening construction would begin upon approval by the Assistant Secretary of the Army (Civil Works) (ASA(CW)) for Federal assumption of maintenance expected in 2013. The Port Freeport Widening Project is shown on Figure 7.

The non-Federal study investigated the feasibility of widening the Outer Bar and Jetty channels by non-Federal interests at no cost to the Federal government, and then having the Federal government assume the maintenance responsibility of the widened increment. The authority to conduct the study is granted by Section 204(f) of WRDA 86, as amended in 1990. If the study determines that widening is economically justified, environmentally acceptable, and complies with Federal law and plan formulation guidance, the same section grants the ASA(CW) authority to approve assumption of such maintenance as part of the Federal project.

The purpose of the proposed non-Federal permit is to widen the channel to eliminate existing operational constraints that include (a) one-way traffic, (b) daylight-only operations for larger vessels, and (c) environmental restrictions (crosscurrents) that do not allow larger vessels to enter the port. Eliminating these operational constraints will allow vessels to avoid delays, thereby reducing shipping costs and logistical problems, improving vessel safety margins, and increasing Port Freeport's ability to accommodate more vessel traffic. The existing restrictions on vessel dimensions and port entry conditions are based solely on the existing dimensions of the Federal channel. A ship simulation study was performed for the non-Federal study, and it was identified that the 600-foot alternative was the minimum project width (400- and 500-foot alternatives were also studied) that will meet the stated goal.

An economic benefits analysis was prepared for the proposed permit project. The study assessed the cost and benefits of 400-, 500-, and 600-foot-wide alternatives. The analysis concluded that the 600-foot-wide alternative had the highest net annual benefits and identified the 600-foot alternative as the NED Plan for Section 204(f) purposes, based on the physical constraints of jetty width.

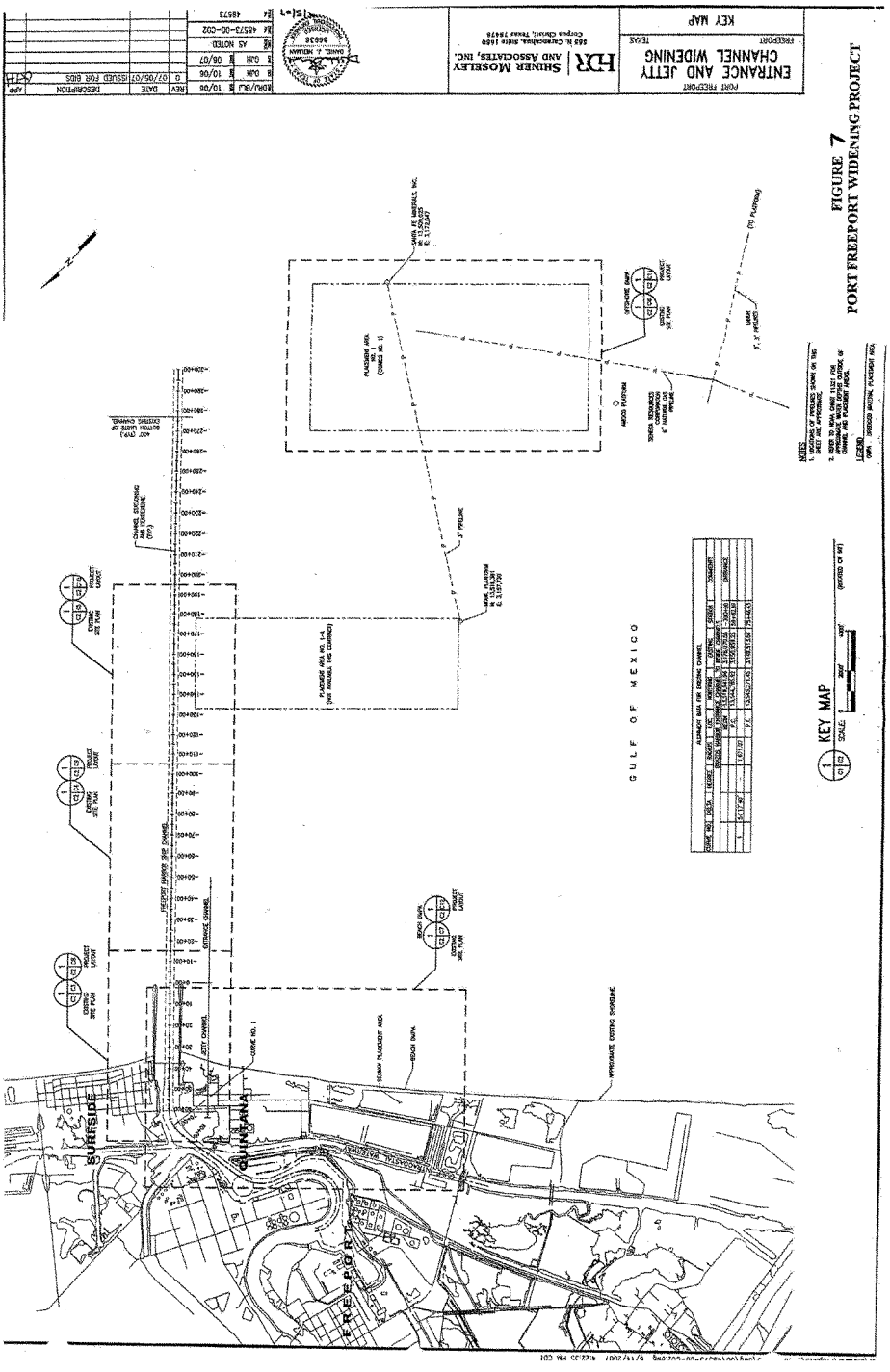



FIGURE 7
PORT FREEPORT WIDENING PROJECT

The environmental, engineering, navigation, and economic analyses also identified the 600-foot project as the preferred alternative. By means of the study, Port Freeport is requesting the Federal assumption of O&M of the widened channel increment. Port Freeport is incurring the cost of the widening feasibility study and the cost of the initial widening.

Scenario analyses addressing the risk and uncertainty of the channel widening by the non-Federal sponsor were performed. Two FWOP conditions were ultimately analyzed during detail plan formulation. FWOP-1 assumed the permit (Section 204(f)) action would be constructed; FWOP-2 (No Action) assumed that the permit action would not be constructed. The FWOP-2 scenario was developed at the request of USACE Headquarters (HQ).

### 4.2.1 FWOP-1

FWOP-1 assumes that construction of the Widening Project would occur before Federal construction of the Freeport Harbor Channel Improvement Project. Under FWOP-1, all channels and turning basins would be maintained at the currently authorized depth of 45 feet, with construction of the permitted 600-foot widening of the Entrance Channel. The widening project is expected to result in approximately 3.2 million cubic yards (mcy) of new work dredged material of which approximately 300,000 cubic yards (cy) of sandy/sand material would be placed on Quintana Beach in front of the Seaway PA. Maintenance dredging of existing ship channels and placement of that dredged material would continue as it is currently. The amount of material dredged from the Outer Bar Channel during maintenance cycles is expected to be about 3.3 mcy per year, an increase of about 1 mcy over existing conditions. The amount of material dredged from the remainder of the channel would remain unchanged. As the most probable project future, FWOP-1 is the condition against which all proposed project alternatives are evaluated, rather than the No Action Alternative or FWOP-2.

### 4.2.2 FWOP-2

The FWOP-2 Alternative is the existing 45-foot project. The 45-foot project depth and width would be maintained throughout the Entrance Channel. The Main Channel, turning basins, and Stauffer Channel dimensions would remain as described in Table 1. Maintenance material would continue to be placed in the existing Maintenance ODMDS for the Entrance Channel, and in PA 1 for the channels inshore of the Jetty Channel. This FWOP-2 scenario assumes that the non-Federal sponsor's Widening Project (Section 204(f)) would not be built as anticipated.

## 4.3 MANAGEMENT MEASURES

A management measure is a feature or activity at a site that addresses one or more of the planning objectives. A wide variety of measures is usually considered. These measures are evaluated separately or combined to form alternative plans for evaluation. Initial measures identified for consideration include both nonstructural and structural.

### 4.3.1 Nonstructural Measures

One nonstructural opportunity available is the continued use of beam width restrictions within the channel. Current pilot rule restrictions prevent two ships from passing in the channel. These rules are agreed upon by the shipping industry, supported by the USCG, and administered by the BRPA. This measure would only maintain current operations, with its increased costs and delays. Another nonstructural measure is use of lightering and lightening vessels. This is another practice already in use and would offer no additional benefits. Therefore, nonstructural alternatives were not considered feasible or did not fully address the problems.

### 4.3.2 Structural Measures

Structural measures considered include dredging to widen and deepen the existing Freeport Harbor. These measures allow existing ships to more fully utilize the proposed channel. It also allows ships to avoid delays due to the ability to meet more safely in a wider channel. However, dredging creates the need for the placement of dredged material. Any plan considered should ensure that placement alternatives address the needed capacities as well as the need to ensure minimal impacts to the environment.

# 5.0 PLAN ASSESSMENT AND SCREENING OF INITIAL ALTERNATIVE PLANS

The ultimate objective of the feasibility study is to arrive at a recommended plan after a full range of alternative plans has been analyzed. This involves a comparison between each alternative plan and the FWOP condition consequences, considering economic, environmental, and social impacts.

## 5.1 SCREENING PROCESS

As mentioned above, there were two nonstructural measures initially considered: continued use of beam width restrictions within the channel and use of lightering and lightening vessels. Both practices are already in use and would offer no additional benefits. Therefore, nonstructural alternatives were not considered feasible, did not fully address the problems, and were eliminated from further consideration.

A general screening process was first used to determine which structural alternative plan would result in the objective of providing reliable and efficient navigation at the least cost while minimizing environmental impacts. The non-Federal sponsor initially expressed a desire for a channel 600 feet wide and 60 feet deep. Preliminarily constraints to widening are in the Jetty Channel and in the channel reach between the Brazosport Turning Basin and the Upper Turning Basin. Multiple alternative plans were evaluated for more-detailed consideration. These initial screening alternative plans (Table 7) included:

- No Action Plan (1).
- Widening of the Outer Bar and Jetty channels only with no deepening (2).
- Deepening to 50, 55, or 60 feet from the Gulf of Mexico to the Upper Turning Basin, with and without widening, and with widening to 500 and 600 feet only through the Jetty Channel (3 and 4).
- Deepening to 40, 42, or 45 feet the Brazos Harbor Channel and Turning Basin, without widening and with widening to 300 feet (5 and 6).
- Reauthorization of Stauffer Channel to 30 feet (7).
- Deepening the lower (3,700-foot) reach of the Stauffer Channel to 36, 40, 42, 45, and 50 feet without widening and with widening to 300 feet (8–10).
- Dredging the upper (remaining 3,400 feet) reach of the Stauffer Channel to its previously authorized 30-foot depth (11).

**Table 7**
**Initial Screening of Project Management Measures**

| | Initial Screening Measures |
|---|---|
| 1 | No Action |
| 2a. | Widening – 500 foot |
| 2b. | Widening – 600 foot |
| 3a. | Deepen – 50 foot |
| 3b. | Deepen – 55 foot |
| 3c. | Deepen – 60 foot |
| 4a. | Deepen/Widen – 50x500 |
| 4b. | Deepen/Widen – 50x600 |
| 4c. | Deepen/Widen – 55x500 |
| 4d. | Deepen/Widen – 55x600 |
| 4e. | Deepen/Widen – 60x500 |
| 4f. | Deepen/Widen – 60x600 |
| 5a. | Deepen Brazos Harbor Channel – 40 foot |
| 5b. | Deepen Brazos Harbor Channel – 42 foot |
| 5c. | Deepen Brazos Harbor Channel – 45 foot |
| 6a. | Deepen/Widen Brazos Harbor Channel – 40x300 |
| 6b. | Deepen/Widen Brazos Harbor Channel – 42x300 |
| 6c. | Deepen/Widen Brazos Harbor Channel – 45x300 |
| 7. | Reauthorization of Stauffer Channel to 30 foot |
| 8a. | Deepen Lower Stauffer Channel – 36 foot |
| 8b. | Deepen Lower Stauffer Channel – 40 foot |
| 8c. | Deepen Lower Stauffer Channel – 42 foot |
| 8d. | Deepen Lower Stauffer Channel – 45 foot |
| 8e. | Deepen Lower Stauffer Channel – 50 foot |
| 9. | Widen Lower Stauffer Channel – 300 foot |
| 10a. | Deepen/Widen Lower Stauffer Channel – 36x300 |
| 10b. | Deepen/Widen Lower Stauffer Channel – 40x300 |
| 10b. | Deepen/Widen Lower Stauffer Channel – 42x300 |
| 10c. | Deepen/Widen Lower Stauffer Channel – 45x300 |
| 10d. | Deepen/Widen Lower Stauffer Channel – 50x300 |
| 11. | Redredge Upper 3,400 feet of Stauffer Channel to 30 foot |

Based on the problems and opportunities identified by the non-Federal sponsor and the public comments received at the public scoping meeting, a variety of alternative plans was identified to address one or more of the planning objectives. Screening of alternative plans focused on whether deepening and widening would be cost effective. The following criteria were used to evaluate and screen the alternative plans:

- Dredging Quantities
- Cultural Resource Concerns
- Construction Costs
- Sponsor's Preferences
- Public Acceptance
- Minimize Environmental Impacts
- Real Estate Issues
- Project Benefits
- Safety Issues

Preliminary benefits and costs were developed in Phase 1 for these alternative plans (see Table 6) and were used to reduce the number of alternative plans considered during more-detailed evaluation. Mitigation was considered to be the same for all alternatives during the screening of alternative plans. Cost factors such as levee construction, dredging, and pipeline relocation/removal, engineering design, and construction management were included in this cost analysis. Although no ecological benefits and mitigation costs were calculated, all alternatives were reviewed for potential effects to the environment in a nonquantitative manner. Costs for O&M for each of the alternatives were not included in the initial evaluation, but were considered in the later screening process. Costs were developed for all of the alternative plans; however, benefits were determined only for traffic associated with terminals on the authorized channel. Benefits for the Stauffer Channel were not calculated for the initial screening.

The channel was divided into its basic reaches, Outer Bar, Jetty, Lower Turning Basin, Channel to Brazosport Turning Basin, Brazosport Turning Basin, Channel to Upper Turning Basin, Upper Turning Basin, Brazos Harbor Channel and Turning Basin, and Stauffer Channel. The various depth and width options were applied to these reaches. In the Channel to Upper Turning Basin reach, there was some width restriction due to docks on both sides of the channel.

Dredged material from the Outer Bar and Jetty channels reach would be placed in ODMDSs by hopper dredges. There are two existing ODMDSs associated with the existing 45-foot project, the New Work ODMDS and the Maintenance ODMDS. Dredged material from the inshore channel reaches would be placed in confined upland PAs by hydraulic pipeline dredging. There are several existing PAs in the vicinity of the channel; however, new PAs would be needed for new work and maintenance material. Port Freeport owns large tracts of land in the area available for use as PAs.

## 5.2 NAVIGABILITY/WIDTH SCREENING

Ship simulation testing was conducted on the ERDC Ship/Tow Simulator to determine the navigation and safety impacts in the Freeport Harbor channel. The main objective of the study

was to determine whether the "design ship" (68,000 DWT – 965 feet by 106 feet wide) could reliably operate within the depth and widths of the proposed channel dimensions. The simulators are "real time," i.e., ship movements on the simulator require the same amount of time as in real life. Environmental forces such as currents, wind, banks, and ship-ship interactions all act upon the vessel during transit. The pilot controls the simulated vessel's engine speed and rudder. The pilot also has radio contact with assist tugs.

Freeport LNG had proposed to construct a new LNG terminal at the southwestern corner of the intersection of the deepwater navigation channel and the GIWW. As part of the initial screening process, a ship maneuvering study was conducted by Waterways Simulation Technology, Inc., at and in coordination with ERDC to test the safety of ship maneuvering and control in Freeport Harbor. Waterways Simulation Technology, Inc., is a private engineering consulting company specializing in navigation studies involving port, harbor, and channel design, systems behavior, ship and/or tow maneuvering simulations, prototype measurements of ship and/or behavior, and hydrodynamic modeling. The study concluded that ships could maneuver safely in and around the new LNG facility. The proposed facility was included in all ship simulation testing. This facility has since been constructed.

Three alternative channel plans were initially developed for ship simulation for Port Freeport. All three plans assumed construction of the proposed LNG facility at Freeport. As a result of this testing, two plans were abandoned for channel improvement based on pilot input and the third was modified into two alternate plans and evaluated. The results of the ship simulation determined that the Outer Bar and Jetty channels should be 600 feet wide to allow safe operation of the design vessel.

Plan 1 proposed a 62-foot Outer Bar Channel and a 60-foot channel from the western end of the jetties to the Upper Turning Basin. Plan 1 also included deepening of a portion of the Stauffer Channel to the Turning Basin to 50 feet. The Plan 1 Outer Bar Channel is 600 feet wide. The Outer Bar Channel extended the Federal channel by approximately 3 miles into the Gulf of Mexico to the 60-foot contour. Plan 1 included a 1,350-foot turning basin at Brazosport.

Plan 2 proposed a 62-foot Outer Bar Channel and 60-foot channel from the western end of the jetties to the Upper Turning Basin. Plans 1 and 2 were identical inland from the western end of the Brazosport Turning Basin. The Plan 2 Outer Bar Channel was 500 feet wide. Plan 2 included a 1,100-foot turning basin at Brazosport.

Plan 3 would not deepen the existing channels. The proposed Outer Bar Channel was 600 feet wide.

As a result of testing at ERDC, Plans 2 and 3 were abandoned and Plan 3 was modified into Plans 4 and 5. Plan 4 was very similar to the Plan 1 channels with deepening in the same manner and a constant width of 600 feet. Plan 4 also had a 1,200-foot turning basin at Brazosport.

However, the area northwest of the turning basin was dredged to 60 feet to allow more area for turning maneuvers needed by the very large crude carriers (VLCCs) and 165,000 DWT LNG tankers.

Plan 5 varied only slightly from Plan 4 in that the Brazosport Turning Basin was reduced to 1,100 feet in diameter. The area northwest of the turning basin was also dredged to allow for extra area during turning maneuvers as well as serve as a bend widener heading into the area downstream of the Upper Turning Basin.

## 5.3 SELECTED ALTERNATIVE PLANS

Initial analysis of the Brazos Harbor Channel and Turning Basin, used for general cargo and not used by large, deep-draft vessels, showed that deepening and widening were not justified. No increase in ship size is projected for the users of this area. The 36-foot-deep channel intersects with the Main Channel near Station 170+00, just above ConocoPhillips's petroleum docks. Brazos Harbor Turning Basin vessel traffic primarily consists of refrigerated container vessels delivering bananas and general cargo vessels shipping rice. The configuration of the access area and turning basin limits future expansion opportunities due to the high density of docks and landside facilities. The water and landside limitations of the general cargo reaches prompted development of the adjacent Velasco property for the construction of the new container terminal. The Brazos Harbor Channel was dropped from detailed plan formulation.

From the analysis of the initially considered management measures and with the selection of the preferred width of 600 feet based on the ship simulation study, nine channel alternative plans were selected for further consideration in Phase 2. These channel alternatives included:

**No Action Plan – Alternative 1**

**Gulf to Upper Turning Basin Channel Alternatives:**

Alternative 2 – Widen only to 600 feet through the Outer Bar and Jetty channels.

Alternative 3 – Deepen to 50 feet from the Gulf of Mexico to the Upper Turning Basin and widen to 600 feet through the Jetty Channel.

Alternative 4 – Deepen to 55 feet from the Gulf of Mexico to the Upper Turning Basin and widen to 600 feet through the Jetty Channel.

Alternative 5 – Deepen to 60 feet from the Gulf of Mexico to the Upper Turning Basin and widen to 600 feet through the Jetty Channel.

**Stauffer Channel Alternatives:**

Alternative 6 – Dredge the Stauffer Channel to the previously authorized dimensions of 30 feet deep and 200 feet wide.

Alternative 7 – Widen the lower 3,700 feet of the Stauffer Channel to 300 feet and its previously authorized depth of 30 feet, with the upper 3,400 feet of the Stauffer Channel dredged to previously authorized dimensions of 30 feet deep and 200 feet wide.

Alternative 8 – Widen the lower 3,700 feet of the Stauffer Channel to 300 feet and deepen to 40 feet, with the upper 3,400 feet of the Stauffer Channel dredged to previously authorized dimensions of 30 feet deep and 200 feet wide.

Alternative 9 – Widen the lower 3,700 feet of the Stauffer Channel to 300 feet and deepen to 50 feet, with the upper 3,400 feet of the Stauffer Channel dredged to previously authorized dimensions of 30 feet deep and 200 feet wide.

With the exception of No Action, a detailed analysis of benefits and costs was performed for each of these alternatives. This information is detailed in the following sections 6.0 through 10.0 and was used in selection of the plan.

## 5.4 ENVIRONMENTAL CONSIDERATIONS ALTERNATIVES

### 5.4.1 No Action Plan

Under the No Action Plan, the Freeport Harbor project will be maintained at the authorized depth of 45 feet. Shoaled material will be removed and placed in the designated offshore site for the Outer Bar and Jetty channels and in PA 1 for the channel inshore reach of the Jetty Channel. None of the dredged material would be used beneficially. Environmental impacts currently associated with the Freeport Harbor Project would continue.

### 5.4.2 Future Without-Project Plan (FWOP-1)

Under the FWOP-1, or non-Federal Widening Project, the channel would be maintained at the authorized depth of 45 feet, with a permitted width of 600 feet for the Outer Bar and Jetty channels. The Widening Project is expected to result in approximately 3.2 mcy of new work dredged material, of which approximately 300,000 cy of sandy/sand material would be placed on Quintana Beach in front of the Seaway PA. Maintenance dredging of existing ship channels and placement of that dredged material would continue as it is currently. The amount of material dredged from the Outer Bar and Jetty channels during maintenance cycles is expected to be about 3.3 mcy per year, an increase of about 1 mcy over existing conditions. The amount of material dredged from the remainder of the channel would remain unchanged from current conditions.

### 5.4.3 Federal Channel Deepening and Widening

Eight channel improvement alternatives were proposed for analysis. All were variations of deepening and/or widening of various reaches or the entire length of the authorized ship channel, as well as an extension of the existing Outer Bar Channel with deepening and widening. The

proposed depths for the existing channel ranged from 47 to 60 feet plus advance maintenance and overdepth dredging. Proposed widening would increase the existing project from 400 feet up to 600 feet along most of its length. With two exceptions, none of the alternatives would impact wetlands or upland areas, and all dredging will be confined to open water. However, initial channel widening (from 400 to 600 feet) would be accomplished by the non-Federal sponsor under a permit, ahead of proposed Federal channel improvements. The permit widening would remove approximately 1.9 acres of upland area located near the Jetty Channel just east of the USCG Station on the north (Surfside Beach) side of the channel. Proposed Federal channel improvements (deepening and selective widening) would follow the permit project, producing no additional impacts in the Jetty Channel portion of the permit project area. Alternatives 3 through 9 would impact benthic organisms that would recover rapidly after construction.

During plan formulation, the Federal project considered potential beneficial uses identified by the permit Widening Project such as beach renourishment and marsh restoration using new work dredged material from inland portions of the ship channel. While soil borings indicated some sandy material, no concentrated sand lenses were identified, and the high percentage of clay could not be used for beach nourishment. Marsh restoration was also precluded because of the presence of oysters at two of the three sites considered for restoration. The third potential site was cost prohibitive because of pump distance. New work and maintenance material from the offshore reaches of the ship channel would be placed in existing New Work and Maintenance ODMDSs located along the Outer Bar Channel for all alternatives considered. The EPA has concurred in the use of the existing ODMDSs for proposed new construction and continued project maintenance.

Both new work and maintenance material removed from inland reaches of the ship channel would be placed in existing PA 1 and two proposed new upland PAs, 8 (168 acres) and 9 (250 acres) (see Figure 17 (page 10-2)). The proposed PAs are currently used as pasture for cattle grazing. Construction of the two new upland PAs would impact approximately 21 acres of riparian forest and 39 acres of ephemeral wetlands. Coordination with USFWS and TPWD regarding these impacts has resulted in proposed mitigation that includes creation and maintenance of riparian forest habitat and wetlands.

A terrestrial cultural resource investigation of proposed PAs 8 and 9 located a possible Civil War gun emplacement that will require avoidance or further investigation if avoidance of the site is not possible. Additional cultural resource investigations will be conducted and coordinated under an executed PAg pursuant to 36 CFR 800.

An HTRW assessment was conducted for the project area, including proposed PAs 8 and 9. While several sources of HTRW were identified at upland industries that line the banks of the Freeport Harbor Channel, no active enforcement actions were under way, and no HTRW sites were located within the project area footprint. Previous sediment quality analyses also revealed

no contaminant concerns. Therefore, it is unlikely that contaminants will be encountered during construction activities.

# 6.0 INITIAL ECONOMIC EVALUATION

The project benefits were calculated based on reductions in transportation costs. The initial screening showed that a channel depth of 60 feet produced the highest net excess benefits for the deepening plans evaluated for the Main Channel. The screening analysis suggested that additional studies were necessary to conclude whether widening the Outer Bar Channel was in the Federal interest. The non-Federal sponsor and BRPA expressed a strong interest in widening the Outer Bar Channel reach due to safety concerns and associated vessel delays and self-imposed vessel-meeting restrictions. The recommendation for deepening and widening the Freeport Harbor was based on the ERDC findings and the safety interest of the BRPA. BRPA presently limits vessels greater than 820 feet in length, 145 feet in beam, or having a draft of more than 42 feet. Oversized, excessive-draft, or unusual-type vessels are handled on a "per job" basis with a one-time waiver to the Basic Operating Procedures. Pilots also reserve the right to deny movement of any vessel during times of excessive wind, excessive crosscurrent, or during times of low water.

## 6.1 GENERAL – INITIAL SCREENING OF SELECTED ALTERNATIVES

This section presents the initial economic benefit analysis for the Freeport Harbor Feasibility Report. The initial project benefits for Freeport Harbor Channel, based only on petroleum, were calculated for a 50-year period of analysis using Economic Guidance Memorandum (EGM) 05-01, Fiscal Year (FY) 05 deep-draft vessel operating costs and FY 05 Federal discount rate of 5.125 percent. In addition to evaluating deepening the existing authorized 45-foot Federal project and widening the Outer Bar and Jetty channels, this analysis presents a discussion of the reauthorization and modification of the Stauffer Channel, which had an authorized channel depth of 30 feet. Depth alternatives between 30 and 50 feet were evaluated for the lower 3,700 feet of the Stauffer Channel. The port anticipates using the channel modification for container cargo. Presently, general cargo is transported through docks located within the 36-foot-deep Brazos Harbor Turning Basin. Deepening the Brazos Harbor Turning Basin, which is part of the federally authorized Freeport Harbor project, was screened out earlier in the study and is not evaluated in this section. The Main Channel leading to the turning basin is 45 feet as is the Upper Turning Basin. The Stauffer Channel, which was deauthorized in 1974, is immediately upstream of the Upper Turning Basin.

For the petroleum benefits presented in the initial analysis, the per ton transportation costs for channel depth alternatives of 50, 55, and 60 feet were compared with the existing 45-foot channel depth costs. For the initial screening, a wide range of depths were examined; 1- to 2-foot increments were evaluated as the study process evolved. The increased channel depths provided improved access to the crude petroleum and petroleum product docks. The non-Federal sponsor

was particularly interested in the 60-foot channel depth; therefore, the initial focus of the economic optimization was to determine whether the net excess benefits for depths between 55 and 60 feet increased. Again, the results of the initial analysis helped determine the focus of further detailed analysis. Benefit calculations presented are limited to petroleum. Discussions of other commodities were presented; however, deepening benefits were not estimated. Channel depths of 50 feet and greater could benefit some other commodity groups; however, it was likely that the inclusion of other commodities, as well as containerized cargo, would not affect the plan optimization because the overall volumes of commodities other than petroleum were proportionally small. A benefit estimate for widening of the Outer Bar and Jetty channels was presented. The widening benefits were based exclusively on the transportation savings from using vessels up to 175,000 DWT. Vessels over 120,000 DWT are presently restricted from using Freeport due to crosswinds and the resulting difficulty of navigating the Outer Bar and Jetty channels. The widening benefits were calculated based on the difference between transportation costs for vessels in the 90,000 to 120,000 DWT range versus those associated with vessels in the 90,000 to 175,000 DWT range. The results of the analysis conducted demonstrated a high BCR for widening the existing 45-foot Entrance Channel to 600 feet and for the 60-foot depth.

### 6.1.1 Benefit Calculations for Petroleum

This section presents the crude petroleum and petroleum product benefit calculations for Freeport Harbor Channel. Channel-deepening benefits for petroleum imports were calculated based on reductions in transportation costs stemming from more-efficient vessel loading of the existing fleet and a higher concentration of larger vessels. The net result of larger loads carried at deeper channel depths is lower per ton transportation costs. The petroleum benefits were estimated based on improved utilization of the existing fleet and a higher concentration of larger vessels. Table 8 presents the FY 05 foreign flag tankers' operating costs used initially for the transportation cost calculations. Table 9 presents Freeport's 2001 and 2003 representative crude oil tankers. Table 10 presents a percentage distribution of 2001 and 2003 crude imports by loaded draft. Table 11 presents representative round-trip mileage for the trade routes or junction points used for the initial transportation savings computations.

In calculating the transportation savings benefits, the without- and with-project transportation costs were initially applied to Freeport's 2001–2002/2003 tonnage. The import projections for crude petroleum and petroleum product were made based on applying the DOE's EIA, published January 2004 reference case growth rates to Freeport's 2000–2002 tonnage. Freeport's 2000–2002 trade route specific base tonnage is presented in Table 12. Table 13 displays transportation savings by channel depths and commodity group. Table 14 presents a summary of the initial project benefits. Also presented are the initial project construction costs, BCRs, and net excess benefits for the 50-, 55-, and 60-foot channel alternatives.

**Table 8**
**Tanker Characteristics and Hourly Operating Cost**
**Foreign Flag Double-Hull Tankers**

| DWT | Hourly Operating Cost ($) | | |
|---|---|---|---|
| | At Sea | In Port | Base Idle |
| 20,000 | 947 | 463 | 560 |
| 25,000 | 1,008 | 500 | 605 |
| 35,000 | 1,135 | 578 | 699 |
| 50,000 | 1,292 | 660 | 799 |
| 60,000 | 1,460 | 780 | 944 |
| 70,000 | 1,552 | 823 | 996 |
| 80,000 | 1,644 | 865 | 1,047 |
| 90,000 | 1,734 | 906 | 1,096 |
| 110,000 | 1,898 | 971 | 1,175 |
| 150,000 | 2,216 | 1,093 | 1,323 |
| 165,000 | 2,345 | 1,148 | 1,389 |
| 265,000 | 3,165 | 1,475 | 1,785 |
| 300,000 | 3,436 | 1,574 | 1,905 |
| 320,000 | 3,588 | 1,628 | 1,970 |

Source: Application of USACE, Foreign Flag Tanker Costs presented in EGM #11-05, Deep-Draft Vessel Operating Cost May 2011.

**Table 9**
**Freeport Harbor**
**Crude Petroleum Tankers, 2001 and 2003**

| DWT Range | 2001 Imports short tons | % | Length Overall (LOA) | Beam | Design Draft (feet) | Year Built |
|---|---|---|---|---|---|---|
| <80,000 | 642,243 | 3.4 | 711.83 | 105.616 | 40 | 1986 |
| 80,000 to 84,999 | 1,741,054 | 9.0 | 799.71 | 137.727 | 40 | 1986 |
| 85,000 to 89,999 | 1,804,534 | 9.3 | 799.83 | 131.233 | 43 | 1985 |
| 90,000 to 94,999 | 3,949,816 | 20.5 | 797.93 | 137.104 | 45 | 1995 |
| 95,000 to 99,999 | 4,183,824 | 21.7 | 809.64 | 137.76 | 44 | 1993 |
| 100,000 to 104,999 | 393,431 | 2.0 | 791.79 | 137.76 | 48 | 1992 |
| 105,000 to 109,999 | 5,854,984 | 30.3 | 802.29 | 137.76 | 49 | 1998 |
| 110,000 to 114,999 | 174,397 | 0.9 | 818.36 | 144.32 | 48 | 2000 |
| 115,000 to 139,999 | 0 | 0.0 | n/a | n/a | n/a | n/a |
| 140,000 to 155,000 | 562,305 | 2.9 | 898.72 | 145.753 | 53 | 1992 |
| Total | 19,306,588 | 100.0 | | | | |

**Table 9, cont'd**

| DWT Range | 2003 Imports short tons | % | Design Draft (feet) | LOA | Beam | Year Built |
|---|---|---|---|---|---|---|
| <80,000 | 652,790 | 3.4 | 41 | 748 | 106 | 2002 |
| 80,000 to 84,999 | 1,035,962 | 5.3 | 40 | 800 | 131 | 1986 |
| 85,000 to 89,999 | 1,120,602 | 5.7 | 43 | 800 | 138 | 1990 |
| 90,000 to 94,999 | 1,087,938 | 5.5 | 43 | 810 | 136 | 1994 |
| 95,000 to 99,999 | 7,140,817 | 36.3 | 45 | 798 | 137 | 1993 |
| 100,000 to 104,999 | 2,141,777 | 10.9 | 48 | 792 | 138 | 1992 |
| 105,000 to 109,999 | 5,256,678 | 26.7 | 49 | 797 | 138 | 1998 |
| 110,000 to 114,999 | 655,084 | 3.3 | 48 | 817 | 144 | 1999 |
| 115,000 to 139,999 | 0 | 0.0 | n/a | n/a | n/a | n/a |
| 140,000 to 155,000 | 580,101 | 2.9 | 53 | 899 | 154 | 1996 |
| Total | 19,671,749 | 100.0 | | | | |

**Table 10**
**Crude Petroleum Imports, 2001–2003 Average**

| By Loaded Draft | Percent |
|---|---|
| ≤36 | 32.2 |
| 37 | 12.5 |
| 38 | 18.5 |
| 39 | 13.4 |
| ≥40 | 23.4 |
| Total | 100.0 |

**Table 11**
**Representative Round-Trip Mileage to Freeport Harbor**

| From | Miles |
|---|---|
| Coatzacoalcos, Mexico | 1,360 |
| U.S. Gulf Coast Lightering/Lightening Zone | 160 |
| Venezuela | 3,934 |
| Panama Canal | 3,132 |
| Salvador, Brazil | 9,606 |
| Rotterdam, Netherlands | 10,318 |
| Sture, Norway | 11,172 |
| North Africa, Algiers | 10,556 |
| West Africa (Nigeria and Angola) | 13,030 |
| Persian Gulf and Indian Subcontinent via Suez Canal | 19,824 |
| Persian Gulf and Indian Subcontinent via Cape of Good Hope | 25,066 |
| Singapore via Panama Canal | 24,248 |
| Singapore via Cape of Good Hope | 26,304 |

**Table 12**
**Freeport Harbor Crude Oil Import Tonnage by Trade Route (short tons)**

| Origin | 2000 | 2001 | 2002 | 2000–2002 Average |
|---|---|---|---|---|
| Mexico | 1,068,128 | 162,723 | 324,042 | 518,298 |
| West Indies | 169,096 | 74,442 | 1,701,232 | 648,257 |
| Colombia (East) | 193,445 | 277,405 | 1,051,073 | 507,308 |
| Ecuador | 65,773 | 1,075,857 | 85,899 | 409,176 |
| Venezuela | 4,751,039 | 10,074,779 | 8,043,919 | 7,623,246 |
| Brazil | 0 | 106,649 | 141,989 | 82,879 |
| North Sea | 564,801 | 86,015 | 2,110,856 | 920,558 |
| West Africa | 689,671 | 72,140 | 1,919,713 | 893,841 |
| Mideast | 94,466 | 94,855 | 1,464,172 | 551,164 |
| Primarily Mideast | 12,173,532 | 7,065,797 | 1,175,678 | 6,805,002 |
| Total Tonnage | 19,769,951 | 19,090,662 | 18,018,573 | 18,959,729 |

**Table 13**
**Transportation Savings by Channel Depth and Commodity Group**
**(1,000s of dollars)**

| Crude Petroleum Imports | | | | | | |
|---|---|---|---|---|---|---|
| **Transportation Savings by Channel Depth 2010–2060** | | | | | | |
| | 45 w/widening | 50 | 52 | 55 | 58 | 60 |
| 2010 | 2,104.7 | 7,327.2 | 9,494.5 | 13,110 | 18,401.3 | 23,793.1 |
| 2020 | 2,704.8 | 9,195.6 | 12,049.1 | 16,524 | 23,927.3 | 32,003.2 |
| 2030 | 3,166.0 | 10,499.8 | 13,760.3 | 18,866 | 27,295.1 | 36,482.3 |
| 2040 | 3,324.3 | 11,024.8 | 14,448.3 | 19,810 | 28,659.9 | 38,306.4 |
| 2050 | 3,490.5 | 11,576.0 | 15,170.7 | 20,800 | 30,092.9 | 40,221.7 |
| 2060 | 3,665.1 | 12,154.8 | 15,929.2 | 21,840 | 31,597.5 | 42,232.8 |
| **Average Annual Benefits (50-Year Period of Analysis at 5.125%)** | | | | | | |
| | 2,788.0 | 9,411.7 | 12,305.5 | 16,897.1 | 24,305.6 | 32,284.9 |
| **Petroleum Product Import and Export Tonnage** | | | | | | |
| **Transportation Savings by Channel Depth 2010–2060** | | | | | | |
| | 45 w/widening | 50 | 52 | 55 | 58 | 60 |
| 2010 | 0.0 | 996.8 | 1,128.9 | 1,128.9 | 1,128.9 | 1,128.9 |
| 2020 | 0.0 | 1,300.6 | 1,473.0 | 1,473.0 | 1,473.0 | 1,473.0 |
| 2030 | 0.0 | 1,664.9 | 1,885.6 | 1,885.6 | 1,885.6 | 1,885.6 |
| 2040 | 0.0 | 2,131.3 | 2,413.7 | 2,413.7 | 2,413.7 | 2,413.7 |
| 2050 | 0.0 | 2,473.4 | 2,801.2 | 2,801.2 | 2,801.2 | 2,801.2 |
| 2060 | 0.0 | 2,870.5 | 3,250.9 | 3,250.9 | 3,250.9 | 3,250.9 |
| **Average Annual Benefits (50-Year Period of Analysis at 5.125%)** | | | | | | |
| | 0.0 | 1,507.4 | 1,707.2 | 1,707.2 | 1,707.2 | 1,707.2 |
| **Total Benefits by Channel Depth (feet)** | | | | | | |
| | 45 w/widening | 50 | 52 | 55 | 58 | 60 |
| | 2,788.0 | 10,919.2 | 14,012.7 | 18,604.3 | 26,012.8 | 33,992.1 |

**Table 14**
**Economic Summary**
**(1,000s of dollars)**

| Economic Summary Data | 45 w/widening | 50 | 55 | 60 |
|---|---|---|---|---|
| First Cost of Construction ($) | 25,766.0 | 210,808.0 | 225,344.0 | 243,085.0 |
| Average Annual Cost ($) | 1,493.9 | 12,222.8 | 13,065.6 | 14,094.2 |
| Average Annual O&M* ($) | 107.7 | 680.5 | 1,242.5 | 1,609.4 |
| Total Annual Cost ($) | 1,601.6 | 12,903.3 | 14,308.1 | 15,703.6 |
| Average Annual Benefits ($) | 2,788.0 | 10,919.1 | 18,604.3 | 33,992.1 |
| Net Excess Benefits ($) | 1,186.4 | −1,984.2 | 4,296.2 | 18,288.5 |
| BCR | 1.7 | 0.8 | 1.3 | 2.2 |

*O&M – Operation and Maintenance

### 6.1.2 Other Cargo

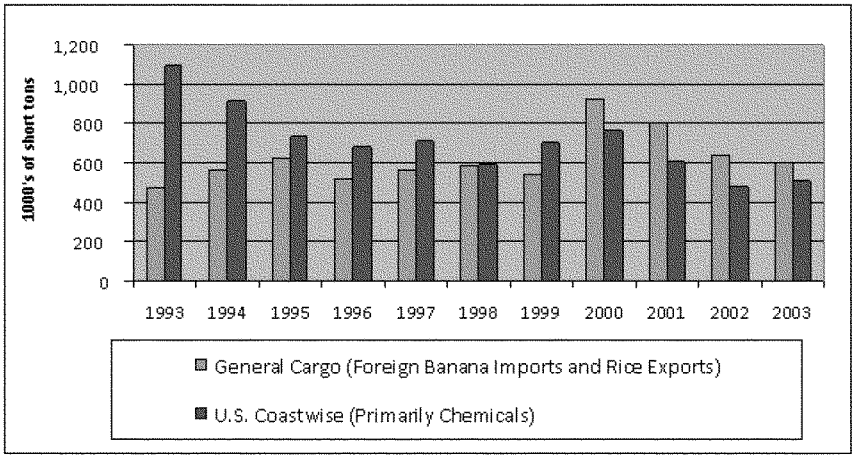
Freeport's remaining cargo primarily consists of banana imports, rice exports, and outbound coastwise chemical shipments. Table 15 presents the 1998–2003 distribution by major group, and Figure 8 displays 1993–2003 cargo trendlines for banana and rice cargoes. Most of the general cargo docks are located adjacent to the Brazos Harbor Turning Basin where the project depth is 36 feet. The Brazos Harbor Channel, leading to the Brazos Harbor Turning Basin, is 36 feet deep.

**Table 15**
**Freeport Harbor General Cargo**
**Deep-Draft Commodities (1,000s of short tons)**
**Other Than Petroleum and Chemical Foreign Imports and Exports**

| Year | Banana Imports | Rice Exports | Limestone & Rock Imports | Coastwise Shipments Chemicals* |
|---|---|---|---|---|
| 1998 | 320 | 175 | 2 | 589 |
| 1999 | 301 | 174 | 3 | 708 |
| 2000 | 255 | 310 | 60 | 764 |
| 2001 | 173 | 210 | 149 | 604 |
| 2002 | 293 | 226 | 33 | 479 |
| 2003 | 233 | 210 | 83 | 511 |

*Primarily shipments of hydrocarbons.

**Figure 8**
**Freeport Harbor General Cargo**
**(Imports and Exports) and Coastwise**



Review of the 2001–2003 fleets showed use of some relatively large carriers for rice exports. The maximum-sized vessels were in the 42,000 to 64,000 DWT range. The design drafts for these vessels are in the 39- to 42-foot range. These larger vessels are used to export rice to Saudi Arabia. In total, rice exports represent an average of 35 percent of total general cargo movements. Annual rice export totals averaged 215,000 short tons for the period 1998–2003.

Over 2001–2003, large bulk carriers were used in the import of limestone and building materials. The vessels used were in the 45,000 to 67,000 DWT range and the design drafts of the vessels in the 40- to 44-foot range. Loaded drafts ranged from 35 to 39 feet. Total limestone imports for 2005 were 433,000 tons. Limestone imports represented 40 percent of 2003–2005 total general cargo tonnage. The majority of imports are from Cozumel, Mexico, and, to a smaller extent, Europe. There is a possibility that some limestone movements may realize deepening benefits.

The remainder of vessels used for general cargo were less than 20,000 DWT and were associated primarily with banana imports. Bananas constitute a significant share of Freeport general cargo; average imports for 1998–2003 were 233,000 short tons. Bananas are transported in refrigerated container vessels, the majority of which are in the 13,000 to 16,000 DWT range.

During initial screening, benefits were not established for these other cargos since petroleum-based cargo was the primary import/export. Also, these cargoes go to the Brazos Harbor Channel docks, which were not being considered for deepening and widening.

### 6.1.3 Container Cargo/Stauffer Channel Modification

The transportation savings benefits for modification of the Stauffer Channel were investigated, and deepening benefits were calculated. The non-Federal sponsor proposed to extend the existing terminus of the Freeport Harbor Channel to reauthorize and include the Stauffer Channel. The length of the proposed channel would extend approximately 3,400 feet from the 45-foot Upper Turning Basin. The port presently ships and receives general cargo through the Brazos Harbor Turning Basin docks. As part of the feasibility study, optimization of the depth for the channel modification was determined. Depth alternatives of 36, 40, 42, 45, and 50 feet were initially evaluated. The results of the initial screening resulted in a more focused evaluation of a smaller range of depths. Analysis was conducted to determine the competitive advantage that Freeport might potentially have over competing ports. For instance, there is considerable overlap between the Houston and Freeport population centers, and a Freeport container terminal has the potential of capturing associated savings. In addition, Freeport offers an advantage over existing facilities in Houston because terminal capacity in Houston is near capacity.

Analyses then indicated that the most favorable geographic markets for containerized cargo terminal facilities situated in Freeport are some market hinterlands that are presently served regionally by the Port of Houston. The proposed Freeport container facility would be in competition with the Port of Houston facilities, specifically existing Barbours Cut and Bayport,

as well as planned phases of facilities at Bayport (Houston) and Shoal Point in Texas City. Presently, Barbours Cut and Bayport are the only facilities in place. Barbours Cut is the Gulf Coast's largest container facility and is the third largest in the Nation and, therefore, the Houston fleet was reviewed as a potential indicator of vessel size expectations.

Table 16 presents the current range of vessel sizes frequenting U.S. Gulf Coast container terminals. In 2003, one of the largest containerships using U.S. Gulf Coast ports included the *MSC Barbara*, an 85,000 DWT vessel operated by the Mediterranean Shipping Company. The *MSC Barbara*, which was constructed in 2002, represented less than 1 percent of container tonnage; however, it was representative of the size of containerships that Freeport wished to attract. For the ERDC ship simulation study, the even larger *Susan Maersk* containership was modeled. The results of the ERDC modeling revealed that none of the pilots controlling the *Susan Maersk* were able to bring the ship safely into the turning basin. In order to safely accommodate this vessel, several other improvements to the channel, including widening, would be necessary. Widening would be needed around the Big Bend area inbound from the Seaway Dock at the lower end of the channel to accommodate the *Susan Maersk*.

**Table 16**
**Representative Gulf Coast Channel Containerships (2003)**

| DWT Range | TEU Range | % of Tonnage | LOA (feet) | Beam (feet) | Design Draft (feet) | Year Built |
|---|---|---|---|---|---|---|
| <40,000 | <3,080 | 35.6 | 689 | 102 | 38 | 1996 |
| 40,000 to 62,000 | 3,300 to 4,315 | 64.0 | 851 | 106 | 42 | 1988 |
| 85,000 | 6,418 | 0.4 | 997 | 131 | 48 | 2002 |
| **Design Vessel for Freeport ERDC Ship Modeling:** *Susan Maersk* | | | | | | |
| 104,696 | 7,226 | n/a | 1,138 | 141 | 48 | 1997 |
| **Additional Container Vessel Under Consideration (*Regina Maersk*, not modeled)** | | | | | | |
| 85,000 | 6,418 | n/a | 1,043 | 141 | 46 | 1996 |

Based on the results of the ERDC modeling and concerns about project construction cost, smaller container vessels were considered (see Table 16). An additional variable in considering vessel size was the expected frequency of trips associated with S-class containerships. There were several containerships in the 50,000 to 62,000 DWT range calling on the Gulf Coast in 2003, and numerous calls for vessels in the 40,000 to 50,000 DWT range. Review of 2003 vessel transits indicated that vessels over 40,000 DWT transported 64 percent of Gulf Coast container cargo. Most vessels over 40,000 DWT have design drafts of 40 feet. The maximum design draft for vessels in the 40,000 to 50,000 DWT range is generally 42 to 43 feet. In 2003, a significant portion of the 50,000 to 62,000 DWT containerships calling the Gulf were constructed after 1995. Review of the percentage of tonnage by loaded draft showed that 5 percent of vessels were loaded to drafts of 36 feet or more and 3 percent were loaded to drafts of 38 feet or more. Initial analysis examined small container vessels.

## 6.2 FREEPORT HARBOR CHANNEL INITIAL BENEFIT SUMMARY

Project benefits were initially calculated at FY 05 discount rate of 5.375 percent and for the period 2006–2056. Based on the preliminary economic analysis, the detailed plan formulation would include deepening Freeport Harbor from 45 to 60 feet; widening of the Outer Bar Channel to 600 feet, based on ERDC modeling and pilot input; and deepening and widening the lower 3,700 feet of the Stauffer Channel, based on non-Federal input. The economic summary in Table 14 shows that the net benefits and BCR are maximized at 60 feet deep.

Based on ship simulation testing and cost and benefits analysis, detailed analysis was performed on project channel depths in the range of 55 to 60 feet.

# 7.0 DETAILED PLAN FORMULATION

## 7.1 GENERAL

The objective of a feasibility study is to arrive at a recommended plan after a reasonable number of alternatives have been analyzed. This involves a comparison between each alternative and the FWOP conditions and consequences, considering economic, environmental, and social impacts.

As previously noted, subsequent to initial plan formulation, the non-Federal sponsor, Port Freeport, applied to the USACE, Galveston District for a Clean Water Act (CWA) Section 404 permit and an RHA Section 10 permit for dredge and fill activities related to the widening of portions of the Freeport Harbor Channel from 400 feet to 600 feet. Port Freeport proposes to widen, but not deepen, portions of the Jetty Channel and the entire Outer Bar Channel. This decision is an integral part of the current LNG facilities that have been constructed. The proposed permit action, widening only, is within the footprint of this proposed Federal project. The permit project site is located along the northern edge of the Jetty and Outer Bar channels. The permit was granted in March 2009, and construction will begin upon approval by the ASA(CW) for Federal assumption of maintenance. For this feasibility study, the permit construction is assumed to be in place and is considered the future without-project (FWOP-1) condition.

## 7.2 PROCESS

As detailed plan formulation began, the alternatives were reevaluated. In reevaluation of the Jetty Channel area, it was determined that in order to provide adequate stability of the rock jetties, the bottom width for a 60-foot-deep channel would have to be reduced. It was determined that 540 feet was the maximum bottom width that could be constructed between the jetties and maintain an acceptable factor of safety for jetty stability.

After the conclusion of the preliminary screening, detailed plan formulation focused on the refinement of two Freeport Harbor Channel alternatives determined to be the most feasible: 60-x-540-foot and 55-x-600-foot channel improvements. Detailed plan formulation was also performed for the Stauffer Channel. All nonstructural alternatives had been eliminated. Detailed engineering analysis focused on development of hydrology and hydraulic analysis, channel layout, engineering quantities, geotechnical analysis, operations and maintenance, and cost estimating.

To evaluate the channel alternatives, several studies were conducted by ERDC. The studies included Hydrodynamic/Salinity Modeling, Ship Simulation, Desktop Sediment Analysis, Hurricane Storm Surge, and Shoreline Impacts.

Along with these studies, benefits and cost analyses were conducted for the alternative depth and width alternatives. Since the new project channel in the Gulf of Mexico could extend an additional 2.6 miles, consideration of O&M costs was deemed necessary in conducting the analysis.

Environmental analyses were performed to identify the affected environment and what impacts the project would have on the area. Coordination with the resource agencies was conducted. Cultural studies were conducted for the study area. Mitigation requirements were determined.

The identification of the Recommended Plan was based on economic and environmental factors and local preferences. Costs were estimated for all the alternatives and compared to the benefits. Based on the ship simulation studies, the Brazosport Turning Basin was set at 1,200 feet. No work was proposed for the Brazos Harbor Channel and Turning Basin. Included in the costs are dredging, PA levee construction, and O&M costs for the 50-year period of analysis. Ecosystem mitigation requirements and costs were determined. More-detailed explanation of the analyses is located in the following sections of the report.

During detailed plan formulation, the non-Federal sponsor expressed their preference for a channel deepening and widening project slightly different than the plan resulting from the NED analysis. This plan was designated as the Locally Preferred Plan (LPP). Analysis of the LPP was conducted.

# 8.0 ENGINEERING STUDIES

## 8.1 GENERAL

Engineering studies included Ship Simulation, Erosion, and Salinity investigations by ERDC; preliminary geotechnical investigations including sampling/analysis and preparation of a preliminary Dredged Material Management Plan (DMMP); in-house channel surveys; and Architect-Engineer land surveys. Other engineering and design features utilized surveying and mapping, environmental quality/mitigation features, civil design, geotechnical design, structural design, access roads, 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.

## 8.2 DATUM REQUIREMENTS

### 8.2.1 Datum

All elevations referred to in this report, unless specifically noted otherwise, are based on Galveston District's local MLT datum. This project is a compilation of NGVD 29 and the newer NAVD 88. Existing after-dredged hydro surveys in the local vertical datum of MLT were used in calculating new work volumes. These vertical datum are presented in the studies performed by ERDC and can be referenced for more clarification.

### 8.2.2 Horizontal

North American Datum (NAD) 27 was used during the initial screening of alternatives. After the Feasibility Scoping Meeting, the study was converted to the newer NAD 83. Final Plates are shown in NAD 83, Texas State Plane Coordinate System, South Central Zone.

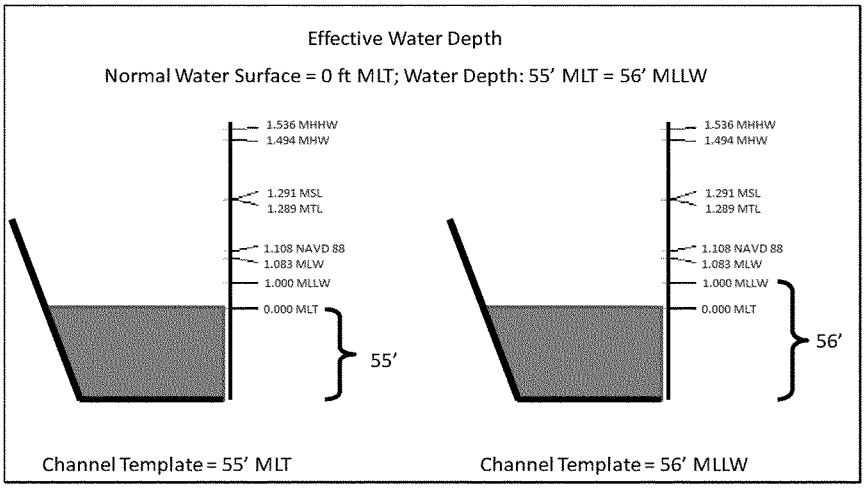
### 8.2.3 Tidal Datum

Army regulations and HQ guidance on tidal datum, provided in Engineer Technical Letter (ETL) 1110-2-349 *REQUIREMENTS AND PROCEDURES FOR REFERENCING COASTAL NAVIGATION PROJECTS TO MEAN LOWER LOW WATER DATUM*, dated April 1, 1993, and Engineer Manual (EM) 1110-2-1003, April 1, 2002 stress the necessity of converting local datum, such as MLT, to MLLW. EM 1110-2-1003 further states that MLLW should be tied to the NAVD 88. The predominant reasons for conversion to MLLW are the need for consistency throughout the ports of the U.S., to enhance the continuity of National Oceanic and Atmospheric Administration (NOAA) and USCG navigation charts, and to avoid misconceptions within the shipping and dredging industries with regard to channel depths.

### 8.2.4 Conversion

The Galveston District has an established survey control network along the Freeport Harbor Channel. To comply with the above referenced guidance on referencing tidal datums using MLLW, the Galveston District took vertical survey measurements at tide gages and benchmarks to estimate the relative difference between MLT and MLLW datums along the Freeport Channel. The objective was to maintain an effective water depth of 55 feet while correctly referencing resulting water surface level in MLLW as shown on Figure 9.

**Figure 9**
**Effective Water Depth**
**Freeport Harbor Channel**
**Mean Low Tide – Mean Lower Low Water**




At Freeport Channel, datum values for MLLW are +1 foot above MLT. However, this does not result in increased water depth, as the additional +1 foot of nominal depth is actually +1 foot above the normal surface water level. Therefore, the actual water depths are equivalent between a 55-foot MLT channel template and a 56-foot MLLW channel template.

As the study and its documentation were completed using MLT, references to MLT have been maintained throughout this document, though numbers are also referenced in MLLW depths at some locations in the report. These references are in parentheses, and the datum is located at each reference point.

## 8.3 HYDROLOGY AND HYDRAULICS

### 8.3.1 Modeling Studies

The proposed modification of the navigation channel required several studies, which included field data collection, hydrodynamics, ship simulation, sediment, storm surge, and shoreline impacts. The Coastal Hydraulics Laboratory (CHL) of ERDC conducted all of these studies.

#### 8.3.1.1 Field Data Collection

A field data collection program was conducted during 2003. The primary purpose of the program was to obtain data needed to validate RMA-2 and TABS-MD numerical hydrodynamic models. The secondary objective of the program was to collect data for a desktop study to estimate the shoaling rates in the proposed modified navigation channels.

#### 8.3.1.2 Hydrodynamic Study

The primary objective of the hydrodynamic model study was to provide accurate and representative current velocity fields for use in the ship simulator for the navigation study. The secondary objective was the development of a tool that was used to evaluate the general impacts of the design alternative improvements on circulation in the harbor.

The results showed that the numerical model was reasonably verified against field observations to make it a valuable tool in the evaluation of circulation effects associated with the design alternatives. The effects of the channel deepening were to have the tidal signal arrive about 30 minutes sooner. The tide range was increased only about 0.3 percent. The deepening reduced the currents as much as 0.2 foot per second (ft/sec) in the western side of the channel, with a small localized increase of 0.1 ft/sec on the eastern flank of the channel. There is a greater reduction in ebb current magnitudes than in flood.

#### 8.3.1.3 Ship Simulation

Three initial alternative channel plans developed for Port Freeport for assessment of the new LNG facilities were simulated by ERDC. Simulations were performed on the Entrance and Jetty Channel reach. All three plans assumed construction of the proposed LNG facility. Two of the initial plans were dropped and two additional plans were adapted for simulation. These simulations recommended the 60(MLT)-x-600-foot (61(MLLW)-x-600-foot) channel, the 1,350-foot-diameter turning basin at Brazosport, and some bend widening. The Stauffer Channel improvements were not recommended. Additional simulations were conducted during detailed plan formulation using a smaller containership for the Stauffer Channel and some tapering of the Outer Bar Channel inside the jetty. The two additional plans simulated were 60(MLT)-x-540-foot (61(MLLW)-x-540-foot) and 55(MLT)-x-600-foot (56(MLLW)-x-600-foot) for the Outer Bar Channel.

The additional simulations indicated, based on BRPA comments and test results, no real problems in this area for either the 60(MLT)-x-540-foot (61(MLLW)-x-540-foot)or 55(MLT)-x-600-foot (56(MLLW)-x-600-foot). Navigation issues do not indicate either of these plans in preference to the other. For example, for the 55(MLT)-x-600-foot (56(MLLW)-x-600-foot) channel, the shallower depth may limit the loading of future vessel traffic that can call at the port. For the 60(MLT)-x-540-foot (61(MLLW)-x-540-foot) channel, the narrow width may cause increased tug usage. Given the data collected by the study and the experience of the BRPA, both plans are acceptable alternatives for the Freeport Harbor project.

Later simulations were developed for a 1,200-foot Brazosport Turning Basin, based on a 900- to 990-foot design vessel. Detailed economic analysis determined that this size vessel had the most economic benefits.

#### 8.3.1.4 Sediment Study

The present dredging pattern and quantities would change as a result of the proposed modifications to the Navigation Channel. The objective of this study was to estimate the shoaling rates in the modified Navigation Channel. A desktop study is an alternative method of obtaining preliminary answers without conducting a full-fledged numerical sediment-transport modeling study. Such a desktop approach required field data on sediments, dredging quantities, and velocity results from a hydrodynamic model. In view of variations in salinity and currents in the Freeport system, velocity results from a three-dimensional (3D) hydrodynamic model were necessary.

All data needed for this study were collected in October 2003. Other data needed were obtained from the Galveston District's Dredging Histories Database, which contains bed sediment data and dredging records.

The 3D model study concluded that there was no significant change or variation between the existing and proposed plan for the tides, currents, salinity, and flow patterns. The quantity of maintenance dredging in the Freeport navigation channel will increase from the present average of 1.6 mcy/yr to 2.92 mcy/yr as a result of deepening and widening the channel to 60 x 600 feet (NED Plan).

Dredging requirements for the LPP/NED Entrance Channel Extensions resulted in one-third of the new dredging volumes for the project. New dredging requirements in the Entrance and Jetty channels are increased by 75 percent due to width and depth changes. Changes in these reaches account for most of the increased dredging requirements for the project. The new dredging requirements in the Freeport Harbor Channel are up 25 percent due to geometry changes. Estimated dredging in the Stauffer Turning Basin is calculated using assumed channel depth at deauthorization (approximately 1950) and at current depth (2009).

#### 8.3.1.5 Hurricane-induced Storm Surge Conditions

A numerical study was conducted to determine whether the planned improvements to the channel would make Freeport Harbor and adjacent low-lying areas more susceptible to inundation due to hurricane-induced storm surge. The improvements modeled were a 60(MLT)-x-540-foot (61(MLLW)-x-540-foot)channel with a 1,350-foot Brazosport Turning Basin, which removed a portion of the southeastern peninsula (North Wave Barrier) that separates the GIWW from the harbor proper, and the proposed LNG improvements. The model found little change in peak water-surface elevations within the harbor resulting from the planned improvements. Estimated increases were about 0.16 foot. Consequently, the planned harbor improvements do not appear to make the harbor and adjacent low-lying areas more susceptible to storm surge from less-intense hurricanes.

#### 8.3.1.6 Shoreline Impact Study

This study assessed the wave-induced impacts of deepening of the Freeport Harbor Channel in the Gulf of Mexico on the open-coastal shorelines adjacent to the project area. Based on coordination with ERDC, the plans proposed for analysis were 50(MLT)-x-600-foot (51(MLLW)-x-600-foot), 55(MLT)-x-600-foot (56(MLLW)-x-600foot), 58(MLT)-x-540-foot (59(MLLW)-x-540-foot), and 60(MLT)-x-540-foot (61(MLLW)-x-540-foot). This study used the numerical model GENESIS to compute sediment transport rates and shoreline change rates for each of the four proposed channels. The conclusion from this analysis is that if any of the proposed deepening alternatives for the Freeport Outer Bar Channel are constructed, the wave-induced sediment transport impacts on the adjacent shorelines will be so slight as to not be noticeable and will be dwarfed by the interannual variability in shoreline position. Within about 0.25 mile of each jetty, the shoreline change rate could increase by up to 1.0 foot per year (ft/year) for the LPP Alternative. However, the background change rates are approximately 10 times greater than the wave-induced impacts attributable to the proposed project, and thus are dramatically higher than the potential change due to the project. In addition, not all of the potential changes would result in an increase in shoreline erosion. A much larger length of shoreline could experience a slight reduction in the erosion rate. In areas from 0.5 to about 3 miles from the jetties, the modeling indicated that the shoreline erosion rate could decrease by up to 0.5 ft/year.

## 8.4 GENERAL ENGINEERING

During plan formulation, general engineering investigations included such items as turning basins, entrance channel extension, relocation of facilities, berthing/dock areas, bottom widths, channel alignment, bend easing, real estate, placement areas, mitigation and restoration areas, relocations, mitigation relocations, aids to navigation, dredging frequency, predicted shoaling rates, new work dredging, allowable overdepth, nonpay dredging, advance maintenance, and access roads.

## 8.5 STRUCTURAL

The structural activities conducted were as follows:

- Site visit and obtaining as-built drawings of the shoreline facilities
- Initial evaluation of the shoreline facilities
- Impact evaluation of the shoreline facilities
- Concept design for modifications of each of the impacted shoreline facilities
- Quantity estimate for cost estimating of each of the necessary modifications
- Refine new work PAs for drop-outlet structures
- PA outlet structural design
- Structural engineering appendix report

The structural engineering portion of Appendix B was prepared to provide sufficient information on design input for PA spill boxes for all of the channel alternatives, and impact verification on each bridge, bulkhead, and dock from the proposed dredging. Design of spillbox structures of the new PAs and rehabilitation of existing spillboxes for use of the existing PA were conducted.

Docks and wharves were not analyzed, but several were identified as potentially requiring modifications due to the proposed incremental increases or channel improvement. Dredging volumes were estimated for the dock and berthing areas by taking the area of the berth and multiplying by assumed depth of cut. Associated costs relating to the facility's ability to utilize the new deep draft were identified by others.

## 8.6 GEOTECHNICAL STUDIES

Geotechnical studies were prepared to provide supporting technical information pertaining to the geotechnical aspects of the Freeport Harbor Project, including the PA site development plan, proposed dredged material distribution to the disposal sites, available project soils information, preliminary design parameters used, and foundation design considerations. Use of available geotechnical investigations information, establishment of suitable design parameters and geotechnical assumptions, and production of quantities for a 50-year DMMP have been performed with the purpose of providing sufficient detail to substantiate the Recommended Plan and the baseline cost estimate.

Borings were obtained from the project area. Soil borings were obtained during the period between November 1962 and September 1978 and generally have been drilled to elevations ranging between 40 to 90 feet below MLT. Additional borings in the vicinity of the channel were obtained by Fugro Consultants, LP, in January and February 2005 under the direction of the Port of Freeport for a separate widening project. Boring logs for PAs 8 and 9 were obtained in

November of 2005, ranging in depth from 30 to 40 feet. Boring logs for existing PA 1 are from boring log data in a report by the Professional Service Industries, Inc., entitled "Subsurface Exploration and Foundation Recommendations for the Proposed Confined Placement Site No. 1 – Port of Freeport – Freeport, TX" that was prepared for and under the direction of the Brazos River Harbor Navigation District in 1996. Borings ranged in depth from about 20 to 60 feet.

Sampling and testing of material was performed. During the drilling of borings referred to in Appendix B, undisturbed sampling of cohesive material was generally achieved by means of using a Shelby or a thin-walled tube with a minimum diameter of 3 inches. Split-spoon sampling was primarily employed on cohesionless to semicohesionless soil layers encountered, whereby disturbed samples were taken concurrent with Standard Penetration Tests (SPT) at various sampling intervals between the different drilling programs employed. Consistencies of cohesive materials were typically determined by means of visual classification, pocket penetrometer tests, and Torvane shear tests. Some basic types of laboratory tests performed on cohesive materials included moisture content, unit dry weight, sieve analyses, liquid limit, and plastic limit. Sieve analyses were also performed on select samples of cohesionless materials. The results of these basic tests along with field boring log data were used to classify various material layers. Through various testing programs associated with borings discussed herein, Unconfined Compression Tests (UC) and Unconsolidated Undrained Triaxial Compression Tests (UU, or Q-tests) on representative samples have been utilized for estimates of undrained shear strengths for "end of construction" or "immediate" foundation loading condition considerations. For undrained shear strength estimates, in some cases the UC and UU laboratory results have been used in conjunction with field testing data and notes on the boring logs, such as pocket penetrometer readings taken, and correlations from SPT testing done on materials encountered during disturbed sampling where some cohesivelike properties were discovered (such as silts, sandy and clayey silts, or clays with various interbedded sand and silt layers).

### 8.6.1 Dredged Materials and Potential for Beneficial Use

Results from bed sediment studies for data collected between September 1987 and May 2000 indicate the following average percentages of bed sediments have been encountered in the channel:

1. Outer Bar – About 82 percent fine-grained sediments (silts and clays) and 18 percent sands
2. Jetty Channel – About 86 percent fine-grained sediments (silts and clays) and 14 percent sands
3. Main Channel – About 95 percent fine-grained sediments (silts and clays) and 5 percent sands

A review of boring data from the Upper Turning Basin out to the Gulf indicates that new work materials are about 80 to 90 percent clays (of primarily stiff consistency with some traces of silts or clayey silts) and about 10 to 20 percent sands of various densities.

The Federal project considered potential beneficial uses identified by the permit widening action such as beach renourishment and marsh restoration for new work dredged material. While soil borings in the project area indicated some sandy material, no concentrated lenses were identified, and the high percentage of clay material present would not be compatible with existing sandy beach soils in terms of renourishment efforts. The potential for marsh restoration was also precluded because sensitive resources (oysters) and fishing activities exist in some of the proposed restoration areas, and the cost of placing new work dredged material for restoration activities at another site would be prohibitive.

### 8.6.2 Ocean Dredged Material Disposal Sites

Existing Maintenance and New Work ODMDSs are located within the project area (see Figure 2) at the coordinates below. These are dispersive sites consisting of approximately 1,291 acres and 2,236 acres, respectively, and were originally designated in the EPA FEIS for the Freeport Harbor 45-foot Project in January 1990. In August 2008, USACE gained EPA concurrence for placing maintenance and new work dredged material from the proposed project into these sites.

1) Maintenance ODMDS: The Maintenance ODMDS is located approximately 3 miles offshore and about 1,000 feet southwest of the centerline of the Outer Bar Channel. The site is rectangular in shape with corner coordinates located at:

   28°54′00″N, 95°15′49″W; 28°53′28″N, 95°15′16″W;

   28°52′00″N, 95°16′59″W; 28°52′32″N, 95°17′32″W

2) New Work ODMDS: The New Work ODMDS is located approximately 6 miles offshore. The site is bounded by the following coordinates:

   28°50′51”N, 95°13′54″W; 28°51′44″N, 95°14′49″W;

   28°50′15″N, 95°16′40″W; 28°49′22″N, 95°15′45″W

The offshore placement areas have been modeled. The MDFATE (Multiple Disposal Fate) model was utilized to analyze the effects of offshore placement to ensure conformance with fill height restrictions on the bottom of the seafloor.

### 8.6.3 Jetty Stability Analysis

Given possible restrictions to channel depth and width due to jetty stability issues, an analysis was performed to determine:

a. the maximum channel width at a project channel depth of 60 feet MLT (61 feet MLLW)

b. the maximum channel depth at a channel width of 600 feet

(Note: for an authorized depth of 60 feet MLT (61 feet MLLW), it was anticipated that the required depth in the Jetty Channel would be 62 feet MLT (63 feet MLLW) with an allowable overdepth of 2 feet, for the analysis)

Slope stability of the North and South jetties was considered between stations 0+00 to 43+00 (north) and 46+00 (south). Latest available surveys at the time of analysis were reviewed including postdredging channel cross sections dated January 2006 and jetty/channel cross sections dated December 2005. Two project constraints were established regarding the configuration of the jetty slopes:

a. do not undercut the toe of the South Jetty

b. maintain a 50-foot bench at the toe of the North Jetty

### 8.6.4 Critical Locations and Findings

Slope stability analyses were conducted at Station 10+00 for both the North and South jetties. This cross section was determined the most critical due to a soft clay layer identified in Boring B-6 along the South Jetty. Slope stability analyses were also conducted at Station 20+00 on the North Jetty due to a changed soil profile at this location. Both borings B-5 and 74-23 indicated a loose to medium-dense sand layer at this location. At each cross section, the stability of the existing slope configuration was evaluated. At Station 10+00, the existing slope angle on the South Jetty was projected to a depth of 62 feet MLT (63 feet MLLW), and the maximum channel width was determined that would enable a bench width of at least 50 feet at the toe of the North Jetty. This maximum width was found to be 540 feet. This configuration is labeled 62x540 in Table 17. A second configuration (55x600) was determined by raising the elevation of the channel until a width of 600 feet was achieved. This channel depth was determined to be approximately 55 feet MLT (56 feet MLLW). Both of these configurations hold the slope angle on the South Jetty side resulting in a shift of the existing channel centerline (110 feet to the north for the 62x540 channel and 120 feet to the north for the 55x600 channel). A summary of the calculated minimum factors of safety, resulting from stability analysis for long-term conditions, is provided in Table 17. It was concluded that in order to maintain an adequate factor of safety for jetty stability, the channel alternative would need to be approximately 60 x 540 feet or 55 x 600 feet.

**Table 17**
**Jetty Stability Analysis – Summary of Calculated Minimum Factors of Safety**

| | Associated Soil Borings | Existing Conditions | 62x540 Channel | 55x600 Channel |
|---|---|---|---|---|
| South Jetty (Sta 10+00) | B-6 | 1.4 | 1.3 | 1.3 |
| North Jetty (Sta 10+00) | 75-92 | 1.5 | 1.5 | 1.5 |
| North Jetty (Sta 20+00) | B-5, 74-23 | 1.6 | 1.5 | 1.6 |

Note: Borings B-5 and B-6 taken by Port Freeport contractor, January 2005. Boring 74-23 taken by USACE, August 1974, and Boring 75-92 taken by USACE, October 1976.

### 8.6.5 Levee and Channel Templates

Slopes of 3 to 1 (horizontal to vertical) were adopted for levee templates and channel cuts, and levee crown widths of 10 feet were used, for generating the feasibility level quantities. Where preliminary stability analyses were pursued, these slope angles were incorporated. Additional and more-detailed stability analyses are anticipated to be done during Preconstruction Engineering and Design (PED). For the channel template, the 3:1 slope is consistent with the original plan presented in General Design Memorandum No. 1 (dated April 1979).

### 8.6.6 Jetty Sand Retention

The core stone structure in the jetties has been designed to minimize sand transport directly through the structure, and any sand that makes it directly through the actual stone structure is likely very minor. Occasional damage incurred or repair work needed to the existing structure from time to time, to ensure the structure continues to function properly, is typically handled under the existing O&M budget/funding, and thus would not be considered a new cost for the new channel deepening.

### 8.6.7 Recommended Additional Investigations

#### 8.6.7.1 Freeport Channel

Along Freeport Channel for the new project, during PED, or prior to the final design for the initial construction contract, it is recommended that additional borings be taken at locations that include but are not limited to (1) along the reach above the Upper Turning Basin and along Stauffer Channel at about 1,000-foot intervals to a depth below the depth of new cut, and at other channel locations where gaps or deficiencies are indentified from prior-obtained foundation information; and (2) verification borings or investigations supplemental to prior work done in areas where channel cuts will encroach on critical features or structures such as the jetties.

#### 8.6.7.2 Upland Placement Areas

At existing PA 1, prior to the next O&M construction contract under the new 50-year period of analysis, it is recommended that additional borings be taken at locations that include but are not limited to (1) areas where levee alignment adjustments have taken place since prior drilling work done at the site; (2) locations where results from prior drilling/testing indicate are most critical for additional analyses; (3) locations where gaps or deficiencies in prior foundation information taken are identified; and (4) at select locations within the placement area to assess the latest crust levels from prior dredge fill placement or other soil materials for use as borrow for the initial mechanical levee work.

#### 8.6.7.3 New Placement Areas 8 and 9

At new PAs 8 and 9, prior to the first O&M construction contract, when stockpiled new work material will be shaped to new levee height, it is recommend that additional drilling be performed into levee foundations to verify extent of consolidation and foundation strength gain from surcharge of initial levee and new work stockpiles, and stability checks be performed in critical foundation areas identified.

## 8.7 COST ESTIMATES

For the Feasibility Study of the deepening and selective widening of the Freeport Channel, two Mii estimates were developed: (1) NED, and (2) LPP. The current existing channel is 45 x 400 feet.

Quantities and design features were developed by the Galveston District Engineering Branch. The estimate was prepared using the latest Unit Price Books and labor rates for FY 2012 (October 2011). The estimate was divided into 8 contracts, with each contract being organized in accordance with the work breakdown structure. The midpoint date of the construction contracts was developed in conjunction with the project manager for developing the fully funded costs. The estimate was prepared in accordance with ER 1110-2-1302, dated September 15, 2008. The costs were escalated in accordance with the above Engineering Regulation and EM 1110-2-1304, dated March 31, 2012. All these data were input into the Total Project Cost Summary (TPCS). The baseline estimate provides for all pertinent elements for a complete project ready for operations.

Since the project is over $40 million, a formal cost risk analysis using Crystal Ball software was done. It was performed with the cooperation of the PDT and Cost Engineering Directory of Expertise (DX) of the Walla Walla District in April 2012. The risks were quantified and a cost risk model developed to determine a contingency at 80 percent confidence level. The new contingencies along with the updated estimates were used to revise the TPCS. The O&M estimate was prepared in April 2012.

The cost estimate has undergone Agency Technical Review and been certified by the DX.

## 8.8 VALUE ENGINEERING

The Value Engineering (VE) Statement VE for the project was deferred to PED. A study was contracted in plan formulation, but the report was unacceptable (unrealistic conclusions) and never finished.

# 9.0 DETAILED ECONOMIC ANALYSIS

## 9.1 GENERAL

This section presents the detailed economic analysis for the Freeport Channel Feasibility Study. The project benefits were calculated based on reductions in transportation costs generated from reductions in vessel delays. The benefits were calculated for a 2017–2067 period of analysis using FY 2012 Federal discount rate of 4.0 percent and the deep-draft vessel operating costs contained in unpublished update to EGM 08-05. The proposed channel improvements are in response to the need for deeper access required by allowing the existing fleet to load more fully, the introduction of larger vessels, and the reauthorization of the upper reaches of the harbor. Additional documentation associated with benefit calculations outlined in this section is contained in Appendix A.

The existing Federal project includes a 47-x-400-foot offshore Outer Bar and Entrance Channel, a 45-x-400-foot Main Channel, and 36-foot depth to its general cargo docks. Figure 10 shows the port facilities and the major terminals. The existing project extends approximately 9.7 miles from its offshore Outer Bar to the base of the Stauffer Channel. A 45-foot project depth extends from the offshore Jetty Channel through the Upper Turning Basin just below the Stauffer Channel. The 36-foot-depth Brazos Harbor Turning Basin, and its associated access channel, intersect the 45-foot channel just below the Stauffer Channel. The Brazos Harbor access channel, harbor, and turning basin contain the majority of existing public facilities, including the multipurpose terminal serving refrigerated and general cargo vessels. Principal commodities include crude petroleum, bulk fuels, chemicals, and general and container cargo. The upper reach of the Main Channel contains the deauthorized Stauffer Channel. Stauffer Channel traffic consists of seismic and crew vessels associated with the offshore oil industry and commercial fishing vessels. Vessel repair and layberth facilities are located on the channel as well. The Stauffer Channel and Turning Basin were deauthorized in 1974 under Section 12, Appendix C, and PL 251. Since deauthorization, the channel depth deteriorated from 25 feet to approximately 18-foot water depth. The depth limitations and impediments associated with silting in the deauthorized channel reach generate safety concerns and contribute to declining utilization patterns. Inclusion of Stauffer as part of the Federal project was evaluated as part of the current study.

## 9.2 EXISTING CHANNEL USE

Freeport provides access to one of the largest petrochemical complexes in the world. Major petrochemical industries include ConocoPhillips Petroleum, Dow Chemical, and BASF. Located adjacent to the channel is Dow Chemical Company's Texas Division plant. Dow produces large quantities of basic industrial chemicals. Crude petroleum and petrochemical products are distributed from Freeport to the Midwest by pipeline, barge, and rail car. The Seaway/TEPPCO

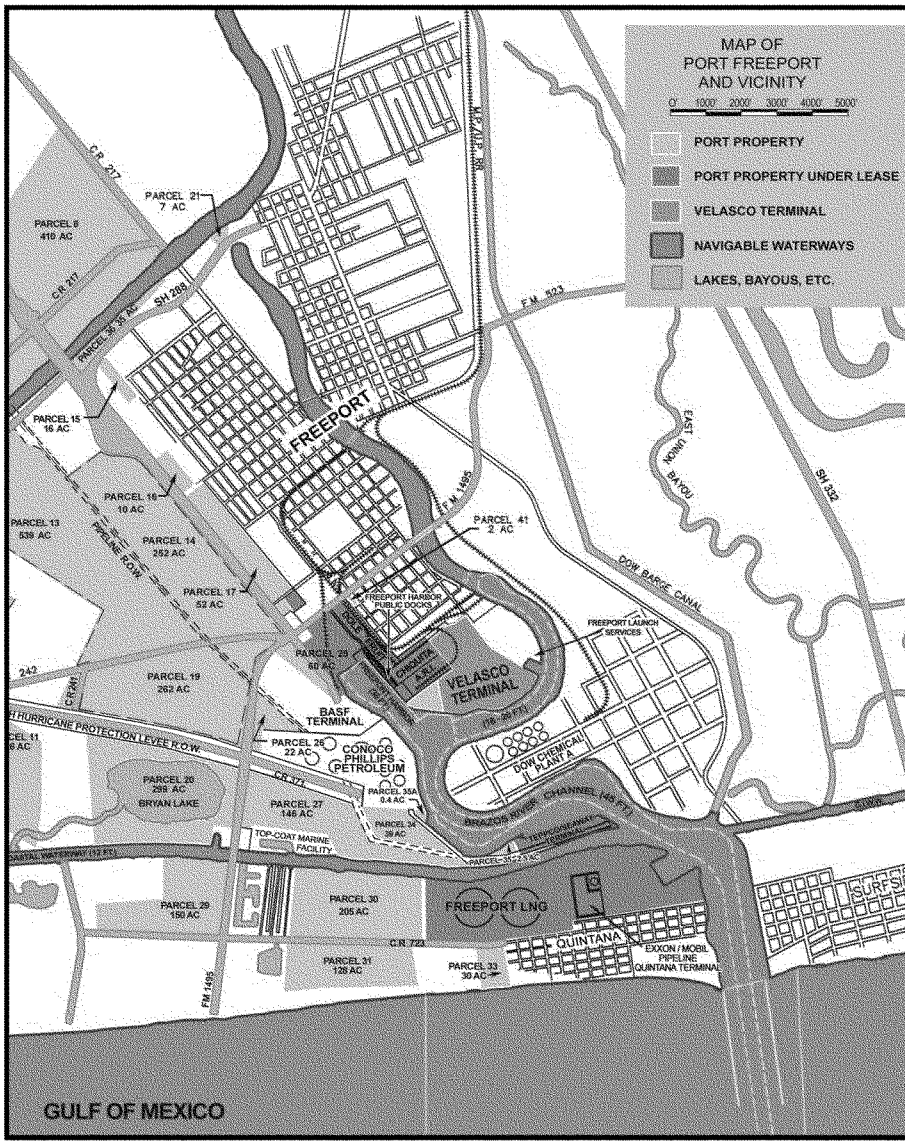



**Figure 10**
**Freeport Harbor Facilities**

Terminal receives Suezmax tankers and is located at the lower end of the channel near Station 115+00. Seaway Crude Pipeline Company is a partnership between wholly owned subsidiaries of TEPPCO and ConocoPhillips. The Seaway pipeline extends from the U.S. Gulf Coast to Cushing, Oklahoma. The pipeline also provides regional connections to refineries in Sweeny, Texas City, and Houston. In addition to Seaway, ConocoPhillips has an oil terminal and large tank farm fronting the waterway near the Upper Turning Basin. The crude petroleum tank farm has six storage tanks capable of handling approximately 3.3 million barrels of crude with pipeline connections to their refinery in nearby Sweeny. Sweeny is 28 miles to the northwest of the Freeport Channel. From Sweeny, crude petroleum is transported to Cushing, Oklahoma. Refined products are also distributed by pipelines to western terminals in Colorado and northeast through Kansas, Missouri, and Illinois. A natural gas liquid processing unit and olefins plant, jointly owned and operated by Chevron and ConocoPhillips, is located at the Sweeny complex.

Freeport's crude petroleum terminals also transmit crude oil to the Bryan Mound SPR site. Bryan Mound is 3 miles southwest of Freeport. Two principal crude pipelines extend from Bryan Mound: a 4-mile, 30-inch-diameter line to the ConocoPhillips terminal and docks and a 46-inch line to Sweeny and Texas City, Houston, and the Midwest. The SPR is a U.S. Government complex of four sites with deep underground storage caverns created in salt domes along the Texas and Louisiana Gulf Coast that store emergency supplies of crude oil.

In addition to its existing base and expansion of its new container terminal, the existing condition includes an LNG terminal. The LNG terminal became operational in late 2008 and was constructed by a partnership that includes ConocoPhillips and Dow Chemical. The terminal is located along the southern edge of the Freeport Harbor Jetty Channel near Station 65+00. Its docks were built to accommodate vessels 1,099 feet long by 177 feet wide. This vessel design prompted the non-Federal sponsor to pursue widening of the offshore Outer Bar and Jetty channels from 400 to 600 feet under the Section 204 authority of WRDA 86, as amended in 1990. Phase 1 of the terminal is presently in operation, and vessel traffic commenced in April 2008. Prior to the Section 204 initiative, widening was being evaluated as part of the current Federal feasibility study. While the LNG terminal provided the impetus for the Section 204 analysis, channel widening would also benefit existing and future traffic. Freeport's existing traffic, particularly crude petroleum tankers and product tankers, is subject to vessel size limitations due to the existing 400-foot channel width. The BRPA's current rules stipulate maximum lengths and beams of 820 feet or 145 feet. Daylight-only operation is enforced for vessels greater than 750 feet long or 107 feet wide. Additionally, the beam constraints for existing traffic and introduction of LNG and container vessels are anticipated to exacerbate traffic delays.

While the majority of Freeport's cargo consists of crude oil, bulk fuels, and chemicals, the port's general cargo base also includes a variety of temperature-sensitive cargos such as meat and vegetables. Freeport cargo includes 6 percent of U.S. rice exports and 6 percent of U.S. banana

imports. P&O, a multinational container terminal operator and stevedore, currently provides container and terminal operations in Freeport for the special requirements of the Dole, Chiquita, and Turbana fruit distributors. Freeport's refrigerated cargo facility has been in operation since 1984. The fruit distribution facilities were constructed by the port and are leased to the terminal operators. The DWT range for refrigerated cargo vessels is 11,000 to 16,000 DWT. The median beam width of the refrigerated cargo vessels is 79 feet. Analysis of vessel-on-order data from the Lloyd's Register-Fairplay (2007) showed that beam widths of 79 feet represent the maximum for refrigerated cargo vessels. The largest general cargo vessels using the public terminal range from 40,000 to 46,000 DWT. The larger carriers are used for meat, sugar, cereal, and vegetable imports from Brazil and Europe. Freeport's existing temperature-sensitive cargos and rice and other general and containerized base cargo docks are located in the 36-foot-deep Brazos Harbor Turning Basin. Traffic through the general cargo basin also includes wind-energy equipment.

## 9.3 CHANNEL REACHES

In terms of vessel traffic and facilities, the existing Federal project contains three general operational reaches and one deauthorized reach. The first reach starts offshore at Station –370+00 and goes to Station 132+66, and includes the Lower Turning Basin and the Brazosport Turning Basin. This 45-foot-deep reach provides access to crude petroleum tankers using docks operated by Seaway Crude Pipeline Company. The maximum-sized vessels using the channel are 820-foot-long by 145-foot-wide crude oil tankers unloaded at Seaway. The length and beam of these vessels generally correspond to a 120,000 DWT vessel. Freeport's LNG terminal is also located in this reach. The LNG terminal became operational in 2008 and was constructed by a partnership that includes ConocoPhillips and Dow Chemical. The terminal is near Station 65+00 and adjacent to the intersection of the Freeport Ship Channel and the GIWW. The docks at the LNG terminal were built to accommodate vessels 1,099 feet long by 177 feet wide. This vessel design prompted the non-Federal sponsor to pursue widening of the offshore Outer Bar and Jetty channels from 400 to 600 feet under the Section 204 authority of the WRDA of 1986 as amended in 1990. Larger tankers, in the 135,000 to 175,000 DWT range, are handled on a "per job" basis with a one-time waiver from the BRPA.

The second major reach of the channel extends from the Brazosport Turning Basin to the Upper Turning Basin near Station 184+20. The Upper Turning Basin is 1,200 feet in diameter. Facilities in this reach include Dow Chemical and ConocoPhillips. Vessel traffic consists of product carriers and crude petroleum tankers. The largest vessels using this upper reach are 90,000 to 100,000 DWT crude petroleum tankers. The chemical carriers used in this section generally range in size from 22,000 to 50,000 DWT. The design drafts for chemical carriers at the upper end of this DWT range generally are 42 to 43 feet. Review of the chemical carriers on order as of January 2009 showed that 22 percent have design drafts over 42 feet and 1.6 percent have design drafts over 46 feet, with 48 feet representing the maximum draft.

The next reach is the side channel providing access to the Brazos Harbor Turning Basin and general cargo facilities. The 36-foot-deep channel intersects with the Main Channel at the Upper Turning Basin. Brazos Harbor Turning Basin vessel traffic primarily consists of refrigerated container vessels delivering bananas and general cargo vessels shipping rice. The configuration of the access area and turning basin limits future expansion opportunities due to the high density of docks and landside facilities. The water and landside limitations of the general cargo reaches prompted development of the new adjacent Velasco property for the construction of the new container terminal. The new Velasco Container Terminal is located on property bordering the existing 45-foot Project and the Stauffer Channel and just outside the Upper Turning Basin (see Figure 10). Work is progressing on 800 feet of dock and 35 acres of backland (Phase I), of what eventually will be a 1,200-foot-long dock and a 90-acre terminal (Phase II).

The fourth reach contains the deauthorized Stauffer Channel and turning basin. The Velasco Container Terminal is located in the lower end of the Stauffer Channel between stations 184+20 and 222+00. The upper reach of the Stauffer Channel is from stations 222+00 to 260+00, just below the Freeport Tide Gate. The existing channel depth is 18 feet from stations 174+00 to 260+00.

Until the mid-1950s, the Stauffer Channel had an authorized depth of 30 feet and an operating depth of 25 feet. In 1955, the channel was placed in an inactive status and was deauthorized in 1974 under Section 12, Appendix C, PL 93-251. It has taken over 50 years since being categorized as "inactive" for the channel to shoal from 25 feet down to its current depth of 18 feet from stations 174+00 to 260+00.

The existing project includes four turning basins. The Lower Turning Basin is 750 feet in diameter and located near Station 70+00. Next is the Brazosport Turning Basin, which is 1,000 feet in diameter and is located near Station 110+00. The Brazos Harbor Turning Basin is 750 feet in diameter and is located in the 36-foot channel reach. The Upper Turning Basin is 1,200 feet in diameter and is located at the upper end of the existing 45-foot-deep Federal project and east of the Brazos Harbor Turning Basin access channel.

## 9.4 EXISTING OPERATING CONSTRAINTS

Freeport's existing traffic, particularly crude petroleum tankers and product tankers, is subject to vessel size limitations due to the existing 400-foot channel width. The maximum ship dimensions permitted by the BRPA, without waiver, are 820-foot length overall (LOA) and 145-foot maximum beam, as shown in Table 18. Vessel length limitations are enforced because crosswinds and crosscurrents force tankers to "crab" at an angle though the entranced

**Table 18**
**Brazos River Pilots Association Guidelines**
**Boarding Instructions**

| **Vessel Dimensions:** | **feet** | **meters** |
|---|---|---|
| Maximum Length | 820 | 249.9 |
| Maximum Beam | 145 | 44.2 |
| Recommended Draft | 42 | 12.8 |
| Draft Restrictions: | | |
| Maximum Draft | 45 | 13.7 |
| Recommended Draft | 42 | 12.8 |
| Brazos Harbor and BASF Channel Maximum Draft | 36 | 10.9 |
| Old River Channel Maximum Draft | 15 | 4.5 |

Special Cases: Oversized, excessive draft or unusual type vessels will be handled on a "per job" basis with a one-time waiver to the Basic Operating Procedures. These vessels will be billed under "special services" and will be by "specific agreement" prior to the move. Pilots reserve the right to deny movement of any vessel during times of excessive wind, excessive current or on times of low water.

**Daylight Restrictions**

| | **Inbound Vessels:** |
|---|---|
| 1. | Vessels over 750 feet LOA |
| 2. | Vessels over 107 feet Beam |
| 3. | Vessels with Draft over 36.5 feet and LOA greater than 700 feet |
| 4. | All vessel movements at Dow A-13 |
| 5. | All vessel movements at Dow A-14 with LOA greater than 600 feet or with a Beam greater than 100 feet |
| | **Outbound Vessels:** |
| 1. | All vessel movements at Dow A-13 |
| 2. | All vessel movements at Dow A-14 with LOA greater than 600 feet or with a Beam greater than 100 feet |
| 3. | Vessels sailing from berths above Phillips Bend (Phillips Petroleum Docks, BASF, and Brazos Harbor) with greater than 750 feet. LOA will require two pilots be handled on a per job basis and be billed under the "special services" agreement. One time deviation waiver from standard operating procedures, signed. |
| | Vessels judged unsafe for handling after dark will be limited to daylight hours. Night operations will be suspended during times when weather conditions do not permit safe navigation. |

Source: http://www.brazospilots.com/operatingprocedures.html

Jetty Channel. Ships of greater length than 820 feet are not able to clear the jetties under adverse wind and current conditions. Waivers are only granted provided that winds are less than 20 knots and that there is no more than a 0.5-knot crosscurrent at the mouth of the jetties. Approximately three to four vessels per month are granted waivers. Daylight-only operation is enforced for vessels greater than 750 feet long or 107 feet wide. Additionally, the beam constraints for existing traffic and introduction of LNG and container vessels are anticipated to exasperate traffic delays. Based on pilot input, the effect of channel widening, to be completed under the Section 204 study, will relax these rules.

In the Section 204 study, discussion with the BRPA and ship simulation studies conducted at ERDC found that a channel width of 600 feet would be necessary to accommodate the 264,000 $m^3$ LNG design vessel. This vessel is 1,131 feet long by 177 feet wide and has a corresponding DWT of 122,000. In general, Freeport presently receives fewer large tankers than other ports with comparable channel depths or even than those with less channel depth due to its existing 400-foot channel width.

With a wider channel, there is reduced potential for delays due to alongshore crosscurrents. Nighttime transits will be possible for vessels larger than 750 feet long and 106 feet wide, and two-way traffic will be possible for a larger range of vessels. Other ports in the region have the capability of handling these larger vessels, so Freeport will not be the only port in the region to accept these vessels.

The ability to deploy larger vessels or load the existing fleet more fully will reduce per ton transportation costs for vessels using Freeport. Larger vessels can carry a greater cargo load than the current restricted size class of vessels, and even with a restricted draft of 42 feet, the greater load should result in a lower cost per ton of transportation, as the percentage increased level of tonnage per ship will be greater than the percentage increase in cost. As a result, cost per ton to move the same level of cargo will decline.

## 9.5 HISTORICAL TRAFFIC

Freeport experienced strong growth over the past decade. Total tonnage increased from an average of 16.1 million short tons in 1994 to 1995 to an average of 28.5 million for 2004 to 2006. In 2008, Freeport ranked 26th in the Nation in terms of total tonnage, up from 38th in the early 1990s.[2] In terms of foreign imports and exports, Freeport ranked 12th among U.S. ports in 2007, up from 25th in the early 1990s. Approximately 85 percent of Freeport's current tonnage consists of deep-draft movements. The remaining 15 percent consists of shallow-draft GIWW traffic.

[2] USACE, Waterborne Commerce of the U.S., Part 5, National Summary, Institute of Water Resources (IWR)-Waterborne Commerce Statistical Center (WCSC)-09, 2006–2008 and 1991–1993.

This section provides an overview of recent historical traffic for the existing commodity base. The discussion is limited to crude petroleum, petroleum and chemical products, general and container cargo, and LNG. Inclusion of recent data is based on availability, report preparation time constraints, and relevance to the presentation. Table 19 presents Freeport's 2006 imports and exports by foreign region of origin or destination. Table 20 presents Freeport's tonnage by major commodity groups through 2009.

In addition to the commodity and container traffic, in 2008 Freeport handled 28,000 tons of wind energy equipment, and twenty-one vessels called at the port with wind energy equipment.

### 9.5.1 Petroleum and Chemical Products

Regional production includes petroleum products such as transportation fuels like gasoline, diesel fuel, and jet fuel, and chemical products such as sodium hydroxide, complex hydrocarbons, and ammonia. For 2004–2006, the petroleum and chemical imports and exports totaled 5.3 million short tons. Freeport's products consist primarily of petroleum product imports and chemical exports. Petroleum products are distributed throughout the Midwest and southeastern United States by pipeline, barge, and railcar. Chemicals are primarily distributed by inland waterway barge.

**Table 19**
**Freeport Harbor**
**2006 Imports and Exports by Region (all Foreign Imports and Exports)**
**Estimated Distribution of Imports and Exports by Region of Origin**
**1,000s of Short Tons**

| Region | Imports | | Exports | | Total | |
|---|---|---|---|---|---|---|
| Canada | 24.1 | 0.10% | 345.8 | 11.50% | 369.9 | 1.30% |
| Mexico | 1,133.6 | 4.70% | 42.1 | 1.40% | 1,175.7 | 4.30% |
| Central America and Caribbean | 1,230.1 | 5.10% | 706.6 | 23.50% | 1,936.7 | 7.00% |
| South America | 11,118.9 | 46.10% | 739.7 | 24.60% | 11,858.6 | 43.80% |
| Western South America | 4,10.0 | 1.70% | 12.0 | 0.40% | 422.1 | 1.60% |
| Europe and Mediterranean | 2,460.1 | 10.20% | 129.3 | 4.30% | 2,589.4 | 9.60% |
| Africa | 2,894.3 | 12.00% | 177.4 | 5.90% | 3,071.7 | 11.40% |
| Middle East | 4,843.1 | 20.08% | 141.3 | 4.70% | 4,984.4 | 18.40% |
| Far East and Pacific | 4.8 | 0.02% | 712.7 | 23.70% | 717.5 | 2.60% |
| Total Tonnage | 24,119.0 | 100.0% | 3,007.0 | 100.0% | 27,126.0 | 100.0% |

Source: USACE, Navigation Data Center (NDC) detailed unpublished data, 2006.

**Table 20**
**Freeport Harbor Tonnage by Major Commodity Groups (1,000s of short tons)**
**(1970–2009)**

| | Major Deep-Draft Commodities | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Crude Oil Imports | Petroleum Products Imports | Petroleum Products Exports | Chemical Imports | Chemical Exports | Other | Total Ocean-Going | Inland Waterway Barge Cargo | Total Tonnage |
| 1970 | 0 | 0 | 0 | 0 | 1,082 | 1,209 | 2,291 | 2,992 | 5,283 |
| 1980 | 12,498 | 221 | 0 | 301 | 1,162 | 3,117 | 17,299 | 2,832 | 20,131 |
| 1990 | 5,472 | 17 | 26 | 149 | 1,093 | 3,407 | 10,164 | 4,330 | 14,494 |
| 1991 | 6,175 | 38 | 10 | 183 | 967 | 1,895 | 9,268 | 6,398 | 15,666 |
| 1992 | 5,891 | 53 | 14 | 163 | 871 | 2,761 | 9,753 | 5,200 | 14,953 |
| 1993 | 7,025 | 18 | 25 | 176 | 931 | 1,564 | 9,739 | 4,286 | 14,025 |
| 1994 | 10,073 | 259 | 17 | 187 | 1,431 | 1,483 | 13,450 | 4,000 | 17,450 |
| 1995 | 10,378 | 1,345 | 73 | 344 | 1,425 | 1,357 | 14,922 | 4,740 | 19,662 |
| 1996 | 15,074 | 1,887 | 27 | 275 | 1,418 | 1,199 | 19,880 | 4,691 | 24,571 |
| 1997 | 16,742 | 1,863 | 117 | 333 | 1,522 | 1,272 | 21,849 | 4,432 | 26,281 |
| 1998 | 19,527 | 1,825 | 46 | 255 | 1,724 | 1,175 | 24,552 | 4,462 | 29,014 |
| 1999 | 18,321 | 1,644 | 39 | 341 | 1,633 | 1,247 | 23,225 | 4,851 | 28,076 |
| 2000 | 19,770 | 2,054 | 45 | 379 | 2,217 | 1,685 | 26,150 | 4,835 | 30,985 |
| 2001 | 19,307 | 2,413 | 40 | 583 | 1,748 | 1,407 | 25,498 | 4,645 | 30,143 |
| 2002 | 18,019 | 736 | 119 | 663 | 1,907 | 1,119 | 22,563 | 4,601 | 27,164 |
| 2003 | 19,672 | 1,857 | 87 | 778 | 2,104 | 1,114 | 25,612 | 4,925 | 30,537 |
| 2004 | 20,602 | 2,873 | 91 | 835 | 2,622 | 2,093 | 29,116 | 4,792 | 33,908 |
| 2005 | 22,000 | 1,779 | 91 | 691 | 2,509 | 1,860 | 28,930 | 4,672 | 33,602 |
| 2006 | 21,706 | 1,080 | 109 | 705 | 2,551 | 1,420 | 27,571 | 4,576 | 32,147 |
| 2007 | 18,523 | 1,046 | 90 | 710 | 2,691 | 1,005 | 24,065 | 5,151 | 29,598 |
| 2008 | 20,607 | 955 | 81 | 602 | 2,406 | 1,347 | 25,998 | 3,844 | 29,842 |
| 2009 | 19,418 | 220 | 200 | 573 | 1,864 | 1,063 | 23,338 | 4,025 | 27,363 |

Source: USACE, Waterborne Commerce of the U.S., Part 2, 1970–2009.

Petroleum product imports experienced high growth after 1994. Imports totaled 259 thousand short tons in 1994 and increased to 1.3 million in 1995, but petroleum product imports are variable. The increases experienced in the mid-1990s were associated with lube oil imports, which represented an average of nearly 70 percent of 1995 to 2000 petroleum product imports. In spite of fluctuating volumes, Freeport's share of U.S. petroleum product imports has remained between 1 and 2 percent since the mid-1990s.

Freeport's petroleum product exports are much lower than imports and are also variable. Freeport's product exports averaged 97 thousand short tons for 2004 to 2006 and represent less than 1 percent of the U.S. total product export. Freeport exports 4.6 percent of U.S. chemicals. Chemical export volumes for 2004 to 2007 averaged 2.6 million short tons and represent record highs.

### 9.5.2 General and Container Cargo

Container vessels carry any cargo that can be stowed into any of the following container types: general purpose, high cube, hardtop, open top, flat, platform, insulated, ventilated, bulk, refrigerated (reefer), and tank-type containers. Cargo can include merchandise in cartons, bales, drums, cars, furniture, electronics, food, livestock, chemicals, and machinery. Oversized cargo such as heavy machinery, trucks, earth-moving equipment, and pleasure boats can be placed in or on open-top, open-side, or flat rack containers or secured to the tops of several containers in a row.

The range and diversity of container cargo has evolved (Seafarer, 2005). The earliest cargo ships carried a plethora of industrial boxes and packages, but today's container ships have a range of containers to deal with their diverse cargo. There are refrigerated containers that plug into special power sockets; there are containers for grain, liquids, and cars; even containers with clothes hanging inside, ready to go straight on to shop floors. Flat rack containers make a bed for outsized items such as yachts and heavy industrial machinery.

Houston and U.S. imports data show that the region's relative percentage of imports of manufactured goods is twice that for the Nation. Manufactured metal and monumental and building stone compose nearly 20 percent of Houston's manufactured goods total, and represent the single largest subgroups. Other manufactured goods include furniture (6.6 percent); iron and steel products (6.5 percent); baby carriages, toys, games, and sporting goods (5.8 percent); appliances (4 percent); and specialized machinery (3.6 percent). Percentage distributions of U.S. and Houston imports and manufacturing goods are (17 percent); food and farm products (22 percent) and other (5 exports by major group).

### 9.5.3 Offshore Supply, Offshore Platform Rigs, and Research and Seismic Traffic

Upper Stauffer Channel traffic consists of offshore supply vessels (OSVs), offshore platform rigs, and research/seismic vessels. The majority of traffic falls under the general classification of OSVs. Oilfield shipments consist primarily of fuel, water, supplies, drill pipes, drill mud, and chemicals. In addition to offshore vessels, the channel currently provides cargo vessel repair and layberth service and informally serves as a harbor of refuge.

Under Federal law, vessel-operating companies must report domestic waterborne commercial movements to USACE. The types of vessels include dry cargo ships and tankers, barges (loaded and empty), fishing vessels, towboats (with or without barges in tow), tugboats, crew boats and supply boats to offshore locations, and newly constructed vessels from the shipyards to the point of delivery. Vessels remaining idle during the monthly reporting period are also required to report. Although vessels are required to report, based on 2000 to 2007 dock records available from USACE NDC and subsequent discussion with NDC personnel, the Galveston District

concluded that vessel activities not associated with cargo discharge frequently go unreported. The District's search of vessel records associated with Freeport, Galveston, and other Texas ports for the period 2001 to 2007 showed no less than five OSVs. The District received limited lists and picture files of vessels docked on the Stauffer Channel.

Channel users estimated that during the 1970s and 1980s prior to the channel shoaling, a count of 20 to 30 vessels per week used the Upper Stauffer Channel, typically consisting of 6 to 7 crew boats and 18 to 21 supply boats. Industry claims an average of 30 to 40 vessels per month currently use the Upper Stauffer facilities. The 2006 trip statistics obtained from the entrance and clearance records include an annual count of 4 vessels for Freeport. NDC entrance and clearance records showed nearly 100 vessels per month for Galveston and nearly 200 for Bayou Lafourche, indicating that offshore vessels are underreported.

The OSVs using the channel are generally based in Louisiana. The OSV fleet, which includes U.S. and foreign-flagged vessels, comprises crewboats, platform supply vessels, and anchor tugs, which come into Freeport for fuel and general restocking or for waiting 1 to 2 days between jobs or due to inclement weather. For longer stays, Louisiana-based vessels would likely go to their homeport in order to avoid port charges.

According to industry literature, the OSV fleet primarily serves exploratory and developmental drilling rigs and production facilities, and supports offshore construction and subsea maintenance activities.[3] OSVs differ from other types of marine vessels in their cargo-carrying flexibility and capacity to transport deck cargo. OSVs carry pipe or drummed material and equipment, liquid mud, potable and drilling water, diesel fuel, dry bulk cement, and personnel between shore bases and offshore rigs and facilities.

The OSV fleet working in the Gulf of Mexico consists of U.S. and foreign flag vessels. The classification of foreign flag OSVs is addressed under 46 CFR Subchapter L as published in the *Federal Register* of 19 September 1997. OSVs of 500 gross tons (U.S. Regulatory Tonnage) but less than 6,000 gross tons meet the requirement of 46 CFR Subchapter L and additional requirements from Subchapter I (Industrial Vessels) that are applicable to OSVs carrying less than 36 offshore workers. Current legislation allows foreign flag vessels to operate within the U.S. boundaries of the outer continental shelf.

Foreign flag OSVs are generally exempt from Section 27 of the 1920 Merchant Marine Act, commonly referred to as the Jones Act. The Jones Act restricts U.S. coastwise trade to U.S.-built, U.S. coastwise citizen-owned, and U.S. flagged vessels. The Jones Act was extended to the U.S. outer continental shelf by the Outer Continental Shelf Lands Act of 1953, as amended in 1978.

[3] Hornbeck Oil Services, webpage information

The U.S. Gulf Coast OSV fleet includes five subtypes. The subtypes are anchor-handling tug supply vessels, crew supply vessels, offshore tug supply vessels, pipe carriers, and platform supply vessels.

Platform Supply Vessels (PSVs) are specially designed for transport of supplies to/from offshore installations, mainly to supply fields in production. This involves the transport of individual items, mainly in containers on deck. In addition, a PSV transports in segregated systems a variety of different products such as methanol, preblended drill fluids, brine, water, and oil. The various fluids are contained in epoxy-painted tanks, with individual pumps and hoses. Dry bulk cargo such as cement, barite, and bentonite are also transported. At the installations, this cargo is discharged by using compressed air. PSVs and anchor-handling and supply tugs are characteristically the largest vessels in the OSV general grouping.

Seismic vessels are used by the oil and gas industry for acquiring drilling data. The boom in offshore exploration and surveying has made seismic vessels key to the industry. Over the past 10 years, many foreign seismic vessels have utilized Freeport for a base of operations and conducted refitting projects. Activities include vessel refitting for mobilization at Gulf of Mexico and in foreign exploration sites. Seismic vessels are normally out to sea no more than 50 to 55 days, then they return to dock for a week and go back out to sea for another 50 to 55 days.

In addition to oilfield-related vessels, the Stauffer Channel provides layberth and associated repair services for small cargo vessels, fishing vessels, and other miscellaneous craft. Research vessels are characteristically layberth customers. Dwell time for layberthing generally ranges from 4 to 6 months.

Vessels have been turned away due to the lack of sufficient water depth.

### 9.5.4 Liquefied Natural Gas

The Freeport Section 204 widening analysis includes detailed analysis of Freeport's LNG market. The Section 204 report shows that import volume of 84.2 billion cubic feet per day was forecasted for 2010, with volumes increasing to 712 billion cubic feet by 2018. The vessel sizes and expected throughput prompted the non-Federal sponsor to pursue widening of the offshore Outer Bar and Jetty channels from 400 to 600 feet under the Section 204 authority of the WRDA as amended in 1990. While LNG provided the impetus for the 204 study, channel widening would also benefit existing and future traffic. The base analysis used for this feasibility study assumes that the channel is widened.

## 9.6 HISTORIC VESSEL UTILIZATION PATTERNS

This section discusses vessel utilization patterns before and after the 45-foot Project depth became available in the mid-1980s. Freeport experienced an overall increase in the number of

vessels associated with loaded drafts over 38 feet from the years 1992 to 2006. In 2006, 265 vessels had loaded drafts over 38 feet. Current volumes associated with loaded drafts of 38 feet or more are over 150 percent higher than when the 45-foot depth first became available. Comparison of the data from the early 1990s shows small variation in the total number of ocean-going vessels used for cargo transport but significant increases in ocean-going tonnage, with total ocean-going tonnage nearly three times greater than in the early 1990s.

While total trips declined from 2,460 in 1992 to 1,690 in 2006, trip counts for some groups grew. Along with increases in trips for vessels with loaded drafts over 38 feet, there were significant increases in the number of movements associated with loaded drafts of 25 feet or more.

General cargo vessels also increased in loaded drafts. In 1993 and 2006, loaded drafts for vessels used to import bananas and export food showed a change from average loaded drafts of 25 feet or less in the early 1990s to 25 feet or more for recent years. While the largest concentration of banana and food product movements are associated with loaded drafts between 25 and 29 feet, some loaded drafts between 36 and 39 feet are used for food products, specifically meat and rice.

### 9.6.1 Underkeel Clearance

Underkeel clearance is defined as the minimum clearance available between the deepest point on the vessel and the channel bottom, in still water. The general rule of the BRPA indicates the underkeel clearance be at least 10 percent of the design draft minus 1 foot, but BRPA said it is their understanding that since the grounding of the Exxon *Valdez* and OPRA 90, the USCG has required a minimum of 3-foot underkeel clearance for all tank vessels. Interpretation of the BRPA rule suggests that loaded drafts in excess of 42 feet should be very rare for the current 45-foot channel.

Freeport's tanker fleet was examined in order to identify the vessel loading patterns. The effect of underkeel clearance policy on existing and future traffic results in greater underkeel clearance for larger vessel sizes. The 2005 and 2006 records show some vessels less than 100,000 DWT being loaded up to 42 feet and vessels over 115,000 DWT not being loaded greater than 40 feet and ranging from 34 to 40 feet.

### 9.6.2 Commodity-Specific Vessel Utilization

This section presents analyses of vessel fleet data, utilization of the existing fleet, and anticipated future constraints associated with draft-constrained vessels. These analyses provide the basis for identifying the commodities expected to utilize vessels loaded to channel depths over 45 feet and for forecasting percentage utilization of larger and/or more fully loaded vessels. The discussions include vessel fleets for petroleum, petroleum products, chemicals, breakbulk, container cargo, OSVs, Seismic, Research, and LNG vessels.

### 9.6.2.1 Crude Petroleum Tanker Fleet

The largest vessels presently using Freeport are crude petroleum tankers. The most common sizes presently using Freeport are between 90,000 and 110,000 DWT, and the largest vessels presently used are in the 145,000 to 159,500 DWT range. Table 21 presents distributions of crude petroleum imports by vessel size for 1990, 1993, and 2003 to 2007. Table 22 displays representative vessel characteristics corresponding to Freeport's current crude petroleum fleet.

**Table 21**
**Freeport Harbor Crude Petroleum Imports by Vessel DWT, 1990–2007 (Percent)**

| DWT Range | 1990 | 1993 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| <50,000 | 1.1 | – | – | – | 1.1 | 0.7 | 1.3 |
| 50,000 to 69,000 | 98.9 | 11.8 | 3.1 | 0.9 | 3.3 | 1.8 | 2.2 |
| 70,000 to 79,999 | – | – | 0.3 | 4.2 | 3.4 | 6.6 | 5.0 |
| 80,000 to 84,999 | – | 24.9 | 5.3 | 4.1 | 1.5 | – | – |
| 85,000 to 89,999 | – | 35.6 | 5.7 | 1.2 | 1.0 | – | – |
| 90,000 to 94,999 | – | – | 5.5 | 6.2 | 5.7 | 9.5 | 7.2 |
| 95,000 to 99,999 | – | 16.9 | 36.3 | 35.8 | 34.5 | 24.3 | 23.4 |
| 100,000 to 104,999 | – | 10.8 | 10.9 | 13.7 | 12.6 | 13.6 | 22.5 |
| 105,000 to 109,999 | – | – | 26.7 | 22.2 | 27.3 | 31.5 | 25.6 |
| 110,000 to 114,999 | – | – | 3.3 | 7.6 | 5.2 | 5.6 | 6.6 |
| 115,000 to 119,999 | – | – | – | – | – | 1.0 | 2.2 |
| 120,000 to 139,999 | | | | | | | – |
| 140,000 to 159,000 | – | – | 2.9 | 4.1 | 4.4 | 5.3 | 4.2 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Source: USACE, NDC, unpublished data.

**Table 22**
**Freeport Harbor**
**Crude Petroleum Representative Tanker Sizes**

| DWT Range | Vessel Characteristics (feet) | | |
|---|---|---|---|
| | LOA | Beam | Design Draft |
| <80,000 | 748 | 106 | 41 |
| 80,000 to 84,999 | 800 | 131 | 43 |
| 85,000 to 89,999 | 800 | 138 | 46 |
| 90,000 to 94,999 | 810 | 136 | 46 |
| 95,000 to 99,999 | 798 | 137 | 47 |
| 100,000 to 104,999 | 792 | 138 | 48 |
| 105,000 to 109,999 | 797 | 138 | 50 |
| 110,000 to 114,999 | 817 | 144 | 49 |
| 115,000 to 139,999 | 820 | 144 | 53 |
| 140,000 to 155,000 | 899 | 154 | 56 |

Source: USACE, NDC unpublished data were used to compile the percentage distribution of tonnage by vessel size. The Fairplay/Lloyd's Register of Ships was used to obtain the vessel DWT and associated characteristics.

#### *9.6.2.1.1 Crude Petroleum Modes of Shipment*

The modes of shipping crude include direct, lightered, lightened, and transshipped. Direct shipment is the transfer of tonnage by vessel between two coastal ports. Lightering is defined as the process involving ship-to-ship transfer of oil cargo. Lightening describes the process where enough cargo is offloaded from a tanker to permit the light-loaded vessel to enter a confined channel system. Transshipments store crude at a terminal and then ship direct from there to ports such as Freeport.

U.S. Gulf Coast lightering occurs in the international waters of the Gulf of Mexico and involves the transfer of tonnage from a larger vessel, called a VLCC (Very Large Crude Carrier), onto one or more shuttle vessels. With lightering, the VLCC does not enter the coastal receiving port.

Lightering is extremely cost effective for long-haul freight. Tankers larger than 175,000 DWT are normally totally lightered offshore onto shuttles. For Freeport's existing project depth of 45 feet, four shuttles are needed to completely offload a 325,000 DWT VLCC, with 325,000 DWT being a representative VLCC size. The use of four shuttles is routine and optimal as it allows for the least number of shuttles based on a 45-foot channel depth.

A frequent alternative to either direct shipment or lightering is lightening. The tanker sizes associated with lightening on the Texas Coast generally range from 120,000 to 175,000 DWT. Tankers larger than 175,000 DWT are normally lightered. There is a gap in the world tanker fleet between 175,000 and 250,000 DWT. The reason for the gap is that it is not cost effective to use tankers significantly larger than 175,000 DWT for direct shipment even for channel depths of 55 to 60 feet, and it is not cost effective to use vessels smaller than 250,000 DWT for lightering.

The transportation costs prepared for this report are based on optimal shuttle sizes and turnaround times. It was found that the efficiencies of offshore transfers are great and have increased in the last 10 to 15 years, and therefore the assumption of optimal efficiencies is reasonable. Offshore off-loading rates are less than dockside rates. The maximum cargo capacity for a 325,000 DWT vessel is approximately 347,400 short tons. Information obtained from industry discussion indicates that the set-up time and finishing time would add a few hours. Shuttle vessels are loaded one at a time and sequencing of shuttle vessel arrivals and departures is subject to variances.

Transshipping is the fourth mode of shipment. Crude oil is also transshipped through deepwater ports in the Caribbean. Crude is transported on VLCCs to the transshipped sites and later transferred to 90,000 to 114,000 DWT range shuttle tankers for shipment to Freeport. Some of the tonnage included in the Central and South America routing is transshipped through the Bahamas. Based on similar mileage and vessel sizes, the cost analysis for tonnage transshipped through the Bahamas was evaluated similarly to direct shipments from ports in Venezuela and Colombia.

The primary sized vessel used on the Mexico/Eastern South America route for direct shipments into Freeport is 90,000 to 114,000 DWT. Western South American shipments are either transported through the Panama Canal or the Trans-Panama Pipeline. The 81-mile pipeline runs from Panama near the Costa Rican border and the port of Charco Azul on the Pacific Coast to the port of Chiriquí Grande, Panama, on the Caribbean Sea. The pipeline opened in 1982 as an alternative to carry crude oil from the Pacific to the Atlantic. Between 1982 and 1996, it transported approximately 2.7 billion barrels of Alaskan oil to the U.S. Gulf Coast ports. After declining Alaskan oil shipments, the pipeline was closed in 1996. In November 2003, it was reopened for transportation of Ecuadorian crude oil to U.S. Gulf ports. Less than 1 percent of Freeport's 2004 to 2006 crude oil imports originated in Ecuador and was transported in relatively small tankers. Nearly 50 percent of crude oil imports originated in Venezuela and approximately 30 percent was from West and North Africa and the Middle East. Table 23 presents Freeport's 2000 to 2009 crude petroleum imports by major trade route. The USACE NDC records only include vessels that come into U.S. ports, such as Freeport, and do not include records of vessels that offload at the lightering zone. Table 23 displays Freeport's 2000-2009 crude petroleum imports by region or country of origin.

Africa, Mediterranean, and Europe movements are lightened, lightered, or shipped direct. Shipments from Africa, the Mediterranean, and Europe are usually transported in tankers between 90,000 and 175,000 DWT, with direct shipments generally using tankers between 90,000 and 120,000 DWT. Facilities to accommodate VLCCs recently became available at Africa ports.

In addition to transportation cost incentives, vessel selection is also related to the way crude petroleum is currently sold and how crude oil is shipped. Parcels are generally sold in 500,000 to 650,000 barrels. A 500,000 to 650,000 barrel parcel converts to approximately 75,000 to 95,000 short tons. Many vessels arrive in the international waters of the Gulf of Mexico with double parcels. Cost analyses show that the most economical sized vessel for single parcels is between 75,000 and 100,000 DWT given the existing channel depth of 45 feet. For double parcels, the most efficient size is between 150,000 and 175,000 DWT.

Gulf Coast industry personnel indicated that parcel size and associated ship size are primarily a function of the existing channel dimensions. The indication suggests that an increase in channel dimensions would likely result in a shift to larger parcel sizes and larger vessels. Comparison of the parcel sizes associated with Freeport's 1993 and 2007 crude oil imports revealed that the distribution of tonnage by parcel size increased. Data for 1993 were chosen to represent conditions when the 45-foot channel was dredged. Transition to more fully loaded, or larger, vessels is generally expected to have some lag time. Comparison of Freeport's current crude oil import parcel sizes for 1993 and 2007 indicate reductions in the volumes discharged offshore. The data comparison also serves to illustrate that larger parcels are being shipped today and

suggests that the channel deepening from 40 to 45 feet facilitated this transition. Table 24 displays percentage distributions of Freeport's 1993 and 2007 imports by parcel size.

**Table 23**
**Freeport Crude Petroleum Imports by Region or Country of Origin**
**2000–2009**

| Region of Origin | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1,000s of short tons | | | | | | | | | | |
| Canada | - | - | - | - | - | - | - | - | 270 | 56 |
| Mexico and Guatemala | 1,068 | 328 | 324 | 1,829 | 288 | 800 | 428 | 748 | 1,071 | 1,368 |
| Venezuela and Colombia | 5,120 | 11,932 | 10,938 | 6,197 | 8,776 | 12,676 | 11,390 | 9,143 | 9,096 | 6,177 |
| Brazil and Argentina | - | - | - | - | - | 823 | 834 | 713 | 514 | 2,116 |
| W. South America | - | - | - | - | - | 204 | 115 | 92 | - | 754 |
| Europe, N. Africa, and Mediterranean[a] | 4,642 | 2,085 | 2,540 | 3,380 | 3,241 | 1,916 | 2,990 | 1,682 | 3,357 | 3,887 |
| West Africa | 4,760 | 2,606 | 2,342 | 3,400 | 3,158 | 4,625 | 2,756 | 3,190 | 3,430 | 3,674 |
| Mideast | 4,180 | 2,356 | 1,875 | 4,865 | 5,138 | 957 | 3,193 | 2,956 | 2,869 | 1,089 |
| Pacific/Far East | - | - | - | - | - | - | - | - | - | 296 |
| Total | 19,770 | 19,307 | 18,019 | 19,672 | 20,602 | 22,000 | 21,706 | 18,523 | 20,337 | 19,362 |
| Percentages | | | | | | | | | | |
| Canada | - | - | - | - | - | - | - | - | 1.3 | 0.3 |
| Mexico and Guatemala | 5 | 2 | 2 | 9 | 1 | 3.6 | 2.0 | 4.0 | 5.2 | 7.0 |
| Venezuela and Colombia | 26 | 62 | 61 | 32 | 43 | 57.6 | 52.5 | 49.4 | 44.1 | 31.8 |
| Brazil and Argentina | - | - | - | - | - | 3.7 | 3.8 | 3.8 | 2.5 | 10.9 |
| W. South America | – | – | – | – | – | 0.9 | 0.5 | 0.5 | 0.0 | 3.9 |
| Europe, N. Africa, and Mediterranean[a] | 23 | 11 | 14 | 17 | 16 | 8.7 | 13.8 | 9.1 | 16.3 | 20.0 |
| West Africa | 24 | 13 | 13 | 17 | 15 | 21.0 | 12.7 | 17.2 | 16.6 | 18.9 |
| Mideast | 21 | 12 | 10 | 25 | 25 | 4.4 | 14.7 | 16.0 | 13.9 | 5.6 |
| Pacific/Far East | 0 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 |
| Total | 100 | 100 | 100 | 100 | 100 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: USACE, NDC detailed files and U.S. Department of Energy

[a] The majority of this tonnage is lightered or lightened. The tonnage total shown includes shuttle vessels and lightened mother vessels.

**Table 24**
**Freeport Percentage of Crude Oil Imports by Vessel Parcel Size**
**1993 and 2007**

| Vessel Parcel (short tons) | % of Imports by Parcel Size | |
|---|---|---|
| | 1993 | 2007 |
| ≤60,000 | 32 | 11 |
| 60,000–70,000 | 13 | 6 |
| 70,000–80,000 | 44 | 18 |
| 80,000–85,000 | 5 | 11 |
| 85,000–95,000 | 7 | 54 |
| Grand Total | 100 | 100 |

Source: USACE, NDC compiled from detailed records.

Data show that the larger parcels are being carried by the larger DWT classes. This transition suggests more cost effective use of vessels. In addition, recent data show the use of some smaller shuttles to accommodate smaller volumes discharged during lightening operations.

#### 9.6.2.2 Petroleum Product Vessels

Since the 45-foot depth became available in the mid-1990s, there has been a transition to larger and more fully loaded vessels for some petroleum product tonnage, including partially refined oils. Partially refined oils are transported in crude petroleum tankers. The geographic origins generally include Algeria (47 percent) and Saudi Arabia (27 percent). Other origins include Southern Europe, the Mediterranean, and Ecuador. Vessel sizes and trade route data indicate potential opportunities to load to increased drafts based on trend data through 2005. Data for 2006 to 2009 show a drop in partially refined products imports and the associated use of relatively larger vessels.

#### 9.6.2.3 Chemical Product Carriers

Larger chemical carriers are using Freeport more than in the 1990s. Detailed examination of data for 1990, 1993, and 2002 to 2005 revealed that beginning in 2002 some chemical exports were transported in vessels loaded to 40 feet or more[4]. The destination ports for these shipments include Brazil, Eastern Canada, and the Far East.

Data show an average of 7 percent of 2003 to 2009 tonnage was transported in vessels with loaded drafts of 40 feet or more. The 2003 shipments were divided among Brazil, Eastern Canada, and the Far East. The 2004 shipments were exported to China. In 2005, the larger shipments were exported to Brazil. Approximately 22 percent of exports were shipped to locations for which the Panama Canal provides the shortest travel distance. Nearly 95 percent of

[4] Continuous detailed data for years prior to 2001 are not readily available.

this tonnage consisted of chemicals. The destinations of shipments through the Panama Canal included South Korea (36 percent), Japan (19 percent), China (16 percent), Australia and New Zealand (15 percent), Singapore (11 percent), Indonesia (2 percent), and Western South America (1 percent). For the period 2007 to 2009, 41 percent of vessels with loaded drafts of 40 feet or more exported chemicals to Brazil, 32 percent to Asia, 18 percent to Northern Europe, and 9 percent to Eastern Canada.

Freeport's largest shipments and more deeply loaded vessels carried sodium hydroxide (commonly referred to as caustic soda). Caustic soda is used in the manufacture of pulp and paper, alumina, soap and detergents, petroleum products, and chemical production. The production of alumina from bauxite is a major end-use application for caustic soda. Caustic soda composes 30 percent of Freeport's 2003 to 2005 chemical exports and approximately 50 percent of 2006 to 2007 exports.

#### 9.6.2.4 Bulk Carriers

Large bulk carriers are used in the import of Freeport's limestone and building materials. The specific type of bulk carriers used for limestone and building materials are "load-on/load-off," or "LoLo," vessels. The present fleet generally consists of 45,000 to 67,000 DWT vessels with design drafts between 40 feet and 44 feet and loaded drafts ranging from 35 feet to 39 feet. The median year of construction for the range of vessels used for this trade is 1985 and is older than the median of 1998 associated with the world fleet. Review of the distribution of vessels on order and channel depths at receiving ports indicates that some transition in the average DWT range from the existing 60,000 to 70,000 DWT into the 80,000 to 94,000 DWT range is reasonable to expect. A portion of future bulk traffic is anticipated to move to the Velasco Terminal dock. This move will allow for the use of larger and more fully loaded bulk carriers.

Rice is transported in general cargo vessels, and the size of these vessels has increased over the last decade. The largest general cargo vessels using the public terminal range from 40,000 to 46,000 DWT. The larger carriers are used for meat, sugar, cereal, and vegetable imports from Brazil and Europe. Also transported in general cargo vessels is wind-energy equipment. While more deeply loaded vessels are not anticipated for the turning basin reach, the port is expanding general and container cargo facilities just outside the turning basin reach due to capacity constraints within the basin and to accommodate larger container vessels for a wider range of commodities.

#### 9.6.2.5 Container Vessels

Bananas and rice are transported through docks located within the Brazos Turning Basin. Bananas constitute a significant share of Freeport general cargo. Freeport imports 6 percent of U.S. banana imports. Average imports for 2003 to 2005 were 257,000 short tons and remained relatively constant over the most recent 10-year period.

Bananas are transported in refrigerated container vessels, the majority of which are in the 13,000 to 16,000 DWT range. The median beam width of the refrigerated cargo vessels is 79 feet. Distribution of vessels on order shows no indication of a transition to larger refrigerated cargo vessels and shows the median beam width of the future is not expected to increase.

An annual volume of approximately 200,000 TEUs is expected during the first full year of operation with one to two vessels per day. A base of 200,000 TEUs represents 0.3 percent of the U.S. container throughput. A full build-out of 800,000 to 1,200,000 TEUs is planned with three construction phases.

Data display changes in the general cargo and container vessels using U.S. ports between 1999 and 2006 and indicate moderate rates of growth. The pace of transitions that occurred between 1999 and 2006 is expected to increase with the Panama Canal expansion. Larger Panamax and post-Panamax container vessels are presently using U.S. Gulf Coast ports. In 2006, 40 of Houston's container vessels were post-Panamax. These vessels, which have design drafts of 48 feet, transported approximately 8 percent of Houston's 2006 containerized imports and 10 percent of exports. Overall, foreign ports represented the first port of call for 45 percent of outbound containerships.[5]

Houston's first domestic port-of-call shipments were from nearby locations such as Mexico (129 vessels), Guatemala (54 vessels), Colombia (43 vessels), Jamaica (15 vessels), Dominican Republic (7 vessels), the Bahamas (5 vessels), and Western Europe. Houston was the first port of call for shipments from Spain (35 vessels), France (25 vessels), and Italy (20 vessels). Houston's container terminals presently have depth constraints of 40 feet, and the maximum loaded draft is 39 feet. The channel depth at the container terminals at many of these ports exceeds 40 feet. Specifically, a channel depth increase from 41.9 to 49 feet is planned for the container terminal in Cartagena, Colombia, and an increase from 42 to 51 feet is planned in Kingston, Jamaica. Container terminal improvements in Santos, Brazil, from 42.3 feet to 52 feet are planned.[6] The container terminal in Algeciras, Spain presently has a channel depth of 54 feet, and the Italian terminal of Galliari has a channel depth of 49 feet.

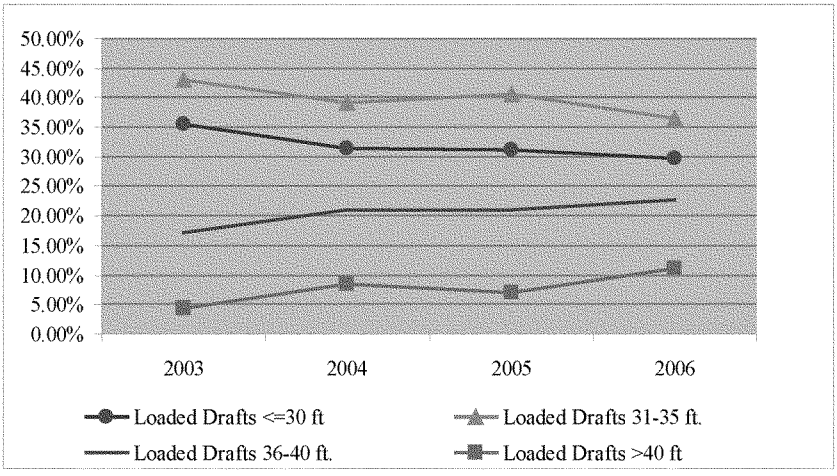
Containerships from 60,000 to 68,000 DWT are representative of mid-sized container vessels and use Houston on a regular basis. These vessels, which have design drafts up to 45 feet, are also representative of the upper end of Panamax containerships.

Figure 11 provides a general illustration of regional changes in loaded draft patterns for 2003 to 2006.

[5] The itineraries for inbound vessels were not available.

[6] Channel-depth information was obtained from Inter-American Committee on Ports, Organization of American States, presentation prepared by Carlos M. Gallegos, http://aapa.files.cms-plus.com

**Figure 11**
**U.S. Total Containership Trips**
**Percentage of Trips by Loaded Draft (2003–2006)**




### 9.6.2.6 Offshore Supply, Seismic, and Research Vessels

Navigation constraints arose after the channel was deauthorized in 1974. A channel that is non-federally maintained presents a navigational hazard in the form of higher accident probabilities. Nonmaintained water depth also presents a financial hazard to the businesses located at the end of the channel. Maintaining alignment is difficult in the silted channel. Sufficient underkeel clearance is extremely important to vessels carrying expensive and highly technical equipment. The channel depth limitations can cause hull and propulsion damage.

In spite of limitations, the channel is still used as a Harbor of Refuge. However, the range of vessels that can be safely served is limited. For example, in 2008 during Hurricane Gustav evacuation, an offshore anchor tug attempted to enter the channel and struck a submerged object and grounded. Damages sustained to one of the vessel's cyclonical thrusters required the vessel to be towed back to its home base in Louisiana after the storm. Offshore anchor vessels typically have cyclonical thrusters that are not removable. The damaged vessel had a design draft of 24.6 feet and was in ballast when it grounded.

A result of reduced depth is a reduction in vessel activity. Vessels are routinely turned away. An inquiry made to BRPA revealed that the pilots do not keep lists of vessels that are turned away. Based on the lack of records of vessels turned away, a detailed investigation of anecodotal information and vessel types similar to those presently using the Stauffer Channel was performed. For example, on 9 March 2009, a 24.6-foot draft vessel requesting to come in for

layberth was turned away due to insufficient channel depth. It was also found that the seismic vessel, *Osprey* was turned away because of insufficient channel depth. *Osprey Explorer* has a design draft of 19 feet. It was a challenge docking the *GSI Admiral*. Frequently, captains cannot agree to bring vessels in due to written rules.

Draft restrictions of just a few feet may result in unplanned delays necessitating reductions in ballast and/or in fuel. Vessels affected by draft restriction will unload fuel or ballast at docks at the lower end of the Freeport Channel before getting to the Upper Stauffer. Ballast and fuel adjustments are later made upon leaving. The time taken for ballast and fuel adjustments results in added operating time and docking charges. For instance in March 2011, the seismic vessel *Discoverer*, which has a design draft of 15.4 feet, was able to take on ballast water necessary for offshore hull balance, it was not able to fully load fuel. The inability to fully load fuel meant the vessel had to make an additional stop down-channel for fuel.

All 2006 records for Freeport, Galveston, and Bayou Lafourche (Louisiana) were obtained from Lloyd's Vessel Register records. The USCG and the USACE's Transportation Lines of the U.S. vessel databases were used to obtain vessel characteristics for some of the vessels not found in Lloyd's/Fairplay. The loaded drafts and general vessel size data, as indicated by net registered tons and gross tons, included in the USACE's Entrance and Clearance file were initially used to help isolate OSVs.

The largest vessels using the channel are approximately 400 feet long. Longer vessels cannot be turned and have to be backed into the channel. Crew and supply vessels have a draft range of 15 to 18 feet. Supply vessels, which made six to seven trips per week, have a draft range of 20 to 30 feet. These vessels fall under the general classification of OSVs.

Associated vessel characteristics were extracted from the Lloyd's vessel databases and matched to the NDC records in determining vessel type. The vessel databases were particularly important in identifying vessel types such as OSV, research vessel, seismic vessel, and crew boat.

A BRPA pilot is required for all foreign flag vessels regardless of size. A pilot is also required for any U.S. flag vessel coming from a foreign port. U.S. vessels coming from the international waters of the Gulf of Mexico do not require pilotage.

In addition to the OSV statistics in the Fairplay/Lloyd's Register of Ships, statistics associated with OSVs registered with the USCG in 2006 and operating in U.S. offshore, and vessel design draft and other characteristics for the 551 USCG vessel records available from the USACE's web page were compiled. The percentage of OSVs built after 1974 and the percentage built after 2000 were determined. The largest increases are primarily associated with design drafts over 20 feet. The data were used to identify the range of vessel drafts associated with the fleet that includes vessels using Freeport.

Seismic vessels are usually similar in size to oilfield supply vessels. They can range from 100 to over 350 feet in length and require drafts up to 30 feet. Discussion with industry indicated that during the early to mid-1970s, most seismic vessels generally ranged in size from 80 to 150 feet and seldom required drafts of more than 15 feet. Comparison of the total fleet with vessels constructed after 2000 shows the largest increase is associated with design drafts over 20 feet.

#### 9.6.2.7 Liquefied Natural Gas

In addition to its large existing base of crude petroleum, petroleum and chemical products, and dry bulk deep-draft cargoes, the FWOP includes construction of an LNG terminal. Phase I, the terminal is presently in operation, and vessel traffic commenced in April 2008.

The maximum design drafts for existing LNG vessels are 42 feet. The industry standard is for LNG vessels to have 4 to 6 feet underkeel clearance, and the expectation is that LNG vessels will be required to have a minimum of 3 to 4 feet. Underkeel clearance rules on the Freeport Channel are strict; however, the existing vessel sizes and underkeel clearance requirements suggest that channel depths of 45 feet should be adequate, and channel-deepening benefits were not taken for LNG cargo. The docks at the Freeport LNG terminal will accommodate vessels 1,099 feet long by 177 feet wide. This vessel design prompted the non-Federal sponsor to pursue widening of the offshore Outer Bar and Jetty channels from 400 to 600 feet under the Section 204 authority of WRDA 86.

#### 9.6.2.8 Effects of Panama Canal Expansion

Expansion of the Panama Canal is expected to have significant impacts on shipping routes, port development, cargo distribution, and a host of others to the U.S. maritime system. One of its greatest impacts will be felt in the fast-growing container trade where expansion will enable larger vessels to transit the canal. Vessel calls on the East and Gulf coasts are also expected to increase significantly as cargo shifts away from the congested West Coast. Expansion of the canal project is expected to be completed in 2014. The canal expansion will accommodate maximum loaded drafts of 15 meters, or approximately 49 feet. Completion of the Panama Canal improvements is expected to increase the number of larger and fully loaded container and general cargo vessels using Texas Gulf Coast ports.

While it does not appear that refrigerated cargo vessel sizes are increasing, significant increases are occurring for other vessel groups, and completion of the Panama Canal expansion by the year 2014 will allow for more fully loaded vessel movements from deepwater ports in the Far East and the western coasts of Mexico and South America. The canal expansion will affect Freeport chemical exports and the container cargo.

Transportation infrastructure limitations have been cited as contributing to changes in regional distribution of the U.S. container market. Examples of transportation infrastructure limitations

and associated effects limiting trade flow were cited in several trade journals. In the 1990s, the use of post-Panamax containerships and the existing constraints at the Panama Canal shifted post-Panamax ships from using the all-water route to using double-stack trains to move goods from West Coast ports eastward.

In addition to greater reliance on rail due to the inability of post-Panamax ships to transit the canal, direct ship movements to the East and Gulf coasts have occurred due to congestion at West Coast ports. At the same time and due to congestion at Los Angeles/Long Beach, some shippers have greatly increased their utilization of the canal, particularly for all-water services from Asia to the U.S. Gulf and East coasts. While there are delays associated with the canal, the delays may be more predictable and easier to plan for than delays at Los Angeles/Long Beach. Increasing costs and decreasing reliability on the U.S. intermodal system, particularly rail connections, and the proliferation of distribution and warehousing centers near ports along the Gulf and Southeast coasts of the U.S., have combined to make the Panama Canal route (also known as the "all-water" route) a more attractive option to shippers serving these markets, particularly those shipping consumer goods in intermodal containers. Effects of shifts in general and container cargo that have taken place in recent years are reflected in Freeport's base.

From 2001 to 2005, the TEU capacity of containerships transiting the canal increased by 59 percent, the number of containerships transiting the canal rose by 47 percent, and average vessel size increased 21 percent. The Panama Canal Authority was quoted as saying, "by the end of 2011, the total post-Panamax containership fleet will consist of approximately 670 ships with a capacity of almost 4.6 million TEUs, close to double the capacity of the existing post-Panamax fleet."

The Panama Canal Authority used a post-Panamax vessel of 366 meters (1,200 feet) long, 49 meters (161 feet) wide, and 15 meters (49 feet) deep as the reference for establishing the ideal lock chamber sizes. Completion of the Panama Canal widening and deepening is expected to result in increases in Texas container traffic. The expansion of the Panama Canal, with its combination of wider navigation channels and locks coupled with strategic marketing partnerships with key U.S. ports, will increase demand through the canal itself and for ports along the Gulf and East coasts.

## 9.7 WITHOUT-PROJECT CONDITION

The maximum vessel sizes for crude oil for the existing condition generally do not exceed 120,000 DWT, but Freeport's 2005 to 2007 historical data include vessels over 150,000 DWT. Vessels up to 175,000 DWT presently use nearby deep-draft projects such as Corpus Christi, Texas City, Houston, and the Sabine-Neches Waterway. The channel widening evaluated under the Section 204 study will allow the range of vessels for the FWOP to increase to 175,000 DWT.

Freeport's recent trade routings and the EIA forecast of imports by country of origin were used to estimate Freeport's 2017 to 2067 trade routing. Under the FWOP and with-project conditions (FWP), imports from origins that include Mexico, Guatemala, Venezuela, Colombia, and Brazil are shipped direct. Under the FWOP imports from Europe, Africa, and the Middle East are either lightered or lightened. For channel depth alternatives of 58 feet or more, the cost of direct shipment for movements from Europe, Africa, and the Middle East is less than that for lightening or lightering. This reduction is expected to result in transition to direct shipment. The "mother vessels" offload partial cargoes to shuttle vessels, and both vessels come into port in the current and future without- and with-project conditions.

For the Lower Stauffer, the FWOP condition is 18 feet. However, it is assumed that the most likely depth that needs to be in place to "call" a new or currently nonexistent operation/facility of concern into existence is between 35 and 40 feet since Houston's container terminals are currently at 40 feet depth. Based on consultation with IWR in 2008 and again in 2011, it was determined that a "threshold depth" of 40 feet was reasonable from which to begin economic incremental analysis. However, the cost of removing the material was calculated based on an existing and FWOP depth of 18 feet.

An off-channel berth area is being constructed in two phases by the non-Federal sponsor. This construction is not part of the Federal project. The transportation savings benefits were calculated based on Phase I of the construction. As part of Phase I, the non-Federal sponsor is constructing a berth area/channel adjacent to the proposed federally constructed Lower Stauffer Channel.

Under the FWOP, the Upper Stauffer Channel would continue to serve OSV vessels. Discussions with channel users and company officials indicated that maneuvering vessels on the silted channel and maintaining a proper alignment for safe passage is hazardous, and this condition is expected to continue. The ability of the channel to serve as a harbor of refuge will deteriorate under the FWOP.

Galveston represents the most likely alternative port for vessel operators that wish to use the Stauffer Channel for layberth and supplies. The FWOP, as well as the FWP, future is characterized by increases in offshore exploration and associated activities. On April 30, 2007, Secretary of the Interior Dirk Kempthorne issued a press release for the previous administration announcing a "major Federal initiative to boost oil and natural gas production on the U.S. Outer Continental Shelf in the Gulf of Mexico and off Alaska. The program could produce 10 billion barrels of oil and 45 trillion cubic feet of natural gas over 40 years, generating almost $170 billion in today's dollars, in net benefits for the Nation."

## 9.8 PROJECT ALTERNATIVES

The project alternatives include deepening Reach 1 to a maximum depth of 60 feet from its current 45 feet depth, Reach 2 to a maximum depth of 50 feet from its current 45 feet depth, Reach 3 (Lower Stauffer) to a maximum depth of 50 feet from its current depth of 18 feet, and Reach 4 (Upper Stauffer) to a maximum depth of 30 feet from its current depth of 18 feet.

Evaluation of deepening alternatives for the existing 45-foot Project reaches was pursued based on the non-Federal sponsor and industry's interest in bringing in larger and more fully loaded crude petroleum tankers. Project depth alternatives of 55 feet and more were proposed by the non-Federal sponsor as an alternative to offshore transfer of crude petroleum. An advantage that Freeport has over other Texas Gulf Coast ports is that it takes 45 minutes to go from the crude petroleum docks to the offshore jetty. In comparison, it takes a minimum of 3 to 8 hours or more to reach the Gulf of Mexico from other Texas ports.

Increases in Freeport's channel depth provide the opportunity to offload a smaller amount of cargo at sea, thus facilitating the use of smaller shuttle vessels. For channel depths over 55 feet, the cost differential between direct shipment and lightering and lightening is reduced, and this would provide cost incentives for diversions from lightering and lightening to direct shipments for Africa, Europe, and Middle East trade routes.

Improvements to the 36-foot-deep Brazos Harbor Turning Basin were not evaluated due to existing capacity constraints.

Depth alternatives to 50 feet were also evaluated for the Lower Reach of the Stauffer Channel. This would provide an extension from the terminus of the federally authorized 45-foot Freeport Harbor Project.

Depth alternatives up to 30 feet were evaluated for the Upper Reach of the Stauffer Channel. Presently the upper reach of the Stauffer Channel has a water depth of approximately 18 feet.

## 9.9 TRAFFIC FORECAST

This section presents the tonnage and fleet projections for Freeport's crude petroleum imports, petroleum product imports, chemical exports, and general and containerized cargo. The focus of the traffic analysis was based on identification of vessels and commodities transported in draft-constrained vessels. Therefore, forecasts were not estimated for petroleum product exports and chemical imports. Freeport's chemical product import tonnage showed less than one-half of 1 percent of chemical imports were transported in vessels with design drafts over 45 feet. The small volumes associated with draft-constrained vessels were associated with vessels transporting crude oil, with the chemical cargoes being incidental. Freeport's petroleum product exports showed a similar pattern as with chemical import cargo. Those movements, which

generally totaled less than 100 thousand short tons annually, were transported in vessels with design drafts over 45 feet and was included as incidental cargo associated with crude petroleum tanker backhauls.

The forecast of a transition to larger and more fully loaded vessels for petroleum, petroleum products, and chemicals is based on vessel order data, world port development trends, the Panama Canal expansion, and transitions in Freeport's vessel use since the early 1990s. Historical vessel utilization and new vessel orders associated with crude petroleum imports and chemical product exports suggests that portions of these cargoes would transition to larger vessels if increases in channel depth were available. Vessel utilization at comparable ports indicates that the use of larger and more fully loaded vessels is apparent for these cargoes as well. Since the authorization of the existing 45-foot Project depth in the 1990s, the size and draft of vessels using the harbor increased to meet the competitive demand for more-efficient movements. Variables used to help evaluate the transition to more deeply loaded vessels include the percentage of tonnage transported in vessels with design drafts over 40 feet, percentages transported in vessels with loaded drafts over 40 feet, vessel DWT, and parcel sizes. Minimization of transportation cost, given trade route constraints and commodity parcel needs, recognizably drives long-term vessel choices.

The assumption about the use of larger and more fully loaded vessels for products has some uncertainty. Most of the uncertainty is associated with the percentage of cargo anticipated to transition to larger or more fully loaded vessels. However, analysis of Freeport's 1990 to 2007 vessel utilization data and world shipping data, including vessels-on-order for chemical and product carriers and port developments, including the Panama Canal expansion, suggests that there will be some transition to more deeply loaded vessels during the 50-year period of analysis.

Vessel fleets and utilization, and existing and future constraints associated with crude petroleum, petrochemical products, and a new fleet of container vessels provided the basis for identifying the commodities expected to be transported in vessels loaded to channel depths over 45 feet. Foreign port depths and constraints such as the Panama Canal with a present width restriction were additional considerations in the analyses.

### 9.9.1 CRUDE PETROLEUM IMPORTS

Freeport's crude petroleum tonnage forecast was prepared using Global Insight's September 2010 projections. Table 25 displays Global Insight's September 2008 and 2010 projection in comparison to the Doe's Annual Energy Outlook (AEO) 2008 to 2011 forecasts and Purvin and Gertz's 2009 forecast.

**Table 25**
**U.S. Crude Oil Imports Projection Comparison**
**Millions of Barrels Per Day**

| Year | AEO 2008 | AEO 2009 | AEO 2010 | AEO 2011 (Preliminary) | Purvin and Gertz 2009 | Global Insight 2008 | Global Insight September 2010 |
|---|---|---|---|---|---|---|---|
| 2007 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 2015 | 10.2 | 8.1 | 9.0 | 8.9 | 11.1 | n/a | 9.6 |
| 2025 | 11.0 | 6.7 | 8.8 | 8.5 | 12.1 | 12.4 | 10.4 |
| 2030 | 11.9 | 7.0 | 8.8 | 8.4 | 12.5 | 12.7 | 10.5 |
| 2035 | n/a | n/a | 8.8 | 8.7 | n/a | 12.9 | 11.0 |
| 2040 | n/a | n/a | n/a | n/a | n/a | n/a | 11.5 |

Source: U.S. Department of Energy, EIA, *2008 Annual Energy Outlook*, Department of Energy/EIA-0383 (2008), *2009 Annual Energy Outlook*, Department of Energy/EIA-0383 (2009), Table 20, Comparison of Liquids Projections, and *2010 Annual Energy Outlook Early Release*, Table 1, December 2009, *2011 Annual Energy Outlook*, Report Number: DOE/EIA-0383ER(2011), Early Release December 2010. The Global Insight September 2010 forecast was obtained directly for Global Insight; note that the 2008 forecast was obtained from the *2009 Annual Energy Outlook*.

The AEO 2010 values shown were converted from BTUs.

Freeport's crude oil import forecast was prepared by incorporating the Global Insight projections into a regression equation using 1990 to 2009 Freeport imports as a function of U.S. imports. An R Square of 0.922 was produced from the equation. The t-value and F statistic for the equation are significant at statistical confidence levels. Table 26 displays Freeport's regression equation application using the Global Insight forecast results and 1990 to 2009 as a historical base. The results of the base application show an average annual growth rate of 0.9 percent for 2007/2009 to 2040 for Freeport's imports. Freeport's base estimate was used for crude petroleum import calculations.

Table 27 displays the maximum cargo tons by vessel size and channel depth alternatives for representative vessels used in the analysis. An increase in Freeport's channel depth from 45 to 50 feet would allow the existing range of 90,000 to 120,000 DWT vessels to carry approximately 17 percent more cargo. A depth increase from 45 to 55 feet or more would allow the same range of vessels to carry 24 percent more cargo.

Table 28 shows the number of shuttle vessels by channel depth alternatives necessary to offload a VLCC. For offshore lightering of crude petroleum, an increase in Freeport's channel depth would provide opportunities to either reduce the number of shuttle vessels or use smaller shuttles. The use of smaller shuttles reduces the overall cost associated for situations where Suezmax tankers are lightened to channel depth.

**Table 26**
**Regression Equation Data for**
**Freeport Crude Oil Imports** [a/]

| Component | | Description of Data and Outputs | |
|---|---|---|---|
| Dependent Variable | | Freeport Crude Imports (1990–2009) | |
| Independent Variable | | U.S. Crude Imports | |
| Adjusted R Square | | 0.922 | |
| No. of Observations | | 20 | |
| Degrees of Freedom | | 1 | |
| X Coefficient Level of Significance of t value | | 1.23418E-11 | |
| F Statistic | | 226.17 | |
| Significance of F statistic | | 1.23418E-11 | |
| | | **Regression Equation Data** | |
| | | Base Output | |
| Constant | | −15,902.1 | |
| Standard Error of Y Estimate | | 1,626.77 | |
| X Coefficient: U.S. Crude Oil Imports | | 0.068618 | |
| | | **Freeport (1,000s of Short Tons) 2004–2009** | |
| **Historical Year** | **U.S. Imports 1,000s of Short Tons**[a] | **Actual** | **Base Estimate**[b] |
| 2005 | 553,923 | 22,000 | 22,107 |
| 2006 | 553,489 | 21,706 | 22,077 |
| 2007 | 548,742 | 18,523 | 21,752 |
| 2008 | 535,170 | 20,607 | 20,820 |
| 2009 | 493,030 | 19,418 | 17,929 |
| 2007/2009 Average | 525,647 | 19,516 | 20,937 |
| | | **Freeport Regression Based Forecast**[b] | |
| **Forecast Year** | **U.S. Imports**[a] | | **Base Estimate**[b] |
| 2017 | 511,119 | | 19,170 |
| 2027 | 579,813 | | 23,884 |
| 2037 | 613,678 | | 26,207 |
| 2040 | 615,446 | | 27,313 |
| % Average Annual Growth 2007/2009–2040 | 0.4% | | 0.9% |

Source: USACE, Waterborne Commerce of the U.S. 2005-09 and Global Insight's September 2010 crude oil import forecast.

[a]Calculated using barrel per day volumes from the EIA. The 2005 BPD volume was 10.13 billion. The Global Insight forecast extends through 2040.

[b]Freeport 2027 Imports = −15,902 + (0.0686 * 579,813) with 579,813 short tons being U.S. imports in 2027.

**Table 27**
**Maximum Loaded Cargo**

| Vessel DWT | Design Draft (feet) | Immersion Factor | Channel Depth (feet) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 45 | 50 | 52 | 55 | 58 | 60 |
| | | | Maximum Loaded Short Tons of Cargo[a] | | | | | |
| 35,000 | 36 | 113 | 35,500 | 35,500 | 35,500 | 35,500 | 35,500 | 35,500 |
| 50,000 | 44 | 141 | 47,000 | 50,700 | 50,700 | 50,700 | 50,700 | 50,700 |
| 60,000 | 46 | 159 | 53,000 | 60,800 | 60,800 | 60,800 | 60,800 | 60,800 |
| 70,000 | 48 | 175 | 59,400 | 71,000 | 73,300 | 73,300 | 73,300 | 73,300 |
| 75,000 | 51 | 183 | 57,900 | 70,000 | 74,900 | 78,500 | 78,500 | 78,500 |
| 80,000 | 53 | 191 | 56,000 | 68,600 | 73,600 | 81,200 | 83,800 | 83,800 |
| 90,000 | 46 | 206 | 82,200 | 94,200 | 94,200 | 94,200 | 94,200 | 94,200 |
| 100,000 | 48 | 220 | 87,100 | 101,600 | 105,100 | 105,100 | 105,100 | 105,100 |
| 110,000 | 50 | 234 | 91,800 | 107,300 | 113,500 | 116,600 | 116,600 | 116,600 |
| 120,000 | 52 | 247 | 96,900 | 113,300 | 119,800 | 128,300 | 128,300 | 128,300 |
| 135,000 | 54 | 266 | 102,000 | 119,700 | 126,700 | 137,300 | 144,300 | 144,300 |
| 150,000 | 56 | 285 | 106,000 | 124,900 | 132,400 | 143,700 | 155,000 | 160,300 |
| 165,000 | 59 | 303 | 108,600 | 128,600 | 136,700 | 148,700 | 160,700 | 168,800 |
| 175,000 | 60 | 314 | 112,100 | 132,900 | 141,200 | 153,700 | 166,100 | 174,400 |

[a/]Estimated short tons ≅ ((DWT * Maximum % Load) – (Immersion Factor * 12 inches per ton * number of feet light-loaded)).

**Table 28**
**Number of Shuttle Vessels Needed by Channel Depth Alternative[a]**

| DWT | 45 | 48 | 50 | 52 | 55 | 58 | 60 |
|---|---|---|---|---|---|---|---|
| 50,000 | 8 | 7 | 7 | 7 | 7 | 7 | 7 |
| 70,000 | 6 | 6 | 5 | 5 | 5 | 5 | 5 |
| 80,000 | 6 | 6 | 6 | 5 | 5 | 5 | 5 |
| 90,000 | 5 | 4 | 4 | 4 | 4 | 4 | 4 |
| 100,000 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 110,000 | 4 | 4 | 4 | 4 | 3 | 3 | 3 |
| 120,000 | 4 | 4 | 4 | 3 | 3 | 3 | 3 |
| 150,000 | 4 | 3 | 3 | 3 | 3 | 3 | 3 |
| 165,000 | 4 | 3 | 3 | 3 | 3 | 3 | 3 |
| 175,000 | 4 | 3 | 3 | 3 | 3 | 3 | 2 |

[a]Application of December 2008 Deep-draft vessel operating costs provided by IWR.

#### 9.9.1.1 Crude Petroleum Imports by Trade Route

Freeport's crude oil imports currently include trade routes with physical constraints. The effects of these constraints were evaluated in relationship to Freeport's FWOP and FWP. Freeport's crude petroleum trade routes suggest that the availability of channel depths over 45 feet would provide cost incentives for crude petroleum import tonnage to be transported in more fully loaded vessels. Freeport's crude petroleum imports and the depths at the ports of origin suggest that 95 percent of current tonnage could be loaded to drafts over 45 feet.

A significant percentage of the vessels used for Freeport's direct shipments of crude petroleum imports are loaded to drafts over 40 feet, and channel deepening beyond 45 feet would increase this trend. Long-term expectations are that nearly all of the vessels used for direct shipment could be more fully loaded.

Relatively small tankers are used for crude oil movements from Guatemala, generally with tankers in the 60,000 to 69,999 DWT range. Freeport regularly receives a small volume of Ecuadoran crude oil and occasionally receives crude from the Far East. Shipments from Ecuador are generally transported in Suezmax tankers. Shipments from Ecuador and Guatemala represent less than 1 percent of Freeport's 2002 to 2005 import average. Shipments arriving from Ecuador can be transported either through the Panama Canal or the Trans-Panama Pipeline.

The Panama Canal represents a current restriction for the west coast of South America and Far East routings. While expansion of the Panama Canal will facilitate the use of larger tankers, it will not accommodate the Suezmax tankers presently associated with the U.S. Gulf Coast's current Trans-Panama Pipeline tonnage. Long-term expectations are that the U.S. Gulf Coast's receipt of crude oil from Western South America will be low.

In addition to the current and future Panama Canal limitations, port depth limitations also exist at the Lake Maracaibo ports in Venezuela due to lapses in maintenance dredging. Maintenance dredging has not been performed in several years, and vessels are limited to loaded drafts of approximately 39.5 feet, but the depth limitations at the Venezuelan ports are expected to change over the 50-year period of analysis. According to the EIA (October 2007), production in the Maracaibo basin is declining relative to Venezuela's other production sites. The EIA notes that Venezuela plans to aggressively develop its Orinoco Belt oil resources in the coming years. Ninety-six percent of Freeport's Venezuelan crude oil imports for 2003 to 2005 were from the deepwater port of La Cruz. In 2006, Venezuela consumed 620,000 BPD of oil and exported 2.2 BPD. Currently, the U.S. is Venezuela's major importer. Other new developments include increases in U.S. imports from Brazil.

Generally, it is not cost effective to use vessels larger than 175,000 DWT for direct shipment to Freeport for the range of channel depth alternatives between 48 and 60 feet. However, it is cost

effective to load vessels up to 175,000 DWT more fully given the range of depth alternatives between 48 and 60 feet.

It would be cost effective for nearly all vessels used to transport crude petroleum from Mexico and Latin America to be loaded to depths over 45 feet given an increase in channel depth. The percentage of Middle East and Africa movements are subject to greater uncertainty because the logistics associated with offshore transfers introduces higher degrees of uncertainty than direct shipment and, therefore, generates large cost variances.

Vessels over 200,000 DWT are used for some Northern Europe transits associated with offshore lightering operations, in particular the North Sea and Norway movements. The maximum sized vessels used for Nigerian crude oil are principally in the 110,000 to 175,000 DWT range. Most crude imported from the Persian Gulf is shipped in large crude carriers that offload their entire contents onto shuttle vessels. Vessels in the 200,000 to 375,000 DWT range are used for Persian Gulf crude, with most tonnage transported in 300,000 to 350,000 DWT vessels.

The trade route forecast for Freeport's crude petroleum imports is based on analysis of U.S. import forecast and the EIA trade route and world production forecasts. The U.S. trade route forecast includes both ocean-going and pipeline imports.

Canada is the leading supplier of U.S. crude oil, with slightly higher imports than Saudi Arabia. Fifteen percent of 2003 to 2005 U.S. crude petroleum imports came from Canada. Most of Canadian movements were transmitted by pipeline, but there are some ocean-going vessel movements. Freeport's 2002 to 2005 vessel records did not show any Canadian cargo, but U.S. Gulf Coast imports showed some import with low volumes. Freeport's 2006 vessel records showed three vessels with Canadian crude. All three vessels were Suezmax tankers. Freeport's 2006 to 2007 Canadian imports represented 0.3 percent of total imports for each year.

Venezuela constitutes a significant share of Freeport's imports. In comparison to other regions, Freeport has the capacity to refine relatively higher shares of light crude shipped from Venezuela as well as the heavy crudes. Venezuela's long-term reserves are significantly higher than Mexico's reserves.

Brazil has the second largest oil reserves in South America, but its reserves of approximately 12 billion barrels are significantly less than Venezuela's 80 billion barrels. Brazil, along with Kazakhstan, United Arab Emirates, and Libya, were recognized as the U.S. market's fastest-growing crude oil providers. Proven reserves for Kuwait, United Arab Emirates, and Libya are 101, 97, and 41 billion barrels, respectively. Comparatively, proven reserves for Saudi Arabia and Canada are estimated at 262 and 179 billion barrels.

The EIA shows large increases in Brazilian production and imports to the U.S., but Brazil currently remains a net importer of crude. The EIA notes that most of Brazil's imports are from

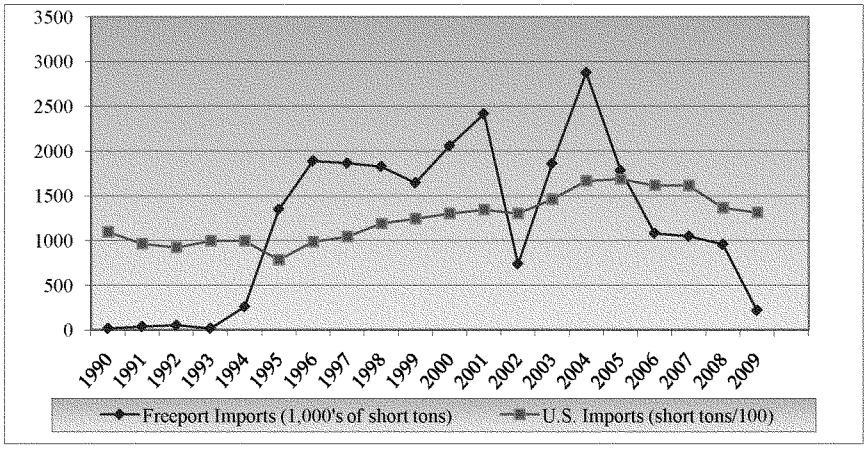
Argentina. Transportation logistics result in Brazil importing crude from Argentina and exporting other crude to the U.S. In 2007, U.S. crude oil imports from Brazil increased by 500 percent over 2006 levels. The EIA shows Brazil's production of conventional fuels increasing at an average annual growth rate of 4.4 percent between 2005 and 2030.

Freeport received a lower share of Mexican crude and a higher share of South American and Caribbean crude compared to the U.S. and Gulf Coast. The 2010-based trade route forecast shows a significant drop in imports from the Middle East. The forecast does not reflect the inclusion of Canadian crude. Future expectations are that the majority of Canadian crude would be transported by pipeline.

### 9.9.2 PETROLEUM PRODUCT IMPORTS

While experiencing tremendous growth in the early 1990s, petroleum product imports remained relatively constant since the mid-1990s before dropping in 2007, shown on Figure 12. Recent record lows occurred in 2008 to 2009. These lows are associated with drops in gasoline and residual fuel oil imports and parallel national figures but to a much greater extent. Gasoline and residual fuel oil are used for blending and feedstock input in refining crude oil.

**Figure 12**
**U.S. and Freeport Petroleum Product Imports, 1990–2010**




Source: USACE, Waterborne Commerce of the U.S. 1990-09.

The 2009 drop in Freeport's product imports relates to an increase in receipt of low-sulphur crude oil from Norway for that year. Low-sulphur crude requires fewer blending components and feedstock inputs than the heavier crudes that Freeport has traditionally imported. The peaks in Freeport product imports relate to years when crude oil imports from Venezuela peaked.

Freeport's 2010 crude oil import data found at the EIA website showed that imports from Venezuela were comparable to 2008[7].

Future expectations concerning the origins of U.S. and regional import volumes of both crude petroleum and sulphur content and subsequent need for blending components and feedstock requirements are subject to a high degree of uncertainty. Recognizing uncertainties, the AEO forecast continues to show imports of partially refined products increasing over the 2008/2009 to 2040 forecast period. Blending components include gasoline, gasoline blending components, jet fuel, and distillate fuel oil. While the AEO forecasts (2009 through the current 2011 early release) shows crude oil imports declining, partially refined products are forecasted to increase to 2008 levels after 2013 and remain steady over the remainder of the forecast period.

Freeport's petroleum product import tonnage forecast was prepared using the AEO 2011 early release projections (December 2010). The AEO 2011 product forecast follows a similar pattern as its 2009 and 2010 projections. Global Insight's September 2010 forecast was also reviewed in preparing Freeport's forecasts.

In general, gasoline and fully finished product imports have historically been concentrated on the U.S. East Coast, with imports to Gulf Coast ports, like Freeport, consisting more heavily of unfinished products. Freeport's imports of gasoline will serve to supplement shortfalls in U.S. refining and continue to be relatively low in comparison to crude petroleum imports. Freeport's imports of partially refined products are expected to experience modest increases after the drop in 2009. Freeport's historical product base consists exclusively of unfinished oils and blending components.

Freeport's product import forecast is a function of the source of crude petroleum. Freeport is expected to continue receiving a steady volume of crude oil imports. This expectation is based on the Conoco Phillips refinery in nearby Sweeny and the extensive network of pipelines from Freeport to other regional and to Midwest refineries. In addition to these movements, crude oil imported to Freeport is transmitted to the Bryan Mound SPR.

#### 9.9.2.1 Petroleum Products Imports by Trade Route

Table 29 shows the 2003 to 2006 trade route distribution for Freeport's petroleum product imports. The 2003 to 2006 petroleum product import trade route distribution consists primarily of imports from Algeria and the Middle East. The future petroleum product import trade route distribution was assumed to include higher volumes of imports from Latin America than presently occurring. This assumption is based on developing trends towards increased investments in refining and based on general informational discussions in the EIA publications.

[7] Company level details associated with imports by country of origin and sulphur content can be found at the following EIA link: http://www.eia.doe.gov/oil_gas/petroleum/data_publications/company_level_imports/cli.html

Freeport's petroleum product imports for 2002 to 2007 showed that Freeport's more deeply loaded vessels carried lube oil and gasoline. Over 50 percent of Freeport's 2003 to 2005 petroleum product imports were shipped from the Algerian port of Arzew. Nearly all lube oil imports came from Arzew, Algeria. Gasoline is imported from both Algeria and Saudi Arabia. An accommodating depth of 49 to 56 feet is noted in the World Port Index at the oil product terminal in Algeria for crude oil and products. The Arzew refinery is owned by the Algerian national oil company Sonatrach, which owns four refineries in Algeria. Other lube oil refineries in the Mediterranean are located in Alexandria and Port Said, Egypt.

**Table 29**
**Freeport Harbor Petroleum Product Trade Route Distribution**
**2003–2006 Representative Distribution by Major Trade Route (Percent)**

| Trade Route | Petroleum Product Imports |
|---|---|
| Canada | – |
| Latin America | 26.7 |
| Northern Europe, Africa, and Mediterranean | 48.9 |
| Middle East and Far East | 24.4 |
| Total | 100 |

Sixty-three percent of Freeport's 2003 to 2005 tonnage was transported in vessels with loaded drafts of 39 feet or more and was transported from vessels with channel depths of 43 feet or more. Freeport's crude petroleum trade routes suggest that the availability of channel depths over 45 feet would provide cost incentives for at least 50 percent of petroleum product import tonnage to be transported in more fully loaded vessels. For purposes of analysis, channel-deepening benefits were calculated for 43 percent of Freeport's 2017 to 2027 petroleum product imports and 63 percent of 2037 to 2067 imports.

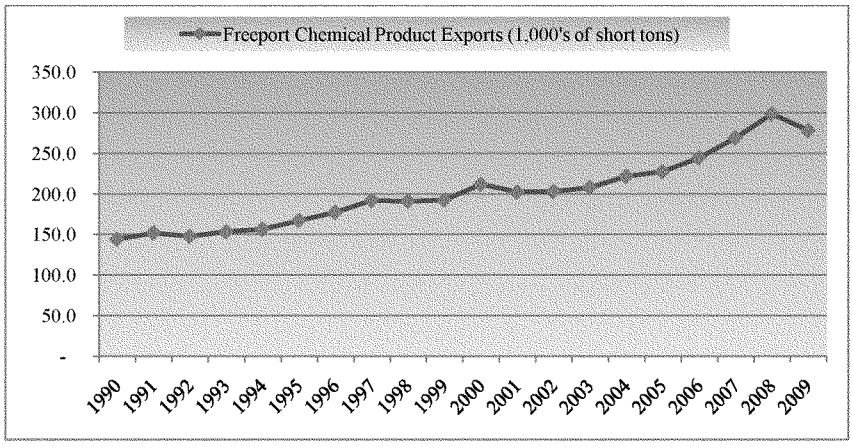
### 9.9.3 CHEMICAL PRODUCT EXPORTS

Forecast of Freeport's chemical exports were estimated based on analysis of 1990 to 2009 trendline data and the export value-associated industrial materials and supplies. As background, industrial materials and supplies include USACE commodity classifications listed as follows.

- Chemical Products (codes 3110–3299)
- Petroleum Products, excluding crude petroleum (codes 2211–2990)
- Crude Materials (codes 4110–4900)
- Primary Manufactured Goods (codes 5110–5540)
- Farm Products, excluding food (codes 6889–6899)

Figure 13 displays Freeport's exports and the value of industrial materials and supplies. Regression equation outputs for Freeport's 1990 to 2009 chemical exports and the value of U.S. industrial materials and supplies were produced. The trendline of Freeport's exports produced a more conservative forecast than the regression, so the trendline was used for the baseline estimate.

**Figure 13**
**Freeport Chemical Product Exports (1990–2009)**




Sources: USACE, Waterborne Commerce of the U.S., Parts 2 and 5, 1990–2009.

Maximum loaded drafts of 36 to 39 feet for Freeport's 1990 and 1993 chemical export tonnage shifted to maximum loaded drafts of 40 to 43 feet for 2002 to 2007 chemical export tonnage. Freeport's vessel utilization patterns from the early 1990s to 2007 show that 5 percent of tonnage was shipped in vessels with loaded drafts of 40 feet or more, up from zero percent in the early 1990s. Recently, chemical exports have exhibited some transition to more fully loaded vessels. Between 5 and 11 percent of 2003 to 2007 chemical exports were transported in vessels with loaded drafts over 40 feet. Chemical vessels on order, the Panama Canal expansion, and the trends in increasing loaded drafts provided the basis for assuming that 14 percent of Freeport's long-term chemical exports will be loaded to drafts of 42 feet or more given the availability of an increase in Freeport's channel depth.

#### 9.9.3.1 Chemical Product Exports by Trade Route

Principal receiving ports include Brazil, Canada, and the Far East. Demand for chemical products is anticipated to remain strong for markets in the Pacific and Brazil, and completion of the Panama Canal improvements in 2014 is expected to result in increases in Freeport's chemical shipments to the Far East. Freeport's chemical exports to Brazil are primarily shipped to the port

of Itaqui. There are port development projects taking place at Itaqui and other Brazilian ports. Presently, the maximum channel depth is approximately 43 feet. Port of Itaqui information states that Petrobrás, Brazil's largest industrial company, leases dock facilities at Itaqui. The maximum loaded draft is 19 meters at Itaqui which is equal to approximately 62 feet. The depth at the docks that export steel slab is 59 feet. The largest vessel that can be accommodated at the Canadian port of Port Alfred is presently 40 feet, and there do not appear to be any plans for expansion. Channel depths and dock accommodations at ports in Korea and Singapore are capable of accommodating vessels with loaded drafts over 50 feet. Table 30 shows port depths at major ports receiving chemical products from Freeport.

**Table 30**
**Port Depths at Major Ports Receiving Chemical Products from Freeport, 2003–2005**

| Region | Port | Country | 2003–2005 Total Tonnage for Vessels with Loaded Drafts ≥39 feet | | Channel Depth at Chemical Pier (feet) |
|---|---|---|---|---|---|
| | | | Short Tons | % of Total | |
| Brazil | Itaqui | Brazil | 94,895 | 33.2 | 59 |
| Northern Europe | Hamburg | Germany | 659 | 0.2 | 43 |
| Northern Europe | Le Havre | France | 6,537 | 2.3 | 43 |
| Northern Europe | Terneuzen | Netherlands | 19,649 | 6.9 | 44 |
| Northern Europe | Rotterdam | Netherlands | 43,378 | 15.2 | 49 |
| Northern Europe | Antwerp | Belgium | 15,629 | 5.5 | 62 |
| Middle East/Far East | Merak | Indonesia | 9,580 | 3.3 | 43 |
| Middle East/Far East | Bombay | India | 5,481 | 1.9 | 47 |
| Pacific | Yokohama | Japan | 8,636 | 3.0 | 40 |
| Pacific | Ning Bo | China (Mainland) | 24,523 | 8.6 | 46 |
| Pacific | Tai Chung | China (Taiwan) | 8,355 | 2.9 | 46 |
| Pacific | Singapore | Singapore | 36,140 | 12.6 | 46 |
| Pacific | Kao Hsiung | China (Taiwan) | 12,701 | 4.4 | 52 |
| Total Tonnage For Vessels With Loaded Drafts ≥39 feet | | | 286,163 | 100 | |
| % of all 2003–2005 Tonnage for All Loaded Drafts | | | 3.8 | | |

Source: National Imagery and Mapping Agency, 2000 World Port Index, Pub. 150; Lloyd's, World Shipping Encyclopedia, April 2003; and USACE, Waterborne Commerce 2003–2005 detailed records.

The 2003 to 2006 chemical export trade routes consist primarily of Brazil, Northern Europe, and the Pacific. Freeport's 2009 chemical export destinations showed that 20 percent of shipments went to Asia. Transportation cost calculations were estimated using average mileage and the present distribution of ports.

### 9.9.4 CONTAINER IMPORTS AND EXPORTS

This section presents the analysis of the Federal interest in channel improvement to the lower reach of Stauffer Channel. Work by the non-Federal sponsor on the initial 800 linear feet of dock/1,200 linear feet of berth for Phase I is complete. At this time, the first 20 acres of backland is complete, and the next 15 acres of backland are under construction. The FWOP condition associated with Phase I is based on an off-channel berth area being constructed by the non-Federal sponsor. This berth area is being constructed in two phases and will be as deep as 45 feet; this construction is not part of the Federal project. Phase II includes a total of 80 acres (35 acres as part of Phase I and 45 acres as part of Phase II). The Phase II features include the construction of an additional 1,200 linear feet of berth and 45 acres of backland development to support the additional berth. The schedule is somewhat market-dependent, but it is safe to assume construction of both the additional berth and the backland will be complete by 2016. The plan would be to have the two projects completed concurrent with each other.

Velasco Terminal, Phase I, which includes the first 800 linear feet of wharf and 20 acres of backland, was completed in October 2010. Water access to the terminal requires a 3,000-foot extension from the upper reach of the existing Federal navigation channel. The FWOP condition is based on the non-Federal sponsor, under a permit dredging a 3,000-foot-long berthing channel from an existing depth of 18 feet to an operating depth of 45 feet. This berthing channel is parallel to the existing Stauffer Channel. Based on a FWOP condition depth of 40 feet, optimization of Federal interest in channel depth improvements over 40 feet was subsequently evaluated. For purposes of analysis, the transportation savings benefits for container cargo were calculated from an existing condition depth of 40 feet.

Global Insight expected increases in domestic products after 2010, based on its April 2009 evaluations. Recent gross domestic product (GDP) had a minor decrease in 2009 but now is steadily increasing, and has been helped by an overall increase in exports due to the declining value of the dollar relative to other currencies. Global Insight's long-term average annual growth rate forecast data are summarized in Table 31. Figure 14 presents Global Insight's 2006 to 2039 forecast of total expenditures, and Figure 15 presents their GDP forecast.

Over the next 20 years, Texas ports, waterways, highways, and rail facilities will handle between 50 and 85 percent more freight, depending on the mode of transportation, according to "Texas Ports 2007–2008 Capital Program," a report by TxDOT.

**Table 31**
**Global Insight U.S. Gross Domestic Product Forecast**

| Average Annual Growth | 1976–2006 Historical (%) | 2006 ($) | 2039 ($) | Average Annual Growth Rate (%) |
|---|---|---|---|---|
| Gross Domestic Product | 3.1 | 13,178 | 62,836 | 4.8 |
| Consumption | 3.3 | 8,029 | 16,736 | 4.8 |
| Imports | 6.8 | 1,315 | 6,452 | 4.8 |
| Exports | 5.9 | 1,931 | 7,199 | 4.8 |

Source: Global Insight, "The U.S. Economy, The 30-Year Focus," April 2009.

**Figure 14**
**U.S. Total Expenditure Forecast**
**Billions of Chained 2000 Dollars (2006–2039)**

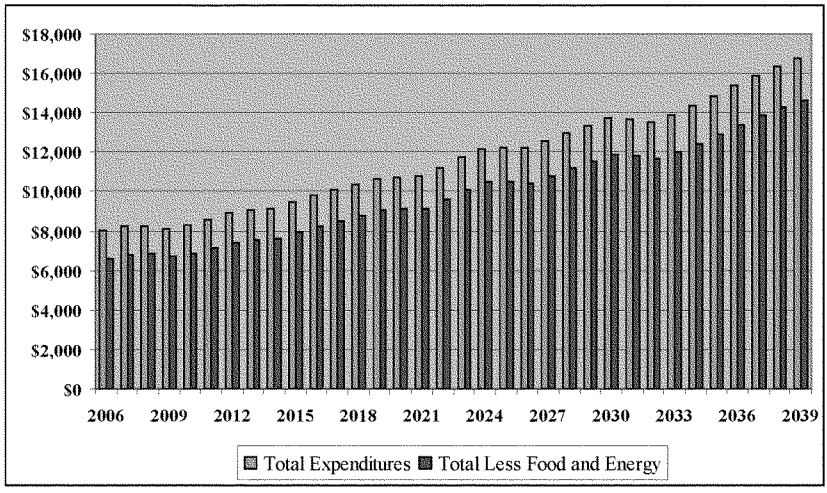
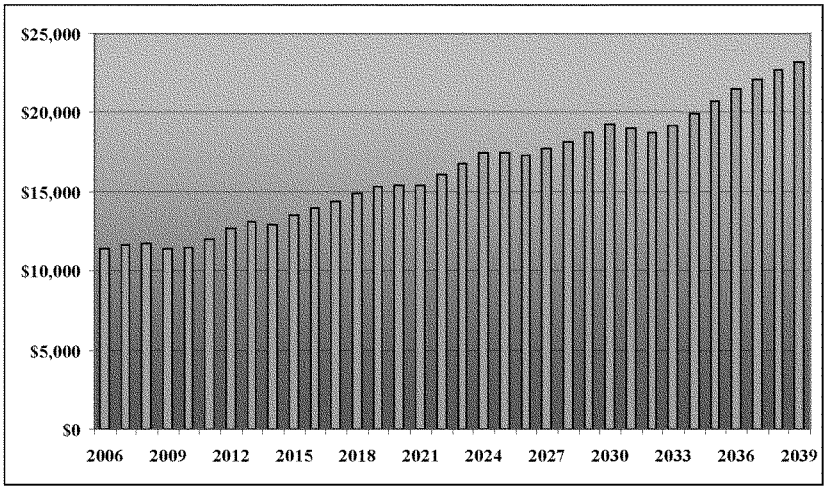


**Figure 15**
**U.S. Gross Domestic Product Forecast**
**Billions of Chained 2000 Dollars (2006–2039)**




Source: Global Insight, "The U.S. Economy, The 30-Year Focus," April 2009.

U.S. demand for imported containerized goods is a function of domestic income, population, exchange rates, and other factors.[8] Demand for containerized exports depends upon economic activity in other countries, exchange rates, and other factors. The geographic pattern of U.S. demand for container port services depends upon (1) the location of domestic consumers with respect to foreign sources for imports, (2) the location of manufacturers, farms, resource industries, and other exporting businesses relative to foreign markets for their goods, and (3) the availability and relative costs of intermodal transport from sources to markets. Several analysts have found a high correlation between population and container volume, particularly imports. While population is one of several variables affecting traffic growth, it is recognizably a key variable particularly for this study region where over 90 percent of existing container tonnage is served by trucks. While the population forecast shows fairly high growth for the region included in the Houston-Galveston-Brazoria Statistical Metropolitan Area, review of 2009 data shows that regional population has increased at higher rates than expected. Population growth for the counties within the Freeport and Houston port areas is presented in Table 32.

[8] University of Rhode Island Transportation Center, Comprehensive Framework for Sustainable Container Port Development for the United States East Coast: *Year One Final Report, October 2001*, P. I-9

**Table 32**
**Houston-Galveston-Brazoria Statistical Metropolitan Area Population Projections**
**Texas Counties Adjacent to Freeport, Texas**

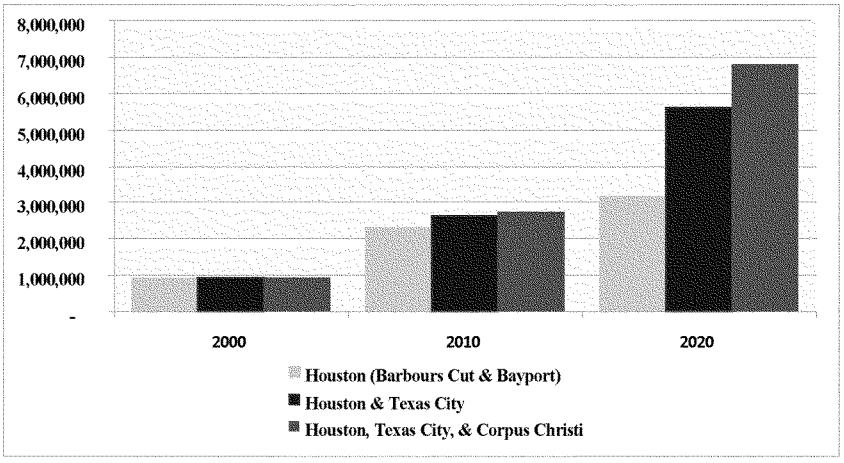
| County | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Average Annual Growth Rate (%) 2000–2060 |
|---|---|---|---|---|---|---|---|---|
| Brazoria County | 241,767 | 285,850 | 331,731 | 375,664 | 416,157 | 459,078 | 503,894 | 1.2 |
| Harris County | 3,321,660 | 3,869,179 | 4,416,793 | 4,964,463 | 5,512,168 | 6,059,895 | 6,607,635 | 1.2 |
| Fort Bend | 354,452 | 490,072 | 630,624 | 802,486 | 979,196 | 1,210,945 | 1,475,761 | 2.4 |
| Wharton County | 41,188 | 43,560 | 46,045 | 47,647 | 48,567 | 48,590 | 48,074 | 0.3 |
| Galveston | 250,158 | 268,714 | 284,731 | 294,218 | 298,057 | 300,915 | 302,774 | 0.3 |
| Matagorda | 37,957 | 40,506 | 43,295 | 44,991 | 45,925 | 45,793 | 45,377 | 0.3 |

Source: Texas Water Development Board, 2006 Regional Water Plan, County Population Projections 2000–2060.

Market demand for an additional U.S. Gulf Coast container terminal, such as Freeport, is a function of ability of competing terminals to meet consumer and producer demand. Figure 16 shows 2000, 2010, and 2020 regional market supply based on terminal availability of Barbours Cut, Bayport, and the potential additions of new terminals in Texas City and Corpus Christi, and a 60 percent expansion of Bayport TEU capacity. The effect of the 2010 market supply levels of 2.3 to 2.8 million TEU shown on Figure 16, and 2010 regional market demand between 2.2 and 2.4 million TEU produced using average annual growth rates of 7.5 and 11 percent indicate that additional capacity is not needed in 2010. However, the effect of the 2020 market supply levels of 4.5 and 7.0 million TEU show insufficient regional container capacity without the planned expansion of Bayport and construction of the Texas City and Corpus Christi terminals. The results of this analysis suggest that the Freeport terminal, which is presently under construction, would fill a market gap in the absence of any of the Bayport expansion and the Texas City and Corpus Christi terminals. The Bayport Container Terminal has plans to be able to handle 2 million TEUs upon full build-out in 2015. Construction of the Freeport terminal indicates that Freeport is poised to capture traffic.

Freeport's market is expected to complement and supplement Houston's market. The specific distribution of tonnage by vessel DWT and loaded draft is subject to some uncertainty. Port officials expect that a larger percentage of cargo will be moved in vessels between 40,000 and 68,000 DWT. The base scenario transportation saving benefits for channel depths between 40 and 50 feet were evaluated using Houston's distribution of container tonnage. Table 33 displays Freeport's base distribution and alternative distributions as sensitivities. The purpose of the sensitivities was to evaluate the effects of the alternative distributions on depth optimization.

**Figure 16**
**Texas Container Cargo (TEUs) 2000-2020**




Source: Compiled from port publications and general literature.

The ERDC ship simulation modeling for Freeport was performed using the 1,138-foot-long by 140.8-foot-wide *Susan Maersk* containership. The results of the modeling revealed that none of the pilots controlling the *Susan Maersk* were able to bring the ship safely into the Brazos Harbor Turning Basin. In order to safely accommodate this vessel, several other improvements to the channel, including widening, would be necessary. Widening would be needed around the Big Bend area inbound from the Seaway Dock at the lower end of the channel in order to accommodate the *Susan Maersk*. While the ERDC modeling showed that the 104,696 DWT *Susan Maersk* could not navigate past Station 180+00, study results indicated that smaller containerships could. Given Freeport's channel dimensions, the ERDC ship simulation results, U.S. Gulf Coast utilization, and world fleet availability, the design vessel for Phase I of Freeport's container terminal expansion is 965 feet long by 106 feet wide.

Table 33 shows the expected container tonnage at Freeport by vessel DWT. This distribution is for South and Central America exports and is based on Houston's distribution. Separate distributions were used for each region for imports and exports. While expectations concerning the distribution for 2017 through 2067 are subject to uncertainty, the general patterns and the shift of larger container vessels to the U.S. Gulf that occurred between 2003 and 2006 are indicative that Freeport's market will receive the larger range Panamax and some post-Panamax containerships on a regular basis. Freeport's market is expected to complement and supplement Houston's market, and the commodity distribution is anticipated to reflect Houston's distribution and the cargo mix is anticipated to consist of a high volume of exports similar to Houston. The base scenario transportation saving benefits for channel depths between 40 and 50 feet were evaluated using Houston's distribution of container tonnage.

**Table 33**
**Expected Container Fleet Distribution by Vessel DWT (South and Central America Exports)**

| Vessel DWT | Distribution of Freeport's Container Tonnage by Vessel Size (%) | | |
|---|---|---|---|
| | Houston Share (Base) | U.S. Share (Sensitivity) | Houston Share Adjusted (Sensitivity) |
| 11,700 | 15.8 | 0.0 | 0.0 |
| 18,400 | 23.1 | 68.2 | 32.8 |
| 24,300 | 19.5 | 23.4 | 14.7 |
| 33,900 | 9.9 | 4.6 | 9.9 |
| 45,000 | 9.9 | 2.9 | 4.9 |
| 56,800 | 11.5 | 0.9 | 37.7 |
| 65,000 | 2.5 | 0.0 | 0.0 |
| 74,000 | 2.5 | 0.0 | 0.0 |
| 86,000 | 2.2 | 0.0 | 0.0 |
| 103,800 | 3.2 | 0.0 | 0.0 |
| Total | 100 | 100 | 100 |

The cargo weight is based on traffic data from Houston container ports by region. Freeport's annual tonnage volume is estimated to be approximately 1.9 million short tons in 2017, or 217,000 TEUs, representing 0.3 percent of the U.S. container throughput. Traffic will initially consist of about two vessels per week. Each vessel will drop off and pick up approximately 1,780 TEUs each vessel visit.

The Center for Transportation Research noted that growth of the Velasco site for containers could be aided by a number of factors. The proximity to Barbours Cut and Bayport provides access to a common network of trucking firms, distribution centers, and other port support assets. According to the port, future intermodal activity originating from Freeport will rely on drays to regional yards, specifically Brazoria County. Union Pacific's relocation of its major east-west intermodal yard from Englewood (north of Houston) to the Rosenberg area (in Brazoria County and southwest of Houston) will aid Freeport in offering dray rates that are competitive with Barbours Cut and Bayport.[9]

Although Global Insight projects a 4.8 percent annual increase in container value until the year 2039, this analysis uses an average annual increase in tonnage of 0.2 percent for container vessels, increasing from 1.9 million short tons in 2017 to 2.1 million short tons in 2067.

Construction of Freeport's additional terminal is partly in response to capacity limitations at Freeport's existing facilities located within the confines of the Brazos Harbor Turning Basin. The

[9] Texas Department of Transportation, Texas Rail System Plan, October 2005, p. 2–4. All references to Texas railroad information presented in the USACE report were obtained from the Texas Department of Transportation report.

terminal is also expected to meet increased long-term demand resulting from higher than anticipated regional population growth.

#### 9.9.4.1 Container Imports And Exports by Trade Route

Table 34 displays the routings associated with a limited extraction of vessels using Houston and published in the Journal of Commerce database. The data presented indicate that the first port of call after leaving Houston includes ports as far away as Brazil and Russia. Trade routes are categorized by three regions for imports and exports in the analysis. These regions are South America and Central America, Europe and Africa, and the Mediterranean and Asia.

### 9.9.5 UPPER STAUFFER

The Mineral Management Service (MMS) 2009 to 2018 U.S. Gulf of Mexico oil and gas forecast shows production potentially peaking at 1.8 million BPD. The MMS full potential forecast is based on offshore production increasing at an average annual rate of 3.1 percent from 2006/2008 through 2018. The U.S. Department of Energy's *2009 Annual Energy Outlook* shows U.S. Gulf of Mexico production growing at an average annual rate of approximately 4.1 percent through 2018 and 2.3 percent from 2006 to 2030. The AEO and MMS forecasts are based on increasingly deep wells. The AEO forecast presented reflects Provisions of the American Recovery and Reinvestment Act.

The transportation savings benefits for the Upper Stauffer Channel were evaluated based on a consideration of the AEO and MMS production forecasts. The average of growth rates of 3.1 to 4.1 percent were used through 2018. These growth rates correspond to the AEO 2006 to 2030 and the MMS 2009 to 2018 production forecasts. For 2018 to 2067, a growth rate of 1 percent was used.

Offshore energy production is potentially one of the largest sources of revenue for the Stauffer Channel. New programs associated with energy independence initiatives have the potential to generate billions of dollars for the area.

It is reasonable to expect Freeport's offshore vessel traffic to increase during the 2017–2067 planning period. An increase in channel depth will result in an increased range of vessel drafts. Channel users estimate that with deeper water they would attract approximately 50 to 60 vessels per year with each vessel returning to dock for fuel and repairs approximately four times per year. An average of 5 vessel movements per week or 30 to 40 OSVs per month will be a reasonable expectation based on the combination of existing traffic and requests and permanent loss of traffic.

**Table 34**
**Containership Vessels by Loaded Draft (Limited Review)**

| Routing Sequence (Limited Review) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| TEU | DWT | Vessel Name | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 6732<br>6402 | 42,233 | *MSC Alessia* | Veracruz | Altamira | Houston | Pt Everglades | Jacksonville | New Orleans | Freeport, Bahamas | Savannah |
| 6402 | 85,806 | *MSC Marina* | Veracruz | Altamira | New Orleans | Charleston | Antwerp | | | |
| 6402 | 85,797 | *MSC Michaela* | Veracruz | Altamira | Houston | New Orleans | Freeport, Bahamas | Charleston | Norfolk | |
| 5606 | 72,044 | *MSC Marta* | Veracruz | Altamira | Houston | New Orleans | Bahamas | Charleston | Norfolk | |
| 4614 | 58,943 | *Sea-Land Commitment* | Newark | Charleston | Houston | Cagliari, Italy | Gioia Tauro, Italy | Spain | | |
| 2728 | 43,178 | *Aramis* | Houston | Colombia | Santa Marta, Cartagena | | | | | |
| – | 22,024 | *Atlantic Trade* | Houston | St Petersburg | Baltimore | | | | | |
| 533 | 17,850 | *Baltic Mercur* | Houston | St Petersburg | New Orleans | Baltimore | | | | |
| 2681 | 58,548 | *CSCL Genoa* | Houston | Miami | Le Havre | | | | | |
| 1064 | 31,507 | *Houston* | Houston | Santos | | | | | | |
| 522 | 8,077 | *Industrial Century* | Houston | Rio de Janeiro | Santos | | | | | |
| 390 | 4,766 | *Karin* | Houston | Esmeraldas | Callao, Peru | Pisco, Peru | | | | |
| 4038 | 52,272 | *Libra Mexico* | Altamira | Houston | New Orleans | Buenos Aires | Santos | Rio de Janeiro | Caucedo, Dominican Republic | Veracruz |
| 167 | 3,504 | *Malte B* | Houston | Santa Marta | Cartagena | | | | | |
| 1464 | 43,700 | *Star Derby* | Houston | Mobile | Zhangiagang | | | | | |
| 1100 | 30,975 | *Yellowstone* | Houston | Altamira | Richards Bay, S. Africa | Durban | | | | |
| 256 | 2,700 | *Baltimar Saturn* | Houston | Esmeraldas | Guayaquil | Callao | | | | |
| 3102 | 40,638 | *CMA CGM Lotus* | Houston | Miami | | Le Havvre | Antwerp | Rotterdam | Charleston | |
| 4248 | 50,869 | *Santos* | Altamira | Houston | New Orleans | Buenos Aires | Santos | Rio de Janeiro | Caucedo, Dominican Republic | Veracruz |
| 4253 | 50,813 | *Westfalia Express* | Montevideo | Buenos Aires | Itajai, Brazil | Santos | Houston | | | |

Source: Journal of Commerce, Vessel Itinerary Search, 2008.

For vessels serving offshore rigs, identification of the location of rigs was determined through examination of MMS maps and discussions with Freeport industry representatives. Five travel zones were identified using MMS maps. The MMS maps were used to identify proximity to the Freeport and Galveston area. The MMS maps indicated a base of 175 rigs will be served by vessels operating from Galveston or Freeport. Table 35 shows approximately 92 rigs are in close proximity to Freeport, and 83 are close to Galveston.

**Table 35**
**Number of Offshore Rigs**
**Freeport and Galveston Vicinity**

| Zone Description | Freeport | Galveston |
|---|---|---|
| Zone A = 20 miles or less | 28 | 22 |
| Zone B = 40 miles or less | 41 | 21 |
| Zone C = 60 miles or less | 5 | 23 |
| Zone D = 80 miles or less | 10 | 3 |
| Zone E =115 miles or less | 8 | 14 |
| Total Rigs | 92 | 83 |

Source: Compiled from U.S. Mineral Management Service Maps, 2006.

An annual seismic vessel count of 55 was used for the 2008-period base. The seismic vessel count is based on three seismic vessels being in port in March 2009. Three vessels making 6 to 7 return trips results in 19 trips per year.

Cargo vessels presently come in about four times per month for repair or layberth. The port estimates that an annual increase of approximately 95 vessels could occur based on improved access. For the base analysis, an annual count of 48 vessels was used with the expectation of increases over the planning period. For purposes of analysis, Freeport's layberths were assumed to be represented by the Texas Gulf Coast fleet.

Transportation savings benefits were calculated based on 420 supply vessels and 55 seismic vessels saving 4 hours traveling time. The difference in travel time for cargo ships between Freeport and Galveston was found to be primarily represented by the reduction in the number of hours to travel from the open waters of the Gulf of Mexico inward through the Freeport Jetties to the launch/supply service and seismic vessel fueling and repair docks in comparison to travel distance through the Galveston Jetties to similar facilities. The travel time for 48 cargo vessels was estimated to be 2 hours round trip.

## 9.10 INCREMENTAL ANALYSIS

This section outlines the incremental analysis for the four operational reaches.

The first reach is 45 feet deep and provides access to crude petroleum tankers using docks operated by Seaway and chemical tankers for Dow Chemical. The maximum-sized crude petroleum carrier presently using the Seaway Terminal and the Brazosport Turning Basin is approximately 160,000 DWT. The largest-sized chemical carriers used are presently about 50,000 DWT. An increase in channel depth above 45 feet would allow for the use of larger chemical carriers. The maximum-sized chemical carrier under the FWP is anticipated to be approximately 80,000 DWT.

The second major reach includes ConocoPhillips. The maximum-sized petroleum product carriers used in the reach will not change for the FWP. The largest-sized crude petroleum and petroleum product tankers presently used are 100,000 DWT.

The third reach will include a new container terminal and will complement and supplement Houston traffic. While Houston has some mileage advantages over Freeport for cargo traveling to Dallas/Fort Worth, the comparative one-way distance to San Antonio's Distribution Centers is less than 5 miles. Therefore, the hinterland is expected to be the same as Houston's market.

The benefits from an increase in operating depth of 18 feet in the fourth reach were based on reductions in travel time that would lead to improved operational efficiency and economic benefits to the Nation. The benefits analysis is also based on the assumption that current practices of allowing foreign flag vessel access will continue for the 50-year planning period. Advantages Freeport has over other ports are open yard space and permission for vessel operators to work on their own boats. This practice is not normally allowed at other locations. The extra room is an advantage for seismic vessels, which characteristically carry 4 to 5 miles, or about 24,000 feet, of cable. There are only four or five seismic vessels operating in the entirety of the U.S. Gulf, but the Freeport yard is a common destination due to yard space and security.

### 9.10.1 CHANNEL DEEPENING BENEFITS

The transportation costs and the savings associated with the proposed project depth increase were calculated using commodity-specific vessel class and trade route distributions. Transportation costs were calculated based on the channel depth alternatives and variables associated with vessel design drafts, maximum feet of light-loading, underkeel clearance, mileage traveled, and the number of hours to load and unload. Maximum vessel cargo capacities for crude oil and petroleum products were estimated based on review of the range of load factors obtained from IWR Report 91-R-13, National Economic Development Procedures Manual Deep Draft Navigation, November 1991, and consultation with industry and BRPA. IWR Report 91-R-13 cargo capacity factors published in the deep-draft manual for dry bulk carriers and tankers are shown in Table 36. Consultation with industry and BRPA revealed that these estimates are reasonable. Table 37 displays representative round-trip mileage for the trade routes or junction points used in the transportation cost computations. Table 38 presents the foreign flag double-hull vessel operating cost update used in the analysis. Table 39 presents the container vessel

operating costs from IWR's Load Factor Tables. Tables 40, 41, and 42 show the Load Factor tables from IWR for each region for container imports and exports used in the analysis.

**Table 36**
**Adjustments for Estimating Actual Vessel Capacity**
**Short Tons of Cargo as a Percentage of Vessel DWT**

| Vessel DWT | % Cargo to DWT |
|---|---|
| <20,000 | 90 |
| 20,000 to 70,000 | 92 |
| 70,000 to 120,000 | 95 |
| >120,000 | 97 |

Source: USACE, IWR Report 91-R-13, National Economic Development Procedures Manual, Deep-Draft Navigation, November 1991, p. 77 and May 2008 draft.

**Table 37**
**Representative Round-trip Mileage to Freeport Harbor**

| Origin | Miles |
|---|---|
| Coatzacoalcos, Mexico | 1,360 |
| U.S. Gulf Coast Lightering/Lightening Zone | 160 |
| Venezuela | 3,934 |
| Panama Canal | 3,132 |
| Salvador, Brazil | 9,606 |
| Rotterdam, Netherlands | 10,318 |
| Sture, Norway | 11,172 |
| North Africa, Algiers | 10,556 |
| West Africa (Nigeria and Angola) | 12,320 |
| Persian Gulf and Indian Subcontinent via Suez Canal | 19,472 |
| Persian Gulf and Indian Subcontinent via Cape of Good Hope | 24,940 |
| Singapore via Panama Canal | 24,248 |
| Singapore via Cape of Good Hope | 26,304 |

Source: Lloyd's Register/Fairplay, Ports & Terminals Guide 2006.

**Table 38**
**Tanker Characteristics and Hourly Operating Cost**
**Foreign Flag Double-Hull Tankers**

| DWT | Hourly Operating Cost ($) | | |
|---|---|---|---|
| | At Sea | In Port | Base Idle |
| 20,000 | 947 | 463 | 560 |
| 25,000 | 1,008 | 500 | 605 |
| 35,000 | 1,135 | 578 | 699 |
| 50,000 | 1,292 | 660 | 799 |
| 60,000 | 1,460 | 780 | 944 |
| 70,000 | 1,552 | 823 | 996 |
| 80,000 | 1,644 | 865 | 1,047 |
| 90,000 | 1,734 | 906 | 1,096 |
| 110,000 | 1,898 | 971 | 1,175 |
| 150,000 | 2,216 | 1,093 | 1,323 |
| 165,000 | 2,345 | 1,148 | 1,389 |
| 265,000 | 3,165 | 1,475 | 1,785 |
| 300,000 | 3,436 | 1,574 | 1,905 |
| 320,000 | 3,588 | 1,628 | 1,970 |

Source: Application of USACE, Foreign Flag Tanker Costs presented in EGM #11-05, Deep-Draft Vessel Operating Cost May 2011.

**Table 39**
**Foreign Flag Container Vessel Operating Costs**

| DWT | TEU | LOA | Beam | Design Draft | Immersion Factor | Speed | At Sea Cost | In Port Cost |
|---|---|---|---|---|---|---|---|---|
| 11,700 | 800 | 466 | 73 | 26 | 44 | 13 | 578 | 214 |
| 18,400 | 1,300 | 535 | 85 | 30 | 59 | 15 | 810 | 292 |
| 24,300 | 1,700 | 585 | 90 | 33 | 70 | 14 | 1,012 | 360 |
| 33,900 | 2,400 | 676 | 99 | 38 | 88 | 16 | 1,344 | 387 |
| 45,000 | 3,200 | 794 | 106 | 40 | 112 | 18 | 1,728 | 425 |
| 56,800 | 4,100 | 907 | 106 | 43 | 132 | 18 | 2,136 | 490 |
| 65,000 | 4,600 | 959 | 106 | 44 | 144 | 18 | 2,418 | 540 |
| 74,100 | 5,300 | 954 | 132 | 46 | 166 | 17 | 2,481 | 525 |
| 86,100 | 6,100 | 1,018 | 143 | 46 | 195 | 17 | 2,775 | 628 |
| 103,800 | 7,400 | 1,106 | 143 | 48 | 218 | 17 | 3,316 | 790 |

Source: IWR Load Factor Analysis, January 2012.

**Table 40**
**Foreign Flag Container Vessel Load Factors (Mediterranean, Asia)**

| DWT | Imports | | | Exports | | |
|---|---|---|---|---|---|---|
| | Ratio of Cargo to DWT (%) | Maximum Practical Cargo Capacity | Actual Maximum Draft Adjusting for Load Factors | Ratio of Cargo to DWT (%) | Maximum Practical Cargo Capacity | Actual Maximum Draft Adjusting for Load Factors |
| 11,700 | 63 | 8,123 | 24 | 75 | 9,692 | 26 |
| 18,400 | 63 | 12,772 | 27 | 75 | 15,239 | 30 |
| 24,300 | 63 | 16,820 | 28 | 75 | 20,070 | 30 |
| 33,900 | 63 | 23,473 | 33 | 75 | 28,008 | 36 |
| 45,000 | 63 | 31,165 | 36 | 75 | 37,185 | 39 |
| 56,800 | 63 | 39,339 | 37 | 75 | 46,938 | 40 |
| 65,000 | 63 | 44,994 | 39 | 75 | 53,686 | 42 |
| 74,100 | 63 | 51,307 | 43 | 75 | 61,218 | 46 |
| 86,100 | 63 | 59,613 | 43 | 75 | 71,129 | 46 |
| 103,800 | 63 | 71,912 | 45 | 75 | 85,805 | 48 |

Source: IWR Load Factor Analysis, January 2012.

**Table 41**
**Foreign Flag Container Vessel Load Factors (South and Central America)**

| DWT | Imports | | | Exports | | |
|---|---|---|---|---|---|---|
| | Ratio of Cargo to DWT (%) | Maximum Practical Cargo Capacity | Actual Maximum Draft Adjusting for Load Factors | Ratio of Cargo to DWT (%) | Maximum Practical Cargo Capacity | Actual Maximum Draft Adjusting for Load Factors |
| 11,700 | 75 | 9,692 | 26 | 75 | 9,692 | 26 |
| 18,400 | 75 | 15,239 | 30 | 75 | 15,239 | 30 |
| 24,300 | 75 | 20,070 | 30 | 75 | 20,070 | 30 |
| 33,900 | 75 | 28,008 | 36 | 75 | 28,008 | 36 |
| 45,000 | 75 | 37,185 | 39 | 75 | 37,185 | 39 |
| 56,800 | 75 | 46,938 | 40 | 75 | 46,938 | 40 |
| 65,000 | 75 | 53,686 | 42 | 75 | 53,686 | 42 |
| 74,100 | 75 | 61,218 | 46 | 75 | 61,218 | 46 |
| 86,100 | 75 | 71,129 | 46 | 75 | 71,129 | 46 |
| 103,800 | 75 | 85,805 | 48 | 75 | 85,805 | 48 |

Source: IWR Load Factor Analysis, January 2012.

**Table 42**
**Foreign Flag Container Vessel Load Factors (Europe, Africa)**

| DWT | Imports | | | Exports | | |
|---|---|---|---|---|---|---|
| | Ratio of Cargo to DWT (%) | Maximum Practical Cargo Capacity | Actual Maximum Draft Adjusting for Load Factors | Ratio of Cargo to DWT (%) | Maximum Practical Cargo Capacity | Actual Maximum Draft Adjusting for Load Factors |
| 11,700 | 63 | 8,123 | 24 | 61 | 7,938 | 24 |
| 18,400 | 63 | 12,772 | 27 | 61 | 12,481 | 27 |
| 24,300 | 63 | 16,820 | 28 | 61 | 16,438 | 28 |
| 33,900 | 63 | 23,473 | 33 | 61 | 22,940 | 33 |
| 45,000 | 63 | 31,165 | 36 | 61 | 30,456 | 35 |
| 56,800 | 63 | 39,339 | 37 | 61 | 38,445 | 37 |
| 65,000 | 63 | 44,994 | 39 | 61 | 43,972 | 38 |
| 74,100 | 63 | 51,307 | 43 | 61 | 50,141 | 43 |
| 86,100 | 63 | 59,613 | 43 | 61 | 58,258 | 43 |
| 103,800 | 63 | 71,912 | 45 | 61 | 70,278 | 44 |

Source: IWR Load Factor Analysis, January 2012.

The basic procedure used to calculate transportation costs, using an 110,000 DWT foreign flag tanker as an example, is illustrated in Table 43. Similar computations were made for appropriate distances and vessel sizes for each of the channel depth alternatives.

**Table 43**
**Transportation Cost Calculation (Mexico to Freeport)**

| Vessel Deadweight Tons (metric tonnes) | 110,000 | 110,000 | 110,000 | 110,000 | 150,000 | 150,000 | 150,000 | 150,000 |
|---|---|---|---|---|---|---|---|---|
| Channel Depth (feet) | 45 | 50 | 55 | 60 | 45 | 50 | 55 | 60 |
| Design Draft (feet) | 50 | 50 | 50 | 50 | 56 | 56 | 56 | 56 |
| Underkeel Clearance (feet) | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Cargo Capacity (short tons) | 116,600 | 116,600 | 116,600 | 116,600 | 160,300 | 160,300 | 160,300 | 160,300 |
| Cargo Capacity by Channel Depth | 91,800 | 107,300 | 116,600 | 116,600 | 106,000 | 124,900 | 143,700 | 160,300 |
| Immersion Factor (tons per inch) | 234 | 234 | 234 | 234 | 285 | 285 | 285 | 285 |
| Hourly Cost at Sea | 1,898 | 1,898 | 1,898 | 1,898 | 2,216 | 2,216 | 2,216 | 2,216 |
| Hourly Cost in Port | 971 | 971 | 971 | 971 | 1,093 | 1,093 | 1,093 | 1,093 |
| Round Trip Mileage from Mexico | 1,314 | 1,314 | 1,314 | 1,314 | 1,314 | 1,314 | 1,314 | 1,314 |
| Speed (knots) | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Total Voyage Cost ($) | 167,400 | 167,400 | 167,400 | 167,400 | 194,100 | 194,100 | 194,100 | 194,100 |
| Loading/Unloading Rate (short tons/hour) | 2,697 | 2,697 | 2,697 | 2,697 | 2,977 | 2,977 | 2,977 | 2,977 |
| Hours in Port | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| Loading and Unloading Cost ($) | 74,400 | 85,600 | 92,300 | 92,300 | 87,200 | 101,000 | 114,900 | 127,100 |
| Pilot and Tug Costs ($) | 27,100 | 27,500 | 27,700 | 27,700 | 41,000 | 41,400 | 41,700 | 42,000 |
| Total Cost Per Ton ($) | 2.93 | 2.61 | 2.46 | 2.46 | 3.04 | 2.69 | 2.44 | 2.27 |

The resulting costs per ton computations were calculated over the relevant range of vessels projected for each channel depth improvement. The associated savings per ton were measured using the net differences in costs between the existing channel depth and the depth alternative.

#### 9.10.1.1 Crude Petroleum Imports Transportation Savings Benefits

Transportation savings benefits from reductions in the vessel operating costs were calculated based on the relative difference in transportation costs between the FWOP and FWP conditions. Transportation costs and savings were calculated for vessels that minimize transportation costs given trade route constraints and pilot rules. One rule that BRPA emphasized would not change between the FWOP and FWP conditions is underkeel clearance. The FWOP and FWP futures reflect changes in trade routes based on traffic forecast data.

The per ton transportation costs used in estimating the transportation savings benefits correspond to the most likely least cost methods of shipment associated with the particular trade route. As channel depth increases, the cost differential between direct shipment and both lightering and lightening is reduced. This reduction introduces cost incentives for potential shifts from lightering and lightening to direct shipments. An increase in channel depth would probably result in an increase in direct shipment movements for Africa, Mediterranean, Europe, and Middle East shipments.

Table 44 summarizes the transportation cost by trade route used for the FWP and FWOP condition calculations. The weighted average transportation costs were calculated by incorporating a share of mode of shipment to each cost for each channel depth. Given the reduction in the differential between lightening and direct shipment as channel depth increases, an additional variable for preference of direct shipment is used since direct shipment cost is subject to less uncertainty than the offshore transfer processes such as lightering and lightening due to the reduction in transfer times and associated logistics-related delays inherent with offshore transfer.

The cost savings for lightering is lower than direct shipment. The savings for lightering results from increases in shuttle loads due to greater channel depth. The effect of increasing channel depths allows for the reduction in the number of shuttle vessels necessary to totally lighter very large crude carriers. Increases in Freeport's channel depth also provide an opportunity to offload a smaller amount of cargo at sea. The cost calculations are based on relatively efficient transfer times and optimal-sized shuttle vessels. Less than optimal turnaround times would result in a larger differential between the FWOP and FWP condition offshore transfer costs.

In spite of uncertainties associated with changes in methods of shipment, an increase in channel depth reduces the cost per ton for lightering by reducing the number of shuttle vessels used to transport a given volume of crude oil. The savings for lightering movements result from increases in shuttle loads due to greater channel depth in Freeport. The savings for lightened

movements result from decreases in offshore unloading time from the mother vessel to shuttles, and the mother vessel is substituting offshore unloading time for dockside unloading time.

**Table 44**
**Freeport Crude Petroleum Imports Transportation Cost and Savings**
**Most Likely Transportation Mode**

| Trade Route/Channel Depth | 45 feet | 50 feet | 52 feet | 55 feet | 58 feet | 60 feet |
|---|---|---|---|---|---|---|
| **Mexico** | Direct | Direct | Direct | Direct | Direct | Direct |
| most likely cost/ton | $3.32 | $2.86 | $2.75 | $2.61 | $2.48 | $2.38 |
| savings/ton | | $0.46 | $0.57 | $0.71 | $0.84 | $0.94 |
| **Central and South America** | Direct | Direct | Direct | Direct | Direct | Direct |
| most likely cost/ton | $7.77 | $6.84 | $6.59 | $6.26 | $5.83 | $5.51 |
| savings/ton | | $0.93 | $1.18 | $1.51 | $1.94 | $2.26 |
| **Africa and Europe** | Lighter | Lighter | Lighter | Lighter | Lighten | Direct |
| most likely cost/ton | $12.90 | $12.63 | $12.54 | $12.31 | $12.16 | $11.86 |
| savings/ton | | $0.27 | $0.36 | $0.59 | $0.74 | $1.04 |
| **Middle East and Far East** | Lighten | Lighten | Lighten | Lighten | Lighten | Direct |
| most likely cost/ton | $21.14 | $20.87 | $20.77 | $20.54 | $20.35 | $19.25 |
| savings/ton | | $0.27 | $0.36 | $0.59 | $.78 | $1.89 |

The availability of a depth over 55 feet will make the use of Suezmax vessels a cost-effective option for direct shipments for many trade routes. Depths at the shipping origins indicate that constraints at the origin will not be an impediment for most routings.

Table 45 shows the percentage of crude oil imports expected to utilize greater drafts as a result of the cost calculations. Historical data for 2005 to 2007 showed that 96.8 percent of tonnage is shipped in vessels with design drafts over 40 feet, and 61 percent of the tonnage was transported at 40 feet or more. This gap is due to offshore lightering and lightening. The FWOP percentage was assumed to be approximately the same as existing conditions. The FWP benefit calculations are based on approximately 94 percent of tonnage loaded to 40 feet or more.

#### 9.10.1.2 Petroleum Product Imports Transportation Savings Benefits

Reductions in the vessel transportation costs for Freeport's foreign petroleum product imports were calculated based on the relative difference in transportation costs between FWOP and FWP conditions. As with crude petroleum, transportation costs and savings for product carriers were calculated for vessels that minimize transportation costs given trade route constraints. Again, long-term fleet selection will continue to reflect goals of minimizing vessel operating costs.

**Table 45**
**Freeport Crude Petroleum Imports**
**Percentage of Tonnage With Draft Constraints**

| Channel Depth (ft) | % of Tonnage Applied to Benefits | | | |
|---|---|---|---|---|
| | Existing Condition[a] | Without-project Future | With-project Future | |
| | | | 2017–2027 | 2037–2067 |
| 45 | 61 | 61 | 94 | 94 |
| 50 | n/a | n/a | 94 | 94 |
| 55 | n/a | n/a | 94 | 94 |
| 60 | n/a | n/a | 94 | 94 |

[a]2003–2007 average.

The effect of channel deepening would allow a portion of the fleet to be more fully loaded. A range of 20 to 63 percent of 2002 to 2007 tonnage was loaded to 40 feet draft or more with an average of 43 percent. The transportation savings from channel deepening was estimated to result in 43 percent of 2017 to 2027 tonnage and 63 percent of 2028 to 2067 tonnage being transported at more fully loaded drafts. The design drafts associated with these shipments ranged from 49 to 54 feet. Table 46 shows the percentage of petroleum product imports expected to utilize greater drafts as a result of the cost calculations.

**Table 46**
**Freeport Petroleum Product Imports**
**Percentage of Tonnage With Draft Constraints**

| Channel Depth (ft) | % of Tonnage Applied to Benefits | | | |
|---|---|---|---|---|
| | Existing Condition[a] | Without-project Future | With-project Future | |
| | | | 2017–2027 | 2037–2067 |
| 45 | 33 | 33 | 43 | 63 |
| 50 | n/a | n/a | 43 | 63 |
| 55 | n/a | n/a | 43 | 63 |
| 60 | n/a | n/a | 43 | 63 |

[a]2003–2007 average.

Table 47 summarizes the annual transportation savings benefits for petroleum product import tonnage. The petroleum product transportation savings benefits were calculated based on vessels from 80,000 to 100,000 DWT. The vessel sizes for existing conditions are the same as those anticipated for the FWOP and FWP futures.

**Table 47**
**Freeport Petroleum Product Imports Benefits ($1,000)**

| Year | 46 feet | 47 feet | 48 feet | 49 feet | 50 feet |
|---|---|---|---|---|---|
| 2017 | 311 | 600 | 869 | 1,119 | 1,316 |
| 2027 | 418 | 805 | 1,165 | 1,501 | 1,766 |
| 2037 | 486 | 937 | 1,357 | 1,748 | 2,056 |
| 2047 | 515 | 994 | 1,439 | 1,854 | 2,180 |
| 2057 | 545 | 1,050 | 1,520 | 1,959 | 2,304 |
| 2067 | 586 | 1,130 | 1,636 | 2,108 | 2,479 |
| Average Annual Savings (4.0%) | 440 | 847 | 1,227 | 1,581 | 1,859 |

### 9.10.1.3 Chemical Product Export Transportation Savings Benefits

The sizes of Freeport's existing chemical carriers range from 22,000 to 50,000 DWT. The design drafts generally range from 42 to 43 feet. Maximum loaded drafts are 40 feet, with 7 percent of 2002 to 2007 tonnage loaded to 40 feet. Lloyd's/Fairplay Vessel Register showed that 2 percent of chemical tankers built since 1995 have design drafts of 42 feet but that less than 1 percent have drafts over 42 feet. The chemical carriers on order as of January 2009 showed that 22 percent have design drafts over 42 feet and 1.6 percent have design drafts over 46 feet. Vessels-on-order records show that the maximum draft for chemical tankers on-order is 48 feet, thereby indicating that transition to larger vessels over the 50-year planning period is likely. The 2002 to 2007 historic data showed an average of 7 percent and a maximum of 11 percent of tonnage transported in vessels with loaded drafts of 40 feet or more, and the design drafts associated these vessel shipments ranged from 40 to 44 feet. The chemical benefits are calculated using 7 percent of 2017 to 2027 tonnage and 14 percent of 2037 to 2067 tonnage.

Table 48 shows the percentage of chemical product export tonnage used in the analysis. The FWOP percentage was assumed to be approximately the same as existing conditions. The FWP percentage is representative of the maximum historical percentage transported at loaded drafts approaching the authorized channel depth.

**Table 48**
**Percentage of Tonnage With Draft Constraints**

| % of Tonnage Applied to Benefits | | | | |
|---|---|---|---|---|
| Channel Depth (ft) | Existing Condition[a] | Without-project Future | With-project Future | |
| | | | 2017–2027 | 2037–2067 |
| 45 | 7 | 7 | 7 | 14 |
| 50 | n/a | n/a | 7 | 14 |
| 55 | n/a | n/a | 7 | 14 |
| 60 | n/a | n/a | 7 | 14 |

[a]2003–2007 average calculated from percentages shown in Table 35.

Current draft constrained movements are primarily shipped to Brazil and the Far East. Completion of the Panama Canal improvements is expected to result in increases in Freeport's shipments to the Far East. A trade route forecast was not prepared, so the transportation cost calculations are conservatively based on Freeport's 2002 to 2007 period routings for chemical products exports transported in vessels loaded to drafts of 40 feet or more.

Table 49 summarizes the annual transportation savings benefits for chemical export tonnage. The transportation costs for chemical products were calculated based on vessels from 50,000 to 65,000 DWT for the existing and FWOP conditions. The FWP transportation costs were calculated using vessels from 50,000 to 80,000 DWT. The transition to larger chemical carriers for 14 percent of future tonnage is based on vessels-on-order and vessel deliveries as of July 2006.

### 9.10.2 Container Transportation Savings Benefits

Increased uncertainty is associated with containers since the Velasco Terminal is currently being built and there are no historical trends at Freeport. Therefore, Houston data were used as a proxy even though Houston's terminals currently have a depth of 40 feet. The vessel sizes vary from 12,000 DWT to 104,000 DWT with the majority of tonnage transported in the 45,000 to 75,000 DWT range. Design drafts generally range from 40 feet to 46 feet, with the large post-Panamax vessels drafting up to 48 feet. Vessels traveling to/from the Mediterranean and Asia carry approximately 50 percent of its tonnage in vessels larger than 65,000 DWT. This tonnage is transported with sailing drafts ranging from 42 to 48 feet. Vessels traveling to/from South and Central America transport approximately 12 percent of its tonnage in vessels larger than 65,000 DWT.

**Table 49**
**Freeport Chemical Product Exports**
**Benefits ($1,000s)**

| Year | 46 feet | 48 feet | 50 feet | 52 feet | 54 feet | 56 feet |
|---|---|---|---|---|---|---|
| 2017 | 126 | 422 | 626 | 772 | 883 | 981 |
| 2027 | 268 | 897 | 1,332 | 1,643 | 1,880 | 2,088 |
| 2037 | 365 | 1,221 | 1,813 | 2,236 | 2,558 | 2,841 |
| 2047 | 421 | 1,410 | 2,093 | 2,581 | 2,953 | 3,280 |
| 2057 | 478 | 1,599 | 2,374 | 2,927 | 3,349 | 3,720 |
| 2067 | 566 | 1,893 | 2,811 | 3,466 | 3,965 | 4,404 |
| Average Annual Savings (4.0%) | 308 | 1,030 | 1,530 | 1,886 | 2,158 | 2,397 |

### 9.10.3 Offshore Supply, Research, and Seismic Vessels Transportation Savings Benefits

Table 50 displays the average annual benefits by channel depth for vessels using the Upper Stauffer Channel.

**Table 50**
**Freeport Offshore Supply, Research, and Seismic Vessels Benefits ($1,000s)**

| Year | 20 feet | 22 feet | 25 feet | 28 feet | 30 feet |
|---|---|---|---|---|---|
| 2017 | 333 | 753 | 1,039 | 1,100 | 1,111 |
| 2027 | 394 | 892 | 1,230 | 1,302 | 1,314 |
| 2037 | 466 | 1,056 | 1,456 | 1,541 | 1,556 |
| 2047 | 552 | 1,249 | 1,724 | 1,823 | 1,841 |
| 2057 | 653 | 1,479 | 2,040 | 2,158 | 2,180 |
| 2067 | 773 | 1,750 | 2,415 | 2,554 | 2,580 |
| Average Annual Savings (4.0%) | 455 | 1,029 | 1,419 | 1,502 | 1,516 |

## 9.11 ECONOMIC SUMMARY

This section presents summaries of the transportation savings benefits by commodity group.

Table 51 presents the economic summary data for the first reach. This reach includes the Lower Turning Basin and the Brazosport Turning Basin. The results of the analysis show that the BCR for all channel depth alternatives from 50 to 60 feet are above unity. Of the plans presented, the 60-foot alternative has the highest net excess benefits.

Table 52 presents the economic summary data for the second reach. This reach extends from the Brazosport Turning Basin to the Upper Turning Basin. The 50-foot alternative provides the highest net excess benefits. Channel depths over 50 feet are not included since deepening beyond 50 feet would necessitate significant bank stabilization and dock modifications.

Table 53 displays the results of the base fleet for the third reach. The results of the analysis show that the net excess benefits continue to increase through channel depths of 50 feet. Depths greater than 50 feet were not analyzed because the LPP is 50 feet, and dredging deeper than 50 feet will require dock modifications in Reach 2 and Reach 3.

Table 54 displays the results of the fourth reach. Although the results of the analysis show that the net excess benefits maximize at 26 feet, it was determined that the marginal increase in net excess benefits from 25 feet to 26 feet is not worth the extra cost to the government. Therefore, the Recommended Plan depth is 25 feet.

**Table 51**
**Crude Petroleum for Seaway Terminal and Chemical Products for Dow Chemical (Reach 1)**
**Average Annual Benefits and Costs (4.0% and $1,000)**

| Channel Alternative | 50 feet | 52 feet | 55 feet | 58 feet | 60 feet |
|---|---|---|---|---|---|
| 2017 | 10,658 | 13,799 | 19,230 | 24,279 | 36,566 |
| 2027 | 15,543 | 20,086 | 27,831 | 34,999 | 51,913 |
| 2037 | 19,668 | 25,409 | 35,176 | 44,193 | 65,445 |
| 2047 | 24,121 | 31,161 | 43,125 | 54,213 | 80,062 |
| 2057 | 28,361 | 36,643 | 50,719 | 63,789 | 94,186 |
| 2067 | 32,758 | 42,318 | 58,546 | 73,611 | 108,556 |
| First Cost of Construction | 169,365 | 194,926 | 233,267 | 290,989 | 329,470 |
| Interest During Construction | 12,105 | 14,444 | 17,953 | 23,488 | 27,179 |
| Total Investment | 181,470 | 209,370 | 251,220 | 314,477 | 356,649 |
| Average Annual Cost | 8,447 | 9,746 | 11,694 | 14,639 | 16,602 |
| Average Annual O&M[a] | 5,784 | 6,676 | 8,016 | 9,160 | 9,900 |
| Total Annual Cost | 14,231 | 16,422 | 19,710 | 23,799 | 26,503 |
| Average Annual Benefits | 18,297 | 23,647 | 32,767 | 41,217 | 61,125 |
| Net Excess Benefits | 4,066 | 7,225 | 13,057 | 17,418 | 34,622 |
| B/C Ratio | 1.3 | 1.4 | 1.7 | 1.7 | 2.3 |

**Table 52**
**Crude Petroleum and Petroleum Products**
**for ConocoPhillips (Reach 2)**
**Average Annual Benefits and Costs (4.0% and $1,000)**

| Channel Alternative | 46 Feet | 47 Feet | 48 Feet | 49 Feet | 50 Feet |
|---|---|---|---|---|---|
| 2017 | 590 | 1,178 | 1,720 | 2,246 | 2,684 |
| 2027 | 813 | 1,624 | 2,372 | 3,098 | 3,704 |
| 2037 | 983 | 1,966 | 2,873 | 3,755 | 4,491 |
| 2047 | 1,128 | 2,264 | 3,310 | 4,329 | 5,184 |
| 2057 | 1,268 | 2,548 | 3,728 | 4,879 | 5,847 |
| 2067 | 1,420 | 2,856 | 4,181 | 5,474 | 6,563 |
| First Cost of Construction | 40,989 | 42,036 | 43,083 | 44,130 | 45,177 |
| Interest During Construction | 1,182 | 1,212 | 1,243 | 1,273 | 1,303 |
| Total Investment | 42,171 | 43,249 | 44,326 | 45,403 | 46,480 |
| Average Annual Cost | 1,963 | 2,013 | 2,063 | 2,114 | 2,164 |
| Average Annual O&M | 1,400 | 1,436 | 1,471 | 1,507 | 1,543 |
| Total Annual Cost | 3,363 | 3,449 | 3,535 | 3,621 | 3,707 |
| Average Annual Benefits | 906 | 1,814 | 2,651 | 3,465 | 4,146 |
| Net Excess Benefits | -2,457 | -1,635 | -884 | -156 | 439 |
| B/C Ratio | 0.3 | 0.5 | 0.8 | 1.0 | 1.1 |

**Table 53**
**Containers for Velasco Terminal (Reach 3)**
**Average Annual Benefits and Costs (4.0% and $1,000)**

| Channel Depth | 41 Feet | 43 Feet | 45 Feet | 48 Feet | 50 Feet |
|---|---|---|---|---|---|
| First Cost of Construction | 10,015 | 10,601 | 11,188 | 12,068 | 12,654 |
| Interest During Construction | 118 | 125 | 131 | 142 | 149 |
| Total Investment | 10,133 | 10,726 | 11,319 | 12,210 | 12,803 |
| Average Annual Cost | 472 | 499 | 527 | 568 | 596 |
| Average Annual O&M | 948 | 965 | 982 | 1,007 | 1,024 |
| Total Annual Cost | 1,420 | 1,464 | 1,509 | 1,575 | 1,620 |
| Average Annual Benefits | 535 | 2,614 | 5,055 | 7,325 | 7,784 |
| Net Excess Benefits | -885 | 1,150 | 3,546 | 5,749 | 6,165 |
| B/C Ratio | 0.4 | 1.8 | 3.4 | 4.6 | 4.8 |

**Table 54**
**Upper Stauffer (Reach 4)**
**Average Annual Benefits and Costs (4.0% and $1,000)**

| Channel Depth | 20 Feet | 24 Feet | 25 Feet | 26 Feet | 27 Feet | 28 Feet | 29 Feet | 30 Feet |
|---|---|---|---|---|---|---|---|---|
| First Cost of Construction | 1,716 | 3,611 | 4,085 | 4,616 | 5,147 | 5,678 | 6,209 | 6,740 |
| Interest During Construction | 3 | 6 | 6 | 8 | 9 | 9 | 10 | 11 |
| Total Investment | 1,718 | 3,617 | 4,091 | 4,623 | 5,155 | 5,687 | 6,219 | 6,751 |
| Average Annual Cost | 80 | 168 | 190 | 215 | 240 | 265 | 289 | 314 |
| Average Annual O&M | 17 | 37 | 42 | 47 | 52 | 57 | 62 | 67 |
| Total Annual Cost | 97 | 206 | 233 | 263 | 293 | 322 | 352 | 382 |
| Average Annual Benefits | 455 | 1,217 | 1,419 | 1,490 | 1,490 | 1,502 | 1,502 | 1,516 |
| Net Excess Benefits | 357 | 1,011 | 1,186 | 1,227 | 1,197 | 1,179 | 1,149 | 1,135 |
| B/C Ratio | 4.7 | 5.9 | 6.1 | 5.7 | 5.1 | 4.7 | 4.3 | 4.0 |

A summary of the economic analyses is presented below. The first part of Table 55 shows the NED benefits and the second half shows the LPP benefits. The average annual benefits and costs are based on the current discount rate of 4.0 percent. Table 56 presents the calculations at 7.0 percent.

## 9.12 REGIONAL ECONOMIC BENEFITS

This section contains discussions and table displays of the regional benefits of port-related activity. The tables and associated discussions are displayed "as presented" in Martin Associates' "The Local and Regional Economic Impacts of Port Freeport." The Freeport regional impact analysis was prepared by Martin Associates for the port of Freeport in 2006.[10] The current report represents an update from an original report prepared in 2003.

The regional benefits contained in the 2006 report and presented here are based on total project effects. While the incremental effects of the Federal action were not calculated, it is generally expected that the proposed deepening project will result in incremental increases beyond the existing base. The expectation that the Federal project will generate increases in regional benefits is based on general conclusions contained in the Martin Associates report that illustrate that Freeport terminal expansions and cargo increases have resulted in increases in jobs, personal earnings, business revenue, and state and local taxes. Additionally, a general observation of multiport analyses is that incremental changes in project depth provide assurances that a port

[10] Martin Associates, "The Local and Regional Economic Impacts of Port Freeport, August 2006,

**Table 55**
**Economic Summary of NED and LPP for Freeport Channel and Stauffer Modification**
**Average Annual Values (4.0% and $1,000)**

| | NED Plan | | | |
|---|---|---|---|---|
| | | Stauffer Modification | | |
| | Freeport Channel 60/50 feet | Lower Reach 50 feet | Upper Reach 25 feet | Totals |
| First Cost of Construction | 374,522 | 12,664 | 4,090 | 391,276 |
| Interest During Construction | 28,477 | 149 | 6 | 28,632 |
| Total Investment | 402,999 | 12,813 | 4,096 | 419,909 |
| Average Annual Cost | 18,760 | 596 | 191 | 19,547 |
| Average Annual O&M | 11,258 | 1,024 | 42 | 12,324 |
| Total Annual Cost | 30,018 | 1,620 | 233 | 31,871 |
| Average Annual Benefits | 65,270 | 7,784 | 1,419 | 74,474 |
| Net Excess Benefits | 35,253 | 6,164 | 1,186 | 42,603 |
| B/C Ratios | 2.2 | 4.8 | 6.1 | 2.3 |
| | LPP | | | |
| | | Stauffer Modification | | |
| | Freeport Channel 55/50 feet | Lower Reach 50 feet | Upper Reach 25 feet | Totals |
| First Cost of Construction | 274,988 | 11,840 | 3,823 | 290,652 |
| Interest During Construction | 19,156 | 139 | 6 | 19,301 |
| Total Investment | 294,144 | 11,979 | 3,829 | 309,953 |
| Average Annual Cost | 13,692 | 558 | 178 | 14,428 |
| Average Annual O&M | 9,569 | 1,024 | 42 | 10,635 |
| Total Annual Cost | 23,261 | 1,581 | 221 | 25,063 |
| Average Annual Benefits | 38,442 | 7,784 | 1,419 | 47,646 |
| Net Excess Benefits | 15,181 | 6,203 | 1,199 | 22,583 |
| B/C Ratios | 1.7 | 4.9 | 6.4 | 1.9 |

**Table 56**
**Economic Summary of NED and LPP for Freeport Channel and Stauffer Modification**
**Average Annual Values (7.0% and $1,000)**

| | NED Plan | | | |
|---|---|---|---|---|
| | | Stauffer Modification | | |
| | Freeport Channel 60/50 feet | Lower Reach 50 feet | Upper Reach 25 feet | Totals |
| First Cost of Construction | 374,522 | 12,664 | 4,090 | 391,276 |
| Interest During Construction | 51,788 | 262 | 11 | 52,060 |
| Total Investment | 426,310 | 12,916 | 4,101 | 443,336 |
| Average Annual Cost | 30,890 | 937 | 297 | 32,124 |
| Average Annual O&M | 11,303 | 1,015 | 35 | 12,353 |
| Total Annual Cost | 42,193 | 1,952 | 332 | 44,477 |
| Average Annual Benefits | 58,797 | 7,734 | 1,312 | 67,842 |
| Net Excess Benefits | 16,604 | 5,782 | 980 | 23,365 |
| B/C Ratios | 1.4 | 4.0 | 3.9 | 1.5 |
| | LPP | | | |
| | | Stauffer Modification | | |
| | Freeport Channel 55/50 feet | Lower Reach 50 feet | Upper Reach 25 feet | Totals |
| First Cost of Construction | 274,988 | 11,840 | 3,823 | 290,652 |
| Interest During Construction | 34,733 | 245 | 11 | 34,989 |
| Total Investment | 309,721 | 12,085 | 3,834 | 325,641 |
| Average Annual Cost | 22,442 | 876 | 278 | 23,596 |
| Average Annual O&M | 9,648 | 1,015 | 35 | 10,699 |
| Total Annual Cost | 32,091 | 1,891 | 313 | 34,295 |
| Average Annual Benefits | 34,564 | 7,734 | 1,312 | 43,610 |
| Net Excess Benefits | 2,474 | 5,843 | 999 | 9,315 |
| B/C Ratios | 1.1 | 4.1 | 4.2 | 1.3 |

will, at a minimum, maintain its regional benefit base. A comparative analysis of the effect on total tonnage throughput and vessel utilization among ports would be helpful measuring post-project on a regional and national level. Compilation and comparison of tonnage data among ports could be aggregated relatively easily.

It is recognized that for the communities within the study area, the Freeport Harbor Channel is responsible for benefits to the local and regional economy. Freeport has one of the largest petrochemical complexes in the world. In 2007, Freeport ranked 5th in the nation in terms of foreign trade and 25th in terms of total tonnage. Petroleum and chemical products represent approximately 95 percent foreign trade in 2006.[11] The remaining 5 percent of foreign trade includes bulk materials and agricultural products. Freeport exports 6 percent of U.S. rice and imports 6 percent of U.S. bananas. Approximately 1,700 vessels called at the port in 2006.

Port activities contribute to the local and regional economy by generating business revenues to local and national firms providing vessel and cargo-handling services at the marine terminals. Businesses, in turn, provide employment and income to individuals. The port's marine and cargo terminals and refinery complexes generate revenue throughout the local, state, and national economies. Port facilities include a diverse range of public and private marine terminals. The public marine terminals are those owned by the port and leased to terminal operators and marine terminal tenants. The port's tenants include Dole Fresh Fruit Company, Turbana Corp., Chiquita Brands, Inc., Bryan Coastal Stevedoring, P&O Ports, Vulcan Materials, and American Rice, Inc. The port's general cargo base also includes a variety of temperature-sensitive cargos such as meat and vegetables. P&O, a multinational container terminal operator and stevedore, currently provides container and terminal operations in Freeport for the special requirements of the Dole, Chiquita, and Turbana fruit distributors. Freeport's refrigerated-cargo facility has been in operation since 1984. The port's private marine terminals include Dow Chemical, BASF Corporation, ConocoPhillips Terminal, and TEPPCO Seaway Pipeline Company. In addition to its established base of terminals, the FWOP includes an LNG and a container terminal. The LNG terminal became operational by late 2008 and was constructed by a partnership that includes ConocoPhillips and Dow Chemical. The terminal is located along the northern edge of the Freeport Harbor Outer Bar and Jetty channels near Station 65+00. The port includes an FTZ (No. 149), which was created in 1988. The FTZ provides customs duty deferent and manufacturing and inventory management benefits.

Revenue generated by the port is produced by firms providing services to the commodity and vessel activity at the terminals, revenue from trucking firms, railroads, pipeline operations, terminal operations, and associated refineries and chemical plants (from loading and discharging vessels), handlers, agents, pilots, towing companies, and maritime support firms. This revenue is used to purchase employment (direct jobs), to provide services, to pay stockholders and for

[11] Complete statistics are not available for 2007 as of January 15, 2009. The most recent annual data available from the USACE NDC at the time of report preparation is presented. This report includes the latest annual data available from the USACE NDC.

retained earnings, and to purchase goods and services from local firms, as well as national and international firms. Businesses also pay taxes from their business revenue.

According to the Martin Associates report used in preparation of this section of the report, marine cargo activity at Freeport's public and private marine terminals in the navigation district is responsible for 11,131 direct jobs with local firms. The estimated 11,131 jobs account for nearly $1.1 billion in personal annual incomes. Seventy-five percent of these direct jobs were found to be held by residents of Brazoria County. The activity at the public port facilities is noted to create 970 of the direct jobs. The 10,161 jobs created by the movement of petroleum and petrochemicals at the private terminals are primarily associated with local refineries and chemical plants with private marine terminals. Table 57 shows total direct jobs associated with port activities.

The effect of dry cargo is shown as 0.35 job per 1,000 tons. Again, the incremental effect on jobs and regional income based on the range of channel depths between 40 and 50 feet evaluated for the Lower Stauffer Channel is recognized to be much smaller.

It is noted that in addition to local and regional purchases by those 11,131 individuals holding the direct jobs, an additional 14,700 induced jobs are supported in the regional economy. The report found that 9,886 indirect jobs were supported by $903.6 million of local purchases by businesses supplying services at the marine terminals and by businesses dependent upon the port for the shipment and receipt of cargo. In addition to the direct, induced, and indirect job impacts, an estimated 20,422 jobs in the state of Texas were found to be related to the cargo exported and imported over marine terminals at the port. It is noted in the report that while these 20,422 jobs are considered to be related to port activity, the degree of dependence on the marine terminals is difficult to quantify and should not be considered as dependent on the port as are the direct, induced, and indirect jobs.

Table 58 displays the summary of economic impacts in current 2006 dollars generated by the port's public and private marine terminals as presented in the 2006 Martin Associates document. The report shows that marine activity supported $4.4 billion of total personal wage and salary income and local consumption expenditures for Texas residents. The $4.4 billion income is noted to include $3.4 billion of direct, indirect, induced, and local consumption expenditures, while the remaining $1.0 billion was received by the related port users. The 11,131 direct jobholders received $1.1 billion of direct wage and salary income for an average salary of $95,130. Additionally, a total of $302.9 million of state and local tax revenue was generated by maritime activity at the port, and $93.7 million of state and local taxes was created due to the economic activity of the related users of the cargo moving via the marine terminals.

**Table 57**
**Employment Impact by Sector and Job Category**
**Number of Jobs**

| Job Sector | Public Terminals | Private Terminals | Total Jobs |
|---|---|---|---|
| Surface transportation | | | |
| Rail | 3 | 56 | 59 |
| Truck | 260 | 459 | 720 |
| Maritime services | | | |
| Terminal employees/consignees | 456 | 9,541 | 9,997 |
| International Longshoremen's Association/ dockworkers | 100 | 0 | 100 |
| Towing | 6 | 14 | 20 |
| Pilots | 3 | 6 | 9 |
| Agents | 1 | 7 | 8 |
| Surveyors/chandlers | 1 | 1 | 2 |
| Forwarders | 54 | 0 | 54 |
| Maritime services | 8 | 10 | 18 |
| Government | 24 | 30 | 53 |
| Marine construction/shipyards | 22 | 8 | 31 |
| Barge | 0 | 29 | 29 |
| Port authority | 31 | NA | 31 |
| Total Jobs | 970 | 10,161 | 11,131 |

Source: Martin Associates, "The Local and Regional Economic Impacts of Port Freeport, August 2006, Table II-1, page 21.

The effect on jobs and personal income associated with the Upper Stauffer Channel fall under the marine construction and shipyard activity and appear to provide significant increases in regional income. Vessel traffic on the Upper Stauffer is associated with offshore oilfields and other traffic back and forth to the main segment of the port. Oilfield shipments primarily consisted of fuel, water, supplies, drill pipes, drill mud, and chemicals along with barges and rigs that needed repair. As shown in Table 57, there are 31 jobs associated with marine construction and shipyard activity. The current job count of 31 is considerable less than in the 1970s and 1980s when a channel operating depth of 30 feet was available.

Table 58 shows that Freeport's 2005 marine cargo activity generated a total of approximately $9.0 billion of total economic activity in the State of Texas. Of the $9.0 billion, $936.2 billion, it is noted that bagged rice creates the largest number of direct jobs per 1,000 tons, followed by bulk rice and refrigerated containers. Table 59 presents the job impacts per 1,000 tons for each commodity moving via the public and private marine terminals. The relatively large impact per 1,000 tons for resin reflects the relatively small tonnage handled. Despite the fact that petroleum generated the second largest direct job impact, on a per 1,000 ton basis, petroleum generates 0.05 jobs per 1,000 tons. Dry bulk cargoes, such as limestone, also generate relatively small numbers

of jobs per 1,000 tons. The jobs impact per 1,000 tons for chemicals reflects the large number of terminal and plant employees employed by the petrochemical industry in the Freeport Port District that are using private terminals to ship and receive petrochemicals. The finding that the petroleum and bulk cargoes generate relatively small direct jobs per 1,000 tons of throughput reflects the fact that the handling of liquid bulk and dry bulk cargoes is much less labor intensive than handling general cargo, and further, the supporting infrastructure of agents, freight forwarders and customhouse brokers, and warehousing and terminal operators is greater for general cargo such as break-bulk fruit, containerized cargo, and bagged grain. If the dependent shippers/consignees were not included in the direct job impacts per 1,000-ton measure, the difference in the labor intensity of general cargo versus liquid bulk cargo would be even more pronounced.

**Table 58**
**Summary of the Local and Regional Economic Impacts Generated by Port Freeport**

| Variable | Public Terminals | Private Terminals | Total |
|---|---|---|---|
| Jobs | 970 | 10,161 | 11,131 |
| Induced | 674 | 14,026 | 14,700 |
| Indirect | 609 | 9,277 | 9,886 |
| Related jobs | 2,514 | 17,908 | 20,422 |
| Total | 4,766 | 51,372 | 56,139 |
| Personal income ($1,000) | | | |
| Direct | 39,049 | 1,019,806 | 1,058,854 |
| Responding/consumption | 67,183 | 1,754,576 | 1,821,759 |
| Indirect | 28,945 | 455,596 | 484,541 |
| Related income | 62,600 | 978,164 | 1,040,764 |
| Total | 197,777 | 4,208,142 | 4,405,919 |
| Economic value ($1,000) | | | |
| Direct revenue | 71,227 | 864,929 | 936,156 |
| Local purchases | 65,946 | 837,676 | 903,621 |
| Related output | 354,712 | 6,838,030 | 7,192,742 |
| Total | 491,885 | 8,540,635 | 9,032,519 |
| State & local taxes ($1,000) | | | |
| Direct, induced and indirect | 12,166 | 290,698 | 302,864 |
| Related state and local taxes | 5,634 | 88,035 | 93,669 |
| Totals | 17,800 | 378,733 | 396,533 |

Source: Martin Associates, "The Local and Regional Economic Impacts of Port Freeport, August 2006, Table E-2, page 4.

[b]Totals may not add due to rounding

**Table 59**
**Job Impacts per 1,000 Tons**

| Commodity | Public | Private | Port-Wide |
|---|---|---|---|
| Dry Containers | 0.35 | | 0.35 |
| Reefer Containers | 0.68 | | 0.68 |
| General Cargo | 0.56 | | 0.56 |
| Resin | 0.74 | | 0.74 |
| Bagged Rice | 1.00 | | 1.00 |
| Bulk Rice | 0.77 | | 0.77 |
| Limestone | 0.04 | | 0.04 |
| Breakbulk Fruit | 0.42 | | 0.42 |
| Petroleum | | 0.05 | 0.05 |
| Chemicals | | 0.66 | 0.66 |

Source: Martin Associates, "The Local and Regional Economic Impacts of Port Freeport, August 2006, Exhibit II-3, page 23.

The port noted that the 2006 Martin Associates report figures reflect substantial gains over those reported in a similar study conducted by Martin Associates in 2003.[12] Specifically, comparison of the 2003 and 2006 reports showed that the number of direct local jobs that rely upon Port Freeport increased by 38 percent, or 3,041 jobs. It is noted that the job growth is in part due to expansion of the Dow Chemical operation as well as the growth in cargo, particularly chemicals, general cargo, limestone, and crude petroleum. Since the 2003 economic impact study, the port has experienced a 1.6-million-ton increase of cargo.[13]

### 9.12.1 Regional Economic Benefits Summary and Conclusions

The Martin Associates report and specific evaluation to the proposed deepening project suggests that incremental increases in jobs as a result of channel deepening would be relatively small. This conclusion is based on the finding that petroleum and bulk cargoes generate relatively small direct jobs per 1,000 tons of throughput since incremental increases beyond 45 feet for the main portion of the Freeport Channel are nearly exclusively associated with petroleum, and benefits for induced tonnage were not included in the benefit calculations. Induced tonnage effects would be minimal due to the large fixed infrastructure associated with petroleum refining and established feedstock requirements as well as regional and national pipeline distribution networks.

While changes in job effects for petroleum will be minimal, the effects associated with the operation of the Velasco Container Terminal will recognizably impact jobs to a greater extent than petroleum. The general effects associated with overall container cargo associated with the

[12] http://www.thefacts.com/downloads/PORT%20FREEPORT%20FINAL_1.pdf

[13] *The Economic Impact of Port Freeport, 2003*, Martin Associates, August 2004

Velasco Terminal should be similar to general cargo and dry containers but would likely not exceed the general cargo effects. General cargo generates 0.56 job per 1,000 tons.

Of the commodities imported and exported at Freeport, petroleum imports contribute the most to national benefits. Benefits from container traffic are the second largest contributor. NED and LPP channel depths, respectively, are 60 feet and 55 feet for Reach 1, 50 feet and 50 feet for Reach 2, 50 feet and 50 feet for Reach 3, and 25 feet and 25 feet for Reach 4. The BCRs for all reaches are above unity in the most likely scenario and most of the sensitivities. Deepening the channel at Freeport will contribute to the local economy and will add value to the national economy.

## 9.13 SUMMARY AND CONCLUSIONS

Although economies go through periods of peaks and troughs, most stable countries experience long-term growth. The recent recession of the late 2000s caused a setback in the national economy, but the economy of the U.S. is resilient. It is likely to experience growth over the next 50 years. As the national economy grows, demand for energy will also grow. There is debate where this energy will come from, but historical trends have shown that a large portion of the Nation's energy comes from crude petroleum and petroleum products. There are tremendous infrastructure challenges to suddenly divert from these long-term trends. Demand for chemical products and consumer goods are also expected to increase as the economy grows.

Freeport is well poised to capitalize on these increases in demand. Infrastructure is in place, the port has land available for expansion, and Freeport is presently a key contributor to the national economy. One of the National SPRs is nearby, and Freeport is only 3 miles from deep water in the Gulf of Mexico and one hour from one of the largest cities in the country. Of the commodities imported and exported at Freeport, petroleum imports contribute the most to national benefits. Benefits from container traffic are the second largest contributor. Table 60 provides the NED and LPP channel depths and BCRs. The BCRs for all reaches are above unity in the most likely scenario and many of the sensitivities. Deepening the channel at Freeport will contribute to the local economy and will add value to the national economy.

**Table 60**
**NED and LPP Channel Depth Summary**

| | NED | | LPP | |
|---|---|---|---|---|
| | **Channel Depth** | **BCR** | **Channel Depth** | **BCR** |
| Reach 1 | 60 | 2.3 | 55 | 1.7 |
| Reach 2 | 50 | 1.1 | 50 | 1.2 |
| Reach 3 | 50 | 4.8 | 50 | 4.9 |
| Reach 4 | 25 | 6.1 | 25 | 6.4 |
| Total | - | 2.3 | - | 1.9 |

# 10.0 ENVIRONMENTAL EVALUATION OF THE RECOMMENDED PLAN AND PROPOSED MITIGATION

An FEIS that addresses the potential impacts of the Recommended Plan (LPP) upon human and environmental resources was prepared and is appended to this feasibility report. Project impacts are summarized below.

## 10.1 PHYSIOGRAPHY

The proposed channel deepening and 1.3-mile extension into the Gulf would increase storm surge elevations by about 0.16 foot (5 centimeters) locally, inside the jetties. However, this increase is considered small given the general inundation of the greater Freeport area during a significant storm surge, and will not have a substantial effect on the level of protection offered by the current levee system.

Similarly, proposed project improvements would have only minor impacts on adjacent shorelines for approximately 3 to 4 miles from the Outer Bar Channel jetties.

## 10.2 TERRESTRIAL AND WETLAND HABITATS

The LPP would require construction of two new upland confined PAs (8 and 9) resulting in the loss of approximately 418 acres of habitat, consisting of 21 acres of riparian forest, 39 acres of ephemeral freshwater wetlands, and 358 acres of grasslands currently used as pasture land. PAs are shown on Figure 17. The Habitat Evaluation Procedure (HEP) was used to model and quantify ecological impacts to develop the project mitigation plan, which fully mitigates impacts to wetlands and riparian forest, as discussed below.

In addition to upland confined placement of new work and maintenance dredged material, dredged material will also be deposited at two existing ODMDSs – the New Work ODMDS and the Maintenance ODMDS. Placement of material at the ODMDSs will result in temporary impacts to aquatic communities (primarily benthos) from increased sedimentation and turbidity. However, these effects are expected to be temporary in nature, and affected benthic organisms and other communities should rapidly recover.

## 10.3 CLEAN WATER ACT

USACE has received Section 401 State Water Quality Certification for the Recommended Plan. TCEQ has determined that the requirements for water quality certification have been met and has concluded that the placement of fill material will not violate water quality standards. The Recommended Plan is the least environmentally damaging practicable alternative. A CWA Section 404(b)(1) evaluation is presented in the EIS. New work sediments are suitable for use in the proposed upland confined PAs (1, 8, and 9) and for placement in the New Work ODMDS.

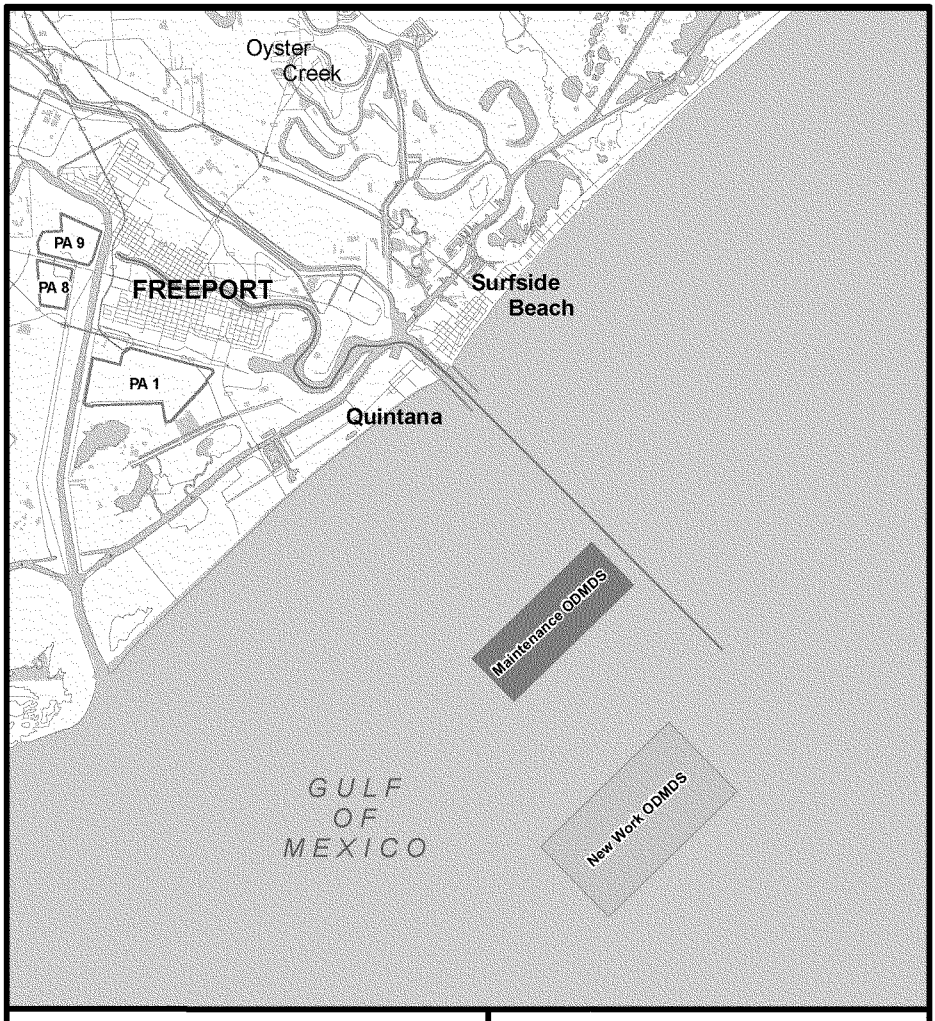



**Figure 17**

**Freeport Harbor Channel Improvement Project**

**Dredged Material Placement Area Alternatives**

| | |
|---|---|
| Prepared for: USACE, Galveston District | |
| Job No.: 044190100 | Scale: 1:120,000 |
| Prepared by: A. Christiansen | Date: 08/06/2008 |
| File: N:/Clients/U_Z/USACE/Projects/Freeport/044190100/figure_16.mxd | |

## 10.4 MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT

This Act requires a determination that dredged material placement in the ocean will not appreciably degrade or endanger human health, welfare, amenities, or the marine environment, ecological systems, or economic potential (shellfish beds, fisheries, or recreation areas). Modeling indicates the existing Maintenance and New Work ODMDSs are large enough to accommodate dredged material for the period of analysis of both the Permit Widening and the Federal deepening project. Appendix B of the EIS contains a Marine Protection, Research and Sanctuaries Act Section 102/103 evaluation report for proposed placement activities and an ODMDS Site Monitoring and Management Plan (SMMP). EPA has concurred that the dredged material is suitable for disposal in the ODMDSs and that the SMMP is acceptable.

## 10.5 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

The Magnuson-Stevens Fishery Conservation and Management Act (PL 94-265), as amended, establishes procedures for identifying EFH and required interagency coordination to further the conservation of federally managed fisheries. Consultation with the NMFS has identified EFH in the study area. USACE anticipates only minor and temporary impacts to EFH during construction.

## 10.6 COASTAL ZONE MANAGEMENT ACT

USACE has evaluated the Recommended Plan for consistency with the Texas Coastal Management Plan and has concluded that it is fully consistent to the maximum extent practicable with the enforceable policies of the Texas program. By letter dated December 15, 2010 (EIS Appendix A-4), USACE requested a review of the Consistency Determination, but to date has received no response.

## 10.7 FISH AND WILDLIFE COORDINATION ACT

USACE has coordinated with USFWS and TPWD concerning impacts to resources from proposed project improvements. These agencies actively participated in identifying sensitive resources and project impacts, and provided recommendations for the project mitigation plan. USFWS has prepared a Coordination Act Report documenting its recommendations found in Appendix A to the EIS.

## 10.8 MARINE MAMMAL PROTECTION ACT OF 1972

The Marine Mammal Protection Act is intended to conserve and protect marine mammals and establish the Marine Mammal Commission, the International Dolphin Conservation Program,

and a Marine Mammal Health and Stranding Response Program. The Recommended Plan is in compliance with this Act. Proposed project improvements are not expected to impact any marine mammals as they are unlikely to occur in the project area.

## 10.9 COASTAL BARRIER IMPROVEMENT ACT OF 1990

There are two Coastal Barrier Improvement Act (CBRA)–designated areas near the project area: Follets Island Unit T04 and Brazos River Complex T05/T05P. Exceptions to the Federal expenditure restrictions of the CBRA include construction of improvements(s) to existing Federal navigation channels and related structures (e.g., jetties), including the disposal of dredged material related to maintenance and construction. Thus, the Recommended Plan is exempt from the prohibitions identified in this CBRA.

## 10.10 FARMLAND PROTECTION POLICY ACT OF 1981 AND THE COUNCIL ON ENVIRONMENTAL QUALITY MEMORANDUM PRIME OR UNIQUE FARMLANDS

Construction of PA 9 will impact approximately 250 acres of prime farmland. The NRCS calculated the Farm Conversion Impact Rating to be a total of 161. The Farmland Conversion Impact Rating of 161 makes the tract for PA 9 subject to the FPPA. However, the project alternatives analyses identify no other practicable alternatives for the placement of dredged material from this project. Accordingly, in compliance with NEPA and pursuant to the FPPA, the project has properly considered a wide range of possible alternatives.

## 10.11 EXECUTIVE ORDER 11988, FLOODPLAIN MANAGEMENT

This Executive Order (EO) directs Federal agencies to evaluate the potential effects of proposed actions on floodplains. Such actions should not be undertaken that directly or indirectly induce growth in the floodplain unless there is no practical alternative. The Recommended Plan includes the development of two new PAs within the Brazos River floodplain. Alternatives to avoid the adverse effects of developing these PAs in the floodplain were evaluated, and it has been determined that this is the only practicable alternative.

## 10.12 EXECUTIVE ORDER 12898, ENVIRONMENTAL JUSTICE

In compliance with EO 12898, an evaluation of potential Environmental Justice (EJ) impacts was completed and is presented in the EIS. The Recommended Plan is not expected to adversely affect low-income or minority populations.

## 10.13 CLEAN AIR ACT

The project study area is located within a severe nonattainment area for ozone. As described in the EIS, new work dredging activities associated with the LPP are expected to exceed the $NO_X$

conformity threshold of 25 tons per year. Based on the General Conformity Concurrence letter provided by TCEQ, a Final General Conformity Determination was prepared by the USACE. TCEQ and USACE's determination of conformity is based on conformance with the currently approved Houston-Galveston-Brazoria area SIP and the emissions information and project schedule proposed at the time. Once a final project schedule is completed in the PED phase, USACE will provide an update of the General Conformity documentation to TCEQ and EPA for final review and concurrence.

## 10.14 NOISE

During construction, noise impacts during dredging operations would be about 3 to 6 dBA (A-weighted sound level) higher at the nearest noise receptors than what is experienced during current maintenance dredging. Construction would be essentially equivalent to increased noise levels currently heard during maintenance dredging.

## 10.15 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

An HTRW assessment revealed that no known regulated sites or hazardous materials exist within the LPP project footprint. Additionally, historic and current sediment data for the existing channel indicate no contaminant concerns. It should also be noted that proposed improvements would remove new work material consisting primarily of clay, which is highly impermeable to contaminant migration, located beneath existing maintenance overburden. Based on this information, HTRW is not expected to be encountered during proposed channel improvements.

## 10.16 THREATENED AND ENDANGERED SPECIES

USACE has determined that construction activities utilizing hopper dredges may adversely affect but are not likely to jeopardize the continued existence of several endangered sea turtle species. Consultation with NMFS under Section 7 of the Endangered Species Act (ESA) has been initiated. A draft BA describing potential impacts on these listed species is presented in the EIS. A new Biological Opinion (BO) from NMFS is anticipated for the project. It is expected that the new BO will institute reasonable and prudent measures to avoid sea turtle impacts, and it may establish new incidental take limits for construction.

## 10.17 CULTURAL RESOURCES

Historical research and investigations identified a potentially National Register–eligible Civil War–period site near PA 9. Further investigation of the Civil War site will be addressed under the conditions of the PAg executed for this project. Compliance with the PAg places the project in compliance with the National Historic Preservation Act.

## 10.18 CUMULATIVE IMPACTS

Cumulative impacts have been evaluated based on existing and reasonably foreseeable projects in the Freeport area, ranging from existing waterways such as the GIWW, to new ship channel industries such as an LNG facility, construction of a new containership berth and a marina, and construction of other industrial and commercial facilities. Total cumulative impacts from these projects are not expected to adversely affect human health, socioeconomic well-being, or the environment of the project area.

## 10.19 PROJECT MITIGATION

Construction of the two new upland PAs 8 and 9 would result in both wetland and riparian forest impacts. The PAs would be developed on land owned or leased by the non-Federal sponsor and will contain approximately 33 mcy of new work and maintenance material from the proposed channel improvements. Impacts to these areas were evaluated using HEP and IWR-Plan to develop a project mitigation plan. The proposed PAs are currently degraded pasture with ephemeral wetland swales that are seasonally dry, and some second-growth riparian forest adjacent to the Brazos River Diversion Channel (Diversion Channel). The pastures are overgrazed and contain substantial numbers of non-native invasives including pasture grasses and Chinese tallow trees (tallow), and native species indicative of disturbance.

Construction of PAs 8 and 9, including pipeline corridors and effluent ditches, would impact 418 acres of land, including 21 acres of secondary riparian forest, 39 acres of ephemeral wetlands, and 358 acres of degraded pasture with some scrub/shrub. Of these habitats, mitigation is proposed for the riparian forest and wetland impacts.

Resource agency personnel from USFWS and TPWD participated in site visits and in collecting the required field data for conducting the HEP analysis for impacted wetlands and riparian forest, and provided valuable advice in completing the analysis. The agencies also provided significant input for siting and design of project mitigation features. During agency coordination for siting project mitigation features, emphasis was placed on in-kind mitigation located in close proximity to impacted habitats. Areas considered for project mitigation and coordinated with the resource agencies included land to the north and east of PA 9 adjacent to the Diversion Channel, and land east of PA 8 to the Diversion Channel (see Figure 17). The area between the proposed PAs and the Diversion Channel contains riparian forest and areas suitable for wetland mitigation.

The agencies made a number of recommendations USACE could not concur with for project mitigation. For example, USFWS recommended that the entire riparian forest between the PAs and the Diversion Channel be selectively cleared of tallow, replanted with a combination of hard mast and flood-tolerant native trees, and be protected in perpetuity by a conservation easement. As demonstrated below, however, this would have resulted in excessive mitigation for project impacts and will not be implemented.

TPWD requested preservation in perpetuity of a 5-acre ephemeral wetland swale located between PA 8 and SH 36 as a mitigation feature. However, the port does not wish to make this property available for project mitigation. The resource agencies also requested mitigation for the 358 acres of pasture impacted by PAs 8 and 9. The agencies classify these pastures as wet coastal prairie. USACE does not concur with this habitat classification. Although the land at one time may have been coastal prairie, it is now degraded grassland planted to and primarily consisting of non-native pasture grasses of limited wildlife habitat value that does not merit mitigation.

A project mitigation plan to address unavoidable impacts to significant habitat resulting from the construction of PAs 8 and 9 was developed that satisfies the USACE's cost effectiveness and incremental cost analysis (CE/ICA) requirements as outlined in ER 1105-2-100, Appendix C. The plan considers the quality and regional significance of the impacted habitats and focuses on mitigating impacts to high-quality habitat while minimizing additional land acquisition costs. HEP models were considered adequate for both the riparian forest and wetland habitats impacted by this project. Once unavoidable project impacts had been identified, several tracts of land owned by the port were considered for mitigation—Peach Point and lands surrounding PAs 8 and 9. Peach Point is located west of Freeport near Jones Creek and consists primarily of tidally influenced wetlands near the GIWW. These wetlands would not provide acceptable mitigation because they are out-of-kind mitigation substitutes for the freshwater, ephemeral wetlands impacted by the project and were not considered further. Two additional sites near Peach Point were also considered for mitigation, but were dropped because they too would have provided out-of-kind mitigation like Peach Point. The port-owned lands adjacent to PAs 8 and 9 provide for in-kind, on-site mitigation, which is desirable. In addition, the port is willing to grant a conservation easement that will protect the riparian forest mitigation tract in perpetuity. A detailed evaluation of these lands based on HEP modeling is documented below. HEP modeling was used to quantify project impacts and mitigation compensation. CE/ICA was also performed to identify an optimal mitigation plan that fully compensates for project impacts.

### 10.19.1 Habitat Evaluation Procedure

A HEP analysis was used to determine the amount of mitigation required to compensate for project impacts. HEP uses evaluation species as representative of habitat quality by determining a Habitat Suitability Index (HSI) for each species using a particular habitat. Each species has an associated HSI model, which is based upon the assumption that a positive relationship exists between the HSI and habitat carrying capacity, and that habitat suitability can be summarized on a scale ranging from 0.0 to 1.0 (USFWS, 1996). Data from field measurements of habitat variables is run through the respective suitability index model to generate a baseline HSI for each species or group of species utilizing the same habitats.

The number of habitat units (HUs) available in the habitat is calculated by multiplying the HSI by the area of habitat being analyzed. The final step in the process is to project the condition of

the habitat into the future, over the period of analysis, and determine what the value of the habitat will be at certain points in time (target years [TYs]), when a change in habitat conditions is likely to occur. HUs are then summed for each species and divided by the years in the period of analysis.

The foregoing procedure provides the average annual habitat units (AAHUs) that can be compared to the AAHUs calculated for the same habitat type and species at different locations or different conditions (management plans) at the same location. AAHUs for the FWP and FWOP conditions are calculated in this manner. The difference between these two conditions is used to calculate project impact and determine the mitigation needed to compensate for habitat losses to the evaluation species.

### 10.19.2 Site Description and Selection of Evaluation Species

PA 8 is utilized as a pasture. The site retains perhaps 30 percent of its original prairie habitat function and value and is vegetated by a large number of non-native invasives and species indicative of pasture maintenance, such as mowing. Species found at the site include rattlebox, Gulf cordgrass, St. Augustine grass, sedges, and tallow. Sparse concentrations of seacoast sumpweed, Carolina wolfberry, marsh-hay cordgrass, and sea-ox eye daisy were also observed. Evidence of overgrazing exists. PA 8 also contains two small stock ponds. At the time of the site visit, these ponds were dry and vegetated with common arrowhead, seacoast sumpweed, and tallow and were surrounded by Gulf cordgrass, marsh-hay cordgrass, and scattered native flowers.

PA 9 is adjacent to the Diversion Channel, and although similar to PA 8, is drier and the ground cover is sparser. The majority of the site consists of heavily overgrazed pasture vegetated with bermudagrass, rattlebox, frog fruit, and scattered Gulf cordgrass. The pasture retains perhaps 10 percent of its original prairie habitat function and value and is considered substantially degraded. It also includes two areas of riparian forest totaling 21 acres, both of which are situated adjacent to the Diversion Channel. The riparian forest is an open, second-growth, mixed-species forest, approximately 40 years in age, with a grazed understory. The forest consists of a diverse range of non-native invasive and native tree and brush species including sugar hackberry, cedar elm, tallow, toothache tree, pecan, red mulberry, gum bumelia, yaupon, palmetto, and other species. The height of this mixed-species canopy reaches 35 feet, and its density, maturity, diversity, and location along the Diversion Channel near the Gulf of Mexico add to its value as a neotropical migrant songbird "fallout" site.

Wildlife species include the northern bobwhite, marsh harrier, black-shouldered kite, great egret, snowy egret, great blue heron, eastern meadowlark, red-winged blackbird, and others. Species seen in the forested portion of PA 9 included the red-shouldered hawk, black-crowned night heron, northern mockingbird, northern cardinal, white-eyed vireo, tufted titmouse, and common blackbird.

For purposes of habitat evaluation, the HSI models for the mottled duck and great egret were used. These species served as surrogates for calculating the quality of the ephemeral wetlands at PAs 8 and 9. Ephemeral wetland swales at these sites generally consist of a semipermanent water regime, with water depths possibly approaching 3–5 inches during wet winter months and drying up during the summer months.

Two evaluation species, the gray squirrel and veery, were used as surrogates to calculate the quality of the riparian forest. The eastern meadowlark was used as an evaluation species for calculating the quality of the grasslands, and only the HSI value for the food component of its model was used in the HEP analysis.

While the gray squirrel, veery, and mottled duck were not observed in the riparian forest or wetland habitats during site visits, the forest may support squirrels and could provide fallout sanctuary for the veery. Similarly, the mottled duck could use the stock ponds and ephemeral swales and potholes within the project area.

Field measurements were collected by USACE assisted by USFWS and TPWD biologists at PAs 8 and 9 on December 4, 2006. Data were collected from representative sampling sites in the riparian forest and at wetland and grassland areas to assess the suitability of these habitats for their respective evaluation species. The initial field data collected from this site visit was compiled by USFWS to establish baseline HSI values for the evaluation species, and was reviewed by TPWD and USACE.

## 10.19.3 HEP Modeling

### 10.19.3.1 Future Without-Project

Table 61 provides the average baseline condition HSI values and HUs for each evaluation species in each of the three habitats. The HSI was obtained by averaging the HSI values for each of the habitats surveyed. Before performing calculations for AAHUs, anticipated changes that will occur in the quality or quantity of each habitat were determined and expressed as TYs, over the designated period of analysis, which is 50 years for this project.

When determining the TYs for the FWOP condition, it was assumed that the forest habitat on PA 9 would not likely experience any meaningful changes (losses) in habitat quality or quantity resulting from tree removal or other activities for development.

**Table 61**
**Average HSI Values and HUs for All Habitats in Project Impact Areas**
**(Baseline Conditions)**

| Evaluation Species | Area of Available Habitat (Acres) | Average HSI Values | Habitat Units |
|---|---|---|---|
| *Forest* | | | |
| Gray Squirrel | 21 | 0.21 | 4.4 |
| Veery | 21 | 0.47 | 9.9 |
| Average HSI: | | 0.34 | 7.14 |
| *Wetlands* | | | |
| Mottled Duck | 39 | 0.13 | 5 |
| Great Egret | 39 | 0.29 | 11.3 |
| Average HSI: | | 0.21 | 8.15 |
| *Grasslands* | | | |
| Eastern Meadowlark | 358 | 0.39 | 139.6 |

Currently, the forested areas function in part as a buffer for Dow operations and, according to Port Freeport, will continue providing that function. Also, the current use of grasslands as maintained pasture for cattle would likely continue. However, the wetland and grassland habitats on PA 8 are expected to experience a change in habitat value for each evaluation species for the FWOP condition, due to planned development actions by the port on Tract Eight. According to port officials, these changes would probably occur approximately 15 years into the future. Prior to this potential development timeframe, the wetlands and grasslands on PA 8 are assumed to experience no change in habitat value for each evaluation species.

In general, the assumption of no change in wetlands for both PAs 8 and 9 is due to their control by the port and Dow. No change to the grasslands is expected because they are maintained pasture and periodically mowed, preventing any meaningful successional change.

The final step in calculating the AAHUs for each habitat is to calculate the HUs contained in a habitat for each evaluation species at each target year, and summing all HUs to get cumulative HUs. The cumulative HUs are then divided by the period of analysis (50 years) to derive the AAHUs, which can be compared with similar habitats in a mitigation plan to ensure adequate compensation for project impacts (losses). Table 62 presents the HUs calculated for the evaluation species in each habitat, the cumulative HUs for all evaluation species in a habitat, and the AAHUs for the FWOP condition.

Table 62 shows that without the project in place, the forests will retain a habitat value of approximately 7.46 AAHUs for the two evaluation species over the 50-year period of analysis. The wetlands and the grasslands will have approximate values of 1.1 and 67 AAHUs, respectively.

**Table 62**
**Future Without-Project AAHUs in Evaluation Species' Habitats**

| Habitat | Species | Target Years (TY) Compared | Acres | HSI Values | Habitat Units Between TY | Average Annual Habitat Units |
|---|---|---|---|---|---|---|
| *Forest* | Gray Squirrel and Veery | $TY_1 - TY_0$ | 21 | 0.34 | 7.14 | |
| | | $TY_{15} - TY_1$ | 21 | 0.46 | 81.20 | |
| | | $TY_{25} - TY_{15}$ | 21 | 0.55 | 74.23 | |
| | | $TY_{51} - TY_{25}$ | 21 | 0.58 | 210.50 | |
| Cumulative Habitat Units: | | | | | 373.07 | |
| AAHUs: | | | | | | 7.46 |
| *Wetlands* | Mottled Duck and Great Egret | $TY_1 - TY_0$ | 39 | 0.21 | 9.2 | |
| | | $TY_2 - TY_1$ | 39 | 0.20 | 9.00 | |
| | | $TY_{15} - TY_2$ | 16 | 0 | 39.36 | |
| | | $TY_{51} - TY_{15}$ | 16 | 0 | 0 | |
| Cumulative Habitat Units: | | | | | 57.56 | |
| AAHUs: | | | | | | 1.15 |
| *Grasslands* | Eastern Meadowlark | $TY_1 - TY_0$ | 358 | 0.39 | 138.7 | |
| | | $TY_2 - TY_1$ | 358 | 0.39 | 138.7 | |
| | | $TY_{15} - TY_2$ | 358 | 0.39 | 317.5 | |
| | | $TY_{51} - TY_{15}$ | 213 | 0.40 | 2,755.0 | |
| Cumulative Habitat Units: | | | | | 3,350.0 | |
| AAHUs: | | | | | | 67.0 |

### 10.19.3.2 Future With-Project

The next step in the HEP analysis involves calculating the AAHUs for each habitat with the dredged material disposal action in place. Because the analysis examines only the construction areas where dredged material placement will occur, resulting in displacement of all surface features (habitats), we would expect that the AAHUs for this condition will be very low. At the end of $TY_1$ when project construction terminates and when project features are in place, the habitat will not recover, so no HUs exist from this point through the period of analysis, which is 50 years with the project features in place. The AAHUs are calculated using the same formula as in the FWOP analysis, and the results are presented in Table 63.

**Table 63**
**Future With-Project AAHUs in Evaluation Species' Habitats**

| Habitat | Species | Target Years (TY) Compared | Acres | HSI Values | Habitat Units Between TY | Average Annual Habitat Units |
|---|---|---|---|---|---|---|
| *Forest* | Gray Squirrel and Veery | $TY_1 - TY_0$ | 21 | 0.34 | 2.38 | |
| | | $TY_{15} - TY_1$ | 0 | 0 | 0 | |
| | | $TY_{25} - TY_{15}$ | 0 | 0 | 0 | |
| | | $TY_{51} - TY_{25}$ | 0 | 0 | 0 | |
| Cumulative Habitat Units: | | | | | 2.38 | |
| AAHUs: | | | | | | 0.047 |
| *Wetlands* | Mottled Duck and Great Egret | $TY_1 - TY_0$ | 39 | 0.21 | 3.15 | |
| | | $TY_2 - TY_1$ | 0 | 0 | 0 | |
| | | $TY_{15} - TY_2$ | 0 | 0 | 0 | |
| | | $TY_{51} - TY_{15}$ | 0 | 0 | 0 | |
| Cumulative Habitat Units: | | | | | 3.15 | |
| AAHUs: | | | | | | 0.063 |
| *Grasslands* | Eastern Meadowlark | $TY_1 - TY_0$ | 358 | 0.39 | 46.3 | |
| | | $TY_2 - TY_1$ | 0 | 0 | 0 | |
| | | $TY_{15} - TY_2$ | 0 | 0 | 0 | |
| | | $TY_{51} - TY_{15}$ | 0 | 0 | 0 | |
| Cumulative Habitat Units: | | | | | 46.3 | |
| AAHUs: | | | | | | 0.93 |

As expected, with project implementation, the AAHUs are greatly diminished compared to the FWOP condition. AAHUs for the FWP conditions range from 0.047 for the forest habitat, to 0.063 for the wetlands, and 0.93 for the grasslands.

#### *10.19.3.2.1 Proposed Mitigation Strategies For Forest and Wetlands*

To determine the amount of new habitat required for compensating project impacts to riparian forests and wetlands, the AAHUs for each habitat in the FWOP condition are subtracted from the AAHUs for each habitat in the FWP condition. Based on this calculation, the approximate AAHUs, which are all negative, required in the new habitats to offset project losses are:

- Riparian Forests: 7.41
- Wetlands: 1.1

Three sites located on project lands adjacent to the proposed PAs were selected for project mitigation planning and were used for developing the CE/ICA. The CE/ICA identifies the most-cost-effective plans for accomplishing the required levels of mitigation at these sites. The three alternative mitigation sites and their associated measures are:

**Mitigation Site 1**

**Riparian and wetland mitigation – riparian forest area north of PA 9 and adjacent to pasture area bordering the forest's southern edge**. This 131.8-acre site includes 117 acres of riparian forest, 5 acres of cleared forest, and about 9.8 acres of grassland. It is large enough for both wetland and riparian mitigation features and is supported by the resource agencies as a mitigation site because it will be protected by a conservation easement. Field surveys revealed that approximately 10 percent of the riparian forest in Mitigation Site 1 (11 acres) is composed of tallows. Riparian mitigation at this site would consist of clearing the tallows, primarily around natural openings in the forest, and planting native trees. After clearing, the openings would be planted with a variety of small hard-mast and flood-tolerant native seedlings or sapling trees to enhance the existing forest. Additionally, 1 acre of these native tree species would be planted around the perimeter of a proposed wetland creation area, described below. A total of 12 acres of new native trees would be planted for riparian mitigation at this site, and the entire 117-acre riparian forest would be preserved as part of the proposed project mitigation plan.

Wetland mitigation would be accomplished by creating a 3-acre ephemeral wetland (pond) in the grassland area of Site 1. The pond would be sloped to reach a maximum center depth of about 12 inches, the limit of accessibility of the mottled duck, and will have areas of between 4 to 9 inches in depth as required by the great egret for wade feeding. A variety of wetland plant species plugs (submerged and emergent) would be planted on 5- to 6-foot centers on the slopes and water's edge of the pond at different elevations, dependent upon the aquatic plant species, for a medium-density planting.

**Mitigation Site 2**

**Riparian mitigation – riparian forest located east of PA 9**. This 14.5-acre site includes 9.5 acres of riparian forest and 5 acres of mixed tallow and scrub/shrub vegetation. The 5-acre tallow and scrub/shrub area would be cleared and planted with small hard-mast and flood-tolerant native seedlings or sapling trees for riparian forest mitigation.

**Mitigation Site 3**

**Riparian and wetland mitigation – riparian forest located east of PA 8**. This 124.7-acre site includes 112 acres of riparian forest and 12.7 acres of very dense tallow stands and scrub/shrub. Riparian forest mitigation would be accomplished by clearing tallows from 30 percent (33 acres) of the 112-acre riparian forest. This 33-acre area would then be planted with small hard-mast

native and flood-tolerant seedlings or sapling trees. Additionally, 1 acre of native trees would be planted around the perimeter of the proposed wetland creation area at this site, for a total of 34 acres of newly planted trees. A 3-acre ephemeral wetland area (pond) would be created within the scrub/shrub area of the site. The same design features and aquatic planting scheme proposed at Site 1 for pond creation would be used.

Native tree and wetland vegetation that could be used for mitigation planting include water oak, willow oak, overcup oak, pecan, green ash, planar tree, water hickory, bald cypress, black willow, red maple, smart weed, common or soft rush, sawgrass, sedge, pickerel weed, Gulf cordgrass, and swamp lily.

## 10.20 COST EFFECTIVENESS AND INCREMENTAL COST ANALYSIS

### 10.20.1 Forest Mitigation

Sufficient acreage exists between mitigation sites (sites 1, 2, and 3) for planting a mixture of tree species to compensate for project losses. To determine the AAHUs the mitigation forest and mitigation wetlands contain, certain TYs representing the time of expected change in habitat values were chosen to measure the gains in habitat value over the 50-year period of analysis. Habitat gains will be reflected in AAHUs calculated for each evaluation species as the trees mature.

#### 10.20.1.1 Scales

Two scales of trees were considered for planting at the sites: seedlings and saplings. For seedlings, a mixture of tree species would be utilized. The seedlings would be 0.5 to 1 inch in diameter, 2 to 4 feet tall, planted at a density of 150 trees per acre, and spaced as forest openings permit. Tree mortality for this size is expected to approach 30 to 40 percent over the 50-year period of analysis, with most of the mortality occurring within the first 2 years after planting. The more-expensive saplings would range between 1.5- to 2-inch-diameter plants, 5–7 feet in height, and be planted at a density of 40 trees per acre as forest openings permit. Mortality for this size tree is expected to approach 25 percent over the 50-year period of analysis, with most of the mortality occurring within the first 2 years after planting.

In a straight cost comparison, the seedlings are less expensive than the saplings, but the saplings are expected to provide value to the forest habitat earlier due to their size. While the larger and more-expensive saplings may initially provide a faster recovery of the forest habitat compared to seedlings, the differences between these two tree sizes with respect to their contribution of value to the existing forest would be negligible over the 50-year period of analysis. Therefore, both tree sizes are deemed to provide the same habitat value, and this was reflected in the HEP analysis by assigning them both the same HSI scores.

A review of the variables that influence habitat quality for the two forest evaluation species revealed that the most important variables common to these species are:

- Percent canopy closure of trees that produce hard mast, which are greater than or equal to 10 inches diameter at breast height;
- Percent of tree canopy closure;
- Number and diversity of tree species that produce hard mast; and
- Soil moisture regime.

#### *10.20.1.1.1 Assumptions Using Seedling Trees*

The variables listed above for the evaluation species were used to identify the TYs for the HEP analysis. While growth is highly variable among species and even among individuals of the same species, it is not unreasonable to expect some of the faster growing trees, such as the oaks, to achieve large crowns that could easily approach 25–30 feet in diameter within 20 years. Therefore, with a mixture of species in the plantings and about a 25–30 percent mortality rate, it is not unreasonable to expect a 40–60 percent canopy closure in about 25 years.

Using all the above assumptions, the habitat value was calculated for each evaluation species, and a cost for mitigation for each site was developed. Table 64 presents the FWOP and projected FWP HSI values for each species for each target year used in the analysis. It also displays FWOP AAHUs at each of the proposed sites, and projects FWP mitigation AAHUs for the proposed sites, if the planting scheme for seedlings was implemented.

### 10.20.2 Wetland Mitigation

Sufficient acreage is available at all proposed mitigation sites, except for Site 2, for wetland creation. Site 2 will not be considered for any wetland habitat creation due to reasons stated earlier.

In determining the AAHUs the mitigation wetlands contain, certain TYs representing the time of expected change in habitat value were chosen to measure the gains in habitat value over the 50-year period of analysis. Habitat gains will be reflected in AAHUs calculated for each evaluation species as the wetland vegetation matures.

As described earlier, a medium-density planting scheme was chosen for wetland mitigation. This scheme would consist of planting mixed wetland plant species and is thought to be most cost effective.

**Table 64**
**AAHUs for Forest Species at Proposed Mitigation Sites**
**FWOP vs. FWP Mitigation***

| Site 1 (Seedlings) Gray Squirrel and Veery | Target Years (TY) Compared | Acres (FWOP) | HSI Value (FWOP) | Habitat Units Between TYs (FWOP) | Average Annual Habitat Units (FWOP) | Acres (FWP) | HSI Value (FWP) | Habitat Units Between TYs (FWP) | Average Annual Habitat Units (FWP) | AAHUs Gained at Site 1 (FWP minus FWOP AAHUs) |
|---|---|---|---|---|---|---|---|---|---|---|
| | $TY_1 - TY_0$ | 117 | 0.34 | 39.78 | | 117 | 0.34 | 39.9 | | |
| | $TY_{15} - TY_1$ | 117 | 0.47 | 460.8 | | 118 | .55 | 507.6 | | |
| | $TY_{25} - TY_{15}$ | 117 | 0.56 | 425.8 | | 118 | .66 | 499.7 | | |
| | $TY_{51} - TY_{25}$ | 117 | 0.6 | 1204 | | 118 | 0.75 | 1469.6 | | |
| AAHUs: | | | | | 42.6 | | | | 50.3 | 7.73 |
| **Site 2 (Seedlings) Gray Squirrel and Veery** | **Target Years (TY) Compared** | **Acres (FWOP)** | **HSI Value (FWOP)** | **Habitat Units Between TYs (FWOP)** | **Average Annual Habitat Units (FWOP)** | **Acres (FWP)** | **HSI Value (FWP)** | **Habitat Units Between TYs (FWP)** | **Average Annual Habitat Units (FWP)** | **AAHUs Gained at Site 2 (FWP minus FWOP AAHUs)** |
| | $TY_1 - TY_0$ | 9.5 | 0.34 | 3.2 | | 9.5 | 0.34 | 4.0 | | |
| | $TY_{15} - TY_1$ | 9.5 | 0.25 | 27 | | 14.5 | 0.35 | 48.3 | | |
| | $TY_{25} - TY_{15}$ | 9.5 | 0.36 | 20.4 | | 14.5 | 0.46 | 41.1 | | |
| | $TY_{51} - TY_{25}$ | 9.5 | 0.40 | 64.2 | | 14.5 | 0.52 | 126.1 | | |
| AAHUs: | | | | | 2.3 | | | | 4.39 | 2.09 |
| **Site 3 (Seedlings) Gray Squirrel and Veery** | **Target Years (TY) Compared** | **Acres (FWOP)** | **HSI Value (FWOP)** | **Habitat Units Between TYs (FWOP)** | **Average Annual Habitat Units (FWOP)** | **Acres (FWP)** | **HSI Value (FWP)** | **Habitat Units Between TYs (FWP)** | **Average Annual Habitat Units (FWP)** | **AAHUs Gained at Site 3 (FWP minus FWOP AAHUs)** |
| | $TY_1 - TY_0$ | 112.7 | 0.07 | 7.8 | | 112.7 | 0.07 | 7.9 | | |
| | $TY_{15} - TY_1$ | 112.7 | 0.08 | 81.7 | | 113.7 | 0.25 | 175.8 | | |
| | $TY_{25} - TY_{15}$ | 112.7 | 0.10 | 71.0 | | 113.7 | 0.40 | 260.0 | | |
| | $TY_{51} - TY_{25}$ | 112.7 | 0.11 | 214.0 | | 113.7 | 0.55 | 959.1 | | |
| AAHUs: | | | | | 7.49 | | | | 28.0 | 20.51 |

*FWOP = future without-project; FWP = future with-project

#### 10.20.2.1 Assumptions Using a Medium-density Wetland Planning Scheme

The mottled duck is more dependent in the HSI model on the density of potential nesting and brooding sites. The variable of most importance to the great egret at the mitigation sites is the availability of feeding habitat, consisting of substrate zones with 4–9 inches of water depth, covered by submerged or emergent vegetation.

Many factors affect the amount of time required for a created wetland to become functional. However, existing data suggest that most aquatic plant species are fast growing and will achieve coverage and density equivalent to naturally occurring wetlands after about 2 years, which is the assumption used for the proposed medium-density planting scheme.

Based upon hydrologic evaluation of the proposed project, it is anticipated that the grasslands and/or forest surrounding the ephemeral pond would periodically flood, but inundation of the ephemeral pond and fringing area proposed for planting would likely not exceed 5 days' duration in any flood event. The suggested plants, once established, can tolerate this duration of flooding without significant impacts to their growth and use for wildlife. Using these assumptions, the habitat value was calculated for each evaluation species and a cost of mitigation for each site was developed. Table 65 presents the FWOP and projected FWP HSI values for the evaluation species for each target year used in the analysis. It also displays FWOP AAHUs at each of the proposed sites, and projects FWP mitigation AAHUs for the proposed sites, if the wetland creation scheme was implemented.

### 10.20.3 IWR-PLAN

IWR-PLAN software was used to perform a cost analysis of the proposed woodland seedling-tree planting and the wetland aquatic planting schemes at each of the proposed, alternative mitigation sites. The software identifies combinations of mitigation measures that produce alternative plans that are cost effective and/or incrementally justified. Plans are identified as cost effective or as Best Buy plans, which are also cost-effective plans. IWR-Plan analyzed each of the proposed mitigation sites and measures and generated 27 possible plan combinations. A total of four cost-effective and four Best Buy mitigation plans were identified and are presented in Table 66. Table 67 provides incremental costs for Best Buy Plan combinations.

IWR-Plan results indicate that implementation of the woodland seedling and wetland planting schemes would be a Best Buy Plan at one individual site, and also leads to additional Best Buy plans when other sites are combined. To fully compensate for project impacts to riparian/hardwood forests and ephemeral wetland habitats, 7.41 and 1.1 AAHUs, respectively, were required for mitigation.

**Table 65**
**AAHUs for Wetland Species at Proposed Mitigation Sites**
**FWOP vs. FWP Mitigation**

| Site 1 (Wetlands) Mottled Duck and Great Egret | Target Years (TY) Compared | Acres (FWOP) | HSI Value (FWOP) | Habitat Units Between TYs (FWOP) | Average Annual Habitat Units (FWOP) | Acres (FWP) | HSI Value (FWP) | Habitat Units Between TYs (FWP) | Average Annual Habitat Units (FWP) | AAHUs Gained at Site 1 (FWP minus FWOP AAHUs) |
|---|---|---|---|---|---|---|---|---|---|---|
| | $TY_1 - TY_0$ | 0 | 0 | 0 | | 3 | 0.13 | 0.13 | | |
| | $TY_2 - TY_1$ | 0 | 0 | 0 | | 3 | 0.45 | 0.87 | | |
| | $TY_3 - TY_2$ | 0 | 0 | 0 | | 3 | 0.71 | 1.74 | | |
| | $TY_{51} - TY_3$ | 0 | 0 | 0 | | 3 | 0.79 | 72.9 | | |
| AAHUs: | | | | | 0 | | | | 1.5 | 1.5 |
| **Site 3 (Wetlands) Mottled Duck and Great Egret** | **Target Years (TY) Compared** | **Acres (FWOP)** | **HSI Value (FWOP)** | **Habitat Units Between TYs (FWOP)** | **Average Annual Habitat Units (FWOP)** | **Acres (FWP)** | **HSI Value (FWP)** | **Habitat Units Between TYs (FWP)** | **Average Annual Habitat Units (FWP)** | **AAHUs Gained at Site 3 (FWP minus FWOP AAHUs)** |
| | $TY_1 - TY_0$ | 0 | 0 | 0 | | 3 | 0.13 | 0.13 | | |
| | $TY_2 - TY_1$ | 0 | 0 | 0 | | 3 | 0.45 | 0.87 | | |
| | $TY_3 - TY_2$ | 0 | 0 | 0 | | 3 | 0.71 | 1.74 | | |
| | $TY_{51} - TY_3$ | 0 | 0 | 0 | | 3 | 0.79 | 72.9 | | |
| AAHUs: | | | | | 0 | | | | 1.5 | 1.5 |

**Table 66**
**IWR-Plan Analysis**
**Costs and Outputs for Cost Effective and Best Buy Plans**

| Plan (Alternative) | Total Annual Cost ($) | Forest Output (AAHUs) | Wetland Output (AAHUs) | Total Output (AAHUs) | Cost Effective |
|---|---|---|---|---|---|
| No Action Plan | 0 | 0 | 0 | 0 | Best Buy |
| A1B0C0 | 3,484 | 7.7 | 1.5 | 9.2 | Best Buy |
| A2B0C0 | 6,485 | 7.7 | 1.5 | 9.2 | No |
| A0B1C0 | 1,134 | 2.1 | 0 | 2.1 | Yes |
| A0B2C0 | 2,385 | 2.1 | 0 | 2.1 | No |
| A1B1C0 | 4,618 | 9.8 | 1.5 | 11.3 | Yes |
| A2B1C0 | 7,619 | 9.8 | 1.5 | 11.3 | No |
| A1B2C0 | 5,869 | 9.8 | 1.5 | 11.3 | No |
| A2B2C0 | 8,870 | 9.8 | 1.5 | 11.3 | No |
| A0B0C1 | 11,240 | 20.6 | 1.5 | 22.1 | Yes |
| A0B0C2 | 19,744 | 20.6 | 1.5 | 22.1 | No |
| A1B0C1 | 14,724 | 28.3 | 3 | 31.3 | Best Buy |
| A2B0C1 | 17,725 | 28.3 | 3 | 31.3 | No |
| A1B0C2 | 23,228 | 28.3 | 3 | 31.3 | No |
| A2B0C2 | 26,229 | 28.3 | 3 | 31.3 | No |
| A0B1C1 | 12,374 | 22.7 | 1.5 | 24.2 | Yes |
| A0B2C1 | 13,625 | 22.7 | 1.5 | 24.2 | No |
| A0B1C2 | 20,878 | 22.7 | 1.5 | 24.2 | No |
| A0B2C2 | 22,129 | 22.7 | 1.5 | 24.2 | No |
| A1B1C1 | 15,858 | 30.4 | 3 | 33.4 | Best Buy |
| A2B1C1 | 18,859 | 30.4 | 3 | 33.4 | No |
| A1B2C1 | 17,109 | 30.4 | 3 | 33.4 | No |
| A2B2C1 | 20,110 | 30.4 | 3 | 33.4 | No |
| A1B1C2 | 24,362 | 30.4 | 3 | 33.4 | No |
| A2B1C2 | 27,363 | 30.4 | 3 | 33.4 | No |
| A1B2C2 | 25,613 | 30.4 | 3 | 33.4 | No |
| A2B2C2 | 28,614 | 30.4 | 3 | 33.4 | No |

KEY:
A1 = Site 1 – North of PA 9 (seedling and wetland measures)
A2 = Site 1 – North of PA 9 (sapling and wetland measures)
B1 = Site 2 – East of PA 9 (seedling measure only)
B2 = Site 2 – East of PA 9 (sapling measure only)
C1 = Site 3 – East of PA 8 (seedling and wetland measures)
C2 = Site 3 – East of PA 8 (sapling and wetland measures)

**Table 67**
**Incremental Cost of Best Buy Plan Combinations**
**(Ordered By Output)**

| Plan (Alternative) | Total Output (AAHUs) | Cost ($1) | Average Cost ($1/AAHU) | Incremental Cost ($1) | Incremental Output (AAHUs) | Incremental Cost ($) Per Output |
|---|---|---|---|---|---|---|
| *No Action Plan* | 0.00 | 0.00 | | | | |
| A1B0C0 | 9.20 | 3,484.00 | 378.69 | 3,484.00 | 9.20 | 378.69 |
| A1B0C1 | 31.30 | 14,724.00 | 470.41 | 11,240.00 | 22.10 | 508.59 |
| A1B1C1 | 33.40 | 15,858.00 | 474.79 | 1,134.00 | 2.10 | 540.00 |

Table 67 shows that Plan A1B0C0 (Site 1) is the most cost effective of all Best Buy plans presented. Tables 64 and 65 reveal that this plan contributes approximately 7.7 AAHUs to the forest habitat and generates about 1.5 AAHUs for newly created wetland habitat, at a total annual cost of $3,484 (see Table 66). The incremental cost per AAHU is $378.69 (see Table 67). The AAHU outputs provided adequately compensate for the losses to forest and wetland habitats resulting from project impacts. The projected first-cost of implementing this plan is approximately $161,000 based on the updated October 2011 price level.

### 10.20.4 Cost Effectiveness and Incremental Cost Analysis Summary

Based on the analysis that was conducted, it was concluded that establishing woodlands on Site 1 by planting mixed tree species consisting of about 150 seedling trees per acre would compensate for the woodland impacts of 7.41 AAHUs on 21 acres, by providing 7.7 AAHUs of woodlands on about 12 acres. In addition, establishing wetlands on Site 1 by creating a 3-acre pond planted with a variety of aquatic plant plugs on 5- to 6-foot centers would compensate for wetland impacts of 1.1 AAHUs on 39 acres, by providing 1.5 AAHUs for wetland habitat on about 3.0 acres. The first cost for implementing the mitigation plan at Site 1, based on the updated October 2011 price level, is $161,000 for planting seedling trees and creating wetlands. O&M for the 50-year period of analysis would consist of additional tallow tree clearing from the mitigation forest area, replanting seedling trees and aquatic vegetation to offset expected mortality, and implementation of mitigation monitoring and contingency plans. These O&M costs would amount to approximately $396,770 for the period of analysis.

## 10.21 MITIGATION MONITORING AND CONTINGENCY PLANS

### 10.21.1 Introduction

Monitoring of mitigation sites is a critical part of the mitigation process. The purpose of monitoring is to:

- obtain an objective assessment of project progress towards predetermined project goals and success criteria;

- identify and correct problems through an adaptive management approach; and
- ensure that USACE Galveston District and Port Freeport (non-Federal sponsor ) meet their compensatory mitigation obligations.

Monitoring of the mitigation sites developed for this proposed project will be a cooperative process. According to ER 1105-2-100, Section C-3(e) (10), the non-Federal sponsor is primarily responsible for mitigation monitoring to determine the success of mitigation measures. While the non-Federal sponsor is responsible for implementing the monitoring plan, the Galveston District will lead initial monitoring efforts, in cooperation with the non-Federal sponsor and the resource agencies (USFWS and TPWD), to ensure successful establishment of the mitigation features (i.e., riparian tree planting and creation of a pond with aquatic vegetation). The Galveston District will review monitoring results and will make decisions regarding corrective actions.

The non-Federal sponsor (Port Freeport) has stated its intent to enter into an agreement with TPWD under terms of a "land conservation easement." The conservation easement would protect and preserve all created mitigation features and would protect the entire 117-acre riparian forest, which would encompass the proposed mitigation seedling plantings. All mitigation lands would be managed and monitored as one continuous ecological unit and would be protected in perpetuity from future development. Under the terms of the conservation easement, TPWD would be responsible for conducting long-term monitoring, once mitigation features are successfully established, to ensure continued success of these features.

## 10.21.2 Success Criteria

Success criteria are used to objectively evaluate the progress of mitigation projects in achieving predetermined objectives and to determine whether corrective actions need to be implemented. Because habitat functions are difficult to measure directly, success criteria may be based on an assessment of the structural attributes of restored habitats. In this way, structural attributes serve as surrogate measures of habitat function. Once site conditions have met or surpassed the predetermined structural thresholds, it is assumed that the desired functions are either currently being provided or will be provided given time.

Separate success criteria have been established for riparian and aquatic pond vegetation plantings. For the riparian forest mitigation feature, success criteria would be based on tree seedling survival. For the aquatic pond plantings, success criteria would be based on area of aquatic plant cover.

## 10.21.3 Riparian Tree Plantings

### 10.21.3.1 Establishment Year

The initial contract for the riparian plantings would require the survival of 90 percent of seedling trees at the end of the first year after completion of planting. To ensure successful establishment,

seedlings would be regularly watered, mulched, and fertilized during the first year. A program of pest/invasive plant control within the seedling planting areas would also be maintained for the establishment year. If the 90 percent targeted survival rate is not met, replacement seedlings would be planted to reach the original planting density of 150 trees per acre. Costs for this survival warranty would be included in the cost of the initial planting contract. Following the establishment year, a 15-year postestablishment monitoring plan would begin.

#### 10.21.3.2 Postestablishment Monitoring

Success criteria for tree seedling survivability are:

- Annually for 5 years after the end of the establishment year, a minimum survival target of 80 percent of original planting density
- At 10 years after the end of the establishment year, a minimum survival target of 75 percent of original planting density
- At 15 years after the end of the establishment year, a minimum survival target of 70 percent of original planting density

Tree mortality for seedlings is expected to approach 30 to 40 percent over the 50-year period of analysis. Supplemental seedling planting to offset tree mortality would occur in years 1–5, 10, and 15 if monitoring indicates that the minimum survival targets for the respective years have not been met. See Section 10.22 for more information on the adaptive management plan.

Success criterion for invasive or exotic plants is:

- Annually for 15 years after the end of the establishment year, invasive or exotic plants cover a maximum of 5 percent of the total acreage planted with tree seedlings

Inasmuch as a known invasive (Chinese tallow) is already present in the mitigation area, it is assumed that monitoring will confirm the presence of invasive/exotic plants in excess of the target maximum in the early years of the monitoring program. Therefore, costs for an annual plant control program are included in the mitigation monitoring cost estimate. Control methods, determined in consultation with resource agencies, would be developed to address specific SOC.

##### *10.21.3.2.1 Monitoring Methods, Timing, and Duration*

The goal for the monitoring program for the riparian tree plantings is to determine the survival rate of the planted seedlings and document the presence/extent of invasive/exotic plant species. Monitoring for survivability would be conducted in years 1–5, 10, and 15 after the end of the establishment year. Monitoring for invasive/exotic species would be conducted annually after the establishment year for 15 years. Field data would be compared to success criteria to determine whether the project has met or exceeded predetermined criteria.

Seedling survival would be recorded by pedestrian survey and photo-documentation. Monitoring data sheets would also document other relevant information such as general site conditions, damage by herbivory or vandalism, and erosion. Photographic monitoring would be conducted: (1) prior to project implementation to document preexisting site conditions: (2) following project implementation: and (3) at the end of annual monitoring of the growing season. Key project areas would be photographed from fixed photo-points (i.e., same station, same angle) to provide a consistent basis for visually comparing seedling growth and development through time. The exact number and location of photo-monitoring stations would be determined in the field during project implementation.

The extent of invasive/exotic species coverage would be documented annually for 15 years after the end of the establishment year by pedestrian survey and photographic monitoring, using the methodology described for tree seedling monitoring above.

#### *10.21.3.2.2 Project Closure*

The riparian mitigation component could be certified as successful at the end of 15 years with a minimum tree seedling survival rate of 70 percent and maximum invasive/exotic plant cover of 5 percent of the total acreage planted with tree seedlings.

### 10.21.4 Aquatic Pond Vegetation

#### 10.21.4.1 Establishment Year

The initial contract for the creation and planting of a wetland pond would require the survival of 60 percent of the planted aquatic vegetation clumps or plugs 1 year after pond creation. Viable herbaceous and grass plants shall be indicated by the evidence of one or more new live plant shoots arising from each separate plant plug or clump. Plugs/clumps would be watered as necessary, and invasive/exotic plants would be removed as needed during the establishment year. If the 60 percent targeted survival rate is not met, replacement plugs/clumps would be replanted to reach the original medium planting density. Corrective actions for pond size, depth, or slope, if needed, would be accomplished during the establishment year. Costs for corrective construction and the plant survivability warranty would be included in the cost of the initial construction and planting contracts. Following the establishment year, a 5-year postestablishment monitoring plan would begin.

#### *10.21.4.1.1 Postestablishment Monitoring*

Success criteria for aquatic plant survivability are:

- At 1 year after the end of the establishment year, a minimum of 30–35 percent aquatic vegetation cover over the pond's total acreage.

- At 3 years after the end of the establishment year, a minimum of 65–70 percent aquatic vegetation cover over the pond's total acreage.
- At 5 years after the end of the establishment year, a minimum of 70–75 percent aquatic vegetation cover over the pond's total acreage.

Supplemental planting to offset aquatic plant mortality or failure to spread naturally would occur in years 1, 3, and 5 if monitoring indicates that the minimum percentage coverage targets for the respective years have not been met. See Section 10.22 for more information on the adaptive management plan.

Success criteria for invasive or exotic plants

- Annually for 5 years after the end of the establishment year, invasive or exotic plants cover a maximum of 5 percent of the total pond acreage.

Inasmuch as a known invasive (Chinese tallow) is already present in the mitigation area, it is assumed that monitoring will confirm the presence of invasive/exotic plants in excess of the target maximum in the early years of the monitoring program. Therefore, costs for an annual plant control program are included in the mitigation monitoring cost estimate. Control methods, determined in consultation with resource agencies, would be developed to address specific SOC.

#### *10.21.4.1.2 Monitoring Methods, Timing, and Duration*

The monitoring goal for evaluation of aquatic pond vegetation is to determine whether the percentage cover of aquatic vegetation is meeting the success criteria for target years. Monitoring would determine whether the aquatic vegetation is establishing itself along the pond perimeter and within the pond by natural colonization, or whether efforts to assist development of aquatic vegetation may be necessary in order to meet minimum percentage cover targets.

Evaluation of aquatic pond vegetation would entail visually assessing and documenting development of vegetation areas within and along the perimeter of the pond, along with the substrates that support aquatic vegetation establishment. Monitoring would include (1) determining area of cover of aquatic vegetation and invasive/exotic species, and (2) documenting overall site conditions through same-station, same-angle photo-monitoring. These monitoring tasks would be performed by pedestrian survey and photographic documentation. Key locations would be photographed from fixed photo-points (i.e., same station, same angle) to provide a consistent basis for visually comparing vegetation growth and development through time. The exact number and location of photo-monitoring stations would be determined in the field during project implementation.

Monitoring for percentage cover of desirable aquatic vegetation would be conducted at years 1, 3, and 5 after the end of the establishment year. Monitoring for invasive/exotic species would be

conducted annually after the establishment year for 5 years. Field data would be compared to the success criteria to determine whether the project has met or exceeded predetermined criteria.

#### *10.21.4.1.3 Project Closure*

The aquatic pond mitigation component could be certified as successful at the end of 5 years with a minimum percentage aquatic plant cover of 70–75 percent and maximum invasive/exotic plant cover of 5 percent of the total pond acreage.

## 10.22 CORRECTIVE ACTIONS (ADAPTIVE MANAGEMENT)

Corrective actions are actions or measures undertaken to address expected plant mortality as well as unforeseen changes to the mitigation features resulting from natural or anthropogenic causes. Corrective actions will be implemented where necessary, in order to meet predetermined success criteria to ensure survival of the mitigation measures.

### 10.22.1 Riparian Tree Plantings

If monitoring indicates that the minimum tree seedling survival rates for the respective monitoring years have not been met, supplemental plantings would be conducted according to original planting specifications. However, the original species composition may be altered to favor those species exhibiting the highest survival rates based on monitoring data. A maximum of two curative replanting responses could be performed, using original planting specifications to achieve success criteria.

### 10.22.2 Aquatic Plantings

If monitoring indicates that the minimum percentage aquatic vegetation cover for the respective monitoring years has not been met, supplemental plantings would be conducted using original planting specifications. Replanted areas would be inspected within 60 days following replanting to determine whether those replanting efforts meet the threshold of a satisfactory stand. "Satisfactory stand" is defined as planting areas with at least a 50–60 percent survival rate within 60 calendar days following the planting effort. Viable herbaceous and grass plants shall be indicated by the evidence of one or more new live plant shoots arising from each separate plant plug or clump.

### 10.22.3 Adaptive Management Costs

Adaptive management costs are included in the O&M cost for the mitigation plan and described in the Operations and Maintenance Manual. Potential adaptive management costs for the 50-year period of analysis are contained in Table 68 below.

**Table 68**
**Adaptive Management Costs**

| Task Description | Frequency | Cost ($) |
|---|---|---|
| Replant Trees<br>(12 acres @ 50 trees/acre) | Twice<br>(As Required) | 31,680 |
| Replant Aquatic Vegetation for Pond<br>(3 acres using original planting specifications) | Twice<br>(As Required) | 7,920 |
| | Total | 39,600 |

### 10.22.4 Annual Monitoring Reports

Monitoring reports would be prepared by the non-Federal sponsor and submitted to the Galveston District annually during the 15-year and 5-year monitoring periods for the riparian trees and aquatic vegetation, respectively. Copies of this report would be provided to representatives of the consulting State and Federal agencies. Monitoring would continue until it has been demonstrated that the mitigation has met the ecological success criteria as documented by the District Engineer and determined by the Division Commander. It is anticipated that ecological success criteria for the riparian tree and aquatic tree planting would be met by Year 15 and Year 5, respectively, and that monitoring will cease when certification is achieved.

Monitoring reports would contain all monitoring data and photographs, and all annual results will be presented in cumulative fashion. Monitoring reports would be submitted to the Galveston District within 3 months of when the monitoring was conducted.

The first report would be submitted after initial mitigation construction has been completed (i.e., riparian tree planting and planting of aquatic vegetation). This report would document and detail the mitigation effort. Any variances from the work plan or standard practices described in the mitigation plan would be noted in this document. A summary of work activities and their respective start and completion dates would be included.

Monitoring reports would consist of introduction, methods, results, and discussion sections. The introduction would include a brief narrative description of existing conditions, a site location map, maps showing key sampling locations (i.e., transects, photo-stations, etc.), and a review of success criteria. The methods section of the report would detail the methodology used to assess project performance for the mitigation features. Results from monitoring riparian tree plantings and aquatic vegetation would be summarized in the results section in tables and/or as text. Monitoring data sheets would be included as an appendix. The results section would also include one set of labeled photographs taken at each of the fixed-point photo-monitoring stations.

The discussion section of monitoring reports for both the riparian and aquatic components would include an assessment of project success based on the monitoring results directly related to set success criteria. The need for any corrective actions (i.e., supplemental planting) would also be

identified in this section. If necessary, a proposed schedule for implementing corrective actions would be included. The discussion section would also include a description of any problems observed within the project site including, but not limited to, excessive inundation, drought, invasion by undesirable plant species, herbivory damage, plant diseases, excessive erosion, and evidence of vandalism or inadvertent damage.

### 10.22.5 Final Close-Out Monitoring Report

A final "close-out" monitoring report would be submitted following certification that success criteria have been met for the riparian trees and aquatic vegetation mitigation areas. This report would include data and a description of the final monitoring evaluation. It would also provide a summary and analyses of annual monitoring results for the monitoring period for the entire mitigation site.

## 10.23 MITIGATION MONITORING AND REPORTING COSTS

Monitoring and reporting costs would be included in the O&M cost for the mitigation plan and described in the Operations and Maintenance Manual. Projected monitoring and reporting costs for the 50-year period of analysis are found in Table 69.

**Table 69**
**Mitigation Monitoring and Reporting Costs**

| Task Description | Monitoring Interval | Cost ($) |
|---|---|---|
| Monitoring of Trees/Pond | Annual (Years 1–5, 10, 15) | 44,330 |
| Monitoring of Pond Aquatic Vegetation | (Years 1, 3, and 5) | 27,280 |
| Invasive Plant Control | Years 1, 2, 3, 4, and 5 (estimated) | 66,000 |
| Monitoring Report | Annual | 82,500 |
| | Total | 220,110 |

# 11.0 50-YEAR DREDGED MATERIAL MANAGEMENT PLAN EVALUATION AND SELECTION

## 11.1 DREDGED MATERIAL PLACEMENT PLAN

Deepening and widening Freeport Harbor to 55/50 feet by 600 feet, as well as the deepening and widening of the Stauffer Channel, will generate approximately 14.3 mcy of new work material and 176 mcy of additional maintenance material over the 50-year period of analysis. New work and maintenance dredged material from berthing areas outside of the Federal Channel (or any other non-Federal interest maintenance responsibilities) anticipated for placement in the placement sites for this project are insignificant when compared to the quantities associated with the Federal project and will not reduce the availability of the disposal facility for Federal navigation purposes; therefore, no additional non-Federal improvements to the placement sites are expected to be required to support containment of non-Federal interests dredged material. Approximately 680 acres of upland confined placement areas as well as one ocean dispersive site with unlimited capacity exist for development of a viable placement plan. Material will be placed in new upland sites and offshore sites.

To evaluate alternatives for placement of this material, existing placement areas were evaluated, along with a new area owned by the non-Federal sponsor. Each alternative plan mixed possible placement methods to maximize potential beneficial uses while minimizing costs.

Each of these plans had similar concepts. No alternative other than upland confined placement was considered for the Main and Stauffer channels due to the availability of existing sites near this channel reach with sufficient existing and future capacity for the required maintenance as well as concerns about contaminants in this highly industrialized area. The close proximity of available land owned by the non-Federal sponsor made upland confined placement the least-cost option.

## 11.2 50-YEAR CAPACITY AND DREDGED MATERIAL MANAGEMENT PLAN

### 11.2.1 Environmental Restrictions Pertaining to Upland and Offshore Dredge Material Placement

#### 11.2.1.1 Upland PA Water Quality

The upland PA levee designs include freeboard allowances that provide needed settling time of soil particles within effluent discharge material at the PA, promote lower levels of turbidity in fluids exiting the drop-outlet structures, and support efforts at meeting the legal/allowable turbidity levels. Development of levee height requirements on this project was based on an

allowance of 3 feet of freeboard above the bulked dredge fill height for each dredging event. Other factors may influence settling time including the discharge flow rate implemented by the dredging contractor. Specification language is added at the time contract plans and specifications are produced that provides additional restrictions on contractor dredging operations such that effluent concentrations at drop-outlet structure are within legal/allowable limits.

#### 11.2.1.2 Ocean Dredged Material Disposal Site

ODMDS areas were modeled using MDFATE to analyze the effects of offshore placement to ensure conformance with fill-height restrictions on the bottom of the seafloor and other EPA criteria. The offshore dredge material quantities estimated for the Recommended Plan are shown in Table 70.

### 11.2.2 Dredge Materials and Potential for Beneficial Use

Results from bed sediment studies (from the *Desktop Sediment Study for Freeport Project* generated by ERDC and Hydrology and Hydraulics [H&H]), for bed sediment data collected between September 1987 through May 2000, indicate the following average percentages of bed sediments have been encountered in the channel:

1. Outer Bar – About 82 percent fine-grained sediments (silts and clays) and 18 percent sands
2. Jetty Channel – About 86 percent fine-grained sediments (silts and clays) and 14 percent sands
3. Freeport Harbor Channel – About 95 percent fine-grained sediments (silts and clays) and 5 percent sands

A review of new work materials from boring data starting at the Upper Turning Basin on out to sea indicate about 80 to 90 percent clays (of primarily stiff consistency with some traces of silts or clayey silts) and about 10 to 20 percent sands of various densities.

Based on groundwork done in the Widening Project study by Port Freeport, which included considering applicability and functionality of material types for particular beneficial use features, cost effectiveness, permanence of features, and other considerations explored by the widening project DMMP workgroup, the decision was made by the Project Delivery Team on the USACE's deepening and widening project to forgo pursuit of beneficial use features in the final selected dredge material management plan.

## 11.3 50-YEAR CAPACITY AND DREDGE MATERIAL PLACEMENT DESIGNATION

Table 70 displays the breakout of new work from the channel and anticipated distribution to the PA sites. Table 71 displays the 50-year levee elevations required for capacity and the anticipated cyclical maintenance dredging of the Main Channel and Stauffer Channel.

## 11.4 OCEAN DREDGE MATERIAL DISPOSAL SITES

Existing Maintenance and New Work ODMDSs are located within the project area at the coordinates below. These are dispersive sites consisting of approximately 1,291 and 2,236 acres, respectively, and were originally designated in the EPA FEIS for the Freeport Harbor 45-foot Project in January 1990. In August 2008, USACE gained EPA concurrence for placing maintenance and new work dredged material from the proposed project into these sites. Modeling was conducted for these sites, and it was determined that sufficient space exists for maintenance and new work material placement from both the non-Federal permit widening project and the proposed Federal project.

1) Maintenance ODMDS: The Maintenance ODMDS is located approximately 3 miles offshore and about 1,000 feet southwest of the centerline of the Outer Bar Channel. The site is rectangular in shape with corner coordinates located at:

   28°54′00″N, 95°15′49″W; 28°53′28″N, 95°15′16″W;

   28°52′00″N, 95°16′59″W; 28°52’32″N, 95°17′32″W

2) New Work ODMDS: The New Work ODMDS is located approximately 6 miles offshore. The site is bounded by the following coordinates:

   28°50′51″N, 95°13′54″W; 28°51′44″N, 95°14′49″W;

   28°50′15″N, 95°16′40″W; 28°49′22″N, 95°15′45″W

In this plan, all of the new work material from the Outer Bar Channel portion of the proposed Federal channel was evaluated for placement offshore.

**Table 70**
**Freeport Harbor Channel Improvement Project – Summary of New Work Dredging**

| Freeport Harbor Deepening & Widening – Summary of New Work Dredging | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Alternative | Channel Reaches | Channel Reach Stationing | | Required Quantity (cy) | Overdepth Quantity (cy) | Total Quantity (cy) | Dredging Stationing & Placement Site Designation | | | Quantity Breakdown to Placement Sites (cy) |
| | | To | From | | | | To | From | Site | |
| NED | Future Channel Extension | –470+00 | –300+00 | 2,000,000 | 670,000 | 2,670,000 | –470+00 | –300+00 | ODMDS 1 | 14,957,454 |
| | Outer Bar Channel | –300+00 | 00+00 | 7,800,000 | 1,300,000 | 9,100,000 | –300+00 | 00+00 | | |
| | Jetty Channel | 00+00 | 71+52 | 2,900,000 | 287,000 | 3,187,000 | 00+00 | 71+52 | | |
| | Lower Turn Basin | 71+52 | 78+52 | 280,000 | 38,000 | 318,000 | 71+52 | 78+52 | PA 8 | 2,087,559 |
| | Ch to Brazosport & New 1,200-foot Brazosport TB | 78+52 | 115+00 | 2,200,000 | 116,000 | 2,316,000 | 78+52 | 102+00 | | |
| | | | | | | | 102+00 | 115+00 | PA 9 | 3,396,987 |
| | Ch from Brazosport TB | 115+00 | 132+66 | 513,000 | 34,000 | 547,000 | 115+00 | 132+66 | | |
| | Ch to Upper TB & Upper TB | 132+66 | 184+20 | 380,000 | 110,000 | 490,000 | 132+66 | 184+20 | | |
| | Stauffer Channel, Lower Stauffer TB | 184+20 | 222+00 | 1,340,000 | 45,000 | 1,113,000 | 184+20 | 222+00 | | |
| | Stauffer Channel, Upper Staffer & TB | 222+00 | 260+00 | 390,000 | 37,000 | 427,000 | 222+00 | 260+00 | | |
| | **Total** | | | **17,803,000** | **2,639,000** | **20,442,000** | | | | **20,442,000** |
| LPP | Future Channel Extension | –370+00 | –300+00 | 500,000 | 295,000 | 795,000 | –470+00 | –300+00 | ODMDS 1 | 9,733,297 |
| | Outer Bar Channel | –300+00 | 00+00 | 4,990,000 | 1,300,000 | 6,290,000 | –300+00 | 00+00 | | |
| | Jetty Channel | 00+00 | 71+52 | 2,345,000 | 303,000 | 2,648,000 | 00+00 | 71+52 | | |
| | Lower Turn Basin | 71+52 | 78+52 | 170,000 | 38,000 | 208,000 | 71+52 | 78+52 | PA 8 | 1,853,144 |
| | Ch to Brazosport & New 1,200-foot Brazosport TB | 78+52 | 115+00 | 1,600,000 | 116,000 | 1,716,000 | 78+52 | 105+20 | | |
| | | | | | | | 105+20 | 115+00 | PA 9 | 2,765,559 |
| | Ch from Brazosport TB | 115+00 | 132+66 | 357,000 | 34,000 | 391,000 | 115+00 | 132+66 | | |
| | Ch to Upper TB & Upper TB | 132+66 | 184+20 | 380,000 | 110,000 | 490,000 | 132+66 | 184+20 | | |
| | Stauffer Channel, Lower Stauffer TB | 184+20 | 222+00 | 1,340,000 | 47,000 | 1,387,000 | 184+20 | 222+00 | | |
| | Stauffer Channel, Upper Staffer & TB | 222+00 | 260+00 | 390,000 | 37,000 | 427,000 | 222+00 | 260+00 | | |
| | **Total** | | | **12,072,000** | **2,280,000** | **14,352,000** | | | | **14,352,000** |

**Table 71**
**Freeport Harbor Channel Improvement Project – Summary of Maintenance Dredging & Placement Area Parameters**

**Freeport Harbor Deepening & Widening - Summary of Maintenance Dredging & Placement Area Parameters**

| Alternative | Channel Reaches | Channel Reach Stationing To | Channel Reach Stationing From | Annual Shoaling Rate From Channel Reaches (CY) | Dredging Stationing & Placement Site Designation To | Dredging Stationing & Placement Site Designation From | Dredging Stationing & Placement Site Designation Site | Approximate Size of Placement Site (Ac) | Aprx. Existing Levee Elevation (ft in MLT) | 1st Construction Lev. Elev. (ft in MLT) | Shaped NW Lev. Elev. (ft in MLT) | 50-Year Levee Elev. (ft in MLT) | Annual Shoaling Rate to Placement Site (CY) | Years Per Cycle | Dredge Quantity Per Cycle (CY) | Total Number of Cycles | Total 50-Year Maintenance Dredging Quantity (cu yds) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NED | NED Extension | -450+00 | -300+00 | 1,044,448 | -450+00 | -300+00 | | | | | | | | | | | |
| | Entrance Bar Channel | -300+00 | 00+00 | 2,088,897 | -300+00 | 00+00 | ODMS 1A | 1,291 | NA | NA | NA | NA | 3,472,580 | 1 | 3,472,580 | 50 | 173,628,985 |
| | Jetty Channel | 00+00 | 71+52 | 316,289 | 00+00 | 71+52 | | | | | | | | | | | |
| | Lower Turning Basin | 71+52 | 78+52 | 22,946 | 71+52 | 78+52 | | | | | | | | | | | |
| | Ch to Brzpt & Brzpt TB | 78+52 | 115+52 | 142,181 | 78+52 | 90+20 | PA 1 | 320 | 29.0 | 31.5 | 31.5 | 33.5 | 44,883 | 3 | 134,649 | 16 | 2,154,384 |
| | | | | | 90+20 | 115+52 | PA 8 | 168 | NA[1] | 20.0 | 32.5 | 32.5 | 119,183 | 3 | 357,550 | 16 | 5,720,805 |
| | Ch to Upper TB | 115+52 | 132+66 | 57,889 | 115+52 | 122+00 | | | | | | | | | | | |
| | | | | | 122+00 | 132+66 | | | | | | | | | | | |
| | Ch to UP TB & UP TB | 132+66 | 184+20 | 141,697 | 132+66 | 184+20 | PA 9 | 254 | NA[1] | 20.0 | 32.5 | 32.5 | 177,700 | 3 | 533,101 | 16 | 8,529,620 |
| | Lower Stauffer TB | 184+20 | 222+00 | 4,826 | 184+20 | 222+00 | | | | | | | | | | | |
| | Upper Staffer TB | 222+00 | 260+00 | 5,000 | 222+00 | 260+00 | | | | | | | 9,826 | 12 | 117,912 | 4 | 471,648 |
| | **Total** | | | **3,824,173** | | | | | | | | | **3,824,173** | | | | **190,505,443** |
| LPP | NED Extension | -450+00 | -300+00 | 873,159 | -450+00 | -300+00 | | | | | | | | | | | |
| | Entrance Bar Channel | -300+00 | 00+00 | 1,969,531 | -300+00 | 00+00 | ODMS 1A | 1,291 | NA | NA | NA | NA | 3,188,339 | 1 | 3,188,339 | 50 | 159,416,960 |
| | Jetty Channel | 00+00 | 71+52 | 324,554 | 00+00 | 71+52 | | | | | | | | | | | |
| | Lower Turning Basin | 71+52 | 78+52 | 21,095 | 71+52 | 78+52 | | | | | | | | | | | |
| | Ch to Brzpt & Brzpt TB | 78+52 | 115+52 | 132,400 | 78+52 | 89+10 | PA 1 | 320 | 29.0 | 31.5 | 31.5 | 33.5 | 37,859 | 3 | 113,577 | 16 | 1,817,240 |
| | | | | | 89+10 | 115+52 | PA 8 | 168 | NA[1] | 18.5 | 32.0 | 32.0 | 119,008 | 3 | 357,025 | 16 | 5,712,400 |
| | Ch to Upper TB | 115+52 | 132+66 | 53,220 | 115+52 | 123+40 | | | | | | | | | | | |
| | | | | | 123+40 | 132+66 | | | | | | | | | | | |
| | Ch to UP TB & UP TB | 132+66 | 184+20 | 141,697 | 132+66 | 184+20 | PA 9 | 254 | NA[1] | 18.5 | 32.0 | 32.0 | 170,450 | 3 | 511,350 | 16 | 8,181,594 |
| | Lower Stauffer TB | 184+20 | 222+00 | 11,507 | 184+20 | 222+00 | | | | | | | 16,907 | 12 | 202,884 | 4 | 811,536 |
| | Upper Staffer TB | 222+00 | 260+00 | 5,400 | 222+00 | 260+00 | | | | | | | | | | | |
| | **Total** | | | **3,532,564** | | | | | | | | | **3,532,564** | | | | **175,939,729** |

Notes:

1) For new PA 8 & 9, an existing ground elevation level of 5 feet MLT is assumed at start of project. Detailed elevation surveys will be performed during subsequent design phases of the project. The initial assumed elevation is anticipated to be on the upper end of the range of potential existing elevations at these new sites.

2) For materials designated to go offshore, approximately 1 million cubic yards per year falls within footprint of separate widening permit action being pursued by Port of Freeport.

## 11.5 UPLAND CONFINED PLACEMENT PLAN

There are a number of existing upland confined sites at Freeport. The Freeport Harbor Project currently uses PA 1, a 330-acre site. Two other PAs, PA 2 and PA 3 (see Figure 2), are designated for use by GIWW dredging. An estimated additional 418 acres were needed for the proposed project.

In this plan, all of the material from the Main Channel (Lower Turning Basin to the Upper Turning Basin) and the Stauffer Channel is to be placed in upland confined sites, PAs 8 and 9.

### 11.5.1 Existing Placement Area 1

Existing PA 1 is located in Freeport about 0.5 mile south of SH 36 and about 1,000 feet east of the Brazos River Diversion Channel. It is estimated at approximately 320 acres in size, with about 20,310 linear feet of exterior perimeter levee, an assumed average interior elevation of 26 feet MLT, and assumed average levee elevation of 29 feet MLT. Assumed average elevations are based on anticipated elevations following the completion of O&M contract awarded in 2009.

### 11.5.2 New Placement Area 8

New PA 8 is located in Freeport just north of SH 36 and approximately 1,600 feet west of the Brazos River Diversion Channel. PA 8 is about 168 acres, with a perimeter length of about 11,480 linear feet, and assumed existing ground elevation around 5 feet MLT. As a currently undeveloped site, and given the proximity to the coast, an initial assumed elevation of 5 feet MLT is anticipated to be on the upper end of the range of potential existing elevations at the site.

### 11.5.3 New Placement Area 9

New PA 9 is located in Freeport just north of Old SH 36, and approximately 300 feet west of the Brazos River Diversion Channel. PA 9 is about 250 acres, with a perimeter length of about 14,000 linear feet, and assumed existing ground elevation around 5 feet MLT. With the proximity to the coast and fact that the land is undeveloped, this initial assumed elevation is anticipated to be on the upper end of the range of potential existing elevations at the site.

### 11.5.4 Verification of Placement Area Elevation Data

The above approximate elevations have been used by Geotechnical Engineering in the preliminary engineering calculations used to produce the cost estimates. During PED or subsequent design phases, the latest available survey data will be utilized and the engineering quantity estimates will be updated accordingly.

## 11.6 BENEFICIAL USE PLACEMENT PLAN

One of the main interests in the consideration of a 50-year DMMP is to maximize the use of suitable-quality dredged material for beneficial purposes. In coordination with the resource agencies and the public, beneficial uses were investigated to determine the feasibility of implementation. Because of the unsuitability of the dredged material, the presence of sensitive resources at sites, and the prohibitive cost of placement at one site, no beneficial use plan was developed.

## 11.7 DREDGED MATERIAL MANAGEMENT PLAN

### 11.7.1 Outer Bar Channel – Stations –370+00 to 71+52.58

All material, both new work and maintenance, will be placed in offshore sites. All of these sites are unconfined, and no structural control will be utilized to contain material. Deepening and widening of the channel will generate approximately 12.7 mcy of new work material and 3.4 mcy of maintenance material annually.

### 11.7.2 Main Channel – Stations 71+52.58 to 184+20

Deepening and widening of this portion of the channel will generate approximately 2.8 mcy of new work material and 364,000 cy of maintenance material annually. New work material is largely made up of sandy clay while the maintenance material is expected to be composed of silt or sandy silt, which will be placed in confined upland PAs.

### 11.7.3 Stauffer Channel – Stations 184+20 to 256+00

Deepening and widening of Stauffer Channel will generate approximately 1.8 mcy of new work material and 187,000 cy of maintenance material annually. New work material generated from deepening and widening of the Stauffer Channel will be placed in new PA 9. Due to the large clay component of the new work material, it will be used in the future to elevate the levees of the PA to contain future maintenance material.

# 12.0 PLAN SELECTION, RECOMMENDED PLAN, AND PLAN IMPLEMENTATION

## 12.1 OVERVIEW

The previous chapters described the analyses conducted during the planning study process to identify the NED Plan and the LPP with the ultimate goal of identifying the Recommended Plan. The plan selected will be recommended for implementation to the U.S. Congress. The Recommended Plan addresses the problems and opportunities identified at the beginning of the study and satisfies the planning objectives of increasing navigation efficiency and reliability along the Freeport Harbor Channel while maintaining or enhancing terrestrial, cultural, estuarine, and coastal resources within the project area.

As described in Section 8.2, all elevations referred to in this report, unless specifically noted otherwise, are based on Galveston District's local MLT datum. Army regulations and HQ guidance on tidal datum, provided in ETL 1110-2-349 *REQUIREMENTS AND PROCEDURES FOR REFERENCING COASTAL NAVIGATION PROJECTS TO MEAN LOWER LOW WATER DATUM*, dated April 1, 1993, and EM 1110-2-1003, April 1, 2002, stress the necessity of converting local datum, such as MLT to MLLW. EM 1110-2-1003 further states that MLLW should be tied to the NAVD 88. The Galveston District has an established survey control network along the Freeport Harbor Channel. To comply with the above-referenced guidance on referencing tidal datums using MLLW, the Galveston District took vertical survey measurements at tide gages and benchmarks to estimate the relative difference between MLT and MLLW datums along the Freeport Channel. The objective was to maintain an effective water depth of 55 feet while correctly referencing resulting water surface level in MLLW.

At Freeport Channel, datum values for MLLW are +1 foot above MLT. However, this does not result in increased water depth, as the additional +1 foot of nominal depth is actually +1 foot above the normal surface water level. Therefore, the actual water depths are equivalent between a 55-foot MLT channel template and a 56-foot MLLW channel template. As the study and its documentation was completed using MLT, references to MLT have been maintained throughout this document, though numbers are also referenced in MLLW depths at some locations in the report. These references are in parentheses, and the datum is referenced at each reference point. The Recommended Plan, described below, is the LPP, the plan preferred by the non-Federal sponsor. The current discount rate of 4.0 percent was used, and the period of analysis is 50 years.

## 12.2 RISK AND UNCERTAINTY

Risk and uncertainty is an important part of the USACE planning process and feasibility analyses. The "Economic and Environmental Principles for Water and Related Land Resources Implementation Studies," established pursuant to WRDA 65 (PL 89-80), as amended (42 United

States Code [USC] 1962, a-2 and d-1), requires that areas of risk and uncertainty be identified and clearly described so that public investment decisions can be made by the degree of reliability of estimated costs, benefits, and effectiveness of alternative plans. This approach captures and quantifies the extent of risk and uncertainty in the various planning and design components of a project. The total effect of risk and uncertainty on the project's design and viability can be examined and conscious decisions made reflecting an explicit trade-off between risks and costs.

More recently, risk-informed decision-making has been emphasized as one of the four major themes in the USACE Actions for Change. This policy, developed from analyses done by the Interagency Performance Evaluation Taskforce in the aftermath of Hurricane Katrina, pointed to the need for organizational changes to transform USACE priorities, processes, and planning in an effort to improve public safety and USACE infrastructure. USACE has committed to developing and employing risk- and reliability-based approaches that evaluate the consequences of design, construction, and management decisions, especially as they affect risks to human health and safety.

Risk and uncertainty arise from measurement errors and the underlying variability of complex natural, social, and economic situations. Plans may be subject to measurement errors if the data are imperfect or the analytical tools are crude. Some future demographic, economic, or navigational uses are essentially unpredictable because they are subject to random influences. However, in some cases, the randomness can be approximated by developing a probability distribution using a historical database that is applicable to the future. If there is no such historical data base, the probability distribution of random future events can be described subjectively, based on best-available insight and judgment (ER 1105-2-100, E-4.a(3)). The latter case could also be applied to situations in which there is uncertainty as to whether historical conditions can be reliably applied to the future. Such is likely the case with environmental parameters affected by global warming, such as sea level rise. None of the historical databases in use today can reliably be used to predict future conditions in which the rates of change are clearly diverging from historical precedents (Intergovernmental Panel on Climate Change [IPCC], 2007).

A variety of specific technical terms and concepts that are employed in risk and uncertainty analysis are described below:

- "Risk" is the probability that a hazardous outcome will occur as a consequence of uncertainty. It is "conventionally defined as those (situations) in which the potential outcome can be described in reasonably well known probability distribution" (ER 1105-2-100, E-4.a.(1)). These distributions are generally based upon well-established, empirical data (historical or experimental). The best-known examples of this concept are applied in flood risk management projects.
- "Uncertainty" is a measure of imprecision of knowledge of parameters and functions used to describe the hydraulic, geotechnical, ecological, and economic aspects of a

project. "In situations of uncertainty, potential outcomes cannot be described in objectively known probability distributions. . . . Because there are no known probability distributions to describe uncertain outcomes, uncertainty is substantially more difficult to analyze than risk" (ER 1105-2-100, E-4.a.(2)).

- "Risk-based analysis" is defined as "an approach to evaluation and decision-making that explicitly . . . incorporates consideration of risk and uncertainty to compare plans in terms of likelihood and variability of physical performance, economic success and residual risk" (ER 1105-2-100, 2-4.g). Analytical evaluation is sometimes restricted by a lack of data and understanding of biological and physical processes, effectively limiting risk considerations to more-subjective comparisons.
- "Sensitivity analysis" is a technique that varies assumptions of economic, demographic, environmental, and other factors and examines the effects of varying these assumptions on outcomes of benefits and costs (ER 1105-2-100, E-4.b.(1)(b)(6)).
- "Residual risk" is a concept best understood in relation to flood risk management studies. However, for navigation studies, one type of residual risk might be risk that benefits are foregone to those situations where LPPs are selected over the NED, such as in this study.

### 12.2.1 Uncertainty in Technical Evaluations

Forecasting future scenarios is an important part of the USACE planning process. In order to evaluate the risks and benefits of alternatives over the period of analysis, a forecast is created based on historical and existing information, as well as quantitative and qualitative assumptions about what may happen within the study area in the future. One method is to identify the "most likely" future or the best guess about what may happen based on observed variables and assumptions of both natural and human behavior. Another method is to conduct scenario planning, where multiple future scenarios are created in order to evaluate what would happen if observed variables or assumptions do not happen as projected. Scenario planning attempts to answer the "what if" questions that arise when making forecasting assumptions and predictions. For the Freeport Harbor Feasibility, the "most likely future" method was chosen due to project scope.

#### 12.2.1.1 Engineering Data and Models

After the identification of the most likely FWOP scenario for the Freeport Harbor Channel, the next step was the evaluation of alternatives using H&H models and economic models. H&H models included RMA-2 and TABS MD numerical hydrodynamic models, ADCIRC and GENESIS.

The primary objective of the hydrodynamic model studies was to provide accurate and representative current velocity fields for use in the ship simulator for the navigation study. The secondary objective was the development of a tool that was used to evaluate the general impacts

of the design alternative improvements on circulation in the harbor. Field data were collected for the hydrodynamic models. The study developed a numerical hydrodynamic model using the TABS-MD modeling system with the Surface-water Modeling System as the graphical user interface. The computational mesh was designed to capture all of the major details of the existing and proposed design alternatives. This study takes into account the proposed LNG terminal.

The numerical model was verified to the field data. The verification was performed by comparing the model to observed water surface elevation fluctuations and to current velocity variations. After the model was verified, the computation mesh was revised to reflect the two design alternatives. The model was then run for the verification period with each of the two alternatives. The simulations were examined for extreme maximum flood and ebb currents, and those conditions were provided to the ship simulator for incorporation into the navigation study. The results showed that the numerical model was reasonably verified against field observations to make it a valuable tool in the evaluation of circulation effects associated with the design alternatives.

A cursory-level numerical study was conducted to determine whether the planned improvements to the channel will make Freeport Harbor and adjacent, low-lying areas more susceptible to inundation due to hurricane-induced storm surge. The improvements modeled was the 60-x-600-foot channel with a 1,350-foot Brazosport Turning Basin, which removes a portion of the southeastern peninsula (North Wave Barrier) that separates the GIWW from the harbor proper, and the proposed LNG improvements. The existing ADCIRC model that was developed for a coastal erosion study was adapted to depict the planned harbor configuration. Hurricanes selected for simulation were based on the September 1941 hurricane and Hurricane Fern, which impacted the Texas coast in September 1971. These hurricanes were selected because both came within close proximity to the study area and produced relatively high surges. Stronger hurricanes, such as the 1900 Hurricane, were omitted from the analysis because they would have generated significantly greater overland flooding; this, in turn, hampers determining whether the planned improvements make the Freeport Harbor more susceptible to storm surge. The model found little change in peak water-surface elevations within the harbor resulting from the planned improvements. Estimated increases were about 0.16 foot. Consequently, the planned harbor improvements do not appear to make the harbor and adjacent low-lying areas more susceptible to storm surge from less-intense hurricanes.

A shoreline impact study was conducted to assess the wave-induced impacts of the proposed deepening of the Freeport Channel in the Gulf of Mexico on the open-coastal shorelines adjacent to the project area. This study used the numerical model GENESIS to compute sediment transport rates and shoreline change rates for each of the four proposed channels. Comparing the GENESIS output for the existing condition with the proposed channels output revealed the effects of the bathymetry changes on the wave-induced longshore transport and the shoreline change rate. Breaker wave heights and angle inputs to GENESIS were obtained from the

numerical wave propagation and refraction model, STWAVE. STWAVE modeled the refraction over the different bathymetry grids corresponding to the existing and proposed channels. Texas shoreline change rates have been calculated by the Bureau of Economic Geology. Their change rates were obtained using a regression analysis of the available shorelines. Their analysis shows that in the vicinity of Freeport Harbor, the shoreline is eroding at a rate of 9 to 10 ft/yr. Five to six miles northeast of the harbor, the shoreline is shown to be stable, and farther northeast it again becomes erosional. Between the Brazos and the San Bernard River mouths, the shoreline is very dynamic, with strong erosional and accretional regions. The conclusion from this analysis is that if any of the proposed deepening alternatives for the Freeport Outer Bar Channel are constructed, the wave-induced sediment transport impacts on the adjacent shorelines will be so slight as to not be noticeable and will be dwarfed by the interannual variability in shoreline position.

#### 12.2.1.2 Economic Analysis

Economic analysis was based on the existing traffic base and vessel utilization. Traffic forecasts were projected for the "most likely" scenario. Project alternatives were evaluated and benefit calculations made. Transportation savings benefits were established and benefit-cost analysis was conducted.

## 12.3 SENSITIVITY OF PROJECT ALTERNATIVES TO RELATIVE SEA LEVEL RISE

Sea level rise can affect coastal communities and habitats in a variety of different ways, including submerging low-lying lands, eroding beaches, converting wetlands to open water, intensifying coastal flooding, and increasing the salinity of estuaries and freshwater aquifers. It is caused by a number of natural and human-induced factors and can vary by region. Some impacts of sea level rise can already be observed along the U.S. coast. The primary causes of global sea level rise are the expansion of ocean water due to warming and the melting of glaciers and ice sheets. Locally, sea level rise is also influenced by changes to the geology of coastal land.

RSLR consists of two components: global (eustatic) sea level rise and local subsidence. The uncertainty inherent in the rates of eustatic sea level rise is evident in the variability of the different modeled rates given for the National Research Council (NRC, 1987) projections and the IPCC (2007). A similar degree of uncertainty exists with the rate of local subsidence.

Recent USACE guidance (Engineering Circular [EC] 1165-2-211, July 2009) provides direction for incorporating the direct and indirect physical effects of projected future sea level change in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects. Recent climate research by the IPCC predicts continued or accelerated global warming for the twenty-first century and possibly beyond, which will cause a

continued or accelerated rise in global mean sea level. Impacts to coastal and estuarine zones caused by sea level change must be considered in all phases of Civil Works programs.

In order to meet the requirements of EC 1165-2-211, the sensitivity of project alternatives to potential FWOP changes in sea level must be evaluated. The range of RSLR was determined using both tide gage and basal peat data for the local subsidence component of RSLR. Tide gage data reflect the effects of recent historical subsidence.

The recent historic rate of local RSLR extracted from the NOAA tide gage at Freeport, Texas, is 0.0143 ft/yr, for the 52-year period between 1954 and 2006 (NOAA, 2006). Data originated by NRC (1987) and modified by IPCC (2007) assume a historic eustatic rate equal to the globally averaged rate, which is 1.7 mm/year (0.0056 ft/yr). Subtracting the historic eustatic rate from the local RSLR rate yields an estimated observed subsidence rate of 2.65 mm/yr (0.0087 ft/yr) for the Freeport area.

To date, however, there is no scientific consensus concerning the projection of future subsidence rates in the Texas and Louisiana coastal region. The relative influence of historic anthropogenic activities in this area (e.g., oil and gas withdrawal) is difficult to quantify. If these activities contributed significantly to recent observations of subsidence, then significant reductions or cessation of these activities may result in rapid deceleration of subsidence rates, returning them to long-term average rates.

Several studies of basal peat layers have been conducted in the Texas and Louisiana coastal region to determine estimates of the long-term average rates of subsidence. These rates are generally on the order to 0.5 mm/yr (0.0016 ft/yr) (Törnqvist et al., 2006). This rate is significantly lower than the observed tide gage rates. Therefore, if historic anthropogenic activities are largely responsible for the accelerated rates observed in the tide records, then we would expect the projected rates to decelerate rapidly over the next several decades.

Deriving RSLR estimates using both basal peat and tide gage data, possible RSLR rates were estimated for a 50-year period of analysis (the period from 2015 to 2065) to range from 0.36 to 2.40 feet. Possible low (historic), intermediate, and high RSLR rates are given for subsidence values that correspond to both the observed tidal gage values (rapid subsidence), and the observed basal peat values (moderate subsidence) and are as follows:

- 0.71 foot, Low (216 mm/yr), based on tide gage subsidence rates
- 0.36 foot, Low (109.7 mm/yr), based on basal peat subsidence rates
- 1.11 feet, Intermediate (338 mm/yr), based on tide gage subsidence rates
- 0.76 foot, Intermediate (232 mm/year), based on basal peat subsidence rates
- 2.40 feet, High (732 mm/yr), based on tide gage subsidence rates

- 2.04 feet, High (662 mm/yr), based on basal peat subsidence rates

RSLR rates for the project area are discussed in greater detail in Appendix L of the FEIS.

The most apparent potential for RSLR impacts in the Freeport Harbor project area includes impacts on wetlands and other sensitive low-lying areas due to higher water levels, impacts on vessel navigation due to changes in current velocities in the area, and impacts on surge levels. These potential impacts are examined in Section 4, Environmental Consequences, of the FEIS.

### 12.3.1 Projected Relative Sea Level Rise Impacts for the Project Area

The potential for RSLR impacts in the Freeport Harbor project area includes impacts on wetlands and other sensitive low-lying areas due to higher water levels, impacts on vessel traffic due to changes in current velocities in the area, and impacts on surge levels.

In general, the functioning of the navigation features associated with all alternatives (channel depths of 55 through 60 feet, turning basins, PAs, and ODMDSs) would be insignificantly affected by the full range of potential sea level change. Upland confined PAs and mitigation features are located at sufficiently high elevations to withstand the full range of potential RSLR. The following discussion describes possible ways that RSLR might affect the project alternatives.

Numerical modeling performed for the proposed project shows that implementation of the NED or LPP, Plan 4 and Plan 5, would result in changes in the velocities in the harbor, the tides in the harbor, and the surge values. The depth-averaged velocities in the harbor show, for both plans, a decrease in peak ebb and flood velocities of from 0.0 to 0.18 ft/sec (5.4 centimeters per second [cm/sec]), the decrease becoming less moving upstream into the harbor. The two plans produce tidal results that are essentially identical. Tidal differences include advancement of the flood and ebb tides by approximately 30 minutes in this diurnal system, and an increase in the mean tide range of about 0.3 percent, or 0.01 foot (0.2 centimeter [cm]). The surge values for the plans are about 0.16 foot (5 cm) higher with the plans than without them.

These differences in tidal velocities, tidal timing and tide range, and surge are the result of physical changes to the system in the plans. The plan changes are of two types. One change involves an increase in the area of the harbor through the removal of parts of the southwest peninsula separating the harbor from the GIWW; the other change is the deepening and widening of the channels.

Both types of changes tend to increase the coupling of the harbor to the Gulf. The excavation of portions of the southwest peninsula will increase the tidal prism of the harbor by about 0.05 percent. This increased tidal prism results in more water moving into and out of the system

during each tidal cycle. Since more water is entering and leaving the system during each tidal cycle, peak velocities are expected to increase as a result. Deepening and widening of the Jetty Channel and the inner basin also result in a stronger coupling between the Gulf and the harbor. This deepening and widening of the harbor results in increases in the volume of the harbor of from 5.8 percent (Plan 5) to 6.4 percent (Plan 4). The increased cross-sectional area for the water to flow into the system will result in decreased peak velocities. Detailed numerical modeling shows that the net effect of these competing processes is to lower the peak velocities, up to 0.18 ft/sec (5.4 cm/sec), in the harbor, as one would expect from the relative size of the effects. With the projected RSLR, the system is, in effect, deepened from 0.36 foot (11.0 cm) to 2.4 feet (73.2 cm), depending on the sea level rise and subsidence scenario. This additional "deepening" will result in further, though slight, decreases in peak velocities by further increasing the cross section of the channel.

The increased coupling also affects the tide. The advancement of the timing of the tide means that, with the deeper and wider channel, the tide can move into and out of the harbor more easily, and thus, the timing of the tide will change. Deepening of this type generally also causes an increase in the tide range inside a waterway; the range of the driving Gulf tide is diminished less as it experiences relatively less friction, due to the deeper water, as it travels up into the system. In this case, however, the system in its existing condition is already well coupled to the Gulf, as evidenced by the similarity of the tides in the jetties to those in the harbor. Given the lack of resonant behavior in the short channel (about 3 miles [5 kilometers]) from jetties to the end of the deepened portion of the channel), only small increases in the tide range, predicted to be about 0.3 percent, or 0.01 foot (0.2 cm) for a mean tide of 1.64 feet (50 cm), can be expected with further deepening and widening. Again, with the projected RSLR for this system, no additional increase in tidal range is expected since the incremental change, due to RSLR, decreases the relative differences between the Base and Plan conditions.

The increased coupling due to the project also affects the surge, increasing the surge levels by about 0.16 foot (5 cm) locally. The percent differences of water level in the system between the with-project and without-project cases for RSLR of 0.36 foot (11.0 cm) to 2.4 feet (73.2 cm) will be smaller than without RSLR. The differences in surge height are thus expected to be less as well. Additionally, the effects of increased surge due to the project are local, and given the general inundation of the greater Freeport area during a significant surge, the additional water elevation due to the project, with or without RSLR, is expected to be small.

Given the above discussion, impacts on wetlands in the Freeport Harbor are thus expected to be negligible for two reasons. First, there are no wetlands in the footprint of the channel system. Second, changes in tidal range are expected to be small and difficult to measure, residing in the millimeter range. Since Freeport Harbor is a highly developed industrial area with no wetlands or other marshes, water level changes due to RSLR will have an effect on the harbor similar to that of a deepening. As seen in the modeling and an examination of the tide data, the harbor is

already, at current depths and cross sections, closely coupled to the Gulf so that any further increases in depth will result in very small increases in tide range. Thus, RSLR is expected to result in an insignificant difference between the existing channel conditions and the plans.

Impacts on navigation are also expected to be negligible, with currents likely decreasing, with RSLR, even further from the decreases expected with the project. RSLR, serving in this case as essentially a deepening, means that an even larger effective cross-sectional area will be available for the flooding and ebbing tides, and that the peak velocities will decrease further. Hence, RSLR is expected to cause an insignificant difference between the existing channel and the plans.

Finally, impact differences on the surge levels due to the project, with and without RSLR, are expected to be very small and local.

## 12.4 DESCRIPTION OF RECOMMENDED PLAN

Based on the economic, engineering, and environmental factors considered, the Recommended Plan (LPP) includes deepening of the Outer Bar Channel from the jetties into the Gulf of Mexico to –57 feet MLT (–58 feet MLLW); deepening from the end of the jetties in the Gulf of Mexico to the Lower Turning Basin to –55 feet MLT (–56 feet MLLW); deepening the Main Channel from the Lower Turning Basin to Sta. 132+66 (ConocoPhillips dock area, above 1,200-foot Brazosport Turning Basin) to –55 feet MLT (–56 feet MLLW); deepening of Freeport Harbor from Sta. 132+66 through the Upper Turning Basin to –50 feet MLT (–51 feet MLLW); deepening and widening the lower 3,700 feet of the Stauffer Channel at a depth of –50 feet MLT (–51 feet MLLW) and 300 feet wide; and dredging the remainder of the Stauffer Channel to a depth of –25 feet MLT (–26 feet MLLW), in lieu of restoring it to its previously authorized dimensions of 30 feet by 200 feet. Depths shown exclude advance maintenance and allowable over-depth. It is estimated that the approximately 14.3 mcy of new work material (including advance maintenance and allowable over-depth) would require eight separate dredging contracts to complete. The work is estimated to begin in 2015 and be complete by 2021. Dredged material management will be performed according to the DMMP. The Recommended Plan meets the requirements for a categorical exemption in accordance with ER 1105-2-100, Section 3-2.b.10.

## 12.5 GENERAL NAVIGATION FEATURES OF THE RECOMMENDED PLAN

Dredging of the Freeport Harbor Channel will include 2 feet of advanced maintenance below designated depths to ensure safe vessel passage. In addition, the Outer Bar Channel will include an additional 2 feet of dredging to account for the high wave environment offshore, outside the jetties.

### 12.5.1 Outer Bar/Jetty Channel

The Outer Bar/Jetty Channel is defined as that portion of Freeport Harbor extending from Station –370+00 in the Gulf of Mexico to Station 71+52 in the Lower Turning Basin. The Jetty Channel is 600 feet wide and protected on two sides by jetties. The land-locked portion of the Outer Bar/Jetty Channel would be deepened to –57 feet MLT (–58 feet MLLW). This would be modified in the portion of the channel that enters the open waters of the Gulf. This segment will be dredged to a –59-foot MLT (–60-foot MLLW) depth. The existing channel will be extended approximately 5,000 feet into the Gulf in order to reach the –59-foot MLT (–60-foot MLLW) contour. No modifications to the existing Freeport Harbor jetties are required by the proposed project. The Outer Bar/Jetty Channel will be constructed by hopper dredge beginning at the Lower Turning Basin and extending into the Gulf of Mexico to the –59-foot MLT (–60-foot MLLW) contour at the same bearing as the existing channel. New channel markers will be required to mark the new channel.

### 12.5.2 Main Channel

The Main Channel portion of Freeport Harbor extends from Station 71+52 in the Lower Turning Basin to the Upper Turning Basin. This segment will be deepened from an authorized depth of –45 feet to –55 feet MLT (–46 feet to –56 feet MLLW). From Station 132+66 to Station 184+20 at the Upper Turning Basin, the channel will be deepened to –50 feet MLT (–51 feet MLLW). Based on ERDC's Ship Simulation Report, the recommended width for this portion of the channel is 400 feet. The Main Channel will be constructed by hydraulic pipeline dredge, with the dredged material going to new PAs 8 and 9. The Lower Turning Basin will maintain its existing 750-foot diameter and be deepened to –55 feet MLT (–56 feet MLLW). The Brazosport Turning Basin will be enlarged from its existing 1,000-foot diameter to a new 1,200-foot diameter. The Upper Turning Bain will maintain its existing 1,200-foot diameter and be deepened to –50 feet MLT (–51 feet MLLW).

### 12.5.3 Stauffer Channel

The Stauffer Channel will be deepened to –50 feet MLT (–51 feet MLLW) and widened to 300 feet for approximately 3,700 feet beyond its confluence with the Upper Turning Basin. The remaining channel will be deepened to a depth of –25 feet MLT (–26 feet MLLW) and 200-foot width to the Stauffer Turning Basin.

Because of the relationship between the deepening and widening of the Stauffer Channel of the existing Federal project and the proposed terminal, Port Freeport must initiate construction of the terminal facilities prior to, or concurrent with, construction of the Stauffer Channel improvements. Port Freeport will be responsible for obtaining the necessary permits required for the container terminal under Section 404 of the CWA, Section 10 of the RHA, and/or any other applicable jurisdictions as appropriate utilizing the procedures described by NEPA.

Table 72 displays the Recommended Plan dimensions. A breakdown of the channel reaches and what PA is designated is shown in Tables 70 and 71.

**Table 72**
**Proposed Freeport Channel Dimensions for Recommended Plan**

| Channel Section | Required Depth MLT[1] (MLLW) | Width (feet) | New Work Quantity (cy)[2] |
|---|---|---|---|
| Future Channel Extension (Sta –300+00 to Stat –370+00) | 59(60) | 600 | 795,000 |
| Outer Bar Channel (Sta 0+00 to Sta –300+00) | 59(60) | 600 | 8,290,000 |
| Jetty Channel (Sta 0+00 to Sta 71+52.58 | 57(58) | 600 | 3,648,000 |
| Lower Turning Basin (Sta 71+52 to Sta 78+52 | 57(58) | existing | 208,000 |
| Channel to Brazosport and New 1,200-foot Turning Basin (Sta 78+52 to Sta 115+00) | 57(58) | existing | 2,916,000 |
| Channel to Upper Turning Basin (Sta 115+00 to Sta 132+66) | 57(58) | existing | 391,000 |
| Channel to Upper Turning Basin and Turning Basin (Sta 132+66 to Sta 184+20 | 52(53) | existing | 490,000 |
| Stauffer Channel – Lower Reach (Sta 184+20 to Sta 222+00) | 52(53) | 300 | 1,387,000 |
| Stauffer Channel – Upper Reach (Sta 222+00 to Sta 260+00) | 27(28) | 200 | 427,000 |

[1] Includes Advance Maintenance (2 feet)

[2] Includes Allowable Over-depth

### 12.5.4 Lands, Easements, and Rights-of-Way

Port Freeport is required to furnish the lands, easements, rights-of-way, and relocations (LERRs) for the proposed cost-shared project. The real estate requirements must support construction as well as O&M of the project after completion. Specific details of the real estate requirements can be found in the Real Estate Plan, Appendix C of this document.

### 12.5.5 Facility Removals/Deep-Draft Utility Relocations

The USACE currently requires pipelines located below deep-draft navigation channels be buried 20 feet below the authorized project depth of the channel (Southwest-Galveston District Operations Manual 1145-2-15). This requirement was developed taking into consideration several factors, including geotechnical, hydraulic, navigation, maintenance dredging, and pipeline placement method considerations. Exceptions to this requirement can be granted on a case-by-case basis.

During the feasibility phase, one pipeline was identified for further consideration. However, surveys were conducted on the pipeline and it was found to have adequate coverage for the project. Therefore, no removals or relocations are required.

### 12.5.6 Regional Sediment Management

Section 2037 of WRDA 07 amended Section 204 of WRDA 92 dealing with regional sediment management. Section 204 states that a regional sediment management plan shall be developed by the Secretary of the Army for sediment obtained through the construction, operation, or maintenance of an authorized Federal water resources project. The purposes of using sediment for the construction, repair, modification, or rehabilitation of Federal water resource projects are to reduce storm damage to property; to protect, restore, and create aquatic and ecologically related habitats, including wetlands; and to transport and place suitable sediment.

During the non-Federal sponsor's Section 204(f) Assumption of Maintenance study, beneficial use of the dredged material was investigated. The study, though not a part of the Federal feasibility study, concluded that use of material for any use in marshland or wetland restoration was not beneficial or cost effective. However, it was determined that there was a sand lens in the area to be widened that could be harvested for placement on the beach at Quintana. The non-Federal sponsor widening project is to place an estimated 300,000 cy of material on the Quintana beach area.

During the feasibility study, no suitable material could be found for beneficial use. Therefore, no regional sediment management plan was developed.

## 12.6 PLAN IMPLEMENTATION

### 12.6.1 Division of Plan Responsibilities and Cost-Sharing Requirements

The non-Federal cost-sharing project cost sharing for the General Navigation Features (GNFs) for the Recommended Plan will be as follows:

1. Ten percent of the costs attributable to dredging to a depth not in excess of 20 feet; plus

2. Twenty-five percent of the costs attributable to dredging to a depth in excess of 20 feet, but not in excess of 45 feet; plus

3. Fifty percent of the costs attributable to dredging to a depth in excess of 45 feet;

4. Pay with interest, over a period not to exceed 30 years following completion of the period of construction of the project, up to an additional 10 percent of the total cost of construction of GNFs. The value of lands, easements, rights-of-way, relocations, and

deep-draft utility relocations provided by the non-Federal sponsor for the GNFs may be credited toward this required payment.

Project cost sharing for the maintenance of the GNFs will be as follows:

1. The non-Federal sponsor will provide 50 percent of the excess cost of O&M of the project over that cost that the Secretary determines would be incurred for O&M if the project had a depth of 45 feet.

2. The Federal share of O&M of GNFs of less than 45 feet is 100 percent.

3. The costs of disposal facilities for O&M are shared as GNFs.

## 12.7 COSTS FOR THE RECOMMENDED PLAN

The total cost for the Recommended Plan is $290,652,000, as shown in Table 73. Costs include implementation costs and associated costs. Implementation costs include postauthorization planning and design costs, construction costs, construction contingency costs, and O&M costs. Construction costs include costs for dredging and placement area construction. Costs for fish and wildlife mitigation are also included. No cultural resource mitigation costs are expected at this time. A programmatic agreement is in effect for any cultural resource mitigation, if required at a later date. Aids to navigation (estimated at $1,352,000) are provided by the USCG and are a Federal cost included in the economic justification, but are not subject to project cost sharing. Construction General funding will fund Federal share of all project construction.

Project costs and price escalation (calculated by estimating the midpoint of the proposed contracts) are combined to create the Fully Funded Cost. The Project First Cost for all project components is separated into expected non-Federal and Federal cost shares and detailed in Table 74. These costs differ from those in Table 73 due to the inclusion of PED and Construction Management costs across the different channel segments. These costs are accurate at different cost share rates based on the work being done at different depths. For a majority of the work where the existing channel is currently at –45-foot MLT (–46-foot MLLW), the work will be cost shared 50 percent Federal/50 percent non-Federal. On the Stauffer Channel where the existing depths are less than 20 feet and depths are proposed to go to –50-foot MLT (–51-foot MLLW), cost share will cover all levels including 90/10 Federal/non-Federal, 75/25, and 50/50. Where Stauffer Channel is proposed to go to –25-foot MLT (–26-foot MLLW), cost share will cover both the 90/10 and 75/25.

**Table 73**
**Recommended Plan Cost**
**Comparison of Costs (rounded)**

| Cost Account | Item Description | First Cost ($) (Oct 11 Price Level) | Fully Funded Cost ($) (Oct 11 Price Level) |
|---|---|---|---|
| **Federal Construction Cost** | | | |
| 01 | Lands & Damages | -0- | -0- |
| 06 | Fish & Wildlife Facilities | 161,000 | 180,000 |
| 12 | Navigation Ports & Harbors | 203,389,000 | 219,370,000 |
| 30 | Planning, Engineering & Design | 17,726,000 | 19,606,000 |
| 31 | Construction Management | 9,192,000 | 10,595,000 |
| **Federal Construction** | | **230,468,000** | **249,751,000** |
| **Non-Federal (LERs/ Associated) Cost** | | | |
| 01 | Lands & Damages | 1,653,000 | 1,753,000 |
| 02 | Relocations | -0- | -0- |
| 12 | Navigation Ports & Harbors (1) | 57,179,000 | 61,829,000 |
| 12 | Aids to Navigation | 1,352,000 | 1,456,000 |
| **Non-Federal Construction** | | **58,832,000** | **63,582,000** |
| **Aids to Navigation** | | **1,352,000** | **1,456,000** |
| **Total Navigation Costs** | | **290,652,000** | **314,788,000** |

(1) Costs include $38,800,000 in non-Federal bulkhead modifications and 18,379,000 in dredging costs for berthing areas adjacent to the Federal channel.

**Table 74**
**Cost Apportionment**

| Cost Apportionment Navigation* | First Cost ($) | Fully Funded Cost ($) |
|---|---|---|
| Federal Navigation: | | |
| Freeport Channel | 108,029,000 | 115,262,000 |
| Lower Stauffer Channel | 7,520,000 | 7,958,000 |
| Upper Stauffer Channel | 2,719,000 | 2,876,000 |
| Lands & Damages | -0- | -0- |
| Mitigation | 134,000 | 142,000 |
| **Total Federal Navigation** | **118,402,000** | **126,238,000** |
| non-Federal Navigation: | | |
| Freeport Channel | 108,029,000 | 115,262,000 |
| Lower Stauffer Channel | 3,104,000 | 3,284,000 |
| Upper Stauffer Channel | 806,000 | 852,000 |
| Land & Damages | 1,653,000 | 1,713,000 |
| Mitigation | 127,000 | 136,000 |
| **Total non-Federal Navigation** | **113,719,000** | **121,247,000** |
| **Total Navigation** | **232,121,000** | **247,485,000** |

*Costs include Preconstruction Engineering & Design and Construction Management totals.

The maintenance of project features will be funded through annual appropriations of the O&M program. The actual amounts will vary on a year-to-year basis because of variability in the volume of material removed during each dredging cycle and the variability of the cycles. Costs for maintenance of the Freeport Harbor Project will be in accordance with Section 101(b) of WRDA 86 (Planning Guidance Letter [PGL] 47, Cost Sharing for Dredged Material Disposal Facilities and Dredged Material Disposal Facility Partnerships), which allocates the increment of costs for maintenance of channel depths less than 45 feet as 100 percent Federal and the increment of costs for channel depths greater than 45 feet as 50 percent non-Federal and 50 percent Federal.

Additional PA capacity for the Recommended Plan will be constructed regularly over the 50-year period of analysis in conjunction with maintenance dredging cycles. Costs for disposal facility maintenance associated with the project will be allocated as 50 percent non-Federal and 50 percent Federal for the incremental cost associated with depths over 45 feet and 100 percent Federal for depths less than 45 feet.

The USCG is responsible for aids to navigation, and the cost is allocated as a Federal expense because the installation of new navigation aids on the Outer Bar Channel Extension and the Outer Bar Channel is related to deepening and widening and the replacement of navigation aids on the channel.

## 12.8 COST-SHARING APPORTIONMENT

The project cost for determining the cost-sharing requirements is based on the Project First Cost. This differs from the cost estimate that was utilized for the economic analysis that determined project benefits and the BCR.

GNF costs for deepening greater than 45 feet are cost shared at 50 percent non-Federal and 50 percent Federal. GNF costs for deepening between 25 and 45 feet are cost shared at 75 percent non-Federal and 25 percent Federal, and costs for deepening in depths less than 20 feet are cost shared at 90 percent Federal and 10 percent non-Federal. A majority of the dredging is in areas where the current channel is already at 45 feet MLT (46 feet MLLW) so a majority of costs will be shared 50/50. Stauffer Channel, however, is currently at 18 feet MLT (19 feet MLLW), and these costs will be cost shared across all the cost share ratios. The costs are separated into expected Federal and non-Federal shares and detailed in Table 74. Fish and wildlife mitigation is considered a GNF and is cost shared in the same manner as other GNF costs. Mitigation is necessary due to the construction of new PAs. Mitigation costs have been apportioned according to the reaches that will utilize these new Pas, and the cost share has been designated appropriately. Should cultural resources data recovery be needed at a later date, it would be handled in accordance with PL 93-291 (Section 7), e.g., data recovery costs would be 100 percent Federal up to 1 percent of the total amount appropriated for the project.

Non-Federal costs include non-Federal sponsor and berthing/dock owner costs. The non-Federal sponsor is responsible for 100 percent of LERRs. All project construction is on lands that are currently owned by the non-Federal sponsor. Pipeline relocations are defined as "deep-draft utility relocations" pursuant to PGL 44. No pipeline relocations are anticipated. Owners of berth and dock facilities that require modification in conjunction with the project would be responsible for 100 percent of those associated costs. Berth deepening and structural modifications will be incurred and are included in the project cost (see Table 73). The USCG is responsible for 100 percent of the cost of aids to navigation.

## 12.9 ADDITIONAL NON-FEDERAL SPONSOR CASH CONTRIBUTION

Section 101 of PL 99-662 requires for all navigation channel depths that the non-Federal sponsor must provide an additional cash contribution equal to 10 percent of fully funded GNF costs (minus costs for LERRs). This total is detailed in Table 75 below. These costs may be paid over a period not to exceed 30 years.

**Table 75**
**Total General Navigation Features Costs and Credits**
**(October 2011 Price Level)**

| | |
|---|---|
| Cost-Shared GNF | $245,772,000 |
| 10% of GNF | $24,577,200 |
| | |
| Creditable Land Costs | $1,713,000 |
| | |
| Creditable Difference | ($22,864,200) |

## 12.10 NON-FEDERAL SPONSOR VIEWS

The non-Federal sponsor for the existing project, Port Freeport, has actively participated in the entire planning process. Their primary concern has been to provide the community with a channel design, preferably 55 feet deep in the Main Channel and 50 feet in the Lower Stauffer Channel, to increase navigation efficiency and safety. Port Freeport is supportive of the Recommended Plan, the LPP, and has indicated a strong interest in beginning construction as soon as possible.

## 12.11 RECOMMENDED PLAN AND RECENT USACE INITIATIVES

As stated earlier, USACE has implemented the USACE Campaign Plan over the past few years. These initiatives were developed to ensure USACE success in the future by improving the current practices and decision-making processes of the USACE organization. The application of those principles as they relate to the Recommended Plan for Freeport Harbor is described below.

### 12.11.1 USACE Actions for Change as Reflected in the Campaign Plan

**Engineering Sustainable Water Resource** (integrated solutions, collaborative approaches, and streamlined processes)

- Freeport Harbor study analyzed potential effects over the study area.
- Construction of the mitigation site was developed for a 50-year period of analysis. Development and design of the site will address potential changes over time.
- The direct and indirect effects of the project on the environment were quantified using ecological modeling. Compensatory mitigation is provided in the Recommended Plan for all project impacts.
- All environmental impacts of the proposed project have been addressed and offset by mitigating for impacts.

- Project impacts were identified and type and location of the compensation to be performed. The recommended mitigation plan results in an excess of overall environmental benefits over impacts.
- Dredged material placement plans were analyzed to beneficially use the material to the benefit of the entire system (inshore and offshore) to the greatest extent possible. The ODMDSs are dispersive sites and will be beneficial in slowing shoreline erosion and littoral drift.
- Opportunities to beneficially use the large quantities of dredged material that would be generated by the project were explored. The needs of the project to find environmentally acceptable placement areas have been satisfied in the development of the PAs and ODMDSs.
- Close coordination among the USACE, non-Federal sponsor, resource agencies, and interested parties occurred throughout the study process. Interactions were professional and respectful, and opinions and expertise of others were obtained and utilized where appropriate. Coordination with the resource agencies and interested parties ensured that the spectrum of environmental habitats of the study and project area were adequately understood, impacts accurately identified, and appropriate amount and type of mitigation was developed.

**Delivering Effective, Resilient, Sustainable Solutions** (sustainable infrastructure, resilience, risk-formed strategy, innovative approaches)

- Developed plans over long-term, 50-year period of analysis.
- Utilized latest development in engineering, economic, and environmental modeling.
- Risk analyses conducted throughout the study are summarized in Section 12.2.
- Review and inspection of work will be conducted during design and construction.
- Project risks are communicated at public meetings and during the public review of the study findings. The public is allowed to comment and/or express concerns throughout the study process.
- Unlike flood risk management and hurricane protection projects, navigation projects involve minimal risk to the public.
- Independent review of the project documents and analyses was performed internally to the USACE and externally by professionals from academia and expert consultants. Comments from those reviews have been incorporated into the study documents, as appropriate.
- The expertise of State and Federal resource agency professionals familiar with the highly complex coastal ecosystems of Texas was integrally involved in the evaluation and development of plans to offset environmental impacts of the project.

# 13.0 SUMMARY OF COORDINATION, PUBLIC VIEWS, AND COMMENTS

## 13.1 OVERVIEW

Public input has been important in the overall planning process to assure that plans considered and developed were compatible with community and regional objectives. The primary purposes of public involvement are (1) to allow the public the opportunity to provide timely information to the USACE so that developed plans will reflect their preferences to the greatest extent possible, and (2) to provide a method by which the USACE can inform the public so that those who choose to participate in the project formulation and the planning process can do so with a relatively complete understanding about the issues, opportunities, and consequences associated with a study. A more-detailed description of the public involvement process and complete list of all comments can be found in Appendix A of the FEIS.

The various measures used during this study to assure open, two-way public communication included public notices, media interviews, and meetings with various interested parties. The feasibility phase was initiated with issuance of a Public Notice in December 2003, which presented a summary of the past and planned study activities for this study. This notice also discussed the study process, the specific problems in the channel, and various alternatives to be investigated. It invited all interested parties to provide input to the study beginning with a public meeting held January 15, 2004. Ongoing coordination with USFWS, TPWD, TCEQ, NMFS, the Texas SHPO, and other Federal and State resource agencies continued throughout the course of the study.

## 13.2 PUBLIC INVOLVEMENT

A Public Scoping Meeting was held on January 15, 2004, at the Lake Jackson Civic Center, Lake Jackson, Texas. The meeting was advertised and promoted in conjunction with the non-Federal sponsor, the Brazos River Harbor Navigation District (Port Freeport). Advertising and promotion activities were initiated at least 3 weeks in advance of the scoping meeting in two local community newspapers. The meeting was also aired by a local community radio station through public service announcements. In addition, a mailout was conducted utilizing public and environmental database information and mailing lists maintained by Port Freeport.

The purpose of the meeting was to inform stakeholders and interested parties about the Freeport Harbor navigation study, to outline the planning and feasibility study processes, to present the proposed project schedule, and to solicit public comments/input. Solicitation of public comments was a primary objective of the scoping meeting to ensure that significant issues relating to the Freeport Harbor navigation study were addressed, as required by NEPA. As such, meeting participants were specifically asked to identify environmental concerns, constraints, opportuni-

ties, and recommendations associated with proposed channel improvements. Meeting attendants included an elected official's representative, maritime industry representatives, a local environmentalist from the Freeport area, and the general public.

The USACE solicited both oral and written comments. A court reporter provided by the non-Federal sponsor documented oral comments. Generally, the attending public provided positive comments in support of the proposed project. However, the local environmentalist expressed concerns regarding potential negative impacts associated with proposed channel improvements. The assertion was the environmental community would probably oppose deepening beyond 50 feet, in an effort to avert similar plans and desires from competing Gulf ports, which if implemented could result in negative cumulative environmental impacts for the Gulf Coast region.

No oral comments were provided by Federal, State, or local resource agencies at the meeting, and no subsequent written comments were received within the allotted comment period. No further public comment has been provided to date from stakeholders or other interested parties.

Two additional public information meetings have been held. One was held in February 2006 to inform the public of study progress and the last was held in February 2008 to inform the public of the study results. No issues were raised at the meetings.

On January 13, 2011, the final public meeting was held. The purposes of the meeting were to present project information and accept public comments on the final draft documents that were released for public review on December 23, 2010. Three public comments were made on the project. Several comments were received by comments cards and mailed statements.

# 14.0 RECOMMENDATIONS

## 14.1 OVERVIEW

It is recommended that the existing projects for Freeport Harbor, Texas, authorized by the RHA of 1970, be modified generally as described in this report as the Recommended Plan, with such modifications as in the discretion of the Chief of Engineers may be advisable, and subject to cost-sharing and financing arrangements satisfactory to the President and the Congress, to provide deep-draft channel improvements to the Port of Freeport from the enlargement and continued maintenance of a portion of the Freeport Harbor.

For the purpose of calculating the Section 902 limit, the total estimated first cost of the project is $232.1 million including an estimated Federal share of $118.4 million and an estimated non-Federal share of $113.7 million. The Project Cost of all project components, minus inflation and interest during construction, totals $290,652,000. The LPP Investment Cost of all components totals $309,952,000 and includes $19,305,000 in interest during construction for project components. Total average annual costs for the project are $25,068,000, which includes $14,434,000 in average annual costs for construction and $10,635,000 incremental annual O&M costs. The Federal government would be responsible for $5,466,000 of the incremental operations and maintenance costs and the non-Federal sponsor would be responsible for the remaining $5,169,000. Fully Funded Cost of the project, which includes Project Costs and expected escalation totals, is $314,788,000.

These recommendations are made with the provision that, prior to implementation of the recommended improvements, the non-Federal sponsor shall enter into binding agreements with the Federal government to comply with the following requirements:

Port Freeport shall:

a. Provide 10 percent of the total cost of construction of the GNF attributable to dredging to a depth not in excess of 20 feet; plus 25 percent of the total cost of construction of the GNFs attributable to dredging to a depth in excess of 20 feet but not in excess of 45 feet; plus 50 percent of the total cost of construction of the GNFs attributable to dredging to a depth in excess of 45 feet as further specified below:

   (1) Provide 25 percent of design costs allocated by the Government to commercial navigation in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

   (2) Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs allocated by the Government to commercial navigation;

(3) Provide, during construction, any additional funds necessary to make its total contribution for commercial navigation equal to 10 percent of the total cost of construction of the GNFs attributable to dredging to a depth not in excess of 20 feet; plus 25 percent of the total cost of construction of the GNFs attributable to dredging to a depth in excess of 20 feet but not in excess of 45 feet; plus 50 percent of the total cost of construction of the GNFs attributable to dredging to a depth in excess of 45 feet;

b. Provide all lands, easement, and rights-of-way (LER), including those necessary for the borrowing of material and disposal of dredged or excavated material, and perform or assure the performance of all relocations, including utility relocations, all as determined by the Government to be necessary for the construction or operation and maintenance of the GNFs;

c. Pay with interest, over a period not to exceed 30 years following completion of the period of construction of the GNFs, an additional amount equal to 10 percent of the total cost of construction of GNFs less the amount of credit afforded by the Government for the value of the LER and relocations, including utility relocations, provided by the non-Federal sponsor for the GNFs. If the amount of credit afforded by the Government for the value of LER, and relocations, including utility relocations, provided by the non-Federal sponsor equals or exceeds 10 percent of the total cost of construction of the GNF, the non-Federal sponsor shall not be required to make any contribution under this paragraph, nor shall it be entitled to any refund for the value of LER and relocations, including utility relocations, in excess of 10 percent of the total costs of construction of the GNFs;

d. Provide, operate, and maintain, at no cost to the Government, the local service facilities in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Government;

e. Provide 50 percent of the excess cost of O&M of the project over that cost which the Government determines would be incurred for O&M if the project had a depth of 45 feet;

f. Give the Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, and maintaining the GNFs;

g. Hold and save the United States free from all damages arising from the construction or O&M of the project, any betterments, and the local service facilities, except for damages due to the fault or negligence of the United States or its contractors;

h. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence is required, to the extent and in such detail as will properly reflect total cost

of construction of the project, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and local governments at 32 CFR, Section 33.20;

i. Perform, or ensure performance of, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601–9675, that may exist in, on, or under LER that the Government determines to be necessary for the construction or O&M of the GNFs. However, for lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude, only the Government shall perform such investigation unless the Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

j. Assume complete financial responsibility, as between the Government and the non-Federal sponsor, for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under LER that the Government determines to be necessary for the construction or O&M of the project;

k. To the maximum extent practicable, perform its obligations in a manner that will not cause liability to arise under CERCLA;

l. Comply with Section 221 of PL 91-611, Flood Control Act of 1970, as amended, (42 USC 1962d-5b) and Section 101(e) of the WRDA 86, PL 99-662, as amended, (33 USC 2211(e)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

m. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, PL 91-646, as amended, (42 USC 4601-4655) and the Uniform Regulations contained in 49 CFR 24, in acquiring lands, easements, and rights-of-way necessary for construction, operation, and maintenance of the project including those necessary for relocations, the borrowing of material, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

n. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, PL 88-352 (42 USC 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto: Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 USC 3141-3148 and 40 USC 3701-3708 (revising, codifying and enacting without substantive changes the provision of the Davis-Bacon Act (formerly 40 USC 276a

et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 USC 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 USC 276c);

o. Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation that are in excess of 1 percent of the total amount authorized to be appropriated for the project;

p Not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefore, to meet any of the non-Federal sponsor's obligations for the project costs unless the Federal agency providing the Federal portion of such funds verifies in writing that such funds are authorized to be used to carry out the project; and

q. Substantially complete the first phase of the Velasco Container Terminal (800-foot berth and 35 acres of supporting backland) on the Stauffer Channel prior to the initiation of construction of the Stauffer Channel portion of the project.

Construction of the recommended channel improvements is estimated to take 5 years to complete. During this period, the Government and the non-Federal sponsor shall diligently maintain the projects at their previously authorized dimensions according to the previous cooperation agreement. Maintenance materials that have accumulated in the channels at the time that "before dredging" profiles are taken for construction payment shall be considered as new work material and cost-shared according to the new cooperation agreement. Any dredging in a construction contract reach after the improvements have been completed and the construction contract closed will be considered to be maintenance material and cost-shared according to the new agreement.

Those portions of the projects for the Freeport Harbor and Stauffer channels that are deepened or newly created shall be operated and maintained according to the terms and provision of the new agreements. All other portions of the existing projects for the Stauffer Channel shall continue to be operated and maintained according to the existing agreement applicable to that portion of the channel.

The recommendations contained herein reflect no current removal of pipelines. Pipeline removal/relocation is recommended, in most cases, for pipelines with less than 20 feet of cover after project construction over the width of the channel plus an additional 25 feet of width on each channel edge. It is proposed that all of the lines remain at their current depth based on several criteria, including type of product transported in the line, whether the line has a casing, type of material the line is buried in, and scour in the portion of the channel the line is located in. Based on these considerations, all pipelines after project construction will remain at their current depth. Additional consideration will be given to cover requirements during design of the project. Should the decision be made that more cover is needed on lines not previously scheduled for removal, the District Engineer will update the project economic evaluation to reflect the

cost, no changes to the Baseline Cost Estimate or Sponsor and Federal cost-sharing will be required.

## 14.2 RECOMMENDATION

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels with the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorizations and implementation funding. However, prior to transmittal to the Congress, the non-Federal sponsor, the State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

16 JUN 2012
Date

Christopher W. Sallese
Colonel, Corps of Engineers
District Engineer

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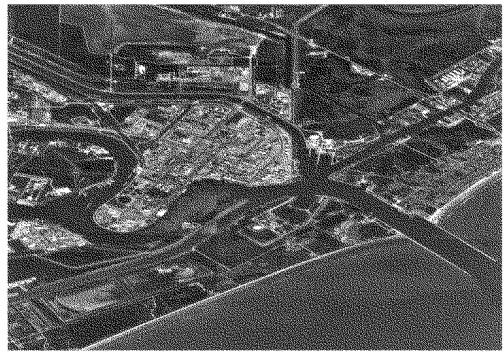
US Army Corps
of Engineers
Galveston District

# VOLUME II
# FINAL
# FREEPORT HARBOR, TEXAS
# CHANNEL IMPROVEMENT PROJECT
# FEASIBILITY REPORT



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## Acronyms and Abbreviations

| | |
|---|---|
| AAE | average annual equivalent |
| AEO | Annual Energy Outlook |
| ARRA | American Recovery and Reinvestment Act |
| BCR | benefit to cost ratio |
| BNSF | Burlington Northern Santa Fe Railway |
| BP | British Petroleum |
| BPD | barrels per day |
| BRPA | Brazos River Pilots Association |
| CFR | Code of Federal Regulations |
| DC | distribution center |
| DOE | U.S. Department of Energy |
| DWT | deadweight ton |
| EGM | Economic Guidance Memorandum |
| EIA | Energy Information Administration |
| ERDC | Engineer Research and Development Center |
| FM | Farm-to-Market Road |
| FTZ | foreign trade zone |
| FY | fiscal year |
| GAO | U.S. General Accounting Office |
| GDP | gross domestic product |
| GIWW | Gulf Intracoastal Waterway |
| HP | Horsepower |
| IWR | Institute of Water Resources |
| KCSR | Kansas City Southern Railroad |
| LA/LB | Los Angeles/Long Beach |
| LNG | liquefied natural gas |
| LOA | length overall |
| LoLo | load-on/load-off |
| LPP | locally preferred plan |
| $m^3$ | cubic meters |
| MMS | Minerals Management Service, now the Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE) |
| NDC | Navigation Data Center |
| NED | National Economic Development |
| NGL | natural gas liquids |
| O&M | operation and maintenance |
| OSV | offshore supply vessel |

**Acronyms and Abbreviations, cont'd**

| | |
|---|---|
| PADD | Petroleum Administration for Defense District |
| PSV | Platform Supply Vessel |
| SH | State Highway |
| SPR | Strategic Petroleum Reserve Storage |
| TEPPCO | Texas Eastern Petroleum Pipeline Company |
| TEU | twenty-foot equivalent unit |
| TexMex | Texas Mexican Railway Company |
| TIP | Transportation Improvement Program |
| TOPS | Texas Offshore Oil Port System |
| TxDOT | Texas Department of Transportation |
| UP | Union Pacific Railway |
| USACE | U.S. Army Corps of Engineers |
| USCG | U.S. Coast Guard |
| VLCC | very large crude carrier |
| WCSC | Waterborne Commerce Statistical Center |
| WRDA | Water Resources Development Act |

## 1.0 OVERVIEW

This appendix presents the economic analysis for the Freeport Channel Feasibility Study. The project benefits were calculated based on reductions in transportation costs generated from more-efficient vessel loading and from reductions in vessel delays. The benefits were calculated for a 2017 to 2067 period of analysis using fiscal year (FY) 2012 Federal discount rate of 4.0 percent and the deep-draft vessel operating costs contained in the Economic Guidance Memorandum (EGM 11-05). The proposed channel improvements are in response to the need for deeper access by allowing the existing fleet to load more fully, for the introduction of larger vessels, and the reauthorization of the upper reaches of the harbor.

The existing Federal project includes a 47- by 400-foot offshore Entrance Channel, a 45-foot by 400-foot Main Channel, and 36-foot depth to its general cargo docks. Figure 1-1 displays the navigation channel and associated features. Figure 1-2 shows the major terminals. The existing project extends approximately 9.7 miles from its offshore entrance to the base of the Stauffer Channel. A 45-foot project depth extends from the offshore Jetty Channel through the Upper Turning Basin just below the Stauffer Channel. The 36-foot-depth Brazos Harbor Turning Basin, and its associated access channel, intersects the 45-foot channel just below the Stauffer Channel. The Brazos Harbor access channel, harbor, and turning basin contain the majority of existing public facilities, including the multipurpose terminal serving refrigerated and general cargo vessels. Freeport's principal commodities include crude petroleum, bulk fuels, chemicals, and general and container cargo. The upper reach of the Main Channel contains the deauthorized Stauffer Channel. Stauffer Channel traffic consists of seismic and crew vessels associated with the offshore oil industry and commercial fishing vessels. Vessel repair and layberth facilities are located on the channel as well. The Stauffer Channel and Turning Basin were deauthorized in 1974 under Section 12, Appendix C, and Public Law 251. Since deauthorization, the channel depth deteriorated from 25 feet to an approximate 18-foot water depth. The depth limitations and impediments associated with silting in the deauthorized channel reach generate safety concerns and contribute to declining utilization patterns. Inclusion of Stauffer as part of the Federal project was evaluated as part of the current study.

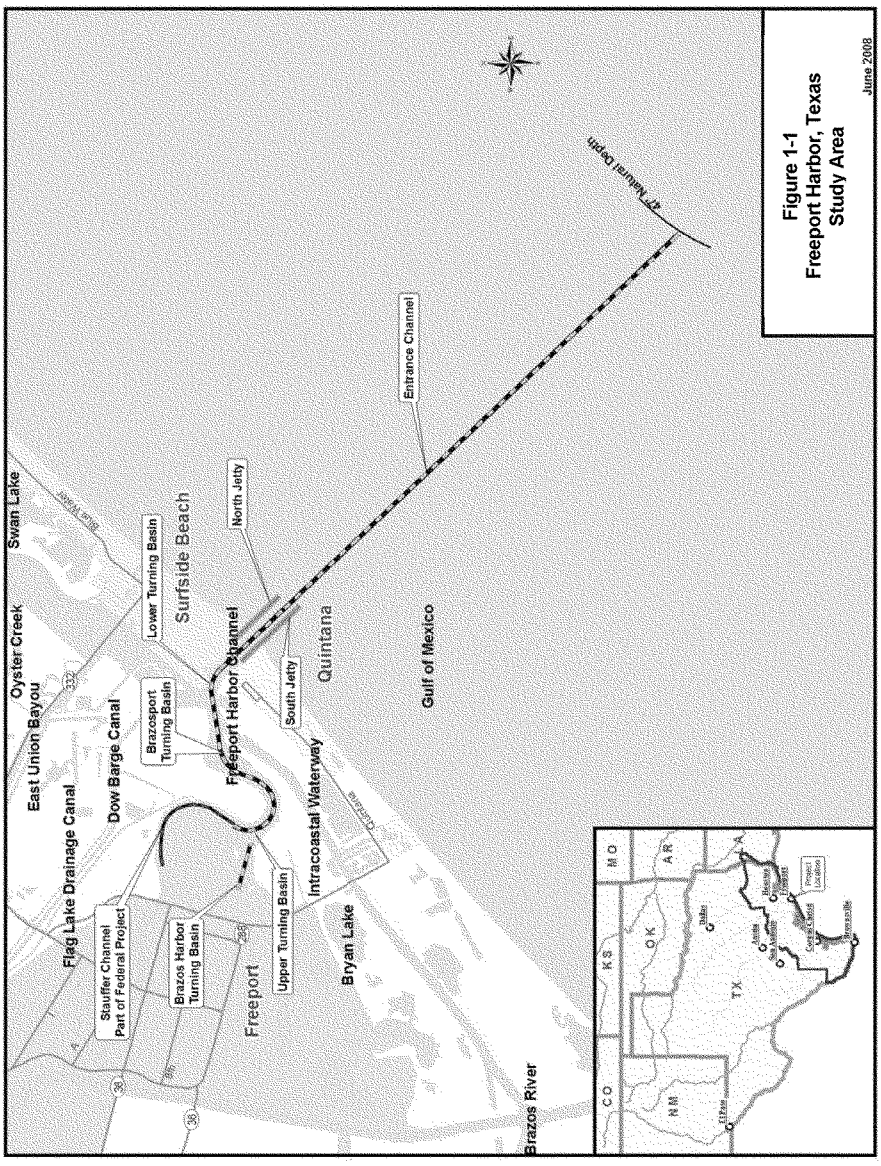
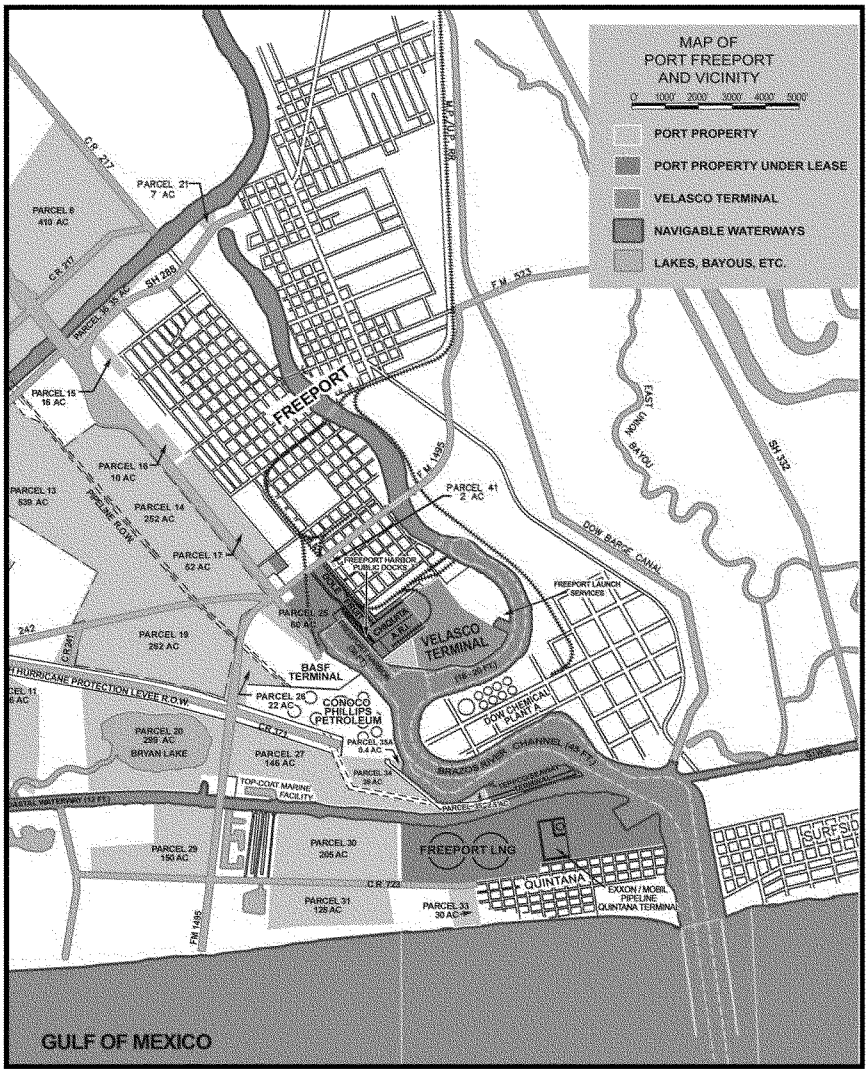

Swan Lake
Oyster Creek
East Union Bayou
Flag Lake Drainage Canal
Dow Barge Canal
Lower Turning Basin
Surfside Beach
North Jetty
Brazosport Turning Basin
Freeport Harbor Channel
South Jetty
Quintana
Entrance Channel
Gulf of Mexico
Stauffer Channel Part of Federal Project
Brazos Harbor Turning Basin
Freeport
Upper Turning Basin
Intracoastal Waterway
Bryan Lake
Brazos River
-45' Natural Depth
CO
KS
MO
AR
OK
NM
TX
LA
Project Location
Figure 1-1
Freeport Harbor, Texas
Study Area
June 2008

**Figure 1-2**
**Freeport Harbor Facilities**



## 1.1 OVERVIEW OF CHANNEL REACHES

The existing Federal project contains three operational reaches and one deauthorized reach. Figure 1-3 shows the reaches used in the economic analysis. The first economic reach is a combination of the first two operational reaches and starts offshore at Station –370+00 and goes to Station 132+66. This reach includes the Lower Turning Basin and the Brazosport Turning Basin. This 45-foot-deep reach provides access to crude petroleum tankers using docks operated by Seaway Crude Pipeline Company and chemical tankers using docks operated by Dow Chemical. The maximum-sized vessels using Seaway on a regular basis are 820-foot-long by 145-foot-wide crude oil tankers. The length and beam of these vessels generally correspond to a 120,000-deadweight ton (DWT) vessel. The chemical carriers typically range in size from 22,000 to 50,000 DWT. The design drafts for chemical carriers at the upper end of this DWT range generally are 42 to 43 feet. Nearly 10 percent of recent tonnage was loaded to 40–43 feet, with only a few at 43 feet. Review of the chemical carriers on order as of January 2009 showed that 22 percent have design drafts over 42 feet and 1.6 percent have design drafts over 46 feet. This compares with a review in 2004/2005 that showed 2.6 percent of chemical tankers built after 1995 having design drafts of 42 feet and less than 1 percent with design drafts over 42 feet. Freeport's liquefied natural gas (LNG)) terminal is also located in this reach. The LNG terminal became operational in 2008 and was constructed by a partnership that includes ConocoPhillips and Dow Chemical. The terminal is near Station 65+00 and adjacent to the intersection of the Freeport Ship Channel and the Gulf Intracoastal Waterway (GIWW). The docks at the LNG terminal were built to accommodate vessels 1,099 feet long by 177 feet wide. This vessel design prompted the non-Federal sponsor to pursue widening of the offshore Outer Bar and Jetty channels from 400 to 600 feet under the Section 204 authority of the Water Resources Development Act (WRDA) of 1986 as amended in 1990.

The second major reach of the channel extends from near the Brazosport Turning Basin to the Upper Turning Basin near Station 184+20. The Upper Turning Basin is approximately 750 feet in diameter. The major terminal includes ConocoPhillips. Vessel traffic consists of product carriers and crude petroleum tankers. The largest vessels using this upper reach are approximately 100,000 DWT crude petroleum tankers.

Part of the third reach is the side channel providing access to the Brazos Harbor Turning Basin and general cargo facilities. The 36-foot-deep channel intersects with the Main Channel near Station 170+00, just above ConocoPhillips's petroleum docks. Brazos Harbor Turning Basin vessel traffic primarily consists of refrigerated container vessels delivering bananas and general cargo vessels shipping rice. The configuration of the access area and turning basin limits future expansion opportunities due to the high density of docks and landside facilities. The water and landside limitations of the general cargo reaches prompted development of the new Velasco Container Terminal.

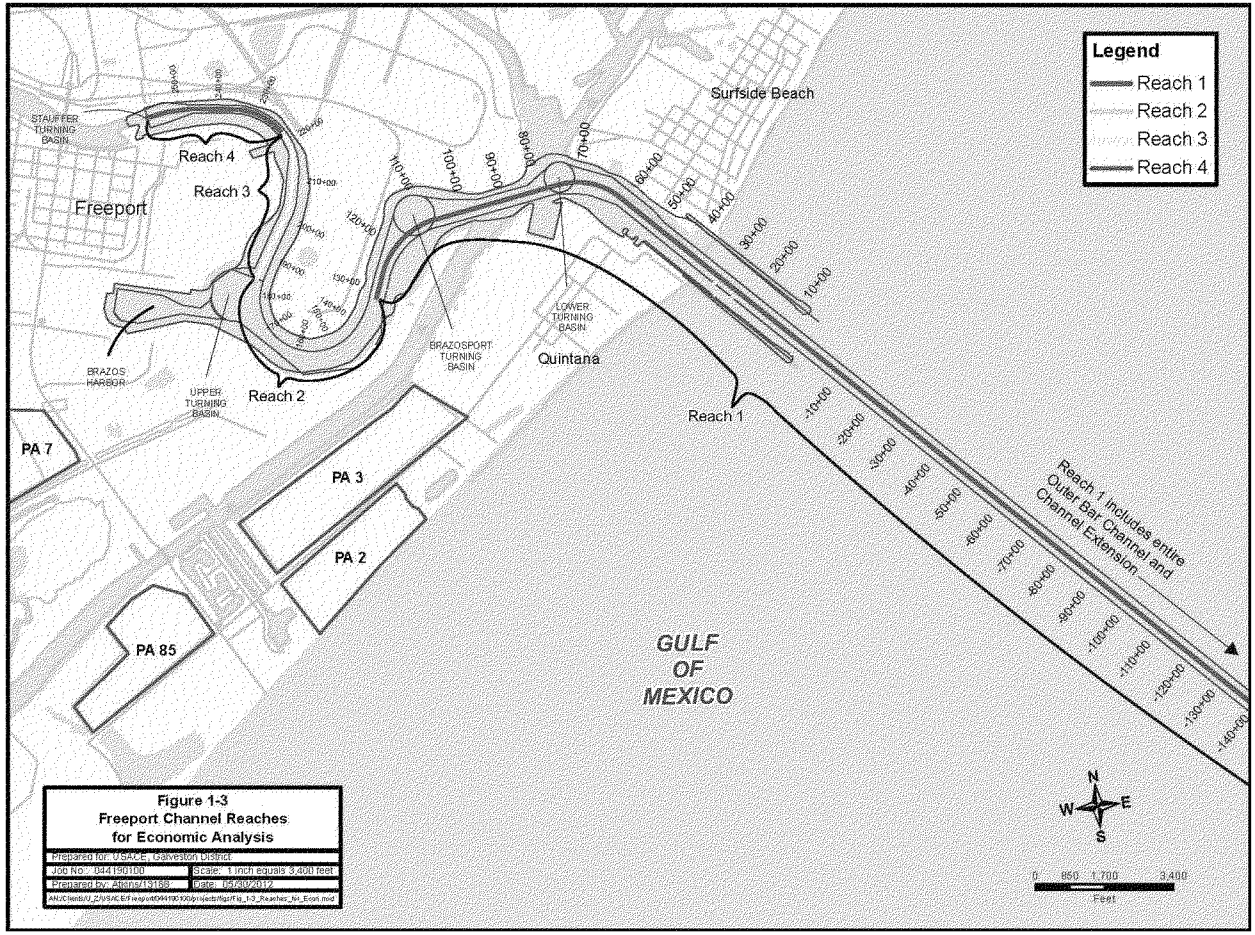



**Figure 1-3**
**Freeport Channel Reaches for Economic Analysis**

Prepared for: USACE, Galveston District
Job No.: 044190100 | Scale: 1 inch equals 3,400 feet
Prepared by: Atkins/13168 | Date: 05/30/2012

The third and fourth economic reaches contain the deauthorized Stauffer Channel and turning basin. The Velasco Container Terminal is located in the lower end of the Stauffer Channel between stations 184+20 and 222+00. The upper reach of the Stauffer Channel is from Station 222+00 to 260+00 and is just below the Freeport Tide Gate.

Until the mid-1950s, the Stauffer Channel had an authorized depth of 30 feet and an operating depth of 25 feet. In 1955, the channel was placed in an inactive status and was deauthorized in 1974 under Section 12, Appendix C, Public Law 93-251. It has taken over 50 years since being categorized as "inactive" for the channel to shoal from 25 feet down to its current depth of 18 feet from Station 184+20 to 260+00.

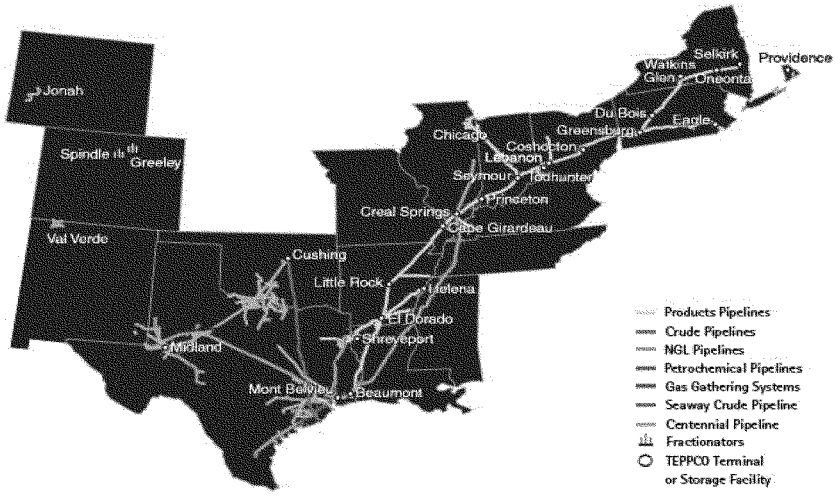
The existing Federal project includes four turning basins. The Lower Turning Basin is 750 feet in diameter and located near Station 70+00. Next is the Brazosport Turning Basin, which is 1,000 feet in diameter and is located near Station 110+00. The Brazos Harbor Turning Basin is 750 feet in diameter and is located in the 36-foot channel reach. The Upper Turning Basin is 1,200 feet in diameter and is located at the upper end of the existing 45-foot-deep Federal project and east of the Brazos Harbor Turning Basin access channel.

## 1.2 OVERVIEW OF EXISTING INFRASTRUCTURE AND COMMODITIES

The Seaway Terminal is located at the lower end of the channel near Channel Station 115+00. Seaway Crude Pipeline Company is a partnership between wholly owned subsidiaries of Texas Eastern Petroleum Pipeline Company (TEPPCO) and ConocoPhillips. The Seaway pipeline extends from the U.S. Gulf Coast to Cushing, Oklahoma. The pipeline also provides regional connections to refineries in Sweeny, Texas City, and Houston.

In addition to Seaway, ConocoPhillips has an oil terminal and large tank farm fronting the waterway near the Upper Turning Basin. During the 1990s, partnerships among ConocoPhillips, TEPPCO, Seaway, and ARCO authorized the construction of two new storage tanks at Phillips's Sweeny tank farm. The two new tanks expanded the shell tank storage capacity at Sweeny from 1.6 to 2.6 million barrels. The expansion increased the capacity of the Seaway crude system from approximately 223,000 barrels per day (BPD) to a volume of 260,000 BPD. Today, the crude petroleum tank farm has six storage tanks capable of handling approximately 3.3 million barrels of crude with pipeline connections to their refinery in nearby Sweeny. Sweeny is 28 miles to the northwest of the Freeport Channel. From Sweeny, crude petroleum is transported to Cushing, Oklahoma. Refined products are also distributed by pipelines to western terminals in Colorado and northeast through Kansas, Missouri, and Illinois. Also, a natural gas liquids (NGL) processing unit and olefins plant, jointly owned and operated by Chevron and Phillips, is located at the Sweeny complex. Figure 1-4 shows the regional pipeline network served by Freeport.

**Figure 1-4**
**Freeport Pipeline Inputs and Output Network**




Freeport's crude petroleum terminals also transmit crude oil to the Bryan Mound Strategic Petroleum Reserve Storage (SPR) Site. The Strategic Petroleum Reserve is a U.S. government complex of four sites with deep underground storage caverns created in salt domes along the Texas and Louisiana Gulf Coast that store emergency supplies of crude oil. One of those sites, Bryan Mound, is located 3 miles southwest of Freeport. Two principal crude pipelines extend from Bryan Mound: a 4-mile, 30-inch-diameter line to the ConocoPhillips terminal and dock, and a 46-inch line to Sweeny and Texas City, Houston, and the Midwest. Figure 1-5 shows the SPR sites.

Freeport is contained in the U.S. Gulf Coast Petroleum Administration for Defense District (PADD III). PADD III includes the states of Texas, Louisiana, Arkansas, Mississippi, Alabama, and New Mexico. Figure 1-6 shows the U.S. PADD boundaries. Freeport's crude petroleum imports represent 4 percent of the U.S. total and 7 percent of the U.S. Gulf Coast PADD III region.

**Figure 1-5**
**U.S. Strategic Petroleum Reserves Gulf Coast Sites**

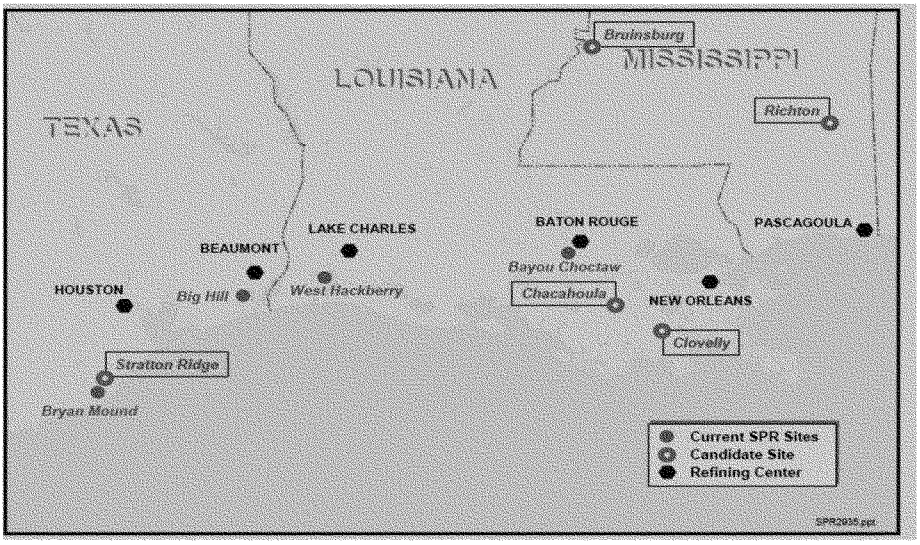
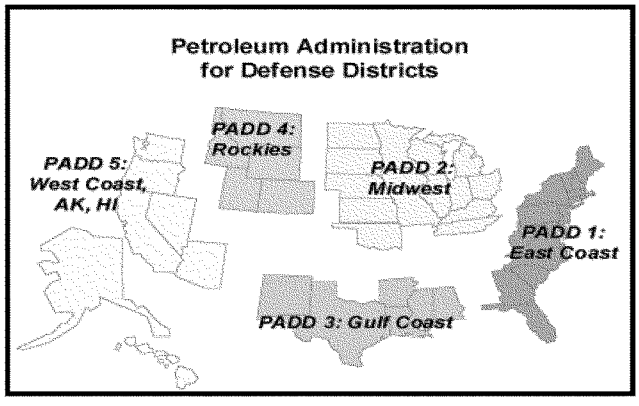



**Figure 1-6**
**U.S. Petroleum Administration for Defense Districts**



Freeport provides access to one of the largest petrochemical complexes in the world. Major petrochemical industries include ConocoPhillips Petroleum, Dow Chemical, and BASF. Located adjacent to the channel is Dow Chemical Company's Texas Division plant. Dow produces large quantities of basic industrial chemicals. Crude petroleum and petrochemical products are distributed from Freeport to the Midwest by pipeline, barge, and rail car.

While the majority of Freeport's cargo consists of crude oil, bulk fuels, and chemicals, the port has a large general cargo base that includes a variety of temperature-sensitive cargos such as meat and vegetables. Freeport is currently the only port in addition to Houston that regularly handles containerized cargo. Freeport's existing temperature-sensitive cargos, rice, and other general and containerized base cargo docks are located in the 36-foot-deep Brazos Harbor Turning Basin (Figure 1-7). Freeport cargo includes 6 percent of U.S. rice exports and 6 percent of U.S. banana imports. P&O, a multinational container terminal operator and stevedore, currently provides container and terminal operations in Freeport for the special requirements of fruit distributors. Currently, Freeport's container trade is concentrated principally on fresh fruit by producers such as Dole, Chiquita, and Turbana. Freeport's refrigerated cargo facility has been in operation since 1984. The fruit distribution facilities were constructed by the port and are leased to the terminal operators. In 2007, container throughput was approximately 60,000 twenty-foot equivalent units (TEU). Freeport maintains an abundance of container storage space and over 7,500 acres available for development.

The Velasco Container Terminal is in the lower reach of the Stauffer Channel (Figure 1-8). Construction of the Velasco Terminal was prompted by increasing existing traffic volumes and vessel size limitations, the inability to deepen the Brazos Harbor Turning Basin access area due to the threat of undermining wharfage, growth in the U.S. container market, and regional and state population growth. Access to the Velasco Terminal will require extending the Federal channel 3,700 feet from its current terminus. Work by the non-Federal sponsor is presently nearing completion on 800 feet (Phase I) of what will be 1,200 feet (Phase II) of dock, and 41 acres of backland of what will be a 90-acre terminal (Phase II). The first vessels are expected to utilize Phase I of the terminal by mid-2013. The current operating depth for the Federal channel at the lower part of the property adjacent to Velasco is 45 feet.

The Velasco Terminal is being constructed in partnership agreement with the Spanish-based Dragados SPL. Both the Velasco Terminal and existing container and general cargo facilities are within 8 miles of the open waters of the Gulf of Mexico. All of Freeport's docks are located within 4 miles from the GIWW.

**Figure 1-7**
**Brazos Harbor Turning Basin Docks**

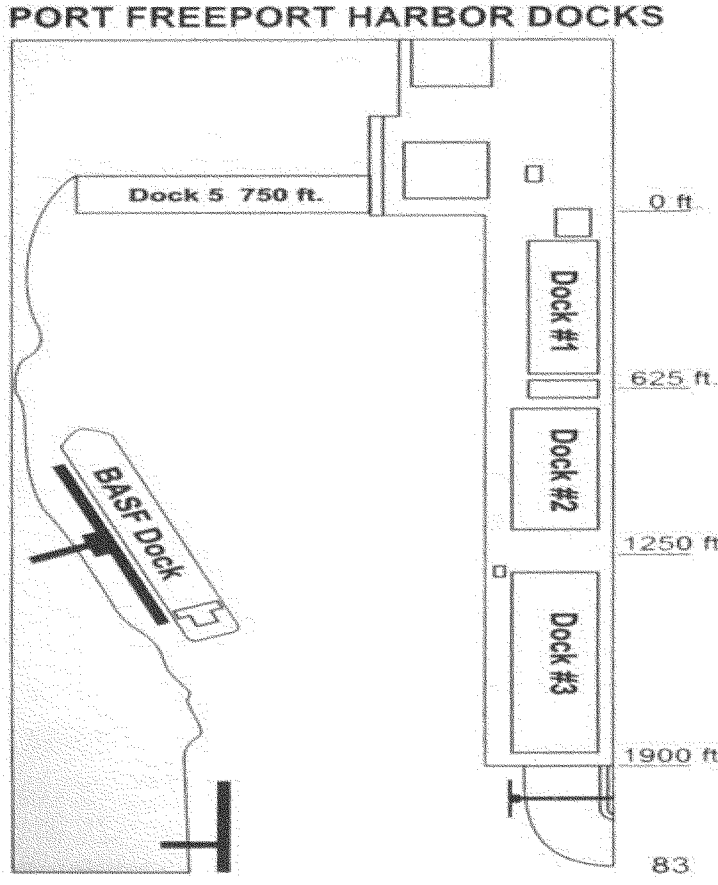
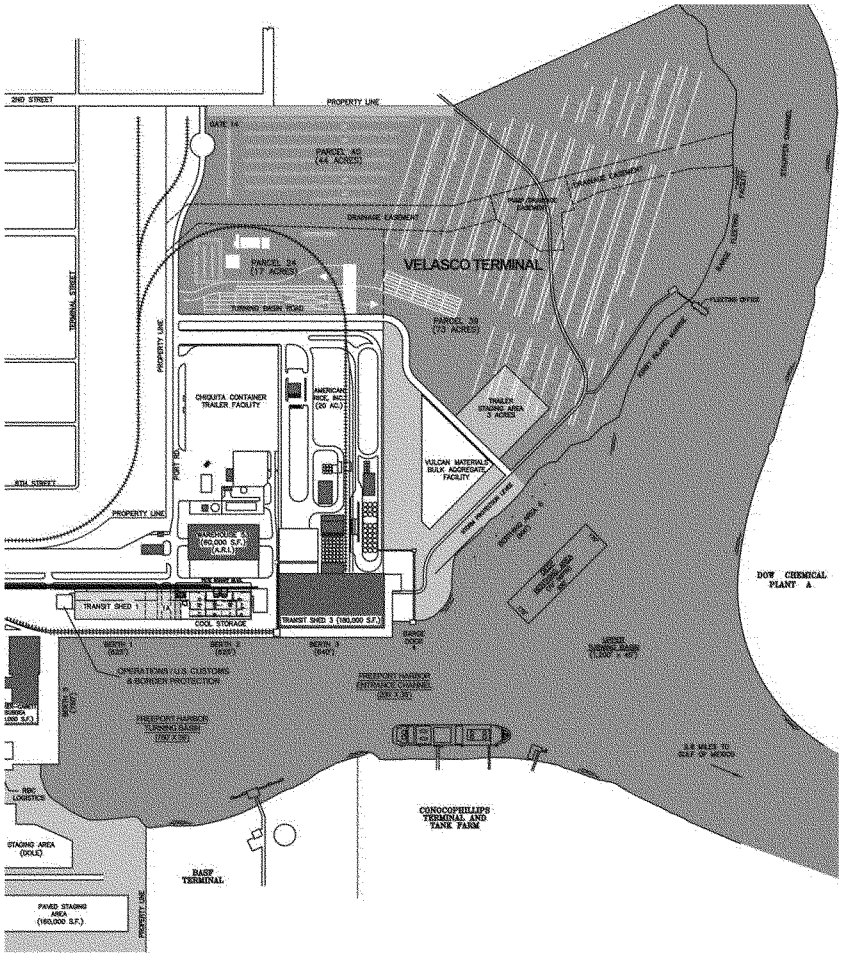
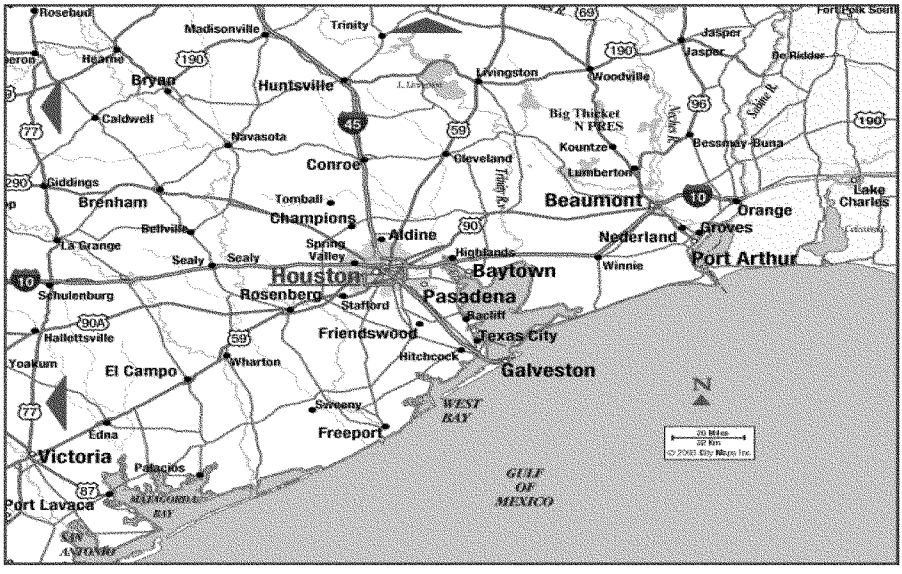


**Figure 1-8**
**Velasco Terminal Site**



The port's proximity to deep water provides efficient transportation to Houston and beyond via highway, rail, and the inland waterway system. The port is accessible from the landside by State Highway (SH) 36, SH 288, and Farm-to-Market Road (FM) 523. Road widening to four lanes from two lanes of SH 36 is in the Texas Department of Transportation's (TxDOT) Transportation Improvement Program (TIP). SH 36 provides a direct access to U.S. Highway 90 and Interstate 10, which provides direct access to San Antonio. SH 288 is accessible going northward from the port on SH 332, turning into SH 288 north of Lake Jackson. The right-of-way for FM 2004, which is presently two lanes, will accommodate four lanes. FM 2004, which intersects with SH 288 north of Lake Jackson, goes from Freeport to Interstate 45. Interstate 45 provides direct access from Houston to Dallas. Figure 1-9 shows the highway network around Freeport.

**Figure 1-9**
**Regional Highway System**




Source: mapplus.com

Port officials are working with the Texas Transportation Commission on advancing both highway and railway improvement. Table 1-1 provides information on TxDOT highway improvement projects for the roads serving the port.

Efficient rail access is also important to container ports. Three Class 1 railroads operated 81 percent of Texas's total track miles in 2003. Class 1 represents the major railroad companies moving significant amounts of freight over long distances and owning track spanning several

states. The three Class I railroads serving Texas are Burlington Northern Santa Fe Railway (BNSF), Kansas City Southern Railroad (KCSR), and Union Pacific (UP).

**Table 1-1**
**Brazoria County Texas Department of Transportation (TxDOT)**
**Planned Road Improvement Projects**

| Road Type | Length (Miles) | Currently Funded (Y/N) | Starting Location[a] | Ending Location[a] | Project Type |
|---|---|---|---|---|---|
| SH 36 | 1.239 | N | 0.9 mile S. of the Brazos River | FM 1495 | Widen roadway |
| SH 36 | 0.001 | N | FM 1495 | . | Construct overpass/ underpass |
| SH 36 | 2.936 | Y | S. of Jones Creek Bridge | 0.2 mile N. of the Brazos River Diversion Channel | Widen roadway |
| SH 36 | 0.001 | N | SH 36 at the Brazos River | | Install/upgrade safety barrier |
| FM 1495 | 0.001 | N | GIWW at the Brazos River | | Repair bridge |
| FM 521 | 0.001 | Y | Brazos River and SH 332 | . | Repair bridge |
| FM 523 | 1.096 | N | SH 332 | Dow Waste Water Canal | Resurface roadway |
| SH 332 | 1.383 | N | 0.657 mile N. of Plantation Dr. | 0.726 mile S. of Plantation Dr. | Construct overpass/ underpass |
| SH 332 | 0.966 | N | 0.480 mile N. of Dixie Dr. | 0.466 mile S. of Dixie Dr. | Construct overpass/ underpass |
| SH 332 | 0.889 | N | 0.492 mile N. of Main Street | 0.397 mile S. of Main St. | Construct overpass/ underpass |
| **Within 5 miles of the Port, Moving West to the Junction of SH 35 with SH 36** | | | | | |
| SH 35 | 0.452 | N | BS 288B | Rock Island Street Junction with SH 288 | Widen roadway |
| SH 35 | 3.210 | N | Rock Island St. Junction with SH 288 | FM 523 | Widen roadway |
| SH 35 | 0.926 | N | SH 288 | T.J. Wright St. | Widen roadway |
| **Greater than 5 miles from the Port, Moving Northwest to Interstate 10** | | | | | |
| SH 36 | 9.644 | Y | S. of Brazoria | S. of Jones Creek Bridge | Widen roadway |
| SH 36 | 4.318 | Y | FM 522 | 2.30 miles N. of SH 332 | Widen roadway |
| SH 36 | 1.799 | Y | SH 35 | FM 522 | Widen roadway |
| SH 36 | 14.005 | Y | Fort Bend County Line | SH 35 | Widen roadway |
| CR | 0.083 | Y | CR 703 at Draw | . | Replace bridge |
| SH 288 | 0.641 | Y | CR 101 (Bailey Rd.) | . | Construct overpass/ underpass |
| FM 521 | 0.001 | Y | Brazos River and SH 332 | . | Repair bridge |
| CR | 0.073 | Y | CR 121 at Hayes Creek | . | Replace bridge |
| FM 523 | 1.241 | N | SH 332 | 0.2 mile S. of FM 1495 | Widen roadway |
| FM 2234 | 2.244 | N | Fort Bend County Line | SH 288 | Widen roadway |
| **Greater than 5 miles from the Port, Moving Northwest to Interstate 45** | | | | | |
| FM 2004 | 2.701 | N | SH 288 | BS 288 | Widen roadway |
| FM 2004 | 2.517 | N | Chocolate Bayou | New Bayou | Widen roadway |

Source: Compiled from TxDOT Database, March 2010.
[a]As defined by TxDOT.

While improvements have been made, conditions of U.S. railroads vary widely and inefficiencies are frequently cited in relation to container cargo distribution. The emphasis on "just in time delivery" cited by many and growing congestion at existing ports and landside transportation networks has prompted growth at smaller and new ports, and contributed to the higher growth rates on the U.S. Gulf and East coasts.

In 2005, the Surface Transportation Board approved the acquisition of abandoned tracks from Victoria to Rosenberg, and improvements to the rail line were completed in June 2009. Prior to 2009, rail traffic followed lines parallel to SH 77 through Victoria to Halletsville, before moving east to Rosenberg on a line paralleling US 90A. The 84.5-mile reactivated rail line parallels SH 59 and is located in the Texas counties of Jackson, Victoria, Wharton, and Fort Bend. These counties border Brazoria County. The rehabilitation of the KCSR line between Victoria and Rosenberg shortened the rail distance from Mexico by approximately 70 miles by eliminating the need for KCSR to operate over nearly 160 miles of Union Pacific–controlled track between Rosenberg and Victoria via Flatonia, which is a heavily used rail corridor. The rehabilitation of the Victoria-Rosenberg line facilitated CenterPoint Properties, and the KCSR recently completed construction of an estimated 636-acre intermodal logistics park (CenterPoint Intermodal Center). This property will be used to facilitate receive, store, and disburse rail and truck containerized cargo (foreign trade zone [FTZ] 149, Site 12).

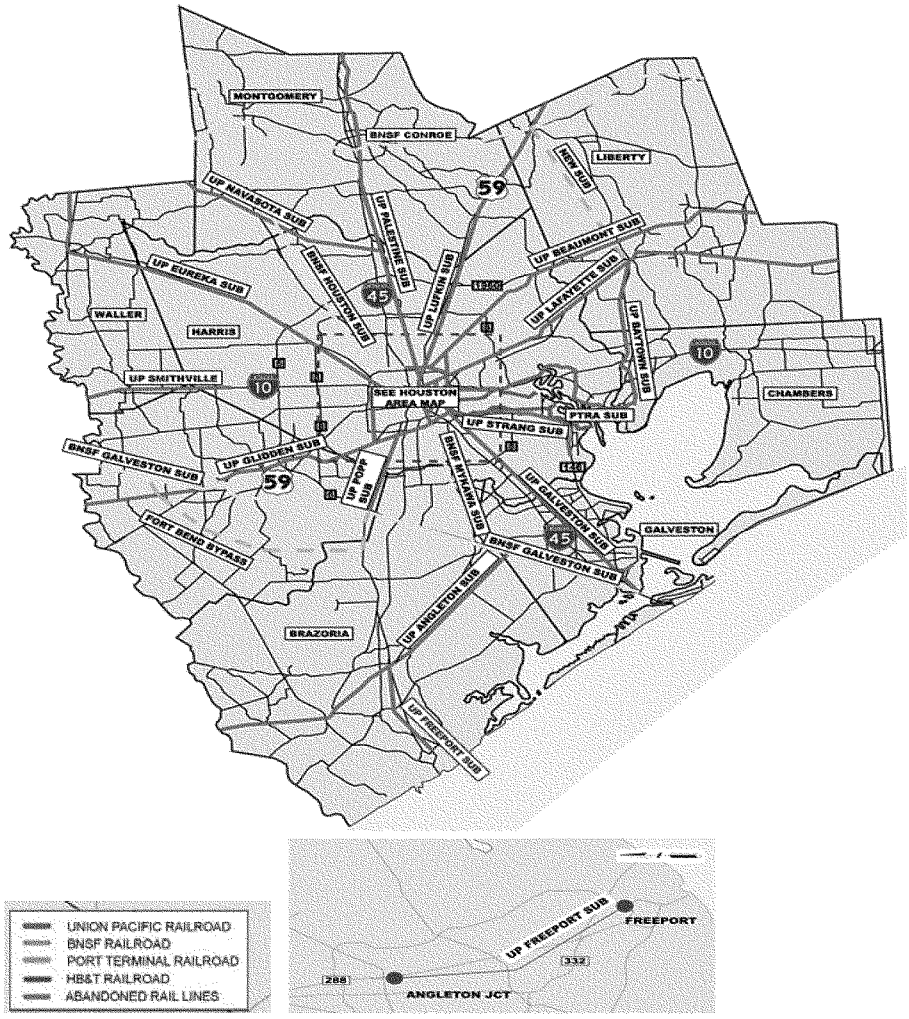
The specific location of the intermodal yard is 35 miles southwest of Houston and immediately south of Kendleton. The recently completed facility includes a 3,500-foot intermodal track with associated parking and facilities. Additional adjacent development will include the 340-acre International Industrial Park (FTZ 149, Site 11) being developed by GBI Group, LLC. Sites 11 and 12 are 61.5 miles from Freeport Velasco Container Terminal and 64 miles from Barbours Cut on the Houston Ship Channel.

UP has a direct connection to Freeport's existing container and general yard site in the Brazosport Basin and Dow Chemical loading areas. The spur provides access to the main UP lines to San Antonio and the separate Houston line that provides connection to Dallas. Rail corridors on the east and west sides of Houston exist similar to the Los Angeles/Long Beach Alameda Rail Corridor, according to Port of Freeport personnel. Freeport is initially anticipated to serve as a truck port, but enhancements to rail capabilities in Brazoria County are planned, including replacement of a World War II–era rail bridge over the old Brazos River channel in downtown Freeport.

In addition to the Victoria to Rosenberg line, another KCSR line renovation from the Texas-Mexico border city of Laredo, Texas, and Corpus Christi, Texas, was recently completed. The *Houston Chronicle* noted that about six rail cars per day move between Lazaro Cardenas on Mexico's Pacific Coast to Houston. KCSR also owns a subsidiary of the Texas Mexican Railway

Company (TexMex)[1]. The affiliation allows access to the Pacific and Gulf coasts of Mexico. Figure 1-10 provides a pictorial of the rail lines presently serving the Freeport study region.

**Figure 1-10**
**Regional Railroad System**




Source: TxDOT, Houston Freight Study, October 2005.

[1] Houston Chronicle, "Revived Route Connects Dots, Kansas City Southern Railway Cuts 67 Miles Off Vital Journey," June 18, 2009.

Table 1-2 displays mileages from Freeport to towns and cities within and adjacent to Brazoria County.

**Table 1-2**
**Mileage Comparison to**
**Cities Within or Adjacent to Brazoria County**

| City | Freeport Miles | LaPorte Miles | Freeport Advantage Plus (+) | 2008 City Population | County |
|---|---|---|---|---|---|
| Lake Jackson | 10 | 64 | 54 | 27,614 | Brazoria |
| Rosenberg | 58 | 58 | 0 | 24,043 | Ft. Bend |
| Bay City | 49 | 90 | 41 | 18,667 | Matagorda |
| Angleton | 27 | 54 | 27 | 18,130 | Brazoria |
| Freeport | 0 | 74 | 74 | 12,708 | Brazoria |
| El Campo | 101 | 102 | 1 | 10,945 | Wharton |
| Clute | 8 | 69 | 61 | 10,424 | Brazoria |
| Wharton | 60 | 82 | 22 | 9,772 | Wharton |
| Palacios | 72 | 128 | 56 | 5,153 | Matagorda |
| West Colombia | 26 | 66 | 40 | 4,199 | Brazoria |
| Sweeny | 27 | 75 | 48 | 3,624 | Brazoria |
| Brazoria | 18 | 66 | 48 | 2,974 | Brazoria |
| Jones Creek | 8 | 72 | 64 | 2,130 | Brazoria |
| Danbury | 25 | 41 | 16 | 1,611 | Brazoria |

In addition to relative distances from Freeport, the locations of "distribution centers (DCs)," also referred to as "inland ports," were examined. DCs used to function primarily as warehouses but currently are involved in repackaging cargo for retailers and adding value to commodities. These centers are established along supply chains to service retail outlets such as Wal-Mart, Target, Home Depot, and Lowes. The inland ports of Alliance (Forth Worth), Wilmer (Dallas), and Kelly (San Antonio) are part of the Texas freight distribution network. The inland ports complement the overland border ports of entry, where consolidation of trade transfers can take place related to the North Atlantic Free Trade Agreement.

The docks located in the Upper Stauffer channel reach are operated by Freeport Launch, VIT Marine, and Baron Marine. The Freeport Launch dock and yard are inside the U.S. Department of Homeland Security secured gated area adjacent to the channel. Since 2001, an estimated $100,000 was spent by industry to ensure that the Freeport Launch facility is in compliance with U.S. Homeland Security regulations associated with foreign flag vessel and associated crew activity. As a result of the Homeland Security upgrades, the boat yard includes gates and a guarded entrance with 24-hour security. VIT is located immediately north of Freeport Launch.

Both facilities are on the west side of the channel. Baron Marine is on the east side of the channel.

Freeport has an existing LNG facility that includes two 160,000-cubic-meter storage tanks and one piled dock capable of handling LNG vessels in excess of 200,000 cubic meters to accommodate the largest LNG tankers under construction today. Freeport's LNG terminal became operational in April 2008 and is located along the northern edge of the Freeport Harbor Entrance channel near Station 65+00 and adjacent to the intersection of the Freeport Ship Channel and the GIWW. The docks at the LNG terminal were built to accommodate vessels 1,099 feet long by 177 feet wide. The first phase of the project allows the facility to have a send-out capacity of 1.75 billion cubic feet per day. Natural gas will be transported from Freeport through a 9.4-mile pipeline to Stratton Ridge, Texas, which is a major point of interconnection with the Texas intrastate gas pipeline system. Benefits from LNG are not captured in this analysis.

## 2.0 HISTORICAL TRAFFIC

Freeport experienced strong growth over the past two decades. Total tonnage increased from an average of 16.1 million short tons in 1994 to 1995 to an average of 28.5 million for 2004 to 2006. In 2008, Freeport ranked 26th in the Nation in terms of total tonnage, up from 38th in the early 1990s.[2] In terms of foreign imports and exports, Freeport ranked 12th among U.S. ports in 2007, up from 25th in the early 1990s. Approximately 85 percent of Freeport's current tonnage consists of deep-draft movements. The remaining 15 percent consists of shallow-draft GIWW traffic.

This section provides an overview of recent historical traffic for the existing commodity base. The discussion is limited to crude petroleum, petroleum and chemical products, general and container cargo, and LNG. Inclusion of recent data is based on availability, report preparation time constraints, and relevance to the presentation. Table 2-1 presents Freeport's 2006 imports and exports by foreign region of origin or destination. Table 2-2 presents Freeport's tonnage by major commodity groups through 2009.

**Table 2-1**
**Freeport Harbor**
**2006 Imports and Exports by Region (all Foreign Imports and Exports)**
**Estimated Distribution of Imports and Exports by Region of Origin**
**1,000s of Short Tons**

| Region | Imports | | Exports | | Total | |
|---|---|---|---|---|---|---|
| Canada | 24.1 | 0.10% | 345.8 | 11.50% | 369.9 | 1.30% |
| Mexico | 1,133.6 | 4.70% | 42.1 | 1.40% | 1,175.7 | 4.30% |
| Central America and Caribbean | 1,230.1 | 5.10% | 706.6 | 23.50% | 1,936.7 | 7.00% |
| South America | 11,118.9 | 46.10% | 739.7 | 24.60% | 11,858.6 | 43.80% |
| Western South America | 4,10.0 | 1.70% | 12.0 | 0.40% | 422.1 | 1.60% |
| Europe and Mediterranean | 2,460.1 | 10.20% | 129.3 | 4.30% | 2,589.4 | 9.60% |
| Africa | 2,894.3 | 12.00% | 177.4 | 5.90% | 3,071.7 | 11.40% |
| Middle East | 4,843.1 | 20.08% | 141.3 | 4.70% | 4,984.4 | 18.40% |
| Far East and Pacific | 4.8 | 0.02% | 712.7 | 23.70% | 717.5 | 2.60% |
| Total Tonnage | 24,119.0 | 100.0% | 3,007.0 | 100.0% | 27,126.0 | 100.0% |

Source: U.S. Army Corps of Engineers (USACE), NDC detailed unpublished data, 2006.

[2] USACE, Waterborne Commerce of the U.S., Part 5, National Summary, Institute of Water Resources (IWR)-Waterborne Commerce Statistical Center (WCSC)-09, 2006–2008 and 1991–1993.

**Table 2-2**
**Freeport Harbor Tonnage by Major Commodity Groups (1,000s of short tons)**
**(1970–2009)**

| | Major Deep-Draft Commodities | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Crude Oil Imports | Petroleum Products Imports | Petroleum Products Exports | Chemical Imports | Chemical Exports | Other | Total Ocean-Going | Inland Waterway Barge Cargo | Total Tonnage |
| 1970 | 0 | 0 | 0 | 0 | 1,082 | 1,209 | 2,291 | 2,992 | 5,283 |
| 1980 | 12,498 | 221 | 0 | 301 | 1,162 | 3,117 | 17,299 | 2,832 | 20,131 |
| 1990 | 5,472 | 17 | 26 | 149 | 1,093 | 3,407 | 10,164 | 4,330 | 14,494 |
| 1991 | 6,175 | 38 | 10 | 183 | 967 | 1,895 | 9,268 | 6,398 | 15,666 |
| 1992 | 5,891 | 53 | 14 | 163 | 871 | 2,761 | 9,753 | 5,200 | 14,953 |
| 1993 | 7,025 | 18 | 25 | 176 | 931 | 1,564 | 9,739 | 4,286 | 14,025 |
| 1994 | 10,073 | 259 | 17 | 187 | 1,431 | 1,483 | 13,450 | 4,000 | 17,450 |
| 1995 | 10,378 | 1,345 | 73 | 344 | 1,425 | 1,357 | 14,922 | 4,740 | 19,662 |
| 1996 | 15,074 | 1,887 | 27 | 275 | 1,418 | 1,199 | 19,880 | 4,691 | 24,571 |
| 1997 | 16,742 | 1,863 | 117 | 333 | 1,522 | 1,272 | 21,849 | 4,432 | 26,281 |
| 1998 | 19,527 | 1,825 | 46 | 255 | 1,724 | 1,175 | 24,552 | 4,462 | 29,014 |
| 1999 | 18,321 | 1,644 | 39 | 341 | 1,633 | 1,247 | 23,225 | 4,851 | 28,076 |
| 2000 | 19,770 | 2,054 | 45 | 379 | 2,217 | 1,685 | 26,150 | 4,835 | 30,985 |
| 2001 | 19,307 | 2,413 | 40 | 583 | 1,748 | 1,407 | 25,498 | 4,645 | 30,143 |
| 2002 | 18,019 | 736 | 119 | 663 | 1,907 | 1,119 | 22,563 | 4,601 | 27,164 |
| 2003 | 19,672 | 1,857 | 87 | 778 | 2,104 | 1,114 | 25,612 | 4,925 | 30,537 |
| 2004 | 20,602 | 2,873 | 91 | 835 | 2,622 | 2,093 | 29,116 | 4,792 | 33,908 |
| 2005 | 22,000 | 1,779 | 91 | 691 | 2,509 | 1,860 | 28,930 | 4,672 | 33,602 |
| 2006 | 21,706 | 1,080 | 109 | 705 | 2,551 | 1,420 | 27,571 | 4,576 | 32,147 |
| 2007 | 18,523 | 1,046 | 90 | 710 | 2,691 | 1,005 | 24,065 | 5,151 | 29,598 |
| 2008 | 20,607 | 955 | 81 | 602 | 2,406 | 1,347 | 25,998 | 3,844 | 29,842 |
| 2009 | 19,418 | 220 | 200 | 573 | 1,864 | 1,063 | 23,338 | 4,025 | 27,363 |

Source: USACE, Waterborne Commerce of the U.S., Part 2, 1970–2009.

In addition to the commodity and container traffic, in 2008 Freeport handled 28,000 tons of wind energy equipment, and 21 vessels called at the port with wind-energy equipment.

## 2.1 CRUDE PETROLEUM IMPORT TRAFFIC

Crude petroleum dominates total tonnage. Crude petroleum represented 75 percent of 2004 to 2006 ocean-going tonnage. Freeport's crude petroleum imports represented an average of 3.9 percent of the U.S. total and 6.9 percent of PADD III. The Seaway pipeline system provides a critical link in the crude oil supply chain for Central and Midwest refining centers.

Freeport's import growth relates to the pipeline distribution network with national links and regional connections from the channel's Seaway and ConocoPhillips terminals. The combination of the channel-deepening project from 40 to 45 feet in the early nineties and refinery expansions

fostered a 178 percent increase in Freeport's crude imports from 1993 to 1998. Over the same period, PADD III imports increased 31 percent and U.S. imports increased by 28 percent. Since 1998, Freeport's growth has leveled and is more comparable to national and regional growth.

Statistics published in IWR-WCSC-09 show Freeport's 2007 total tonnage at approximately 30 million short tons, down from 32 million in 2006. Data from the U.S. Department of Energy (DOE) show that Freeport's crude oil imports were down in both 2007 and 2008 from 2006 levels. However, review of the 2008 monthly data showed that Freeport crude oil imports were generally higher in 2008 than 2007 for all months except September when Hurricane Ike hit the region.

Table 2-3 displays Freeport's crude petroleum imports and shows the port's share of the national and regional totals. Table 2-4 lists crude oil volumes imported to Freeport and distributed to regional and national domestic processing area. Table 2-5 indicates approximately 25 percent of the crude oil imported to Freeport is sent from PADD III to PADD II.

**Table 2-3**
**Comparison of Freeport and Regional and National Totals**
**Crude Petroleum Imports (1,000s of short tons)**

| Year | Freeport Imports | Waterborne and Pipeline Imports | | Freeport % of | |
|---|---|---|---|---|---|
| | | PADD III | U.S. Total | PADD III | U.S. Total |
| 1990 | 5,472 | 178,052 | 322,433 | 3.1 | 1.7 |
| 1991 | 6,175 | 174,852 | 316,310 | 3.5 | 2.0 |
| 1992 | 5,891 | 184,871 | 333,666 | 3.2 | 1.8 |
| 1993 | 7,025 | 204,356 | 371,267 | 3.4 | 1.9 |
| 1994 | 10,073 | 221,020 | 386,381 | 4.6 | 2.6 |
| 1995 | 10,378 | 222,164 | 395,484 | 4.7 | 2.6 |
| 1996 | 15,074 | 237,708 | 411,824 | 6.3 | 3.7 |
| 1997 | 16,742 | 252,270 | 449,961 | 6.6 | 3.7 |
| 1998 | 19,527 | 267,175 | 476,231 | 7.3 | 4.1 |
| 1999 | 18,321 | 270,491 | 477,592 | 6.8 | 3.8 |
| 2000 | 19,770 | 281,170 | 497,547 | 7.0 | 4.0 |
| 2001 | 19,307 | 292,859 | 510,298 | 6.6 | 3.8 |
| 2002 | 18,019 | 282,226 | 499,999 | 6.4 | 3.6 |
| 2003 | 19,672 | 300,325 | 528,703 | 6.6 | 3.7 |
| 2004 | 20,602 | 316,402 | 553,337 | 6.5 | 3.7 |
| 2005 | 22,000 | 310,493 | 553,923 | 7.1 | 4.0 |
| 2006 | 21,706 | 309,399 | 553,489 | 7.0 | 3.9 |
| 2007 | 18,523 | 306,956 | 548,742 | 6.0 | 3.6 |
| 2008 | 20,607 | 294,045 | 535,170 | 7.0 | 3.9 |
| 2009 | 19,418 | 278,454 | 493,030 | 7.0 | 3.9 |

Source: USACE and Energy Information Administration (EIA), 1990–2009.

**Table 2-4**
**Freeport Crude Oil Imports by State and PADD Destination by Tonnage**
**1993 and 2003–2008 (1,000s of barrels)**

| Destination | 1993 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|
| Illinois | 0 | 12,995 | 6,998 | 4,583 | 14,262 | 11,606 | 14,849 |
| Indiana | 0 | 0 | 315 | 0 | 0 | 0 | 0 |
| Kansas | 0 | 1,910 | 16,144 | 10,546 | 7,969 | 792 | 1,539 |
| Kentucky | 0 | 0 | 540 | 0 | 0 | 0 | 0 |
| Louisiana | 0 | 0 | 0 | 1,447 | 1,204 | 0 | 0 |
| Michigan | 0 | 313 | 1,137 | 1,433 | 751 | 0 | 0 |
| Minnesota | 0 | 0 | 0 | 500 | 0 | 0 | 0 |
| Ohio | 0 | 0 | 0 | 500 | 0 | 0 | 0 |
| Oklahoma | 0 | 599 | 8,116 | 9,623 | 7,261 | 8,979 | 13,273 |
| Texas | 0 | 89,502 | 92,644 | 87,514 | 95,291 | 93,864 | 85,774 |
| Beaumont | 0 | 0 | 0 | 0 | 1,100 | 557 | 0 |
| Borger | 0 | 12,292 | 12,098 | 520 | 4,133 | 3,858 | 0 |
| Houston | 0 | 0 | 0 | 297 | 0 | 0 | 3,080 |
| Sweeny | 46,993 | 76,162 | 80,546 | 85,009 | 89,270 | 89,449 | 82,593 |
| Texas City | 0 | 525 | 0 | 1,688 | 395 | 0 | 101 |
| Other | 0 | 15,296 | 3,535 | 3,832 | 7,888 | 9,407 | 7,464 |
| Freeport Total | 46,993 | 120,615 | 129,429 | 119,978 | 134,626 | 124,648 | 122,899 |
| PADD II | 0 | 15,817 | 33,250 | 27,185 | 30,243 | 21,377 | 29,661 |
| PADD III | 46,993 | 104,275 | 96,179 | 92,793 | 103,990 | 103,271 | 93,238 |
| Freeport Total | 46,993 | 120,092 | 129,429 | 119,978 | 134,233 | 124,648 | 122,899 |
| PADD II | 0 | 13% | 26% | 23% | 23% | 17% | 24% |
| PADD III | 100% | 87% | 74% | 77% | 77% | 83% | 76% |
| Freeport Total | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

Source: USACE and EIA, compiled from public website files, 1993 and 2003–2008.

While the Energy Information Administration (EIA) shows all of Freeport's crude oil imports being tied to ConocoPhillips's Sweeny refinery, the point of demarcation is one of two docks on the Freeport Ship Channel. Approximately 90 percent of Freeport's total crude oil ship tonnage is discharged at Seaway, with the remaining 10 percent discharged at the ConocoPhillips dock.

The data presented in Tables 2-4 and 2-5 were compiled from the DOE's databases. The 2003 to 2006 annual EIA volumes show differences with the U.S. Army Corps of Engineers' (USACE) Navigation Data Center (NDC) data available for the same years. For instance, the NDC and the EIA 1993 to 2003 Freeport import rates of change are relatively similar, but comparison of Freeport's 2005 to 2008 rate of change shows imports decreasing and the EIA's rate shows an increase. The differences in the relative totals can be attributable to conversion factor applications based on the various properties of the different types of crude oil. The NDC data account for the specific crude types and their relative weights.

**Table 2-5**
**Freeport Crude Oil Imports by State and PADD Destination by Percent**
**1993 and 2003–2008 (1,000s of barrels)**

| Destination | Percent | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1993 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| Sweeny, TX (PADD III) | 100.0 | 63.1 | 62.2 | 70.9 | 66.3 | 71.8 | 67.2 |
| Wood River, IL (PADD II) | 0.0 | 10.8 | 5.4 | 3.8 | 10.6 | 9.3 | 12.1 |
| Ponca City, OK (PADD II) | 0.0 | 0.5 | 6.3 | 8.0 | 5.4 | 4.5 | 6.7 |
| Cushing, OK (PADD II) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.7 | 4.1 |
| Other | 0.0 | 25.6 | 26.1 | 17.3 | 17.7 | 11.7 | 9.9 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: USACE and EIA, compiled from public website files.

Table 2-6 shows a comparison of the EIA and NDC data.

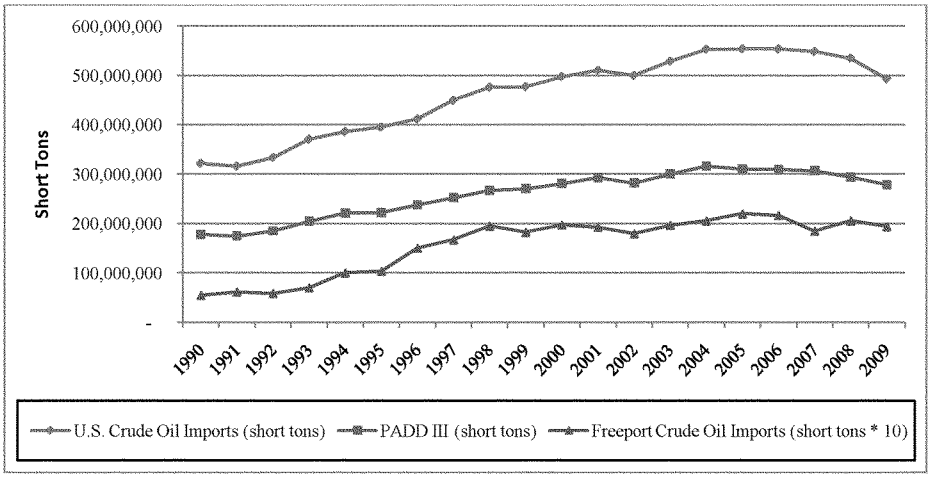
**Table 2-6**
**Comparison of USACE and EIA Data**
**Freeport Crude Petroleum Imports**

| Year | Freeport Channel | | | |
|---|---|---|---|---|
| | NDC Short Tons | Factor Change | EIA Barrels[a] | Factor Change |
| 1993 | 7,025 | | 46,993 | |
| 2003 | 18,672 | 2.66 | 120,615 | 2.57 |
| 2004 | 20,602 | 1.05 | 129,685 | 1.08 |
| 2005 | 22,000 | 1.07 | 119,978 | 0.93 |
| 2006 | 21,706 | 0.99 | 134,233 | 1.12 |
| 2007 | 18,523 | 0.85 | 124,648 | 0.93 |
| 2008 | 20,607 | 1.12 | 122,899 | 0.99 |

Source: USACE and EIA, compiled from public website files.
[a]1,000s of barrels

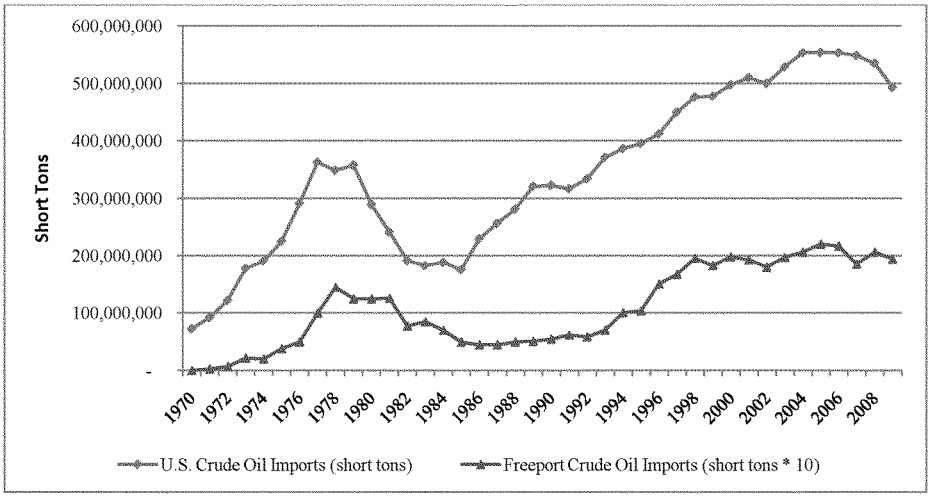
Figure 2-1 presents 1990 to 2009 Freeport, PADD III, and U.S. statistics and again helps to illustrate Freeport's 1993 to 1998 relative increase in imports. Comparison of the Freeport and U.S. 1970 to 2009 longer-period relationship is illustrated in Figure 2-2.

**Figure 2-1**
**U.S. PAD III and Freeport Crude Petroleum Imports (1990–2009)**




Source: USACE, Waterborne Commerce of the U.S., Part 2, 1990–2009, and EIA.

**Figure 2-2**
**U.S. and Freeport Crude Petroleum Imports (1970–2009)**




Source: USACE, Waterborne Commerce of the U.S., Part 2, 1970–2009, and EIA.

Freeport's growth rates for crude petroleum imports exceed several other regional ports. Table 2-7 shows a comparison of annual growth rate data for Freeport and other Texas ports. Freeport's imports are expected to grow at rates generally comparable to the regional and national trends. This expectation is based on the study area's established infrastructure of regional and national pipeline distribution links.

**Table 2-7**
**Texas Port and U.S. Crude Petroleum Waterborne Imports (1993–2007)**
**(1,000s of short tons)**

| Year | Freeport | Texas City | Houston | Sabine-Neches Waterway | Corpus Christi | Total | U.S. Total |
|---|---|---|---|---|---|---|---|
| 1993 | 7,025 | 33,111 | 27,952 | 32,639 | 18,395 | 119,122 | 371,267 |
| 1994 | 10,073 | 22,863 | 30,812 | 37,226 | 29,756 | 130,730 | 387,335 |
| 1995 | 10,378 | 27,781 | 22,392 | 38,743 | 27,183 | 126,477 | 371,415 |
| 1996 | 15,074 | 31,901 | 34,636 | 40,930 | 36,737 | 159,278 | 401,694 |
| 1997 | 16,742 | 33,900 | 46,516 | 51,142 | 41,627 | 189,927 | 429,301 |
| 1998 | 19,527 | 27,958 | 43,446 | 53,877 | 39,886 | 184,694 | 433,427 |
| 1999 | 18,321 | 26,900 | 37,472 | 53,834 | 36,029 | 172,556 | 439,806 |
| 2000 | 19,770 | 34,646 | 53,339 | 67,187 | 35,840 | 210,782 | 521,619 |
| 2001 | 19,307 | 38,688 | 46,755 | 64,226 | 32,226 | 201,202 | 486,249 |
| 2002 | 18,019 | 32,864 | 45,686 | 66,383 | 28,534 | 191,486 | 479,318 |
| 2003 | 19,672 | 38,773 | 52,623 | 70,158 | 32,516 | 213,742 | 515,747 |
| 2004 | 20,602 | 42,845 | 55,940 | 69,875 | 30,140 | 219,402 | 531,598 |
| 2005 | 22,000 | 35,644 | 58,037 | 59,691 | 30,514 | 205,886 | 522,784 |
| 2006 | 21,706 | 30,431 | 58,452 | 57,616 | 30,068 | 198,273 | 524,668 |
| 2007 | 18,523 | 32,620 | 54,112 | 56,171 | 33,520 | 194,946 | 521,948 |
| 1995–1997 Avg. | 14,065 | 31,194 | 34,515 | 43,605 | 35,182 | 158,561 | 400,803 |
| 2005–2007 Avg. | 20,743 | 32,898 | 56,867 | 57,826 | 31,367 | 199,702 | 540,361 |
| Average Annual Growth Rate (%) | 4.0 | 0.5 | 5.1 | 2.9 | −1.1 | 2.3 | 2.7 |

Source: USACE, Waterborne Commerce of the U.S., Part 2, 1970–2007.

## 2.2 PETROLEUM AND CHEMICAL PRODUCT TRAFFIC

Regional production includes petroleum products and chemical products. Petroleum products include transportation fuels such as gasoline, diesel fuel, and jet fuel. Chemical products include sodium hydroxide, complex hydrocarbons, and ammonia. Freeport's products consist primarily of petroleum product imports and chemical exports. Petroleum products are distributed throughout the Midwest and southeastern United States by pipeline, barge, and railcar.

Chemicals are primarily distributed by inland waterway barge. For 2004 to 2006, petroleum and chemical imports and exports totaled 5.3 million short tons.

Petroleum product imports experienced high growth after 1994. Imports totaled 259 thousand short tons in 1994 and increased to 1.3 million in 1995, but petroleum product imports are variable. The increases experienced in the mid-1990s were associated with lube oil imports, which represented an average of nearly 70 percent of 1995 to 2000 petroleum product imports. In spite of fluctuating volumes, Freeport's share of U.S. petroleum product imports has remained between 1 and 2 percent since the mid-1990s.

Freeport's petroleum product exports are much lower than imports and are also variable. Freeport's product exports averaged 97 thousand short tons for 2004 to 2006 and represent less than 1 percent of the U.S. total product export. Table 2-8 shows Freeport's 1992 to 2007 percent of the U.S. totals. Freeport exports 4.6 percent of U.S. chemicals. Chemical export volumes for 2004 to 2007 averaged 2.6 million short tons and represent record highs.

**Table 2-8**
**Freeport Harbor**
**Petroleum and Chemical Product Imports and Exports**
**Percentages of U.S. Totals**

| | Petroleum Products | | Chemical Products | |
|---|---|---|---|---|
| | Freeport Percentage of the U.S. Total | | Freeport Percentage of the U.S. Total | |
| Year | Imports | Exports | Imports | Exports |
| 1992 | 0.1 | 0.0 | 1.0 | 2.1 |
| 1993 | 0.0 | 0.0 | 0.9 | 2.3 |
| 1994 | 0.3 | 0.0 | 0.8 | 3.2 |
| 1995 | 1.7 | 0.1 | 1.4 | 2.9 |
| 1996 | 1.9 | 0.1 | 1.1 | 3.0 |
| 1997 | 1.8 | 0.2 | 1.3 | 3.0 |
| 1998 | 1.5 | 0.1 | 0.9 | 3.4 |
| 1999 | 1.3 | 0.1 | 1.2 | 3.1 |
| 2000 | 1.6 | 0.1 | 1.0 | 3.8 |
| 2001 | 1.8 | 0.1 | 1.3 | 3.2 |
| 2002 | 0.6 | 0.2 | 1.7 | 3.5 |
| 2003 | 1.3 | 0.2 | 1.9 | 3.9 |
| 2004 | 1.7 | 0.1 | 1.9 | 4.3 |
| 2005 | 1.1 | 0.1 | 1.5 | 4.2 |
| 2006 | 1.1 | 0.1 | 1.5 | 4.4 |
| 2007 | 0.6 | 0.1 | 1.5 | 4.6 |

Source: USACE, Waterborne Commerce of the U.S., Part 2, 1992–2007.

Table 2-9 and Table 2-10 show Freeport's petroleum product imports and exports by major commodity group. Table 2-11 shows Freeport imports 14 percent of U.S. chemical hydrocarbons and 7.4 percent of ammonia. Chemical imports averaged 768 thousand short tons for 2003 to 2005 and 710 thousand short tons in 2007, which is less than one-third of exports. Freeport exports 32.8 percent of U.S. sodium hydroxide, 8.5 percent of U.S. organic chemicals, 8.8 percent of U.S. chemical hydrocarbon, and 7.3 percent of alcohols. Table 2-12 presents Freeport's chemical exports.

**Table 2-9**
**Freeport Petroleum Products Imports by Major Commodity Group**
**Comparison with U.S. Petroleum Product Totals**
**(1,000s of short tons)**

| | Freeport Petroleum Product Imports | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Major Group** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** |
| Gasoline | – | – | – | 5 | 26 | – | 222 | 1,395 | 960 | 733 | 623 |
| Naphtha & solvents | 149 | 157 | 74 | 547 | 833 | 323 | 417 | 351 | 180 | 175 | 125 |
| Distillate fuel oil | 52 | 5 | 67 | – | – | – | – | 140 | 102 | 3 | – |
| Residual fuel oil | 109 | – | – | 212 | – | 2 | – | – | 117 | – | 55 |
| Lube oil | 1,275 | 1,174 | 1,329 | 1,290 | 1,379 | 323 | 1,168 | 862 | – | 58 | 0 |
| Hydrocarbons, Petroleum Gases & Other | 161 | 485 | 169 | – | 175 | 23 | 50 | 123 | 337 | 111 | 242 |
| Other | 117 | 1,833 | 5 | – | – | 65 | – | 2 | 83 | – | 1 |
| Freeport Petroleum Imports | 1,863 | 3,654 | 1,644 | 2,054 | 2,413 | 736 | 1,857 | 2,873 | 1,779 | 1,080 | 1,046 |

| | U.S. Petroleum Product Imports[a] | | | | | | | | | | Freeport 2004–2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Major Group** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **% of U.S.** |
| Gasoline | 19,374 | 17,381 | 18,404 | 24,157 | 27,732 | 29,282 | 32,294 | 50,746 | 63,022 | 64,261 | 1.7 |
| Kerosene | 4,977 | 6,134 | 6,736 | 7,320 | 7,059 | 5,002 | 4,189 | 1,569 | 1,555 | 1,847 | – |
| Naphtha & solvents | 13,825 | 13,592 | 15,278 | 17,844 | 15,718 | 16,227 | 17,405 | 7,994 | 8,634 | 7,109 | 3.0 |
| Distillate fuel oil | 16,619 | 23,291 | 25,781 | 21,111 | 20,589 | 19,936 | 29,115 | 53,876 | 52,679 | 53,670 | 0.2 |
| Residual fuel oil | 29,198 | 35,327 | 35,229 | 40,361 | 40,891 | 35,411 | 31,330 | 13,955 | 13,757 | 9,723 | 0.3 |
| Lube oil | 11,144 | 12,736 | 10,901 | 9,040 | 10,353 | 8,606 | 10,653 | 10,148 | 6,393 | 666 | 5.3 |
| Petroleum Coke | 4,020 | 4,163 | 4,244 | 2,926 | 3,180 | 7,354 | 4,608 | 5,170 | 5,262 | 4,950 | – |
| Other (primarily Naphtha and Solvents) | 5,010 | 6,042 | 7,476 | 7,273 | 8,785 | 8,152 | 16,198 | 22,792 | 17,055 | 19,184 | 1.2 |
| U.S. Petroleum Imports | 104,167 | 118,666 | 124,049 | 130,032 | 134,307 | 129,970 | 145,792 | 166,250 | 162,479 | 161,410 | 1.2 |

Source: USACE, Waterborne Commerce of the U.S., Part 2, 1997–2007.

[a]Commodity-specific data for 2007 U.S. tonnage were not compiled for this presentation. U.S. imports totaled 161,160 thousand short tons.

**Table 2-10**
**Freeport Petroleum Products Exports by Major Commodity Group**
**Comparison with U.S. Petroleum Product Totals (1,000s of short tons)**

| Major Group | Freeport Petroleum Product Exports | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
| Distillate fuel oil | 72 | 22 | 19 | 0 | 0 | 1 | 3 | 66 | 15 | 50 | 20 |
| Residual fuel oil | 0 | 0 | 0 | 2 | 0 | 13 | 0 | 1 | 0 | 0 | 0 |
| Lube oil & greases | 10 | 14 | 14 | 18 | 16 | 0 | 8 | 2 | 3 | 4 | 3 |
| Gasoline | 33 | 4 | 5 | 20 | 13 | 98 | 67 | 20 | 67 | 50 | 58 |
| Other | 2 | 5 | 1 | 6 | 5 | 7 | 9 | 2 | 6 | 5 | 9 |
| Freeport Petroleum Exports | 117 | 45 | 39 | 46 | 34 | 119 | 87 | 91 | 91 | 109 | 90 |

| Major Group | U.S. Petroleum Product Exports[a] | | | | | | | | | | Freeport 2004–2006 % of U.S. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | |
| Distillate fuel oil | 5,879 | 4,591 | 4,148 | 4,953 | 4,982 | 5,861 | 7,046 | 16,202 | 15,642 | 26,249 | 0.23 |
| Residual fuel oil | 8,519 | 9,282 | 10,030 | 12,693 | 14,032 | 12,129 | 9,420 | 1,269 | 3,501 | 2,538 | 0.01 |
| Lube oil & greases | 1,662 | 1,410 | 1,583 | 1,595 | 1,191 | 1,302 | 1,240 | 263 | 287 | 829 | 0.65 |
| Gasoline | 5,786 | 4,828 | 4,140 | 6,434 | 6,906 | 6,726 | 6,630 | 11,053 | 9,564 | 10,661 | 0.44 |
| Other | | | | | | | | | | | |
| Liquid Natural Gas | 2,170 | 2,144 | 2,197 | 2,842 | 2,150 | 2,757 | 2,327 | 2,251 | 1,889 | 2,441 | – |
| Petroleum coke | 21,239 | 19,298 | 17,926 | 23,508 | 23,859 | 26,520 | 26,904 | 30,588 | 28,676 | 30,202 | – |
| Naphtha & Solvents | 3,473 | 3,877 | 4,263 | 1,896 | 2,598 | 2,180 | 2,146 | 1,577 | 2,426 | 2,285 | – |
| Kerosene | 1,642 | 893 | 994 | 1,497 | 1,078 | 1,075 | 767 | 55 | 615 | 546 | – |
| Asphalt, Tar & Pitch | 3,960 | 3,340 | 2,693 | 58 | 32 | 81 | 365 | 291 | 279 | 474 | – |
| Other | 115 | 77 | 78 | 157 | 120 | 90 | 106 | 115 | 80 | 113 | – |
| U.S. Total Petroleum Exports | 54,445 | 49,740 | 48,052 | 55,633 | 56,948 | 58,721 | 56,951 | 63,664 | 62,959 | 76,338 | 0.13 |

Source: USACE, Waterborne Commerce of the U.S., Part 2, 1997–2007.

[a]Commodity-specific data for 2007 U.S. tonnage was not compiled for this presentation. U.S. exports totaled 82,317 thousand short tons.

**Table 2-11**
**Freeport Chemical Products Imports by Major Commodity Group**
**Comparison with U.S. Chemical Product Totals**
**(1,000s of short tons)**

| Major Group | Freeport Chemical Product Imports | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
| Benzene & Toluene | 7 | 61 | 65 | 100 | 82 | 136 | 75 | 26 | 27 | 34 | 63 |
| Other Hydrocarbons | 58 | 53 | 108 | 40 | 84 | 46 | 99 | 150 | 102 | 97 | 71 |
| Alcohols | 90 | 33 | 9 | 23 | 2 | 3 | 42 | 54 | 21 | 0 | 1 |
| Carboxylic Acids | 27 | 11 | 11 | 1 | 0 | 1 | 4 | 0 | 0 | 0 | 0 |
| Organic Compounds | 16 | 6 | 6 | 4 | 0 | 0 | 2 | 10 | 3 | 9 | 0 |
| Ammonia | 105 | 77 | 138 | 172 | 414 | 444 | 529 | 592 | 515 | 480 | 546 |
| Sodium Hydroxide | 6 | 7 | 0 | 0 | 0 | 1 | 0 | 0 | 5 | 0 | 12 |
| Other (Inorganic Compounds, Nitrogen, and Paints) | 24 | 7 | 4 | 56 | 1 | 31 | 27 | 3 | 18 | 94 | 17 |
| Freeport Chemical Imports | 333 | 255 | 341 | 379 | 583 | 663 | 778 | 835 | 691 | 705 | 710 |

| Major Group | U.S. Chemical Product Imports[a] | | | | | | | | | | Freeport 2004–2006 % of U.S. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | |
| Benzene & Toluene | 292 | 513 | 584 | 1,603 | 1,260 | 1,224 | 1,378 | 1,883 | 1,874 | 2,473 | 1.4 |
| Other Hydrocarbons | 870 | 540 | 489 | 851 | 714 | 748 | 797 | 767 | 829 | 883 | 14.1 |
| Alcohols | 3,587 | 3,806 | 4,626 | 5,794 | 7,091 | 6,950 | 6,236 | 7,218 | 8,348 | 10,653 | 0.3 |
| Carboxylic Acids | 669 | 703 | 736 | 807 | 859 | 839 | 904 | 994 | 1,066 | 1,090 | – |
| Organic Compounds | 4,049 | 4,733 | 4,742 | 4,882 | 4,965 | 4,300 | 2,099 | 2,438 | 1,143 | 1,087 | 0.3 |
| Ammonia | 3,381 | 3,517 | 3,811 | 4,284 | 5,974 | 5,396 | 6,630 | 6,809 | 7,433 | 7,083 | 7.4 |
| Sodium Hydroxide | 599 | 731 | 591 | 899 | 940 | 877 | 874 | 931 | 1,215 | 1,494 | – |
| Plastics | 1,694 | 1,776 | 2,074 | 2,227 | 2,034 | 2,282 | 2,626 | 2,054 | 3,646 | 3,850 | – |
| Fertilizers | 4,280 | 5,062 | 4,317 | 7,827 | 11,274 | 6,134 | 8,577 | 7,527 | 8,894 | 7,875 | – |
| Inorganic Elem., Oxides & Halogen Salts | 766 | 838 | 1,051 | 2,153 | 1,305 | 3,046 | 2,288 | 2,981 | 2,134 | 2,625 | – |
| Other | 4,867 | 5,224 | 5,120 | 7,150 | 7,417 | 7,776 | 9,598 | 10,208 | 8,835 | 8,900 | – |
| U.S. Total Chemical Imports | 25,054 | 27,443 | 28,141 | 38,477 | 43,833 | 39,572 | 42,007 | 43,810 | 45,417 | 48,013 | 1.6 |

Source: USACE, Waterborne Commerce of the U.S., Part 2, 1997–2007.

[a]Commodity-specific data for 2007 U.S. tonnage was not compiled for this presentation.
U.S. imports totaled 82,317 thousand short tons.

**Table 2-12**
**Freeport Chemical Products Exports by Major Commodity Group**
**Comparison with U.S. Chemical Product Totals (1,000s of short tons)**

| Major Group | Freeport Chemical Product Exports | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
| Benzene & Toluene | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 9 | 1 | 0 | 2 |
| Other Hydrocarbons | 240 | 380 | 409 | 546 | 385 | 350 | 578 | 486 | 478 | 383 | 460 |
| Alcohols | 12 | 31 | 57 | 96 | 137 | 112 | 148 | 241 | 159 | 174 | 200 |
| Carboxylic Acids | 66 | 23 | 5 | 3 | 14 | 69 | 22 | 91 | 24 | 35 | 35 |
| Organic Compounds | 162 | 166 | 160 | 232 | 216 | 231 | 211 | 268 | 189 | 318 | 218 |
| Sodium Hydroxide | 788 | 820 | 752 | 1,043 | 836 | 817 | 874 | 1,162 | 1,318 | 1,280 | 1,304 |
| Plastics | 205 | 258 | 209 | 197 | 282 | 273 | 257 | 273 | 262 | 289 | 337 |
| Other | 49 | 46 | 40 | 100 | 78 | 54 | 14 | 92 | 78 | 72 | 135 |
| Freeport Chemical Exports | 1,522 | 1,724 | 1,632 | 2,217 | 1,948 | 1,907 | 2,104 | 2,622 | 2,509 | 2,551 | 2,691 |

| Major Group | U.S. Chemical Product Exports[a] | | | | | | | | | | Freeport 2004–2006 % of U.S. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | |
| Benzene & Toluene | 325 | 162 | 66 | 225 | 649 | 151 | 545 | 847 | 670 | 397 | 0.5 |
| Other Hydrocarbons | 4,471 | 4,554 | 5,525 | 6,188 | 4,457 | 5,116 | 5,821 | 6,144 | 4,867 | 4,328 | 8.8 |
| Alcohols | 2,814 | 2,143 | 2,090 | 2,649 | 2,617 | 2,604 | 2,726 | 2,763 | 2,261 | 2,828 | 7.3 |
| Carboxylic Acids | 2,216 | 2,102 | 1,912 | 2,541 | 2,640 | 3,030 | 2,700 | 2,782 | 2,464 | 2,886 | 1.8 |
| Organic Compounds | 1,361 | 2,019 | 1,905 | 2,226 | 2,233 | 2,454 | 2,201 | 2,342 | 2,597 | 4,182 | 8.5 |
| Ammonia | 577 | 821 | 777 | 716 | 825 | 577 | 482 | 532 | 649 | 187 | – |
| Sodium Hydroxide | 2,950 | 3,102 | 3,219 | 4,384 | 3,379 | 3,631 | 3,422 | 3,892 | 3,795 | 3,776 | 32.8 |
| Plastics | 6,046 | 5,774 | 5,376 | 6,883 | 6,568 | 6,268 | 5,971 | 7,868 | 7,255 | 7,767 | 3.6 |
| Fertilizers | 16,030 | 17,818 | 18,956 | 13,536 | 13,577 | 13,246 | 12,878 | 13,411 | 12,983 | 12,165 | – |
| Metallic Salts | 4,908 | 4,468 | 4,221 | 5,751 | 5,389 | 5,204 | 5,195 | 5,926 | 5,431 | 5,457 | – |
| Inorganic Elem., Oxides & Halogen Salts | 1,136 | 1,158 | 993 | 3,322 | 2,959 | 3,301 | 2,518 | 4,369 | 4,486 | 5,325 | – |
| Nitrogen | 1,711 | 1,538 | 1,619 | 2,174 | 2,431 | 2,132 | 2,201 | 2,342 | 1,944 | 2,096 | – |
| Other | 5,992 | 5,688 | 5,540 | 7,293 | 7,017 | 7,248 | 6,915 | 7,516 | 7,282 | 7,275 | – |
| U.S. Total Chemical Exports | 50,537 | 51,345 | 52,199 | 57,888 | 54,741 | 54,962 | 53,575 | 60,734 | 56,684 | 58,669 | 4.4 |

Source: USACE, Waterborne Commerce of the U.S., Part 2, 1997–2007.

[a]Commodity-specific data for 2007 U.S. tonnage was not compiled for this presentation.
U.S. exports totaled 60,168 thousand short tons.

## 2.3 GENERAL AND CONTAINER CARGO TRAFFIC

Container vessels carry any cargo that can be stowed into any of the following container types: general purpose, high cube, hardtop, open top, flat, platform, insulated, ventilated, bulk, refrigerated (reefer), and tank-type containers. Cargo can include merchandise in cartons, bales, drums, cars, furniture, electronics, food, livestock, chemicals, and machinery. Oversized cargo such as heavy machinery, trucks, earth-moving equipment, and pleasure boats can be placed in or on open-top, open-side, or flat rack containers or secured to the tops of several containers in a row.

The range and diversity of container cargo has evolved.[3] The earliest cargo ships carried a plethora of industrial boxes and packages, but today's container ships have a range of containers to deal with their diverse cargo. There are refrigerated containers that plug into special power sockets; there are containers for grain, liquids, and cars; even containers with clothes hanging inside, ready to go straight onto shop floors. Flat rack containers make a bed for outsized items such as yachts and heavy industrial machinery.

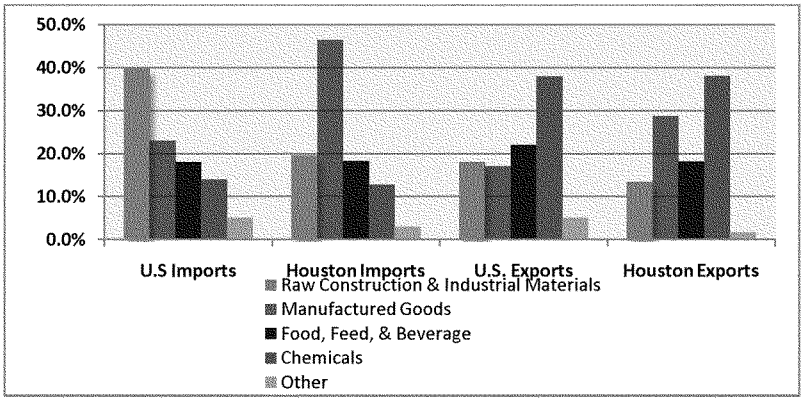
Since Freeport's container terminal is new, the Port of Houston was analyzed for historical traffic data. U.S. and Houston imports data show that the region's relative percentage of imports of manufactured goods is twice that for the Nation. Manufactured metal and monumental and building stone compose nearly 20 percent of Houston's manufactured goods total, and represent the single largest subgroups. Other manufactured goods include furniture (6.6 percent); iron and steel products (6.5 percent); baby carriages, toys, games, and sporting goods (5.8 percent); appliances (4 percent); and specialized machinery (3.6 percent). Figure 2-3 displays percentage distributions of U.S. and Houston imports and manufacturing goods (17 percent); food and farm products (22 percent) and other (5 exports by major group).

Container traffic is generally grouped as either local or intermodal. Local cargo can be delivered by truck within one day. Intermodal is generally rail bound for more-distant locations. Information shown in the Center for Transportation Research's 2007 study indicates that over 90 percent of Houston container cargo is transported through the port by truck.[4]

[3] Seafarer, *The Rise of the Supership*, Summer 2005, p. 12

[4] University of Texas Center for Transportation Research, *Planning for Container Growth along the Houston Ship Channel and Other Texas Seaports*, November 2006 revised February 2007, p. 15.

**Figure 2-3**
**U.S. and Houston Container Cargo (2006–2007 Period)**
**Percentage of Imports and Exports by Major Commodity Group**




Source: USACE, NDC.

Comparison of regional and national container TEU volumes for 1980 to 2008 is summarized in Table 2-13. The term TEU refers to Twenty Foot-Equivalent Units or equivalent capacity of one 20-foot container. A 40-foot container is two TEUs. Figures 2-4 and 2-5 provide comparisons of U.S. West Coast, East Coast, and Gulf Coast 1999 to 2008 container throughputs. The figures show that the Gulf Coast traffic increased relative to the West and East coasts.

While U.S. container growth continued through 2007, fourth-quarter 2007 volumes were relatively flat due to weakening of the dollar in relation to other currencies. A weakening dollar contributes to a downturn in imports and an increase in exports. Freeport's throughput increased through 2007.

The USACE 2007 Waterborne Commerce statistics show an approximate 50/50 split between Houston's imports and exports. In classifying the markets served by Houston in comparison to the U.S. West and East coasts, the U.S. West Coast ports of Los Angeles and Long Beach primarily process imports from the Far East. The U.S. East Coast ports, particularly Newark and New York, process a high volume of European imports and, to a smaller extent, Far East traffic. Table 2-14 displays the 2007 estimated distribution of imports and exports by major U.S. container port.

**Table 2-13**
**U.S. Container Cargo by Region (TEUs including empties)**

| Year | Freeport | Houston | Texas | U.S. Gulf | U.S. Pacific | U.S. Atlantic | U.S. Total |
|---|---|---|---|---|---|---|---|
| 1980 | 0.0 | 300.4 | 300.4 | 579.9 | 3,511.9 | 4,348.0 | 8,439.9 |
| 1981 | 0.0 | 318.7 | 361.2 | 564.6 | 2,595.6 | 4,485.5 | 7,645.7 |
| 1982 | 0.0 | 306.1 | 387.5 | 692.8 | 3,435.8 | 4,299.0 | 8,427.6 |
| 1983 | 0.0 | 303.5 | 378.3 | 670.0 | 3,045.5 | 4,651.1 | 8,366.7 |
| 1984 | 17.4 | 372.3 | 439.4 | 831.2 | 5,384.9 | 5,554.5 | 11,770.6 |
| 1985 | 19.4 | 362.7 | 402.1 | 812.1 | 5,398.8 | 5,513.3 | 11,724.2 |
| 1986 | 38.8 | 403.0 | 484.4 | 928.3 | 5,997.6 | 5,805.8 | 12,731.8 |
| 1987 | 36.7 | 484.6 | 578.6 | 911.2 | 6,568.6 | 5,776.4 | 13,256.2 |
| 1988 | 37.2 | 530.6 | 625.4 | 895.1 | 6,993.9 | 6,250.7 | 14,139.7 |
| 1989 | 27.9 | 498.8 | 593.7 | 813.8 | 7,824.2 | 6,432.1 | 15,070.1 |
| 1990 | 29.9 | 502.0 | 583.1 | 822.4 | 8,185.4 | 6,564.1 | 15,571.9 |
| 1991 | 24.0 | 535.1 | 652.8 | 937.5 | 8,376.9 | 7,001.8 | 16,316.2 |
| 1992 | 29.7 | 490.1 | 640.0 | 1,141.7 | 8,961.3 | 7,212.3 | 17,315.3 |
| 1993 | 30.5 | 538.7 | 672.8 | 1,191.2 | 9,253.6 | 8,254.0 | 18,698.8 |
| 1994 | 34.1 | 578.7 | 696.9 | 1,222.3 | 10,458.9 | 8,807.2 | 20,488.4 |
| 1995 | 30.5 | 704.0 | 774.9 | 1,186.5 | 11,421.9 | 9,728.9 | 22,337.3 |
| 1996 | 48.2 | 797.7 | 856.5 | 1,361.8 | 11,202.6 | 10,046.2 | 22,610.6 |
| 1997 | 45.1 | 933.5 | 993.8 | 1,491.9 | 12,086.7 | 10,945.6 | 24,524.1 |
| 1998 | 54.7 | 959.1 | 1,028.3 | 1,470.1 | 13,208.9 | 11,486.6 | 26,165.7 |
| 1999 | 63.4 | 1,031.1 | 1,164.7 | 1,618.6 | 14,085.0 | 12,303.7 | 28,007.3 |
| 2000 | 71.5 | 1,061.5 | 1,217.3 | 1,687.6 | 15,665.7 | 13,042.5 | 30,395.8 |
| 2001 | 74.3 | 1,057.9 | 1,216.0 | 1,703.1 | 15,951.5 | 13,009.2 | 30,663.8 |
| 2002 | 74.5 | 1,147.5 | 1,265.5 | 1,717.9 | 17,363.5 | 13,621.4 | 32,702.9 |
| 2003 | 67.8 | 1,243.9 | 1,321.6 | 1,838.0 | 20,060.4 | 14,401.7 | 36,300.0 |
| 2004 | 68.6 | 1,437.6 | 1,516.4 | 2,068.7 | 21,179.6 | 15,406.4 | 38,654.7 |
| 2005 | 76.3 | 1,594.4 | 1,678.0 | 2,174.4 | 23,010.8 | 16,783.2 | 41,968.4 |
| 2006 | 73.6 | 1,606.4 | 1,690.7 | 2,238.7 | 24,682.9 | 17,446.6 | 44,368.2 |
| 2007 | 75.7 | 1,768.6 | 1,853.7 | 2,531.5 | 24,533.9 | 17,942.6 | 45,008.0 |
| 2008 | 71.9 | 1,794.3 | 1,878.3 | 2,544.9 | 22,597.6 | 17,685.1 | 42,827.6 |
| % Average Annual Growth Rate 1983/1985 to 2006/2008 | 6.1 | 6.8 | 6.2 | 4.8 | 6.2 | 4.9 | 5.5 |

Source: Compiled from American Association of Port Authorities website, November 2007.

**Figure 2-4**
**U.S. East Coast and West Coast Container Cargo (TEUs)**
**Billions of Chained 2000 Dollars (1999–2008)**

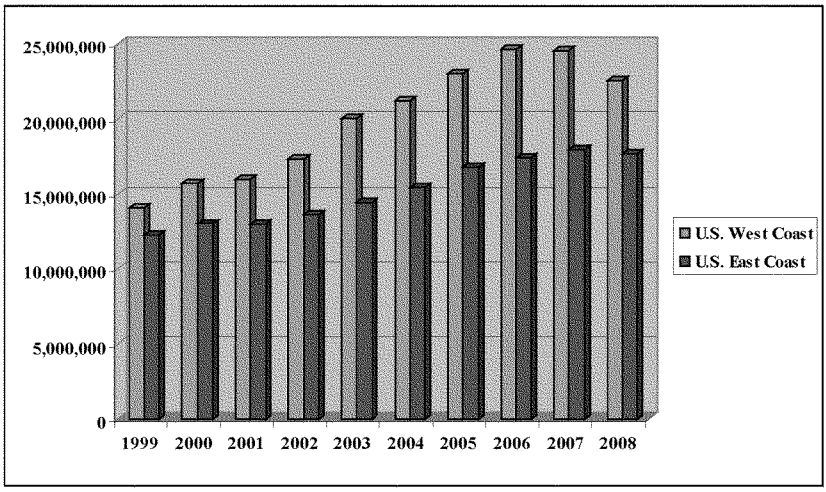



**Figure 2-5**
**U.S. Gulf Coast Container Cargo (TEUs)**
**Billions of Chained 2000 Dollars (1999–2008)**

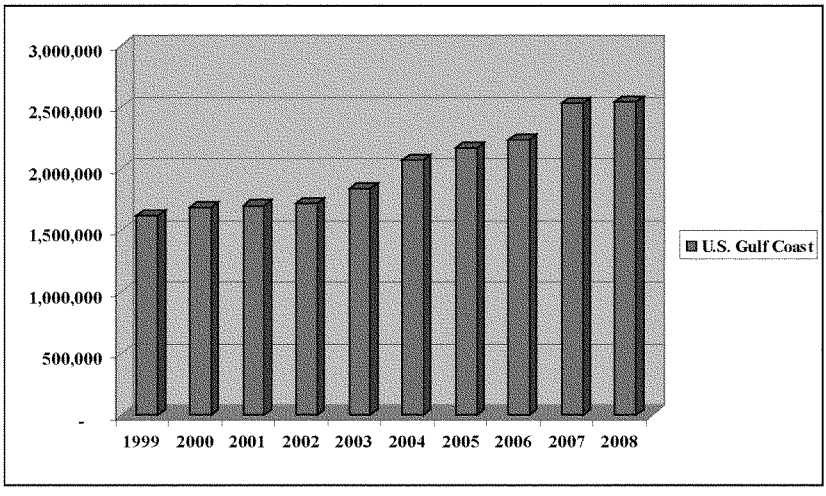


**Table 2-14**
**U.S. Waterborne Container Traffic by Port/Waterway**
**(% of Loaded and Empty TEUs[a])**

| Port | Inbound | Outbound | Total |
|---|---|---|---|
| Long Beach | 78 | 22 | 100 |
| Los Angeles | 79 | 21 | 100 |
| New York (NY & NJ) | 73 | 27 | 100 |
| Oakland | 62 | 38 | 100 |
| Tacoma | 75 | 25 | 100 |
| Charleston | 60 | 40 | 100 |
| Savannah | 54 | 46 | 100 |
| Seattle | 70 | 30 | 100 |
| Norfolk Harbor | 62 | 38 | 100 |
| Houston | 53 | 47 | 100 |
| All Other | 75 | 25 | 100 |
| U.S. Total | 72 | 28 | 100 |

Source: USACE, NDC Website data, CY 2007.

[a]TEU = 20-foot equivalent units. Foreign empties not included.

Declines in growth seen on the West Coast and to a lesser extent on the East Coast, and relatively flat rates on the U.S. Gulf Coast are attributable to falling home prices, lower employment growth, tighter credit, high oil prices, and the declining value of the dollar in the world market. While having a negative effect on investment and other general indicators, the decline in interest rates has improved the competitiveness of U.S. producers and contributed to recent increases in exports.

Another factor that influences trade is regional population growth. Table 2-15 displays regional population data obtained from the U.S. Census.

Freeport's remaining cargo primarily consists of banana imports, rice exports, and outbound coastwise chemical shipments. Distribution of these commodities by major group is displayed in Table 2-16 and Figure 2-6. Freeport imports 6 percent of the U.S. banana imports and exports 6 percent of U.S. rice exports. Bananas and rice are transported through docks located within the Brazos Turning Basin.

Rock and limestone are used in residential and commercial building construction and have increased at all Texas ports. These cargoes are presently transported through the facilities in the Brazos Harbor Basin. Limestone imports represented 40 percent of 2003 to 2005 general cargo tonnage. Total limestone imports for 2005 were 433,000 tons. The majority of imports are from Cozumel, Mexico, and, to a smaller extent, Europe.

**Table 2-15**
**Houston-Galveston-Brazoria Consolidated Metropolitan Statistical Area**
**2000–2008 Population Estimates, Select Communities**

| County | 2000 | 2008 | 2000–2008 Actual Growth Rate (%) | 2000–2010 Anticipated Growth Rate (%)[a] |
|---|---|---|---|---|
| Brazoria County | 241,767 | 301,004 | 2.8 | 1.9 |
| Harris County | 3,321,660 | 3,984,349 | 2.3 | 1.7 |
| Fort Bend | 354,452 | 532,141 | 5.2 | 3.7 |
| Wharton County | 41,188 | 40,791 | –0.1 | 0.6 |
| Galveston | 250,158 | 288,239 | 1.8 | 0.8 |
| Matagorda | 37,957 | 37,265 | –0.2 | 0.7 |
| Total | 4,247,182 | 5,183,789 | 2.5 | 1.8 |

Source: U.S. Bureau of Census, State and County Quick Facts, 2009.

[a]Texas Water Development Board, 2006 Regional Water Plan, County Population Projections.

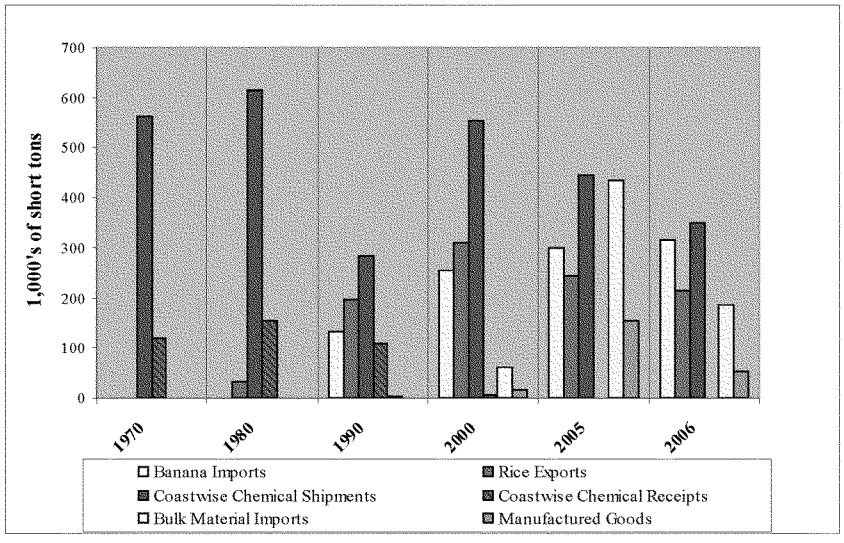
**Table 2-16**
**Freeport Harbor Other Ocean-going Cargo**
**Major Commodities 1970–2007**
**(1,000s of short tons)**

| Year | Banana Imports | Rice Exports | Bulk Materials & Manufactured Goods | Coastwise Chemicals | | Group Total | Total Ocean-going Tonnage | % of Total Ocean-going Tonnage |
|---|---|---|---|---|---|---|---|---|
| | | | | Receipts | Shipments[a] | | | |
| 1970 | 0 | 0 | 1 | 118 | 563 | 682 | 2,291 | 30 |
| 1975 | 0 | 100 | 18 | 130 | 537 | 784 | 5,482 | 14 |
| 1980 | 0 | 32 | 1 | 154 | 614 | 801 | 17,299 | 5 |
| 1985 | 203 | 24 | 1 | 158 | 217 | 602 | 10,319 | 6 |
| 1990 | 133 | 195 | 4 | 109 | 284 | 725 | 10,164 | 7 |
| 1995 | 174 | 287 | 8 | 62 | 380 | 911 | 14,922 | 6 |
| 1996 | 202 | 247 | 12 | 41 | 344 | 846 | 19,880 | 4 |
| 1997 | 133 | 212 | 8 | 71 | 527 | 951 | 21,849 | 4 |
| 1998 | 320 | 175 | 5 | 86 | 426 | 1,012 | 24,552 | 4 |
| 1999 | 301 | 174 | 11 | 82 | 428 | 996 | 23,225 | 4 |
| 2000 | 255 | 310 | 76 | 6 | 555 | 1,202 | 26,150 | 5 |
| 2001 | 173 | 210 | 160 | 10 | 533 | 1,086 | 25,498 | 4 |
| 2002 | 293 | 226 | 47 | 0 | 419 | 985 | 22,563 | 4 |
| 2003 | 233 | 210 | 89 | 0 | 443 | 975 | 25,612 | 4 |
| 2004 | 237 | 203 | 504 | 0 | 712 | 1,656 | 29,116 | 6 |
| 2005 | 300 | 245 | 591 | 1 | 445 | 1,582 | 28,930 | 5 |
| 2006 | 315 | 215 | 240 | 0 | 350 | 1,120 | 27,571 | 4 |
| 2007 | 354 | 101 | 405 | 0 | 281 | 1,141 | 24,065 | 5 |

Source: USACE, Waterborne Commerce of the U.S., Part 2, 1970–2007.

[a]Primarily consist of shipments of hydrocarbons.

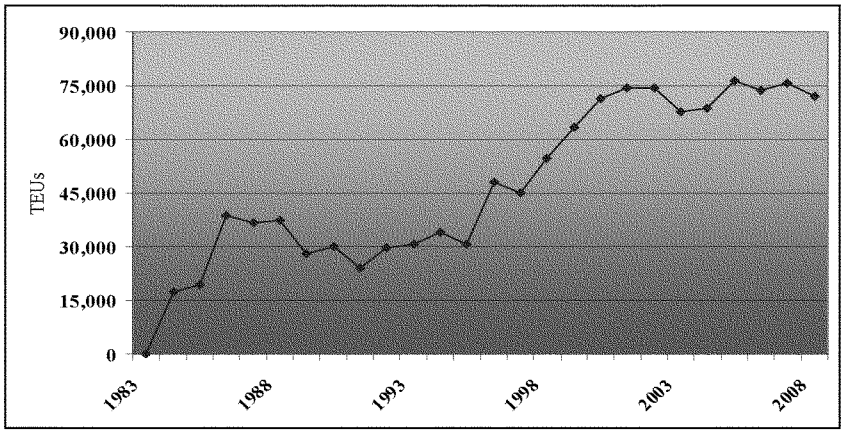
**Figure 2-6**
**Freeport Harbor 1970–2006**
**Other Ocean-going Cargo**
**(1,000s of Short Tons)**




Source: USACE, Waterborne Commerce of the U.S., Part 2, 1970–2006.

For 2008, the port throughput totaled 72,000 TEUs, in part as a result of containerization of some cargo that previously moved in palletized form. With the acquisition of a mobile harbor crane, the port unloads a greater percentage of containers as opposed to relying on shipboard cranes. Figure 2-7 displays Freeport's 1983 to 2008 container cargo totals.

**Figure 2-7**
**Freeport Channel Container Cargo 1983–2008 (TEUs)**

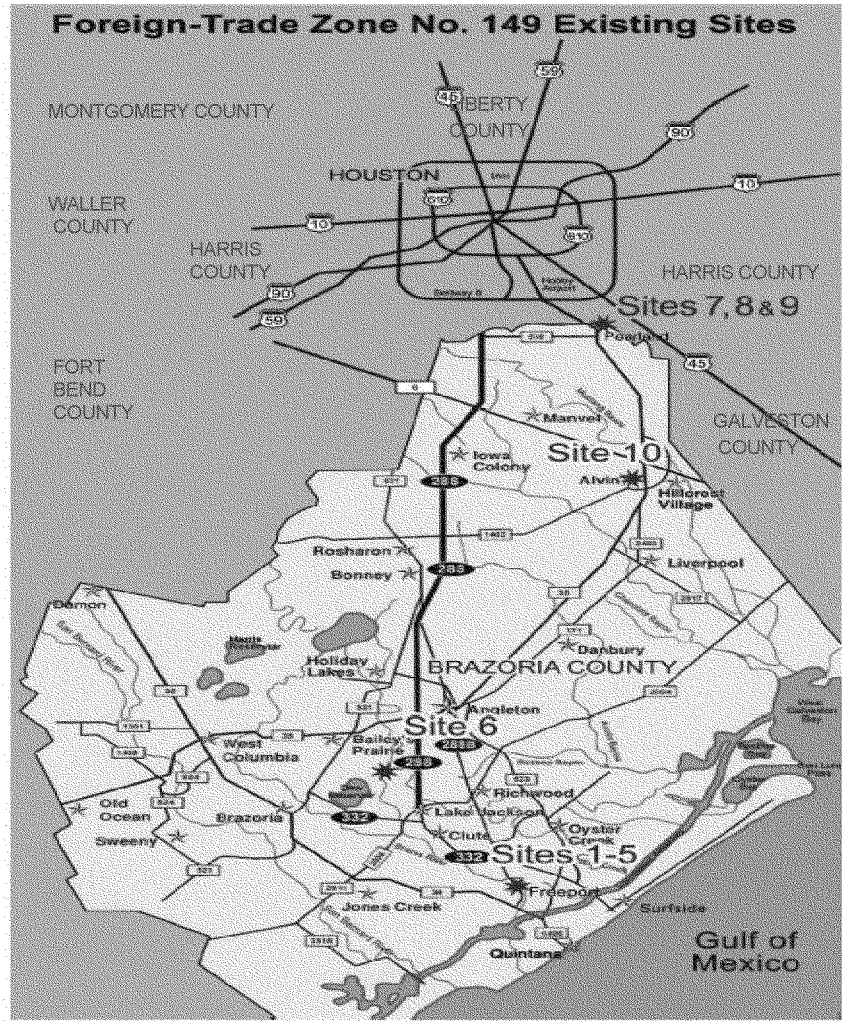



Source: Compiled from American Association of Port Authorities website, May 2009.

The Port of Freeport is contained in a relatively large foreign trade zone (FTZ No. 149). The purpose of an FTZ is to attract and promote U.S. participation in international trade and commerce. Merchandise in an FTZ is considered to be outside the U.S. Customs territory. Therefore, the merchandise is subject to duty only when it leaves the FTZ for consumption in the U.S. market. If FTZ merchandise is exported, there is no duty liability. While in the FTZ, foreign merchandise and domestic merchandise may be stored, sold, exhibited, assembled, disassembled, repackaged, distributed, sorted, tested, graded, cleaned, mixed with other merchandise, otherwise manipulated, or destroyed. The merchandise may also undergo manufacturing operations. Merchandise subject to quota may be stored in an FTZ until a closed quota reopens.

In March 2010 the U.S. Department of Commerce approved the application for expansion of the Port Freeport FTZ to include two new sites in adjacent Fort Bend County. The addition of the Fort Bend sites results in a total of 12 sites. Sites 11 and 12 are located south of Interstate 10 and adjacent to SH 59. Site 11 is 311 acres being developed by GBI Group LLC. Site 12 is approximately 636 acres being developed by KCSR and CenterPoint Intermodal Center. Both sites are adjacent to the KCSR track. Figure 2-8 displays the FTZ within the port and Brazoria County as of 2009.

**Figure 2-8**
**Port Freeport Foreign Trade Zone No. 149 Sites as of 2009**



## 2.4 OFFSHORE SUPPLY, OFFSHORE PLATFORM RIGS, AND RESEARCH AND SEISMIC TRAFFIC

Upper Stauffer Channel traffic consists of offshore supply vessels (OSVs), offshore platform rigs, and research/seismic vessels. The majority of traffic falls under the general classification of OSVs. Oilfield shipments consist primarily of fuel, water, supplies, drill pipes, drill mud, and chemicals. In addition to offshore vessels, the channel currently provides cargo vessel repair and layberth service and informally serves as a harbor of refuge.

Under Federal law, vessel-operating companies must report domestic waterborne commercial movements to the USACE. The types of vessels mooring in the Upper Stauffer Channel include dry cargo ships and tankers, barges (loaded and empty), fishing vessels, towboats (with or without barges in tow), tugboats, crew boats and supply boats to offshore locations, and newly constructed vessels from the shipyards to the point of delivery. Vessels remaining idle during the monthly reporting period are also required to report. Although vessels are required to report, based on 2000 to 2007 dock records available from the USACE NDC and subsequent discussion with NDC personnel, the Galveston District concluded that vessel activities not associated with cargo discharge frequently go unreported. To get a more accurate estimate of traffic, the District's search of vessel records associated with Freeport, Galveston, and other Texas ports for the period 2001 to 2007 showed no less than five OSVs. Also, the District contacted industry and received limited lists and picture files of vessels docked on the Stauffer Channel.

Channel users estimated that during the 1970s and 1980s prior to the channel shoaling, a count of 20 to 30 vessels per week used the Upper Stauffer channel, typically consisting of 6 to 7 crew boats and 18 to 21 supply boats. Industry claims an average of 30 to 40 vessels per month currently use the Upper Stauffer facilities. The 2006 trip statistics obtained from the entrance and clearance records include an annual count of 4 vessels for Freeport. In comparison, the NDC entrance and clearance records showed nearly 100 vessels per month for Galveston and nearly 200 for Bayou Lafourche, indicating that offshore vessels at Freeport are underreported.

The OSVs using the channel are generally based in Louisiana. The OSV fleet, which includes U.S. and foreign-flagged vessels, consists of crewboats, platform supply vessels, and anchor tugs and comes into Freeport for fuel and general restocking, or for waiting 1 to 2 days between jobs or due to inclement weather. For longer stays, Louisiana-based vessels would likely go to their homeport in order to avoid port charges.

According to industry literature, the OSV fleet primarily serves exploratory and developmental drilling rigs and production facilities, and supports offshore construction and subsea maintenance activities.[5] OSVs differ from other types of marine vessels in their cargo-carrying flexibility and capacity to transport deck cargo. OSVs carry pipe or drummed material and equipment, liquid

[5] Hornbeck Oil Services, webpage information

mud, potable and drilling water, diesel fuel, dry bulk cement, and personnel between shore bases and offshore rigs and facilities.

The OSV fleet working in the Gulf of Mexico consists of U.S. and foreign flag vessels. The classification of foreign flag OSVs is addressed under 46 *Code of Federal Regulations* (CFR) Subchapter L as published in the *Federal Register* of 19 September 1997. OSVs of 500 gross tons (U.S. Regulatory Tonnage) but less than 6,000 gross tons meet the requirement of 46 CFR Subchapter L and additional requirements from Subchapter I (Industrial Vessels) that are applicable to OSVs carrying less than 36 offshore workers. Current legislation allows foreign flag vessels to operate within the U.S. boundaries of the outer continental shelf.

Foreign flag OSVs are generally exempt from Section 27 of the 1920 Merchant Marine Act, commonly referred to as the Jones Act. The Jones Act restricts U.S. coastwise trade to U.S.-built, U.S. coastwise citizen-owned, and U.S. flagged vessels. The Jones Act was extended to the U.S. outer continental shelf by the Outer Continental Shelf Lands Act of 1953, as amended in 1978.

The U.S. Gulf Coast OSV fleet includes five subtypes. The subtypes are anchor-handling tug supply vessels, crew supply vessels, offshore tug supply vessels, pipe carriers, and platform supply vessels. Table 2-17 displays the world OSV fleet by vessel type major classification.

Platform Supply Vessels (PSVs) are specially designed for transport of supplies to/from offshore installations, mainly to supply fields in production. This involves the transport of individual items, mainly in containers on deck. In addition, a PSV transports in segregated systems a variety of different products such as methanol, preblended drill fluids, brine, water, and oil. The various fluids are contained in epoxy-painted tanks, with individual pumps and hoses. Dry bulk cargo such as cement, barite, and bentonite are also transported. At the installations, this cargo is discharged by using compressed air. PSVs and anchor-handling and supply tugs are characteristically the largest vessels in the OSV general grouping.

Seismic vessels are used by the oil and gas industry for acquiring drilling data. The boom in offshore exploration and surveying has made seismic vessels key to the industry. Over the past 10 years, many foreign seismic vessels have utilized Freeport for a base of operations and conducted refitting projects. Activities include vessel refitting for mobilization in the Gulf of Mexico and in foreign exploration sites. Seismic vessels are normally out to sea no more than 50 to 55 days, then they return to dock for a week and go back out to sea for another 50 to 55 days.

In addition to oilfield-related vessels, the Stauffer Channel provides layberth and associated repair services for small cargo vessels, fishing vessels, and other miscellaneous craft. Research vessels are characteristically layberth customers. Dwell time for layberthing generally ranges from 4 to 6 months.

Vessels have been turned away due to the lack of sufficient water depth.

**Table 2-17**
**Offshore Supply Vessels**
**World Fleet, Active Vessels, and Vessels on Order**

| Year Built | Anchor-Handling Tug Supply Vessel | Crew Supply Vessel | Tug Supply Vessel | Pipe Carrier | Platform Supply Vessel | Grand Total |
|---|---|---|---|---|---|---|
| **Number of Vessels** | | | | | | |
| 1974 to 1978 | 127 | 41 | 133 | 18 | 194 | 513 |
| 1979 to 1983 | 267 | 97 | 144 | 21 | 453 | 982 |
| 1984 to 1988 | 144 | 60 | 46 | 30 | 92 | 372 |
| 1989 to 1993 | 28 | 83 | 14 | 18 | 39 | 182 |
| 1994 to 1998 | 45 | 78 | 20 | 3 | 112 | 258 |
| 1999 to 2003 | 154 | 140 | 30 | 2 | 260 | 586 |
| 2004 to 2008 | 466 | 190 | 76 | 1 | 421 | 1,154 |
| 2009 to 2012 | 427 | 38 | 34 | – | 226 | 725 |
| Total | 1,658 | 727 | 497 | 93 | 1,797 | 4,772 |
| **Percentage of Vessels** | | | | | | |
| 1974 to 1978 | 7.7 | 5.6 | 26.8 | 19.4 | 10.8 | 10.8 |
| 1979 to 1983 | 16.1 | 13.3 | 29.0 | 22.6 | 25.2 | 20.6 |
| 1984 t o 1988 | 8.7 | 8.3 | 9.3 | 32.3 | 5.1 | 7.8 |
| 1989 to 1993 | 1.7 | 11.4 | 2.8 | 19.4 | 2.2 | 3.8 |
| 1994 to 1998 | 2.7 | 10.7 | 4.0 | 3.2 | 6.2 | 5.4 |
| 1999 to 2003 | 9.3 | 19.3 | 6.0 | 2.2 | 14.5 | 12.3 |
| 2004 to 2008 | 28.1 | 26.1 | 15.3 | 1.1 | 23.4 | 24.2 |
| 2009 to 2012 | 25.8 | 5.2 | 6.8 | 0.0 | 12.6 | 15.2 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: Lloyd's Register – Fairplay, PC Register of Ships, November 2008.

## 2.5 LIQUEFIED NATURAL GAS TRAFFIC

The Freeport Section 204 widening analysis includes detailed analysis of Freeport's LNG market. The Section 204 report shows that import volume of 84.2 billion cubic feet per day was forecasted for 2010, with volumes increasing to 712 billion cubic feet by 2018. The vessel sizes and expected throughput prompted the non-Federal sponsor to pursue widening of the offshore Outer Bar and Jetty channels from 400 to 600 feet under the Section 204 authority of the WRDA as amended in 1990. While LNG provided the impetus for the 204 study, channel widening would also benefit existing and future traffic. The base analysis used for this feasibility study assumes that the channel is widened and claims no benefits from LNG.

## 2.6 EXISTING OPERATING CONSTRAINTS

Freeport's existing traffic, particularly crude petroleum tankers and product tankers, are subject to vessel size limitations due to the existing 400-foot channel width. The maximum ship dimensions permitted by the Brazos River Pilots Association (BRPA), without waiver, are 820-foot length overall (LOA) and 145-foot maximum beam, as shown in Table 2-18. Vessel length limitations are enforced because crosswinds and crosscurrents force tankers to "crab" at an angle though the entranced Jetty Channel. Ships of greater length than 820 feet are not able to clear the jetties under adverse wind and current conditions. Waivers are only granted provided that winds are less than 20 knots and that there is no more than a 0.5-knot crosscurrent at the mouth of the jetties. Approximately three to four vessels per month are granted waivers. Daylight-only operation is enforced for vessels greater than 750 feet long or 107 feet wide. Additionally, the beam constraints for existing traffic and introduction of LNG and container vessels are anticipated to exacerbate traffic delays. Based on BRPA input, the effect of channel widening, to be completed under the Section 204 study, will relax these rules.

In the Section 204 study, discussion with the BRPA and ship simulation studies conducted at the Engineer Research and Development Center (ERDC) found that a channel width of 600 feet would be necessary to accommodate the 264,000-cubic-meter ($m^3$) LNG design vessel. This vessel is 1,131 feet long by 177 feet wide and has a corresponding DWT of 122,000. In general, Freeport presently receives fewer large tankers than other ports with comparable channel depths or even than those with less channel depth due to its existing 400-foot channel width.

With a wider channel, there is reduced potential for delays due to longshore crosscurrents. Nighttime transits will be possible for vessels larger than 750 feet long and 106 feet wide, and two-way traffic will be possible for a larger range of vessels. Other ports in the region have the capability of handling these larger vessels, so Freeport will not be the only port in the region to accept these vessels.

The ability to deploy larger vessels or load the existing fleet more fully will reduce per ton transportation costs for vessels using Freeport. Larger vessels can carry a greater cargo load than the current restricted size class of vessels, and even with a restricted draft of 42 feet, the greater load should result in a lower cost per ton of transportation, as the percentage increased level of tonnage per ship will be greater than the percentage increase in cost. As a result, cost per ton to move the same level of cargo will decline.

**Table 2-18**
**Brazos River Pilots Association Guidelines**

**Boarding Instructions**

| **Vessel Dimensions:** | **feet** | **Meters** |
|---|---|---|
| Maximum Length | 820 | 249.9 |
| Maximum Beam | 145 | 44.2 |
| Recommended Draft | 42 | 12.8 |
| Draft Restrictions: | | |
| Maximum Draft | 45 | 13.7 |
| Recommended Draft | 42 | 12.8 |
| Brazos Harbor and BASF Channel Maximum Draft | 36 | 10.9 |
| Old River Channel Maximum Draft | 15 | 4.5 |

Special Cases: Oversized, excessive draft, or unusual type vessels will be handled on a "per job" basis with a one-time waiver to the Basic Operating Procedures. These vessels will be billed under "special services" and will be by "specific agreement" prior to the move. Pilots reserve the right to deny movement of any vessel during times of excessive wind, excessive current or on times of low water.

**Daylight Restrictions**

| | **Inbound Vessels:** |
|---|---|
| 1. | Vessels over 750 feet LOA |
| 2. | Vessels over 107 feet beam |
| 3. | Vessels with draft over 36.5 feet and LOA greater than 700 feet |
| 4. | All vessel movements at Dow A-13 |
| 5. | All vessel movements at Dow A-14 with LOA greater than 600 feet or with a beam greater than 100 feet |
| | **Outbound Vessels:** |
| 1. | All vessel movements at Dow A-13 |
| 2. | All vessel movements at Dow A-14 with LOA greater than 600 feet or with a Beam greater than 100 feet |
| 3. | Vessels sailing from berths above Phillips Bend (Phillips Petroleum Docks, BASF, and Brazos Harbor) with greater than 750 feet LOA will require two pilots be handled on a per job basis and be billed under the "special services" agreement. One-time deviation waiver from standard operating procedures, signed. |
| 4. | Vessels judged unsafe for handling after dark will be limited to daylight hours. Night operations will be suspended during times when weather conditions do not permit safe navigation. |

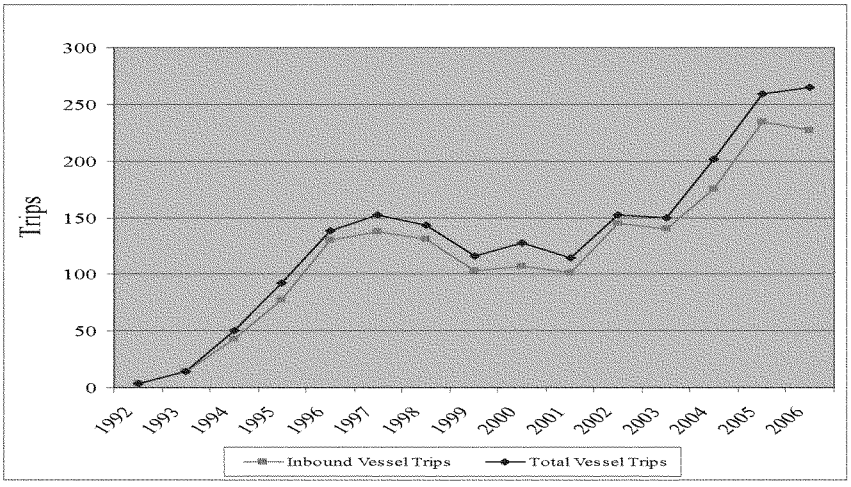
Source: http://www.brazospilots.com/operatingprocedures.html

## 3.0 HISTORIC VESSEL UTILIZATION PATTERNS

This section discusses vessel utilization patterns before and after the 45-foot Project depth became available in the mid-1980s. Figure 3-1 shows that Freeport experienced an overall increase in the number of vessels associated with loaded drafts over 38 feet from the years 1992 to 2006.

Table 3-1 presents 1992 to 2006 inbound vessels by loaded draft. In 2006, 265 vessels had loaded drafts over 38 feet. Current volumes associated with loaded drafts of 38 feet or more are over 150 percent higher than when the 45-foot depth first became available. Comparison of the data from the early 1990s shows small variation in the total number of ocean-going vessels used for cargo transport but significant increases in ocean-going tonnage, with total ocean-going tonnage nearly three times greater than in the early 1990s.

**Figure 3-1**
**Vessel Trips for Vessels with**
**Loaded Drafts Over 38 Feet**
**(1992–2006)**




Source: USACE, Waterborne Commerce of the U S., Part 2, 1992–2006.

**Table 3-1**
**Freeport Harbor**
**Estimated Vessel Movements by Loaded Draft (1992–2006),**
**Number of Vessel Movements (Self-Propelled Vessels), and Total Vessel Tonnage**

| Year | Vessel Movements by Loaded Draft (feet) | | | | | | | Short Tons (1,000s) Total Tonnage |
|---|---|---|---|---|---|---|---|---|
| | <18 | 19–24 | 25–29 | 30–35 | 36–38 | >38 | Total | |
| 1992 | 1,456 | 321 | 352 | 195 | 133 | 3 | 2,460 | 9,753 |
| 1993 | 2,956 | 369 | 298 | 170 | 76 | 14 | 3,883 | 9,739 |
| 1994 | 2,057 | 346 | 352 | 165 | 98 | 50 | 3,068 | 13,450 |
| 1995 | 5,617 | 369 | 288 | 178 | 112 | 92 | 6,656 | 14,922 |
| 1996 | 3,692 | 274 | 423 | 196 | 121 | 138 | 4,844 | 19,880 |
| 1997 | 2,729 | 254 | 479 | 249 | 127 | 152 | 3,990 | 21,849 |
| 1998 | 2,587 | 312 | 594 | 249 | 157 | 143 | 4,042 | 24,552 |
| 1999 | 1,530 | 311 | 434 | 216 | 172 | 116 | 2,779 | 23,225 |
| 2000 | 2,749 | 357 | 557 | 222 | 154 | 127 | 4,166 | 26,150 |
| 2001 | 4,293 | 233 | 554 | 223 | 210 | 114 | 5,627 | 25,498 |
| 2002 | 438 | 213 | 626 | 320 | 138 | 152 | 1,887 | 22,563 |
| 2003 | 397 | 199 | 796 | 312 | 137 | 150 | 1,991 | 25,612 |
| 2004 | 413 | 170 | 787 | 378 | 152 | 201 | 2,101 | 29,116 |
| 2005 | 175 | 125 | 782 | 309 | 122 | 259 | 1,772 | 28,930 |
| 2006 | 163 | 191 | 705 | 250 | 116 | 265 | 1,690 | 27,571 |

Source: USACE, Waterborne Commerce of the U.S., Part 2, 1992–2006.

While total trips declined from 2,460 in 1992 to 1,690 in 2006, trip counts for some groups grew. Along with increases in trips for vessels with loaded drafts over 38 feet, there were significant increases in the number of movements associated with loaded drafts of 25 feet or more.

General cargo vessels also increased in loaded drafts. In 1993 and 2006, loaded drafts for vessels used to import bananas and export food showed a change from average loaded drafts of 25 feet or less in the early 1990s to 25 feet or more for recent years. While the largest concentration of banana and food product movements is associated with loaded drafts between 25 and 29 feet, some loaded drafts between 36 and 39 feet are used for food products, specifically meat and rice. Table 3-2 shows inbound and outbound trips for loaded drafts over 38 feet.

**Table 3-2**
**Freeport Harbor Number of Vessels for Loaded Drafts Over 38 Feet**
**Inbound and Outbound Vessel Movements (1992–2006)**

| Year | Inbound Vessels by Loaded Draft (feet) | | | | | | | % Deep-Draft Vessels[a] |
|---|---|---|---|---|---|---|---|---|
| | 39 | 40 | 41 | 42 | 43 | 44 | Total | |
| 1992 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 0.2 |
| 1993 | 8 | 3 | 0 | 2 | 1 | 0 | 14 | 0.7 |
| 1994 | 21 | 17 | 3 | 2 | 0 | 0 | 43 | 1.7 |
| 1995 | 36 | 23 | 12 | 6 | 0 | 0 | 77 | 2.3 |
| 1996 | 59 | 37 | 16 | 18 | 0 | 0 | 130 | 5.4 |
| 1997 | 52 | 63 | 9 | 12 | 1 | 0 | 137 | 6.9 |
| 1998 | 73 | 43 | 11 | 4 | 0 | 0 | 131 | 6.8 |
| 1999 | 54 | 26 | 10 | 10 | 3 | 0 | 103 | 7.5 |
| 2000 | 49 | 20 | 16 | 22 | 0 | 0 | 107 | 5.2 |
| 2001 | 30 | 19 | 11 | 41 | 0 | 0 | 101 | 3.5 |
| 2002 | 23 | 14 | 4 | 104 | 0 | 0 | 145 | 14.9 |
| 2003 | 39 | 26 | 21 | 54 | 0 | 0 | 140 | 13.6 |
| 2004 | 55 | 29 | 49 | 42 | 0 | 0 | 175 | 17.2 |
| 2005 | 47 | 136 | 8 | 43 | 0 | 0 | 234 | 26.7 |
| 2006 | 47 | 86 | 90 | 4 | 0 | 0 | 227 | 26.1 |
| | Outbound Vessels by Loaded Draft (feet)[b] | | | | | | | |
| 1992 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| 1993 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| 1994 | 4 | 3 | 0 | 0 | 0 | 0 | 7 | 0.3 |
| 1995 | 7 | 7 | 1 | 0 | 0 | 0 | 15 | 0.5 |
| 1996 | 6 | 2 | 0 | 0 | 0 | 0 | 8 | 0.3 |
| 1997 | 5 | 9 | 0 | 0 | 0 | 0 | 15 | 0.7 |
| 1998 | 6 | 4 | 0 | 2 | 0 | 0 | 12 | 0.6 |
| 1999 | 9 | 3 | 1 | 0 | 0 | 0 | 13 | 0.9 |
| 2000 | 7 | 11 | 1 | 1 | 0 | 0 | 20 | 1.0 |
| 2001 | 9 | 2 | 0 | 2 | 0 | 0 | 13 | 0.5 |
| 2002 | 3 | 1 | 2 | 1 | 0 | 0 | 7 | 0.7 |
| 2003 | 4 | 5 | 1 | 0 | 0 | 0 | 10 | 1.0 |
| 2004 | 18 | 8 | 0 | 0 | 0 | 0 | 26 | 2.4 |
| 2005 | 12 | 11 | 1 | 1 | 0 | 0 | 25 | 2.8 |
| 2006 | 15 | 19 | 1 | 1 | 0 | 2 | 38 | 4.5 |

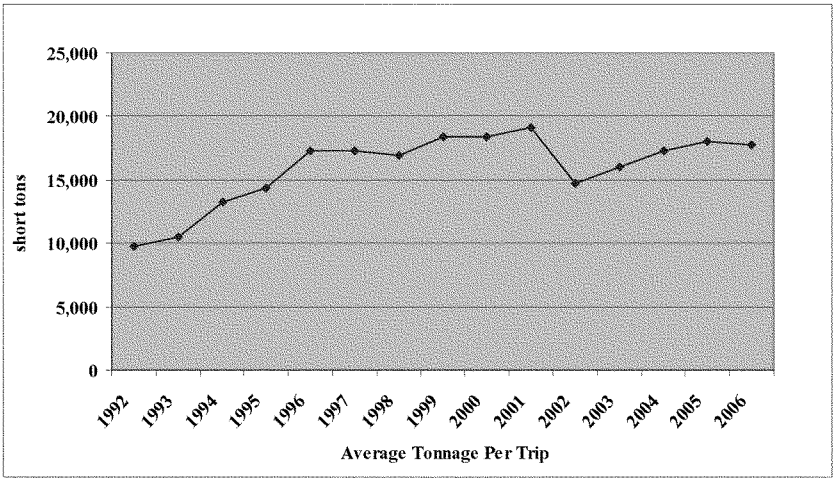
Source: USACE, Waterborne Commerce of the U.S., Part 2, 1992–2006.

[a]Percentage of loaded vessel drafts >=39 feet to all trips with loaded drafts greater than 18 feet.

[a]In 2006, there were 2 outbound vessels with loaded drafts of 45 feet. The next largest loaded draft group was 42 feet.

Freeport's vessel utilization data show a general increase in average tonnage per trip and suggests use of more fully loaded vessels. The increase in the volume of tonnage per trip is primarily associated with crude petroleum and petrochemical products, but other commodities are being transported in larger parcels as well. Figure 3-2 shows average tonnage per trip for ocean-going traffic, and it is based on vessels with loaded drafts over 18 feet and total ocean-going tonnage.

**Figure 3-2**
**Freeport Channel**
**Average Tonnage Per Vessel Trip**
**(1992–2006)**




Source: USACE, Waterborne Commerce of the U.S., Part 2, 1992–2006.

## 3.1 UNDERKEEL CLEARANCE

Underkeel clearance is defined as the minimum clearance available between the deepest point on the vessel and the channel bottom, in still water. The general rule of the BRPA indicates the underkeel clearance be at least 10 percent of the design draft minus 1 foot, but the BRPA said it is their understanding that since the grounding of the Exxon *Valdez* and OPRA 90, the U.S. Coast Guard (USCG) has required a minimum of 3-foot underkeel clearance for all tank vessels. Interpretation of the BRPA rule suggests that loaded drafts in excess of 42 feet should be very rare for the current 45 foot channel. The transit data show this to be true.

Freeport's tanker fleet was examined in order to identify the vessel loading patterns. The effect of underkeel clearance policy on existing and future traffic results in greater underkeel clearance for larger vessel sizes. The 2005 and 2006 records show some vessels less than 100,000 DWT

being loaded up to 42 feet and vessels over 115,000 DWT not being loaded greater than 40 feet and ranging from 34 to 40 feet.

## 3.2 COMMODITY-SPECIFIC VESSEL UTILIZATION

This section presents analysis of vessel fleet data, utilization of the existing fleet, and anticipated future constraints associated with draft-constrained vessels. These analyses provide the basis for identifying the commodities expected to utilize vessels loaded to channel depths over 45 feet and for forecasting percentage utilization of larger and/or more fully loaded vessels. The discussions include vessel fleets for petroleum, petroleum products, chemicals, breakbulk, container cargo, OSVs, seismic, research, and LNG vessels.

### 3.2.1 Crude Petroleum Tanker Fleet

The largest vessels presently using Freeport are crude petroleum tankers. The most common sizes presently using Freeport are between 90,000 and 110,000 DWT, and the largest vessels presently used are in the 145,000 to 159,500 DWT range. Table 3-3 presents distributions of crude petroleum imports by vessel size for 1990, 1993 and 2003 to 2007. The period between 1993 and 2003 shows a clear distinction of transition to larger vessels. Table 3-4 displays representative vessel characteristics corresponding to Freeport's current crude petroleum fleet.

**Table 3-3**
**Freeport Harbor Crude Petroleum Imports by Vessel DWT 1990–2007 (Percent)**

| DWT Range | 1990 | 1993 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| <50,000 | 1.1 | – | – | – | 1.1 | 0.7 | 1.3 |
| 50,000 to 69,000 | 98.9 | 11.8 | 3.1 | 0.9 | 3.3 | 1.8 | 2.2 |
| 70,000 to 79,999 | – | – | 0.3 | 4.2 | 3.4 | 6.6 | 5.0 |
| 80,000 to 84,999 | – | 24.9 | 5.3 | 4.1 | 1.5 | – | – |
| 85,000 to 89,999 | – | 35.6 | 5.7 | 1.2 | 1.0 | – | – |
| 90,000 to 94,999 | – | – | 5.5 | 6.2 | 5.7 | 9.5 | 7.2 |
| 95,000 to 99,999 | – | 16.9 | 36.3 | 35.8 | 34.5 | 24.3 | 23.4 |
| 100,000 to 104,999 | – | 10.8 | 10.9 | 13.7 | 12.6 | 13.6 | 22.5 |
| 105,000 to 109,999 | – | – | 26.7 | 22.2 | 27.3 | 31.5 | 25.6 |
| 110,000 to 114,999 | – | – | 3.3 | 7.6 | 5.2 | 5.6 | 6.6 |
| 115,000 to 119,999 | – | – | – | – | – | 1.0 | 2.2 |
| 120,000 to 139,999 | | | | | | | – |
| 140,000 to 159,000 | – | – | 2.9 | 4.1 | 4.4 | 5.3 | 4.2 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Source: USACE, NDC, unpublished data.

**Table 3-4**
**Freeport Harbor**
**Crude Petroleum Representative Tanker Sizes**

| DWT Range | Vessel Characteristics (feet) | | |
|---|---|---|---|
| | LOA | Beam | Design Draft |
| <80,000 | 748 | 106 | 41 |
| 80,000 to 84,999 | 800 | 131 | 43 |
| 85,000 to 89,999 | 800 | 138 | 46 |
| 90,000 to 94,999 | 810 | 136 | 46 |
| 95,000 to 99,999 | 798 | 137 | 47 |
| 100,000 to 104,999 | 792 | 138 | 48 |
| 105,000 to 109,999 | 797 | 138 | 50 |
| 110,000 to 114,999 | 817 | 144 | 49 |
| 115,000 to 139,999 | 820 | 144 | 53 |
| 140,000 to 155,000 | 899 | 154 | 56 |

Source: USACE, NDC unpublished data were used to compile the percentage distribution of tonnage by vessel size. The Fairplay/Lloyd's Register of Ships was used to obtain the vessel DWT and associated characteristics.

Table 3-5 displays Freeport's 2005 to 2006 fleet of 115,000 to 159,500 DWT tankers. The first section of the table shows the 147,080 to 159,999 DWT vessels. Freeport's load patterns for the larger class of tankers showed the loaded drafts for 147,080 to 159,500 DWT tankers ranged from 30 to 40 feet. In 2005, thirteen vessels were in this range with the median loaded draft of 33 feet. In 2006, fifteen vessels were in this range with the median loaded draft of 37 feet. These vessels are most likely associated with lightening, the process where a fully loaded tanker sails from locations such as West Africa to the Gulf of Mexico. These vessels offload a partial load of cargo in order allow them to enter ports such as Freeport. The effect of an increase in channel depth at Freeport would allow these vessels to offload less cargo offshore.

Based on the current BRPA rules, vessels in the 145,000 to 150,000 DWT range require waivers. Waivers are only granted provided that winds are less than 20 knots and that there is no more than a 0.5-knot crosscurrent at the mouth of the jetties. Approximately three to four ships per month are granted waivers.

Table 3-6 shows Freeport's 2005 to 2007 average crude oil imports by vessel class and associated vessel dimensions. Table 3-7 displays the distribution of Freeport's 1990, 1993, and 2000 to 2007 crude petroleum imports by loaded draft. The distribution of tonnage by loaded draft shows annual variations but illustrates greater concentration of loaded drafts of 40 feet or more in the years since 2000.

**Table 3-5**
**Freeport Harbor's 2005–2006 Fleet of 115,000 to 159,500 DWT Tankers**

| Vessel Name | Loaded Draft (feet) | DWT | LOA (feet) | Beam (feet) | Design Draft (feet) | Year Built | Region of Origin | Current Shipping Method | Date of Entry (month, year, day) |
|---|---|---|---|---|---|---|---|---|---|
| *Axel Spirit* | 40 | 115,392 | 820 | 144 | 49 | 2004 | Venezuela | Direct | 06520 |
| *Dubai Legend* | 39 | 112,661 | 820 | 144 | 48 | 2002 | Venezuela | Direct | 08617 |
| *Mare Tirrenum* | 40 | 110,729 | 805 | 138 | 48 | 2004 | West Africa | Direct | 06515 |
| *Avor* | 38 | 113,033 | 820 | 144 | 48 | 2003 | Colombia | Direct | 11627 |
| *Krymsk* | 37 | 115,605 | 820 | 144 | 49 | 2003 | Bahamas | Direct | 05619 |
| *Montigny* | 37 | 115,418 | 817 | 144 | 49 | 2003 | Bahamas | Direct | 02617 |
| *Helga Spirit* | 37 | 114,780 | 820 | 144 | 49 | 2005 | Bahamas | Direct | 06606 |
| *Atlantic Galaxy* | 34 | 115,583 | 817 | 144 | 48 | 2005 | West Africa | Lightening | 08629 |
| *Kazan* | 30 | 115,727 | 820 | 144 | 49 | 2003 | Colombia | Lightened | 12522 |
| *Sonangol Girassol* | 40 | 159,057 | 899 | 157 | 52 | 2000 | West Africa | Lightening | 04523 |
| *Sks Saluda* | 40 | 159,000 | 899 | 164 | 52 | 2003 | West Africa | Lightening | 12625 |
| *Astro Polaris* | 40 | 158,892 | 899 | 157 | 52 | 2004 | West Africa | Lightening | 03604 |
| *Sks Sira* | 39 | 159,453 | 899 | 158 | 56 | 2002 | North Africa | Lightening | 04614 |
| *Scf Altai* | 39 | 159,168 | 899 | 157 | 52 | 2001 | West Africa | Lightening | 10625 |
| *Nordic Hunter* | 36 | 151,401 | 899 | 158 | 53 | 1997 | North Africa | Lightening | 02524 |
| *Knock Dun* | 35 | 147,048 | 899 | 146 | 53 | 1994 | West Africa | Lightening | 03527 |
| *Pecos* | 33 | 157,400 | 899 | 151 | 56 | 1998 | United Kingdom | Lightening | 10524 |
| *Astro Phoenix* | 32 | 158,892 | 899 | 157 | 52 | 2004 | North Africa | Lightening | 06613 |
| *Kaspiy* | 32 | 150,812 | 883 | 151 | 57 | 1998 | United Kingdom | Lightening | 08513 |
| *Front Brabant* | 32 | 149,999 | 883 | 151 | 57 | 1998 | West Africa | Lightening | 12515 |
| *Sea Star* | 31 | 148,435 | 882 | 151 | 55 | 1996 | West Africa | Lightening | 05520 |
| *Sks Saluda* | 30 | 159,000 | 899 | 157 | 52 | 2003 | North Africa | Lightening | 09511 |

Source: USACE, NDC detailed unpublished data, 2005-2006.

**Table 3-6**
**Freeport Crude Oil Imports 2005–2007**
**Total Tonnage and Representative Vessel Characteristics**

| DWT Range | Freeport Crude Oil % of Imports by DWT 2005–2007 Average | Median Dimensions | | | Design Draft (feet) | | | Year Built[a] |
|---|---|---|---|---|---|---|---|---|
| | | DWT | Length (feet) | Beam (feet) | Median | Min. | Max | |
| <50,000 | 1.0 | 46,000 | 600 | 106 | 38 | 12 | 41 | 2004 |
| 50,000 to 69,000 | 2.4 | 65,275 | 724 | 106 | 44 | 40 | 46 | 2005 |
| 70,000 to 79,999 | 5.0 | 72,604 | 750 | 106 | 46 | 41 | 48 | 2005 |
| 80,000 to 84,999 | 0.5 | 84,999 | 784 | 125 | 43 | 43 | 48 | 2002 |
| 85,000 to 89,999 | 0.3 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 90,000 to 94,999 | 7.5 | 92,998 | 773 | 138 | 47 | 45 | 50 | 2003 |
| 95,000 to 99,999 | 27.4 | 99,850 | 805 | 138 | 47 | 44 | 49 | 2003 |
| 100,000 to 104,999 | 16.2 | 104,075 | 800 | 138 | 48 | 44 | 49 | 2005 |
| 105,000 to 109,999 | 28.1 | 105,994 | 800 | 138 | 49 | 40 | 51 | 2004 |
| 110,000 to 114,999 | 5.8 | 113,782 | 820 | 144 | 49 | 39 | 49 | 2005 |
| 115,000 to 119,999 | 1.1 | 115,572 | 817 | 144 | 49 | 48 | 51 | 2005 |
| 120,000 to 139,999 | 0.0 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 140,000 to 154,999 | 3.3 | 149,991 | 899 | 158 | 54 | 52 | 57 | 2004 |
| 155,000 to 159,999 | 0.5 | 159,117 | 899 | 157 | 56 | 52 | 56 | 2004 |
| 160,000 to 169,999 | 0.1 | 163,750 | 899 | 164 | 56 | 49 | 57 | 2005 |

Source: USACE, NDC unpublished data were used to compile the percentage distribution of tonnage by vessel size.
The Fairplay/Lloyd's Register of Ships was used to obtain the vessel DWT and associated characteristics.
[a]Representative Year.

**Table 3-7**
**Freeport Crude Petroleum Imports Percentage of Short Tons by Loaded Draft**
**1990, 1993, and 2000–2007**

| Loaded Draft (feet) | 1990 | 1993 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|
| <=36 | 42.3 | 73.6 | 43.1 | 38.9 | 21.1 | 23.1 | 17.6 | 14.2 | 12.4 | 17.4 |
| 37 | 26.0 | 6.6 | 8.9 | 13.8 | 7.4 | 9.1 | 9.8 | 5.2 | 5.0 | 6.3 |
| 38 | 31.7 | 4.1 | 11.8 | 14.6 | 12.5 | 19.2 | 15.9 | 8.1 | 5.6 | 6.0 |
| 39 | – | 9.3 | 20.8 | 11.6 | 9.6 | 13.0 | 15.8 | 13.7 | 13.6 | 10.3 |
| 40 | – | 3.8 | 7.3 | 6.5 | 5.5 | 6.2 | 7.6 | 40.2 | 29.4 | 9.7 |
| 41 | – | 1.3 | 3.0 | 1.0 | 0.6 | 6.5 | 18.6 | 3.0 | 32.9 | 39.9 |
| 42 | – | 1.3 | 5.1 | 13.6 | 43.3 | 22.9 | 14.7 | 15.6 | 1.1 | 10.4 |
| 43 | – | – | – | – | – | – | – | – | – | – |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Source: USACE, NDC detailed files.

The next series of tables provides data associated with crude petroleum imports by loaded draft and design draft. Table 3-8 displays a matrix of 2005 to 2007 average tonnage by loaded draft and design draft and shows that 96.8 percent of 2005 to 2007 tonnage is shipped in vessels with design drafts over 40 feet. Freeport's deep-draft vessel fleet statistics show that 80 percent of recent crude petroleum tonnage was transported in vessels with design drafts over 44 feet. Sixty-one percent of tonnage was loaded to 40 feet or greater. Table 3-9 displays trips by vessel DWT and loaded draft for 2004 to 2006.

**Table 3-8**
**Crude Petroleum Short Tons 2005–2007 Average**
**by Design Draft and Loaded Draft**
**1,000s of Short Tons**

| Design Draft (feet) | Loaded Draft (feet) | | | | | | | | Total % |
|---|---|---|---|---|---|---|---|---|---|
| | 25–29 | 30–34 | 35–37 | 38–39 | 40 | 41 | 42 | Total | |
| <30 | | | | | | | | – | |
| 34–36 | | 11.7 | | | | | | 11.7 | 0.1 |
| 37–39 | 13.7 | 10.0 | | | | | | 23.7 | 0.1 |
| 40 | 22.3 | 47.7 | 109.7 | 181.7 | 176.3 | 56.7 | – | 594.3 | 3.1 |
| 41 | | 22.0 | 22.0 | 92.3 | 33.3 | | 47.7 | 217.3 | 1.1 |
| 42 | | | 27.7 | 56.7 | 57.0 | 53.3 | | 194.7 | 1.0 |
| 43 | | 41.3 | 237.0 | 85.0 | 232.0 | | 28.0 | 623.3 | 3.2 |
| 44 | | 42.7 | 97.7 | 88.0 | 105.0 | 340.3 | 57.0 | 730.7 | 3.8 |
| 45 | 70.3 | 360.0 | 731.3 | 1,033.7 | 1,754.0 | 2,154.3 | 662.0 | 6,765.7 | 34.7 |
| 46 | 37.7 | 102.0 | 77.3 | 571.0 | 710.3 | 142.3 | 141.0 | 1,781.7 | 9.1 |
| 47 | | 32.0 | 56.0 | 80.0 | 135.7 | 164.3 | 31.7 | 499.7 | 2.6 |
| 48 | 27.0 | 184.0 | 245.7 | 506.3 | 594.7 | 602.0 | 693.3 | 2,853.0 | 14.7 |
| 49 | 31.0 | 195.0 | 659.3 | 1,000.3 | 1,247.7 | 1,145.7 | 197.0 | 4,476.0 | 23.0 |
| 50 | | 24.7 | | | 60.7 | 27.0 | | 112.3 | 0.6 |
| 51 | | | | | 27.7 | | | 27.7 | 0.1 |
| 52 | | 48.7 | 26.7 | | 12.3 | 23.7 | | 111.3 | 0.6 |
| 53 | | 27.0 | 29.0 | | 44.7 | | | 100.7 | 0.5 |
| 54 | | – | – | | | | | – | – |
| 55 | | 47.0 | 58.7 | | | | | 105.7 | 0.5 |
| 56 | | | 24.3 | | 61.0 | 44.3 | | 129.7 | 0.7 |
| 57 | 12.3 | 30.0 | 26.7 | | | 44.3 | | 113.3 | 0.6 |
| | 214.3 | 1,225.7 | 2,429.0 | 3,695.0 | 5,252.3 | 4,798.3 | 1,857.7 | 19,472.3 | 100 |
| | Percentage by Loaded Draft | | | | | | | | |
| | 1.1 | 6.3 | 12.5 | 19.0 | 27.0 | 24.6 | 9.5 | 100 | |

Source: USACE, NDC detailed files.

Note: Totals may not add due to rounding.

**Table 3-9**
**Freeport Crude Petroleum Imports Vessels by Vessel DWT and Loaded Draft Range**

| DWT 1,000s | 30–34 | 35–37 | 38–40 | 41–42 | Total | |
|---|---|---|---|---|---|---|
| | **2004 Inbound Vessels by Loaded Draft Range** | | | | | |
| <80 | 1 | 4 | 17 | 1 | 23 | 8.3% |
| 80–84.9 | 0 | 4 | 5 | 0 | 9 | 3.2% |
| 85–89.9 | 0 | 0 | 2 | 1 | 3 | 1.1% |
| 90–94.9 | 2 | 7 | 8 | 1 | 18 | 6.5% |
| 95–99.9 | 9 | 20 | 20 | 52 | 101 | 36.3% |
| 100–104.9 | 0 | 9 | 6 | 9 | 24 | 8.6% |
| 105–109.9 | 3 | 14 | 36 | 15 | 68 | 24.5% |
| 110–114.9 | 6 | 1 | 14 | 4 | 25 | 9.0% |
| 140–155 | 3 | 1 | 2 | 0 | 6 | 2.2% |
| >155 | 1 | 0 | 0 | 0 | 1 | 0.4% |
| Total | 25 | 60 | 110 | 83 | 278 | 100% |
| Trips (%) | 9.0 | 21.6 | 39.6 | 29.9 | 100 | |
| | **2005 Inbound Vessels by Loaded Draft Range** | | | | | |
| <80 | 0 | 5 | 22 | 3 | 30 | 9.3% |
| 80–84 | 0 | 0 | 2 | 0 | 2 | 0.6% |
| 85–89 | 0 | 0 | 1 | 0 | 1 | 0.3% |
| 90–94 | 4 | 6 | 35 | 16 | 61 | 19.0% |
| 95–99 | 2 | 0 | 5 | 0 | 7 | 2.2% |
| 95–99.9 | 7 | 9 | 36 | 5 | 57 | 17.8% |
| 100–104.9 | 1 | 3 | 16 | 4 | 24 | 7.5% |
| 105–109.9 | 10 | 9 | 66 | 18 | 103 | 32.1% |
| 110–114.9 | 1 | 2 | 18 | 4 | 25 | 7.8% |
| 140–155 | 5 | 2 | 0 | 0 | 7 | 2.2% |
| >155 | 1 | 0 | 3 | 0 | 4 | 1.2% |
| Total | 31 | 36 | 204 | 50 | 321 | 100% |
| Trips (%) | 9.7 | 11.2 | 63.6 | 15.6 | 100 | |
| | **2006 Inbound Vessels by Loaded Draft Range** | | | | | |
| <80 | 7 | 3 | 11 | 4 | 25 | 7.6% |
| 80–84 | 0 | 0 | 0 | 0 | 0 | – |
| 85–89.9 | 0 | 0 | 1 | 0 | 1 | 0.3% |
| 90–94.9 | 5 | 5 | 21 | 20 | 51 | 15.6% |
| 95–99.9 | 2 | 2 | 23 | 31 | 58 | 17.7% |
| 100–104.9 | 0 | 0 | 2 | 0 | 2 | 0.6% |
| 105–109.9 | 1 | 1 | 10 | 0 | 12 | 3.7% |
| 110–114.9 | 5 | 21 | 80 | 44 | 150 | 45.9% |
| 140–155 | 3 | 11 | 5 | 0 | 19 | 5.8% |
| >155 | 1 | 0 | 8 | 0 | 9 | 2.8% |
| Total | 24 | 43 | 161 | 99 | 327 | 100% |
| Trips (%) | 7.3 | 13.1 | 49.2 | 30.3 | 100 | |

Source: USACE, NDC compiled from detailed records. The Fairplay/Lloyd's Register of Ships was used to obtain the vessel DWT and associated characteristics.

Tables 3-10 to Table 3-16 provide additional detail on the relationship between loaded and design drafts for Freeport's crude oil imports. Table 3-10 to Table 3-15 provide matrices of 2005 to 2007 annual inbound vessels and imports by loaded draft and design draft. Table 3-16 summarizes the inbound vessel and tonnage data and shows that 50 percent of 2007 tonnage was transported in vessels with loaded drafts over 40 feet.

**Table 3-10**
**2005 Crude Petroleum Short Tons (1,000s)[a]**
**by Design Draft and Loaded Draft**

| Design Draft (feet) | Loaded Draft (feet) | | | | | | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | |
| 36 | | | | | | | | | 44 | | | | | | | 44 |
| 40 | | | | | | | | | 108 | | 309 | 85 | 529 | | | 1,031 |
| 42 | | | | | | | | | 83 | | | 57 | 58 | 160 | 64 | 422 |
| 43 | | | | | 59 | | 65 | | 74 | 167 | 97 | 158 | 296 | | 84 | 998 |
| 44 | | | | | | | 52 | | 199 | | | 170 | 236 | | 171 | 829 |
| 45 | 169 | | 120 | | | 349 | | 77 | 166 | 365 | 261 | 1,148 | 2,957 | | 1,560 | 7,171 |
| 46 | | 39 | | | 77 | | | | | 70 | 236 | 316 | 1,173 | | 361 | 2,273 |
| 47 | | | | | | | | | | 168 | | 162 | 251 | 89 | 95 | 765 |
| 48 | 81 | | | | | 162 | | 70 | 83 | 73 | 424 | 231 | 1,468 | 82 | 931 | 3,605 |
| 49 | | | 62 | 83 | 7 | 67 | 61 | | 145 | 155 | 284 | 504 | 1,325 | 328 | 159 | 3,181 |
| 52 | | | 69 | | | 77 | | | | | | | 37 | | | 183 |
| 53 | | | | | 81 | | | 74 | | | | | | | | 155 |
| 55 | | | | 70 | | | | | | | | | | | | 70 |
| 56 | | | | | | | | | 73 | | | | 100 | | | 173 |
| 57 | | | | | 59 | | | | | | | | | | | 59 |
| Grand Total | 249 | 39 | 251 | 154 | 283 | 655 | 178 | 222 | 975 | 999 | 1,611 | 2,830 | 8,430 | 659 | 3,425 | 20,959 |

Source: USACE, NDC compiled from detailed records. The Fairplay/Lloyd's Register of Ships was used to obtain the vessel DWT and associated characteristics.

[a]Obtained from the USACE, detailed records, totals may differ from IWR-NDC publication. The presentation only includes records that showed loaded draft and for which design drafts could be found.

Note: Totals may not add due to rounding.

**Table 3-11**
**2005 Crude Petroleum Vessels by Design Draft and Loaded Draft[a]**

| Design Draft (feet) | Loaded Draft (feet) | | | | | | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | |
| 36 | | | | | | | | | 1 | | | | | | | 1 |
| 40 | | | | | | | | | 2 | | 4 | 1 | 8 | | | 15 |
| 42 | | | | | | | | | 1 | | | 1 | 1 | 2 | 1 | 6 |
| 43 | | | | | 1 | | 1 | | 1 | 2 | 2 | 2 | 4 | | 1 | 14 |
| 44 | | | | | | | 1 | | 3 | | | 2 | 3 | | 2 | 11 |
| 45 | 2 | | 3 | | | 4 | | 1 | 2 | 5 | 4 | 16 | 37 | | 18 | 92 |
| 46 | | 1 | | | 1 | | | | | 1 | 3 | 4 | 13 | | 4 | 27 |
| 47 | | | | | | | | | | 2 | | 2 | 4 | 1 | 1 | 10 |
| 48 | 1 | | | | | 2 | | 1 | 1 | 1 | 7 | 3 | 19 | 1 | 11 | 47 |
| 49 | | | 1 | 1 | 1 | 1 | 1 | | 2 | 2 | 4 | 8 | 20 | 4 | 2 | 47 |
| 52 | | | 1 | | | 1 | | | | | | | 1 | | | 3 |
| 53 | | | | | 1 | | | 1 | | | | | | | | 2 |
| 55 | | | | 1 | | | | | | | | | | | | 1 |
| 56 | | | | | | | | | 1 | | | | 1 | | | 2 |
| 57 | | | | | 1 | | | | | | | | | | | 1 |
| Grand Total | 3 | 1 | 5 | 2 | 5 | 8 | 3 | 3 | 14 | 13 | 24 | 39 | 111 | 8 | 40 | 279 |

Source: USACE, NDC compiled from detailed records. The Fairplay/Lloyd's Register of Ships was used to obtain the vessel DWT and associated characteristics.

[a]Obtained from the USACE, detailed records, totals may differ from IWR-NDC publication. The presentation only includes records that showed loaded draft and for which design drafts could be found.

**Table 3-12**
**2006 Crude Petroleum Short Tons (1,000s) by Design Draft and Loaded Draft[a]**

| Design Draft (feet) | Loaded Draft (feet) | | | | | | | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 | 26 | 28 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | |
| 36 | | | | | | | | | | 170 | | | | | | | 170 |
| 41 | | 27 | | | | | | 66 | 66 | | | | 220 | 100 | | 79 | 558 |
| 42 | | | | | | | | | | | | | 59 | 113 | | | 172 |
| 43 | | | | | | | | | 68 | | 67 | | | 162 | | | 297 |
| 44 | | | | | | | 17 | | | | | | | 79 | 490 | | 586 |
| 45 | | | | 69 | | 86 | 111 | 96 | 202 | 223 | 386 | 93 | 1,003 | 1,978 | 3,143 | 70 | 7,460 |
| 46 | | | | | | | 58 | 171 | 71 | | | 168 | 291 | 958 | 247 | | 1,964 |
| 47 | | | | | | | | | | | | 78 | | 82 | | | 160 |
| 48 | | | | | 38 | | | | | 77 | | | 291 | 24 | 163 | 91 | 684 |
| 49 | 46 | | | 56 | | | 63 | | 151 | 567 | 514 | 684 | 930 | 1,819 | 2,360 | | 7,190 |
| 50 | | | | | | 74 | | | | | | | | 182 | 81 | | 337 |
| 51 | | | | | | | | | | | | | | 83 | | | 83 |
| 53 | | | | | | | | | 13 | | | | | 134 | | | 147 |
| 57 | | | 37 | | | | | | 80 | | | | | | | | 117 |
| Grand Total | 46 | 27 | 37 | 125 | 38 | 160 | 248 | 333 | 651 | 867 | 967 | 1,023 | 2,795 | 5,884 | 6,563 | 240 | 19,925 |

Source: USACE, NDC compiled from detailed records. The Fairplay/Lloyd's Register of Ships was used to obtain the vessel DWT and associated characteristics.

[a]Obtained from the USACE, detailed records, totals may differ from IWR-NDC publication. The presentation only includes records that showed loaded draft and for which design drafts could be found.

Note: Totals may not add due to rounding.

**Table 3-13**
**2006 Crude Petroleum Vessels by Design Draft and Loaded Draft[a]**

| Design Draft (feet) | Loaded Draft (feet) | | | | | | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 | 26 | 28 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | |
| 40 | | | | | | | | | | | | | | 2 | | 2 |
| 41 | | 1 | | | | | | 1 | 1 | | | | 3 | 2 | 1 | 9 |
| 42 | | | | | | | | | | | | | 1 | 2 | | 3 |
| 43 | | | | | | | | | 1 | | 1 | | | 2 | | 4 |
| 44 | | | | | | | 1 | | | | | | | 1 | 6 | 8 |
| 45 | | | | 1 | | 2 | 2 | 2 | 4 | 3 | 6 | 3 | 12 | 25 | 40 | 100 |
| 46 | | | | | | | 1 | 3 | 1 | | | 2 | 4 | 13 | 3 | 27 |
| 47 | | | | | | | | | | | | 1 | | 1 | | 2 |
| 48 | | | | | 1 | | | | | 1 | | | 4 | 1 | 2 | 9 |
| 49 | 1 | | | 1 | | | 1 | | 2 | 8 | 7 | 9 | 12 | 24 | 30 | 95 |
| 50 | | | | | | 1 | | | | | | | | 3 | 1 | 5 |
| 51 | | | | | | | | | | | | | | 1 | | 1 |
| 53 | | | | | | | | | 1 | | | | | 2 | | 3 |
| 57 | | | 1 | | | | | | 1 | | | | | | | 2 |
| Grand Total | 1 | 1 | 1 | 2 | 1 | 3 | 5 | 6 | 11 | 12 | 14 | 15 | 36 | 79 | 83 | 270 |

Source: USACE, NDC compiled from detailed records. The Fairplay/Lloyd's Register of Ships was used to obtain the vessel DWT and associated characteristics.

[a]Obtained from the USACE, detailed records, totals may differ from IWR-NDC publication. The presentation only includes records that showed loaded draft and for which design drafts could be found.

**Table 3-14**
**2007 Crude Petroleum Short Tons (1,000s) by Design Draft and Loaded Draft[a]**

| Design Draft (feet) | Loaded Draft (feet) | | | | | | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 27 | 28 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | |
| 34 | | | | | | 35 | | | | | | | | | | 35 |
| 37 | | | | 30 | | | | | | | | | | | | 30 |
| 38 | 41 | | | | | | | | | | | | | | | 41 |
| 40 | 67 | | 22 | 72 | | | 49 | | 73 | 148 | 95 | 56 | | | | 582 |
| 41 | | | | | | | | | | | | 57 | | | | 57 |
| 42 | | | | | | | | | | | | 54 | | | | 54 |
| 43 | | | | | | | | | 211 | 124 | | | 238 | | | 573 |
| 44 | | | | 59 | | | | | 70 | 24 | 72 | 22 | | 531 | | 779 |
| 45 | | 42 | 42 | 20 | 71 | | 116 | 133 | 288 | 354 | 200 | 396 | 327 | 3,320 | 356 | 5,666 |
| 46 | | 74 | | | | | | 91 | | | 261 | 441 | | 180 | 62 | 1,109 |
| 47 | | | | 67 | 29 | | | | | | | | 74 | 404 | | 574 |
| 48 | | | | 17 | 67 | 89 | 179 | 69 | 72 | 293 | 360 | 213 | 292 | 1,561 | 1,058 | 4,270 |
| 49 | | 47 | | | 65 | 91 | 30 | | 372 | 74 | 88 | 511 | 599 | 749 | 432 | 3,058 |
| 52 | | | | | | | | 80 | | | | | | 71 | | 151 |
| 55 | | | | | 71 | | | | 89 | 87 | | | | | | 247 |
| 56 | | | | | | | | | | | | | 83 | 133 | | 217 |
| 57 | | | | 31 | | | | | | | | | | 133 | | 165 |
| Grand Total | 107 | 163 | 64 | 297 | 303 | 215 | 373 | 374 | 1,176 | 1,103 | 1,077 | 1,750 | 1,612 | 7,083 | 1,908 | 17,606 |

Source: USACE, NDC compiled from detailed records. The Fairplay/Lloyd's Register of Ships was used to obtain the vessel DWT and associated characteristics.

[a]Obtained from the USACE, detailed records, totals may differ from IWR-NDC publication. The presentation only includes records that showed loaded draft and for which design drafts could be found.

Note: Totals may not add due to rounding.

**Table 3-15**
**2007 Crude Petroleum Vessels by Design Draft and Loaded Draft[a]**

| Design Draft (feet) | Loaded Draft (feet) | | | | | | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 27 | 28 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | |
| 34 | | | | | | 1 | | | | | | | | | | 1 |
| 37 | | | | 1 | | | | | | | | | | | | 1 |
| 38 | 1 | | | | | | | | | | | | | | | 1 |
| 40 | 1 | | 1 | 2 | | | 1 | | 1 | 2 | 2 | 1 | | | | 11 |
| 41 | | | | | | | | | | | | 1 | | | | 1 |
| 42 | | | | | | | | | | | | 1 | | | | 1 |
| 43 | | | | | | | | | 3 | 2 | | | 3 | | | 8 |
| 44 | | | | 1 | | | | | 1 | 1 | 1 | 1 | | 6 | | 11 |
| 45 | | 1 | 1 | 1 | 1 | | 2 | 2 | 4 | 5 | 3 | 5 | 4 | 38 | 4 | 71 |
| 46 | | 1 | | | | | | 1 | | | 4 | 5 | | 3 | 1 | 15 |
| 47 | | | | 1 | 1 | | | | | | | | 1 | 5 | | 8 |
| 48 | | | | 1 | 1 | 1 | 3 | 1 | 1 | 4 | 5 | 3 | 4 | 18 | 12 | 54 |
| 49 | | 1 | | | 1 | 2 | 1 | | 5 | 1 | 1 | 6 | 8 | 8 | 5 | 39 |
| 52 | | | | | | | | 1 | | | | | | 1 | | 2 |
| 55 | | | | | 1 | | | | 1 | 1 | | | | | | 3 |
| 56 | | | | | | | | | | | | | 2 | 2 | | 4 |
| 57 | | | | 1 | | | | | | | | | | 1 | | 2 |
| Grand Total | 2 | 3 | 2 | 8 | 5 | 4 | 7 | 5 | 16 | 16 | 16 | 23 | 22 | 82 | 22 | 233 |

Source: USACE, NDC compiled from detailed records. The Fairplay/Lloyd's Register of Ships was used to obtain the vessel DWT and associated characteristics.

[a]Obtained from the USACE, detailed records, totals may differ from IWR-NDC publication. The presentation only includes records that showed loaded draft and for which design drafts could be found.

**Table 3-16**
**Crude Petroleum Imports by Loaded Draft**
**Number of Vessels and Short Tons**

| Number of Vessels by Loaded Draft Increment | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Year** | **≤30 feet** | **31–35 feet** | **36–38 feet** | **39 feet** | **40 feet** | **≥41 feet** | **Total** |
| 2005 | 9 | 21 | 51 | 39 | 111 | 48 | 279 |
| 2006 | 5 | 26 | 41 | 36 | 77 | 87 | 272 |
| 2007 | 7 | 29 | 48 | 23 | 22 | 104 | 233 |
| **% of Vessels by Loaded Draft Increment** | | | | | | | |
| 2005 | 3.2 | 7.5 | 18.3 | 14.0 | 39.8 | 17.2 | 100 |
| 2006 | 1.8 | 9.6 | 15.1 | 13.2 | 28.3 | 32.0 | 100 |
| 2007 | 3.0 | 12.4 | 20.6 | 9.9 | 9.4 | 44.6 | 100 |
| **1,000s of Crude Petroleum Import Short Tons by Loaded Draft Increment** | | | | | | | |
| 2005 | 539 | 1,492 | 3,585 | 2,830 | 8,430 | 4,084 | 20,960 |
| 2006 | 235 | 1,430 | 2,857 | 2,795 | 5,716 | 6,894 | 19,927 |
| 2007 | 334 | 1,562 | 3,356 | 1,750 | 1,612 | 8,991 | 17,605 |
| **% of Tons by Loaded Draft Increment** | | | | | | | |
| 2005 | 2.6 | 7.1 | 17.1 | 13.5 | 40.2 | 19.5 | 100 |
| 2006 | 1.2 | 7.2 | 14.3 | 14.0 | 28.7 | 34.6 | 100 |
| 2007 | 1.9 | 8.9 | 19.1 | 9.9 | 9.2 | 51.1 | 100 |

Source: USACE, NDC compiled from detailed records.

[a]Obtained from the USACE, detailed records, totals may differ from IWR-NDC publication. The presentation only includes records that showed loaded draft.

### 3.2.1.1 Crude Petroleum Modes of Shipment

The modes of shipping crude include direct, lightered, lightened, and transshipped. Direct shipment is the transfer of tonnage by vessel between two coastal ports. Lightering is defined as the process involving ship-to-ship transfer of oil cargo. Lightening describes the process where enough cargo is offloaded from a tanker to permit the light-loaded vessel to enter a confined channel system. Transshipments store crude at a terminal and then ship direct from there to ports such as Freeport.

U.S. Gulf Coast lightering occurs in the international waters of the Gulf of Mexico and involves the transfer of tonnage from a larger vessel, called a VLCC (Very Large Crude Carrier), onto one or more shuttle vessels. With lightering, the VLCC does not enter the coastal receiving port. Figure 3-3 shows the U.S. Gulf offshore lightering zones.

Lightering is extremely cost effective for long-haul freight. Tankers larger than 175,000 DWT are normally totally lightered offshore onto shuttles. For Freeport's existing project depth of 45 feet, four shuttles are needed to completely offload a 325,000 DWT VLCC, with 325,000 DWT

being a representative VLCC size. The use of four shuttles is routine and optimal as it allows for the least number of shuttles based on a 45-foot channel depth.

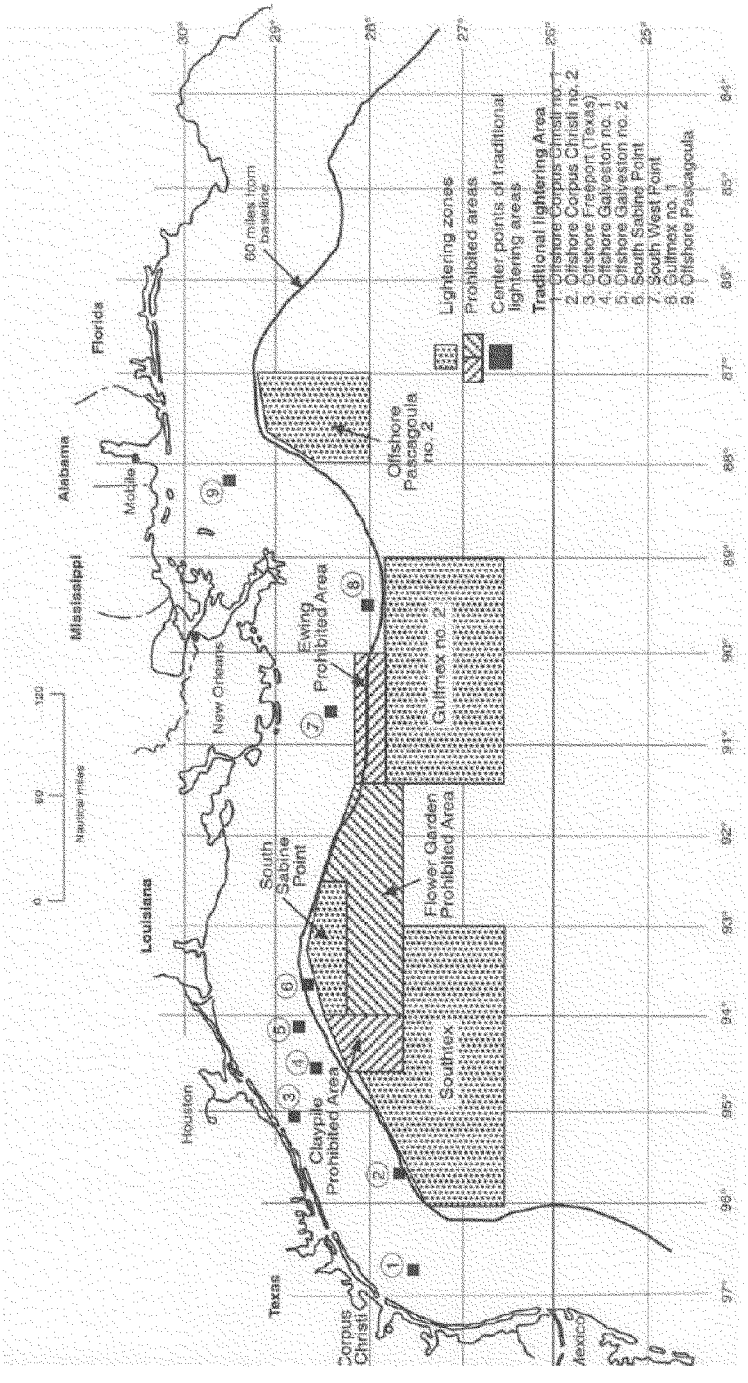
A frequent alternative to either direct shipment or lightering is lightening. The tanker sizes associated with lightening on the Texas Coast generally range from 120,000 to 175,000 DWT. Tankers larger than 175,000 DWT are normally lightered. There is a gap in the world tanker fleet between 175,000 and 250,000 DWT. The reason for the gap is that it is not cost effective to use tankers significantly larger than 175,000 DWT for direct shipment even for channel depths of 55 to 60 feet, and it is not cost effective to use vessels smaller than 250,000 DWT for lightering.

The transportation costs prepared for this report are based on optimal shuttle sizes and turnaround times. It was found that the efficiencies of offshore transfers are great and have increased in the last 10 to 15 years, and therefore the assumption of optimal efficiencies is reasonable. Offshore off-loading rates are less than dockside rates. The maximum cargo capacity for a 325,000 DWT vessel is approximately 347,400 short tons. Information obtained from industry discussion indicates that the set-up time and finishing time would add a few hours. Shuttle vessels are loaded one at a time and sequencing of shuttle vessel arrivals and departures is subject to variances.

Transshipping is the fourth mode of shipment. Crude oil is also transshipped through deepwater ports in the Caribbean. Crude is transported on VLCCs to the transshipped sites and later transferred to 90,000 to 114,000 DWT range shuttle tankers for shipment to Freeport. Some of the tonnage included in the Central and South America routing is transshipped through the Bahamas. Based on similar mileage and vessel sizes, the cost analysis for tonnage transshipped through the Bahamas was evaluated similarly to direct shipments from ports in Venezuela and Colombia.

The primary sized vessel used on the Mexico/Eastern South America route for direct shipments into Freeport is 90,000 to 114,000 DWT. Western South American shipments are either transported through the Panama Canal or the Trans-Panama Pipeline. The 81-mile pipeline runs from Panama near the Costa Rican border and the port of Charco Azul on the Pacific Coast to the port of Chiriquí Grande, Panama, on the Caribbean Sea. The pipeline opened in 1982 as an alternative to carry crude oil from the Pacific to the Atlantic. Between 1982 and 1996, it transported approximately 2.7 billion barrels of Alaskan oil to the U.S. Gulf Coast ports. After declining Alaskan oil shipments, the pipeline was closed in 1996. In November 2003, it was reopened for transportation of Ecuadorian crude oil to U.S. Gulf ports. Less than 1 percent of Freeport's 2004 to 2006 crude oil imports originated in Ecuador and was transported in relatively small tankers. Nearly 50 percent of crude oil imports originated in Venezuela and approximately 30 percent was from West and North Africa and the Middle East. Table 3-17 presents Freeport's 2000 to 2009 crude petroleum imports by major trade route. The USACE NDC records only

**Figure 3-3**
**U.S. Gulf Coast Crude Petroleum Lightering Zones**




Source: Skaugen PetroTrans.

vessels that come into U.S. ports, such as Freeport, and do not include records of vessels that offload at the lightering zone.

In May 2008, British Petroleum (BP) signed an agreement with Petroterminal de Panama S.A. to modernize the pipeline and reverse shipments to transport BP's Angolan and other crude oil to the U.S. West Coast refineries. Future Ecuadoran movements are expected to use the Panama Canal.

**Table 3-17**
**Freeport Crude Petroleum Imports by Region or Country of Origin**
**2000–2009**

| Region of Origin | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1,000s of short tons | | | | | | | | | | |
| Canada | - | - | - | - | - | - | - | - | 270 | 56 |
| Mexico and Guatemala | 1,068 | 328 | 324 | 1,829 | 288 | 800 | 428 | 748 | 1,071 | 1,368 |
| Venezuela and Colombia | 5,120 | 11,932 | 10,938 | 6,197 | 8,776 | 12,676 | 11,390 | 9,143 | 9,096 | 6,177 |
| Brazil and Argentina | - | - | - | - | - | 823 | 834 | 713 | 514 | 2,116 |
| W. South America | - | - | - | - | - | 204 | 115 | 92 | - | 754 |
| Europe, N. Africa, and Mediterranean[a] | 4,642 | 2,085 | 2,540 | 3,380 | 3,241 | 1,916 | 2,990 | 1,682 | 3,357 | 3,887 |
| West Africa | 4,760 | 2,606 | 2,342 | 3,400 | 3,158 | 4,625 | 2,756 | 3,190 | 3,430 | 3,674 |
| Mideast | 4,180 | 2,356 | 1,875 | 4,865 | 5,138 | 957 | 3,193 | 2,956 | 2,869 | 1,089 |
| Pacific/Far East | - | - | - | - | - | - | - | - | - | 296 |
| Total | 19,770 | 19,307 | 18,019 | 19,672 | 20,602 | 22,000 | 21,706 | 18,523 | 20,337 | 19,362 |
| Percentages | | | | | | | | | | |
| Canada | - | - | - | - | - | - | - | - | 1.3 | 0.3 |
| Mexico and Guatemala | 5 | 2 | 2 | 9 | 1 | 3.6 | 2.0 | 4.0 | 5.2 | 7.0 |
| Venezuela and Colombia | 26 | 62 | 61 | 32 | 43 | 57.6 | 52.5 | 49.4 | 44.1 | 31.8 |
| Brazil and Argentina | - | - | - | - | - | 3.7 | 3.8 | 3.8 | 2.5 | 10.9 |
| W. South America | – | – | – | – | – | 0.9 | 0.5 | 0.5 | 0.0 | 3.9 |
| Europe, N. Africa, and Mediterranean[a] | 23 | 11 | 14 | 17 | 16 | 8.7 | 13.8 | 9.1 | 16.3 | 20.0 |
| West Africa | 24 | 13 | 13 | 17 | 15 | 21.0 | 12.7 | 17.2 | 16.6 | 18.9 |
| Mideast | 21 | 12 | 10 | 25 | 25 | 4.4 | 14.7 | 16.0 | 13.9 | 5.6 |
| Pacific/Far East | 0 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 |
| Total | 100 | 100 | 100 | 100 | 100 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: USACE, NDC detailed files and DOE.

[a] The majority of this tonnage is lightered or lightened. The tonnage total shown includes shuttle vessels and lightened mother vessels

Table 3-18 displays distribution of vessel sizes used for Central and South America routes. While the distributions show limited current utilization of vessels over 140,000 DWT for the Central and South America routes, vessels over 140,000 DWT are generally restricted from using Freeport due to its length and beam restrictions. The distribution of Central and South America tonnage by vessel size shows larger vessel sizes are employed in recent years in comparison to earlier periods.

**Table 3-18**
**Distribution of Freeport Crude Petroleum Imports for Central and South America Routes by Vessel Class (2004–2006)**
**1,000s of Short Tons and Percentages[a]**

| Country of Embarkment | <50,000 | 60,000–79,999 | 70,000–79,999 | 80,000–89,999 | 90,000–99,999 | 100,000–119,999 | >140,000 | Grand Total |
|---|---|---|---|---|---|---|---|---|
| Bahamas | – | – | – | 91.1 | 81.9 | 81.7 | – | 254.8 |
| Colombia | – | 200.2 | – | 236.2 | 334.0 | 233.7 | – | 1,004.1 |
| Ecuador | – | 113.7 | – | – | – | – | – | 113.7 |
| Mexico | – | – | – | – | 88.7 | 86.0 | – | 174.7 |
| Panama | – | 57.0 | – | 83.2 | – | 83.0 | – | 223.2 |
| Venezuela | – | 300.9 | – | 251.2 | 4,510.7 | 3,155.1 | – | 8,217.8 |
| Annual Total 2004 | – | 671.8 | – | 661.8 | 5,015.2 | 3,639.5 | – | 9,988.3 |
| **2004 Distribution (%)** | – | 6.7 | – | 6.6 | 50.2 | 36.5 | – | 100 |
| Bahamas | 44.4 | – | – | 77.3 | 78.1 | 245.4 | – | 445.3 |
| Brazil | – | – | 74.9 | – | 77.3 | 219.2 | – | 371.4 |
| Colombia | – | – | 79.4 | – | 81.5 | 1,175.4 | – | 1,336.2 |
| Ecuador | – | 232.6 | – | – | – | – | – | 232.6 |
| Mexico | – | 114.1 | 115.9 | – | 235.8 | 110.2 | – | 576.1 |
| Venezuela | – | 126.4 | 177.5 | 78.2 | 3,663.1 | 5,560.4 | – | 9,605.7 |
| Annual Total 2005 | 44.4 | 473.2 | 447.7 | 155.5 | 4,135.8 | 7,310.6 | – | 12,567.1 |
| **2005 Distribution (%)** | 0.3 | 3.8 | 3.6 | 1.2 | 32.9 | 58.2 | – | 100 |
| Bahamas | – | 88.1 | – | – | 165.8 | 398.1 | – | 652.0 |
| Brazil | – | 78.7 | – | – | 74.2 | 235.5 | 77.8 | 466.3 |
| Canada | – | – | – | – | – | – | 69.1 | 69.1 |
| Colombia | – | 37.1 | – | – | 163.5 | 44.7 | – | 945.3 |
| Ecuador | 58.5 | – | – | – | 52.9 | – | – | 111.4 |
| Mexico | 55.0 | 137.6 | – | – | 64.3 | 55.9 | – | 312.8 |
| Venezuela | – | 723.2 | – | – | 3,509.2 | 5,474.7 | – | 9,707.1 |
| Annual Total 2006 | 113.5 | 1,064.8 | – | – | 4,029.9 | 6,908.8 | 146.9 | 12,263.9 |
| **2006 Distribution (%)** | 0.9 | 8.7 | – | – | 32.9 | 56.3 | 1.2 | 100 |

Source: USACE, NDC detailed files.

[a]Note: Totals may not add due to rounding.

Africa, Mediterranean, and Europe movements are lightened, lightered, or shipped direct. Shipments from Africa, the Mediterranean, and Europe are usually transported in tankers between 90,000 and 175,000 DWT, with direct shipments generally using tankers between 90,000 and 120,000 DWT. Facilities to accommodate VLCCs recently became available at Africa ports.

Table 3-19 presents the distribution of tonnage by loaded draft, trade route, and general method of shipment. The data show that direct shipments are loaded to greater drafts than vessels associated with lightering and lightening. The longer travel distances associated with direct shipments provide cost incentives to load vessels more fully.

**Table 3-19**
**Freeport Crude Petroleum Imports**
**Estimated Distribution of Imports by**
**Loaded Draft, Trade Route, and Method of Shipment (Percent)**

| Loaded Draft (feet) | Primarily Direct Shipment Routes | | | | Primarily Lightened Tonnage Routes[b] | | | Lightering | Total |
|---|---|---|---|---|---|---|---|---|---|
| | Mexico | Central and South America | Venezuela[a] | Western South America | North Sea and Europe | Western Africa | Africa & Europe Shuttle Vessels | Middle East Shuttle Vessels | |
| **2003** | | | | | | | | | |
| ≤35 | 8.4 | 13.5 | – | – | 21.2 | 100 | 17.5 | 54.8 | 12.4 |
| 36–39 | 56.3 | 32.9 | 5.5 | 100 | – | – | 75.8 | 45.2 | 49.6 |
| 40–42 | 35.2 | 53.7 | 94.5 | – | 78.8 | – | 6.7 | – | 38.0 |
| **2004** | | | | | | | | | |
| ≤35 | – | – | 3.6 | 51.3 | 34.0 | 45.7 | 6.7 | 5.5 | 11.4 |
| 36–39 | – | 76.6 | 12.3 | 48.7 | 53.8 | 47.2 | 86.2 | 82.7 | 47.0 |
| 40–42 | 100 | 23.4 | 84.1 | – | 12.2 | 7.1 | 7.1 | 11.8 | 41.5 |
| **2005** | | | | | | | | | |
| ≤35 | – | 10.0 | 5.2 | – | 26.8 | 20.3 | 8.2 | – | 9.6 |
| 36–39 | 40.8 | 49.9 | 5.2 | 74.9 | 43.0 | 49.8 | 56.3 | 73.1 | 31.6 |
| 40–42 | 59.2 | 40.1 | 89.5 | 25.1 | 30.2 | 29.9 | 35.5 | 26.9 | 58.8 |

[a]97 percent of Freeport's Venezuelan crude oil imports are from the deepwater port of La Cruz. There are depth limitations at other Venezuela ports.

[b]Includes shuttle vessels

In addition to transportation cost incentives, vessel selection is also related to the way crude petroleum is currently sold and how crude oil is shipped. Parcels are generally sold in 500,000 to 650,000 barrels. A 500,000 to 650,000 barrel parcel converts to approximately 75,000 to 95,000 short tons. Many vessels arrive in the international waters of the Gulf of Mexico with double parcels. Cost analyses show that the most economical sized vessel for single parcels is between 75,000 and 100,000 DWT given the existing channel depth of 45 feet. For double parcels, the most efficient size is between 150,000 and 175,000 DWT.

Gulf Coast industry personnel indicated that parcel size and associated ship size are primarily a function of the existing channel dimensions. The indication suggests that an increase in channel dimensions would likely result in a shift to larger parcel sizes and larger vessels. Comparison of the parcel sizes associated with Freeport's 1993 and 2007 crude oil imports revealed that the distribution of tonnage by parcel size increased. Data for 1993 were chosen to represent conditions when the 45-foot channel was dredged. Transition to more fully loaded, or larger, vessels is generally expected to have some lag time. Comparison of Freeport's current crude oil import parcel sizes for 1993 and 2007 indicate reductions in the volumes discharged offshore. The data comparison also serves to illustrate that larger parcels are being shipped today and suggests that the channel deepening from 40 to 45 feet facilitated this transition. Table 3-20 displays percentage distributions of Freeport's 1993 and 2007 imports by parcel size.

**Table 3-20**
**Freeport Percentage of Crude Oil Imports by Vessel Parcel Size**
**1993 and 2007**

| Vessel Parcel (short tons) | % of Imports by Parcel Size | |
|---|---|---|
| | 1993 | 2007 |
| ≤60,000 | 32 | 11 |
| 60,000–70,000 | 13 | 6 |
| 70,000–80,000 | 44 | 18 |
| 80,000–85,000 | 5 | 11 |
| 85,000–95,000 | 7 | 54 |
| Grand Total | 100 | 100 |

Source: USACE, NDC compiled from detailed records.

Table 3-21 and Table 3-22 present Freeport's 1993 and 2007 crude oil import distributions by parcel and vessel DWT range. The data show that the larger parcels are being carried by the larger DWT classes. This transition suggests more cost effective use of vessels. In addition, recent data show the use of some smaller shuttles to accommodate smaller volumes discharged during lightening operations.

**Table 3-21**
**Distribution of Freeport 1993 Crude Oil Imports by Parcel Size and Estimated DWT (Percent)**

| Parcel Size 1,000 | Vessel DWT | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | <50,000 | 60,000–75,000 | 75,000–89,000 | 90,000–99,999 | 115,000–139,999 | 140,000–159,000 | |
| ≤60 | – | 100 | 10 | 53 | – | – | 32 |
| 60–70 | – | – | 26 | 3 | 16 | – | 13 |
| 70–80 | – | – | 60 | 25 | 71 | – | 44 |
| 80–85 | – | – | 3 | 6 | 7 | – | 5 |
| 85–95 | – | – | – | 14 | 7 | – | 6 |
| Total | – | 100 | 100 | 100 | 100 | – | 100 |

Source: USACE, NDC compiled from detailed records

**Table 3-22**
**Distribution of Freeport 2007 Crude Oil Imports by Parcel Size and Estimated DWT (Percent)**

| Parcel Size 1,000 | Vessel DWT | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | <50,000 | 60,000–75,000 | 75,000–89,000 | 90,000–99,999 | 115,000–139,999 | 140,000–159,000 | |
| ≤60 | 100 | 78 | 63 | 6 | 7 | 15 | 11 |
| 60–70 | – | 22 | 17 | 4 | 7 | – | 6 |
| 70–80 | – | – | 19 | 12 | 21 | 30 | 18 |
| 80–85 | – | – | – | 6 | 14 | 26 | 11 |
| 85–95 | – | – | – | 71 | 51 | 29 | 54 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Source: USACE, NDC compiled from detailed records

### 3.2.2 Petroleum Product Vessels

Since the 45-foot depth became available in the mid-1990s, there has been a transition to larger and more fully loaded vessels for some petroleum product tonnage, including partially refined oils. Partially refined oils are transported in crude petroleum tankers. The geographic origins generally include Algeria (47 percent) and Saudi Arabia (27 percent). Other origins include Southern Europe, the Mediterranean, and Ecuador. Vessel sizes and trade route data indicate potential opportunities to load to increased drafts based on trend data through 2005. Data for 2006 to 2009 show a drop in partially refined products imports and the associated use of relatively larger vessels.

Table 3-23 presents Freeport's 1990, 1993, and 2002 to 2009 petroleum product imports by loaded draft, and also includes total imports and maximum vessel loaded and design draft by year. The 2002 to 2009 records reveal an average of 32 percent of imports transported in vessels with loaded drafts over 40 feet.

**Table 3-23**
**Freeport Petroleum Product Imports**
**by Loaded Draft (1990, 1993, and 2002–2009)**

| | % of Petroleum Product Imports by Loaded Draft and Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Loaded Draft (feet)** | **1990** | **1993** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
| <30 | 85 | 100 | 20 | 5 | 4 | 5 | 11 | 9 | 5 | 0 |
| 30–35 | 15 | 0 | 16 | 23 | 28 | 24 | 24 | 40 | 48 | 16 |
| 36–39 | 0 | 0 | 17 | 9 | 20 | 24 | 33 | 31 | 31 | 84 |
| ≥40 | 0 | 0 | 48 | 63 | 49 | 46 | 32 | 20 | 17 | 0 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | | | | | | | | | | |
| Total Imports (1,000s of short tons) | 17 | 18 | 736 | 1,857 | 2,873 | 1,779 | 1,080 | 1,046 | 955 | 220 |
| % of Petroleum Product Imports Transported in Vessels With Loaded Drafts ≥40 feet and Year | 0 | 0 | 48 | 63 | 49 | 46 | 32 | 20 | 17 | 0 |
| Maximum Design Draft (feet) | 33 | 28 | 49 | 53 | 56 | 53 | 49 | 54 | 54 | 49 |

Source: USACE, NDC detailed files.

Table 3-24 shows the distribution of Freeport's 1990, 1993, and 2002 to 2009 petroleum product exports. Vessels associated with petroleum product exports have maximum loaded drafts of 38 feet. The vessel sizes and trade route data indicate limited opportunities to load to increased drafts for the export market.

Table 3-25 shows world petroleum product fleet data compiled from the Lloyd's/Fairplay Vessel Register and includes the percentage of vessel DWT delivered between 2005 and 2009.

**Table 3-24**
**Freeport Petroleum Product Exports**
**by Loaded Draft (1990, 1993, and 2002–2009)**

| Loaded Draft (feet) | % of Petroleum Product Exports by Loaded Draft and Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 1993 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| <30 | 85 | 63 | 94 | 82 | 85 | 83 | 83 | 83 | 42 | 56 |
| 30–35 | 11 | 38 | 5 | 18 | 14 | 17 | 17 | 17 | 53 | 36 |
| 36–39 | 4 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 5 | 8 |
| ≥40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | | | | | | | | | | |
| Total Exports (1,000s of short tons) | 26 | 25 | 119 | 87 | 91 | 91 | 109 | 89 | 81 | 126 |
| % of Petroleum Product Exports Transported in Vessels With Design Drafts ≥40 feet and Year | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum Design Draft (feet) | 36 | 35 | 37 | 34 | 35 | 36 | 35 | 35 | 38 | 38 |

Source: USACE, NDC detailed files.

**Table 3-25**
**Petroleum Product Fleet**

| Design Draft (feet) | Median DWT | Percentage of Total DWT | |
|---|---|---|---|
| | | Built 1985–2004 | On Order as of Jan 2009 |
| <36 | 13,000 | 13 | 4 |
| 36–38 | 38,500 | 14 | 2 |
| 39–40 | 46,000 | 23 | 13 |
| 41–42 | 47,000 | 26 | 12 |
| 43–44 | 68,000 | 5 | 12 |
| 45–46 | 85,000 | 7 | 0 |
| 47–49 | 99,900 | 9 | 45 |
| 50–51 | 110,000 | 2 | 12 |
| | Total | 100 | 100 |

Source: Lloyd's Vessel Register, 2009.

[a]Excludes crude oil and chemical tankers.

### 3.2.3 Chemical Product Carriers

Larger chemical carriers are using Freeport more than in the 1990s. Detailed examination of data for 1990, 1993, and 2002 to 2005 revealed that beginning in 2002 some chemical exports were transported in vessels loaded to 40 feet or more[6]. The destination ports for these shipments include Brazil, Eastern Canada, and the Far East.

Table 3-26 shows an average of 7 percent of 2003 to 2009 tonnage was transported in vessels with loaded drafts of 40 feet or more. The 2003 shipments were divided between Brazil, Eastern Canada, and the Far East. The 2004 shipments were exported to China. In 2005, the larger shipments were exported to Brazil. Approximately 22 percent of exports were shipped to locations for which the Panama Canal provides the shortest travel distance. Nearly 95 percent of this tonnage consisted of chemicals. The destinations of shipments through the Panama Canal included South Korea (36 percent), Japan (19 percent), China (16 percent), Australia and New Zealand (15 percent), Singapore (11 percent), Indonesia (2 percent), and Western South America (1 percent). For the period 2007 to 2009, 41 percent of vessels with loaded drafts of 40 feet or more exported chemicals to Brazil, 32 percent to Asia, 18 percent to Northern Europe, and 9 percent to Eastern Canada.

**Table 3-26**
**Freeport Chemical Product Exports**
**by Loaded Draft (1990, 1993, and 2002 to 2009)**

| | % of Chemical Product Exports by Loaded Draft and Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Loaded Draft (feet)** | **1990** | **1993** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
| <30 | 46 | 53 | 42 | 39 | 31 | 31 | 39 | 35 | 35 | 39 |
| 30–35 | 35 | 43 | 39 | 43 | 44 | 44 | 31 | 50 | 41 | 30 |
| 36–39 | 19 | 4 | 17 | 13 | 15 | 18 | 19 | 10 | 17 | 24 |
| ≥40 | 0 | 0 | 2 | 5 | 10 | 7 | 11 | 5 | 7 | 7 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Total Exports (1,000s of short tons) | 1,093 | 871 | 1,957 | 2,104 | 2,622 | 2,509 | 2,551 | 2,690 | 2,403 | 1,863 |
| % Chemical Product Exports Transported in Vessels With Loaded Drafts ≥40 feet and Year | 0 | 0 | 0 | 5 | 8 | 7 | 11 | 5 | 7 | 7 |
| Maximum Design Draft (feet) | 37 | 39 | 43 | 44 | 43 | 40 | 42 | 42 | 43 | 43 |

Source: USACE, NDC detailed files.

[6] Continuous detailed data for years prior to 2001 are not readily available.

Freeport's largest shipments and more deeply loaded vessels carried sodium hydroxide (commonly referred to as caustic soda). Caustic soda is used in the manufacture of pulp and paper, alumina, soap and detergents, petroleum products, and chemical production. The production of alumina from bauxite is a major end-use application for caustic soda. Caustic soda composes 30 percent of Freeport's 2003 to 2005 chemical exports and approximately 50 percent of 2006 to 2007 exports.

Table 3-27 shows the destination for Freeport's 2003 to 2007 chemical product exports transported in vessels with loaded drafts of 40 feet or more. Data for 2008 to 2009 is not presented; however, 51 percent of 2009 exports for deeply loaded vessels were destined for China, 38 percent for Brazil, and the remaining 11 percent for Northern Europe.

Table 3-28 shows world chemical fleet data as compiled from the Lloyd's/Fairplay Vessel Register. The table shows that 21.7 percent of the chemical tanker DWT delivered through the end of 2009 have design drafts of 43 feet or more and 1.8 percent have design drafts of 47 feet or more.

Existing chemical carrier fleet data show the youngest fleet sector includes a large number of vessels between 30,000 and 49,999 DWT. This portion of the fleet represents over 50 percent of the total fleet. Tables 3-29 to 3-31 present data associated with the existing fleet and with vessels on order. The new vessel order data show a large increase in the number of vessels between 50,000 and 59,999 DWT.

**Table 3-27**
**Freeport Chemical Product Exports by Destination (2003–2007)**
**for Vessels with Loaded Drafts Over 40 Feet (Percent)**

| Destination | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| Antwerp, Belgium | | | 0.1 | 2.5 | |
| Belem, Brazil | 24.0 | 56.8 | 27.2 | 34.0 | 34.2 |
| Bombay, India | | | 3.1 | | |
| Buenos Aires, Argentina | | | | | 0.7 |
| Durban, South Africa | | | 0.5 | | |
| Itaqui, Brazil | 12.0 | 39.6 | | 10.0 | |
| Jebel Ali, United Arab Emirates | | | 0.3 | | |
| Jiangyin, China (Mainland) | | | 1.3 | | |
| Kao Hsiung, China (Taiwan) | | | 1.5 | 0.9 | 5.9 |
| Kobe, Japan | | | 0.6 | | |
| Merak, Indonesia | | | 5.5 | | |
| Ning Bo, China (Mainland) | | | 9.3 | 1.8 | |
| Port Alfred, Quebec | 37.7 | | | 7.3 | 18.7 |
| Rotterdam, Netherlands | | 2.2 | 0.7 | 3.0 | |
| Sao Paulo, Brazil | 16.1 | | 8.5 | | 1.5 |
| Shanghai | | | | | 0.2 |
| Singapore | | | 11.3 | 6.9 | 5.6 |
| Tai Chung | | | 0.9 | 0.4 | |
| Terneuzen, Netherlands | | 1.4 | 5.2 | 11.9 | |
| Three Rivers, Quebec | | | | 1.4 | 5.5 |
| Yokohama, Japan | | | 0.7 | | |
| All Other Canada Atlantic Region Ports | 10.2 | | | 4.2 | 2.6 |
| All Other China (Taiwan) Ports | | | 0.7 | | |
| All Other Japan Ports | | | 2.1 | 2.7 | 1.3 |
| All Other Peoples Republic of China Ports | | | 6.3 | 1.4 | 8.5 |
| All Other South Korea Ports | | | 14.2 | 11.6 | 15.3 |
| Total | 100 | 100 | 100 | 100 | 100 |
| Number of Unique Outbound Vessels | 6 | 8 | 10 | 17 | 9 |

Source: USACE, NDC detailed files.

**Table 3-28**
**Chemical Product Fleet**

| Design Draft (feet) | Median DWT | Percentage of Total DWT | |
|---|---|---|---|
| | | Built 1985–2004 | On Order as of January 2009 |
| <36 | 13,000 | 36 | 34 |
| 36–38 | 38,500 | 24 | 19 |
| 39–40 | 46,000 | 24 | 18 |
| 41–42 | 47,000 | 7 | 6 |
| 43–44 | 50,000 | 4 | 22 |
| 45–46 | 85,000 | 1 | 0 |
| 47–49 | 95,000 | 5 | 2 |
| 50–51 | n/a | – | – |
| | Total | 100 | 100 |

Source: Lloyd's Vessel Register, 2009.

**Table 3-29**
**World Chemical Product Fleet, Vessels Built Between 1985–2004**

| DWT Range | Total DWT | % of DWT | Median Vessel Characteristics | | | | Year Built | No. of Vessels |
|---|---|---|---|---|---|---|---|---|
| | | | DWT | LOA | Beam | Design Draft | | |
| <10,000 | 2,793,389 | 9.9 | 5,780 | 338 | 54 | 21 | 1997 | 505 |
| 10,000 to 20,000 | 3,479,986 | 12.4 | 14,364 | 454 | 71 | 29 | 1999 | 236 |
| 20,000 to 30,000 | 1,593,037 | 5.7 | 25,415 | 557 | 84 | 34 | 1998 | 61 |
| 30,000 to 39,999 | 6,544,848 | 23.3 | 37,068 | 599 | 91 | 36 | 2001 | 182 |
| 40,000 to 49,999 | 11,246,740 | 4.0 | 45,632 | 599 | 106 | 40 | 2000 | 252 |
| 50,000 to 59,999 | 568,838 | 2.0 | 50,600 | 600 | 106 | 44 | 1987 | 11 |
| 60,000 to 69,999 | 129,976 | 0.5 | 64,988 | 750 | 106 | 43 | 2000 | 2 |
| 70,000 to 79,999 | 146,521 | 0.5 | 73,261 | 749 | 106 | 47 | 1996 | 2 |
| 80,000 to 102,000 | 1,620,338 | 5.8 | 83,987 | 750 | 106 | 53 | 1988 | 19 |
| Total | 28,123,673 | 100 | | | | Number of Vessels | | 1,270 |

Source: Lloyd's Vessel Register, 2006.

**Table 3-30**
**World Chemical Product Vessels Deliveries Between 2005-2009**

| DWT Range | Total DWT | % of DWT | Median Vessel Characteristics | | | | Year Built | No. of Vessels |
|---|---|---|---|---|---|---|---|---|
| | | | DWT | LOA | Beam | Design Draft | | |
| <10,000 | 4,145,481 | 9.1% | 5,738 | 344 | 54 | 21 | 2008 | 741 |
| 10,000 to 20,000 | 10,403,885 | 22.9% | 14,000 | 452 | 71 | 29 | 2008 | 693 |
| 20,000 to 30,000 | 1,543,504 | 3.4% | 25,197 | 528 | 86 | 32 | 2008 | 63 |
| 30,000 to 39,999 | 7,163,102 | 15.8% | 37,320 | 599 | 90 | 37 | 2007 | 195 |
| 40,000 to 49,999 | 12,378,645 | 27.2% | 46,196 | 600 | 106 | 40 | 2007 | 274 |
| 50,000 to 59,999 | 9,047,468 | 19.9% | 50,974 | 600 | 106 | 43 | 2008 | 177 |
| 60,000 to 69,999 | 0 | - | - | - | - | - | - | 0 |
| 70,000 to 79,999 | 589,654 | 1.3% | 73,715 | 750 | 106 | 48 | 2008 | 8 |
| 80,000 to 102,000 | 207,261 | 0.5% | 103,631 | 800 | 138 | 48 | 2007 | 2 |
| Total | 45,479,000 | | | | | Number of Vessels: | | 2,153 |

Source: Lloyd's Vessel Register, March 2010.

**Table 3-31**
**World Chemical Carrier Fleet Characteristics (2008)**

| Year Built | Total No. of Vessels by Year Built | % Vessels by Year Built | Total DWT | % of Total DWT | Average Vessel DWT | Average Vessel Design Draft (feet) | Mu DWT | Max DWT | Min Design Draft (feet) | Max Design Draft (feet) | Vessels With Design Drafts >40 feet | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | No. | Avg DWT |
| 1985 | 70 | 3.6 | 1,075,046 | 2.6 | 15,358 | 27 | 379 | 59,999 | 10 | 44 | 9 | 49,440 |
| 1986 | 53 | 2.7 | 1,220,903 | 3.0 | 23,036 | 30 | 801 | 83,930 | 10 | 53 | 4 | 66,757 |
| 1987 | 31 | 1.6 | 1,064,255 | 2.6 | 34,331 | 34 | 1,195 | 83,970 | 14 | 53 | 14 | 57,083 |
| 1988 | 28 | 1.5 | 839,283 | 2.0 | 29,974 | 32 | 750 | 84,040 | 11 | 53 | 7 | 71,649 |
| 1989 | 17 | 0.9 | 412,598 | 1.0 | 24,270 | 28 | 1,185 | 84,040 | 13 | 53 | 3 | 84,040 |
| 1990 | 23 | 1.2 | 665,743 | 1.6 | 28,945 | 31 | 1,003 | 84,040 | 13 | 53 | 4 | 83,943 |
| 1991 | 34 | 1.8 | 437,957 | 1.1 | 12,881 | 25 | 1,142 | 45,998 | 13 | 40 | 0 | – |
| 1992 | 53 | 2.7 | 551,335 | 1.3 | 10,403 | 24 | 774 | 41,327 | 12 | 40 | 0 | – |
| 1993 | 29 | 1.5 | 298,030 | 0.7 | 10,277 | 24 | 1,104 | 41,354 | 13 | 40 | 0 | – |
| 1994 | 32 | 1.7 | 256,823 | 0.6 | 8,026 | 21 | 260 | 40,024 | 8 | 37 | 0 | – |
| 1995 | 36 | 1.9 | 720,009 | 1.8 | 20,000 | 29 | 670 | 47,629 | 11 | 42 | 2 | 46,314 |
| 1996 | 73 | 3.8 | 1,564,261 | 3.8 | 21,428 | 29 | 868 | 46,170 | 10 | 40 | 0 | – |
| 1997 | 65 | 3.4 | 1,279,517 | 3.1 | 19,685 | 29 | 3,159 | 47,198 | 18 | 41 | 1 | 47,198 |
| 1998 | 99 | 5.1 | 1,827,742 | 4.5 | 18,462 | 28 | 2,772 | 47,431 | 14 | 42 | 1 | 47,198 |
| 1999 | 100 | 5.2 | 2,079,420 | 5.1 | 20,794 | 29 | 2,700 | 47,363 | 14 | 40 | 0 | – |
| 2000 | 79 | 4.1 | 1,740,968 | 4.2 | 22,038 | 29 | 1,100 | 65,017 | 12 | 43 | 6 | 53,456 |
| 2001 | 76 | 3.9 | 1,672,751 | 4.1 | 22,010 | 29 | 1,100 | 47,087 | 12 | 42 | 1 | 47,087 |
| 2002 | 99 | 5.1 | 2,507,161 | 6.1 | 25,325 | 31 | 2,391 | 47,465 | 14 | 42 | 3 | 47,119 |
| 2003 | 127 | 6.6 | 3,592,330 | 8.7 | 28,286 | 32 | 2,945 | 71,522 | 14 | 45 | 6 | 51,932 |
| 2004 | 146 | 7.6 | 4,317,541 | 10.5 | 29,572 | 32 | 1,198 | 101,970 | 11 | 49 | 6 | 66,892 |
| 2005 | 256 | 13.3 | 5,517,612 | 13.4 | 21,553 | 28 | 711 | 101,970 | 13 | 46 | 21 | 52,770 |
| 2006 | 6 | 0.3 | 16,626 | – | 2,771 | 17 | 935 | 4,999 | 13 | 21 | 0 | – |
| 2007 | 82 | 4.2 | 941,427 | 2.3 | 11,481 | 23 | 390 | 51,218 | 9 | 43 | 4 | 50,801 |
| 2008 | 317 | 16.4 | 6,456,069 | 15.7 | 20,366 | 28 | 1,000 | 73,711 | 12 | 48 | 35 | 52,653 |
| Grand Total | 1,931 | 100 | 41,055,407 | 100 | 21,261 | | | | | | 127 | 56,409 |

Source: Lloyd's Vessel Register, Compiled from 2004–2009 data extractions.

### 3.2.4 Bulk Carriers

Large bulk carriers are used in the import of Freeport's limestone and building materials. The specific type of bulk carriers used for limestone and building materials are "load-on/load-off," or "LoLo" vessels. The present fleet generally consists of 45,000 to 67,000 DWT vessels with design drafts between 40 feet and 44 feet and loaded drafts ranging from 35 feet to 39 feet. The median year of construction for the range of vessels used for this trade is 1985 and is older than the median of 1998 associated with the world fleet. Review of the distribution of vessels on order and channel depths at receiving ports indicates that some transition in the average DWT range from the existing 60,000 to 70,000 DWT into the 80,000 to 94,000 DWT range is reasonable to expect. A portion of future bulk traffic is anticipated to move to the Velasco Terminal dock. This move will allow for the use of larger and more fully loaded bulk carriers.

Rice is transported in general cargo vessels, and the size of these vessels has increased over the last decade. The largest general cargo vessels using the public terminal range from 40,000 to 46,000 DWT. The larger carriers are used for meat, sugar, cereal, and vegetable imports from Brazil and Europe. Also transported in general cargo vessels is wind-energy equipment. While more deeply loaded vessels are not anticipated for the turning basin reach, the port is expanding general and container cargo facilities just outside the turning basin reach due to capacity constraints within the basin and to accommodate larger container vessels for a wider range of commodities.

### 3.2.5 Container Vessels

Bananas and rice are transported through docks located within the Brazos Turning Basin. Bananas constitute a significant share of Freeport general cargo. Freeport imports 6 percent of U.S. banana imports. Average imports for 2003 to 2005 were 257 thousand short tons and remained relatively constant over the most recent 10-year period.

Bananas are transported in refrigerated container vessels, the majority of which are in the 13,000 to 16,000 DWT range. The median beam width of the refrigerated cargo vessels is 79 feet. Distribution of vessels on order shows no indication of a transition to larger refrigerated cargo vessels and shows the median beam width of the future is not expected to increase.

An annual volume of approximately 200,000 TEUs is expected during the first full year of operation with one to two vessels per day. A base of 200,000 TEUs represents 0.3 percent of the U.S. container throughput. A full build-out of 800,000 to 1,200,000 TEUs is planned with three construction phases.

Table 3-32 displays changes in the general cargo and container vessels using U.S. ports between 1999 and 2006 and indicates moderate rates of growth. The pace of transitions that occurred between 1999 and 2006 is expected to increase with the Panama Canal expansion. Larger Panamax and post-Panamax container vessels are presently using U.S. Gulf Coast ports. In 2006, 40 of Houston's container vessels were post-Panamax. These vessels, which have design drafts of 48 feet, transported approximately 8 percent of Houston's 2006 containerized imports and 10 percent of exports. Overall, foreign ports represented the first port of call for 45 percent of outbound containerships.[7]

**Table 3-32**
**U.S. Port Trends**
**Average Vessel Size Per Call**
**U.S. Total by Vessel Type**

| | General Cargo Vessels | Container Vessels | |
|---|---|---|---|
| Year | DWT | DWT | TEU |
| 1999 | 21,783 | 37,262 | 2,585 |
| 2000 | 22,357 | 38,534 | 2,695 |
| 2001 | 23,416 | 39,656 | 3,801 |
| 2002 | 23,496 | 42,158 | 3,020 |
| 2003 | 23,655 | 43,168 | 3,144 |
| 2004 | 24,542 | 43,610 | 3,234 |
| 2005 | 25,101 | 44,593 | 3,013 |
| 2006 | 25,446 | 46,598 | 3,445 |
| Percentage Change 1999–2006 | 16.8% | 25.1% | 33.3% |
| Average Annual Growth Rate | 2.2% | 3.2% | 4.2% |

Source: U.S. Department of Transportation, Maritime Administration, U.S. Calls at U.S. Ports Snapshot, 2005 and 2006 publications.

Houston's first domestic port-of-call shipments were from nearby locations such as Mexico (129 vessels), Guatemala (54 vessels), Colombia (43 vessels), Jamaica (15 vessels), Dominican Republic (7 vessels), the Bahamas (5 vessels), and Western Europe. Houston was the first port of call for shipments from Spain (35 vessels), France (25 vessels), and Italy (20 vessels). Houston's container terminals presently have depth constraints of 40 feet, and the maximum loaded draft is 39 feet. The channel depth at the container terminals at many of these ports exceeds 40 feet. Specifically, a channel depth increase from 41.9 to 49 feet is planned for the container terminal in Cartagena, Colombia, and an increase from 42 to 51 feet is planned in Kingston, Jamaica. Container terminal improvements in Santos, Brazil, from 42.3 feet to 52 feet are planned.[8] The

[7] The itineraries for inbound vessels were not available.

[8] Channel-depth information was obtained from Inter-American Committee on Ports, Organization of American States, presentation prepared by Carlos M. Gallegos, http://aapa.files.cms-plus.com

container terminal in Algeciras, Spain presently has a channel depth of 54 feet, and the Italian terminal of Galliari has a channel depth of 49 feet.

Containerships from 60,000 to 68,000 DWT are representative of mid-sized container vessels and use Houston on a regular basis. These vessels, which have design drafts up to 45 feet, are also representative of the upper end of Panamax containerships.

Table 3-33 presents U.S. regional containership vessel movements by loaded draft and illustrates a higher concentration of loaded drafts over 40 feet in 2006 than in previous years. Table 3-34 presents 2003 to 2006 trips by loaded draft. Figure 3-4 provides a general illustration of regional changes in loaded draft patterns for 2003 to 2006.

**Table 3-33**
**Total Container Vessel Trips by Loaded Draft (2006) for U.S. Ports**

| | Vessels by Loaded Draft (feet) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Region** | **≤30** | **31–35** | **36–40** | **41–44** | **45–49** | **≥50** | **Total** |
| California | 767 | 1,641 | 1,865 | 408 | 15 | 2 | 4,698 |
| Northwest | 254 | 594 | 390 | 105 | 3 | – | 1,346 |
| Northeast | 776 | 1,311 | 1,482 | 95 | 7 | – | 3,671 |
| Southeast | 2,813 | 2,854 | 2,009 | 107 | 13 | – | 7,796 |
| Gulf Coast | 621 | 615 | 102 | – | – | – | 1,338 |
| Houston | 343 | 423 | 54 | – | – | – | 820 |
| Freeport | 104 | – | – | – | – | – | 104 |
| Other | 602 | 149 | 43 | 1 | – | – | 795 |
| Total | 6,280 | 7,587 | 5,945 | 716 | 38 | 2 | 19,644 |

Source: USACE, NDC, Entrances and Clearance (public data), 2003–2006.

**Table 3-34**
**Total Containership Trips by Loaded Draft to U.S. Ports**
**2003–2006**

| Loaded Draft (feet) | Vessel Trips By Loaded Draft (feet) | | | |
|---|---|---|---|---|
| | 2003 | 2004 | 2005 | 2006 |
| ≤30 | 6,330 | 5,679 | 5,683 | 5,833 |
| 31–35 | 7,695 | 7,052 | 7,384 | 7,164 |
| 36–38 | 3,082 | 3,816 | 3,843 | 4,468 |
| 39 | 384 | 619 | 667 | 879 |
| 40 | 200 | 394 | 282 | 544 |
| 41 | 84 | 273 | 166 | 316 |
| 42 | 81 | 171 | 127 | 232 |
| 43 | 5 | 26 | 16 | 108 |
| 44 | 3 | 16 | 6 | 60 |
| 45 | 1 | 7 | 14 | 31 |
| 46 | 1 | 3 | 6 | 3 |
| 47 | 1 | 1 | – | 2 |
| 48 | – | 3 | 1 | 1 |
| 49 | – | – | – | 1 |
| 50 | – | – | 2 | – |
| >50 | – | – | 4 | 2 |
| Total Vessels | 17,867 | 18,060 | 18,201 | 19,644 |

Source: USACE, NDC, Entrances and Clearance (public data), 2003–2006.

**Figure 3-4**
**U.S. Total Containership Trips**
**Percentage of Trips by Loaded Draft (2003–2006)**

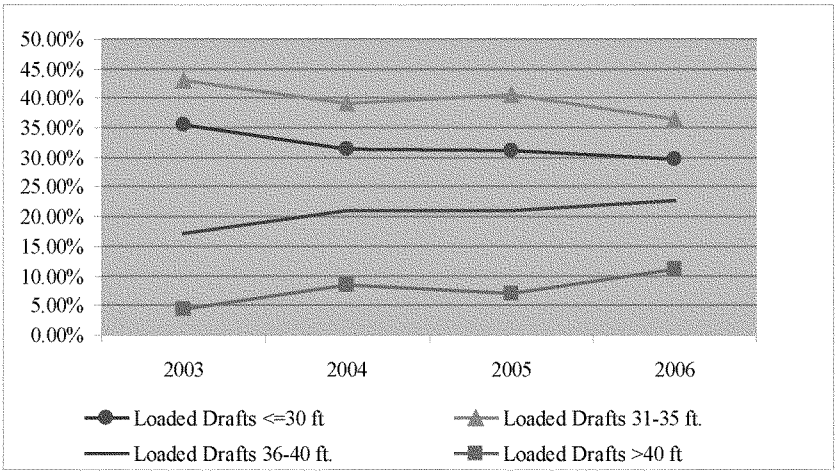



Table 3-35 displays 2006 Texas and U.S. container traffic by vessel DWT. The 2006 data illustrate a wide variance between the regional and the U.S. fleet distribution.

**Table 3-35**
**Containership Traffic by Vessel DWT**
**Houston and U.S. Data (2006)**

| Vessel DWT | Vessel TEU | % of Houston 2006 Short Tons by Vessel Size | Estimated % of Houston 2006 Containership Trips by Vessel Size | % of U.S. 2006 Containership Trips by Vessel Size |
|---|---|---|---|---|
| 22,900 | 1,400 | 11.4 | 24.7 | 66.2 |
| 33,900 | 2,300 | 18.1 | 11.3 | 22.7 |
| 45,400 | 3,400 | 37.3 | 19.9 | 4.5 |
| 55,600 | 4,000 | 24.0 | 8.8 | 2.8 |
| 62,949 | 4,800 | 2.1 | 15.8 | 0.9 |
| 67,652 | 5,000 | 5.1 | 12.6 | 0.2 |
| ≥80,596 | 6,500 | 2.0 | 4.4 | 2.8 |
| | Total | 100 | 100 | 100 |

Table 3-36 was prepared based on the distribution of loaded drafts for Houston 2006 container cargo.

**Table 3-36**
**Distribution of Regional Cargo Tonnage by Loaded Draft (feet)**

| Vessel DWT | Design Draft | Loaded Draft (feet) | | | Standard Deviation |
|---|---|---|---|---|---|
| | | Minimum | Median | Maximum | |
| 22,900 | 34 | 17 | 28 | 37 | 3.25 |
| 31,900 | 37 | 25 | 32 | 39 | 2.67 |
| 40,300 | 40 | 25 | 32 | 38 | 2.30 |
| 42,800 | 42 | 23 | 32 | 39 | 2.61 |
| 46,400 | 44 | 26 | 32 | 39 | 3.06 |
| 55,600 | 45 | 27 | 33 | 40 | 2.36 |
| 65,000 | 46 | 26 | 36 | 40 | 2.81 |
| >=80,700 | 47 | 32 | 35 | 39 | 1.86 |
| **Percentage of Tonnage by Loaded Draft and DWT Range** | | | | | |
| 22,900 | 34 | 1 | 97 | 2 | 100 |
| 31,900 | 37 | 13 | 72 | 15 | 100 |
| 40,300 | 40 | 12 | 86 | 2 | 100 |
| 42,800 | 42 | 19 | 77 | 3 | 100 |
| 46,400 | 44 | 12 | 66 | 21 | 100 |
| 55,600 | 45 | 10 | 81 | 8 | 100 |
| 65,000 | 46 | 3 | 63 | 34 | 100 |
| >=80,700 | 47 | 10 | 64 | 27 | 100 |

Source: USACE, NDC, 2006

### 3.2.6 Offshore Supply, Seismic, and Research Vessels

Navigation constraints arose after the channel was deauthorized in 1974. A channel that is not federally maintained presents a navigational hazard in the form of higher accident probabilities. Nonmaintained water depth also presents a financial hazard to the businesses located at the end of the channel. Maintaining alignment is difficult in the silted channel. Sufficient underkeel clearance is extremely important to vessels carrying expensive and highly technical equipment. The channel depth limitations can cause hull and propulsion damage.

In spite of limitations, the channel is still used as a Harbor of Refuge. However, the range of vessels that can be safely served is limited. For example, in 2008 during Hurricane Gustav evacuation, an offshore anchor tug attempted to enter the channel and struck a submerged object and grounded. Damages sustained to one of the vessel's cyclonical thrusters required the vessel to be towed back to its home base in Louisiana after the storm. Offshore anchor vessels typically have cyclonical thrusters that are not removable. The damaged vessel had a design draft of 24.6 feet and was in ballast when it grounded.

A result of reduced depth is a reduction in vessel activity. Vessels are routinely turned away. An inquiry made to the BRPA revealed that they do not keep lists of vessels that are turned away. Based on the lack of records of vessels turned away, a detailed investigation of anecdotal information and vessel types similar to those presently using the Stauffer was performed. For example, on 9 March 2009, a 24.6-foot-draft vessel requesting to come in for layberth was turned away due to insufficient channel depth. It was also found that the seismic vessel *Osprey* was turned away because of insufficient channel depth. The *Osprey Explorer* has a design draft of 19 feet. It was a challenge docking the *GSI Admiral*. Frequently, captains cannot agree to bring vessels in due to written rules.

Draft restrictions of just a few feet may result in unplanned delays necessitating reductions in ballast and/or in fuel. Vessels affected by draft restriction will unload fuel or ballast at docks at the lower end of the Freeport Channel before getting to the Upper Stauffer. Ballast and fuel adjustments are later made upon leaving. The time taken for ballast and fuel adjustments results in added operating time and docking charges. For instance in March 2011, the seismic vessel *Discoverer*, which has a design draft of 15.4 feet, was able to take on ballast water necessary for offshore hull balance, but it was not able to fully load fuel. The inability to fully load fuel meant the vessel had to make an additional stop down-channel for fuel.

All 2006 records for Freeport, Galveston, and Bayou Lafourche (Louisiana) were obtained from Lloyd's Vessel Register records. The USCG and the USACE's Transportation Lines of the U.S. vessel databases were used to obtain vessel characteristics for some of the vessels not found in Lloyd's/Fairplay. The loaded drafts and general vessel size data, as indicated by net registered

tons and gross tons, included in the USACE's Entrance and Clearance file were initially used to help isolate OSVs.

The largest vessels using the channel are approximately 400 feet long. Longer vessels cannot be turned and have to be backed into the channel. Crew and supply vessels have a draft range of 15 to 18 feet. Supply vessels, which made 6 to 7 trips per week, have a draft range of 20 to 30 feet. These vessels fall under the general classification of OSVs.

Associated vessel characteristics were extracted from the Lloyd's vessel databases and matched to the NDC records in determining vessel type. The vessel databases were particularly important in identifying vessel types such as OSV, research vessel, seismic vessel, and crew boat.

A BRPA pilot is required for all foreign flag vessels regardless of size. A pilot is also required for any U.S. flag vessel coming from a foreign port. U.S. vessels coming from the international waters of the Gulf of Mexico do not require pilotage.

Table 3-37 displays a vessel list compiled from photo files provided by Freeport Launch. In addition to the vessels listed, the photo files include offshore rigs being transported to the Upper Stauffer Channel. The listing includes five vessels typed as "research survey vessels" and one vessel typed as "seismic survey vessel." The subtype classification for these six vessels is "seismic vessel."

Tables 3-37 and 3-38 summarize the range of loaded drafts for vessels presently using Galveston and Bayou Lafourche. The vessel drafts represent the range of vessels that Freeport has lost due to insufficient water depth and hazardous conditions. The focus of comparative port and fleet investigations was to determine sailing drafts, light drafts, and associated vessel characteristics. An additional focus was to help determine the range of loaded drafts for ports with less-restrictive depths. The *Kondor Explorer,* which moved to Galveston, will be returning to Freeport because the boarding charges are lower in Freeport and the port provides better security.

**Table 3-37**
**Limited Vessel List for the Upper Stauffer Channel**

| Vessel Name | Loaded Draft | Estimated Light Draft[a] | Horse-power | Length Overall | Beam | Gross Tons | Net Registered Tons | Vessel Type | Flag |
|---|---|---|---|---|---|---|---|---|---|
| *Brenda Lee* | 7 | 5 | 2050 | – | 25 | 99 | 67 | Platform Supply Ship | U.S. |
| *Brooks McCall* | 10 | 7 | 2400 | 160 | 40 | 806 | 564 | Research Survey Vessel | U.S. |
| *Christina* | 24 | 17 | 5384 | 328 | 56 | 4,320 | 2,260 | General Cargo Ship | Norway Gibraltar |
| *GGS Atlantic* | 13 | 9 | 2248 | – | – | 1,151 | – | Research Survey Vessel | Marshall Islands |
| *GSI Admiral* | 19 | 13 | 4801 | 297 | 64 | 3,435 | 1,031 | Research Survey Vessel | Canada |
| *GSI Pacific* | 14 | 10 | 2180 | 185 | 41 | 1,114 | 334 | Research Survey Vessel | Panama |
| *Jonathan Chouest* | 14 | 10 | 2248 | 180 | 40 | 1,096 | 341 | Research Survey Vessel | U.S. |
| *Kit Kat* | 7 | 5 | 2040 | 110 | 26 | 98 | 66 | Crewboat | U.S. |
| *Kondor Explorer* | 17 | 12 | 6004 | 200 | 46 | 1,163 | 2,048 | Seismic Survey Vessel | Cyprus |
| *Linda C* | 11 | 8 | 365 | 116 | 26 | 269 | 81 | Utility Vessel | Cambodia |
| *Milky Way* | 7 | 5 | 2050 | 110 | 26 | 98 | 66 | Crewboat | U.S. |
| *Miss Flo* | 9 | 6 | 1200 | 110 | 26 | 98 | 66 | Platform Supply Ship | U.S. |
| *New Yorker* | – | – | – | – | – | – | – | Gambling Boat | – |
| *Ocean Rover* | – | – | – | 320 | 266 | 18,871 | 5,661 | Rig | Cayman Islands |
| *Paul Candies* | 19 | 13 | 5697 | 140 | 42 | – | 785 | Offshore Tug | Mexico |
| *Stanco Traveler* | 8 | 6 | 1875 | 143 | 36 | 1,200 | 541 | Platform Supply Ship | U.S. |
| *Sunday Silence* | 7 | 5 | 2040 | 110 | 26 | 98 | 66 | Crewboat | U.S. |
| *Twix* | 7 | 5 | 2040 | 110 | 26 | 98 | 66 | Crewboat | U.S. |

[a]Light drafts are not published for many vessels. This table includes estimated light drafts. Light draft would be applicable for transport without cargo and supplies.

**Table 3-38**
**Offshore Supply Vessels**
**Range of Design and Loaded Drafts (feet)**
**Bayou Lafourche, Galveston, and Freeport (2006)**

| Inbound Offshore Supply | | | | Outbound Offshore Supply | | | |
|---|---|---|---|---|---|---|---|
| Vessel Design Draft | Loaded Draft | | | Vessel Design Draft | Loaded Drafted | | |
| | Minimum | Median | Maximum | | Minimum | Median | Maximum |
| 15 | 6 | 12 | 15 | 15 | 12 | 15 | 15 |
| 16 | 6 | 12 | 16 | 16 | 7 | 10 | 10 |
| 17 | 7 | 12 | 15 | 17 | 12 | 17 | 17 |
| 18 | 10 | 14 | 17 | 18 | 14 | 18 | 18 |
| 19 | 12 | 16 | 18 | 19 | 16 | 18 | 18 |
| 20 | 6 | 17 | 20 | 20 | 7 | 14 | 14 |
| 21 | 7 | 15 | 21 | 21 | – | – | – |
| 22 | 7 | 17 | 20 | 22 | 16 | 19 | 19 |
| 23 | 18 | 19 | 19 | 23 | 19 | 19 | 19 |
| 24 | – | – | – | 24 | – | – | – |
| 25 | – | – | – | 25 | – | – | – |
| 26 | – | – | – | 26 | – | – | – |
| 27 | – | – | – | 27 | 15 | 21 | 21 |
| 28 | – | – | – | 28 | 10 | 13 | 13 |
| 29 | – | – | – | 29 | 14 | 15 | 15 |

Source: USACE, compiled from NDC Entrances and Clearances File, 2006.

Table 3-39 shows the world fleet by design draft and U.S. versus foreign flag.

**Table 3-39**
**World Offshore Supply Vessel Fleet by Design Draft**
**U.S. Flag and non-U.S. Flag**
**Vessels Built After 1974 or Under Construction as of November 2008**

| Design Draft (feet) | Flag | | | | | |
|---|---|---|---|---|---|---|
| | U.S. Flag | | Foreign Flag | | Total Vessels | |
| 3 | – | 0.0% | 109 | 2.8% | 109 | 2.3% |
| 7 | 121 | 14.3% | 367 | 9.4% | 488 | 10.2% |
| 10 | 186 | 21.9% | 506 | 12.9% | 692 | 14.5% |
| 13 | 312 | 36.8% | 863 | 22.0% | 1,175 | 24.6% |
| 16 | 152 | 17.9% | 962 | 24.5% | 1,114 | 23.4% |
| 20 | 63 | 7.4% | 751 | 19.1% | 813 | 17.0% |
| 23 | 13 | 1.5% | 258 | 6.6% | 271 | 5.7% |
| 26 | – | 0.0% | 103 | 2.6% | 103 | 2.2% |
| 30 | 3 | 0.3% | 4 | 0.1% | 6 | 0.1% |
| Total | 849 | 100.0% | 3,923 | 100.1% | 4,772 | 100.0% |

Source: Lloyd's Register – Fairplay, PC Register of Ships, November 2008.

In addition to the OSV statistics in the Fairplay/Lloyd's Register of Ships, statistics associated with OSVs registered with the USCG in 2006 and operating in U.S. offshore, and vessel design draft and other characteristics for the 551 USCG vessel records available from the USACE's web page were compiled. The percentage of OSVs built after 1974 and the percentage built after 2000 are displayed in Table 3-41. The largest increases are primarily associated with design drafts over 20 feet. The data presented in Tables 3-40 and 3-41 were used to identify the range of vessel drafts associated with the fleet that includes vessels using Freeport.

**Table 3-40**
**Offshore Vessel Fleet by Design Draft**
**USCG, World Fleet, and U.S. Flag Fleet**

| Design Draft (feet) | World Offshore Vessel Fleet | | | | | | U.S. Flag Vessels | |
|---|---|---|---|---|---|---|---|---|
| | Offshore Vessels Registered with the USCG[a] | | Constructed after 1974 | | Constructed after 2000 or "On Order" | | Louisiana and Texas Home Bases | |
| | Number | % | Number | % | Number | % | Number | % |
| ≤12 | 231 | 41.9 | 1,422 | 33.7 | 375 | 19.5 | 469 | 56.4 |
| 13–14 | 146 | 26.5 | 398 | 9.4 | 95 | 4.9 | 91 | 11.1 |
| 15 | 82 | 14.9 | 410 | 9.7 | 165 | 8.6 | 80 | 9.6 |
| 16 | 28 | 5.1 | 502 | 11.9 | 308 | 16.0 | 67 | 8.1 |
| 17 | 18 | 3.3 | 244 | 5.8 | 141 | 7.3 | 21 | 2.5 |
| 18 | 1 | 0.2 | 127 | 3.0 | 55 | 2.9 | 25 | 3.0 |
| 19 | 1 | 0.2 | 293 | 6.9 | 196 | 10.2 | 11 | 1.3 |
| 20 | 14 | 2.5 | 313 | 7.4 | 219 | 11.4 | 32 | 3.8 |
| 21 | 6 | 1.1 | 181 | 4.3 | 113 | 5.9 | 20 | 2.4 |
| 22 | 3 | 0.5 | 139 | 3.3 | 113 | 5.9 | 4 | 0.5 |
| 23 | 3 | 0.5 | 56 | 1.3 | 36 | 1.9 | 9 | 1.1 |
| 24 | 5 | 0.9 | 25 | 0.6 | 23 | 1.2 | – | 0.0 |
| 25 | 3 | 0.5 | 31 | 0.7 | 20 | 1.0 | – | 0.0 |
| 26 | – | 0.0 | 54 | 1.3 | 48 | 2.5 | – | 0.0 |
| 27 | – | 0.0 | 10 | 0.2 | 5 | 0.3 | – | 0.0 |
| 28 | 1 | 0.2 | 15 | 0.4 | 15 | 0.8 | 2 | 0.2 |
| 29 | – | 0.0 | – | 0.0 | – | 0.0 | – | 0.0 |
| 30 | 9 | 1.6 | 1 | 0.0 | 1 | 0.1 | 0 | 0.0 |
| Totals | 551 | 100.0 | 4,225 | 100.0 | 1,928 | 100.0 | 832 | 100.0 |

Source: Lloyd's Register – Fairplay, PC Register of Ships, November 2008, and USACE, NDC website data.

[a]Offshore vessels registered with the USCG include U.S. and foreign flag vessels. The list of offshore vessels registered with the USCG was compiled from the USACE NDC website.

[b]The remaining lists shown in the table were compiled from the Lloyd's Register – Fairplay, PC Register of Ships, November 2008.

Note: Totals may not add due to rounding.

**Table 3-41**
**World Offshore Supply Vessel Fleet**
**Comparison of Percentage of Vessels Built After 1974 and 2000**

| Design Draft (feet) | Constructed After 1974 | % | Constructed After 2000 or "On Order" | % | % Constructed After 2000 or "On Order" |
|---|---|---|---|---|---|
| <=12 | 1,422 | 33.7 | 375 | 19.5 | 26.4 |
| 13–14 | 398 | 9.4 | 95 | 4.9 | 23.9 |
| 15 | 410 | 9.7 | 165 | 8.6 | 40.2 |
| 16 | 502 | 11.9 | 308 | 16.0 | 61.4 |
| 17 | 244 | 5.8 | 141 | 7.3 | 57.8 |
| 18 | 127 | 3.0 | 55 | 2.9 | 43.3 |
| 19 | 293 | 6.9 | 196 | 10.2 | 66.9 |
| 20 | 313 | 7.4 | 219 | 11.4 | 70.0 |
| 21 | 181 | 4.3 | 113 | 5.9 | 62.4 |
| 22 | 139 | 3.3 | 113 | 5.9 | 81.3 |
| 23 | 56 | 1.3 | 36 | 1.9 | 64.3 |
| 24 | 25 | 0.6 | 23 | 1.2 | 92.0 |
| 25 | 31 | 0.7 | 20 | 1.0 | 64.5 |
| 26 | 54 | 1.3 | 48 | 2.5 | 88.9 |
| 27 | 10 | 0.2 | 5 | 0.3 | 50.0 |
| 28 | 15 | 0.4 | 15 | 0.8 | 100.0 |
| 29 | 0 | 0.0 | 0 | 0.0 | – |
| 30 | 1 | 0.0 | 1 | 0.1 | 100.0 |
| 31 | 0 | 0.0 | 0 | 0.0 | – |
| Total | 4,225 | 100 | 1,928 | 100 | 45.6 |

Compiled from Lloyd's Register – Fairplay, PC Register of Ships, November 2008.
Note: Totals may not add due to rounding.

Seismic vessels are usually similar in size to oilfield supply vessels. They can range from 100 to over 350 feet in length and require drafts up to 30 feet. Discussion with industry indicated that during the early to mid-1970s, most seismic vessels generally ranged in size from 80 to 150 feet and seldom required drafts of more than 15 feet. Comparison of the total fleet with vessels constructed after 2000 shows the largest increase is associated with design drafts over 20 feet. Table 3-42 presents comparison of the percentage of research vessels built after 1974 with the percentage built after 2000.

**Table 3-42**
**World Research Vessel Fleet**
**Comparison of Percentage of Vessels Built After 1974 and 2000**

| Design Draft (feet) | Constructed After 1974 | | Constructed After 2000 or "On Order" | | % Constructed After 2000 or "On Order" |
|---|---|---|---|---|---|
| | Number | % | Number | % | |
| ≤12 | 321 | 47.1 | 55 | 45.1 | 17.1 |
| 13–14 | 96 | 14.1 | 2 | 1.9 | 2.5 |
| 15 | 39 | 5.7 | 2 | 1.9 | 6.2 |
| 16 | 31 | 4.6 | 1 | 0.8 | 3.2 |
| 17 | 31 | 4.6 | 7 | 5.7 | 22.6 |
| 18 | 18 | 2.6 | 1 | 0.8 | 5.6 |
| 19 | 45 | 6.6 | 5 | 4.1 | 11.1 |
| 20 | 18 | 2.6 | 8 | 6.6 | 44.4 |
| 21 | 15 | 2.2 | 6 | 4.9 | 40.0 |
| 22 | 17 | 2.5 | 13 | 10.7 | 76.5 |
| 23 | 11 | 1.6 | 2 | 1.6 | 18.2 |
| 24 | 10 | 1.5 | 2 | 1.6 | 20.0 |
| 25 | 13 | 1.9 | 8 | 6.6 | 61.5 |
| 26 | 8 | 1.2 | 5 | 4.1 | 62.5 |
| 27 | 4 | 0.6 | 4 | 3.3 | 100.0 |
| 28 | 3 | 0.4 | 0 | 0.0 | 0.0 |
| 29 | 0 | 0.0 | 0 | 0.0 | – |
| 30 | 1 | 0.1 | 0 | 0.0 | 0.0 |
| Totals | 681 | 100.0 | 122 | 100.0 | 17.9 |

Compiled from Lloyd's Register – Fairplay, PC Register of Ships, November 2008.

The fleet statistics shown in Table 3-43 include vessels operating in the U.S. Gulf of Mexico.

**Table 3-43**
**Seismic and Research Vessels**
**Range of Design and Loaded Drafts (feet)**
**Bayou Lafourche, Galveston, and Freeport (2006)**

| Inbound Offshore Supply | | | | Outbound Offshore Supply | | | |
|---|---|---|---|---|---|---|---|
| Vessel Design Draft | Loaded Draft | | | Vessel Design Draft | Loaded Drafted | | |
| | Minimum | Median | Maximum | | Minimum | Median | Maximum |
| 15 | – | – | – | 15 | – | | – |
| 16 | – | – | – | 16 | 16 | 14 | 16 |
| 17 | – | – | – | 17 | 12 | 12 | 12 |
| 18 | – | – | – | 18 | 17 | 17 | 17 |
| 19 | – | – | – | 19 | 12 | 12 | 12 |
| 20 | – | – | – | 20 | 6 | 10 | 18 |
| 21 | 20 | 20 | 20 | 21 | – | – | – |
| 22 | 17 | 17 | 17 | 22 | 16 | 17 | 17 |
| 23 | 17 | 17 | 17 | 23 | 17 | 17 | 17 |
| 24 | 19 | 19 | 19 | 24 | 19 | 19 | 19 |
| 25 | 21 | 22 | 23 | 25 | – | – | – |

Source: USACE, compiled from NDC Entrances and Clearances File, 2006.

The fleet distribution of the vessels other than oilfield classifications was compiled from the Lloyd's Register of Vessels and Texas Gulf Coast ports. Table 3-44 summarizes the number of vessels by draft for the world fleet and Texas Gulf Coast ports.

**Table 3-44**
**World Vessel Fleet and Texas Gulf Coast**
**(Excluding Offshore Vessels)**
**Maximum Vessel Length of 400 feet**

| Design Draft (feet) | World Fleet (Maximum Length of 400 feet) Vessels Constructed After 2000 (%) | Texas Gulf Coast Fleet (%) | Freeport's Estimated Repair Layberth Cargo Vessels | Percentage |
|---|---|---|---|---|
| ≤12 | n/a | 3.4 | 2 | 3.4 |
| 13–14 | 20.3 | 9.2 | 4 | 9.2 |
| 15 | 7.3 | 10.1 | 5 | 10.1 |
| 16 | 7.2 | 8.4 | 4 | 8.4 |
| 17 | 6.8 | 3.4 | 2 | 3.4 |
| 18 | 8.3 | 2.5 | 1 | 2.5 |
| 19 | 8.8 | 1.7 | 1 | 1.7 |
| 20 | 9.1 | 8.4 | 4 | 8.4 |
| 21 | 7.5 | 8.4 | 4 | 8.4 |
| 22 | 7.6 | 5.9 | 3 | 5.9 |
| 23 | 5.1 | 6.7 | 3 | 6.7 |
| 24 | 1.9 | 10.9 | 5 | 10.9 |
| 25 | 3.1 | 5.0 | 2 | 5.0 |
| 26 | 1.9 | 2.5 | 1 | 2.5 |
| 27 | 1.1 | 0.0 | 0 | 0.0 |
| 28 | 1.9 | 4.2 | 2 | 4.2 |
| 29 | 0.8 | 4.2 | 2 | 4.2 |
| 30 | 0.9 | 5.0 | 2 | 5.0 |
| 31 | 0.5 | – | 0 | – |
| | 100.0 | 100.0 | 48 | 100.0 |

Source: Lloyd's Register – Fairplay, PC Register of Ships, November 2008 and USACE, detailed vessel files.

### 3.2.7 Liquefied Natural Gas

In addition to its large existing base of crude petroleum, petroleum and chemical products, and dry bulk deep-draft cargoes, the without-project future includes construction of an LNG terminal. Phase I of the terminal is presently in operation, and vessel traffic commenced in April 2008.

The maximum design drafts for existing LNG vessels are 42 feet. The industry standard is for LNG vessels to have 4 to 6 feet underkeel clearance, and the expectation is that LNG vessels will be required to have a minimum of 3 to 4 feet. Underkeel clearance rules on the Freeport Channel are strict; however, the existing vessel sizes and underkeel clearance requirements suggest that channel depths of 45 feet should be adequate, and channel-deepening benefits were not taken for

LNG cargo. The docks at the Freeport LNG terminal will accommodate vessels 1,099 feet long by 177 feet wide. This vessel design prompted the non-Federal sponsor to pursue widening of the offshore Outer Bar and Jetty channels from 400 to 600 feet under the Section 204 authority of WRDA 1986.

### 3.2.8 Effects of Panama Canal Expansion

Expansion of the Panama Canal is expected to have significant impacts on shipping routes, port development, cargo distribution, and a host of others to the U.S. maritime system. One of its greatest impacts will be felt in the fast-growing container trade where expansion will enable larger vessels to transit the canal. Vessel calls on the East and Gulf coasts are also expected to increase significantly as cargo shifts away from the congested West Coast. Expansion of the canal project is expected to be completed in 2014. The canal expansion will accommodate maximum loaded drafts of 15 meters, or approximately 49 feet. Completion of the Panama Canal improvements is expected to increase the number of larger and fully loaded container and general cargo vessels using Texas Gulf Coast ports.

While it does not appear that refrigerated cargo vessel sizes are increasing, significant increases are occurring for other vessel groups, and completion of the Panama Canal expansion by the year 2014 will allow for more fully loaded vessel movements from deepwater ports in the Far East and the western coasts of Mexico and South America. The canal expansion will affect Freeport chemical exports and the container cargo.

Transportation infrastructure limitations have been cited as contributing to changes in regional distribution of the U.S. container market. Examples of transportation infrastructure limitations and associated effects limiting trade flow were cited in several trade journals. In the 1990s, the use of post-Panamax containerships and the existing constraints at the Panama Canal shifted post-Panamax ships from using the all-water route to using double-stack trains to move goods from West Coast ports eastward.

In addition to greater reliance on rail due to the inability of post-Panamax ships to transit the canal, direct ship movements to the East and Gulf coasts have occurred due to congestion at West Coast ports. At the same time and due to congestion at Los Angeles and Long Beach, some shippers have greatly increased their utilization of the canal, particularly for all-water services from Asia to the U.S. Gulf and East coasts. While there are delays associated with the canal, the delays may be more predictable and easier to plan for than delays at Los Angeles and Long Beach. Increasing costs and decreasing reliability on the U.S. intermodal system, particularly rail connections, and the proliferation of distribution and warehousing centers near ports along the Gulf and Southeast coasts of the U.S., have combined to make the Panama Canal route (also known as the "all-water" route) a more attractive option to shippers serving these markets,

particularly those shipping consumer goods in intermodal containers. Effects of shifts in general and container cargo that have taken place in recent years are reflected in Freeport's base.

From 2001 to 2005, the TEU capacity of containerships transiting the canal increased by 59 percent, the number of containerships transiting the canal rose by 47 percent, and average vessel size increased 21 percent. The Panama Canal Authority was quoted as saying, "by the end of 2011, the total post-Panamax containership fleet will consist of approximately 670 ships with a capacity of almost 4.6 million TEUs, close to double the capacity of the existing post-Panamax fleet."

The Panama Canal Authority used a post-Panamax vessel of 366 meters (1,200 feet) long, 49 meters (161 feet) wide, and 15 meters (49 feet) deep as the reference for establishing the ideal lock chamber sizes.

Completion of the Panama Canal widening and deepening is expected to result in increases in Texas container traffic. The expansion of the Panama Canal, with its combination of wider navigation channels and locks coupled with strategic marketing partnerships with key U.S. ports, will increase demand through the canal itself and for ports along the Gulf and East coasts, including those in Texas.

## 4.0 WITHOUT PROJECT CONDITION

The maximum vessel sizes for crude oil for the existing condition in the first reach generally do not exceed 120,000 DWT, but Freeport's 2005 to 2007 historical data include vessels over 150,000 DWT. Vessels up to 175,000 DWT presently use nearby deep-draft projects such as Corpus Christi, Texas City, Houston, and the Sabine-Neches Waterway. The channel widening evaluated under the Section 204 study will allow the range of vessels for the without-project future to increase to 175,000 DWT.

Freeport's recent trade routings and the EIA forecast of imports by country of origin were used to estimate Freeport's 2017 to 2067 trade routing. Under the without- and with-project conditions, imports from origins that include Mexico, Guatamala, Venezuela, Colombia, and Brazil are shipped direct. Under the without-project future imports from Europe, Africa, and the Middle East are either lightered or lightened. For channel depth alternatives of 58 feet or more, the cost of direct shipment for movements from Europe, Africa, and the Middle East is less than that for lightering or lightening. This reduction is expected to result in transition to direct shipment. For lightening, the "mother vessels" offload partial cargoes to shuttle vessels, and both vessels come into port in the current and future without- and with-project conditions.

For the Lower Stauffer, the without-project condition is 18 feet. However, it is assumed that the most likely depth that needs to be in place to "call" a new or currently nonexistent operation/facility of concern into existence is between 35 and 40 feet since Houston's container terminals are currently at 40 feet depth. Based on consultation with IWR in 2008 and again in 2011, it was determined that a "threshold depth" of 40 feet was reasonable from which to begin economic incremental analysis. However, the cost of removing the material was calculated based on an existing and without-project future depth of 18 feet.

An off-channel berth area on the Lower Stauffer Channel is being constructed in two phases by the non-Federal sponsor. This construction is not part of the Federal project. The transportation savings benefits were calculated based on Phase I of the construction. As part of Phase I, the non-Federal sponsor is constructing a berth area/channel adjacent to the proposed federally constructed Lower Stauffer Channel.

Under the without-project future, the Upper Stauffer Channel would continue to serve OSVs. Discussions with channel users and company officials indicated that maneuvering vessels on the silted channel and maintaining a proper alignment for safe passage is hazardous, and this condition is expected to continue. The ability of the channel to serve as a harbor of refuge will deteriorate under the without-project future.

Galveston represents the most likely alternative port for vessel operators that wish to use the Stauffer Channel for layberth and supplies. The without-project, as well as the with-project,

future is characterized by increases in offshore exploration and associated activities. On April 30, 2007, Secretary of the Interior Dirk Kempthorne issued a press release for the previous administration announcing a "major Federal initiative to boost oil and natural gas production on the U.S. Outer Continental Shelf in the Gulf of Mexico and off Alaska. The program could produce 10 billion barrels of oil and 45 trillion cubic feet of natural gas over 40 years, generating almost $170 billion in today's dollars, in net benefits for the Nation."

Distribution of Upper Stauffer Channel vessel traffic by design draft was calculated using the total number of vessels and the fleet distributions for supply, seismic, and cargo vessels. Application of the fleet distributions for the without-project future is summarized in Table 4-1.

**Table 4-1**
**Number of Vessels per Year for Without-Project Future**

| Vessel Design Draft (feet) | Number of Vessels by Type | | |
|---|---|---|---|
| | Offshore Supply | Seismic | Cargo/Other |
| <12 | 81 | 25 | 2 |
| 13–14 | 21 | 1 | 4 |
| 15 | 36 | 1 | 5 |
| 16 | 67 | 0 | 4 |
| 17 | 31 | 3 | 2 |
| 18 | 12 | 0 | 1 |
| 19 | 43 | 2 | 1 |
| Most Likely | 236 | 30 | 17 |
| Maximum | 291 | 32 | 19 |

## 5.0 PROJECT ALTERNATIVES

The project alternatives include deepening Reach 1 to a maximum depth of 60 feet from its current 45 feet depth, Reach 2 to a maximum depth of 50 feet from its current 45 feet depth, Reach 3 (Lower Stauffer) to a maximum depth of 50 feet from its current depth of 18 feet, and Reach 4 (Upper Stauffer) to a maximum depth of 30 feet from its current depth of 18 feet.

Evaluation of deepening alternatives for the existing 45-foot project reaches (Reach 1 and Reach 2) was pursued based on the non-Federal sponsor and industry's interest in bringing in larger and more fully loaded crude petroleum tankers. In Reach 1, project depth alternatives of 55 feet and more were proposed by the non-Federal sponsor as an alternative to offshore transfer of crude petroleum. An advantage that Freeport has over other Texas Gulf Coast ports is that it takes 45 minutes to go from the crude petroleum docks to the offshore jetty. In comparison, it takes a minimum of 3 to 8 hours or more to reach the Gulf of Mexico from other Texas ports.

Increases in Freeport's channel depth provide the opportunity to offload a smaller amount of cargo at sea, thus facilitating the use of smaller shuttle vessels. For channel depths over 55 feet, the cost differential between direct shipment and lightering and lightening is reduced, and this would provide cost incentives for diversions from lightering and lightening to direct shipments for Africa, Europe, and Middle East trade routes.

Improvements to the 36-foot-deep Brazos Harbor Turning Basin were not evaluated due to existing capacity constraints.

Depth alternatives to 50 feet were also evaluated for the Lower Reach of the Stauffer Channel. This would provide an extension from the terminus of the federally authorized 45-foot Freeport Harbor Project.

Depth alternatives up to 30 feet were evaluated for the Upper Reach of the Stauffer Channel. Presently the upper reach of the Stauffer Channel has a water depth of approximately 18 feet.

# 6.0 TRAFFIC FORECAST

This section presents the tonnage and fleet projections for Freeport's crude petroleum imports, petroleum product imports, chemical exports, and general and containerized cargo. The focus of the traffic analysis was based on identification of vessels and commodities transported in draft-constrained vessels. Therefore, forecasts were not estimated for petroleum product exports and chemical imports. Freeport's chemical product import tonnage showed less than one-half of 1 percent of chemical imports were transported in vessels with design drafts over 45 feet. The small volumes associated with draft-constrained vessels were associated with vessels transporting crude oil, with the chemical cargoes being incidental. Freeport's petroleum product exports showed a similar pattern as with chemical import cargo. Those movements, which generally totaled less than 100,000 short tons annually, were transported in vessels with design drafts over 45 feet and were included as incidental cargo associated with crude petroleum tanker backhauls.

The forecast of a transition to larger and more fully loaded vessels for petroleum, petroleum products, and chemicals is based on vessel order data, world port development trends, the Panama Canal expansion, and transitions in Freeport's vessel use since the early 1990s. Historical vessel utilization and new vessel orders associated with crude petroleum imports and chemical product exports suggests that portions of these cargoes would transition to larger vessels if increases in channel depth were available. Vessel utilization at comparable ports indicates that the use of larger and more fully loaded vessels is apparent for these cargoes as well. Since the authorization of the existing 45-foot Project depth in the 1990s, the size and draft of vessels using the harbor increased to meet the competitive demand for more-efficient movements. Variables used to help evaluate the transition to more deeply loaded vessels include the percentage of tonnage transported in vessels with design drafts over 40 feet, percentages transported in vessels with loaded drafts over 40 feet, vessel DWT, and parcel sizes. Minimization of transportation cost, given trade route constraints and commodity parcel needs, recognizably drives long-term vessel choices.

The assumption about the use of larger and more fully loaded vessels for products has some uncertainty. Most of the uncertainty is associated with the percentage of cargo anticipated to transition to larger or more fully loaded vessels. However, analysis of Freeport's 1990 to 2007 vessel utilization data and world shipping data, including vessels-on-order for chemical and product carriers and port developments, including the Panama Canal expansion, suggests that there will be some transition to more deeply loaded vessels during the 50-year period of analysis.

Vessel fleets and utilization, and existing and future constraints associated with crude petroleum, petrochemical products, and a new fleet of container vessels provided the basis for identifying the commodities expected to be transported in vessels loaded to channel depths over 45 feet.

Foreign port depths and constraints such as the Panama Canal with a present width restriction were additional considerations in the analyses.

## 6.1 CRUDE PETROLEUM IMPORTS

Freeport's crude petroleum tonnage forecast was prepared using Global Insight's September 2010 projections. IHS Global Insight is a private company that provides economic forecasts, industry analysis, and market intelligence for over 200 countries and 170 industries. Although the DOE also provides forecasts for crude petroleum imports, their forecasts show an outlook inconsistent with historical trends, tend to be more volatile and more easily politically tainted from year to year, and are based on national data. For instance, the DOE US energy consumption forecast for 2010 to 2025 was 20 to 25 percent higher in 2006 than in 2008, and has been reduced another 20 percent since 2008. The Government Accountability Office has also published material contradictory to DOE's recent forecasts. The Global Insight forecast is still significantly lower than historical trends, but it is more consistent from year to year and provides regional data more relevant to the Gulf Coast. Also, Global Insight forecasts are widely accepted throughout the USACE and have been used on numerous other projects in the Galveston District. Table 6-1 displays Global Insight's September 2008 and 2010 projection in comparison to the DOE's Annual Energy Outlook (AEO) 2008 to 2011 forecasts and Purvin and Gertz's 2009 forecast.

**Table 6-1**
**U.S. Crude Oil Imports Projection Comparison**
**Millions of Barrels Per Day**

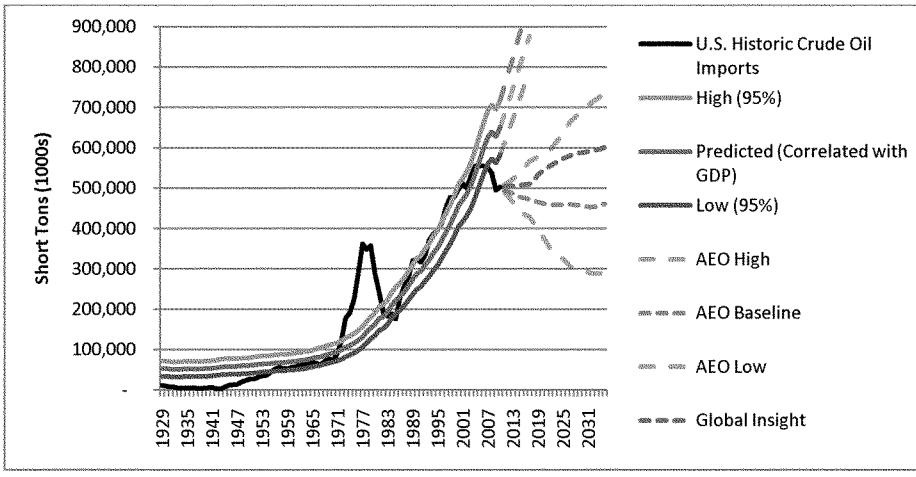
| Year | AEO 2008 | AEO 2009 | AEO 2010 | AEO 2011 (Preliminary) | Purvin and Gertz 2009 | Global Insight 2008 | Global Insight September 2010 |
|---|---|---|---|---|---|---|---|
| 2007 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 2015 | 10.2 | 8.1 | 9.0 | 8.9 | 11.1 | n/a | 9.6 |
| 2025 | 11.0 | 6.7 | 8.8 | 8.5 | 12.1 | 12.4 | 10.4 |
| 2030 | 11.9 | 7.0 | 8.8 | 8.4 | 12.5 | 12.7 | 10.5 |
| 2035 | n/a | n/a | 8.8 | 8.7 | n/a | 12.9 | 11.0 |
| 2040 | n/a | n/a | n/a | n/a | n/a | n/a | 11.5 |

Source: DOE, EIA, *2008 Annual Energy Outlook*, DOE/EIA-0383 (2008), *2009 Annual Energy Outlook*, DOE/EIA-0383 (2009), Table 20, Comparison of Liquids Projections, and *2010 Annual Energy Outlook Early Release*, Table 1, December 2009, *2011 Annual Energy Outlook*, Report Number: DOE/EIA-0383ER(2011), Early Release December 2010. The Global Insight September 2010 forecast was obtained directly for Global Insight; note that the 2008 forecast was obtained from the *2009 Annual Energy Outlook*.

The AEO 2010 values shown were converted from BTUs.

Figure 6-1 graphically shows the historic crude oil imports and the forecasts by AEO and Global Insight. The AEO high and AEO low display the range within AEO's forecast, with AEO baseline as their most likely prediction.

**Figure 6-1**
**Historic and Projected U.S. Crude Oil Imports (1929–2035)**




Contrary to the forecasts by DOE and Global Insight, the U.S. General Accounting Office (GAO) states that the United States relies on imported oil for more than half of its supply of energy and appears likely to increase its reliance in the future. Crude oil imports are anticipated to increase for several reasons. The primary reason is that there is a very high correlation between energy consumption and Gross Domestic Product (GDP) based on 80 years of historical data. As the economy grows, more energy is required. Given current technology, it is most cost effective and efficient to use oil as compared to other energy sources. Presently, according to GAO, other countries can provide oil cheaper than the U.S. Therefore, oil is imported into the U.S.

Another reason for crude oil imports to increase is population growth. According to industry, residential energy consumption steadily increases as population increases, and commercial energy consumption is more cyclical but also steadily increases over time. During recessions, commercial energy consumption may decrease slightly, which was experienced in 2009 to 2010. Per capita residential energy consumption has been relatively constant since the early 1970s. Contrary to historic trends, AEO's recent forecasts show per capita energy use decreasing by

about 15 percent over the next 20 years, and by 2035, overall energy consumption increasing 20 percent less than the 60-year historic trend.

Also, despite DOE's projections of a 15 percent increase in energy consumption by 2035, DOE projects a decrease in crude oil imports due to an increase in liquefied natural gas and biofuel consumption. However, natural gas prices are currently at historic lows and likely will not remain at these levels over the next 30 years, and challenges must be overcome before biofuels can fill the gap in energy consumption. According to GAO, biofuels are 25 percent less efficient than gasoline and cannot increase production without a new form of technology. Ethanol production from corn has reached its maximum production capacity. Ethanol from cellulose is possible but costs twice as much to produce as corn so is not economically feasible presently. With current technology, the energy to produce a gallon of ethanol uses almost as much energy as it provides per gallon. Also, GAO argues that development of infrastructure is needed to increase production. Meanwhile, DOE reduced the funding for Research and Development in alternative energies by 85 percent from 1980 to 2006. Developing the infrastructure and technology to make alternative energies economically feasible will take several years and increased funding. GAO states the use of biofuels is optimistically expected to be 4 percent of overall energy consumption by 2015. Imported crude oil continues to be the cheapest form of energy per British thermal unit (BTU) for the United States. For this reason, an underlying assumption in the analysis is that companies will adapt for any potential supply-chain bottlenecks in the future to accommodate for demand.

Therefore, Freeport's crude oil import forecast was prepared by incorporating the Global Insight projections into a regression equation using 1990 to 2009 Freeport imports as a function of U.S. imports. An R Square of 0.922 was produced from the equation. The t-value and F statistic for the equation are significant at statistical confidence levels. Table 6-2 displays Freeport's regression equation application using the Global Insight forecast results and 1990 to 2009 as a historical base. The results of the base application show an average annual growth rate of 0.9 percent for 2007/2009 to 2040 for Freeport's imports. Freeport's base estimate, in conjunction with Freeport's share of U.S. oil imports, was used in crude petroleum import calculations. Figure 6-2 displays Freeport's crude petroleum historical imports and forecast.

**Table 6-2**
**Regression Equation Data for**
**Freeport Crude Oil Imports [a/]**

| Component | | Description of Data and Outputs | |
|---|---|---|---|
| Dependent Variable | | Freeport Crude Imports (1990–2009) | |
| Independent Variable | | U.S. Crude Imports | |
| Adjusted R Square | | 0.922 | |
| No. of Observations | | 20 | |
| Degrees of Freedom | | 1 | |
| X Coefficient Level of Significance of t value | | 1.23418E-11 | |
| F Statistic | | 226.17 | |
| Significance of F statistic | | 1.23418E-11 | |
| | | **Regression Equation Data** | |
| | | Base Output | |
| Constant | | −15,902.1 | |
| Standard Error of Y Estimate | | 1,626.77 | |
| X Coefficient: U.S. Crude Oil Imports | | 0.068618 | |
| | | **Freeport (1,000s of Short Tons) 2004–2009** | |
| **Historical Year** | **U.S. Imports 1,000s of Short Tons[a]** | **Actual** | **Base Estimate[b]** |
| 2005 | 553,923 | 22,000 | 22,107 |
| 2006 | 553,489 | 21,706 | 22,077 |
| 2007 | 548,742 | 18,523 | 21,752 |
| 2008 | 535,170 | 20,607 | 20,820 |
| 2009 | 493,030 | 19,418 | 17,929 |
| 2007/2009 Average | 525,647 | 19,516 | 20,937 |
| | | **Freeport Regression Based Forecast[b]** | |
| **Forecast Year** | **U.S. Imports[a]** | | **Base Estimate[b]** |
| 2017 | 511,119 | | 19,170 |
| 2027 | 579,813 | | 23,884 |
| 2037 | 613,678 | | 26,207 |
| 2040 | 615,446 | | 27,313 |
| % AAG 2007/2009–2040 | 0.4% | | 0.9% |

Source: USACE, Waterborne Commerce of the U.S. 2005-09 and Global Insight's September 2010 crude oil import forecast.
[a]Calculated using barrel per day volumes from the EIA. The 2005 BPD volume was 10.13 billion. The Global Insight forecast extends through 2040.
[b]Freeport 2027 Imports = −15,902 + (0.0686 * 579,813) with 579,813 short tons being U.S. imports in 2027.

**Figure 6-2**
**Historic and Projected Freeport Crude Oil Imports (1990–2035)**

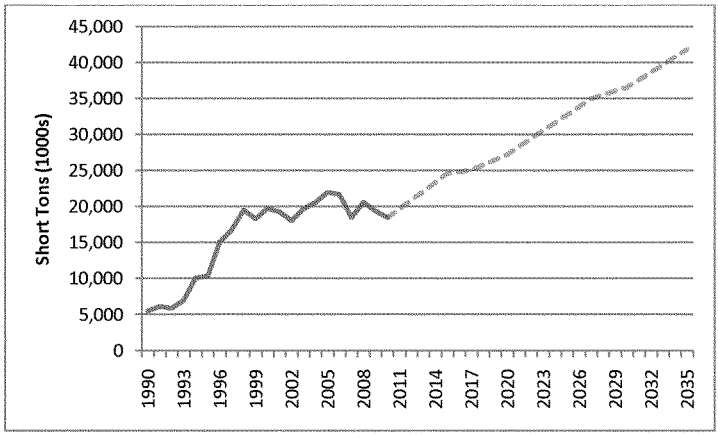



Table 6-3 displays the maximum cargo tons by vessel size and channel depth alternatives for representative vessels used in the analysis. The design draft is based on Lloyd's Registry and empirical data at Freeport. An increase in Freeport's channel depth from 45 to 50 feet would allow the existing range of 90,000 to 120,000 DWT vessels to carry approximately 17 percent more cargo. A depth increase from 45 to 55 feet or more would allow the same range of vessels to carry 24 percent more cargo.

**Table 6-3**
**Maximum Loaded Cargo**

| Vessel DWT | Design Draft (feet) | Immersion Factor | Channel Depth (feet) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 45 | 50 | 52 | 55 | 58 | 60 |
| | | | Maximum Loaded Short Tons of Cargo[a] | | | | | |
| 35,000 | 36 | 113 | 35,500 | 35,500 | 35,500 | 35,500 | 35,500 | 35,500 |
| 50,000 | 44 | 141 | 47,000 | 50,700 | 50,700 | 50,700 | 50,700 | 50,700 |
| 60,000 | 46 | 159 | 53,000 | 60,800 | 60,800 | 60,800 | 60,800 | 60,800 |
| 70,000 | 48 | 175 | 59,400 | 71,000 | 73,300 | 73,300 | 73,300 | 73,300 |
| 75,000 | 51 | 183 | 57,900 | 70,000 | 74,900 | 78,500 | 78,500 | 78,500 |
| 80,000 | 53 | 191 | 56,000 | 68,600 | 73,600 | 81,200 | 83,800 | 83,800 |
| 90,000 | 46 | 206 | 82,200 | 94,200 | 94,200 | 94,200 | 94,200 | 94,200 |
| 100,000 | 48 | 220 | 87,100 | 101,600 | 105,100 | 105,100 | 105,100 | 105,100 |
| 110,000 | 50 | 234 | 91,800 | 107,300 | 113,500 | 116,600 | 116,600 | 116,600 |
| 120,000 | 52 | 247 | 96,900 | 113,300 | 119,800 | 128,300 | 128,300 | 128,300 |
| 135,000 | 54 | 266 | 102,000 | 119,700 | 126,700 | 137,300 | 144,300 | 144,300 |
| 150,000 | 56 | 285 | 106,000 | 124,900 | 132,400 | 143,700 | 155,000 | 160,300 |
| 165,000 | 59 | 303 | 108,600 | 128,600 | 136,700 | 148,700 | 160,700 | 168,800 |
| 175,000 | 60 | 314 | 112,100 | 132,900 | 141,200 | 153,700 | 166,100 | 174,400 |

[a] Estimated short tons ≅ ((DWT * Maximum % Load) – (Immersion Factor * 12 inches per ton * number of feet light-loaded)).

Table 6-4 shows the number of shuttle vessels by channel depth alternatives necessary to offload a VLCC. For offshore lightering of crude petroleum, an increase in Freeport's channel depth will provide opportunities to reduce the number of shuttle vessels by using larger shuttles thereby providing transportation cost savings. For Suezmax tankers that are lightened to channel depth, an increase in channel depth will provide the ability to use smaller shuttles and reduce the overall transportation cost.

**Table 6-4**
**Number of Shuttle Vessels Needed by Channel Depth Alternative[a]**

| DWT of Shuttle Vessel | 45 | 48 | 50 | 52 | 55 | 58 | 60 |
|---|---|---|---|---|---|---|---|
| 50,000 | 8 | 7 | 7 | 7 | 7 | 7 | 7 |
| 70,000 | 6 | 6 | 5 | 5 | 5 | 5 | 5 |
| 80,000 | 6 | 6 | 6 | 5 | 5 | 5 | 5 |
| 90,000 | 5 | 4 | 4 | 4 | 4 | 4 | 4 |
| 100,000 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 110,000 | 4 | 4 | 4 | 4 | 3 | 3 | 3 |
| 120,000 | 4 | 4 | 4 | 3 | 3 | 3 | 3 |
| 150,000 | 4 | 3 | 3 | 3 | 3 | 3 | 3 |
| 165,000 | 4 | 3 | 3 | 3 | 3 | 3 | 3 |
| 175,000 | 4 | 3 | 3 | 3 | 3 | 3 | 2 |

[a]Application of December 2008 Deep-draft vessel operating costs provided by IWR.

### 6.1.1 Crude Petroleum Imports by Trade Route

Freeport's crude oil imports currently include trade routes with physical constraints. The effects of these constraints were evaluated in relationship to Freeport's without- and with-project future. Freeport's crude petroleum trade routes suggest that the availability of channel depths over 45 feet would provide cost incentives for crude petroleum import tonnage to be transported in more fully loaded vessels. The depths for the principal trading ports associated with 2002 to 2005 imports are shown in Table 6-5. Freeport's crude petroleum imports and the depths at the ports of origin suggest that 95 percent of current tonnage could be loaded to drafts over 45 feet.

**Table 6-5**
**Port Depths at Major Ports Transporting Crude Oil to Freeport**

| Region and Port | Country | Depth (feet) Port or Region |
|---|---|---|
| **North and South America** | | |
| High Seas, Gulf of Mexico | International Waters | 76 |
| Grand Bahamas, Freeport | Bahamas | 76 |
| All Other Brazil Ports North Of Recife | Brazil | 75 at Itagui |
| All Other Colombia, Caribbean | Colombia | >45 at several Eastern Ports |
| Coatzacoalcos[a] | Mexico | 42 |
| Pajaritos[a] | Mexico | 55 |
| Tuxpan | Mexico | 42 |
| Cayo Arcas[a] | Mexico | 72.2 |
| Dos Bocas[a] | Mexico | 89.9 |
| Orangestad | Netherland Antilles | 76 |
| San Nicolas Bay | Netherland Antilles | 76 |
| Point A Pierre | Trinidad | 52 |
| Rio Haina | Trinidad | 58 |
| Puerto Miranda | Venezuela | 39.5 |
| Amuay Bay | Venezuela | 41 to 45 |
| Puerto La Cruz | Venezuela | 55 |
| La Libertad | Ecuador | Panama Canal Restriction[b] |
| **Middle East** | | |
| Ras Tanura | Saudi Arabia | 61–65 |
| All Other Saudi Arabia Ports | Saudi Arabia | 61–65 at Ras Tanura |
| **Africa and North Europe** | | |
| Bonny | Nigeria | 74.8 |
| Kwa Ibo Terminal | Nigeria | 85.3 |
| Calabar | Nigeria | <40; planned improvements at Calabar |
| Sture | Norway | 75.4 |

Source: National Imagery and Mapping Agency, 2000 World Port Index, Pub. 150; Lloyd's, World Shipping Encyclopedia, April 2003; and USACE, Waterborne Commerce 2003–2005 detailed records.

[a]Located in the same region as the offshore Cayo Arcas, Mexico's offshore oil terminal. Cayo Arcas can load vessel drafts of up to 76 feet.

[b]The current Panama Canal's vessel draft limit is 39.6 feet. The vessel draft limit for the new canal chambers, which are under construction, is 49.2 feet, or 15 meters. The new lock chambers will fit vessels of 366 meters long and 49 meters wide.

A significant percentage of the vessels used for Freeport's direct shipments of crude petroleum imports are loaded to drafts over 40 feet, and channel deepening beyond 45 feet would increase this trend. Long-term expectations are that nearly all of the vessels used for direct shipment could be more fully loaded.

Relatively small tankers are used for crude oil movements from Guatemala, generally with tankers in the 60,000 to 69,999 DWT range. Freeport regularly receives a small volume of Ecuadoran crude oil and occasionally receives crude from the Far East. Shipments from Ecuador are generally transported in Suezmax tankers. Shipments from Ecuador and Guatemala represent less than 1 percent of Freeport's 2002 to 2005 import average. Shipments arriving from Ecuador can be transported either through the Panama Canal or the Trans-Panama Pipeline.

The Panama Canal represents a current restriction for the west coast of South America and Far East routings. While expansion of the Panama Canal will facilitate the use of larger tankers, it will not accommodate the Suezmax tankers presently associated with the U.S. Gulf Coast's current Trans-Panama Pipeline tonnage. Long-term expectations are that the U.S. Gulf Coast's receipt of crude oil from Western South America will be low.

In addition to the current and future Panama Canal limitations, port depth limitations also exist at the Lake Maracaibo ports in Venezuela due to lapses in maintenance dredging. Maintenance dredging has not been performed in several years, and vessels are limited to loaded drafts of approximately 39.5 feet, but the depth limitation at the Venezuelan ports is expected to change over the 50-year period of analysis. According to the EIA (October 2007), production in the Maracaibo basin is declining relative to Venezuela's other production sites. The EIA notes that Venezuela plans to aggressively develop its Orinoco Belt oil resources in the coming years. Ninety-six percent of Freeport's Venezuelan crude oil imports for 2003 to 2005 were from the deepwater port of La Cruz. In 2006, Venezuela consumed 620,000 BPD of oil and exported 2.2 BPD. Currently, the U.S. is Venezuela's major importer. Other new developments include increases in U.S. imports from Brazil.

Generally, it is not cost effective to use vessels larger than 175,000 DWT for direct shipment to Freeport for the range of channel depth alternatives between 48 and 60 feet. However, it is cost effective to load vessels up to 175,000 DWT more fully given the range of depth alternatives between 48 and 62 feet.

It would be cost effective for nearly all vessels used to transport crude petroleum from Mexico and Latin America to be loaded to depths over 45 feet given an increase in channel depth. The percentages of Middle East and Africa movements are subject to greater uncertainty because the logistics associated with offshore transfers introduces higher degrees of uncertainty than direct shipment and, therefore, generates large cost variances.

Vessels over 200,000 DWT are used for some Northern Europe transits associated with offshore lightering operations, in particular the North Sea and Norway movements. The maximum-sized vessels used for Nigerian crude oil are principally in the 110,000 to 175,000 DWT range. Most crude imported from the Persian Gulf is shipped in large crude carriers that offload their entire contents onto shuttle vessels. Vessels in the 200,000 to 375,000 DWT range are used for Persian Gulf crude, with most tonnage transported in 300,000 to 350,000 DWT vessels.

The trade route forecast for Freeport's crude petroleum imports is based on analysis of U.S. import forecast and the EIA trade route and world production forecasts. The U.S. trade route forecast includes both ocean-going and pipeline imports. Freeport's 2000 to 2004 imports by country of origin or trade route with the U.S. is shown in Table 6-6.

**Table 6-6**
**U.S. Total and U.S. Gulf Coast**
**Trade Route Forecast Distributions**
**Crude Petroleum Imports (Percent)**

| | 2000–2004 Period for U.S. Gulf, Freeport, and U.S. Total | | | U.S. Totals 2010–2030 | | |
|---|---|---|---|---|---|---|
| | Historical Base | | | Energy Information Administration Forecast | | |
| Trade Route | U.S. Gulf | Freeport | U.S. Total | 2010 | 2020 | 2030 |
| Mexico | 25.2 | 3.8 | 15.6 | 14.3 | 13.8 | 13.3 |
| Central and South America | 25.4 | 43.0 | 19.1 | 15.6 | 15.8 | 16.6 |
| Western South America | 0.6 | 0.7 | 0.3 | 4.0 | 3.8 | 3.4 |
| Mediterranean & Europe | 7.5 | 8.4 | 7.1 | 5.2 | 4.9 | 4.4 |
| Western Africa | 9.5 | 8.0 | 13.6 | 15.3 | 15.0 | 15.2 |
| Middle East | 31.0 | 36.0 | 26.1 | 26.4 | 25.8 | 23.5 |
| Far East | 0.2 | – | 2.8 | 3.3 | 3.6 | 3.8 |
| Canada | 0.6 | – | 15.4 | 16.0 | 17.3 | 19.9 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

Source: DOE, EIA, Early Release December 2007, Table 117.

Canada is the leading supplier of U.S. crude oil, with slightly higher imports than Saudi Arabia. Fifteen percent of 2003 to 2005 U.S. crude petroleum imports came from Canada. Most of Canadian movements were transmitted by pipeline, but there are some ocean-going vessel movements. Freeport's 2002 to 2005 vessel records did not show any Canadian cargo, but U.S. Gulf Coast imports showed some import with low volumes. Freeport's 2006 vessel records showed three vessels with Canadian crude. All three vessels were Suezmax tankers. Freeport's 2006 to 2007 Canadian imports represented 0.3 percent of total imports for each year.

Venezuela constitutes a significant share of Freeport's imports. In comparison to other regions, Freeport has the capacity to refine relatively higher shares of light crude shipped from Venezuela as well as the heavy crudes. Venezuela's long-term reserves are significantly higher than Mexico's reserves.

Brazil has the second largest oil reserves in South America, but its reserves of approximately 12 billion barrels are significantly less than Venezuela's 80 billion barrels. Brazil, along with Kazakhstan, United Arab Emirates, and Libya, were recognized as the U.S. market's fastest-growing crude oil providers. Proven reserves for Kuwait, United Arab Emirates, and Libya are 101, 97, and 41 billion barrels, respectively. Comparatively, proven reserves for Saudi Arabia and Canada are estimated at 262 and 179 billion barrels.

The EIA shows large increases in Brazilian production and imports to the U.S., but Brazil currently remains a net importer of crude. The EIA notes that most of Brazil's imports are from Argentina. Transportation logistics result in Brazil importing crude from Argentina and exporting other crude to the U.S. In 2007, U.S. crude oil imports from Brazil increased by 500 percent over 2006 levels. The EIA shows Brazil's production of conventional fuels increasing at an average annual growth rate of 4.4 percent between 2005 and 2030.

The AEO 2008 production forecast and projection of U.S. import trade routes show relatively high growth rates of U.S. imports from Latin America. In 2007, the Brazilian government signed contracts for the construction of 10 Suezmax tankers with the goal of modernizing state-run oil company Petrobras's fleet. Petrobras plans to acquire a total of 42 new ships between 2007 and 2015.[9] In 2007, 29 percent of vessels over 140,000 DWT using Freeport transported Brazilian crude oil imports.

Freeport received a lower share of Mexican crude and a higher share of South American and Caribbean crude compared to the U.S. and Gulf Coast. Table 6-7 presents Freeport's 2005 to 2009 trade route distribution and application of the EIA's 2010 trade route forecast. The 2010-based trade route forecast shows a significant drop in imports from the Middle East. The forecast does not reflect the inclusion of Canadian crude. Future expectations are that the majority of Canadian crude would be transported by pipeline. Table 6-8 shows the tonnage forecast used in the analysis by incorporating Global Insight's tonnage forecast for the U.S. and EIA's trade route forecast.

[9] Marine Digest and Cargo Business News, Summary for January 29–February 2, 2007.

**Table 6-7**
**Distribution of Freeport Crude Oil Tonnage by Trade Route and Decade**
**2005/2009 and 2017/2027/2035**

| Trade Route | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2017 | 2027 | 2035 |
|---|---|---|---|---|---|---|---|---|---|
| | Percentage Distribution | | | | | | | | |
| Canada | – | – | – | 1 | 0 | - | 1 | 1 | 1 |
| Mexico and E. South America | 4 | 2 | 4 | 5 | 7 | 4 | 5 | 5 | 5 |
| Venezuela and Colombia | 58 | 52 | 49 | 44 | 32 | 58 | 40 | 37 | 37 |
| Brazil and Argentina | 4 | 4 | 4 | 2 | 11 | 4 | 7 | 9 | 9 |
| Western S. America | 1 | 1 | 0 | 0 | 4 | 1 | 10 | 11 | 11 |
| Europe, Africa, and Mediterranean | 9 | 14 | 9 | 16 | 20 | 9 | 13 | 13 | 13 |
| W. Africa | 21 | 13 | 17 | 17 | 19 | 21 | 20 | 20 | 20 |
| Middle East | 4 | 15 | 16 | 14 | 6 | 4 | 4 | 4 | 4 |
| Pacific/Asia | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Source: Application of AEO2010 Trade Route Forecast.

**Table 6-8**
**Freeport Crude Petroleum Import Tonnage**
**by Representative Trade Route and Decade (1,000s)**
**FY 2009 Vessel Costs December 2008**

| | 2017 | 2027 | 2037 | 2047 | 2057 | 2067 | Average Annual Growth (%) |
|---|---|---|---|---|---|---|---|
| Mexico | 4,220 | 5,748 | 7,222 | 8,927 | 10,490 | 12,054 | 2.1 |
| Central/South America | 5,921 | 8,666 | 10,888 | 13,536 | 16,026 | 18,517 | 2.3 |
| Europe and Africa | 6,022 | 8,518 | 10,702 | 13,227 | 15,587 | 17,946 | 2.1 |
| Middle East | 8,913 | 12,063 | 15,157 | 18,281 | 21,458 | 24,636 | 2.2 |
| Total Tonnage (1,000s) | 25,076 | 34,994 | 43,969 | 53,971 | 63,562 | 73,153 | 2.2 |

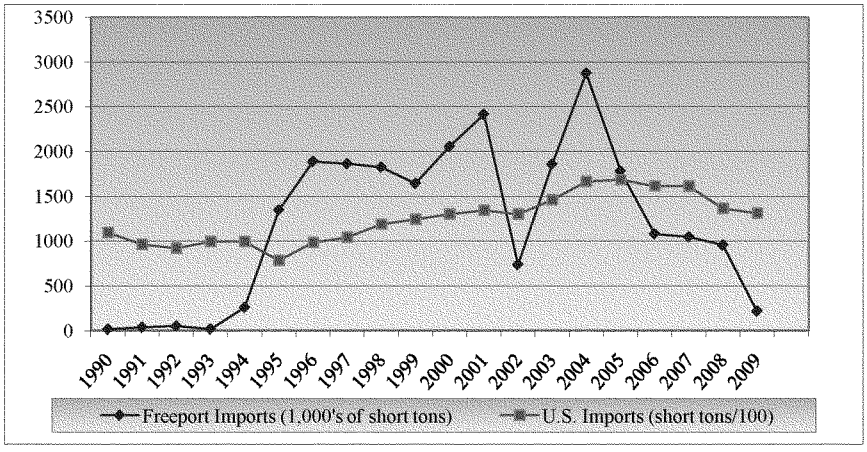
## 6.2 PETROLEUM PRODUCT IMPORTS

While experiencing tremendous growth in the early 1990s, petroleum product imports remained relatively constant since the mid-1990s before dropping in 2007, shown in Figure 6-3. Recent record lows occurred in 2008 to 2009. These lows are associated with drops in gasoline and residual fuel oil imports and parallel national figures but to a much greater extent. Gasoline and residual fuel oil are used for blending and feedstock input in refining crude oil.

The 2009 drop in Freeport's product imports relates to an increase in receipt of low-sulphur crude oil from Norway for that year. Low-sulphur crude requires fewer blending components and feedstock inputs than the heavier crudes that Freeport has traditionally imported. The peaks in Freeport product imports relate to years when crude oil imports from Venezuela peaked.

Freeport's 2010 crude oil import data found at the EIA website showed that imports from Venezuela were comparable to 2008[10].

**Figure 6-3**
**U.S. and Freeport Petroleum Product Imports 1990–2010**



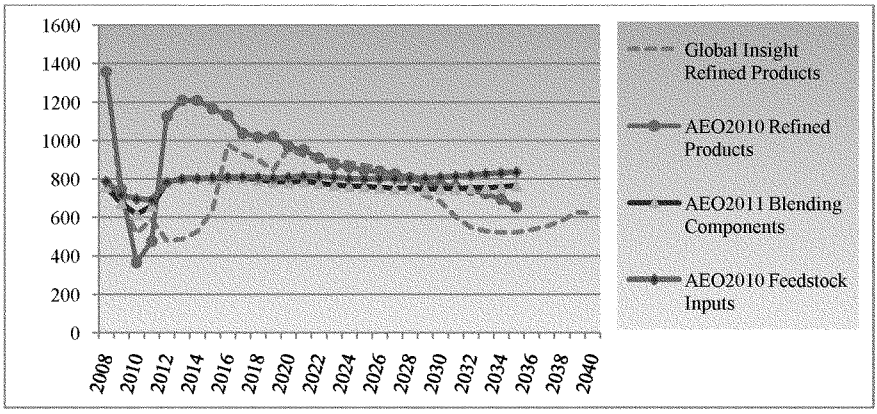

Source: USACE, Waterborne Commerce of the U.S. 1990-09.

Future expectations concerning the origins of U.S. and regional import volumes of both crude petroleum and sulphur content and subsequent need for blending components and feedstock requirements are subject to a high degree of uncertainty. Recognizing uncertainties, the AEO forecast continues to show imports of partially refined products increasing over the 2008/2009 to 2040 forecast period. Blending components include gasoline, gasoline blending components, jet fuel, and distillate fuel oil. While the AEO forecasts (2009 through the 2011 early release) show crude oil imports declining, partially refined products are forecasted to increase to 2008 levels after 2013 and remain steady over the remainder of the forecast period

Freeport's petroleum product import tonnage forecast was prepared using the AEO2011 early release projections (December 2010). The AEO2011 product forecast follows a similar pattern as its 2009 and 2010 projections. Global Insight's September 2010 forecast was also reviewed in preparing Freeport's forecasts. Figure 6-4 shows the AEO2011 and Global Insight forecast data. Imports of refined products are forecasted to decline by AEO and Global Insight. AEO shows partially refined products increasing to 2008 levels after 2013 and then remaining relatively steady for the remainder of the forecast period.

[10] Company level details associated with imports by country of origin and sulphur content can be found at the following EIA link: http://www.eia.doe.gov/oil_gas/petroleum/data_publications/company_level_imports/cli.html

**Figure 6-4**
**U.S. and Freeport Petroleum Product Imports (2008-2040)**




Source: Aggregated from *2011 Annual Energy Outlook*, Report Number: DOE/EIA-0383ER(2011), Early Release December 2010. The Global Insight September 2010 forecast

In general, gasoline and fully finished product imports have historically been concentrated on the U.S. East Coast, with imports to Gulf Coast ports, like Freeport, consisting more heavily of unfinished products. Freeport's imports of gasoline will serve to supplement shortfalls in U.S. refining and continue to be relatively low in comparison to crude petroleum imports. Freeport's imports of partially refined products are expected to experience modest increases after the drop in 2009. Freeport's historical product base consists exclusively of unfinished oils and blending components.

Freeport's product import forecast is a function of the source of crude petroleum. Freeport is expected to continue receiving a steady volume of crude oil imports. This expectation is based on the ConocoPhillips refinery in nearby Sweeny and the extensive network of pipelines from Freeport to other regional and to Midwest refineries. In addition to these movements, crude oil imported to Freeport is transmitted to the Bryan Mound SPR.

Table 6-9 summarizes Freeport's petroleum product import forecast. Three scenarios are presented. The scenarios are based on application of the 2007 to 2009 to 2017 to 2035 U.S. growth rates for blending component and feedstock inputs to Freeport's 2007 to 2009 product imports. While specific sources and relative sulphur content of future crude oil imports is subject to uncertainty, the EIA and other experts have noted that the relative percentage of crude with high sulphur content is expected in the future. A higher percentage of high-sulphur crudes was imported in 2007, and a low percentage of high-sulphur crudes was imported in 2009. U.S. growth rate applied to Freeport's 2007 tonnage was used for base scenario used for the benefit calculations.

**Table 6-9**
**U.S. and Freeport Petroleum Product Imports**
**Freeport Shift Share Percentage Application**

| Year | Blending Component (millions of barrels/day) | Feedstock Inputs (millions of barrels/day) | Total (millions of barrels/day) | Freeport Imports 1,000s of short tons | | |
|---|---|---|---|---|---|---|
| 2007 | 0.72 | 0.75 | 1.47 | 1,046 | | |
| 2008 | 0.76 | 0.79 | 1.55 | 955 | | |
| 2009 | 0.68 | 0.72 | 1.40 | 220 | | |
| | Blending Component Forecast | Feedstock Inputs Forecast | U.S. Total | Freeport Forecast | | |
| | | | | 2007 Base | 2008 Base | 2009 Base |
| 2017 | 0.81 | 0.81 | 1.62 | 1,151 | 996 | 254 |
| 2020 | 0.78 | 0.81 | 1.60 | 1,135 | 983 | 251 |
| 2027 | 0.75 | 0.80 | 1.55 | 1,106 | 958 | 244 |
| 2030 | 0.75 | 0.81 | 1.56 | 1,111 | 962 | 245 |
| 2035 | 0.77 | 0.84 | 1.60 | 1,141 | 988 | 252 |

### 6.2.1 Petroleum Products Imports by Trade Route

Table 6-10 shows the 2003 to 2006 trade route distribution for Freeport's petroleum product imports. The 2003 to 2006 petroleum product import trade route distribution consists primarily of imports from Algeria and the Middle East. The future petroleum product import trade route distribution was assumed to include higher volumes of imports from Latin America than presently occurring. This assumption is based on developing trends towards increased investments in refining and based on general informational discussions in the EIA publications.

**Table 6-10**
**Freeport Harbor Petroleum Product**
**Trade Route Distribution, 2003–2006**
**Representative Distribution by**
**Major Trade Route (Percent)**

| Trade Route | Petroleum Product Imports |
|---|---|
| Canada | – |
| Latin America | 26.7 |
| Northern Europe, Africa, and Mediterranean | 48.9 |
| Middle East and Far East | 24.4 |
| Total | 100 |

Freeport's petroleum product imports for 2002 to 2007 showed that Freeport's more deeply loaded vessels carried lube oil and gasoline. Over 50 percent of Freeport's 2003 to 2005 petroleum product imports were shipped from the Algerian port of Arzew. Nearly all lube oil imports came from Arzew, Algeria. Gasoline is imported from both Algeria and Saudi Arabia.

An accommodating depth of 49 to 56 feet is noted in the World Port Index at the oil product terminal in Algeria for crude oil and products. The Arzew refinery is owned by the Algerian national oil company Sonatrach, which owns four refineries in Algeria. Other lube oil refineries in the Mediterranean are located in Alexandria and Port Said, Egypt.

Table 6-11 presents data associated with the ports of origin for Freeport's 2003 to 2005 petroleum product imports transported in vessels with loaded drafts of 39 feet or more. Sixty-three percent of Freeport's 2003 to 2005 tonnage was transported in vessels with loaded drafts of 39 feet or more and was transported from vessels with channel depths of 43 feet or more. Freeport's crude petroleum trade routes suggest that the availability of channel depths over 45 feet would provide cost incentives for at least 50 percent of petroleum product import tonnage to be transported in more fully loaded vessels. For purposes of analysis, channel-deepening benefits were calculated for 43 percent of Freeport's 2017 to 2027 petroleum product imports and 63 percent of 2037 to 2067 imports.

**Table 6-11**
**Port Depths at Major Ports Transporting Petroleum Products to Freeport (2003–2005)**

| Region | Port | Country | 2003–2005 Total Tonnage for Vessels with Loaded Drafts ≥39 Feet | | Channel Depth at Product Pier (feet) |
|---|---|---|---|---|---|
| | | | Short Tons | % of Total | |
| Mexico | Pajaritos | Mexico | 59,073 | 1.7 | 55 |
| Mexico | Dos Bocas | Mexico | 58,329 | 1.6 | 72 |
| Eastern South America | Puerto La Cruz | Venezuela | 88,741 | 2.5 | 55 |
| Western South America | Balao | Ecuador | 55,889 | 1.6 | 51 |
| Northern Europe | Wilhelmshaven | Fed Germany | 31,757 | 0.9 | 51 |
| Mediterranean | Elefsis | Greece | 133,976 | 3.8 | 43 |
| Mediterranean | Milazzo | Italy | 90,303 | 2.5 | 52 |
| Mediterranean | Mohammedia | Morocco | 77,632 | 2.2 | 52 |
| Mediterranean | Skikda | Algeria | 104,651 | 2.9 | 52 |
| Mediterranean | Arzew | Algeria | 1,893,266 | 53.1 | 56 |
| Middle East | Jebel Ali | United Arab Emirates | 42,427 | 1.2 | 46 |
| Middle East | Al Jubail | Saudi Arabia | 32,626 | 0.9 | 50 |
| Middle East | Jiddah | Saudi Arabia | 38,546 | 1.1 | 51 |
| Middle East | All Other Saudi Arabia Ports | Saudi Arabia | 806,624 | 22.6 | 50 |
| Middle East | Jebel Dhanna | United Arab Emirates | 48,488 | 1.4 | 56 |
| Total Tonnage For Vessels With Loaded Drafts ≥39 feet | | | 3,562,328 | 100 | |
| % of all Tonnage for All Loaded Drafts | | | 62.5 | | |

Source: National Imagery and Mapping Agency, 2000 World Port Index, Pub. 150; Lloyd's, World Shipping Encyclopedia, April 2003; and USACE, Waterborne Commerce 2003–2005 detailed records.

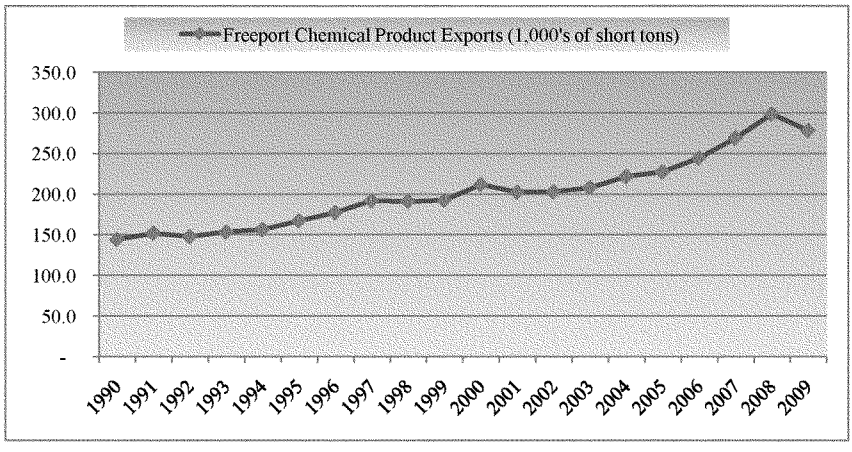
## 6.3 CHEMICAL PRODUCT EXPORTS

Forecast of Freeport's chemical exports were estimated based on analysis of 1990 to 2009 trendline data and the export value associated industrial materials and supplies. As background, industrial materials and supplies include the USACE commodity classifications listed as follows.

- Chemical Products (codes 3110–3299)
- Petroleum Products, excluding crude petroleum (codes 2211–2990)
- Crude Materials (codes 4110–4900)
- Primary Manufactured Goods (codes 5110–5540)
- Farm Products, excluding food (codes 6889–6899)

Figure 6-5 displays Freeport's exports and the value of industrial materials and supplies. Regression equation outputs for Freeport's 1990 to 2009 chemical exports and the value of U.S. industrial materials and supplies are displayed in Table 6-12. The trendline of Freeport's exports produced a more conservative forecast than the regression, so the trendline was used for the baseline estimate. Table 6-13 displays the result of the trendline equation data. Table 6-14 shows application of these estimates to base tonnage.

**Figure 6-5**
**Freeport Chemical Product Exports (1990–2009)**




Sources: USACE, Waterborne Commerce of the U.S., Parts 2 and 5, 1990–2009.

**Table 6-12**
**Regression Equation Data for**
**Freeport Chemical Product Export Forecast**

| Component | Description of Data and Outputs |
|---|---|
| Dependent Variable | Freeport Chemical Product Export Tonnage 1990–2009 |
| Independent Variable | U.S. Industrial Materials & Supplies Export Value |
| Adjusted R Square | 0.6774 |
| No. of Observations | 20 |
| Degrees of Freedom | 1 |
| X Coefficient Level of Significance of t value | 5.07E-06 |
| F Statistic | 40.90 |
| Significance of F statistic | 5.07E06 |

| | Regression Equation Data | | |
|---|---|---|---|
| | Base Output | Application of Standard Deviation | |
| | | Minus 1 | Plus 1 |
| Constant | –426.57 | –1,168.60 | 315.45 |
| Standard Error of Y Estimate | 332.79 | 332.79 | 332.79 |
| X Coefficient: U.S. Industrial Materials & Supplies Export Value | 0.01093 | 0.00734 | 0.014524 |

| | | Freeport (1,000s of Short Tons) 2005-09 | | | |
|---|---|---|---|---|---|
| | | | Base | Application of Standard Deviation | |
| Historical Year | U.S. Industrial Materials & Supplies | Actual | Estimate[a] | Minus 1 | Plus 1 |
| 2005 | 227,475 | 2,509 | 2,060 | 501 | 3,619 |
| 2006 | 244,600 | 2,551 | 2,247 | 627 | 3,868 |
| 2007 | 269,175 | 2,691 | 2,516 | 807 | 4,225 |
| 2008 | 298,525 | 2,403 | 2,837 | 1,023 | 4,651 |
| 2009 | 278,100 | 1,863 | 2,614 | 873 | 4,354 |

| | | Freeport Regression Based Forecast[a] | | |
|---|---|---|---|---|
| | | | Application of Standard Deviation | |
| Forecast Year | U.S. Industrial Materials & Supplies | Base Estimate[a] | Minimum | Maximum |
| 2017 | 458,280 | 4,583 | 2,196 | 6,971 |
| 2027 | 683,351 | 7,044 | 3,848 | 10,240 |
| 2037 | 909,301 | 9,514 | 5,507 | 13,522 |
| 2040 | 977,504 | 10,260 | 6,007 | 14,512 |

Source: USACE, Waterborne Commerce of the U.S. 2001–2005, and Global Insight, 3rd Quarter 2007 Long-Term Forecast using Table Trd1A. Global Insight's forecast extends through 2040.

[a]Freeport 2027 Exports = –426.6 + (0.010932 * 683,351) with $683,351 being the forecasted value of U.S. industrial materials and supplies in 2027.

**Table 6-13**
**Trendline Equation Output for**
**Freeport Chemical Product Exports**

| Component | Description of Data and Outputs |
|---|---|
| Dependent Variable | Freeport Chemical Product Export Tonnage 1990–2009 |
| Independent Variable | Year |
| Adjusted R Square | 0.783 |
| No. of Observations | 20 |
| Degrees of Freedom | 1 |
| X Coefficient Level of Significance of t value | 1.3398E-07 |
| F Statistic | 69.61 |
| Significance of F statistic | 1.34E-07 |

| | Trendline Equation Data | | |
|---|---|---|---|
| | Base Output | Application of Standard Deviation | |
| | | Minus 1 | Plus 1 |
| Constant | –174,739.8 | –219,186.6 | –130,290.9 |
| Standard Error of Y Estimate | 272.9 | 272.9 | 272.9 |
| X Coefficient: U.S. Industrial Materials & Supplies Export Value | 88.29 | 66.05 | 110.52 |

| | Freeport (1,000s of Short Tons) 2001–2005 | | | |
|---|---|---|---|---|
| | | | Application of Standard Deviation | |
| Historical Year | Actual | Base Estimate[a] | Minus 1 | Plus 1 |
| 2005 | 2,509 | 2,261 | (86,753) | 91,287 |
| 2006 | 2,551 | 2,355 | (86,687) | 91,397 |
| 2007 | 2,691 | 2,444 | (86,621) | 91,508 |
| 2008 | 2,403 | 2,532 | (86,555) | 91,618 |
| 2009 | 1,863 | 2,620 | (86,489) | 91,729 |

[a]Freeport 2020 Exports = –174,739.8 + (88.29 *2005) produced a base estimate of 2,267.1 for 2005.

**Table 6-14**
**Freeport Chemical Product Exports Trendline Equation Residual Application**

| Year | Actual Exports | Predicted Exports | Residuals Values | Application of Absolute Residual Values | | Factor Difference Between Predicted Exports and Absolute Residual Values | |
|---|---|---|---|---|---|---|---|
| | | | | Minus | Plus | Minus | Plus |
| 1990 | 1,093 | 942.8 | 150.2 | 943 | 1,243 | 0.86 | 1.14 |
| 1991 | 967 | 1,031.1 | (64.1) | 903 | 1,031 | 0.93 | 1.07 |
| 1992 | 871 | 1,119.4 | (248.4) | 623 | 1,119 | 0.71 | 1.29 |
| 1993 | 931 | 1,207.7 | (276.7) | 654 | 1,208 | 0.70 | 1.30 |
| 1994 | 1,431 | 1,295.9 | 135.1 | 1,296 | 1,566 | 0.91 | 1.09 |
| 1995 | 1,425 | 1,384.2 | 40.8 | 1,384 | 1,466 | 0.97 | 1.03 |
| 1996 | 1,418 | 1,472.5 | (54.5) | 1,363 | 1,473 | 0.96 | 1.04 |
| 1997 | 1,522 | 1,560.8 | (38.8) | 1,483 | 1,561 | 0.97 | 1.03 |
| 1998 | 1,724 | 1,649.1 | 74.9 | 1,649 | 1,799 | 0.96 | 1.04 |
| 1999 | 1,633 | 1,737.4 | (104.4) | 1,529 | 1,737 | 0.94 | 1.06 |
| 2000 | 2,217 | 1,825.6 | 391.4 | 1,826 | 2,608 | 0.82 | 1.18 |
| 2001 | 1,748 | 1,913.9 | (165.9) | 1,582 | 1,914 | 0.91 | 1.09 |
| 2002 | 1,907 | 2,002.2 | (95.2) | 1,812 | 2,002 | 0.95 | 1.05 |
| 2003 | 2,104 | 2,090.5 | 13.5 | 2,090 | 2,118 | 0.99 | 1.01 |
| 2004 | 2,622 | 2,178.8 | 443.2 | 2,179 | 3,065 | 0.83 | 1.17 |
| 2005 | 2,509 | 2,267.1 | 241.9 | 2,267 | 2,751 | 0.90 | 1.10 |
| 2006 | 2,551 | 2,355.3 | 195.7 | 2,355 | 2,747 | 0.92 | 1.08 |
| 2007 | 2,691 | 2,443.6 | 247.4 | 2,444 | 2,938 | 0.91 | 1.09 |
| 2008 | 2,403 | 2,531.9 | (128.9) | 2,274 | 2,532 | 0.95 | 1.05 |
| 2009 | 1,863 | 2,620.2 | (757.2) | 1,106 | 2,620 | 0.59 | 1.41 |
| | | | | | minimum | 0.59 | 1.01 |
| | | | | | maximum | 0.99 | 1.41 |
| | | | | | | | |
| | | **Base** | | **Minimum[a]** | **Maximum[a]** | | |
| | | **Exports** | | **Exports** | **Exports** | | |
| 2017 | | 3,326 | | 1,974 | 4,678 | | |
| 2027 | | 4,209 | | 2,498 | 5,920 | | |
| 2037 | | 5,092 | | 3,023 | 7,162 | | |
| 2047 | | 5,975 | | 3,547 | 8,403 | | |
| 2057 | | 6,858 | | 4,071 | 9,645 | | |
| 2067 | | 7,741 | | 4,595 | 10,887 | | |

[a]Minimum exports were calculated using the minimum absolute difference between 1990–2009 predicted exports and actual exports; this value was 0.59. Maximum exports were calculated using the maximum absolute difference between 1990–2009 predicted exports and actual exports; this value was 1.41.

Maximum loaded drafts of 36 to 39 feet for Freeport's 1990 and 1993 chemical export tonnage shifted to maximum loaded drafts of 40 to 43 feet for 2002 to 2007 chemical export tonnage. Freeport's vessel utilization patterns from the early 1990s to 2007 show that 5 percent of tonnage was shipped in vessels with loaded drafts of 40 feet or more, up from zero percent in the early 1990s. Recently, chemical exports have exhibited some transition to more fully loaded vessels. Between 5 and 11 percent of 2003 to 2007 chemical exports were transported in vessels with loaded drafts over 40 feet. Chemical vessels on order, the Panama Canal expansion, and the trends in increasing loaded drafts provided the basis for assuming that 14 percent of Freeport's long-term chemical exports will be loaded to drafts of 42 feet or more given the availability of an increase in Freeport's channel depth.

### 6.3.1 Chemical Product Exports by Trade Route

Principal receiving ports include Brazil, Canada, and the Far East. Demand for chemical products is anticipated to remain strong for markets in the Pacific and Brazil, and completion of the Panama Canal improvements in 2014 is expected to result in increases in Freeport's chemical shipments to the Far East. Freeport's chemical exports to Brazil are primarily shipped to the port of Itaqui. There are port development projects taking place at Itaqui and other Brazilian ports. Presently, the maximum channel depth is approximately 43 feet. Port of Itaqui information states that Petrobrás, Brazil's largest industrial company, leases dock facilities at Itaqui. The maximum loaded draft is 19 meters at Itaqui, which is equal to approximately 62 feet. The depth at the docks that export steel slab is 59 feet. The largest vessel that can be accommodated at the Canadian port of Port Alfred is presently 40 feet, and there do not appear to be any plans for expansion. Channel depths and dock accommodations at ports in Korea and Singapore are capable of accommodating vessels with loaded drafts over 50 feet. Table 6-15 shows port depths at major ports receiving chemical products from Freeport.

**Table 6-15**
**Port Depths at Major Ports Receiving Chemical Products from Freeport (2003–2005)**

| Region | Port | Country | 2003–2005 Total Tonnage for Vessels with Loaded Drafts ≥39 feet | | Channel Depth at Chemical Pier (feet) |
|---|---|---|---|---|---|
| | | | Short Tons | % of Total | |
| Brazil | Itaqui | Brazil | 94,895 | 33.2 | 59 |
| Northern Europe | Hamburg | Germany | 659 | 0.2 | 43 |
| Northern Europe | Le Havre | France | 6,537 | 2.3 | 43 |
| Northern Europe | Terneuzen | Netherlands | 19,649 | 6.9 | 44 |
| Northern Europe | Rotterdam | Netherlands | 43,378 | 15.2 | 49 |
| Northern Europe | Antwerp | Belgium | 15,629 | 5.5 | 62 |
| Middle East/Far East | Merak | Indonesia | 9,580 | 3.3 | 43 |
| Middle East/Far East | Bombay | India | 5,481 | 1.9 | 47 |
| Pacific | Yokohama | Japan | 8,636 | 3.0 | 40 |
| Pacific | Ning Bo | China (Mainland) | 24,523 | 8.6 | 46 |
| Pacific | Tai Chung | China (Taiwan) | 8,355 | 2.9 | 46 |
| Pacific | Kao Hsiung | China (Taiwan) | 12,701 | 4.4 | 52 |
| Pacific | Singapore | Singapore | 36,140 | 12.6 | 46 |
| Total Tonnage For Vessels With Loaded Drafts ≥39 feet | | | 286,163 | 100 | |
| % of all 2003–2005 Tonnage for All Loaded Drafts | | | 3.8 | | |

Source: National Imagery and Mapping Agency, 2000 World Port Index, Pub. 150; Lloyd's, World Shipping Encyclopedia, April 2003; and USACE, Waterborne Commerce 2003–2005 detailed records.

Table 6-16 shows the 2003 to 2006 trade route distribution presented for Freeport's chemical product exports were assumed to remain constant in the future.

**Table 6-16**
**Freeport Harbor Chemical Product**
**Trade Route Distribution, 2003–2006**
**Representative Distribution by Major Trade Route (Percent)**

| Trade Route | Chemical Product Exports |
|---|---|
| Canada | 17.2 |
| Latin America | 63.8 |
| Northern Europe, Africa, and Mediterranean | 10.0 |
| Middle East and Far East | 9.0 |
| Total | 100 |

The 2003 to 2006 chemical export trade routes consist primarily of Brazil, Northern Europe, and the Pacific. Freeport's 2009 chemical export destinations showed that 20 percent of shipments went to Asia. Transportation cost calculations were estimated using average mileage and the present distribution of ports.

## 6.4 CONTAINER IMPORTS AND EXPORTS

Global Insight expected increases in domestic products after 2010, based on its April 2009 evaluations. Recent GDP had a minor decrease in 2009 but now is steadily increasing, and has been helped by an overall increase in exports due to the declining value of the dollar relative to other currencies. Global Insight's long-term average annual growth rate forecast data are summarized in Table 6-17. Figure 6-6 presents Global Insight's 2006 to 2039 forecast of total expenditures, and Figure 6-7 presents their GDP forecast.

**Table 6-17**
**Global Insight U.S. Gross Domestic Product Forecast**

| Average Annual Growth | 1976–2006 Historical (%) | 2006 ($) | 2039 ($) | Average Annual Growth Rate (%) |
|---|---|---|---|---|
| Gross Domestic Product | 3.1 | 13,178 | 62,836 | 4.8 |
| Consumption | 3.3 | 8,029 | 16,736 | 4.8 |
| Imports | 6.8 | 1,315 | 6,452 | 4.8 |
| Exports | 5.9 | 1,931 | 7,199 | 4.8 |

Source: Global Insight, "The U.S. Economy, The 30-Year Focus," April 2009.

**Figure 6-6**
**U.S. Total Expenditure Forecast**
**Billions of Chained 2000 Dollars (2006–2039)**

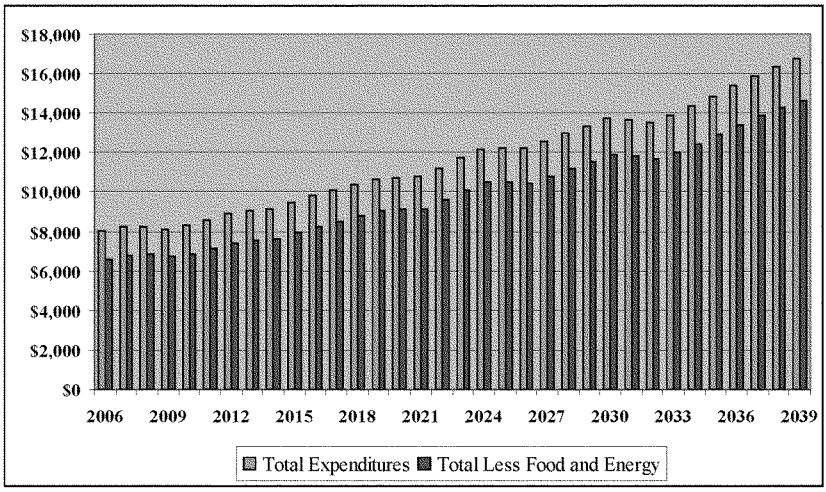
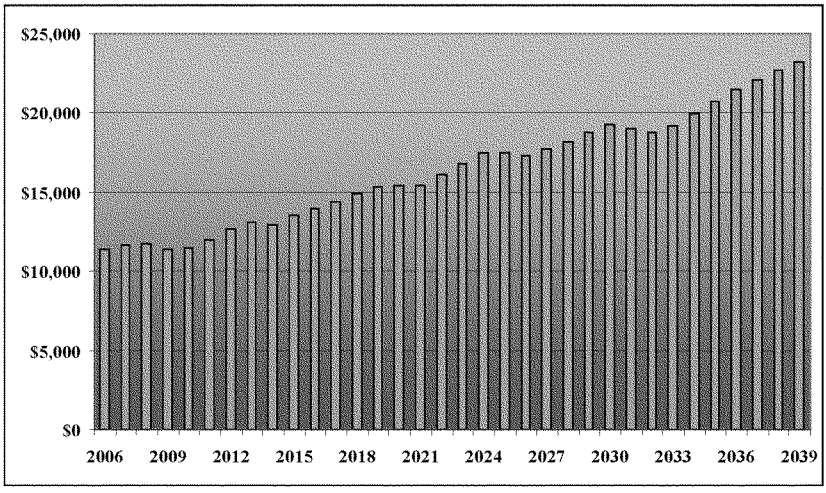



**Figure 6-7**
**U.S. Gross Domestic Product Forecast**
**Billions of Chained 2000 Dollars (2006–2039)**




Source: Global Insight, "The U.S. Economy, The 30-Year Focus," April 2009.

Over the next 20 years, Texas ports, waterways, highways, and rail facilities will handle between 50 and 85 percent more freight, depending on the mode of transportation, according to a report by TxDOT entitled "Texas Ports 2007 to 2008 Capital Program."

U.S. demand for imported containerized goods is a function of domestic income, population, exchange rates, and other factors.[11] Demand for containerized exports depends upon economic activity in other countries, exchange rates, and other factors. The geographic pattern of U.S. demand for container port services depends upon (1) the location of domestic consumers with respect to foreign sources for imports, (2) the location of manufacturers, farms, resource industries, and other exporting businesses relative to foreign markets for their goods, and (3) the availability and relative costs of intermodal transport from sources to markets. Several analysts have found a high correlation between population and container volume, particularly imports. While population is one of several variables affecting traffic growth, it is a key variable particularly for this study region where over 90 percent of existing container tonnage is served by trucks. While the population forecast shows fairly high growth for the region included in the Houston-Galveston-Brazoria Consolidated Metropolitan Statistical Area, 2009 data show that regional population has increased at higher rates than expected. Population growth for the counties within the Freeport and Houston port areas is presented in Table 6-18.

**Table 6-18**
**Houston-Galveston-Brazoria Consolidated Metropolitan Statistical Area**
**Population Projections, Texas Counties Adjacent to Freeport, Texas**

| County | 2000 | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 | Average Annual Growth Rate (%) 2000–2060 |
|---|---|---|---|---|---|---|---|---|
| Brazoria County | 241,767 | 285,850 | 331,731 | 375,664 | 416,157 | 459,078 | 503,894 | 1.2 |
| Harris County | 3,321,660 | 3,869,179 | 4,416,793 | 4,964,463 | 5,512,168 | 6,059,895 | 6,607,635 | 1.2 |
| Fort Bend | 354,452 | 490,072 | 630,624 | 802,486 | 979,196 | 1,210,945 | 1,475,761 | 2.4 |
| Wharton County | 41,188 | 43,560 | 46,045 | 47,647 | 48,567 | 48,590 | 48,074 | 0.3 |
| Galveston | 250,158 | 268,714 | 284,731 | 294,218 | 298,057 | 300,915 | 302,774 | 0.3 |
| Matagorda | 37,957 | 40,506 | 43,295 | 44,991 | 45,925 | 45,793 | 45,377 | 0.3 |

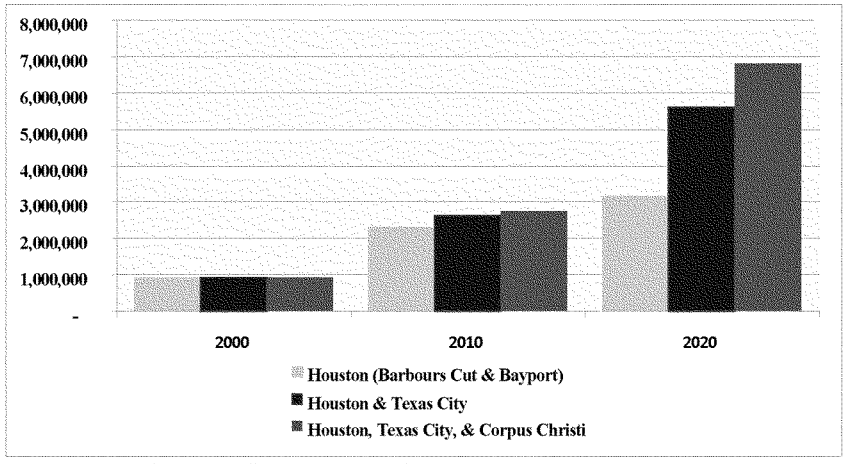
Source: Texas Water Development Board, 2006 Regional Water Plan, County Population Projections 2000–2060.

[11] University of Rhode Island Transportation Center, Comprehensive Framework for Sustainable Container Port Development for the United States East Coast: *Year One Final Report, October 2001*, P. I-9

Market demand for an additional U.S. Gulf Coast container terminal, such as Freeport, is a function of ability of competing terminals to meet consumer and producer demand. Figure 6-8 shows 2000, 2010, and 2020 regional market supply based on terminal availability of Barbours Cut, Bayport, and the potential additions of new terminals in Texas City and Corpus Christi, and a 60 percent expansion of Bayport TEU capacity. The effect of the 2010 market supply levels of 2.3 to 2.8 million TEUs, and 2010 regional market demand between 2.2 and 2.4 million TEUs produced using average annual growth rates of 7.5 and 11 percent indicate that additional capacity is not needed in 2010. However, the effect of the 2020 market supply levels of 4.5 and 7.0 million TEUs shows insufficient regional container capacity without the planned expansion of Bayport and construction of the Texas City and Corpus Christi terminals. The results of this analysis suggest that the Freeport terminal, which is presently under construction, would fill a market gap in the absence of any of the Bayport expansion and the Texas City and Corpus Christi terminals. The Bayport Container Terminal has plans to be able to handle 2 million TEUs upon full build-out in 2015. Construction of the Freeport terminal indicates that Freeport is poised to capture traffic.

The ERDC ship simulation modeling for Freeport was performed using the 1,138-foot-long by 140.8-foot-wide *Susan Maersk* containership. The results of the modeling revealed that none of the pilots controlling the *Susan Maersk* were able to bring the ship safely into the Brazos Harbor Turning Basin and could not navigate past Station 180+00 but smaller containerships could. In order to safely accommodate this vessel, several other improvements to the channel, including widening, is necessary. Widening is needed around the Big Bend area inbound from the Seaway Dock at the lower end of the channel. Given Freeport's channel dimensions, the ERDC ship simulation results, U.S. Gulf Coast utilization, and world fleet availability, the design vessel for Phase I of Freeport's container terminal expansion is 965 feet long by 106 feet wide.

**Figure 6-8**
**Texas Container Cargo (TEUs) 2000-2020**




Source: Compiled from port publications and general literature.

Table 6-19 shows the expected container tonnage at Freeport by vessel DWT. This distribution is for South and Central America exports and is based on Houston's distribution. Separate distributions were used for each region for imports and exports. While expectations concerning the distribution for 2017 through 2067 are subject to uncertainty, the general patterns and the shift of larger container vessels to the U.S. Gulf that occurred between 2003 and 2006 are indicative that Freeport's market will receive the larger range Panamax and some post-Panamax containerships on a regular basis. Freeport's market is expected to complement and supplement Houston's market, and the commodity distribution is anticipated to reflect Houston's distribution and the cargo mix is anticipated to consist of a high volume of exports similar to Houston. The base scenario transportation saving benefits for channel depths between 40 and 50 feet were evaluated using Houston's distribution of container tonnage.

The cargo weight is based on traffic data from Houston container ports by region. Freeport's annual tonnage volume is estimated to be approximately 1.9 million short tons in 2017, or 217,000 TEUs, representing 0.3 percent of the U.S. container throughput. Traffic will initially consist of about two vessels per week. Each vessel will drop off and pick up approximately 1,780 TEUs each vessel visit.

**Table 6-19**
**Expected Container Fleet Distribution by Vessel DWT (South and Central America Exports)**

| Vessel DWT | Distribution of Freeport's Container Tonnage by Vessel Size (%) | | |
|---|---|---|---|
| | Houston Share (Base) | U.S. Share (Sensitivity) | Houston Share Adjusted (Sensitivity) |
| 11,700 | 15.8 | 0.0 | 0.0 |
| 18,400 | 23.1 | 68.2 | 32.8 |
| 24,300 | 19.5 | 23.4 | 14.7 |
| 33,900 | 9.9 | 4.6 | 9.9 |
| 45,000 | 9.9 | 2.9 | 4.9 |
| 56,800 | 11.5 | 0.9 | 37.7 |
| 65,000 | 2.5 | 0.0 | 0.0 |
| 74,000 | 2.5 | 0.0 | 0.0 |
| 86,000 | 2.2 | 0.0 | 0.0 |
| 103,800 | 3.2 | 0.0 | 0.0 |
| Total | 100 | 100 | 100 |

The Center for Transportation Research noted that growth of the Velasco site for containers could be aided by a number of factors. The proximity to Barbours Cut and Bayport provides access to a common network of trucking firms, distribution centers, and other port support assets. According to the port, future intermodal activity originating from Freeport will rely on drays to regional yards, specifically Brazoria County. UP's relocation of its major east-west intermodal rail yard from Englewood (north of Houston) to the Rosenberg area (in Brazoria County and southwest of Houston) will aid Freeport in offering dray rates that are competitive with Barbours Cut and Bayport.[12]

Although Global Insight projects a 4.8% annual increase in container value until the year 2039, this analysis uses an average annual increase in tonnage of 0.2% for container vessels, increasing from 1.9 million short tons in 2017 to 2.1 million short tons in 2067.

Construction of Freeport's additional terminal is partly in response to capacity limitations at Freeport's existing facilities located within the confines of the Brazos Harbor Turning Basin. The terminal is also expected to meet increased long-term demand resulting from higher than anticipated regional population growth.

### 6.4.1 Container Imports And Exports by Trade Route

Table 6-20 displays the routings associated with a limited extraction of vessels using Houston and published in the Journal of Commerce database. The data presented indicate that the first

[12] TxDOT, Texas Rail System Plan, October 2005, p. 2–4. All references to Texas railroad information presented in the USACE report were obtained from the TxDOT report.

port of call after leaving Houston includes ports as far away as Brazil and Russia. Trade routes are categorized by three regions for imports and exports in the analysis. These regions include South America and Central America, Europe and Africa, and the Mediterranean and Asia.

**Table 6-20**
**Containership Vessels by Loaded Draft (Limited Review)**

| Routing Sequence (Limited Review) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| TEU | DWT | Vessel Name | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 6732<br>6402 | 42,233 | *MSC Alessia* | Veracruz | Altamira | Houston | Pt Everglades | Jacksonville | New Orleans | Freeport, Bahamas | Savannah |
| 6402 | 85,806 | *MSC Marina* | Veracruz | Altamira | New Orleans | Charleston | Antwerp | | | |
| 6402 | 85,797 | *MSC Michaela* | Veracruz | Altamira | Houston | New Orleans | Freeport, Bahamas | Charleston | Norfolk | |
| 5606 | 72,044 | *MSC Marta* | Veracruz | Altamira | Houston | New Orleans | Bahamas | Charleston | Norfolk | |
| 4614 | 58,943 | *Sea-Land Commitment* | Newark | Charleston | Houston | Cagliari, Italy | Gioia Tauro Italy | Spain | | |
| 2728 | 43,178 | *Aramis* | Houston | Colombia | Santa Marta, Cartagena | | | | | |
| – | 22,024 | *Altantic Trade* | Houston | St Petersburg | Baltimore | | | | | |
| 533 | 17,850 | *Baltic Mercur* | Houston | St Petersburg | New Orleans | Baltimore | | | | |
| 2681 | 58,548 | *CSCL Genoa* | Houston | Miami | Le Havre | | | | | |
| 1064 | 31,507 | *Houston* | Houston | Santos | | | | | | |
| 522 | 8,077 | *Industrial Century* | Houston | Rio de Janeiro | Santos | | | | | |
| 390 | 4,766 | *Karin* | Houston | Esmeraldas | Callao, Peru | Pisco, Peru | | | | |
| 4038 | 52,272 | *Libra Mexico* | Altamira | Houston | New Orleans | Buenos Aires | Santos | Rio de Janeiro | Caucedo, Dominican Republic | Veracruz |
| 167 | 3,504 | *Malte B* | Houston | Santa Marta | Cartagena | | | | | |
| 1464 | 43,700 | *Star Derby* | Houston | Mobile | Zhangiagang | | | | | |
| 1100 | 30,975 | *Yellowstone* | Houston | Altamira | Richards Bay, S. Africa | Durban | | | | |
| 256 | 2,700 | *Baltimar Saturn* | Houston | Esmeraldas | Guayaquil | Callao | | | | |
| 3102 | 40,638 | *CMA CGM Lotus* | Houston | Miami | | Le Havre | Antwerp | Rotterdam | Charleston | |
| 4248 | 50,869 | *Santos* | Altamira | Houston | New Orleans | Buenos Aires | Santos | Rio de Janeiro | Caucedo, Dominican Republic | Veracruz |
| 4253 | 50,813 | *Westfalia Express* | Montevideo | Buenos Aires | Itajai, Brazil | Santos | Houston | | | |

Source: Journal of Commerce, Vessel Itinerary Search, 2008.

## 6.5 UPPER STAUFFER

The Minerals Management Service (MMS) 2009 to 2018 U.S. Gulf of Mexico oil and gas forecast shows production potentially peaking at 1.8 million BPD. Table 6-21 displays the MMS forecast.

**Table 6-21**
**Gulf of Mexico (GOM) Annual Oil Production Rates (1,000s Barrels/Day)**

| Year | Shallow Water Historical | MMS Shallow Water Projection | Deepwater Historical | Industry Deepwater Projection | MMS Deepwater Projection | Committed Scenario Total GOM | Industry Deepwater Projection | Undiscovered Resources | Full Potential Scenario Total GOM |
|---|---|---|---|---|---|---|---|---|---|
| 1981 | 719 | | | | | | | | |
| 1987 | 892 | | | | | | | | |
| 1997 | 830 | | 296 | | | 1,126 | | | |
| 1998 | 781 | | 436 | | | 1,217 | | | |
| 1999 | 738 | | 515 | | | 1,353 | | | |
| 2000 | 690 | | 743 | | | 1,433 | | | |
| 2001 | 667 | | 864 | | | 1,531 | | | |
| 2002 | 601 | | 955 | | | 1,556 | | | |
| 2003 | 577 | | 957 | | | 1,534 | | | |
| 2004[a] | 513 | | 953 | | | 1,466 | | | |
| 2005[a] | 387 | | 892 | | | 1,279 | | | |
| 2006[a] | 357 | | 929 | | | 1,286 | | | |
| 2007[a] | 381 | | 895 | | | 1,276 | | | |
| 2008[b] | 313 | | 829 | | | 1,142 | | | |
| 2009[c] | | 288 | | 925 | | 1,213 | 0 | 2 | 1,215 |
| 2010[c] | | 251 | | 1,140 | | 1,391 | 7 | 7 | 1,405 |
| 2011[c] | | 218 | | 1,417 | | 1,635 | 13 | 18 | 1,667 |
| 2012[c] | | 190 | | 1,418 | | 1,608 | 94 | 33 | 1,735 |
| 2013[c] | | 165 | | 1,393 | | 1,558 | 241 | 80 | 1,879 |
| 2014[c] | | 144 | | | 1,226 | 1,369 | 341 | 138 | 1,849 |
| 2015[c] | | 125 | | | 1,079 | 1,204 | 425 | 205 | 1,833 |
| 2016[c] | | 109 | | | 949 | 1,058 | 463 | 288 | 1,909 |
| 2017[c] | | 95 | | | 835 | 930 | 431 | 399 | 1,760 |
| 2018[c] | | 82 | | | 735 | 817 | 410 | 508 | 1,735 |

Source: U.S. Department of Interior, MMS, Gulf of Mexico Oil and Gas Production Forecast 2009–2018, OCS Report 2009-012, May 2009, p. 16.

[a]Years with known anomalies due to hurricane affect shut-in

[b]Estimate

[c]Projected

Table 6-22 summarizes the MMS "full potential" forecast and also includes the DOE's 2009 forecast. The MMS full potential forecast is based on offshore production increasing at an average annual rate of 3.1 percent from 2006/2008 through 2018. The DOE's *2009 Annual Energy Outlook* shows U.S. Gulf of Mexico production growing at an average annual rate of approximately 4.1 percent through 2018 and 2.3 percent from 2006 to 2030. The AEO and MMS forecasts are based on increasingly deep wells. The AEO forecast presented reflects provisions of the American Recovery and Reinvestment Act (ARRA).

**Table 6-22**
**Gulf of Mexico Annual Oil Production Rate Comparison**
**Minerals Management Service and**
**Annual Energy Outlook Forecasts**
**(1,000s Barrels/Day)**

| Year | MMS[a] | AEO[b] |
|---|---|---|
| 1997/1999 | 1,334 | 1,334 |
| 2000/2002 | 1,540 | 1,540 |
| 2003/2005[a] | 1,426 | 1,426[a] |
| 2006/2008[a] | 1,235 | 1,235[a] |
| 2009 | 1,215 | 1,660 |
| 2010 | 1,405 | 1,851 |
| 2011 | 1,667 | 2,004 |
| 2012 | 1,735 | 2,090 |
| 2013 | 1,879 | 2,084 |
| 2014 | 1,849 | 1,985 |
| 2015 | 1,833 | 1,915 |
| 2016 | 1,909 | 1,868 |
| 2017 | 1,760 | 1,864 |
| 2018 | 1,735 | 1,913 |
| 2020 | n/a | 1,859 |
| 2030 | n/a | 2,098 |
| **Average Annual Growth Rates** | | |
| 2006/2008 to 2018 | 3.1% | 4.1% |
| 2018–2030 | n/a | 0.8% |
| 2006/2008 to 2030 | n/a | 2.3% |

Source: U.S. Department of Interior, MMS, Gulf of Mexico Oil and Gas Production Forecast 2009–2018, OCS Report 2009-012, May 2009, p. 16,

[a]Includes years with known anomalies due to hurricane affect shut-in.

[b]DOE, Lower 48 Production, Table 114, "An Updated Reference Case Reflecting Provisions of the American Recovery and Reinvestment Act, April 2009.

The transportation savings benefits for the Upper Stauffer Channel were evaluated based on a consideration of the AEO and MMS production forecasts. The average of growth rates of 3.1 to 4.1 percent were used through 2018. These growth rates correspond to the AEO 2006 to 2030 and the MMS 2009 to 2018 production forecasts. For 2018 to 2067, a growth rate of 1 percent was used.

Offshore energy production is potentially one of the largest sources of revenue for the Stauffer Channel. New programs associated with energy independence initiatives have the potential to generate billions of dollars for the area.

It is reasonable to expect Freeport's offshore vessel traffic to increase during the 2017 to 2067 planning period. An increase in channel depth will result in an increased range of vessel drafts. Channel users estimate that with deeper water they would attract approximately 50 to 60 vessels per year with each vessel returning to dock for fuel and repairs approximately four times per year. An average of 5 vessel movements per week or 30 to 40 OSVs per month will be a reasonable expectation based on the combination of existing traffic and requests and permanent loss of traffic.

For vessels serving offshore rigs, identification of the location of rigs was determined through examination of MMS maps and discussions with Freeport industry representatives. Five travel zones were identified using MMS maps. The MMS maps were used to identify proximity to the Freeport and Galveston area and indicated a base of 175 rigs will be served by vessels operating from Galveston or Freeport. Table 6-23 shows approximately 92 rigs are in close proximity to Freeport, and 83 are close to Galveston.

**Table 6-23**
**Number of Offshore Rigs**
**Freeport and Galveston Vicinity**

| Zone Description | Freeport | Galveston |
|---|---|---|
| Zone A = 20 miles or less | 28 | 22 |
| Zone B = 40 miles or less | 41 | 21 |
| Zone C = 60 miles or less | 5 | 23 |
| Zone D = 80 miles or less | 10 | 3 |
| Zone E =115 miles or less | 8 | 14 |
| Total Rigs | 92 | 83 |

Source: Compiled from MMS Maps, 2006.

An annual seismic vessel count of 55 was used for the 2008 base period. The seismic vessel count is based on three seismic vessels being in port in March 2009. Three vessels making 6 to 7 return trips results in 19 trips per year.

Cargo vessels presently come in about four times per month for repair or layberth. The port estimates that an annual increase of approximately 95 vessels could occur based on improved access. An annual count of 48 vessels was used with the expectation of increases over the planning period. For purposes of analysis, Freeport's layberths were assumed to be represented by the Texas Gulf Coast fleet.

Expansion of Freeport's OSV fleet is expected to include a similar range of loaded drafts presently using Galveston and Bayou Lafourche. The Galveston Channel has an operating depth of 45 feet and Bayou Lafourche has an authorized and operating channel depth of 24 feet. Table 6-24 shows the expected number of vessels per year to call at Freeport by vessel design draft.

**Table 6-24**
**Upper Stauffer Estimated Number of Vessels per Year by Design Draft for With-Project Future**

| Vessel Design Draft (feet) | Number of Vessels by Type | | |
|---|---|---|---|
| | Offshore Supply | Seismic | Cargo/Other |
| <12 | 81 | 25 | 8 |
| 13–14 | 21 | 1 | 5 |
| 15 | 36 | 1 | 2 |
| 16 | 67 | 0 | 4 |
| 17 | 31 | 3 | 1 |
| 18 | 12 | 0 | 4 |
| 19 | 43 | 2 | 4 |
| 20 | 48 | 4 | 3 |
| 21 | 25 | 3 | 3 |
| 22 | 27 | 6 | 2 |
| 23 | 8 | 1 | 2 |
| 24 | 5 | 1 | 3 |
| 25 | 5 | 4 | 2 |
| 26 | 10 | 2 | 2 |
| 27 | 1 | 2 | 0 |
| 28 | 3 | 0 | 1 |
| 29 | 0 | 0 | 1 |
| 30 | 0 | 0 | 1 |
| Total[a] | 420 | 55 | 48 |

Source: Application of vessel fleet distributions prepared using Lloyd's Register – Fairplay, PC Register of Ships, November 2008 and Freeport vessel trip estimates.

[a]Note: Totals may not add due to rounding.

The mileage zones and transportation time savings for each zone are shown in Table 6-25. Transportation savings benefits were calculated based on 420 supply vessels and 55 seismic vessels saving 4 hours traveling time. The difference in travel time for cargo ships between Freeport and Galveston was primarily represented by the reduction in the number of hours to travel from the open waters of the Gulf of Mexico inward through the Freeport jetties to the launch/supply service and seismic vessel fueling and repair docks in comparison to travel distance through the Galveston jetties to similar facilities. The travel time for 48 cargo vessels was estimated to be 2 hours round trip.

**Table 6-25**
**Stauffer Channel Difference in Transit Time (Hours)**

| Zone | Freeport Time (hours) | Galveston Time (hours) | Freeport Reduced Time (hours) |
|---|---|---|---|
| Zone A = 20 miles or less | 2 | 4 | 2 |
| Zone B = 40 miles or less | 4 | 6 | 2 |
| Zone C = 60 miles or less | 6 | 8 | 2 |
| Zone D = 80 miles or less | 8 | 10 | 2 |
| Zone F =115 miles or less | 13 | 15 | 2 |

Source: Compiled from MMS Maps, 2006.

# 7.0 INCREMENTAL ANALYSIS

This section outlines the incremental analysis for the four operational reaches.

The first reach is 45 feet deep and provides access to crude petroleum tankers using docks operated by Seaway and chemical tankers for Dow Chemical. The maximum-sized crude petroleum carrier presently using the Seaway Terminal and the Brazosport Turning Basin is approximately 160,000 DWT. The largest-sized chemical carriers used are presently about 50,000 DWT. An increase in channel depth above 45 feet would allow for the use of larger chemical carriers. The with-project future would result in a greater number of 160,000 DWT vessels for crude petroleum. The maximum-sized chemical carrier under the with-project future is anticipated to be approximately 80,000 DWT.

The second major reach includes ConocoPhillips. The maximum-sized petroleum product carriers used in the reach will not change for the with-project future. The largest-sized crude petroleum and petroleum product tankers presently used are 100,000 DWT.

The third reach will include a new container terminal and will complement and supplement Houston traffic. While Houston has some mileage advantages over Freeport for cargo traveling to Dallas/Fort Worth, the comparative one-way distance to San Antonio's Distribution Centers is less than 5 miles. Therefore, the hinterland is expected to be the same as Houston's market.

The benefits from an increase in operating depth of 18 feet in the fourth reach were based on reductions in travel time that would lead to improved operational efficiency and economic benefits to the Nation. The benefits analysis is also based on the assumption that current practices of allowing foreign flag vessel access will continue for the 50-year planning period. Advantages Freeport has over other ports are open yard space and permission for vessel operators to work on their own boats. This practice is not normally allowed at other locations. The extra room is an advantage for seismic vessels, which characteristically carry 4 to 5 miles, or about 24,000 feet, of cable. There are only four or five seismic vessels operating in the entirety of the U.S. Gulf, but the Freeport yard is a common destination due to yard space and security.

## 7.1 CHANNEL DEEPENING BENEFITS

The transportation costs and the savings associated with the proposed project depth increase were calculated using commodity-specific vessel class and trade route distributions. Transportation costs were calculated based on the channel depth alternatives and variables associated with vessel design drafts, maximum feet of light-loading, underkeel clearance, mileage traveled, and the number of hours to load and unload. Maximum vessel cargo capacities for crude oil and petroleum products were estimated based on review of the range of load factors obtained from IWR Report 91-R-13, National Economic Development Procedures Manual Deep

Draft Navigation, November 1991, and consultation with industry and the BRPA. The IWR Report 91-R-13 cargo capacity factors published in the deep-draft manual for dry bulk carriers and tankers are shown in Table 7-1. Consultation with industry and the BRPA revealed that these estimates are reasonable. Table 7-2 displays representative round-trip mileage for the trade routes or junction points used in the transportation cost computations. Table 7-3 presents the foreign flag double-hull vessel operating cost update used in the analysis. Table 7-4 presents the container vessel operating costs from IWR's Load Factor Tables. Tables 7-5 to 7-7 show the Load Factor tables from IWR for each region for container imports and exports used in the analysis.

**Table 7-1**
**Adjustments for Estimating Actual Vessel Capacity**
**Short Tons of Cargo as a Percentage of Vessel DWT**

| Vessel DWT | % Cargo to DWT |
|---|---|
| <20,000 | 90 |
| 20,000 to 70,000 | 92 |
| 70,000 to 120,000 | 95 |
| >120,000 | 97 |

Source: USACE, IWR Report 91-R-13, National Economic Development Procedures Manual, Deep-Draft Navigation, November 1991, p. 77 and May 2008 draft.

**Table 7-2**
**Representative Round-trip Mileage to Freeport Harbor**

| Origin | Miles |
|---|---|
| Coatzacoalcos, Mexico | 1,360 |
| U.S. Gulf Coast Lightering/Lightening Zone | 160 |
| Venezuela | 3,934 |
| Panama Canal | 3,132 |
| Salvador, Brazil | 9,606 |
| Rotterdam, Netherlands | 10,318 |
| Sture, Norway | 11,172 |
| North Africa, Algiers | 10,556 |
| West Africa | 12,320 |
| Persian Gulf and Indian Subcontinent via Suez Canal | 19,472 |
| Persian Gulf and Indian Subcontinent via Cape of Good Hope | 24,940 |
| Singapore via Panama Canal | 24,248 |
| Singapore via Cape of Good Hope | 26,304 |

Source: Lloyd's Register/Fairplay, Ports & Terminals Guide 2006.

**Table 7-3**
**Tanker Characteristics and Hourly Operating Cost**
**Foreign Flag Double-Hull Tankers**

| DWT | Hourly Operating Cost ($) | | |
|---|---|---|---|
| | At Sea | In Port | Base Idle |
| 20,000 | 947 | 463 | 560 |
| 25,000 | 1,008 | 500 | 605 |
| 35,000 | 1,135 | 578 | 699 |
| 50,000 | 1,292 | 660 | 799 |
| 60,000 | 1,460 | 780 | 944 |
| 70,000 | 1,552 | 823 | 996 |
| 80,000 | 1,644 | 865 | 1,047 |
| 90,000 | 1,734 | 906 | 1,096 |
| 110,000 | 1,898 | 971 | 1,175 |
| 150,000 | 2,216 | 1,093 | 1,323 |
| 165,000 | 2,345 | 1,148 | 1,389 |
| 265,000 | 3,165 | 1,475 | 1,785 |
| 300,000 | 3,436 | 1,574 | 1,905 |
| 320,000 | 3,588 | 1,628 | 1,970 |

Source: Application of USACE, Foreign Flag Tanker Costs presented in EGM #11-05, Deep-Draft Vessel Operating Cost May 2011.

**Table 7-4**
**Foreign Flag Container Vessel Operating Costs**

| DWT | TEU | LOA | Beam | Design Draft | Immersion Factor | Speed | At Sea Cost | In Port Cost |
|---|---|---|---|---|---|---|---|---|
| 11,700 | 800 | 466 | 73 | 26 | 44 | 13 | 578 | 214 |
| 18,400 | 1,300 | 535 | 85 | 30 | 59 | 15 | 810 | 292 |
| 24,300 | 1,700 | 585 | 90 | 33 | 70 | 14 | 1,012 | 360 |
| 33,900 | 2,400 | 676 | 99 | 38 | 88 | 16 | 1,344 | 387 |
| 45,000 | 3,200 | 794 | 106 | 40 | 112 | 18 | 1,728 | 425 |
| 56,800 | 4,100 | 907 | 106 | 43 | 132 | 18 | 2,136 | 490 |
| 65,000 | 4,600 | 959 | 106 | 44 | 144 | 18 | 2,418 | 540 |
| 74,100 | 5,300 | 954 | 132 | 46 | 166 | 17 | 2,481 | 525 |
| 86,100 | 6,100 | 1,018 | 143 | 46 | 195 | 17 | 2,775 | 628 |
| 103,800 | 7,400 | 1,106 | 143 | 48 | 218 | 17 | 3,316 | 790 |

Source: IWR Load Factor Analysis, January 2012.

**Table 7-5**
**Foreign Flag Container Vessel Load Factors (Mediterranean, Asia)**

| DWT | Imports | | | Exports | | |
|---|---|---|---|---|---|---|
| | Ratio of Cargo to DWT (%) | Maximum Practical Cargo Capacity | Actual Maximum Draft Adjusting for Load Factors | Ratio of Cargo to DWT (%) | Maximum Practical Cargo Capacity | Actual Maximum Draft Adjusting for Load Factors |
| 11,700 | 63 | 8,123 | 24 | 75 | 9,692 | 26 |
| 18,400 | 63 | 12,772 | 27 | 75 | 15,239 | 30 |
| 24,300 | 63 | 16,820 | 28 | 75 | 20,070 | 30 |
| 33,900 | 63 | 23,473 | 33 | 75 | 28,008 | 36 |
| 45,000 | 63 | 31,165 | 36 | 75 | 37,185 | 39 |
| 56,800 | 63 | 39,339 | 37 | 75 | 46,938 | 40 |
| 65,000 | 63 | 44,994 | 39 | 75 | 53,686 | 42 |
| 74,100 | 63 | 51,307 | 43 | 75 | 61,218 | 46 |
| 86,100 | 63 | 59,613 | 43 | 75 | 71,129 | 46 |
| 103,800 | 63 | 71,912 | 45 | 75 | 85,805 | 48 |

Source: IWR Load Factor Analysis, January 2012.

**Table 7-6**
**Foreign Flag Container Vessel Load Factors (South and Central America)**

| DWT | Imports | | | Exports | | |
|---|---|---|---|---|---|---|
| | Ratio of Cargo to DWT (%) | Maximum Practical Cargo Capacity | Actual Maximum Draft Adjusting for Load Factors | Ratio of Cargo to DWT (%) | Maximum Practical Cargo Capacity | Actual Maximum Draft Adjusting for Load Factors |
| 11,700 | 75 | 9,692 | 26 | 75 | 9,692 | 26 |
| 18,400 | 75 | 15,239 | 30 | 75 | 15,239 | 30 |
| 24,300 | 75 | 20,070 | 30 | 75 | 20,070 | 30 |
| 33,900 | 75 | 28,008 | 36 | 75 | 28,008 | 36 |
| 45,000 | 75 | 37,185 | 39 | 75 | 37,185 | 39 |
| 56,800 | 75 | 46,938 | 40 | 75 | 46,938 | 40 |
| 65,000 | 75 | 53,686 | 42 | 75 | 53,686 | 42 |
| 74,100 | 75 | 61,218 | 46 | 75 | 61,218 | 46 |
| 86,100 | 75 | 71,129 | 46 | 75 | 71,129 | 46 |
| 103,800 | 75 | 85,805 | 48 | 75 | 85,805 | 48 |

Source: IWR Load Factor Analysis, January 2012.

**Table 7-7**
**Foreign Flag Container Vessel Load Factors (Europe, Africa)**

| DWT | Imports | | | Exports | | |
|---|---|---|---|---|---|---|
| | Ratio of Cargo to DWT (%) | Maximum Practical Cargo Capacity | Actual Maximum Draft Adjusting for Load Factors | Ratio of Cargo to DWT (%) | Maximum Practical Cargo Capacity | Actual Maximum Draft Adjusting for Load Factors |
| 11,700 | 63 | 8,123 | 24 | 61 | 7,938 | 24 |
| 18,400 | 63 | 12,772 | 27 | 61 | 12,481 | 27 |
| 24,300 | 63 | 16,820 | 28 | 61 | 16,438 | 28 |
| 33,900 | 63 | 23,473 | 33 | 61 | 22,940 | 33 |
| 45,000 | 63 | 31,165 | 36 | 61 | 30,456 | 35 |
| 56,800 | 63 | 39,339 | 37 | 61 | 38,445 | 37 |
| 65,000 | 63 | 44,994 | 39 | 61 | 43,972 | 38 |
| 74,100 | 63 | 51,307 | 43 | 61 | 50,141 | 43 |
| 86,100 | 63 | 59,613 | 43 | 61 | 58,258 | 43 |
| 103,800 | 63 | 71,912 | 45 | 61 | 70,278 | 44 |

Source: IWR Load Factor Analysis, January 2012.

The basic procedure used to calculate transportation costs, using a 110,000 DWT foreign flag tanker as an example, is illustrated in Table 7-8. Similar computations were made for appropriate distances and vessel sizes for each of the channel depth alternatives.

**Table 7-8**
**Transportation Cost Calculation (Mexico to Freeport)**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Vessel Deadweight Tons (metric tonnes) | 110,000 | 110,000 | 110,000 | 110,000 | 150,000 | 150,000 | 150,000 | 150,000 |
| Channel Depth (feet) | 45 | 50 | 55 | 60 | 45 | 50 | 55 | 60 |
| Design Draft (feet) | 50 | 50 | 50 | 50 | 56 | 56 | 56 | 56 |
| Underkeel Clearance (feet) | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Cargo Capacity (short tons) | 116,600 | 116,600 | 116,600 | 116,600 | 160,300 | 160,300 | 160,300 | 160,300 |
| Cargo Capacity by Channel Depth | 91,800 | 107,300 | 116,600 | 116,600 | 106,000 | 124,900 | 143,700 | 160,300 |
| Immersion Factor (tons per inch) | 234 | 234 | 234 | 234 | 285 | 285 | 285 | 285 |
| Hourly Cost at Sea | 1,898 | 1,898 | 1,898 | 1,898 | 2,216 | 2,216 | 2,216 | 2,216 |
| Hourly Cost in Port | 971 | 971 | 971 | 971 | 1,093 | 1,093 | 1,093 | 1,093 |
| Round Trip Mileage from Mexico | 1,314 | 1,314 | 1,314 | 1,314 | 1,314 | 1,314 | 1,314 | 1,314 |
| Speed (knots) | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Total Voyage Cost ($) | 167,400 | 167,400 | 167,400 | 167,400 | 194,100 | 194,100 | 194,100 | 194,100 |
| Loading/Unloading Rate (short tons/hour) | 2,697 | 2,697 | 2,697 | 2,697 | 2,977 | 2,977 | 2,977 | 2,977 |
| Hours in Port | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| Loading and Unloading Cost ($) | 74,400 | 85,600 | 92,300 | 92,300 | 87,200 | 101,000 | 114,900 | 127,100 |
| Pilot and Tug Costs ($) | 27,100 | 27,500 | 27,700 | 27,700 | 41,000 | 41,400 | 41,700 | 42,000 |
| Total Cost Per Ton ($) | 2.93 | 2.61 | 2.46 | 2.46 | 3.04 | 2.69 | 2.44 | 2.27 |

The resulting costs per ton computations were calculated over the relevant range of vessels projected for each channel depth improvement. The associated savings per ton were measured using the net differences in costs between the existing channel depth and the depth alternative.

### 7.1.1 Crude Petroleum Imports Transportation Savings Benefits

Transportation savings benefits from reductions in the vessel operating costs were calculated based on the relative difference in transportation costs between the without-project and with project conditions. Transportation costs and savings were calculated for vessels that minimize transportation costs given trade route constraints and pilot rules. One rule that the BRPA emphasized would not change between the without- and with-project conditions is underkeel clearance. The without- and with-project futures reflect changes in trade routes based on traffic forecast data.

Table 7-9 presents direct shipment costs for all routes. The transportation cost calculations were based on vessels sizes between 50,000 and 175,000 DWT, and then weighted by expected fleet distribution to get the most likely average cost per ton. Depths at trading ports and detailed analysis of current vessel use indicate that a significant share of Mexico and Latin American shipments would be likely to accrue benefits from increases in channel depth. Vessels from 60,000 to 120,000 DWT generally represent the range used for shipments from Mexico and Central and South America, with approximately 90 percent of 2004 to 2006 imports being shipped in vessels in the 90,000 to 120,000 DWT range. The per ton costs for direct shipment for the Central and South America routing shows significant reductions in costs for Suezmax vessels between 135,000 and 150,000 DWT for the 58- and 60-foot channel depth alternatives. Information obtained from Martin and Associates, who prepared the Freeport regional impact analysis, has indicated that transition would occur.[13] Freeport's 2006 and 2007 vessel transits show the use of Suezmax tankers for crude oil shipped from Brazil.

Table 7-10 presents the transportation costs per ton range for lightening for applicable trade routes. Table 7-11 presents the costs per ton range for lightering for applicable trade routes. Costs for offshore transfer approach the cost of direct shipment at greater channel depth alternatives.

[13] Personal communication, Martin and Associates, 2008.

**Table 7-9**
**Crude Petroleum Transportation Cost Per Ton for Direct Shipments to Freeport**

| Channel Depth | 45 feet | 50 feet | 52 feet | 55 feet | 58 feet | 60 feet |
|---|---|---|---|---|---|---|
| **DWT, Mexico** | | | | | | |
| 50,000 | 3.79 | 3.56 | 3.56 | 3.56 | 3.56 | 3.56 |
| 60,000 | 3.72 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 |
| 70,000 | 3.52 | 3.05 | 2.98 | 2.98 | 2.98 | 2.98 |
| 80,000 | 3.92 | 3.33 | 3.16 | 2.93 | 2.87 | 2.87 |
| 90,000 | 2.89 | 2.60 | 2.60 | 2.60 | 2.60 | 2.60 |
| 100,000 | 2.89 | 2.58 | 2.51 | 2.51 | 2.51 | 2.51 |
| 110,000 | 2.93 | 2.61 | 2.51 | 2.46 | 2.46 | 2.46 |
| 120,000 | 2.97 | 2.64 | 2.54 | 2.41 | 2.41 | 2.41 |
| 135,000 | 3.10 | 2.76 | 2.65 | 2.51 | 2.42 | 2.42 |
| 150,000 | 3.04 | 2.69 | 2.58 | 2.44 | 2.32 | 2.27 |
| 165,000 | 3.17 | 2.80 | 2.69 | 2.53 | 2.41 | 2.33 |
| 175,000 | 3.08 | 2.72 | 2.60 | 2.45 | 2.32 | 2.25 |
| Most Likely Average Cost | 3.32 | 2.86 | 2.75 | 2.61 | 2.48 | 2.38 |
| **Central and South America** | | | | | | |
| 50,000 | 10.31 | 9.60 | 9.60 | 9.60 | 9.60 | 9.60 |
| 60,000 | 10.20 | 8.97 | 8.97 | 8.97 | 8.97 | 8.97 |
| 70,000 | 9.67 | 8.20 | 7.96 | 7.96 | 7.96 | 7.96 |
| 80,000 | 10.68 | 8.86 | 8.30 | 7.60 | 7.39 | 7.39 |
| 90,000 | 7.75 | 6.84 | 6.84 | 6.84 | 6.84 | 6.84 |
| 100,000 | 7.70 | 6.69 | 6.49 | 6.49 | 6.49 | 6.49 |
| 110,000 | 7.69 | 6.69 | 6.36 | 6.21 | 6.21 | 6.21 |
| 120,000 | 7.77 | 6.75 | 6.42 | 6.05 | 6.05 | 6.05 |
| 135,000 | 7.94 | 6.89 | 6.55 | 6.10 | 5.84 | 5.84 |
| 150,000 | 7.83 | 6.76 | 6.42 | 5.97 | 5.59 | 5.43 |
| 165,000 | 8.11 | 6.97 | 6.61 | 6.14 | 5.75 | 5.51 |
| 175,000 | 8.04 | 6.90 | 6.53 | 6.06 | 5.66 | 5.43 |
| Most Likely Average Cost | 7.81 | 6.84 | 6.59 | 6.26 | 5.83 | 5.51 |

**Table 7-9, cont'd**

| Channel Depth | 45 feet | 50 feet | 52 feet | 55 feet | 58 feet | 60 feet |
|---|---|---|---|---|---|---|
| **DWT, Africa and North Sea** | | | | | | |
| 50,000 | 23.00 | 21.36 | 21.36 | 21.36 | 21.36 | 21.36 |
| 60,000 | 22.81 | 19.97 | 19.97 | 19.97 | 19.97 | 19.97 |
| 70,000 | 21.65 | 18.22 | 17.66 | 17.66 | 17.66 | 17.66 |
| 80,000 | 23.87 | 19.62 | 18.32 | 16.68 | 16.20 | 16.20 |
| 90,000 | 17.21 | 15.11 | 15.11 | 15.11 | 15.11 | 15.11 |
| 100,000 | 17.06 | 14.72 | 14.25 | 14.25 | 14.25 | 14.25 |
| 110,000 | 16.97 | 14.63 | 13.87 | 13.52 | 13.52 | 13.52 |
| 120,000 | 17.14 | 14.77 | 14.00 | 13.12 | 13.12 | 13.12 |
| 135,000 | 17.37 | 14.93 | 14.14 | 13.12 | 12.51 | 12.51 |
| 150,000 | 17.15 | 14.67 | 13.88 | 12.85 | 11.96 | 11.59 |
| 165,000 | 17.75 | 15.11 | 14.27 | 13.18 | 12.25 | 11.71 |
| 175,000 | 17.69 | 15.04 | 14.20 | 13.11 | 12.18 | 11.64 |
| Most Likely Average Cost | 17.37 | 14.95 | 14.31 | 13.44 | 12.52 | 11.86 |
| **Middle East** | | | | | | |
| 50,000 | 38.25 | 35.48 | 35.48 | 35.48 | 35.48 | 35.48 |
| 60,000 | 37.96 | 33.18 | 33.18 | 33.18 | 33.18 | 33.18 |
| 70,000 | 36.04 | 30.25 | 29.32 | 29.32 | 29.32 | 29.32 |
| 80,000 | 39.71 | 32.54 | 30.36 | 27.60 | 26.79 | 26.79 |
| 90,000 | 28.58 | 25.03 | 25.03 | 25.03 | 25.03 | 25.03 |
| 100,000 | 28.30 | 24.35 | 23.56 | 23.56 | 23.56 | 23.56 |
| 110,000 | 28.11 | 24.16 | 22.89 | 22.30 | 22.30 | 22.30 |
| 120,000 | 28.39 | 24.40 | 23.10 | 21.62 | 21.62 | 21.62 |
| 135,000 | 28.69 | 24.59 | 23.26 | 21.54 | 20.52 | 20.52 |
| 150,000 | 28.35 | 24.18 | 22.84 | 21.10 | 19.62 | 19.00 |
| 165,000 | 29.31 | 24.87 | 23.46 | 21.63 | 20.07 | 19.15 |
| 175,000 | 29.28 | 24.82 | 23.41 | 21.57 | 20.01 | 19.09 |
| Most Likely Average Cost | 28.78 | 24.85 | 23.89 | 22.47 | 20.61 | 19.25 |

**Table 7-10**
**Freeport Crude Petroleum Imports Lightened Cost Per Ton**
**by Channel Depth and Trade Route**

| | Channel Depth (feet) and Vessel DWT for West Africa, North Sea, and Middle East Cargo | | | | | |
|---|---|---|---|---|---|---|
| **Mother Vessels (DWT)** | **45 feet** | **50 feet** | **52 feet** | **55 feet** | **58 feet** | **60 feet** |
| Minimum | 150,000 | 150,000 | 150,000 | 150,000 | 150,000 | 150,000 |
| Maximum | 175,000 | 175,000 | 175,000 | 175,000 | 175,000 | 175,000 |
| **Shuttle Vessels (DWT)** | | | | | | |
| Minimum | 60,000 | 35,000 | 35,000 | 40,000 | 14,000 | 0 |
| Maximum | 60,000 | 60,000 | 50,000 | 60,000 | 14,000 | 14,000 |
| **West Africa and North Sea** | Per Ton Transportation Cost/Ton to Freeport | | | | | |
| Minimum Lightening Cost | 12.43 | 12.43 | 12.39 | 12.25 | 12.12 | 11.64 |
| Most Likely Lightening Cost | 12.89 | 12.84 | 12.76 | 12.62 | 12.48 | 12.02 |
| Maximum Lightening Cost | 13.39 | 13.20 | 13.11 | 12.96 | 12.84 | 12.40 |
| **Middle East** | Per Ton Transportation Cost/Ton to Freeport | | | | | |
| Minimum Lightening Cost | 19.38 | 19.38 | 19.34 | 19.20 | 19.07 | 18.98 |
| Most Likely Lightening Cost | 20.05 | 20.00 | 19.91 | 19.77 | 19.63 | 19.18 |
| Maximum Lightening Cost | 20.79 | 20.60 | 20.51 | 20.36 | 20.24 | 19.52 |

**Table 7-11**
**Freeport Crude Petroleum Imports Lightering Cost Per Ton**
**by Channel Depth and Trade Route**

| **Cost by Channel Depth (feet)** | **45 feet** | **50 feet** | **52 feet** | **55 feet** | **58 feet** | **60 feet** |
|---|---|---|---|---|---|---|
| **West Africa and North Sea** | | | | | | |
| Minimum Lightering Cost | 11.86 | 11.62 | 11.59 | 11.59 | 11.59 | 11.16 |
| Most Likely Lightering Cost | 12.12 | 11.96 | 11.94 | 11.76 | 11.76 | 11.75 |
| Maximum Lightering Cost | 13.44 | 13.44 | 13.44 | 13.44 | 13.44 | 13.44 |
| **Middle East** | | | | | | |
| Minimum Lightering Cost | 21.16 | 20.93 | 20.89 | 20.89 | 20.89 | 20.47 |
| Most Likely Lightering Cost | 21.43 | 21.27 | 21.25 | 21.07 | 21.07 | 21.06 |
| Maximum Lightering Cost | 22.75 | 22.75 | 22.75 | 22.75 | 22.75 | 22.75 |

The per ton transportation costs used in estimating the transportation savings benefits correspond to the most likely least cost methods of shipment associated with the particular trade route. As channel depth increases, the cost differential between direct shipment and both lightering and lightening is reduced. This reduction introduces cost incentives for potential shifts from lightering and lightening to direct shipments. An increase in channel depth would probably result in an increase in direct shipment movements for Africa, Mediterranean, Europe, and Middle East shipments.

Table 7-12 summarizes the transportation cost by trade route used for the with- and without-project future condition calculations. The weighted average transportation costs were calculated by incorporating a share of mode of shipment to each cost for each channel depth. Given the reduction in the differential between lightening and direct shipment as channel depth increases, an additional variable for preference of direct shipment is used since direct shipment cost is subject to less uncertainty than the offshore transfer processes such as lightering and lightening due to the reduction in transfer times and associated logistics-related delays inherent with offshore transfer.

**Table 7-12**
**Freeport Crude Petroleum Imports Transportation Cost and Savings**
**Most Likely Transportation Mode**

| Trade Route/Channel Depth | 45 feet | 50 feet | 52 feet | 55 feet | 58 feet | 60 feet |
|---|---|---|---|---|---|---|
| **Mexico** | Direct | Direct | Direct | Direct | Direct | Direct |
| most likely cost/ton | $3.32 | $2.86 | $2.75 | $2.61 | $2.48 | $2.38 |
| savings/ton | | $0.46 | $0.57 | $0.71 | $0.84 | $0.94 |
| **Central and South America** | Direct | Direct | Direct | Direct | Direct | Direct |
| most likely cost/ton | $7.77 | $6.84 | $6.59 | $6.26 | $5.83 | $5.51 |
| savings/ton | | $0.93 | $1.18 | $1.51 | $1.94 | $2.26 |
| **Africa and Europe** | Lighter | Lighter | Lighter | Lighter | Lighten | Direct |
| most likely cost/ton | $12.90 | $12.63 | $12.54 | $12.31 | $12.16 | $11.86 |
| savings/ton | | $0.27 | $0.36 | $0.59 | $0.74 | $1.04 |
| **Middle East and Far East** | Lighten | Lighten | Lighten | Lighten | Lighten | Direct |
| most likely cost/ton | $21.14 | $20.87 | $20.77 | $20.54 | $20.35 | $19.25 |
| savings/ton | | $0.27 | $0.36 | $0.59 | $.78 | $1.89 |

The cost savings for lightering is lower than direct shipment. The savings for lightering results from increases in shuttle loads due to greater channel depth. The effect of increasing channel depths allows for the reduction in the number of shuttle vessels necessary to totally lighter very large crude carriers. In spite of uncertainties associated with changes in methods of shipment, an increase in channel depth reduces the cost per ton for lightering by reducing the number of shuttle vessels used to transport a given volume of crude oil.

Increases in Freeport's channel depth also provide an opportunity to offload a smaller amount of cargo at sea. The cost calculations are based on relatively efficient transfer times and optimal-sized shuttle vessels. Less than optimal turnaround times would result in a larger differential between the without- and with-project condition offshore transfer costs. The savings for lightened movements result from decreases in offshore unloading time from the mother vessel to shuttles, and the mother vessel is substituting offshore unloading time for dockside unloading time.

The availability of a depth over 55 feet will make the use of Suezmax vessels a cost effective option for direct shipments for many trade routes. Depths at the shipping origins indicate that constraints at the origin will not be an impediment for most routings.

Table 7-13 shows the percentage of crude oil imports expected to utilize greater drafts as a result of the cost calculations. Historical data for 2005 to 2007 showed that 96.8 percent of tonnage is shipped in vessels with design drafts over 40 feet, and 61 percent of the tonnage was transported at 40 feet or more. This gap is due to offshore lightering and lightening. The without-project future percentage was assumed to be approximately the same as existing conditions. The with-project future benefit calculations are based on approximately 94 percent of tonnage loaded to 40 feet or more.

**Table 7-13**
**Freeport Crude Petroleum Imports**
**Percentage of Tonnage With Draft Constraints**

| Channel Depth (ft) | % of Tonnage Applied to Benefits | | | |
|---|---|---|---|---|
| | Existing Condition[a] | Without Project Future | With Project Future | |
| | | | 2017–2027 | 2037–2067 |
| 45 | 61 | 61 | 94 | 94 |
| 50 | n/a | n/a | 94 | 94 |
| 55 | n/a | n/a | 94 | 94 |
| 60 | n/a | n/a | 94 | 94 |

[a]2003–2007 average.

Table 7-14 summarizes the annual transportation savings benefits for crude petroleum import tonnage.

**Table 7-14**
**Freeport Crude Petroleum Imports Benefits ($1,000)**

| **Reach 1** | **50 feet** | **52 feet** | **55 feet** | **58 feet** | **60 feet** |
|---|---|---|---|---|---|
| 2017 | 10,031 | 13,027 | 18,296 | 23,298 | 35,585 |
| 2027 | 14,211 | 18,444 | 25,844 | 32,911 | 49,825 |
| 2037 | 17,855 | 23,174 | 32,472 | 41,352 | 62,604 |
| 2047 | 22,027 | 28,580 | 40,003 | 50,933 | 76,781 |
| 2057 | 25,987 | 33,716 | 47,179 | 60,070 | 90,467 |
| 2067 | 29,948 | 38,852 | 54,354 | 69,206 | 104,152 |
| Average Annual Savings (4.0%) | 16,767 | 21,760 | 30,486 | 38,819 | 58,728 |
| **Reach 2** | **46 feet** | **47 feet** | **48 feet** | **49 feet** | **50 feet** |
| 2017 | 279 | 578 | 852 | 1,127 | 1,368 |
| 2027 | 395 | 819 | 1,207 | 1,597 | 1,938 |
| 2037 | 496 | 1,029 | 1,517 | 2,006 | 2,435 |
| 2047 | 613 | 1,270 | 1,872 | 2,476 | 3,004 |
| 2057 | 723 | 1,498 | 2,208 | 2,921 | 3,544 |
| 2067 | 833 | 1,726 | 2,545 | 3,366 | 4,084 |
| Average Annual Savings (4.0%) | 466 | 966 | 1,424 | 1,884 | 2,286 |

### 7.1.2 Petroleum Product Imports Transportation Savings Benefits

Reductions in the vessel transportation costs for Freeport's foreign petroleum product imports were calculated based on the relative difference in transportation costs between the without-project and with-project conditions. As with crude petroleum, transportation costs and savings for product carriers were calculated for vessels that minimize transportation costs given trade route constraints. Long-term fleet selection will continue to reflect goals of minimizing vessel operating costs.

The effect of channel deepening would allow a portion of the fleet to be more fully loaded. A range of 20 to 63 percent of 2002 to 2007 tonnage was loaded to 40-foot draft or more with an average of 43 percent. The transportation savings from channel deepening was estimated to result in 43 percent of 2017 to 2027 tonnage and 63 percent of 2028 to 2067 tonnage being transported at more fully loaded drafts. The design drafts associated these shipments ranged from 49 to 54 feet. Table 7-15 shows the percentage of petroleum product imports expected to utilize greater drafts as a result of the cost calculations.

**Table 7-15**
**Freeport Petroleum Product Imports**
**Percentage of Tonnage With Draft Constraints**

| % of Tonnage Applied to Benefits | | | | |
|---|---|---|---|---|
| Channel Depth (ft) | Existing Condition[a] | Without-Project Future | With-Project Future | |
| | | | 2017–2027 | 2037–2067 |
| 45 | 33 | 33 | 43 | 63 |
| 47 | n/a | n/a | 43 | 63 |
| 48 | n/a | n/a | 43 | 63 |
| 50 | n/a | n/a | 43 | 63 |

[a]2003–2007 average.

Table 7-16 summarizes the annual transportation savings benefits for petroleum product import tonnage. The petroleum product transportation savings benefits were calculated based on vessels from 80,000 to 100,000 DWT. The vessel sizes for existing conditions are the same as those anticipated for the without- and with-project futures.

**Table 7-16**
**Freeport Petroleum Product Imports Benefits ($1,000)**

| Year | 46 feet | 47 feet | 48 feet | 49 feet | 50 feet |
|---|---|---|---|---|---|
| 2017 | 311 | 600 | 869 | 1,119 | 1,316 |
| 2027 | 418 | 805 | 1,165 | 1,501 | 1,766 |
| 2037 | 486 | 937 | 1,357 | 1,748 | 2,056 |
| 2047 | 515 | 994 | 1,439 | 1,854 | 2,180 |
| 2057 | 545 | 1,050 | 1,520 | 1,959 | 2,304 |
| 2067 | 586 | 1,130 | 1,636 | 2,108 | 2,479 |
| Average Annual Savings (4.0%) | 440 | 847 | 1,227 | 1,581 | 1,859 |

### 7.1.3 Chemical Product Exports Transportation Savings Benefits

The sizes of Freeport's existing chemical carriers range from 22,000 to 50,000 DWT. The design drafts generally range from 42 to 43 feet. Maximum loaded drafts are 40 feet, with 7 percent of 2002 to 2007 tonnage loaded to 40 feet. Lloyd's/Fairplay Vessel Register showed that 2 percent of chemical tankers built since 1995 have design drafts of 42 feet but that less than 1 percent have drafts over 42 feet. The chemical carriers on order as of January 2009 showed that 22 percent have design draft over 42 feet and 1.6 percent have design drafts over 46 feet. Vessels-on-order records show that the maximum draft for chemical tankers on-order is 48 feet, thereby indicating that transition to larger vessels over the 50-year planning period is likely. The 2002 to 2007 historic data showed an average of 7 percent and a maximum of 11 percent of tonnage transported in vessels with loaded drafts of 40 feet or more, and the design drafts associated with

these vessel shipments ranged from 40 to 44 feet. The chemical benefits are calculated using 7 percent of 2017 to 2027 tonnage and 14 percent of 2037 to 2067 tonnage.

Table 7-17 shows the percentage of chemical product export tonnage used in the analysis. The without-project future percentage was assumed to be approximately the same as existing conditions. The with-project future percentage is representative of the maximum historical percentage transported at loaded drafts approaching the authorized channel depth.

Current draft-constrained movements are primarily shipped to Brazil and the Far East. Completion of the Panama Canal improvements is expected to result in increases in Freeport's shipments to the Far East. A trade route forecast was not prepared, so the transportation cost calculations are conservatively based on Freeport's 2002 to 2007 period routings for chemical products exports transported in vessels loaded to drafts of 40 feet or more.

**Table 7-17**
**Percentage of Tonnage With Draft Constraints**

| % of Tonnage Applied to Benefits | | | | |
|---|---|---|---|---|
| Channel Depth (ft) | Existing Condition[a] | Without-Project Future | With-Project Future | |
| | | | 2017–2027 | 2037–2067 |
| 45 | 7 | 7 | 7 | 14 |
| 50 | n/a | n/a | 7 | 14 |
| 55 | n/a | n/a | 7 | 14 |
| 60 | n/a | n/a | 7 | 14 |

[a]2003–2007 average calculated from percentages shown in Table 35.

Table 7-18 summarizes the annual transportation savings benefits for chemical export tonnage.

**Table 7-18**
**Freeport Chemical Product Exports**
**Benefits ($1,000s)**

| Year | 46 feet | 48 feet | 50 feet | 52 feet | 54 feet | 56 feet |
|---|---|---|---|---|---|---|
| 2017 | 126 | 422 | 626 | 772 | 883 | 981 |
| 2027 | 268 | 897 | 1,332 | 1,643 | 1,880 | 2,088 |
| 2037 | 365 | 1,221 | 1,813 | 2,236 | 2,558 | 2,841 |
| 2047 | 421 | 1,410 | 2,093 | 2,581 | 2,953 | 3,280 |
| 2057 | 478 | 1,599 | 2,374 | 2,927 | 3,349 | 3,720 |
| 2067 | 566 | 1,893 | 2,811 | 3,466 | 3,965 | 4,404 |
| Average Annual Savings (4.0%) | 308 | 1,030 | 1,530 | 1,886 | 2,158 | 2,397 |

The transportation costs for chemical products were calculated based on vessels from 50,000 to 65,000 DWT for the existing condition and the without-project future. The with-project future transportation costs were calculated using vessels from 50,000 to 80,000 DWT. The transition to larger chemical carriers for 14 percent of future tonnage is based on vessels-on-order and vessel deliveries as of July 2006.

### 7.1.4 Container Transportation Savings Benefits

Increased uncertainty is associated with containers since the Velasco Terminal is currently being built and there are no historical trends at Freeport. Therefore, Houston data was used as a proxy even though Houston's terminals currently have a depth of 40 feet. The vessel sizes vary from 12,000 DWT to 104,000 DWT with the majority of tonnage transported in the 45,000 to 75,000 DWT range. Design drafts generally range from 40 feet to 46 feet, with the large post-Panamax vessels drafting up to 48 feet. Vessels traveling to/from the Mediterranean and Asia carry approximately 50 percent of its tonnage in vessels larger than 65,000 DWT. This tonnage is transported with sailing drafts ranging from 42 to 48 feet. Vessels traveling to/from South and Central America transport approximately 12 percent of its tonnage in vessels larger than 65,000 DWT.

According to IWR, Houston data show the average TEU is 9.11 short tons and generally ranges between 8.80 and 10.50 by geographic region. The share of empty containers is approximately 23.9 percent, and the share of vacant slots on containerships is 6.6 percent. These figures were used as base assumptions in the economic model.

Table 7-19 to Table 7-24 show the transportation cost per ton and associated benefits by channel depth by region for imports and exports of containers. Table 7-25 aggregates these regions to show the average annual benefits by channel depth for container trade at Freeport.

**Table 7-19**
**Containers Transportation Cost Per Ton (Mediterranean, Asia Imports)**

| DWT | 40 feet | 42 feet | 45 feet | 48 feet | 50 feet |
|---|---|---|---|---|---|
| 12,000 | 70.30 | 70.30 | 70.30 | 70.30 | 70.30 |
| 18,000 | 66.00 | 66.00 | 66.00 | 66.00 | 66.00 |
| 24,000 | 65.29 | 65.29 | 65.29 | 65.29 | 65.29 |
| 34,000 | 70.23 | 70.26 | 70.26 | 70.26 | 70.26 |
| 45,000 | 68.42 | 68.50 | 68.55 | 68.55 | 68.55 |
| 57,000 | 48.91 | 46.89 | 46.93 | 46.93 | 46.93 |
| 65,000 | 44.32 | 40.48 | 39.51 | 39.51 | 39.51 |
| 74,000 | 55.56 | 49.44 | 42.43 | 38.44 | 38.44 |
| 86,000 | 91.00 | 80.84 | 69.26 | 62.32 | 62.32 |
| 104,000 | 96.48 | 86.02 | 74.00 | 64.95 | 63.44 |
| Weighted Cost Per Ton | 60.75 | 57.40 | 54.64 | 52.99 | 52.90 |
| Savings Per Ton | | 3.35 | 6.11 | 7.76 | 7.85 |

**Table 7-20**
**Containers Transportation Cost Per Ton (South and Central America Imports)**

| DWT | 40 feet | 42 feet | 45 feet | 48 feet | 50 feet |
|---|---|---|---|---|---|
| 12,000 | 17.21 | 17.21 | 17.21 | 17.21 | 17.21 |
| 18,000 | 23.04 | 23.04 | 23.04 | 23.04 | 23.04 |
| 24,000 | 15.36 | 15.36 | 15.36 | 15.36 | 15.36 |
| 34,000 | 12.22 | 12.23 | 12.23 | 12.23 | 12.23 |
| 45,000 | 13.88 | 12.72 | 12.42 | 12.42 | 12.42 |
| 57,000 | 14.36 | 13.18 | 12.29 | 12.29 | 12.29 |
| 65,000 | 41.90 | 38.41 | 34.15 | 33.48 | 33.48 |
| 74,000 | 52.64 | 47.12 | 40.73 | 35.89 | 33.24 |
| 86,000 | 68.48 | 61.17 | 52.76 | 46.40 | 42.94 |
| 104,000 | 58.93 | 52.81 | 45.71 | 40.31 | 37.38 |
| Weighted Cost Per Ton | 22.43 | 21.34 | 20.25 | 19.65 | 19.34 |
| Savings Per Ton | | 1.09 | 2.18 | 2.78 | 3.09 |

**Table 7-21**
**Containers Transportation Cost Per Ton (Europe, Africa Imports)**

| DWT | 40 feet | 42 feet | 45 feet | 48 feet | 50 feet |
|---|---|---|---|---|---|
| 12,000 | 105.11 | 105.11 | 105.11 | 105.11 | 105.11 |
| 18,000 | 71.62 | 71.62 | 71.62 | 71.62 | 71.62 |
| 24,000 | 35.60 | 35.60 | 35.60 | 35.60 | 35.60 |
| 34,000 | 39.61 | 39.63 | 39.63 | 39.63 | 39.63 |
| 45,000 | 40.27 | 40.34 | 40.39 | 40.39 | 40.39 |
| 57,000 | 22.78 | 21.84 | 21.88 | 21.88 | 21.88 |
| 65,000 | 34.79 | 31.80 | 31.08 | 31.08 | 31.08 |
| 74,000 | 44.12 | 39.30 | 33.78 | 30.64 | 30.64 |
| 86,000 | 20.24 | 18.39 | 16.28 | 15.02 | 15.02 |
| 104,000 | 54.19 | 48.33 | 41.60 | 36.52 | 35.68 |
| Weighted Cost Per Ton | 36.56 | 34.70 | 33.26 | 32.40 | 32.34 |
| Savings Per Ton | | 1.86 | 3.30 | 4.16 | 4.22 |

**Table 7-22**
**Containers Transportation Cost Per Ton (Mediterranean, Asia Exports)**

| DWT | 40 feet | 42 feet | 45 feet | 48 feet | 50 feet |
|---|---|---|---|---|---|
| 12,000 | 44.06 | 44.06 | 44.06 | 44.06 | 44.06 |
| 18,000 | 42.64 | 42.64 | 42.64 | 42.64 | 42.64 |
| 24,000 | 42.54 | 42.54 | 42.54 | 42.54 | 42.54 |
| 34,000 | 47.53 | 47.55 | 47.55 | 47.55 | 47.55 |
| 45,000 | 52.60 | 48.20 | 47.06 | 47.06 | 47.06 |
| 57,000 | 35.76 | 32.81 | 30.55 | 30.55 | 30.55 |
| 65,000 | 31.53 | 28.86 | 25.62 | 25.07 | 25.07 |
| 74,000 | 38.94 | 34.81 | 30.03 | 26.42 | 24.45 |
| 86,000 | 69.27 | 61.85 | 53.30 | 46.84 | 43.33 |
| 104,000 | 74.30 | 66.55 | 57.57 | 50.74 | 47.03 |
| Weighted Cost Per Ton | 42.96 | 39.84 | 36.73 | 35.15 | 34.35 |
| Savings Per Ton | | 3.12 | 6.23 | 7.81 | 8.61 |

**Table 7-23**
**Containers Transportation Cost Per Ton (South and Central America Exports)**

| DWT | 40 feet | 42 feet | 45 feet | 48 feet | 50 feet |
|---|---|---|---|---|---|
| 12,000 | 24.29 | 24.29 | 24.29 | 24.29 | 24.29 |
| 18,000 | 27.93 | 27.93 | 27.93 | 27.93 | 27.93 |
| 24,000 | 21.04 | 21.04 | 21.04 | 21.04 | 21.04 |
| 34,000 | 17.11 | 17.12 | 17.12 | 17.12 | 17.12 |
| 45,000 | 18.70 | 17.14 | 16.73 | 16.73 | 16.73 |
| 57,000 | 19.04 | 17.48 | 16.28 | 16.28 | 16.28 |
| 65,000 | 44.50 | 40.78 | 36.26 | 35.54 | 35.54 |
| 74,000 | 55.70 | 49.85 | 43.09 | 37.97 | 35.16 |
| 86,000 | 70.60 | 63.06 | 54.38 | 47.83 | 44.26 |
| 104,000 | 62.70 | 56.19 | 48.63 | 42.88 | 39.76 |
| Weighted Cost Per Ton | 26.14 | 25.20 | 24.31 | 23.84 | 23.60 |
| Savings Per Ton | | 0.94 | 1.83 | 2.30 | 2.55 |

**Table 7-24**
**Containers Transportation Cost Per Ton (Europe, Africa Exports)**

| DWT | 40 feet | 42 feet | 45 feet | 48 feet | 50 feet |
|---|---|---|---|---|---|
| 12,000 | 118.92 | 118.92 | 118.92 | 118.92 | 118.92 |
| 18,000 | 85.52 | 85.52 | 85.52 | 85.52 | 85.52 |
| 24,000 | 52.47 | 52.47 | 52.47 | 52.47 | 52.47 |
| 34,000 | 53.23 | 53.26 | 53.26 | 53.26 | 53.26 |
| 45,000 | 52.34 | 52.41 | 52.46 | 52.46 | 52.46 |
| 57,000 | 35.26 | 34.32 | 34.35 | 34.35 | 34.35 |
| 65,000 | 47.13 | 43.06 | 42.71 | 42.71 | 42.71 |
| 74,000 | 59.32 | 52.82 | 45.37 | 41.85 | 41.85 |
| 86,000 | 37.03 | 33.29 | 29.03 | 26.88 | 26.88 |
| 104,000 | 69.57 | 62.02 | 53.36 | 46.83 | 46.55 |
| Weighted Cost Per Ton | 53.21 | 50.27 | 47.92 | 46.62 | 46.60 |
| Savings Per Ton | | 2.94 | 5.29 | 6.59 | 6.61 |

**Table 7-25**
**Freeport Container Import and Export Benefits ($1,000s)**

| Year | 41 feet | 45 feet | 46 feet | 48 feet | 50 feet |
|---|---|---|---|---|---|
| 2017 | 504 | 4,764 | 5,695 | 6,903 | 7,336 |
| 2027 | 543 | 5,137 | 6,142 | 7,444 | 7,911 |
| 2037 | 543 | 5,137 | 6,142 | 7,444 | 7,911 |
| 2047 | 543 | 5,137 | 6,142 | 7,444 | 7,911 |
| 2057 | 543 | 5,137 | 6,142 | 7,444 | 7,911 |
| 2067 | 543 | 5,137 | 6,142 | 7,444 | 7,911 |
| Average Annual Savings (4.0%) | 535 | 5,055 | 6,044 | 7,444 | 7,784 |

### 7.1.5 Offshore Supply, Research, and Seismic Vessels Transportation Savings Benefits

Table 7-26 displays the average annual benefits by channel depth for vessels using the Upper Stauffer Channel.

**Table 7-26**
**Freeport Offshore Supply, Research, and Seismic Vessels Benefits ($1,000s)**

| Year | 20 feet | 22 feet | 25 feet | 28 feet | 30 feet |
|---|---|---|---|---|---|
| 2017 | 333 | 753 | 1,039 | 1,100 | 1,111 |
| 2027 | 394 | 892 | 1,230 | 1,302 | 1,314 |
| 2037 | 466 | 1,056 | 1,456 | 1,541 | 1,556 |
| 2047 | 552 | 1,249 | 1,724 | 1,823 | 1,841 |
| 2057 | 653 | 1,479 | 2,040 | 2,158 | 2,180 |
| 2067 | 773 | 1,750 | 2,415 | 2,554 | 2,580 |
| Average Annual Savings (4.0%) | 455 | 1,029 | 1,419 | 1,502 | 1,516 |

## 7.2 SENSITIVITY ANALYSIS

This section provides sensitivity analyses. Effects of construction cost contingencies, growth forecasts, share of tonnage applied to benefits, variations to container fleet, and sensitivities on many of the assumptions used in the model were analyzed to recognize variables causing the greatest risk and uncertainty and the magnitude of those unknowns. Based on historical trends, regional factors, and well-respected experts in the field, every effort was made to use the most likely assumptions for the with-project condition. The most likely or historical average figures were used in much of the model, but fluctuations from the most likely scenarios will occur because of market conditions and global economies. The sensitivities aim to capture the potential range of uncertainty in the model.

### 7.2.1 Reduced Construction Cost Contingencies

The effect of lower construction cost contingencies on plan optimization is addressed in this section. Table 7-27 displays the project construction cost by construction contract. In accordance with economic analysis procedures, all of the calculations were performed using economic costs that reflect the inclusion of cost contingencies. The base cost is the cost without the contingency factored into the cost. The total cost includes the contingency and is used as the construction cost for BCR calculations. The low and high show the effects on cost if the percent contingency is reduced by 5 percent and if the percent contingency is increased by 20 percent. The National Economic Development (NED) plan is the alternative with the highest net excess benefits. Net excess benefits is the difference between average annual benefits and average annual costs. The Locally Preferred Plan (LPP) is the alternative that the non-Federal sponsor prefers.

**Table 7-27**
**Construction Cost by Contract for NED and LPP**

| Contract | Contract Description | Base Cost | Contingency (%) | Total Cost Including Contingency | Low (-5%) | High (+20%) |
|---|---|---|---|---|---|---|
| **NED Project Construction Cost ($1,000)** | | | | | | |
| 1 | New Extension & Part of Outer | 90,058 | 24 | 111,672 | 107,169 | 129,684 |
| 2 | Remaining Outer Bar & Jetty | 106,317 | 24 | 131,833 | 126,517 | 153,096 |
| 3 | Lower Turning Basin | 14,801 | 24 | 18,345 | 17,613 | 21,313 |
| 4 | Placement Area Jetty Grouting | 490 | 10 | 540 | 515 | 637 |
| 5 | Dredge to Brazosport to Brazosport Turning Basin | 53,880 | 24 | 66,806 | 64,117 | 77,587 |
| 6 | Dredge to Upper Turning Basin | 36,433 | 24 | 45,064 | 43,355 | 52,464 |
| 7 | Lower Stauffer | 10,205 | 24 | 12,664 | 12,144 | 14,695 |
| 7 | Upper Stauffer | 3,294 | 24 | 4,090 | 3,920 | 4,743 |
| 8 | Mitigation | 211 | 24 | 262 | 251 | 304 |
| | Total Cost with IDC | | | 419,909 | 403,087 | 487,785 |
| **LPP Project Construction Cost ($1,000)** | | | | | | |
| 1 | New Extension & Part of Outer | 50,124 | 24 | 62,154 | 59,648 | 72,179 |
| 2 | Remaining Outer Bar & Jetty | 80,751 | 24 | 100,131 | 96,094 | 116,281 |
| 3 | Lower Turning Basin | 13,086 | 24 | 16,218 | 15,572 | 18,844 |
| 4 | Placement Area Jetty Grouting | 490 | 10 | 540 | 515 | 637 |
| 5 | Dredge to Brazosport to Brazosport Turning Basin | 43,512 | 24 | 53,950 | 51,779 | 62,657 |
| 6 | Dredge to Upper Turning Basin | 33,747 | 24 | 41,733 | 40,159 | 48,596 |
| 7 | Lower Stauffer | 9,540 | 24 | 11,840 | 11,353 | 13,738 |
| 7 | Upper Stauffer | 3,079 | 24 | 3,823 | 3,664 | 4,434 |
| 8 | Mitigation | 211 | 24 | 262 | 251 | 304 |
| | Total Cost with IDC | | | 310,066 | 297,564 | 360,092 |

The table shows a range of construction costs for the NED of about $84 million ranging from $403 million to $488 million with the most likely at $420 million, and for the LPP of about $62 million ranging from $298 million to $360 million with the most likely at $310 million.

### 7.2.2 Lower and Higher Growth Forecasts

Table 7-28 displays the base tonnage forecasts and the low and high ranges associated with each commodity group to represent the range of scenarios. The low value for the crude petroleum import forecast was based on the AEO low forecast. The high value for the crude petroleum import forecast was based on a trendline of 80 years of historical data for U.S. crude oil imports correlated with historical GDP and Global Insight's forecasted GDP. The low and high values for the petroleum product forecast are based on the base year. The low and high values for the chemical export forecast are based on application of the residual values associated with the trendline equation used to prepare the base forecast.

**Table 7-28**
**Crude Petroleum, Petroleum Product, and Chemical Tonnage Forecasts**
**Comparison of Base, Low, and High Ranges (Short Tons)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Crude Oil Forecasts (Based on Regression Using Global Insight September 2010 Projections with Freeport Imports as a function of U.S. Imports)** | | | | | | | |
| | **2007/2009** | **2017** | **2027** | **2037** | **2047** | **2057** | **2067** |
| base | 19,516,000 | 19,516,000 | 25,076,000 | 34,994,000 | 43,969,000 | 53,971,000 | 73,153,000 |
| low | 19,516,000 | 18,806,000 | 14,153,000 | 14,464,000 | 13,831,000 | 12,573,000 | 11,316,000 |
| high | 19,516,000 | 38,439,000 | 61,892,000 | 99,454,000 | 120,440,000 | 147,996,000 | 175,552,000 |
| **Petroleum Product Import Forecast (Application of AEO2010 Product Import Forecast)** | | | | | | | |
| | **2007/2009** | **2017** | **2027** | **2037** | **2047** | **2057** | **2067** |
| base | 740,000 | 1,151,000 | 1,106,000 | 1,141,000 | 1,216,000 | 1,287,000 | 1,359,000 |
| low | 740,000 | 254,000 | 244,000 | 252,000 | 269,000 | 284,000 | 300,000 |
| high | 740,000 | 1,266,000 | 1,217,000 | 1,255,000 | 1,338,000 | 1,416,000 | 1,495,000 |
| **Chemical Product Export Forecast (Trendline Application)** | | | | | | | |
| | **2007/2009** | **2017** | **2027** | **2037** | **2047** | **2057** | **2067** |
| base | 2,412,000 | 3,326,000 | 4,209,000 | 5,092,000 | 5,975,000 | 6,858,000 | 7,741,000 |
| low | 2,412,000 | 1,974,000 | 2,498,000 | 3,023,000 | 3,547,000 | 4,071,000 | 4,595,000 |
| high | 2,412,000 | 4,678,000 | 5,920,000 | 7,162,000 | 8,403,000 | 9,645,000 | 10,887,000 |
| **Container Import and Export Forecast (TEUs)** | | | | | | | |
| | **2007/2009** | **2017** | **2027** | **2037** | **2047** | **2057** | **2067** |
| base | 168,000 | 217,000 | 234,000 | 234,000 | 234,000 | 234,000 | 234,000 |
| low | 168,000 | 168,000 | 168,000 | 168,000 | 168,000 | 168,000 | 168,000 |
| high | 168,000 | 234,000 | 234,000 | 234,000 | 234,000 | 234,000 | 234,000 |

Table 7-29 shows the benefits for the low and high growth scenario. The benefits increase in both the low and high scenarios to 60, 50, and 50 feet, respectively, for reaches 1, 2, and 3. These depths also provide the highest BCR, although in the low scenario, the BCR for Reach 1 and Reach 2 fall below unity. Hence, the risk for this sensitivity is mostly associated with the BCR rather than selection of optimal channel depths.

**Table 7-29**
**Low and High Average Annual Benefits for Reach 1, Reach 2, and Reach 3 ($1,000s)**

| **Reach 1** | **50 feet** | **52 feet** | **55 feet** | **58 feet** | **60 feet** |
|---|---|---|---|---|---|
| Low | 6,978 | 8,998 | 12,393 | 15,480 | 22,704 |
| B/C Ratio | 0.5 | 0.5 | 0.6 | 0.7 | 0.9 |
| High | 36,505 | 47,236 | 65,666 | 82,902 | 123,672 |
| B/C Ratio | 2.6 | 2.9 | 3.3 | 3.5 | 4.7 |
| **Reach 2** | **46 feet** | **47 feet** | **48 feet** | **49 feet** | **50 feet** |
| Low | 266 | 537 | 787 | 1,031 | 1,238 |
| B/C Ratio | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 |
| High | 1,439 | 2,912 | 4,268 | 5,599 | 6,730 |
| B/C Ratio | 0.4 | 0.8 | 1.2 | 1.5 | 1.8 |
| **Reach 3** | **41 feet** | **45 feet** | **46 feet** | **48 feet** | **50 feet** |
| Low | 390 | 3,688 | 4,409 | 5,344 | 5,679 |
| B/C Ratio | 0.3 | 2.4 | 2.9 | 3.4 | 3.5 |
| High | 543 | 5,137 | 6,142 | 7,444 | 7,911 |
| B/C Ratio | 0.4 | 3.4 | 4.0 | 4.7 | 4.9 |

### 7.2.3 Lower and Higher Share of Constrained Tonnages

The purpose of this sensitivity is to evaluate the effect of a lower and higher percentage of crude petroleum being loaded to drafts approaching the without- and with-project future channel depth constraint.

Table 7-30 displays the results of the sensitivity of using a lower (90%) and higher (100%) percentage of crude petroleum tonnage constrained by draft, or in other words, the percent of crude petroleum tonnage applied towards the benefits in the analysis. The results show that average annual benefits for Reach 1 and Reach 2 are affected approximately 4 percent and the BCR remains above unity. The 60-foot-depth for Reach 1 and the 50-foot depth for Reach 2 continue to have the highest BCRs, thereby showing little risk in channel depth selection for each reach.

**Table 7-30**
**Crude Petroleum Imports Average Annual Benefits ($1,000s)**
**Adjusting Share of Constrained Tonnage**

| Reach 1 | 50 feet | 52 feet | 55 feet | 58 feet | 60 feet |
|---|---|---|---|---|---|
| Low | 17,584 | 22,721 | 31,470 | 39,565 | 58,626 |
| B/C Ratio | 1.2 | 1.4 | 1.6 | 1.7 | 2.2 |
| High | 19,367 | 25,036 | 34,713 | 43,694 | 64,873 |
| B/C Ratio | 1.4 | 1.5 | 1.8 | 1.8 | 2.1 |
| **Reach 2** | **46 feet** | **47 feet** | **48 feet** | **49 feet** | **50 feet** |
| Low | 886 | 1,773 | 2,591 | 3,385 | 4,048 |
| B/C Ratio | 0.3 | 0.5 | 0.7 | 0.9 | 1.1 |
| High | 936 | 1,875 | 2,742 | 3,585 | 4,292 |
| B/C Ratio | 0.3 | 0.5 | 0.8 | 1.0 | 1.2 |

### 7.2.4 Variations to Container Fleet

Two sensitivities were conducted for the selection of container fleet. Table 7-31 displays the container benefits based on a U.S. fleet distribution adjusted to exclude vessels over 65,000 DWT.

**Table 7-31**
**Container Import and Export Benefits ($1,000s)**
**Vessel Fleet Distribution Sensitivity No. 1: Based on U.S. Trip Distribution**
**(Excluding Vessels over 65,000 DWT)**

| Year | 41 feet | 45 feet | 46 feet | 48 feet | 50 feet |
|---|---|---|---|---|---|
| 2017 | 10 | 42 | 42 | 42 | 42 |
| 2027 | 10 | 45 | 45 | 45 | 45 |
| 2037 | 10 | 45 | 45 | 45 | 45 |
| 2047 | 10 | 45 | 45 | 45 | 45 |
| 2057 | 10 | 45 | 45 | 45 | 45 |
| 2067 | 10 | 45 | 45 | 45 | 45 |
| Average Annual Savings (4.0%) | 10 | 44 | 44 | 44 | 44 |
| B/C Ratio (Reach 3) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

The second sensitivity is based on the Houston tonnage with a maximum-sized vessel of 57,000 DWT. The 18,000 DWT group is calculated using Houston data, plus one-half of the percentage associated with the 24,000 DWT group. The percentage of tonnage for the 24,000 DWT vessels is calculated based on the inclusion of one-half of the smaller class of 24,000 DWT and one-half of the 34,000 DWT group. The percentage of tonnage for the 34,000 DWT group is assumed to be the same as Houston. Freeport's percentage of tonnage for the 45,000 DWT group is assumed to be one-half of Houston's percentage. Freeport's remaining percent is assumed to be transported by vessels represented by the 57,000 DWT group. Table 7-32 shows the container benefits based on Houston distribution disaggregated by region for imports and exports capping

at 57,000 DWT. In both sensitivities, the BCR falls below unity for all channel depths, indicating that the BCR for the Lower Stauffer Channel is highly sensitive to assumptions made about fleet selection of containers.

**Table 7-32**
**Container Import and Export Benefits ($1,000s)**
**Vessel Fleet Distribution Sensitivity No. 2:**
**Based on Houston Step Share Distribution**
**(Excluding Vessels over 57,000 DWT)**

| Year | 41 feet | 45 feet | 46 feet | 48 feet | 50 feet |
|---|---|---|---|---|---|
| 2017 | 301 | 1,096 | 1,096 | 1,096 | 1,096 |
| 2027 | 325 | 1,182 | 1,182 | 1,182 | 1,182 |
| 2037 | 325 | 1,182 | 1,182 | 1,182 | 1,182 |
| 2047 | 325 | 1,182 | 1,182 | 1,182 | 1,182 |
| 2057 | 325 | 1,182 | 1,182 | 1,182 | 1,182 |
| 2067 | 325 | 1,182 | 1,182 | 1,182 | 1,182 |
| Average Annual Savings (4.0%) | 320 | 1,163 | 1,163 | 1,163 | 1,163 |
| B/C Ratio (Reach 3) | 0.2 | 0.8 | 0.8 | 0.7 | 0.7 |

### 7.2.5 Other Sensitivity Analyses

Table 7-33 lists the low and high ranges of sensitivities as well as the BCR and its change from the most likely condition by reach. A '-' indicates no statistical change from the most likely condition. As the table shows, the sensitivities that have the potential to lower the BCR below unity for a particular reach have to do with the growth forecasts, the share of crude being imported to Seaway/TEPPCO docks, or the container fleet forecast being representative of the U.S. fleet with a maximum-sized vessel of 65,000 DWT. The AEO low forecast lowers the BCR for Reach 1 and Reach 2 below unity. The petroleum products low forecast lowers the BCR below unity for Reach 2. The U.S. container fleet lowers the BCR for Reach 3 below unity. However, when only one sensitivity is adjusted at a time, the overall project BCR still remains above unity in all scenarios, ceterus paribus.

**Table 7-33**
**Other Sensitivity Analyses**

| LPP | Range | | LPP B/C Ratio in Reaches | | | | | LPP % Change in B/C Ratio in Reaches | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sensitivity** | **Low/ High** | **Value** | **All** | **1** | **2** | **3** | **4** | **All** | **1** | **2** | **3** | **4** |
| Cost Contingency | Low | -5% | 1.95 | 1.70 | 1.24 | 5.00 | 6.66 | 2 | 2 | 2 | 1 | 3 |
| | High | 20% | 1.74 | 1.52 | 1.10 | 4.66 | 5.70 | -9 | -9 | -9 | -5 | -12 |
| Underkeel Clearance | Low | 2.5 | 1.76 | 1.56 | 1.11 | 4.30 | - | -7 | -6 | -8 | -13 | - |
| | High | 4 | 2.10 | 1.78 | 1.30 | 6.28 | - | 10 | 7 | 8 | 28 | - |
| Hours to Lightering Zone | Low | 7 | 1.89 | 1.65 | 1.20 | - | - | -1 | -1 | -1 | - | - |
| | High | 9 | 1.91 | 1.68 | 1.22 | - | - | 1 | 1 | 1 | - | - |
| Hours to Discharge for Lightering-Mother Vessel | Low | 10 | - | - | - | - | - | - | - | - | - | - |
| | High | 136 | 1.92 | 1.68 | 1.22 | - | - | 1 | 1 | 1 | - | - |
| Port Time | Low | 20 | - | - | - | - | - | - | - | - | - | - |
| | High | 30 | 1.92 | 1.68 | 1.22 | - | - | 1 | 1 | 1 | - | - |
| Hours Gauging, Setup | Low | 3 | 1.89 | 1.65 | - | - | - | -1 | -1 | - | - | - |
| | High | 5 | - | - | - | - | - | - | - | - | - | - |
| Hours Downtime of Mother Vessel-Lightening | Low | 30 | - | - | - | - | - | - | - | - | - | - |
| | High | 60 | - | - | - | - | - | - | - | - | - | - |
| Hours Downtime of Mother Vessel-Lightering | Low | 50 | 1.88 | 1.64 | 1.20 | - | - | -1 | -1 | -1 | - | - |
| | High | 90 | 1.91 | 1.68 | - | - | - | 1 | 1 | - | - | - |
| Hours to Discharge for Lightening-Shuttle Vessel | Low | 4 | - | - | - | - | - | - | - | - | - | - |
| | High | 12 | - | - | - | - | - | - | - | - | - | - |
| Hours to Discharge for Lightering-Shuttle Vessel | Low | 4 | - | - | - | - | - | - | - | - | - | - |
| | High | 10 | - | - | - | - | - | - | - | - | - | - |
| Hours Downtime of Shuttle Vessel-Lightening | Low | 8 | - | 1.65 | - | - | - | - | -1 | - | - | - |
| | High | 24 | 1.93 | 1.70 | 1.23 | - | - | 2 | 2 | 2 | - | - |
| Hours Downtime of Shuttle Vessel-Lightering | Low | 8 | - | - | - | - | - | - | - | - | - | - |
| | High | 16 | - | 1.67 | - | - | - | - | 1 | - | - | - |
| Share of Mideast/Far East Oil from Far East | Low | 1 | - | - | - | - | - | - | - | - | - | - |
| | High | 14 | - | - | - | - | - | - | - | - | - | - |
| % Tonnage Utilization-Mexico | Low | 90 | - | 1.65 | - | - | - | - | -1 | - | - | - |
| | High | 100 | 1.91 | 1.68 | 1.21 | - | - | 1 | 1 | 1 | - | - |
| % Tonnage Utilization-South America | Low | 90 | 1.88 | 1.63 | 1.19 | - | - | -1 | -2 | -1 | - | - |
| | High | 100 | 1.94 | 1.71 | 1.23 | - | - | 2 | 3 | 2 | - | - |

**Table 7-33, cont'd**

| LPP | Range | | LPP B/C Ratio in Reaches | | | | | LPP % Change in B/C Ratio in Reaches | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sensitivity** | **Low/ High** | **Value** | **All** | **1** | **2** | **3** | **4** | **All** | **1** | **2** | **3** | **4** |
| % Tonnage Utilization-Mideast and Far East | Low | 90 | 1.89 | 1.65 | 1.20 | - | - | -1 | -1 | -1 | - | - |
| | High | 100 | 1.92 | 1.69 | 1.22 | - | - | 1 | 1 | 1 | - | - |
| % Tonnage Utilization-Africa and Europe | Low | 90 | 1.89 | 1.65 | - | - | - | -1 | -1 | - | - | - |
| | High | 100 | 1.91 | 1.68 | - | - | - | 1 | 1 | - | - | - |
| Freeport Market % Share increase to US crude imports | Low | .03 | 1.53 | 1.22 | 1.02 | - | - | -20 | -26 | -16 | - | - |
| | High | .15 | 2.02 | 1.81 | 1.27 | - | - | 6 | 9 | 5 | - | - |
| % Crude Oil Imported to Seaway/TEPPCO dock | Low | 75 | 1.82 | 1.43 | 1.93 | - | - | -4 | -14 | 60 | - | - |
| | High | 95 | 1.94 | 1.79 | 0.82 | - | - | 2 | 7 | -32 | - | - |
| % Cost Differential Preference Lightening to Lightering | Low | 0 | - | - | - | - | - | - | - | - | - | - |
| | High | 5 | - | - | - | - | - | - | - | - | - | - |
| % Cost Differential Preference of Direct Shipment | Low | 0 | - | - | - | - | - | - | - | - | - | - |
| | High | 5 | - | - | - | - | - | - | - | - | - | - |
| Crude Tonnage Forecast | Low | AEO | 1.25 | 0.89 | 0.88 | - | - | -34 | -46 | -27 | - | - |
| | High | Trend | 4.36 | 4.58 | 2.46 | - | - | 130 | 175 | 104 | - | - |
| Share of Petroleum Products from South America | Low | 5 | - | - | 1.22 | - | - | - | - | 1 | - | - |
| | High | 20 | - | - | 1.17 | - | - | - | - | -3 | - | - |
| Petro Prod Tonnage Forecast | Low | 2009 | 1.84 | - | 0.79 | - | - | -3 | - | -35 | - | - |
| | High | 2007 *1.2 | - | - | 1.26 | - | - | - | - | 4 | - | - |
| Chemicals Sensitivity | Low | 0.5 | - | - | - | - | - | - | - | - | - | - |
| | High | 2 | - | - | - | - | - | - | - | - | - | - |
| % Chemicals from South America | Low | 25 | 1.93 | 1.69 | - | - | - | 2 | 1 | - | - | - |
| | High | 75 | 1.87 | 1.64 | - | - | - | -2 | -1 | - | - | - |
| Chemicals Tonnage Forecast | Low | | 1.84 | 1.62 | - | - | - | -3 | -3 | - | - | - |
| | High | | 1.96 | 1.71 | - | - | - | 3 | 3 | - | - | - |
| TEU to Short Tons | Low | 7.5 | 1.84 | - | - | 4.02 | - | -3 | - | - | -18 | - |
| | High | 11 | 1.97 | - | - | 5.95 | - | 3 | - | - | 21 | - |
| (Un)Loading rate Containers | Low | 273 | - | - | - | 4.88 | - | - | - | - | -1 | - |
| | High | 456 | - | - | - | - | - | - | - | - | - | - |
| Hours in Port-Containers | Low | 20 | 1.88 | - | - | 4.60 | - | -1 | - | - | -7 | - |
| | High | 30 | 1.93 | - | - | 5.37 | - | 1 | - | - | 9 | - |

**Table 7-33, cont'd**

| LPP | Range | | LPP B/C Ratio in Reaches | | | | | LPP % Change in B/C Ratio in Reaches | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sensitivity** | **Low/ High** | **Value** | **All** | **1** | **2** | **3** | **4** | **All** | **1** | **2** | **3** | **4** |
| Share of Imports | Low | 35 | - | - | - | 4.98 | - | - | - | - | 1 | - |
| | High | 45 | - | - | - | 4.86 | - | - | - | - | -1 | - |
| Share of Cargo Unloaded from Mediterranean, Asia | Low | 8 | - | - | - | 4.81 | - | - | - | - | -2 | - |
| | High | Hous ton | - | - | - | - | - | - | - | - | - | - |
| Share of Cargo Loaded to Mediterranean, Asia | Low | 8 | 1.89 | - | - | 4.77 | - | -1 | - | - | -3 | - |
| | High | Hous ton | - | - | - | - | - | - | - | - | - | - |
| Share of Cargo Unloaded from South and Central America | Low | 8 | 1.89 | - | - | 4.76 | - | -1 | - | - | -3 | - |
| | High | Hous ton | - | - | - | - | - | - | - | - | - | - |
| Share of Cargo Loaded to South and Central America | Low | 8 | 1.88 | - | - | 4.66 | - | -1 | - | - | -5 | - |
| | High | Hous ton | - | - | - | - | - | - | - | - | - | - |
| Share of Cargo Unloaded from Europe, Africa | Low | 8 | - | - | - | 4.83 | - | - | - | - | -2 | - |
| | High | Hous ton | - | - | - | - | - | - | - | - | - | - |
| Share of Cargo Loaded to Europe, Africa | Low | 8 | 1.87 | - | - | 4.50 | - | -1 | - | - | -9 | - |
| | High | Hous ton | - | - | - | - | - | - | - | - | - | - |
| Share of Container Imports from Mediterranean, Asia | Low | 35 | - | - | - | 4.88 | - | - | - | - | -1 | - |
| | High | 45 | - | - | - | 5.01 | - | - | - | - | 2 | - |
| Share of Container Imports from South and Central America | Low | 20 | - | - | - | - | - | - | - | - | - | - |
| | High | 30 | - | - | - | - | - | - | - | - | - | - |
| Share of Container Exports from Mediterranean, Asia | Low | 18 | - | - | - | 4.87 | - | - | - | - | -1 | - |
| | High | 30 | 1.91 | - | - | 5.11 | - | 1 | - | - | 4 | - |
| Share of Container Exports from South and Central America | Low | 30 | - | - | - | 5.04 | - | - | - | - | 2 | - |
| | High | 40 | - | - | - | 4.81 | - | - | - | - | -2 | - |
| Share of Empty Containers-Mediterranean, Asia Imports | Low | 9.2 | 1.96 | - | - | 5.83 | - | 3 | - | - | 18 | - |
| | High | 23.9 | - | - | - | - | - | - | - | - | - | - |
| Share of Empty Containers-Mediterranean, Asia Exports | Low | 9.2 | 1.92 | - | - | 5.30 | - | 1 | - | - | 8 | - |
| | High | 23.9 | - | - | - | - | - | - | - | - | - | - |

**Table 7-33, cont'd**

| LPP | Range | | LPP B/C Ratio in Reaches | | | | | LPP % Change in B/C Ratio in Reaches | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sensitivity** | **Low/ High** | **Value** | **All** | **1** | **2** | **3** | **4** | **All** | **1** | **2** | **3** | **4** |
| Share of Empty Containers-South and Central America Imports | Low | 9.2 | - | - | - | 5.00 | - | - | - | - | 2 | - |
| | High | 23.9 | - | - | - | - | - | - | - | - | - | - |
| Share of Empty Containers-South and Central America Exports | Low | 9.2 | 1.91 | - | - | 5.10 | - | 1 | - | - | 3 | - |
| | High | 23.9 | - | - | - | - | - | - | - | - | - | - |
| Share of Empty Containers-Europe, Africa Imports | Low | 9.2 | 1.93 | - | - | 5.40 | - | 2 | - | - | 10 | - |
| | High | 23.9 | - | - | - | - | - | - | - | - | - | - |
| Share of Empty Containers-Europe, Africa Exports | Low | 9.2 | 1.99 | - | - | 6.33 | - | 5 | - | - | 29 | - |
| | High | 23.9 | - | - | - | - | - | - | - | - | - | - |
| Weight per TEU-Mediterranean, Asia Imports | Low | 8.4 | - | - | - | 4.78 | - | - | - | - | -3 | - |
| | High | 9.34 | 1.91 | - | - | 5.11 | - | 1 | - | - | 4 | - |
| Weight per TEU-Mediterranean, Asia Exports | Low | 8.94 | 1.88 | - | - | 4.63 | - | -1 | - | - | -6 | - |
| | High | 10.5 | - | - | - | - | - | - | - | - | - | - |
| Weight per TEU-South and Central America Imports | Low | 8.94 | - | - | - | 4.86 | - | - | - | - | -1 | - |
| | High | 10.5 | - | - | - | - | - | - | - | - | - | - |
| Weight per TEU-South and Central America Exports | Low | 8.94 | - | - | - | 4.80 | - | - | - | - | -3 | - |
| | High | 10.5 | - | - | - | - | - | - | - | - | - | - |
| Weight per TEU-Europe, Africa Imports | Low | 8.4 | - | - | - | 4.84 | - | - | - | - | -2 | - |
| | High | 9.34 | - | - | - | 5.03 | - | - | - | - | 2 | - |
| Weight per TEU-Europe, Africa Exports | Low | 8.27 | 1.89 | - | - | 4.76 | - | -1 | - | - | -3 | - |
| | High | 8.94 | 1.91 | - | - | 5.11 | - | 1 | - | - | 4 | - |
| Fleet Forecast | Low | US-max 65K | 1.59 | - | - | 0.03 | - | -16 | - | - | -99 | - |
| | High | Houston | - | - | - | - | - | - | - | - | - | - |
| Share of Vessels with Competitive Advantage to Freeport over Houston | Low | 10 | 1.88 | - | - | 4.62 | - | -1 | - | - | -6 | - |
| | High | 50 | 1.96 | - | - | 5.83 | - | 3 | - | - | 18 | - |
| Underkeel Clearance-Upper Stauffer | Low | 1 | 1.89 | - | - | - | 4.80 | -1 | - | - | - | -26 |
| | High | 3 | - | - | - | - | - | - | - | - | - | - |

**Table 7-33, cont'd**

| LPP | Range | | LPP B/C Ratio in Reaches | | | | | LPP % Change in B/C Ratio in Reaches | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sensitivity** | **Low/ High** | **Value** | **All** | **1** | **2** | **3** | **4** | **All** | **1** | **2** | **3** | **4** |
| Hours to Upper Stauffer Roundtrip | Low | 3.5 | - | - | - | - | 5.64 | - | - | - | - | -13 |
| | High | 4.5 | - | - | - | - | 7.25 | - | - | - | - | 12 |
| Traffic Growth Rate-Upper Stauffer | Low | 1 | 1.89 | - | - | - | 5.18 | -1 | - | - | - | -20 |
| | High | 3 | 1.93 | - | - | - | 9.87 | 2 | - | - | - | 53 |
| Months to Construct-Upper Stauffer | Low | 1 | - | - | - | - | - | - | - | - | - | - |
| | High | 3 | - | - | - | - | - | - | - | - | - | - |

## 8.0 ECONOMIC SUMMARY

This section presents summaries of the transportation savings benefits by commodity group.

Table 8-1 presents the economic summary data for the first reach. This reach includes the Lower Turning Basin and the Brazosport Turning Basin. The results of the analysis show that the BCR for all channel depth alternatives from 50 to 60 feet are above unity. Of the plans presented, the 60 foot alternative has the highest net excess benefits.

**Table 8-1**
**Crude Petroleum for Seaway Terminal and Chemical Products for Dow Chemical (Reach 1)**
**Average Annual Benefits and Costs (4.0% and $1,000)**

| Channel Alternative | 50 feet | 52 feet | 55 feet | 58 feet | 60 feet |
|---|---|---|---|---|---|
| 2017 | 10,658 | 13,799 | 19,230 | 24,279 | 36,566 |
| 2027 | 15,543 | 20,086 | 27,831 | 34,999 | 51,913 |
| 2037 | 19,668 | 25,409 | 35,176 | 44,193 | 65,445 |
| 2047 | 24,121 | 31,161 | 43,125 | 54,213 | 80,062 |
| 2057 | 28,361 | 36,643 | 50,719 | 63,789 | 94,186 |
| 2067 | 32,758 | 42,318 | 58,546 | 73,611 | 108,556 |
| First Cost of Construction | 169,353 | 194,914 | 233,255 | 290,977 | 329,458 |
| Interest During Construction | 12,104 | 14,443 | 17,952 | 23,487 | 27,178 |
| Total Investment | 181,457 | 209,357 | 251,207 | 314,464 | 356,636 |
| Average Annual Cost | 8,447 | 9,746 | 11,694 | 14,638 | 16,601 |
| Average Annual O&M[a] | 5,786 | 6,679 | 8,019 | 9,163 | 9,903 |
| Total Annual Cost | 14,233 | 16,424 | 19,713 | 23,802 | 26,505 |
| Average Annual Benefits | 18,297 | 23,647 | 32,767 | 41,217 | 61,125 |
| Net Excess Benefits | 4,064 | 7,223 | 13,054 | 17,415 | 34,620 |
| B/C Ratio | 1.3 | 1.4 | 1.7 | 1.7 | 2.3 |

Table 8-2 presents the economic summary data for the second reach. This reach extends from the Brazosport Turning Basin to the Upper Turning Basin. The 50-foot channel depth provides the highest net excess benefits of the alternatives analyzed. Channel depths over 50 feet are not included since deepening beyond 50 feet would necessitate significant bank stabilization and dock modifications.

**Table 8-2**
**Crude Petroleum and Petroleum Products**
**for ConocoPhillips (Reach 2)**
**Average Annual Benefits and Costs (4.0% and $1,000)**

| Channel Alternative | 46 Feet | 47 Feet | 48 Feet | 49 Feet | 50 Feet |
|---|---|---|---|---|---|
| 2017 | 590 | 1,178 | 1,720 | 2,246 | 2,684 |
| 2027 | 813 | 1,624 | 2,372 | 3,098 | 3,704 |
| 2037 | 983 | 1,966 | 2,873 | 3,755 | 4,491 |
| 2047 | 1,128 | 2,264 | 3,310 | 4,329 | 5,184 |
| 2057 | 1,268 | 2,548 | 3,728 | 4,879 | 5,847 |
| 2067 | 1,420 | 2,856 | 4,181 | 5,474 | 6,563 |
| First Cost of Construction | 40,884 | 41,929 | 42,974 | 44,019 | 45,064 |
| Interest During Construction | 1,179 | 1,209 | 1,240 | 1,270 | 1,300 |
| Total Investment | 42,063 | 43,138 | 44,214 | 45,289 | 46,364 |
| Average Annual Cost | 1,958 | 2,008 | 2,058 | 2,108 | 2,158 |
| Average Annual O&M | 1,397 | 1,433 | 1,468 | 1,504 | 1,540 |
| Total Annual Cost | 3,355 | 3,441 | 3,526 | 3,612 | 3,698 |
| Average Annual Benefits | 906 | 1,814 | 2,651 | 3,465 | 4,146 |
| Net Excess Benefits | -2,449 | -1,627 | -875 | -147 | 448 |
| B/C Ratio | 0.3 | 0.5 | 0.8 | 1.0 | 1.1 |

Table 8-3 displays the results of the base fleet for the third reach. The results of the analysis show that the net excess benefits continue to increase through channel depths of 50 feet. Depths greater than 50 feet were not analyzed because the LPP is 50 feet, and dredging deeper than 50 feet will require structural adjustments to the docks in both Reach 2 and Reach 3, thereby causing the marginal costs to exceed marginal benefits.

Table 8-4 displays the results of the fourth reach. Although the results of the analysis show that the net excess benefits maximize at 26 feet, it was determined by USACE economists that the marginal increase in net excess benefits from 25 feet to 26 feet is not worth the extra cost to the government. Therefore, the recommended depth is 25 feet.

**Table 8-3**
**Containers for Velasco Terminal (Reach 3)**
**Average Annual Benefits and Costs (4.0% and $1,000)**

| Channel Depth | 41 Feet | 43 Feet | 45 Feet | 48 Feet | 50 Feet |
|---|---|---|---|---|---|
| First Cost of Construction | 10,021 | 10,608 | 11,196 | 12,077 | 12,664 |
| Interest During Construction | 118 | 125 | 131 | 142 | 149 |
| Total Investment | 10,139 | 10,733 | 11,327 | 12,219 | 12,813 |
| Average Annual Cost | 472 | 500 | 527 | 569 | 596 |
| Average Annual O&M | 948 | 965 | 982 | 1,007 | 1,024 |
| Total Annual Cost | 1,420 | 1,465 | 1,509 | 1,576 | 1,620 |
| Average Annual Benefits | 535 | 2,614 | 5,055 | 7,325 | 7,784 |
| Net Excess Benefits | -886 | 1,149 | 3,546 | 5,749 | 6,164 |
| B/C Ratio | 0.4 | 1.8 | 3.3 | 4.6 | 4.8 |

**Table 8-4**
**Upper Stauffer (Reach 4)**
**Average Annual Benefits and Costs (4.0% and $1,000)**

| Channel Depth | 20 Feet | 24 Feet | 25 Feet | 26 Feet | 27 Feet | 28 Feet | 29 Feet | 30 Feet |
|---|---|---|---|---|---|---|---|---|
| First Cost of Construction | 1,718 | 3,616 | 4,090 | 4,622 | 5,153 | 5,685 | 6,217 | 6,749 |
| Interest During Construction | 3 | 6 | 6 | 8 | 9 | 9 | 10 | 11 |
| Total Investment | 1,721 | 3,622 | 4,096 | 4,630 | 5,162 | 5,695 | 6,227 | 6,760 |
| Average Annual Cost | 80 | 169 | 191 | 216 | 240 | 265 | 290 | 315 |
| Average Annual O&M | 17 | 37 | 42 | 47 | 52 | 57 | 62 | 67 |
| Total Annual Cost | 97 | 206 | 233 | 263 | 293 | 322 | 352 | 382 |
| Average Annual Benefits | 455 | 1,217 | 1,419 | 1,490 | 1,490 | 1,502 | 1,502 | 1,516 |
| Net Excess Benefits | 357 | 1,011 | 1,186 | 1,227 | 1,197 | 1,179 | 1,149 | 1,135 |
| B/C Ratio | 4.7 | 5.9 | 6.1 | 5.7 | 5.1 | 4.7 | 4.3 | 4.0 |

A summary of the economic analyses is presented below. The first part of Table 8-5 shows the NED benefits and the second half shows the LPP benefits. Although net excess benefits maximized at a channel depth of 60 feet for Reach 1, the non-Federal sponsor opted for a depth of 55 feet and preferred slight other modifications to save in construction costs. The average annual benefits and costs are based on the current discount rate of 4.0 percent. Table 8-6 presents the calculations at 7.0 percent.

**Table 8-5**
**Economic Summary of NED and LPP for Freeport Channel and Stauffer Modification**
**Average Annual Values (4.0% and $1,000)**

| | NED Plan | | | |
|---|---|---|---|---|
| | | Stauffer Modification | | |
| | Freeport Channel 60/50 feet | Lower Reach 50 feet | Upper Reach 25 feet | Totals |
| First Cost of Construction | 374,522 | 12,664 | 4,090 | 391,276 |
| Interest During Construction | 28,477 | 149 | 6 | 28,632 |
| Total Investment | 402,999 | 12,813 | 4,096 | 419,909 |
| Average Annual Cost | 18,760 | 596 | 191 | 19,547 |
| Average Annual O&M | 11,258 | 1,024 | 42 | 12,324 |
| Total Annual Cost | 30,018 | 1,620 | 233 | 31,871 |
| Average Annual Benefits | 65,270 | 7,784 | 1,419 | 74,474 |
| Net Excess Benefits | 35,253 | 6,164 | 1,186 | 42,603 |
| B/C Ratios | 2.2 | 4.8 | 6.1 | 2.3 |
| | LPP | | | |
| | | Stauffer Modification | | |
| | Freeport Channel 55/50 feet | Lower Reach 50 feet | Upper Reach 25 feet | Totals |
| First Cost of Construction | 274,988 | 11,840 | 3,823 | 290,651 |
| Interest During Construction | 19,156 | 139 | 6 | 19,301 |
| Total Investment | 294,144 | 11,979 | 3,829 | 309,952 |
| Average Annual Cost | 13,692 | 558 | 178 | 14,428 |
| Average Annual O&M | 9,569 | 1,024 | 42 | 10,635 |
| Total Annual Cost | 23,261 | 1,581 | 221 | 25,063 |
| Average Annual Benefits | 38,442 | 7,784 | 1,419 | 47,646 |
| Net Excess Benefits | 15,181 | 6,203 | 1,199 | 22,583 |
| B/C Ratios | 1.7 | 4.9 | 6.4 | 1.9 |

**Table 8-6**
**Economic Summary of NED and LPP for Freeport Channel and Stauffer Modification**
**Average Annual Values (7.0% and $1,000)**

| | NED Plan | | | |
|---|---|---|---|---|
| | | Stauffer Modification | | |
| | Freeport Channel 60/50 feet | Lower Reach 50 feet | Upper Reach 25 feet | Totals |
| First Cost of Construction | 374,522 | 12,664 | 4,090 | 391,276 |
| Interest During Construction | 51,788 | 262 | 11 | 52,060 |
| Total Investment | 426,310 | 12,926 | 4,101 | 443,336 |
| Average Annual Cost | 30,890 | 937 | 297 | 32,124 |
| Average Annual O&M | 11,303 | 1,015 | 35 | 12,353 |
| Total Annual Cost | 42,193 | 1,952 | 332 | 44,477 |
| Average Annual Benefits | 58,797 | 7,734 | 1,312 | 67,842 |
| Net Excess Benefits | 16,604 | 5,782 | 980 | 23,365 |
| B/C Ratios | 1.4 | 4.0 | 3.9 | 1.5 |
| | LPP | | | |
| | | Stauffer Modification | | |
| | Freeport Channel 55/50 feet | Lower Reach 50 feet | Upper Reach 25 feet | Totals |
| First Cost of Construction | 274,988 | 11,840 | 3,823 | 290,651 |
| Interest During Construction | 34,733 | 245 | 11 | 34,989 |
| Total Investment | 309,721 | 12,085 | 3,834 | 325,640 |
| Average Annual Cost | 22,442 | 876 | 278 | 23,596 |
| Average Annual O&M | 9,648 | 1,015 | 35 | 10,699 |
| Total Annual Cost | 32,091 | 1,891 | 313 | 34,295 |
| Average Annual Benefits | 34,564 | 7,734 | 1,312 | 43,610 |
| Net Excess Benefits | 2,474 | 5,843 | 999 | 9,315 |
| B/C Ratios | 1.1 | 4.1 | 4.2 | 1.3 |

## 8.1 REGIONAL ECONOMIC BENEFITS

This section contains discussions and table displays of the regional benefits of port-related activity. The tables and associated discussions are displayed "as presented" in Martin Associates' "The Local and Regional Economic Impacts of Port Freeport." The Freeport regional impact analysis was prepared by Martin Associates for the port of Freeport in 2006.[14] The current report represents an update from an original report prepared in 2003.

[14] Martin Associates, "The Local and Regional Economic Impacts of Port Freeport, August 2006,

The regional benefits contained in the 2006 report and presented here are based on total project effects. While the incremental effects of the Federal action were not calculated, it is generally expected that the proposed deepening project will result in incremental increases beyond the existing base. The expectation that the Federal project will generate increases in regional benefits is based on general conclusions contained in the Martin Associates report that illustrate that Freeport terminal expansions and cargo increases have resulted in increases in jobs, personal earnings, business revenue, and state and local taxes. Additionally, a general observation of multiport analyses is that incremental changes in project depth provide assurances that a port will, at a minimum, maintain its regional benefit base. A comparative analysis of the effect on total tonnage throughput and vessel utilization among ports would be helpful measuring post-project on a regional and national level. Compilation and comparison of tonnage data between ports could be aggregated relatively easily.

It is recognized that for the communities within the study area, the Freeport Harbor Channel is responsible for benefits to the local and regional economy. Freeport has one of the largest petrochemical complexes in the world. In 2007, Freeport ranked 5th in the Nation in terms of foreign trade and 25th in terms of total tonnage. Petroleum and chemical products represent approximately 95 percent foreign trade in 2006.[15] The remaining 5 percent of foreign trade includes bulk materials and agricultural products. Freeport exports 6 percent of U.S. rice and imports 6 percent of U.S. bananas. Approximately 1,700 vessels called at the port in 2006.

Port activities contribute to the local and regional economy by generating business revenues to local and national firms providing vessel and cargo-handling services at the marine terminals. Businesses, in turn, provide employment and income to individuals. The port's marine and cargo terminals and refinery complexes generate revenue throughout the local, state, and national economies. Port facilities include a diverse range of public and private marine terminals. The public marine terminals are those owned by the port and leased to terminal operators and marine terminal tenants. The port's tenants include Dole Fresh Fruit Company, Turbana Corp., Chiquita Brands, Inc., Bryan Coastal Stevedoring, P&O Ports, Vulcan Materials, and American Rice, Inc. The port's general cargo base also includes a variety of temperature-sensitive cargos such as meat and vegetables. P&O, a multinational container terminal operator and stevedore, currently provides container and terminal operations in Freeport for the special requirements of the Dole, Chiquita, and Turbana fruit distributors. Freeport's refrigerated-cargo facility has been in operation since 1984. The port's private marine terminals include Dow Chemical, BASF Corp., ConocoPhillips Terminal, and TEPPCO Seaway Pipeline Company. In addition to its established base of terminals, the without-project future includes an LNG and a container terminal. The LNG terminal became operational by late 2008 and was constructed by a partnership that includes ConocoPhillips and Dow Chemical. The terminal is located along the northern edge of the

[15] Complete statistics are not available for 2007 as of January 15, 2009. The most recent annual data available from the USACE NDC at the time of report preparation are presented. This report includes the latest annual data available from the USACE NDC.

Freeport Harbor Outer Bar and Jetty channels near Station 65+00. The port includes an FTZ (No. 149), which was created in 1988. The FTZ provides customs duty deferent and manufacturing and inventory management benefits.

Revenue generated by the port is produced by firms providing services to the commodity and vessel activity at the terminals, revenue from trucking firms, railroads, pipeline operations, terminal operations, and associated refineries and chemical plants (from loading and discharging vessels), handlers, agents, pilots, towing companies, and maritime support firms. This revenue is used to purchase employment (direct jobs), to provide services, to pay stockholders and for retained earnings, and to purchase goods and services from local firms, as well as national and international firms. Businesses also pay taxes from their business revenue.

According to the Martin Associates report used in preparation of this section of the report, marine cargo activity at Freeport's public and private marine terminals in the navigation district is responsible for 11,131 direct jobs with local firms. The estimated 11,131 jobs account for nearly $1.1 billion in personal annual incomes. Seventy-five percent of these direct jobs were found to be held by residents of Brazoria County. The activity at the public port facilities is noted to create 970 of the direct jobs. The 10,161 jobs created by the movement of petroleum and petrochemicals at the private terminals are primarily associated with local refineries and chemical plants with private marine terminals. Table 8-7 shows total direct jobs associated with port activities.

The effect of dry cargo is shown as 0.35 job per 1,000 tons. Again, the incremental effect on jobs and regional income based on the range of channel depths between 40 and 50 feet evaluated for the Lower Stauffer Channel is recognized to be much smaller.

It is noted that in addition to local and regional purchases by those 11,131 individuals holding the direct jobs, an additional 14,700 induced jobs are supported in the regional economy. The report found that 9,886 indirect jobs were supported by $903.6 million of local purchases by businesses supplying services at the marine terminals and by businesses dependent upon the port for the shipment and receipt of cargo. In addition to the direct, induced, and indirect job impacts, an estimated 20,422 jobs in the state of Texas were found to be related to the cargo exported and imported over marine terminals at the port. It is noted in the report that while these 20,422 jobs are considered to be related to port activity, the degree of dependence on the marine terminals is difficult to quantify and should not be considered as dependent on the port as are the direct, induced, and indirect jobs.

**Table 8-7**
**Employment Impact by Sector and Job Category**
**Number of Jobs**

| Job Sector | Public Terminals | Private Terminals | Total Jobs |
|---|---|---|---|
| Surface transportation | | | |
| Rail | 3 | 56 | 59 |
| Truck | 260 | 459 | 720 |
| Maritime services | | | |
| Terminal employees/consignees | 456 | 9,541 | 9,997 |
| ILA/dockworkers | 100 | 0 | 100 |
| Towing | 6 | 14 | 20 |
| Pilots | 3 | 6 | 9 |
| Agents | 1 | 7 | 8 |
| Surveyors/chandlers | 1 | 1 | 2 |
| Forwarders | 54 | 0 | 54 |
| Maritime services | 8 | 10 | 18 |
| Government | 24 | 30 | 53 |
| Marine construction/ shipyards | 22 | 8 | 31 |
| Barge | 0 | 29 | 29 |
| Port authority | 31 | NA | 31 |
| Total Jobs | 970 | 10,161 | 11,131 |

Source: Martin Associates, "The Local and Regional Economic Impacts of Port Freeport, August 2006, Table II-1, page 21.

Table 8-8 displays the summary of economic impacts in current 2006 dollars generated by the port's public and private marine terminals as presented in the 2006 Martin Associates document. The report shows that marine activity supported $4.4 billion of total personal wage and salary income and local consumption expenditures for Texas residents. The $4.4 billion income is noted to include $3.4 billion of direct, indirect, induced, and local consumption expenditures, while the remaining $1.0 billion was received by the related port users. The 11,131 direct jobholders received $1.1 billion of direct wage and salary income for an average salary of $95,130. Additionally, a total of $302.9 million of state and local tax revenue was generated by maritime activity at the port, and $93.7 million of state and local taxes was created due to the economic activity of the related users of the cargo moving via the marine terminals.

The effect on jobs and personal income associated with the Upper Stauffer Channel falls under the marine construction and shipyard activity and appears to provide significant increases in regional income. Vessel traffic on the Upper Stauffer is associated with offshore oilfields and other traffic back and forth to the main segment of the port. Oilfield shipments primarily consisted of fuel, water, supplies, drill pipes, drill mud, and chemicals along with barges and rigs that needed repair. There are 31 jobs associated with marine construction and shipyard activity.

The current job count of 31 is considerably less than in the 1970s and 1980s when a channel operating depth of 30 feet was available.

Table 8-8 shows that Freeport's 2005 marine cargo activity generated a total of approximately $9.0 billion of total economic activity in the State of Texas.

**Table 8-8**
**Summary of the Local and Regional**
**Economic Impacts Generated by Port Freeport**

| Variable | Public Terminals | Private Terminals | Total |
|---|---|---|---|
| Jobs | 970 | 10,161 | 11,131 |
| Induced | 674 | 14,026 | 14,700 |
| Indirect | 609 | 9,277 | 9,886 |
| Related jobs | 2,514 | 17,908 | 20,422 |
| Total | 4,766 | 51,372 | 56,139 |
| Personal income ($1,000) | | | |
| Direct | 39,049 | 1,019,806 | 1,058,854 |
| Responding/consumption | 67,183 | 1,754,576 | 1,821,759 |
| Indirect | 28,945 | 455,596 | 484,541 |
| Related income | 62,600 | 978,164 | 1,040,764 |
| Total | 197,777 | 4,208,142 | 4,405,919 |
| Economic value ($1,000) | | | |
| Direct revenue | 71,227 | 864,929 | 936,156 |
| Local purchases | 65,946 | 837,676 | 903,621 |
| Related output | 354,712 | 6,838,030 | 7,192,742 |
| Total | 491,885 | 8,540,635 | 9,032,519 |
| State & local taxes ($1,000) | | | |
| Direct, induced and indirect | 12,166 | 290,698 | 302,864 |
| Related state and local taxes | 5,634 | 88,035 | 93,669 |
| Totals | 17,800 | 378,733 | 396,533 |

Source: Martin Associates, "The Local and Regional Economic Impacts of Port Freeport, August 2006, Table E-2, page 4.

[t]Totals may not add due to rounding

Table 8-9 presents the job impacts per 1,000 tons for each commodity moving via the public and private marine terminals. Bagged rice creates the largest number of direct jobs per 1,000 tons, followed by bulk rice and refrigerated containers. The relatively large impact per 1,000 tons for resin reflects the relatively small tonnage handled. Despite the fact that petroleum generated the second largest direct job impact, on a per 1,000 ton basis, petroleum generates 0.05 job per 1,000 tons. Dry bulk cargoes, such as limestone, also generate relatively small numbers of jobs per 1,000 tons. The jobs impact per 1,000 tons for chemicals reflects the large number of terminal

**Table 8-9**
**Job Impacts per 1,000 Tons**

| Commodity | Public | Private | Port-Wide |
|---|---|---|---|
| Dry Containers | 0.35 | | 0.35 |
| Reefer Containers | 0.68 | | 0.68 |
| General Cargo | 0.56 | | 0.56 |
| Resin | 0.74 | | 0.74 |
| Bagged Rice | 1.00 | | 1.00 |
| Bulk Rice | 0.77 | | 0.77 |
| Limestone | 0.04 | | 0.04 |
| Breakbulk Fruit | 0.42 | | 0.42 |
| Petroleum | | 0.05 | 0.05 |
| Chemicals | | 0.66 | 0.66 |

Source: Martin Associates, "The Local and Regional Economic Impacts of Port Freeport, August 2006, Exhibit II-3, page 23.

and plant employees employed by the petrochemical industry in the Freeport Port District that are using private terminals to ship and receive petrochemicals. The finding that the petroleum and bulk cargoes generate relatively small direct jobs per 1,000 tons of throughput reflects the fact that the handling of liquid bulk and dry bulk cargoes is much less labor intensive than handling general cargo, and further, the supporting infrastructure of agents, freight forwarders and customhouse brokers, and warehousing and terminal operators is greater for general cargo such as break-bulk fruit, containerized cargo, and bagged grain. If the dependent shippers/consignees were not included in the direct job impacts per 1,000-ton measure, the difference in the labor intensity of general cargo versus liquid bulk cargo would be even more pronounced.

The port noted that the 2006 Martin Associates report figures reflect substantial gains over those reported in a similar study conducted by Martin Associates in 2003.[16] Specifically, comparison of the 2003 and 2006 reports showed that the number of direct local jobs that rely upon Port Freeport increased by 38 percent, or 3,041 jobs. It is noted that the job growth is in part due to expansion of the Dow Chemical operation as well as the growth in cargo, particularly chemicals, general cargo, limestone, and crude petroleum. Since the 2003 economic impact study, the port has experienced a 1.6-million-ton increase of cargo.[17]

The Martin Associates report and specific evaluation to the proposed deepening project suggest that incremental increases in jobs as a result of channel deepening would be relatively small. This conclusion is based on the finding that petroleum and bulk cargoes generate relatively small

[16] http://www.thefacts.com/downloads/PORT%20FREEPORT%20FINAL_1.pdf

[17] *The Economic Impact of Port Freeport, 2003*, Martin Associates, August 2004

direct jobs per 1,000 tons of throughput since incremental increases beyond 45 feet for the main portion of the Freeport Channel are nearly exclusively associated with petroleum, and benefits for induced tonnage were not included in the benefit calculations. Induced tonnage effects would be minimal due to the large fixed infrastructure associated with petroleum refining and established feedstock requirements as well as regional and national pipeline distribution networks.

While changes in job effects for petroleum will be minimal, the effects associated with the operation of the Velasco Container Terminal will recognizably impact jobs to a greater extent than petroleum. The general effects associated with overall container cargo associated with the Velasco Terminal should be similar to general cargo and dry containers but would likely not exceed the general cargo effects. General cargo generates 0.56 jobs per 1,000 tons.

# 9.0 SUMMARY AND CONCLUSIONS

Although economies go through periods of peaks and troughs, most stable countries experience long-term growth. The recent recession of the late 2000s caused a set back in the national economy, but the economy of the U.S. is resilient. It is likely to experience growth over the next 50 years. As the national economy grows, demand for energy will also grow. There is debate where this energy will come from, but historical trends have shown that a large portion of the Nation's energy comes from crude petroleum and petroleum products. There are tremendous infrastructure challenges to suddenly divert from these long-term trends. Demand for chemical products and consumer goods is also expected to increase as the economy grows.

Freeport is well poised to capitalize on these increases in demand. Infrastructure is in place, the port has land available for expansion, and Freeport is presently a key contributor to the national economy. One of the National SPRs is nearby, and Freeport is only 3 miles from deep water in the Gulf of Mexico and 1 hour from one of the largest cities in the country. Of the commodities imported and exported at Freeport, petroleum imports contribute the most to national benefits. Benefits from container traffic is the second largest contributor. Table 9-1 provides the NED and LPP channel depths and BCRs. The BCRs for all reaches are above unity in the most likely scenario and many of the sensitivities. Deepening the channel at Freeport will contribute to the local economy and will add value to the national economy.

**Table 9-1**
**NED and LPP Channel Depth Summary**

| | NED | | LPP | |
|---|---|---|---|---|
| | **Channel Depth** | **BCR** | **Channel Depth** | **BCR** |
| Reach 1 | 60 | 2.3 | 55 | 1.7 |
| Reach 2 | 50 | 1.1 | 50 | 1.2 |
| Reach 3 | 50 | 4.8 | 50 | 4.9 |
| Reach 4 | 25 | 6.1 | 25 | 6.4 |
| Total | - | 2.3 | - | 1.9 |

# Appendix B

# Engineering Appendix

Job No. 044190100

# APPENDIX B
# ENGINEERING
# FREEPORT HARBOR
# CHANNEL IMPROVEMENT PROJECT
# BRAZORIA COUNTY, TEXAS

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## Acronyms and Abbreviations

| | |
|---|---|
| 3D | three-dimensional |
| AM | Advance Maintenance |
| ATON | Aids to Navigation |
| CEDEP | Cost Engineering Dredge Estimating Programs |
| CHL | Coastal and Hydraulic Laboratory |
| CSRA | Cost and Schedule Risk Analysis |
| CU | Consolidated Undrained Triaxial Compression Test |
| cy | cubic yards |
| cy/yr | cubic yards per year |
| DMMP | Dredged Material Management Plan |
| EM | Engineering Manual |
| ER | Engineer Regulation |
| ERDC | Engineer Research and Development Center |
| ETL | Engineering Technical Letter |
| fps | feet per second |
| GIWW | Gulf Intracoastal Waterway |
| H&H | Hydrology and Hydraulics |
| HQUSACE | Headquarter, U.S. Army Corps of Engineers |
| LNG | liquefied natural gas |
| LOA | length overall (ship) |
| LPP | Locally Preferred Plan |
| LTB | Lower Turning Basin |
| mg/l | milligram per liter |
| MLLW | mean lower low water |
| MLT | mean low tide |
| NAD | North American Datum |
| NAVD | North American Vertical Datum |
| NED | National Economic Development |
| NGVD | National Geodetic Vertical Datum |
| NOAA | National Oceanic and Atmospheric Administration |
| O&M | Operation and Maintenance |
| ODMDS | Ocean Dredged Material Disposal Site |
| P&S | Plans and Specifications |
| PA | placement area |
| PDT | Project Delivery Team |
| PED | Preconstruction Engineering and Design |
| PMP | Project Management Plan |

| | |
|---|---|
| ppt | parts per thousand |
| SWG | Southwest Division, Galveston District (USACE) |
| TPCS | Total Project Cost summary |
| UC | Unconfined Compression Test |
| USACE | U.S. Army Corps of Engineers |
| UU | Unconsolidated Undrained Triaxial Compression Test (Q-tests) |
| VLCC | very large crude carrier |

# APPENDIX B
# ENGINEERING
# FREEPORT HARBOR
# CHANNEL IMPROVEMENT PROJECT
# BRAZORIA COUNTY, TEXAS

## 1.0 CIVIL ENGINEERING

### 1.1 INTRODUCTION

The Freeport Harbor Feasibility Study Engineering Appendix follows the requirements of Engineer Regulation (ER) 1110-2-1150, Appendix C. This appendix includes applicable items and information required for the comparative engineering studies, investigations, and design. The specific studies include the ship simulation and shoreline impacts by the U.S. Army Corps of Engineers' (USACE) Engineer Research and Development Center (ERDC). Also, preliminary geotechnical investigations including sampling/analysis and preparation of a preliminary Dredged Material Management Plan (DMMP) were performed. Use of hydrographic surveys, surveying and mapping, environmental quality/mitigation features, preliminary structural design investigations, access roads, operations and maintenance, associated cost estimates, data management, and schedules for design and construction were all considered for development of design features and screening-level cost estimates. These estimates were developed in sufficient detail to substantiate the recommended plan and baseline cost estimate. The first construction contract will consist of hopper dredging of the channel. The design features presented in this appendix provide the basis for the plans and specifications that will be prepared later during Preconstruction Engineering and Design (PED).

The Design Team assisted the Planner and Environmental Lead during the Plan Formulation process. This includes Planning Objectives and Preliminary Plan Formulation consisting of the No-Action Alternative and Action Plan alternatives pertaining to navigation improvements. Engineering work during Detailed Plan Formulation consisted of evaluating alternatives advanced for further screening as detailed in the Feasibility Report. The study generated a National Economic Development (NED) plan and a Locally Preferred Plan (LPP); both are defined as:

*The NED Alternative is referred to as the 60-foot by 540-foot project because the width of the Jetty Channel would be restricted to 540 feet. This alternative proposes to extend the Outer Bar Channel (Channel Extension) 3.2 miles farther into the Gulf of Mexico at a depth of 62 feet and a width of 600 feet, deepen the existing Outer Bar Channel to 62 feet and the Jetty Channel to 60 feet, deepen the main channel from the Lower Turning Basin through Station 132+66 (just above the Brazosport Turning Basin) to 60 feet and widen the Brazosport Turning Basin to 1,200 feet, deepen the main channel from Station 132+66 through the Upper Turning Basin to 50 feet,*

*deepen and widen the Lower Stauffer Channel to 50 feet by 300 feet, and dredge the Upper Stauffer Channel to 25 feet deep by 200 feet wide in lieu of restoring its previous dimensions of 30 feet by 200 feet.*

*The LPP Alternative is referred to as the 55-foot by 600-foot project. This alternative proposes to extend the Outer Bar Channel (Channel Extension) 1.3 miles farther into the Gulf of Mexico at a depth of 57 feet and a width of 600 feet, deepen the existing Outer Bar Channel to 57 feet and the Jetty Channel to 55 feet, deepen the main channel from the Lower Turning Basin through Station 132+66 (just above the Brazosport Turning Basin) to 55 feet and widen the Brazosport Turning Basin to 1,200 feet, deepen the main channel from Station 132+66 through the Upper Turning Basin to 50 feet, deepen and widen the Lower Stauffer Channel to 50 feet by 300 feet wide, and dredge the Upper Stauffer Channel to 25 feet deep by 200 feet wide in lieu of restoring its previous dimensions of 30 feet by 200 feet.*

This section on civil design focuses primarily on analysis of existing cross-section surveys, proposed channel templates, and geometric design for proposed channel deepening and widening alternatives. Considerations consisted of conceptual assumptions to navigation channel realignment, proposed new work, maintenance dredging requirements, and placement plan for dredged material as needed to establish feasibility-level cost estimates. The design tables and preliminary CADD study plates incorporated are in sufficient detail to provide the basis for the plans and specifications that will be prepared later during the PED phase.

The objectives of civil design were to present the design rationale for the proposed plans (i.e., NED Plan and LPP); develop the project, plan new work volumes and 50-year maintenance dredging requirements, identify the extent of removals and relocations, identify potential impacts to existing infrastructure and environmentally sensitive areas, and determine real estate requirements as needed. The analysis began using the existing channel template configuration as a basis to derive different improved channel alignments, dredge toes, and templates (i.e., depths, widths, and side slopes). In evaluating and assessing the technical practicality of several different channel improvement alternatives and design features, items such as the existing and future-planned facilities; existing pipelines, utilities, and structures; disposal requirements for dredged material; and real estate requirements were considered for the feasibility study. Civil design focused on conceptually functional design requirements such as dredge limit layout, performance, and placement plan footprints. Cost Engineering was provided resulting data, in the form of new work quantity tables for estimating the initial construction for a technically feasible improved channel. The preliminary costs were contrasted against potential future benefits (see Economics Appendix) derived from the conceptual improvement alternatives. This process basically yielded competing Benefit-Cost Ratios and is further discussed in the Feasibility Report. The channel that yielded the maximum net excess benefits became the NED Plan due to Federal project requirements.

The site selection and project development consisted of three distinct phase systems: Initial Plan Formulation, Plan Formulation, and Detail Design. The Initial Plan Formulation and Plan Formulation phases included gathering site data and validating data pertaining to existing conditions. The Detail Design phase consisted of assessing problems with the proposed channel reconfigurations and making a learned recommendation based on analytical findings to yield the NED Plan and the LPP.

## 1.2 DREDGING TERMS

The term "new work" refers to the material below the existing channel template that is needed to be removed in order to increase to the new project depth. The new work material quantities were calculated using an overall surface of x,y,z coordinate data points referred to as a digital terrain model or dtm file, generated by the MicroStation CADD Bentley InRoads software program. The surface is a three-dimensional (3D) representation of the existing channel conditions of various survey mergers taken between 2003 and 2006. Each channel configuration had its own existing template and proposed template. The template is a trapezoidal shape, defined by bottom width and side slopes. A model was developed and volumes were computed. These design analyses are documented each time a run is updated in CADD.

### 1.2.1 Advance Maintenance

Advance Maintenance (AM) consists of dredging deeper than the authorized channel dimensions so as to provide for the accumulation and storage of sediment. In critical and fast-shoaling areas, it is required to avoid frequent redredging and to ensure the reliability and least overall cost for operating and maintaining the project authorized dimensions. The existing channel has a constant 2-foot AM. During the Detail Design phase, an analysis was performed by the Hydrology and Hydraulics (H&H) section to determine any changes in dredging frequencies based on predicted shoal rates and whether an increase to AM would be required. Based on the H&H analyses, there was no recommendation to increase AM. Therefore, results are assumed to match current conditions.

### 1.2.2 Allowable Overdepth

An additional depth outside the required template is permitted to allow for inaccuracies in the dredging process. District of commanders may dredge a maximum of 2 feet of allowable overdepth in coastal regions and in inland navigation channels (ER 1130-2-520 *Navigation and Dredging Operations and Maintenance Policies)*. This additional dredging allowance is referred to as a dredging tolerance, or allowable overdepth. The existing channel overdepth from deeper water up to Station 82+66 is 2 feet and was assumed to remain constant for the proposed channel. As the stationing increases upstream beyond Station 82+66, a 1-foot overdepth was assumed to match existing.

### 1.2.3 Nonpay Dredging

Nonpay dredging is dredging outside the paid allowable overdepth that may occur due to such factors as unanticipated variations in substrate, incidental removal of submerged obstructions, or wind or wave conditions. There are no known conditions that would indicate that the contractor will require extensive dredging in order to cut the proposed channel template. Thus, the new work volumes do not include any estimate of nonpay dredging. New work material volumes can be seen for the NED Plan and the LPP in tables 1 and 2.

Table 1
Freeport New Work Dredging Volumes for 60x540 NED Plan*

| Authorized Depth (feet) | Adv. Maint. Shoaling (feet) | Allowable Dredging Pay Tolerance (feet) | Bottom Width (feet) | New Work Section of Waterway (NED 60x540 Plan) | NED Station Start | NED Station End | Required Quantity (cubic yards) | Allowable Quantity (cubic yards) |
|---|---|---|---|---|---|---|---|---|
| 62 | 2 | 2 | 600 | Future Channel Extension | –300+00 | –470+00 | 2,000,000 | 670,000 |
| 62 | 2 | 2 | 600 | Outer Bar | 0+00 | –300+00 | 7,800,000 | 1,300,000 |
| 60 | 2 | 2 | 540 | Jetty Reach | 71+52 | 0+00 | 2,900,000 | 287,000 |
| 60 | 2 | 2 | Match existing | Lower Turning Basin | 78+52 | 71+52 | 280,000 | 38,000 |
| 60 | 2 | 1 | 1,200 turning basin | Channel to Brazosport & New 1,200-foot Brazosport Turning Basin | 115+00 | 78+52 | 2,200,000 | 116,000 |
| 60 | 2 | 1 | Match existing | Channel from Brazosport Turning Basin | 132+66 | 115+00 | 513,000 | 34,000 |
| 50 | 2 | 1 | Match existing | Channel to Upper Turning Basin & Upper Turning Basin | 184+20 | 132+66 | 380,000 | 110,000 |
| 50 | 2 | 1 | 300 | Stauffer Channel, Lower Reach | 222+00 | 184+20 | 1,340,000 | 47,000 |
| 25 | 2 | 1 | 200 | Stauffer Channel, Upper Reach & Turning Basin | 260+00 | 222+00 | 390,000 | 37,000 |
| | | | | | Sub-Total | | 17,803,000 | 2,639,000 |
| | | | | | TOTAL | | 20,442,000 | |

*From the Government interests, the action plan evaluated is the NED Plan. This plan is the Federal plan shown in the table and is also referred to as the 60x540 Plan.

1. Required Quantity includes the AM.
2. Overdepth (Allowable Dredging) is an additional 2 feet at Station 82+66 towards deeper water in Gulf of Mexico and is 1 foot going from Station 82+66 up-station to end of Stauffer.
3. Proposed Extension quantities extrapolated using nautical chart contour limits.
4. Stauffer Channel Volume to –20-foot depth is:
   89,000 cubic yards (Sta. 222+00 to 260+00)
   30,000 cubic yards (Sta. 184+20 to 222+00)
5. If costing excavation above water line at Seaway Containment dike, deduct:
   260,000 cubic yards (from volume in reach Sta. 78+52 to 115+00)
6. Existing bottom widths vary and for cost purposes assumed average is 400 feet.

Table 2
Freeport New Work Dredging Volumes for 55x600 LPP*

| Authorized Depth (feet) | Adv. Maint. Shoaling (feet) | Allowable Dredging Pay Tolerance (feet) | Bottom Width (feet) | New Work Section of Waterway (LPP 55x600 Plan) | LPP Station Start | LPP Station End | Required Quantity (cubic yards) | Allowable Quantity (cubic yards) |
|---|---|---|---|---|---|---|---|---|
| 57 | 2 | 2 | 600 | Future Channel Extension | –300+00 | –370+00 | 500,000 | 295,000 |
| 57 | 2 | 2 | 600 | Outer Bar | 0+00 | –300+00 | 4,990,000 | 1,300,000 |
| 55 | 2 | 2 | 600 | Jetty Reach | 71+52 | 0+00 | 3,345,000 | 303,000 |
| 55 | 2 | 2 | Match existing | Lower Turning Basin (LTB) | 78+52 | 71+52 | 170,000 | 38,000 |
| 55 | 2 | 1 | 1,200 turning basin | Channel to Brazosport & New 1,200-foot Brazosport Turning Basin | 115+00 | 78+52 | 1,600,000 | 116,000 |
| 55 | 2 | 1 | Match existing | Channel from Brazosport Turning Basin | 132+66 | 115+00 | 357,000 | 34,000 |
| 50 | 2 | 1 | Match existing | Channel to Upper Turning Basin & Upper Turning Basin | 184+20 | 132+66 | 380,000 | 110,000 |
| 50 | 2 | 1 | 300 | Stauffer Channel, Lower Reach | 222+00 | 184+20 | 1,340,000 | 47,000 |
| 25 | 2 | 1 | 200 | Stauffer Channel, Upper Reach & Turning Basin | 260+00 | 222+00 | 390,000 | 37,000 |
| | | | | | Sub-Total | | 12,072,000 | 2,280,000 |
| | | | | | TOTAL | | 14,352,000 | |

*The non-Federal sponsor's plan referred to as the LPP is shown in this table and is also referred to as the 55x600 Plan.

1. Required Quantity includes the AM.
2. Overdepth (Allowable Dredging) is an additional 2 feet at Station 82+66 towards deeper water in Gulf of Mexico and is 1 foot going from Station 82+66 up-station to end of Stauffer.
3. Proposed Extension quantities extrapolated using nautical chart contour limits.
4. Stauffer Channel Volume to –20-foot depth is:

   89,000 cubic yards (Sta. 222+00 to 260+00)

   30,000 cubic yards (Sta. 184+20 to 222+00)
5. If costing excavation above water line at Seaway Containment dike, deduct:

   260,000 cubic yards (from volume in reach Sta. 78+52 to 115+00)
6. Existing bottom widths vary and for cost purposes assumed average is 400 feet.

In restating, required quantities column shown in tables 1 and 2 does include the 2-foot AM. Maximum allowable overdepth volume was broken out separately for use by Cost Engineering.

The amounts shown in tables 1 and 2 represent the neat line in situ material volume with a minimal amount of shoal material present that would otherwise be dredged in conjunction with maintaining the existing project channel.

Refer to the Geotechnical portion of this appendix for the characteristics of the material to be encountered as well as the DMMP.

### 1.2.4 Dredging Frequency

The dredging cycle of a channel is defined by the average number of years between the Operation and Maintenance (O&M) dredging operations for a historical period. Each channel has its own dredging frequency. The USACE, Galveston District's Dredging Histories Database Management System contains this information, and is the major source for the ERDC Sediment Study Report. It is assumed for the new project that the dredging frequency will adjust from the existing channel conditions, and this change is discussed in the H&H desktop shoaling study. Estimated frequency breakout and discussion are provided in the Geotechnical DMMP (Section 4.7, Table 7) and the H&H (Section 2.0, Table 3) sections of this appendix.

### 1.2.5 Predicted Shoaling Rates

A desktop study for sediment-related problems was performed by ERDC and is presented in Section 2.0 (H&H) of this appendix. The study produced estimates based on entire reaches. An adjustment was performed on the ERDC values to approximate the dredging sections. Refer to Section 2.0 of this appendix for dredge requirements.

The NED Alternative is referred to as the 60-foot by 540-foot project because the width of the Jetty Channel would be restricted to 540 feet. This alternative proposes to extend the Outer Bar Channel (Channel Extension) 3.2 miles farther into the Gulf of Mexico at a depth of 62 feet and a width of 600 feet, deepen the existing Outer Bar Channel to 62 feet and the Jetty Channel to 60 feet, deepen the main channel from the Lower Turning Basin through Station 132+66 (just above the Brazosport Turning Basin) to 60 feet and widen the Brazosport Turning Basin to 1,200 feet, deepen the main channel from Station 132+66 through the Upper Turning Basin to 50 feet, deepen and widen the Lower Stauffer Channel to 50 feet by 300 feet, and dredge the Upper Stauffer Channel to 25 feet deep by 200 feet wide in lieu of restoring its previous dimensions of 30 feet by 200 feet.

The LPP Alternative is referred to as the 55-foot by 600-foot project. This alternative proposes to extend the Outer Bar Channel (Channel Extension) 1.3 miles farther into the Gulf of Mexico

at a depth of 57 feet and a width of 600 feet, deepen the existing Outer Bar Channel to 57 feet and the Jetty Channel to 55 feet, deepen the main channel from the Lower Turning Basin through Station 132+66 (just above the Brazosport Turning Basin) to 55 feet and widen the Brazosport Turning Basin to 1,200 feet, deepen the main channel from Station 132+66 through the Upper Turning Basin to 50 feet, deepen and widen the Lower Stauffer Channel to 50 feet by 300 feet wide, and dredge the Upper Stauffer Channel to 25 feet deep by 200 feet wide in lieu of restoring its previous dimensions of 30 feet by 200 feet.

As defined in the global scope above, the required depth project geometric navigation improvements are summarized reach by reach below:

A. Future Channel Extension for LPP (Sta. –300+00 to Sta. –370+00). Should the LPP be selected, this proposed future reach will extend from the present offshore terminus out farther into the Gulf of Mexico until the 59-foot contour is encountered.

B. Future Channel Extension for NED (Sta. –300+00 to Sta. –470+00). Should the NED be selected, this proposed future reach will extend from the present offshore terminus out farther into the Gulf of Mexico until the 62-foot contour is encountered.

C. Outer Bar (Sta. –300+00 to Sta. 0+00). This offshore channel reach under present authorization extends 30,000 feet out into the Gulf of Mexico from its juncture with the Jetty Channel. Vessels in the Entrance Channel are completely exposed to crosscurrents and waves from the open Gulf.

D. Jetty Channel (Sta. 0+00 to Sta. 71+52). This offshore channel reach under present authorization extends 6,346 feet landward from its juncture with the Entrance Channel. Vessels in the Jetty Channel are sheltered from crosscurrents and waves by the jetties.

E. Lower Turning Basin (Sta. 71+52 to Sta. 78+52). This turning basin reach under present authorization is 750 feet in diameter and is located at the intersection of the Gulf Intracoastal Waterway (GIWW) and Freeport Channel adjacent to the future liquefied natural gas (LNG) facility. The proposed plans provide for no change other than deepening as required per LPP or NED.

F. Channel to Brazosport and New 1,200-foot Brazosport Turning Basin (Sta. 78+52 to Sta. 115+00). This reach under present authorization varies in width and extends westward from the intersection of the GIWW and Freeport Channel adjacent to the future LNG facility. New Brazosport Turning Basin. This turning basin reach under present authorization is 1,000 feet in diameter and is located at the terminus of Seaway Terminal adjacent to the GIWW. The proposed plans provide for increasing the footprint to 1,200-foot diameter and associated deepening as required per the LPP or NED Plan.

G. Channel from Brazosport Turning Basin (Sta. 115+00 to Sta. 132+66). This reach under present authorization varies in width from 250 to 400 feet and extends west from the existing Brazosport Turning Basin parallel to the Seaway Terminal. The

proposed plans provide for no change other than deepening as required per the LPP or NED Plan.

H. Channel to Upper Turning Basin and Upper Turning Basin (Sta. 132+66 to Sta. 184+20). This reach under present authorization varies in width from 275 to 550 feet and extends west from the existing Brazosport Turning Basin parallel to the Seaway Terminal. The proposed plans provide for no change other than deepening as required per LPP or NED. Upper Turning Basin. This Turning Basin reach under present authorization is 1,200 feet in diameter and is the existing project terminus offset the Brazos Harbor Channel. The proposed plans provide for no change other than deepening as required per LPP or NED.

I. Stauffer Channel, Lower Reach (Sta. 184+20 to Sta. 222+00). This lower existing 200-foot-wide reach adjacent to Dow Chemical under present authorization is deauthorized. The proposed plans provide for reauthorizing and improving the channel reach to 52x300 feet in case of the NED or 52x300 feet in case of the LPP.

J. Stauffer Channel, Upper Reach and Turning Basin (Sta. 222+00 to Sta. 260+00). This upper existing reach, which includes a 500-foot-wide turning basin, is currently deauthorized. The proposed plans provide for reauthorizing and improving the channel reach to 27x200 feet to include a 500-foot-diameter turning basin for the NED or 27x200 feet to include a 500-foot-diameter turning basin for the LPP.

## 1.3 INITIAL PLAN FORMULATION AND PLAN FORMULATION PHASE

Initial Plan Formulation considered several alternative depths such as 45, 48, 50, 52, 55, 57, 59, 60, and 62 feet. Other considerations included Ship Tracks Navigating the Inland Reaches, Jetty Channel, and Outer Bar Channel and are addressed in Section 2.0 (H&H) of this appendix.

### 1.3.1 Turning Basins

An improvement to the Brazosport Turning Basin was considered and developed. The existing Brazosport Turning Basin (1,000-foot diameter) shall be enlarged and configured to accommodate a 1,200-foot turning diameter. The other basin to be affected is the currently deauthorized Stauffer Turning Basin (Sta. 259+00 or north end of project). The Stauffer Turning Basin shall be reauthorized to its former 500-foot diameter for the NED Plan or the LPP. The other existing turning basins in the Freeport Channel inland reaches shall remain unchanged.

### 1.3.2 Channel Geometry

The proposed Extension to the Entrance Channel was determined for the various depths, and the existing channel centerline alignment was adjusted (shifted away from the South Jetty) as required per Geotechnical investigations during the Initial and Planning stage. The problem is the location of the new Entrance and Jetty Channel centerline will be dependent on not only the channel width but also the channel depth. For instance, if the channel is widened from 400 feet

to 600 feet and not deepened, the new centerline would be 100 feet northward of the existing channel centerline. If the channel depth is increased by 10 feet (45 to 55 feet) and widened from 400 to 600 feet (the LPP), the new centerline will shift 130 feet northward of the existing channel centerline. If the channel depth is increased by 15 feet (45 to 60 feet) and widened from 400 to 540 feet (NED Plan), the centerline will shift 115 feet northward of the existing channel centerline.

Attached in the drawings at end of this document is the "official" existing alignment and the preliminary LPP and NED Plan centerlines.

### 1.3.3 Relocations

With respect to the channel pipelines if encountered, the current District policy requirements for an underground pipeline is that it must be located at least 20 feet below the authorized bottom depth of the channel and at least 50 feet from the channel bottom edge, or channel toe above the plane of the prescribed channel bottom.

A total of two pipelines were identified. One known as the Enbridge Offshore PLS Seacrest LP (formerly Tejas Power Corporation) 16-inch pipeline (Permit No. 18902), located at Station 37+60 and a proposed pipeline via LNG Permit action to be installed at required depth near Sta. 65+00 in advance of any future project authorization. The pipeline crossing in the vicinity of Sta. 37+60 appears on USACE permit (#18902 Enbridge 16-inch pipeline). The non-Federal sponsor stated this pipeline was reset at an elevation closer to –92 MLT. At the time of this report, the project team resolved all pipeline depth is sufficient to accommodate channel improvement.

No bridges or electrical towers required relocation.

## 1.4 DETAIL FORMULATION DESIGN PHASE

This phase concentrates on refinement and development of the selected plans (NED and LPP). The selected plans were identified by the Project Delivery Team (PDT) and are technically defined according to tables 1 and 2 presented earlier in this section. Both tables outline the proposed dimensions and volumes accordingly.

### 1.4.1 Alignments

The centerline alignments differ slightly from the existing due to the selective widening in the plans (Permit, LPP, or NED). The centerline of the proposed channel will be shifted as this related to the geotechnical stability concerns of the South Jetty. The technical description for the preliminary alignments for the NED and LPP are attached in the drawings that accompany this document. Also attached for reference is the technical description of the existing channel alignment. Final layout will be performed during PED phase.

### 1.4.2 Bend Easing

Bend easing (transitioning) approaching the Lower Turning Basin is desirable and one reason for adjusting the channel bottom to accommodate the new LNG facility on the Quintana side and a proposed dock on Surfside Beach side. The easing is accomplished by widening landward up to approximately Sta. 45+00 and transitioning the channel footprint down to varying widths as needed on the right side nearing the existing North Jetty shoreline protection adjacent to the U.S. Coast Guard Station. It should be noted that in either the LPP or NED Plan, the North Jetty shoreline protection will be slightly impacted by top of cut in the range of Sta. 40+00 to Sta. 60+00, and therefore a tapered transition is proposed to keep encroachment to a minimum.

### 1.4.3 Real Estate

Additional land was required for the NED Plan or LPP improvements for long-term disposal purposes. The real estate is required for the 50-year DMMP as called out in Section 4.0 (Geotechnical) of this report. The areas provided are placement areas (PAs) 8 and 9. Further real estate actions to secure rights and actual acreages of all relevant areas are discussed in the Feasibility Report.

The existing open-water ocean dredged material disposal site (ODMDS) can be used provisionally under navigational servitude.

With respect to placement areas, both offshore and upland disposal areas identified on drawings will be utilized for construction of the project. Material removed from the Jetty reach and Outer Bar will be disposed of offshore. For dredging main channel reaches, the two new upland confined PAs (8 and 9) will be containment diked and contain spillways for discharge of effluent. Effluent from the new PAs will be discharged into the Brazos River. The surface area of new PAs 8 and 9 is 168 and 250 acres, respectively.

### 1.4.4 Mitigation

The term "mitigation" is used to refer to measures that were studied to reduce impacts from the deepening and widening project. Coordination with Cultural Resources and Environmental will occur as required to confirm measures or areas to avoid, minimize, or compensate for negative impacts. Final measures for mitigation are discussed more in the Environmental Impact Statement to this Feasibility Report.

### 1.4.5 Aids to Navigation

All of the existing aids to navigation (ATON, or "aids") for the channel will be adjusted as required. However, other aids affected by the plan, such as the reauthorized Stauffer Channel, will need to be evaluated during PED. In addition, new aids will be required in the offshore reach

beyond the existing channel limits for the NED Plan or LPP. The proposed Permit Widening Action will take place primarily on the north side of the Outer Bar and Jetty channels, which will result in the centerline of the Entrance Channel shifting to the north in this reach of the channel. The widening will impact existing aids to navigation along the north sides of both the Outer Bar and Jetty channels. Most significantly, the existing entrance range towers will no longer be aligned with the centerline of the widened channel. In order to mark the centerline of the improved channel, the range towers will have to be adjusted to the north and on tangent to the improved channel centerline unless it is decided to maintain an offset centerline.

### 1.4.6 Access Roads

All existing and proposed placement areas have existing access routes. The new upland Pas are basically configured on non-Federal sponsor–prescribed plats adjacent to the Brazos River and can be reached from existing access roads near these new areas. Additional access to project sites will be by water, with some sites only being accessible through waterborne equipment. No public roads require any improvement for access to the project sites.

## 1.5 SURVEYING, MAPPING, AND OTHER GEOSPATIAL DATA REQUIREMENTS

### 1.5.1 Surveys

For this study, survey coverage consists of maintenance cross sections along with non-Federal sponsor–delivered multi-beam condition surveys. The surveys mentioned were utilized to identify principal design features, volume estimates, impacts, and anomalies primarily associated in the vicinity of the Outer Bar and Jetty Channel and Main Channel reaches. The District utilized color orthodigital aerial photographs taken in 1995 to identify existing topographical features such as shoreline, docks, creeks, potential upland PA sites, wooded areas, etc. Additional land elevations were implied from the orthodigital maps. When applicable, interpolation between hydro-surveys and land surveys was performed using the MicroStation Bentley InRoads Civil Design software program once processed survey data were provided. An overall 3D surface or digital terrain model (.dtm) was generated using the software application providing a very good representation of the existing conditions along the Freeport Harbor Channel.

### 1.5.2 Additional Surveys

Additional surveys in the form of multi-beam were provided by the non-Federal sponsor and deemed useful in developing feasibility design layout in terms of the Jetty Reach. Due to stability concerns of the South Jetty, the surveys gave a clear .dtm in order to investigate various best-fit LPP or NED channel configuration. These surveys were gathered by the non-Federal sponsor with USACE scope coordination and will be further utilized during the PED phase, although it

should be noted for contract purposes standard updated hydrographic surveys will be taken. Land surveys will be performed at necessary locations to include anticipated new upland confined PAs and any mitigation measures (features), as required. At this time, no significant mitigation measures have been identified.

### 1.5.3 Mapping

For this study, existing maps available through the Galveston District of the vicinity were used during the Initial and Plan Formulation phases. This feasibility phase study report only includes plates of an adequacy to define the principal features as detailed in this appendix.

### 1.5.4 Additional Mapping

The mapping will require only additional updating as time progresses. It is not anticipated that any major changes will occur relating to the mapping presented in this appendix.

### 1.5.5 Vertical Datum

All elevations referred to in this report, unless specifically noted otherwise, are based on the Galveston District's local mean low tide (MLT) datum. This project is a compilation of National Geodetic Vertical Datum of 1929 (NGVD 29) and the newer North American Vertical Datum of 1988 (NAVD 88). Existing after-dredged hydro surveys in the local vertical datum of MLT were used in calculating new work volumes. These vertical datums are presented in the studies performed by ERDC, and can be referenced for more clarification.

### 1.5.6 Horizontal Datum

The North American Datum of 1927 (NAD 27) was used during the Initial and Plan Formulation phases. During Final Plan, the study was converted to the newer North American Datum of 1983 (NAD 83). Final Plates are shown in NAD 83, Texas State Plane Coordinate System, South Central Zone.

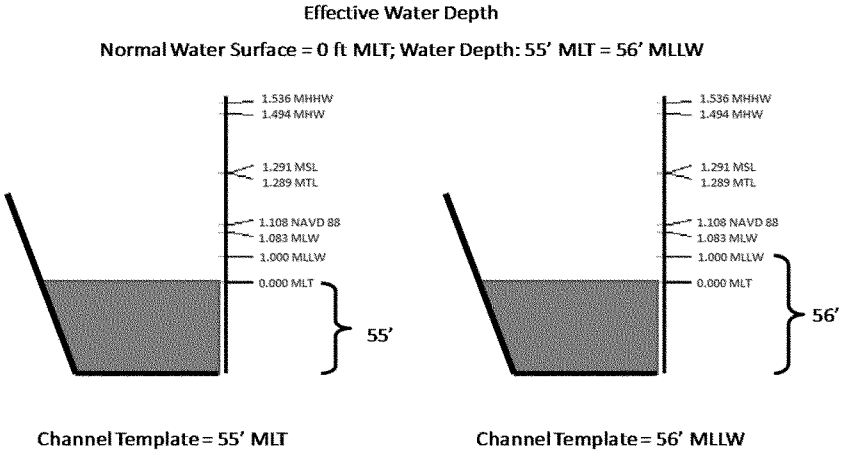
### 1.5.7 Tidal Datum

Army regulations and Headquarters, USACE (HQUSACE) guidance on tidal datum, provided in Engineering Technical Letter (ETL) 1110-2-349 *REQUIREMENTS AND PROCEDURES FOR REFERENCING COASTAL NAVIGATION PROJECTS TO MEAN LOWER LOW WATER DATUM*, dated 1 April 1993, and Engineering Manual (EM) 1110-2-1003, 1 April 2002, stress the necessity of converting local datum such as MLT to Mean Lower Low Water (MLLW). EM 1110-2-1003 further states that MLLW should be tied to the NAVD 88. The predominant reasons for conversion to MLLW are the need for consistency throughout the ports of the U.S., to enhance the continuity of National Oceanic and Atmospheric Administration (NOAA) and

Coast Guard navigation charts, and to avoid misconceptions within the shipping and dredging industries with regard to channel depths.

### 1.5.8 Tidal Datum Conversion

The Galveston District has an established survey control network along the Freeport Harbor Channel. To comply with the above-referenced guidance on referencing tidal datums using MLLW, the Galveston District took vertical survey measurements at tide gages and benchmarks to estimate the relative difference between MLT and MLLW datums along the Freeport Channel. The objective was to maintain an Effective Water Depth of 55 feet while correctly referencing resulting water surface level in MLLW as shown on the following figure.




At Freeport Channel, datum values for MLLW are +1 above MLT. However, this does not result in increased water depth, as the additional +1 foot of nominal depth is actually +1 foot above the normal surface water level. Therefore, the actual water depths are equivalent between a 55-foot MLT channel template and a 56-foot MLLW channel template.

As the study and its documentation was completed using MLT, references to MLT have been maintained throughout this document. As the project moves to PED phase, tidal data references will be documented as MLLW.

# 2.0 HYDROLOGY AND HYDRAULICS

## 2.1 MODELING STUDIES

The proposed modification of the Navigation Channel required several studies including field data collection, hydrodynamics, ship simulation, sediment, storm surge, and shoreline impacts. The Coastal and Hydraulics Laboratory (CHL) of USACE ERDC conducted all of these studies, and they are described separately following this section. These reports are:

Freeport Harbor Field Data Collection Program, Final Report. June 2007. ERDC/CHL (M. Tubman, T.M. Parchure, B. Brown, N. Raphelt, and B. Guay)

Freeport Harbor Ship Simulator Hydrodynamic Study. February 2005. ERDC-CHL (J.V. Letter Jr., W.L. Boyt, B. Brown, C.T. Goodin, and D.M. McVan)

Navigation Study for Freeport, Texas Turning Basin Data Report. August 2010. ERDC-CHL (Dennis W. Webb)

Navigation Study for Port Freeport, Texas. August 2007. ERDC-CHL (T. Shelton)

Desktop Sediment Study for Freeport Project. Draft September 2005. ERDC-CHL (T.M. Parchure, B. Brown, N. Raphelt, L. Vera, and J. Pena)

Evaluation of Improvements to the Freeport, Texas Ship Channel Under Hurricane-Induced Storm Surge Conditions. May 2007. ERDC-CHL (David J. Mark)

Shoreline Impacts Due To Proposed Deepening of Freeport, Texas Entrance Channel. July 2007. ERDC/CHL (David B. King Jr.)

As this section consists of only concise descriptions and summarized conclusions of various modeling projects conducted by ERDC, a reviewer is advised to refer to the original study reports for a detailed description of these studies.

## 2.2 FIELD DATA COLLECTION

A field data collection program was conducted during the fall of 2003. The primary purpose of the program was to obtain data needed to validate RMA-2 and TABS-MD numerical hydrodynamic models. The secondary objective of the program was to collect data for a desktop study to estimate the shoaling rates in the proposed modified navigation channels.

The work plan included water-level and water-quality measurements for a 24- to 30-day period at four locations, transects of current measurements across the navigation channel, and water-quality measurements, over a spring tidal cycle, and 35 bottom-sediment samples. During collection of the bottom-sediment samples, mid-depth water samples were collected for water-quality measurements.

Tidal characteristics at the water-level recorders did not vary significantly from each other. They were predominantly diurnal with neap tide ranges of 0.8 to 1.5 feet, and spring tidal ranges of 2.5 to 3 feet. There are small oscillations with periods that are roughly 20 times shorter than the diurnal tidal period present at all four locations. These are likely the result of harbor seiching.

There is no specific spatial or temporal trend in suspended sediment concentrations seen in the results of the analyses of the water samples from the automatic water samplers. The concentrations mostly ranged between 10 and 80 milligrams per liter (mg/l) at the three stations in the navigation channel. At the station to the southwest in the GIWW toward the Brazos River, concentrations varied between 50 and 185 mg/l. This was probably due to the samples containing sediment from the river. Nearbed suspension showed some large fluxuations, due to bed sediment entering water samples during collection, or due to instantaneous high resuspension caused by ship and barge traffic. The median diameter of sediment in suspension varied between 46 and 92 micron-size.

Salinities during the program ranged from around 15 parts per thousand (ppt) to around 32 ppt at all locations except those at the GIWW near the Brazos River, where salinities as low as around 5 ppt were measured. The data indicate that the Brazos River is a source of fresh water for the Harbor. In general, mid-depth and bottom salinities stayed within relatively narrow ranges near 30 ppt at all stations, while surface salinities varied significantly over the tidal cycle. Higher salinity from the Gulf of Mexico enters the Harbor through the Entrance Channel.

A 25-hour current transect survey was conducted at four transect locations during spring tide, which was recognized as having the strongest currents. One transect was located in the Entrance Channel, and one was across the inner navigation channel. The other two were in the GIWW, northeast and southwest of the navigation channel. Each transect was surveyed every hour. During these surveys, the flow in the inner navigation channel was very low and within the noise level for the survey. During flood flow, there were significant cross-channel variations in the current along the Entrance Channel and in the northeast GIWW transect. A maximum speed of 3.56 feet per second (fps) toward the Entrance Channel was measured along this transect on the eastern side of the GIWW. Maximum flood flows along the transect in the Entrance Channel were between 2.0 and 2.5 fps, while maximum ebb flows were between 1.0 and 1.5 fps. The tidal currents measured in the Freeport Harbor inner navigation channel are all within the noise level of the survey. The noise can be the result of a combination of rocking of the survey vessel, in response to waves and boat wakes, and harbor seiching at frequencies much higher than that of

the tides, as well as turbulence from stirring of the harbor by ships, barges, and even the survey vessel. The noise level appears to be about 0.5 fps, so what is known from the survey is that tidal currents in the Harbor were less than 0.5 fps.

No specific spatial pattern was observed in the suspended sediment results. The salinity results indicate that the Brazos River supplies fresh water to the GIWW, which then gets transported into Freeport Harbor. Higher-salinity water enters the Harbor through the Entrance Channel. The bed in the Navigation Channel is predominantly silt and clay with an average organic content of around 5 to 7 percent.

Overall the field data study produced solid results that were useful as input to further studies. There were some data gaps and noise within the data, but there were logical explanations and enough data collected to conclude that the field data study had been successful.

## 2.3 HYDRODYNAMIC STUDY

The primary objective of this model study was to provide accurate and representative current velocity fields for use in the ship simulator for the navigation study. The secondary objective was the development of a tool that was used to evaluate the general impacts of the design alternative improvements on circulation in the harbor.

The study developed a numerical hydrodynamic model using RMA-2, the TABS-MD modeling system with the Surface-water Modeling System as the graphical user interface. RMA-2 computes water surface elevations and horizontal velocity components. The computational mesh was designed to capture all of the major details of the existing and two proposed design alternatives. The design alternatives were both a 60-x-600-foot-deep channel. Plan 4 has a 1,350-foot diameter for the Brazosport Turning Basin while Plan 5 has a 1,100-foot diameter. This study takes into account the proposed LNG terminal. No hydrodynamic runs were made for the 1,200-foot-diameter turning basin, as the results from the 1,350-foot- and 1,100-foot diameter basins could be interpolated.

The numerical model was verified to the field data collection efforts. The verification was performed by comparing the model to observed water surface elevation fluctuations and to current velocity variations.

After the model was verified, the computation mesh was revised to reflect the two design alternatives. The model was then run for the verification period with each of the two alternatives. The simulations were examined for extreme maximum flood and ebb currents, and those conditions were provided to the ship simulator for incorporation into the navigation study.

The results showed that the numerical model was reasonably verified against field observations to make it a valuable tool in the evaluation of circulation effects associated with the design

alternatives. The effects of the channel deepening were to have the tidal signal arrive about 30 minutes sooner. The tide range was increased only about 0.3 percent. There is no discernible difference between the two plans for the tidal response. The deepening reduced the currents as much as 0.2 fps on the western side of the channel, with a small localized increase of 0.1 fps on the eastern flank of the channel. There is a greater reduction in ebb current magnitudes than in flood.

In conclusion, the plans had a slight effect on the phasing of the tides (approximately 30 minutes) and a minor increase in tide range. The current velocities were also slightly reduced. There is some minimal concern that the changes in tide and efficiency of the evacuating tidal prism can lead to changes in current velocities in the GIWW adjacent to the deepened channel, although these will likely be minimal.

## 2.4 NAVIGATION STUDY

Three alternative channel plans were simulated. All three plans assumed construction of the proposed LNG facility. The three ships modeled were the *Susan Maersk*, the 165k LNG Tanker, and the Very Large Crude Carrier (VLCC). The *Susan Maersk* measures 1,140 feet by 140 feet and drafts 47 feet, the 165k Tanker measures 990 feet by 156 feet and drafts 58 feet, and the VLCC measures 1,120 feet by 195 feet and drafts 58 feet.

Plan 1 is the 60-x-600-foot channel, a 1,350-foot-diameter turning basin at Brazosport, and deepening of a portion of the Channel to Stauffer to 50 feet and widening from 200 to 300 feet.

Plan 2 is the 60-x-500-foot channel, a 1,100-foot-diameter turning basin at Brazosport, and the 50-x-300-foot Stauffer Channel.

Plan 3 is the widening of the Entrance Channel to 600 feet.

Preliminary testing results abandoned plans 2 and 3, and plan 3 was modified into two alternate plans, plans 4 and 5.

Plan 4 will also have a 1,350-foot-diameter Brazosport Turning Basin, but the area northwest of the turning basin will be dredged to 60 feet in order to accommodate the additional turning radius needed.

Plan 5 varies only slightly from plan 4 in that the turning basin at Brazosport is reduced to 1,100 feet.

After several weeks of simulations, the study recommended the 60-x-600-foot channel, the 1,350-foot-diameter turning basin at Brazosport, some bend widening, and the Stauffer Channel improvements. The 1,350-foot-diameter basin was later changed to a 1,200-foot basin as described below.

Additional simulations were conducted in August 2007. The new simulations used a smaller containership for the Stauffer Channel and some tapering of the channel inside the jetty. The two plans simulated were the NED Plan of 60 x 540 feet and the LPP of 55 x 600 feet. The additional simulations indicated, based on pilot comments and test results, no real problems in this area for either the 60-x-540-foot or 55-x-600-foot plan. Navigation issues do not indicate either of these plans in preference to the other.

In 2010 additional ship simulations were done to include a Plan 6 and Plan 7 to reassess the need for the 1,350-foot-diameter turning basin. The design vessels included a VLCC with dimensions of 1,087 feet x 195 feet x 24 feet (which was always tested turning outbound and empty) and a Suezmax tanker with dimensions of 922 feet x 164 feet x 28 feet.

Plan 6 was a 1,200-foot-diameter turning basin, and plan 7 was a 1,350-foot diameter turning basin. The VLCC was minimally successful turning in the configuration in plan 7 and unable to turn in plan 6. The Suezmax was able to navigate the 1,200-foot-diameter turn, but pilots preferred a larger diameter basin if economically viable.

Based on the outcome of this final ship simulation study, the NED Plan and the LPP were adjusted to include a Brazosport turning basin diameter of 1,200 feet.

## 2.5 SEDIMENT STUDY

The present dredging pattern and quantities would change as a result of the proposed modifications to the navigation channel. The objective of this study was to estimate the shoaling rates in the modified navigation channel.

A desktop study is an alternative method of obtaining preliminary answers without conducting a full-fledged numerical sediment-transport modeling study. Such a desktop approach required field data on sediments, dredging quantities, and velocity results from a hydrodynamic model. In view of variations in salinity and currents in the Freeport system, velocity results from a 3D hydrodynamic model were necessary.

All data needed for this study were collected in October 2003. Other data needed were obtained from the Galveston District's Dredging Histories Database, which contains bed sediment data and dredging records.

The 3D model study concluded that there was no significant change or variation between the existing and proposed plan for the tides, currents, salinity, and flow patterns.

The quantity of maintenance dredging in the Freeport navigation channel will increase from the present average of 1.6 million cubic yards per year (cy/yr) to 2.92 cy/yr as a result of deepening and widening the channel to 60 x 600 feet.

Table 3
Dredging Requirements

| Existing Configuration | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reach # | Name | From | To | Length (feet) | Length (Miles) | Width (feet) | Area Factor | Depth (Feet) | Trap Factor | Combined Factor | Dredging (Cu Yd/Year) | Rate (CY/Year) Ft |
| Present | | | | | | | | | | | | |
| 1A | Entrance Bar Channel | -300 + 00 | 0 + 00 | 30,000 | 5.68 | 400 | 1 | 47 | 1 | 1 | 1,122,036 | 37.40 |
| 2 | Jetty Channel | 0 + 00 | +71 + 52 | 7,152 | 1.35 | 400 | 1 | 47 | 1 | 1 | 189,491 | 26.49 |
| 3 | Harbor Channel | +71+ 52 | +184 + 20 | 11,268 | 2.13 | 400 | 1 | 47 | 1 | 1 | 280,000 | 24.85 |
| | LTB Reach | +71 + 52 | +78 + 52 | 700 | 0.13 | 400 | 1 | 47 | 1 | 1 | 17,394 | 24.85 |
| | CH to Brzpt & Brzpt TB | +78 + 52 | +115 + 52 | 3,700 | 0.70 | 1100 | 1 | 47 | 1 | 1 | 91,942 | 24.85 |
| | CH to UP TB | +115 + 00 | +132 + 66 | 1,766 | 0.33 | 400 | 1 | 47 | 1 | 1 | 43,884 | 24.85 |
| | CH to UP TB and Upper TB | 132 + 66 | +184 + 20 | 5,154 | 0.98 | 400 | 1 | 47 | 1 | 1 | 128,072 | 24.85 |
| 4A | Lower Stauffer TB* | +184 + 20 | +222 + 00 | 3,780 | 0.72 | 230 | 1 | 25 | 1 | 1 | 4,826 | 1.28 |
| 4B | Upper Stauffer TB* | +222 + 00 | +260 + 00 | 3,800 | 0.72 | 200 | 1 | 25 | 1 | 1 | 5,000 | 1.32 |
| | | | Total | **56,000** | **11** | | | | | | **1,601,353** | **91.34** |
| | | | | | | | | | | | | |
| **LPP** | | | | | | | | | | | | |
| Reach # | Name | From | To | Length (feet) | Length (Miles) | Width (feet) | Area Factor | Depth (Feet) | Trap Factor | Combined Factor | Dredging (Cu Yd/Year) | Rate (CY/Year) Ft |
| 1 | LPP Extension | -433 + 00 | -300 + 00 | 13,300 | 2.52 | 600 | 1.50 | 59 | 1.26 | 1.76 | 873,159 | 65.65 |
| 1A | Entrance Bar Channel | -300 + 00 | 0 + 00 | 30,000 | 5.68 | 600 | 1.50 | 59 | 1.26 | 1.76 | 1,969,531 | 65.65 |
| 2 | Jetty Channel | 0 + 00 | +71 + 52 | 7,152 | 1.35 | 600 | 1.50 | 57 | 1.21 | 1.71 | 324,554 | 45.38 |
| 3 | Harbor Channel | +71+ 52 | +184 + 20 | 11,268 | 2.13 | | | | | | 348,413 | 30.92 |
| | LTB Reach | +71 + 52 | +78 + 52 | 700 | 0.13 | 400 | 1.00 | 57 | 1.21 | 1.21 | 21,095 | 30.14 |
| | CH to Brzpt & Brzpt TB | +78 + 52 | +115 + 52 | 3,700 | 0.70 | 1350 | 1.23 | 57 | 1.21 | 1.44 | 132,400 | 35.78 |
| | CH to UP TB | +115 + 00 | +132 + 66 | 1,766 | 0.33 | 400 | 1.00 | 57 | 1.21 | 1.21 | 53,220 | 30.14 |
| | CH to UP TB and Upper TB | 132 + 66 | +184 + 20 | 5,154 | 0.98 | 400 | 1.00 | 52 | 1.11 | 1.11 | 141,697 | 27.49 |
| 4A | Lower Stauffer TB* | +184 + 20 | +222 + 00 | 3,780 | 0.72 | 300 | 1.30 | 52 | 2.08 | 2.38 | 11,507 | 3.04 |
| 4B | Upper Stauffer TB* | +222 + 00 | +260 + 00 | 3,800 | 0.72 | 200 | 1.00 | 27 | 1.08 | 1.08 | 5,400 | 1.42 |
| | | | Total | **69,300** | **13** | | | | | | **3,532,563** | **146.42** |
| **NED** | | | | | | | | | | | | |
| Reach # | Name | From | To | Length (feet) | Length (Miles) | Width (feet) | Area Factor | Depth (Feet) | Trap Factor | Combined Factor | Dredging (Cu Yd/Year) | Rate (CY/Year) Ft |
| 1 | NED Extension | -450 + 00 | -300 + 00 | 15,000 | 2.84 | 600 | 1.50 | 64 | 1.36 | 1.86 | 1,044,448 | 69.63 |
| 1A | Entrance Bar Channel | -300 + 00 | 0 + 00 | 30,000 | 5.68 | 600 | 1.50 | 64 | 1.36 | 1.86 | 2,088,897 | 69.63 |
| 2 | Jetty Channel | 0 + 00 | +71 + 52 | 7,152 | 1.35 | 540 | 1.35 | 62 | 1.32 | 1.67 | 316,289 | 44.22 |
| 3 | Harbor Channel | +71+ 52 | +184 + 20 | 11,268 | 2.13 | | 0.00 | | 0.00 | | 384,713 | 32.37 |
| | LTB Reach | +71 + 52 | +78 + 52 | 700 | 0.13 | 400 | 1.00 | 62 | 1.32 | 1.32 | 22,946 | 32.78 |
| | CH to Brzpt & Brzpt TB | +78 + 52 | +115 + 52 | 3,700 | 0.70 | 1350 | 1.23 | 62 | 1.32 | 1.55 | 142,181 | 38.43 |
| | CH to UP TB | +115 + 00 | +132 + 66 | 1,766 | 0.33 | 400 | 1.00 | 62 | 1.32 | 1.32 | 57,889 | 32.78 |
| | CH to UP TB and Upper TB | 132 + 66 | +184 + 20 | 5,154 | 0.98 | 400 | 1.00 | 52 | 1.11 | 1.11 | 141,697 | 27.49 |
| 4A | Lower Stauffer TB* | +184 + 20 | +222 + 00 | 3,780 | 0.72 | 300 | 1.30 | 47 | 1.88 | 2.18 | 4,826 | 1.28 |
| 4B | Upper Stauffer TB* | +222 + 00 | +260 + 00 | 3,800 | 0.72 | 200 | 1.00 | 27 | 1.08 | 1.08 | 5,000 | 1.32 |
| | | | Total | **71,000** | **13** | | | | | | **3,824,173** | **218.44** |

* Estimated Dredging is calculated using difference between assumed channel depth at deauthorization (approx. 1950) and current depth (2009).

Dredging requirements for the LPP/NED Plan Extensions resulted in one-third of the new dredging volumes for the project. New dredging requirements in the Entrance and Jetty channels are increased by 75 percent due to width and depth changes. Changes in these reaches account for most of the increased dredging requirements for the project. The new dredging requirements in the Freeport Harbor Channel are up 25 percent due to geometry changes. Table 3 indicates dredging maintenance requirements for the Existing Configuration, the LPP, and the NED plans. Estimated dredging in the Stauffer Turning Basin is calculated using assumed channel depth at deauthorization (approximately 1950) and at current depth (2009). Existing configuration assumes keeping nondredged depths and widths.

## 2.6 HURRICANE-INDUCED STORM SURGE CONDITIONS

A cursory-level numerical study was conducted to determine whether the planned improvements to the channel will make Freeport Harbor and adjacent, low-lying areas more susceptible to inundation due to hurricane-induced storm surge.

The improvements modeled were the 60-x-600-foot channel with the 1,200-foot Brazosport Turning Basin, which removes a portion of the southeastern peninsula (North Wave Barrier) that separates the GIWW from the harbor proper, and the proposed LNG improvements.

The existing ADCIRC (Advanced Circulation) model that was developed for a coastal erosion study was adapted to depict the planned harbor configuration. Hurricanes selected for simulating were based on the September 1941 hurricane and Hurricane Fern, which impacted the Texas coast in September 1971. These hurricanes were selected for simulation because both came within close proximity of the study area and produced relatively high surges. (Stronger hurricanes, such as the 1900 Hurricane, were omitted from this analysis because they would have generated significantly greater overland flooding; this, in turn, hampers determining whether the planned improvements make the harbor more susceptible to storm surge.) Furthermore, the two hurricanes provided two angles-of-approach; the 1941 hurricane approached the coast from the southwest, whereas Hurricane Fern skirted the coast while moving from the northeast to the southwest. The data came from NOAA's HURicane DATabase (HURDAT), which contains the latitude and longitude locations of the eye of the hurricane with corresponding central pressure and maximum wind speeds at 6-hour intervals.

The model found little change in peak water-surface elevations within the harbor resulting from the planned improvements. Estimated increases were about 0.16 foot. Consequently, the planned harbor improvements do not appear to make the harbor and adjacent low-lying areas more susceptible to storm surge from less-intense hurricanes.

## 2.7 SHORELINE IMPACT STUDY

The purpose of the study is to assess the wave-induced impacts of the proposed deepening of the Freeport Channel in the Gulf of Mexico on the open-coastal shorelines adjacent to the project area.

The four proposed plans were the 50-x-600-foot, 55-x-600-foot, 58-x-540-foot, and 60-x-540-foot channels.

This study used the numerical model GENESIS to compute sediment transport rates and shoreline change rates for each of the four proposed channels. Comparing the GENESIS output for the existing condition with the proposed channels output revealed the effects of the bathymetry changes on the wave-induced longshore transport and the shoreline change rate. Breaker wave heights and angle inputs to GENESIS were obtained from the numerical wave propagation and refraction model, STWAVE. STWAVE modeled the refraction over the five different bathymetry grids corresponding to the existing and proposed channels.

Average wave heights were a meter, periods were a little over 5 seconds, and there was a broad spread in wave direction with a small majority from the south. Bathymetry data came from NOS hydrographic surveys from GEODAS vs 4.0 developed by the National Geophysical Data Center.

Texas shoreline change rates have been calculated by the Bureau of Economic Geology. Their change rates were obtained using a regression analysis of the available shorelines. Their analysis shows that in the vicinity of Freeport Harbor, the shoreline is eroding at a rate of 9 to 10 feet per year. Five to 6 miles northeast of Freeport Harbor, the shoreline is shown to be stable, and farther northeast, it again becomes erodible. Between the Brazos and the San Bernard River mouths, the shoreline is very dynamic, with strong erodible and accretion regions.

The conclusion from this analysis is that if any of the proposed deepening alternatives for the Freeport Entrance Channel are constructed, the wave-induced sediment transport impacts on the adjacent shorelines will be so slight as to not be noticeable and will be dwarfed by the interannual variability in shoreline position. Net transport is primarily to the southwest. Breaker heights do not exceed 10 percent change anywhere and become negligible within 4 miles of the harbor entrance. For the most common occurring wave dataset, maximum wave heights increase by only 3 percent mainly within the left portion of the channel and maximum decrease is 9 percent in the right of the channel with along-shoreline changes of less than 2 percent extending less than 3 miles from the jetties.

The model predicts that the greater the proposed depth alternative, the greater the shoreline change, but for any alternative, these impacts will be minor and will not extend farther than 3 to 4 miles on either side of the Freeport jetties.

# 3.0 STRUCTURAL ENGINEERING

## 3.1 INTRODUCTION

The structural activities conducted were as follows.

Site visit and obtaining As-Built Drawings of the Shoreline Facilities

Initial Evaluation of the Shoreline Facilities

Impact Evaluation of the Shoreline Facilities

Concept Design for Modifications of each of the impacted Shoreline Facilities

Quantity Estimate for Cost Estimating of each of the necessary modifications

Refine new work PAs for Drop-outlet structures

PA Outlet Structural Design

Structural Engineering Appendix Report

This structural engineering portion of the Engineering Appendix to the Feasibility Report was prepared to provide sufficient information on design input for PA spill boxes for all of the channel alternatives, and impact verification on each bridge, bulkhead, and dock from the proposed dredging.

**LPP and NED Plans**. The LPP was identified in October 2006, and the NED Plan, which differs from the LPP, was outlined in July 2006 (Table 4):

Table 4
Comparison of NED Plan and LPP

| Channel Reach | NED Plan | LPP |
|---|---|---|
| Proposed Extension | 64 x 600 feet | 59 x 600 feet |
| Outer Bar | 64 x 600 feet | 59 x 600 feet |
| Jetty Channel | 62 x 540 feet | 57 x 600 feet |
| Lower Turning Basin (LTB) | 62 feet x Existing | 57 feet x Existing |
| Channel to Brazosport & New 1,200-foot Turning Basin | 62 x 1,200 feet TB | 57x1,200 feet TB |
| Channel from Brazosport Turning Basin | 62 feet x Existing | 57 feet x Existing |
| Channel to Upper Turning Basin & Upper Turning Basin | 52 feet x Existing | 52 feet x Existing |
| Stauffer Channel Lower Reach | 52 x 300 feet | 52x300 feet |
| Stauffer Channel Upper Reach | 27 feet x Existing | 27 feet x Existing |

## 3.2 FUNCTIONAL DESIGN REQUIREMENTS

The Project Management Plan (PMP) for feasibility studies on Freeport Harbor Dredging was prepared by the PDT in cooperation with the non-Federal sponsor in March 2003. The PMP is a document that presents the activities required to accomplish the feasibility study and submit a feasibility report to Congress for authorization. Freeport Harbor is a deep-draft navigation project that connects harbor facilities in the Freeport area with the Gulf of Mexico as follows:

| | |
|---|---|
| Outer Bar Channel | 400 feet wide x 47 feet deep |
| Main Channel | 400 feet wide x 45 feet deep |
| Turning Basin(s) | 750–1,200 feet diameter x 45 feet deep |
| Brazos Harbor Channel | 200 feet wide x 36 feet deep |
| Brazos Harbor Turning Basin | 750 feet wide x 36 feet deep |

Alternatives for deepening and widening of Freeport Harbor were screened for structures in the following increments:

Outer Bar Channel and Jetty Channel
Lower Turning Basin
Lower Turning Basin to Upper Turning Basin
Upper Turning Basin
Brazos Harbor Channel (no change)
Brazos Harbor Turning Basin (no change)
Stauffer Channel
Stauffer Channel Turning Basin

Docks and wharfs were not analyzed by structures (EC-ES), and several were identified as requiring modifications due to the proposed incremental increases or channel improvement (tables 5 and 6). These docks and berthing areas that would utilize the new project depth are identified below and had dredging volumes estimated. The volumes were computed by taking the area of the berth multiplied by assumed depth of cut. All berthing areas were assumed to be at the existing depth of the waterway. Associated costs relating to the facility's ability to utilize the new deep draft were identified by others.

Table 5
Freeport Dock Berths Current Depth

| Berth | Owner | Location | Contract No. | Water Depth, feet | | Berthing Area, SF | Upgrade Cost, ($1,000)[2] | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | Current | Design | | | |
| 2 | ConocoPhillips | 166+00 | 6 | 45 | 50 | 152,000 | 7,500 | 820 feet LOA Design Vessel |
| 3 | ConocoPhillips | 173+00 | 6 | 45 | 50 | 152,000 | 7,500 | 820 feet LOA Design Vessel |
| 4 | ConocoPhillips | B.H. 22+00 | 2 | 14 | 20 | N/A | N/A | Barges Only |
| | | | | | | | | |
| 1 | Seaway/TEPPCO | 133+00 | 6 | 20 | 20 | N/A | N/A | Barges Only |
| 2 | Seaway/TEPPCO | 124+00 | 6 | 45 | 60 | 270,000 | 0 | Outside Berth |
| 3 | Seaway/TEPPCO | 124+00 | 6 | 45 | 60 | [1] | [1] | Inside Berth |
| 1 | Dow | Stauffer Channel | 7 | 15 | 25 | N/A | N/A | Barges Only |
| 3A | Dow | 119+00 | 6 | 16 | 20 | N/A | N/A | Barges Only |
| 8 | Dow | 82+00 | 5 | 44 | 45 | 130,000 | 7,500 | |
| 13 | Dow | 77+00 | 5 | < 20 | | N/A | N/A | Barges Only |
| 14 | Dow | 75+00 | 3 | 45 | 47 | 180,000 | 7,500 | |
| 22 | Dow | 107+00 | 5 | 45 | 47 | 130,000 | 7,500 | |

[1]Included in upgrade cost of Berth 2
[2] Cost to upgrade to NED Plan depths
[3] LOA means length overall

Table 6
Freeport Dock Description

| Facility User/Owner | Description |
|---|---|
| N/A | Wave Barrier |
| Phillips 66 Co. | Freeport Terminal No. 1, Ship Dock No. 3 |
| Phillips 66 Co. | Freeport Terminal No. 1, Ship Dock No. 2 |
| N/A | SPL PIT /Barrier |
| Phillips 66 Co. | Freeport Terminal No. 2, Berth No. 1 |
| Dow Chemical | Texas Operations, A-2 Dock |
| Phillips 66 | Dock |
| Dow Chemical | Texas Operations, A-3 Dock |
| Dow Chemical | N/A |
| Dow Chemical | Texas Operations, A-6 Dock |
| Monsanto Co. | Quintana Barge |
| Quintana Marine | Boat Basin & Marine Railway Slip |
| U.S. Coast Guard Station | Freeport Mooring basin |

**Design Quality Control Plan Assumptions**:

1. Existing jetties not to be destabilized, as deepening and widening of the channel will be modified as necessary.
2. Extensive saltwater barriers will not be required for any increased salinity due to proposed channel dredging.
3. Sufficient structural design is performed for placement area spill boxes and bridges, bulkhead and dock analyses to allow for Plans and Specifications (P&S) preparation.
4. Existing state highway bridges and utility towers will not be impacted by the proposed dredging.

**Concept Design for Modifications**. No modification to any shoreline facilities is expected.

**Quantity Estimates**. Estimated quantities for each of the facilities were given to cost estimating based on Table 5 provided by the non-Federal sponsor.

**Refine New Work PAs**. Structural considerations necessary during PED.

**PA Outlet Structure Design**. Standard drawings for drop-outlet structures.

## 3.3 TECHNICAL DESIGN CRITERIA

### 3.3.1 Corrosion Mitigation

Structural steel used on this project for drop-outlet structures and steel sheet-piling will be protected against corrosion by the use of protective coatings (paint). The steel will be cleaned to bare metal by sandblasting and then coated with a suitable material to resist corrosion. Cathodic protection will not be used.

### 3.3.2 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 drop-outlet structures in the placement areas, 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.

### 3.3.3 Environmental Operating Principles

The purpose of this section is to provide examples of how the Engineering Appendix integrates Environmental Operating Principles as applicable to engineering and design as required for

sustainability, preservation, stewardship, and restoration of the project area's natural resources. Also, this section provides additional detail as applicable for addressing USACE policy concerning risk and uncertainty.

As part of incorporating USACE "Environmental Operating Principles," including maintaining "accountability under the law for activities and decisions under our control that impact human health and welfare," the PDT identified no potential for Hazardous, Toxic, and Radioactive Waste.

### 3.3.4 Risk and Uncertainty

No potential for contaminated materials was identified or included in the DMMP for the placement of maintenance material from the 50-year life of the proposed project.

Additional risk and uncertainty with regards to other areas in the project are:

**Dredging**: In order to minimize water quality degradation, the most efficient dredging techniques and equipment will be utilized for new work and maintenance dredging. Also, any contaminants in the dredged material would be properly addressed. Further, all necessary efforts would be undertaken to reduce any adverse impacts.

**Dredge Material Disposal**: Selection of PA sites and placement of dredged material were optimized for existing and new PAs so that the sizing of upland disposal sites was reduced to the best-fit extent possible.

Contingencies for all contracts were developed using the Cost and Schedule Risk Analysis (CSRA) process and the Crystal Ball software as referenced in Section 5.0, Cost Engineering.

## 4.0 GEOTECHNICAL

### 4.1 PURPOSE

This section has been prepared to provide supporting technical information pertaining to the geotechnical aspects of the Freeport Harbor Deepening and Widening Project, including the disposal site development plan, proposed dredge material distribution to the disposal sites, available project soils information, and preliminary design parameters used. Use of available geotechnical investigations information, establishment of suitable design parameters and geotechnical assumptions, and production of quantities for a 50-year dredge disposal plan have been performed with the purpose of providing sufficient detail to substantiate the recommended plan and the baseline cost estimate.

## 4.2 PROJECT CONDITIONS

### 4.2.1 General Geology

The Freeport Harbor project area is situated in the eastern portion of the Colorado-Brazos deltaic plain. Formations across the plain become progressively younger in the seaward direction. These formations consist of sediments deposited during the Cenozoic era. Beach areas in the vicinity are composed primarily of littoral sands and shell of recent age. Heavy calcareous clays with interbedded silt and sand strata, Pleistocene in age, underlie the recent sediments. The natural land surface slopes gradually upward from elevations of about 3 to 4 feet above mean sea level behind the beaches to an elevation of 15 feet above mean sea level about 15 miles inland.

### 4.2.2 Soils Investigation

Subsurface soil investigation samples taken at locations in the project area are shown on Engineering Plates F1 and F2, with accompanying boring log profiles on plates F3 through F13. Freeport Harbor Channel borings, shown on plates F3 through F5, were obtained during the period from November 1962 to September 1978 and generally have been drilled down to elevations ranging from 40 to 90 feet below MLT. Additional borings in the vicinity of the channel were obtained by Fugro Consultants LP in January and February of 2005 under the direction of the Port of Freeport for a separate Widening project. Subsurface soil information is contained in a report (dated February 2006) entitled "Geotechnical Study - Jetty Stability and Channel Widening Project - Freeport Ship Channel - Port of Freeport - Freeport, Texas," by Fugro Consultants LP. Subsurface soil profiles for PAs 8 and 9, located on plates F6 and F7, were obtained in November 2005 and the investigation depth ranges from natural ground to 40 feet below. Additional subsurface soil samples were taken at PAs 8 and 9 in 2008 to verify the previous soil investigation conducted in November 2005. Boring logs for existing PA 1, located on plates F8 through F13, are from boring log data in a report by Professional Service Industries, Inc. entitled "Subsurface Exploration and Foundation Recommendations for the Proposed Confined Placement Site No. 1 - Port of Freeport - Freeport, TX" that was prepared for and under the direction of the Brazos River Harbor Navigation District in 1996 and range from 20 to 60 feet deep.

### 4.2.3 Sampling and Testing

Cohesive subsurface soil samples were taken according to ASTM D 1587 "Standard Practice for Thin-Wall Tube Geotechnical Sampling of Soil." Undisturbed cohesive samples were taken at every 2-foot interval, and undrained shear strength was measured for each cohesive sample with a hand penetrometer. Field visual classification was performed, and information was recorded for each sample when the sample was taken at the site.

Cohesionless soil samples were taken according to ASTM D 1586 "Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils." Spilt-spoon sampling was primarily employed on cohesionless to semicohesionless soil layers, whereby disturbed samples were taken in a glass jar at ever 5-foot interval if the cohesionless strata is greater than 5 feet. Field visual classification was conducted and recorded for each cohesionless sample.

Initial ground water depth was measured and recorded, and a free water depth was also measured and recorded at 24-hour time frames.

Selected samples were tested in accordance with a respective ASTM Standard such as ASTM D 2216 "Moisture Content," ASTM D 4318 "Liquid and Plastic Limit," ASTM D 1140 "Abbreviated Mechanical Analysis," ASTM D 2166 "Unconfined Compression Test," ASTM D 2487 "Engineering Classification of Soil," ASTM D 4767 "Consolidated Undrained Triaxial Test," and ASTM D 698 "Standard Compaction Test." Selected sample test summary and undrained triaxial shear strength test results from Contract No. DACW64-03-D-0008 (FY 06) Delivery Order No. 0044 is attached. The results of these tests along with field boring log data were used to obtain engineering properties for the Jetty, Pas 8 and 9 containment dike, and foundation design. Through various testing programs associated with borings discussed herein, Unconfined Compression Tests (UC) and Consolidated Undrained Triaxial Compression Tests (CU) on representative samples have been utilized for estimates of undrained shear strengths for "end of construction." For undrained shear strength estimates, in some cases the UC laboratory results have been used in conjunction with field hand penetrometer testing data that was recorded on the field boring logs. A correlation from standard penetration testing was done on materials encountered during disturbed sampling where some cohesivelike properties were discovered (such as silts, sandy and clayey silts, or clays with various interbedded sands and silts layers).

Subsurface soil investigation lab test results and soil strata profiles are attached to this appendix.

## 4.3 UPLAND PLACEMENT AREAS

### 4.3.1 Existing Placement Area 1

Existing PA 1 is located in Freeport, about ½ mile south of Highway 36, and about 1,000 feet east of the Brazos River Diversion Channel. It is estimated at approximately 320 acres in size, with about 20,310 linear feet of exterior perimeter containment dike, an assumed average interior elevation of 26 feet MLT, and assumed average containment dike elevation of 29 feet MLT. Assumed average elevations are based on anticipated elevations following the completion of O&M contract awarded in 2009.

### 4.3.2 New Placement Area 8

New PA 8 is located in Freeport, just north of Highway 36, and approximately 1,600 feet west of the Brazos River Diversion Channel. PA 8 is about 168 acres, with a perimeter length of about 11,480 linear feet and assumed existing ground elevation around 5 feet MLT. As a currently undeveloped site, and given the proximity to the coast, an initial assumed elevation of 5 feet MLT is anticipated to be on the upper end of the range of potential existing elevations at the site.

### 4.3.3 New Placement Area 9

New PA 9 is located in Freeport, just north of Old Highway 36, and approximately 300 feet west of the Brazos River Diversion Channel. PA 9 is about 254 acres, with a perimeter length of about 14,000 linear feet and assumed existing ground elevation around 5 feet MLT. With the proximity to the coast and fact that the land is undeveloped, this initial assumed elevation is anticipated to be on the upper end of the range of potential existing elevations at the site.

### 4.3.4 Verification of Placement Area Elevation Data

The above approximate elevations have been used by Geotechnical Engineering in the preliminary engineering calculations used to produce the cost estimates. During PED or subsequent design phases, the latest available survey data will be utilized and the engineering quantity estimates will be updated accordingly.

## 4.4 OCEAN DREDGED MATERIAL DISPOSAL SITES - ODMDS

There are two ODMDSs for the maintenance and new work material. One is about 1,291 acres and the other is 2,236 acres, respectively. Below is the horizontal coordinates for the ODMDSs:

1. Maintenance Material ODMDS Coordinates (NAD 83) are as follows:

   X = 3,163,694 Y = 13,530,298

   X = 3,166,836 Y = 13,527,077

   X = 3,157,888 Y = 13,518,349

   X = 3,154,745 Y = 13,521,570

2. New Work Material ODMDS Coordinates (NAD 83) are as follows:

   X = 3,169,494 Y = 13,516,802

   X = 3,174,571 Y = 13,511,584

   X = 3,164,981 Y = 13,502,254

   X = 3,159,904 Y = 13,507,472

Additional discussions about these sites can be found in the Environmental Impact Statement document for this project.

## 4.5 DREDGED MATERIAL FACTORS

### 4.5.1 Bulking Factor

The bulking factor is a design parameter primarily used to develop containment dike height requirements for each dredge event. The bulking process is a result of the structural disruption of the dredged sediments and the entrainment of water into the sediments during dredging. This factor is traditionally defined as the ratio of the volume occupied by the dredged material in the placement area immediately after completion of dredging to the volume occupied by the same material in the channel before dredging.

$$\textit{Bulking Factor} = \frac{\textit{(Volume of Dredged Material in Placement Area)}}{\textit{(Volume in Channel Prior to Dredging)}}$$

The amount of bulking varies with the type of sediments and the method of dredging (mechanical or hydraulic). Other factors that affect bulking include size of dredge, horsepower, and residence time in the pipeline. For this project, dredging will primarily be conducted hydraulically. The new work dredging for this project will consist of about 80 to 90 percent clays (of primarily stiff consistency with some traces of silts or clayey silts), and about 10 to 20 percent sands of various densities, based on available boring data from the Upper Turning Basin on out to sea.

Development of containment dike height requirements on this project was based on a bulking factor of about 1.3 for maintenance material and about 2 for the portion of new work material anticipated to go into a slurry state before final discharge at the disposal sites. The remaining portion of new work material that will come out of the dredge pipe in the form of solid clay fragments (informally referred to as "clay balls") or segregate from the dredge mixture soon after discharge (such as sands) is anticipated to remain fairly close to the original density from the channel.

### 4.5.2 Retention Factor

For calculations and quantities produced on this project, the definition adopted for the term "retention factor" is the fraction of new work material from the channel that, when dredged to the site, retains a degree of consistency from the original in situ state necessary for use as fill materials for hydraulic containment dike and containment dike foundation construction or future borrow for future mechanical containment dike construction; and that, when pumped to the site, tends to accumulate or stack within the general vicinity of the end of the dredge pipe.

$$\textit{Retention Factor} = \frac{\textit{(Volume of Dredged Material Suitable for Containment Dike Fill Material)}}{\textit{(Actual Dredging Quantity)}}$$

Variables that can influence this factor include original in situ material properties and consistencies, size of dredge, type and control of cutter head, horsepower, and pump distance. For feasibility level, a retention factor of about 0.5 was assumed for this project.

### 4.5.3 Shrinkage Factor

The shrinkage factor is a design parameter used to evaluate the long-term storage capacity of a PA for use in developing the DMMP. It is defined as the ratio of the long-term volume occupied by a certain quantity of dredged material in a PA, to the volume it occupied in the channel prior to dredging. Generally, this parameter is associated with maintenance material, but may also be associated with new work material.

$$\textit{Shrinkage Factor} = \frac{\textit{(Long-term Volume in Disposal Area)}}{\textit{(Volume in Channel Prior to Dredging)}}$$

Items that affect the shrinkage include the soil composition, pan of evaporation rate, consolidation, desiccation, climatological conditions, drainage efficiency or dewatering measures implemented, and dredging schedule of maintenance material placed at the sites. Determination of a precise shrinkage factor for a placement area can be a complex task and include modeling the consolidation and desiccation shrinkage based on laboratory test data, climatological data, drainage characteristics, and operational characteristics. For feasibility level, the development of the long-term storage capacity and containment dike height requirements on this project was based on a shrinkage factor of about 0.65 for maintenance material.

## 4.6 MECHANICAL CONTAINMENT DIKE CONSTRUCTION AND NEW WORK PLACEMENT PLAN

At PAs 8 and 9, during initial construction, the proposed plan involves using borrow material from the interior of the sites to mechanically raise the perimeter containment dikes to an estimated height to contain the new work materials, which are slurry materials generated from degraded new work. During new work dredging, the hydraulic new work materials will be placed along the perimeter containment dikes at PAs 8 and 9, to the inside of the placement areas to serve as a foundation for future containment dike raising and strategically placed stockpile to be reshaped to desired containment dike heights during subsequent O&M cycles. At PA 1, it is anticipated that borrow materials for O&M containment dike construction will generally be obtained through conventional side-cast methods. The initial containment dike elevations and projected future containment dike elevations at the placement areas, to accommodate project capacity needs, are shown in Table 7.

## 4.7 50-YEAR DREDGED MATERIAL MANAGEMENT PLAN

### 4.7.1 Environmental Restrictions Pertaining to Upland and Offshore Dredged Material Placement

#### 4.7.1.1 Upland Placement Area Water Quality

The upland PA containment dike designs include freeboard allowances that provide needed settling time of soil particles within effluent discharge material at the PA, promote lower levels of turbidity in fluids exiting the drop-outlet structures, and support efforts at meeting the legal/allowable turbidity levels. Development of containment dike height requirements on this project was based on an allowance of 3 feet of freeboard above the bulked dredge fill height for each dredging event. Other factors may influence settling time including the discharge flow rate implemented by the dredging contractor. Specification language is added at the time contract plans and specifications are produced that provides additional restrictions on contractor dredging operations such that effluent concentrations at drop-outlet structure are within legal/allowable limits.

#### 4.7.1.2 Offshore Placement Areas

Offshore placement areas have been modeled by PBS&J under direction of and coordination with the Galveston District Environmental Section. A computer model referred to as MDFATE (Multiple Disposal Fate) was utilized by PBS&J to analyze the effects of offshore placement to ensure conformance with fill height restrictions on the bottom of the seafloor and other restrictions as worked out between the Environmental Protection Agency and USACE for a 50-year placement plan. Further details of the restrictions and agreements can be found in the accompanying Environmental Impact Statement. The estimated offshore dredge quantities for the new project are shown in Table 6.

### 4.7.2 Dredged Materials and Potential for Beneficial Use

Results from bed sediment studies (from the *Desktop Sediment Study for Freeport Project* generated by ERDC and H&H), for bed sediment data collected between September of 1987 through May of 2000 indicate the following average percentages of bed sediments have been encountered in the channel:

1. Outer Bar – About 82 percent fine-grained sediments (silts and clays) and 18 percent sands
2. Jetty Channel – About 86 percent fine-grained sediments (silts and clays) and 14 percent sands
3. Freeport Harbor Channel – About 95 percent fine-grained sediments (silts and clays) and 5 percent sands

A review of new work materials from boring data starting at the Upper Turning Basin on out to sea indicate about 80 to 90 percent clays (of primarily stiff consistency with some traces of silts or clayey silts) and about 10 to 20 percent sands of various densities.

On a separate widening project currently pursued by the Port of Freeport, potential beneficial uses of dredge materials were considered, including marsh restoration, beach nourishment, an energy-dissipating berm, habitat berm, and feeder berm. These features are described in further detail in the Environmental Impact Statement document dated February 2007, that accompanies the Feasibility Report for the "Freeport Entrance and Jetty Channel Widening Project."

Based on groundwork done in the Widening Project study by Freeport, which included considering applicability and functionality of material types for particular beneficial use features, cost effectiveness, permanence of features, and other considerations explored by the Widening Project DMMP workgroup, the decision was made by PDT on the USACE's deepening and widening project to forgo pursuit of beneficial use features in the final selected dredged material management plan.

### 4.7.3 Fifty-Year Capacity and Dredged Material Placement Designation

Table 7 contains the 50-year containment dike elevations required for capacity and the anticipated cyclical maintenance dredging. Table 8 contains the breakout of new work from the channel and anticipated distribution to the placement area sites.

## 4.8 JETTY STABILITY ANALYSIS

### 4.8.1 Scope

The scope of this study was identified at a PDT meeting in January 2006. The scope was as follows: given possible restrictions to channel depth and width due to jetty stability issues, determine:

a. the maximum channel width at a project channel depth of 60 feet
b. the maximum channel depth at a channel width of 600 feet

   (Note: for an authorized depth of 60 feet, it was anticipated that the required depth in the Jetty Channel would be 62 feet with an allowable overdepth of 2 feet, for the analysis)

Slope stability of the North and South jetties was considered between stations 0+00 to 43+00 (north) and 46+00 (south). Latest available surveys at time of analysis were reviewed including postdredging channel cross sections dated January 2006 and jetty/channel cross sections dated December 2005. In addition, the history and performance of the jetties was discussed with the USACE Operations Division. Two project constraints were established regarding the configuration of the jetty slopes:

Table 7
Freeport Harbor Deepening and Widening – Summary of Maintenance Dredging and Placement Area Parameters

**Freeport Harbor Deepening & Widening - Summary of Maintenance Dredging & Placement Area Parameters**

| Alternative | Channel Reaches | Channel Reach Stationing | | Annual Shoaling Rate From Channel Reaches (CY) | Dredging Stationing & Placement Site Designation | | | Approximate Size of Placement Site (Ac) | Apx. Existing Levee Elevation (ft in MLT) | 1st Construction Lev. Elev. (ft in MLT) | Shaped NWP Lev. Elev. (ft in MLT) | 50-Year Levee Elev. (ft in MLT) | Annual Shoaling Rate to Placement Site (CY) | Years Per Cycle | Dredge Quantity Per Cycle (CY) | Total Number of Cycles | Total 50-Year Maintenance Dredging Quantity (cu yds) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | To | From | | To | From | Site | | | | | | | | | | |
| NED | NED Extension | -450+00 | -300+00 | 1,044,448 | -450+00 | -300+00 | | | | | | | | | | | |
| | Entrance Bar Channel | -300+00 | 00+00 | 2,088,897 | -300+00 | 00+00 | ODMS | 1,291 | NA | NA | NA | NA | 3,472,580 | 1 | 3,472,580 | 50 | 173,628,985 |
| | Jetty Channel | 00+00 | 71+52 | 316,289 | 00+00 | 71+52 | 1A | | | | | | | | | | |
| | Lower Turning Basin | 71+52 | 78+52 | 22,946 | 71+52 | 78+52 | | | | | | | | | | | |
| | Ch to Brzpt & Brzpt TB | 78+52 | 115+52 | 142,181 | 78+52 | 90+20 | PA 1 | 320 | 29.0 | 31.5 | 31.5 | 33.5 | 44,883 | 3 | 134,649 | 16 | 2,154,384 |
| | | | | | 90+20 | 115+52 | PA 8 | 168 | NA[1] | 20.0 | 32.5 | 32.5 | 119,183 | 3 | 357,550 | 16 | 5,720,805 |
| | Ch to Upper TB | 115+52 | 132+66 | 57,889 | 115+52 | 122+00 | | | | | | | | | | | |
| | | | | | 122+00 | 132+66 | | | | | | | | | | | |
| | Ch to UP TB & UP TB | 132+66 | 184+20 | 141,697 | 132+66 | 184+20 | PA 9 | 254 | NA[1] | 20.0 | 32.5 | 32.5 | 177,700 | 3 | 533,101 | 16 | 8,529,620 |
| | Lower Stauffer TB | 184+20 | 222+00 | 4,826 | 184+20 | 222+00 | | | | | | | | | | | |
| | Upper Staffer TB | 222+00 | 260+00 | 5,000 | 222+00 | 260+00 | | | | | | | 9,826 | 12 | 117,912 | 4 | 471,648 |
| | **Total** | | | **3,824,173** | | | | | | | | | **3,824,173** | | | | **190,505,443** |
| LPP | NED Extension | -450+00 | -300+00 | 873,159 | -450+00 | -300+00 | | | | | | | | | | | |
| | Entrance Bar Channel | -300+00 | 00+00 | 1,969,531 | -300+00 | 00+00 | ODMS | 1,291 | NA | NA | NA | NA | 3,188,339 | 1 | 3,188,339 | 50 | 159,416,960 |
| | Jetty Channel | 00+00 | 71+52 | 324,554 | 00+00 | 71+52 | 1A | | | | | | | | | | |
| | Lower Turning Basin | 71+52 | 78+52 | 21,095 | 71+52 | 78+52 | | | | | | | | | | | |
| | Ch to Brzpt & Brzpt TB | 78+52 | 115+52 | 132,400 | 78+52 | 89+10 | PA 1 | 320 | 29.0 | 31.5 | 31.5 | 33.5 | 37,859 | 3 | 113,577 | 16 | 1,817,240 |
| | | | | | 89+10 | 115+52 | PA 8 | 168 | NA[1] | 18.5 | 32.0 | 32.0 | 119,008 | 3 | 357,025 | 16 | 5,712,400 |
| | Ch to Upper TB | 115+52 | 132+66 | 53,220 | 115+52 | 123+40 | | | | | | | | | | | |
| | | | | | 123+40 | 132+66 | | | | | | | | | | | |
| | Ch to UP TB & UP TB | 132+66 | 184+20 | 141,697 | 132+66 | 184+20 | PA 9 | 254 | NA[1] | 18.5 | 32.0 | 32.0 | 170,450 | 3 | 511,350 | 16 | 8,181,594 |
| | Lower Stauffer TB | 184+20 | 222+00 | 11,507 | 184+20 | 222+00 | | | | | | | 16,907 | 12 | 202,884 | 4 | 811,536 |
| | Upper Staffer TB | 222+00 | 260+00 | 5,400 | 222+00 | 260+00 | | | | | | | | | | | |
| | **Total** | | | **3,532,564** | | | | | | | | | **3,532,564** | | | | **175,939,729** |

Notes:

1) For new PA 8 & 9, an existing ground elevation level of 5 feet MLT is assumed at start of project. Detailed elevation surveys will be performed during subsequent design phases of the project. The initial assumed elevation is anticipated to be on the upper end of the range of potential existing elevations at these new sites.

2) For materials designated to go offshore, approximately 1 million cubic yards per year falls within footprint of separate widening permit action being pursued by Port of Freeport.

Table 8
Freeport Harbor Deepening and Widening – Summary
of New Work Dredging

| Freeport Harbor Deepening & Widening – Summary of New Work Dredging | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Alternative | Channel Reaches | Channel Reach Stationing | | Required Quantity (cy) | Overdepth Quantity (cy) | Total Quantity (cy) | Dredging Stationing & Placement Site Designation | | | Quantity Breakdown to Placement Sites (cy) |
| | | From | To | | | | From | To | Site | |
| NED | Future Channel Extension | –300+00 | –470+00 | 2,000,000 | 670,000 | 2,670,000 | -300+00 | -470+00 | ODMDS 1 | 14,957,000 |
| | Outer Bar Channel | 0+00 | 300+00 | 7,800,000 | 1,300,000 | 11,100,000 | 0+00 | -300+00 | | |
| | Jetty Channel | 71+52 | 0+00 | 2,900,000 | 287,000 | 1,187,000 | 71+52 | 0+00 | | |
| | Lower Turn Basin | 78+52 | 71+52 | 280,000 | 38,000 | 318,000 | 78+52 | 71+52 | PA 8 | 2,087,559 |
| | Ch to Brazosport & New 1,200-foot Brazosport TB | 115+00 | 78+52 | 2,200,000 | 116,000 | 2,316,000 | 702+00 | 78+52 | | |
| | | | | | | | 115+00 | 102+00 | PA 9 | 3,397,441 |
| | Ch from Brazosport TB | 132+66 | 115+00 | 513,000 | 34,000 | 547,000 | 132+66 | 115+00 | | |
| | Ch to Upper TB & Upper TB | 184+20 | 132+66 | 380,000 | 110,000 | 490,000 | 184+20 | 132+66 | | |
| | Stauffer Channel, Lower Stauffer TB | 222+00 | 184+20 | 1,340,000 | 47,000 | 1,387,000 | 220+00 | 184+00 | | |
| | Stauffer Channel, Upper Staffer & TB | 260+00 | 222+00 | 390,000 | 37,000 | 427,000 | 260+00 | 220+00 | | |
| | **Total** | | | **20,803,000** | **2,639,000** | **20,442,000** | | | | **20,442,000** |
| LPP | Future Channel Extension | –300+00 | –370+00 | 500,000 | 295,000 | 795,000 | –470+00 | –300+00 | ODMDS 1 | 9,733,297 |
| | Outer Bar Channel | 0+00 | -300+00 | 4,990,000 | 1,300,000 | 8,290,000 | –300+00 | 00+00 | | |
| | Jetty Channel | 71+52 | 0+00 | 2,345,000 | 303,000 | 648,000 | 00+00 | 71+52 | | |
| | Lower Turn Basin | 78+52 | 71+52 | **170,000** | 38,000 | 208,000 | 71+52 | 78+52 | PA 8 | 1,853,144 |
| | Ch to Brazosport & New 1,200-foot Brazosport TB | 115+00 | 78+52 | 1,600,000 | 116,000 | 1,716,000 | 78+52 | 105+20 | | |
| | | | | | | | 105+20 | 115+00 | PA 9 | 2,765,559 |
| | Ch from Brazosport TB | 132+66 | 115+00 | 357,000 | 34,000 | 391,000 | 115+00 | 132+66 | | |
| | Ch to Upper TB & Upper TB | 184+20 | 132+66 | 380,000 | 110,000 | 490,000 | 132+66 | 184+20 | | |
| | Stauffer Channel, Lower Stauffer TB | 222+00 | 184+20 | 1,340,000 | 47,000 | 1,387,000 | 184+20 | 222+00 | | |
| | Stauffer Channel, Upper Staffer & TB | 260+00 | 222+00 | 390,000 | 37,000 | 427,000 | 222+00 | 260+00 | | |
| | **Total** | | | **15,072,000** | **2,280,000** | **14,352,000** | | | | **14,352,000** |

a. do not undercut the toe of the South Jetty
b. maintain a 50-foot bench at the toe of the North Jetty

### 4.8.2 Critical Locations and Findings

#### 4.8.2.1 End of Construction Stability

In reviewing of prior stability analysis conducted by Fugro Engineering on the prior Deepening and Widening project, these results have indicated the "long-term" factors of safety for widening scenarios to be notably lower than the "end of construction" factors of safety. Additionally, after a number of long-term stability analysis trials were run on the new Deepening Project, an "end of construction" stability analysis was conducted at a conservative location (South Jetty Station 10+00) based on the long-term results, and an "end of construction" factor of safety above 3 was realized for a 57-foot-deep channel configuration. Based on study of prior stability analyses done, the high factor of safety for follow-up "end of construction" analysis at conservative location, and engineering judgment, the decision was made to focus primarily on the long-term stability conditions for the new deepening project.

#### 4.8.2.2 Long-Term Stability

Slope stability analyses for long-term conditions were conducted at station 10+00 for both the North and South jetties. This cross section was determined the most critical due to a soft clay layer identified in Boring B-6 along the South Jetty. Slope stability analyses for long-term conditions were also conducted at Station 20+00 on the North Jetty due to a changed soil profile at this location. Both borings B-5 and 74-23 indicated a loose to medium-dense sand layer at this location. At each cross section, the long-term stability of the existing slope configuration was evaluated. At station 10+00, the existing slope angle on the South Jetty was projected to a depth of 62 feet, and the maximum channel width was determined that would enable a bench width of at least 50 feet at the toe of the North Jetty. This maximum width was found to be 540 feet. This configuration is labeled 62/540 in Table 7. A second configuration (54/600) was determined by raising the elevation of the channel until a width of 600 feet was achieved. This channel depth was determined to be 54 feet. Both of these configurations hold the slope angle on the South Jetty side resulting in a shift of the existing channel centerline (110 feet to the north for the 62/540 channel and 120 feet to the north for the 54/600 channel). A summary of the calculated minimum factors of safety, resulting from stability analysis for long-term conditions, is provided in Table 9. For the long-term stability analyses, a minimum factor of safety criteria of 1.3 was adopted for the jetty, based on consideration of the consequences of failure and likelihood that a slide along the jetty would not be an immediate danger to human health or loss of life. The primary consequences of failure would be economic, and a factor of safety of 1.3 was considered to be reasonable.

Table 9
Jetty Stability Analysis - Summary of Calculated Minimum Factors of Safety

| | Associated Soil Borings | Existing Conditions | 62/540 Channel | 54/600 Channel |
|---|---|---|---|---|
| South Jetty (sta. 10+00) | B-6 | 1.4 | 1.3 | 1.3 |
| North Jetty (sta. 10+00) | 75-92 | 1.5 | 1.5 | 1.5 |
| North Jetty (sta. 20+00) | B-5, 74-23 | 1.6 | 1.5 | 1.6 |

Note: Borings B-5 and B-6 taken by Fugro Consultants, January 2005. Boring 74-23 taken by USACE, August 1974; and Boring 75-92 by USACE, October 1976.

## 4.9 CONTAINMENT DIKE'S SLOPE STABILITY ANALYSIS AT PA 8 AND PA 9

Slope stability analysis was performed with a computerized program "Slope W" for proposed new PAs 8 and 9 using the limited equilibrium procedures Morgenstern and Price analysis method.

The slope stability is determined by the factor of safety which is defined by:

Factor of Safety = Total available shear (or moment) strength / shear stress (or moment) needed for static equilibrium

Or $F = S / \tau$ C-1, EM 1110-2-1902

$F = (C' + (\sigma - u)\tan(\phi'))/ \tau$ C-2, EM 1110-2-1902

$F = (C + \sigma * \tan(\phi)) / \tau$ C-4, EM 1110-2-1902

Drained shear strength is determined in a soil laboratory through CU testing; undrained strength or total stress is related to total stress failure plane in CU plots. In addition to CU tests, a pen penetrometer reading can be used to estimate undrained shear strength during soil sampling; unconfined compression (UU) tests were also used to determine the undrained shear strength of a sample in soil laboratories. Due to economical constraints, only a few samples was selected for triaxial shear strength test. The test results of the samples are presented with the Mohr-Coulumb failure criterion plots in an attachment to this appendix; summaries of the rest of the test results and UU test information are also attached.

Total shear strength: $S = C + \sigma \tan(\phi)$ 2-1, EM 1110-2-1902

Effective shear strength: $S = C' + \sigma' \tan(\phi')$ 2-2, EM1110-2-1902

S = maximum possible value of shear strength

C = cohesion intercept

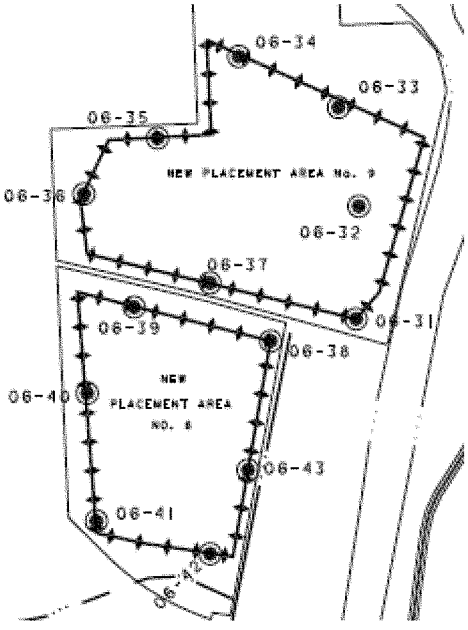
$\sigma$ = normal stress on the failure plane

u = pore water pressure; $(\sigma-u)$ is the effective normal stress on the failure plane

$\phi$ = total stress friction angle

A precise analysis is unreasonable for engineering practice because of the variable natures of soil particles in the foundation and mathematical formulae. Since it is not economically feasible to obtained engineering properties of each sample, a geotechnical engineer's judgments are applied to select shear strength for slope stability analyses. After reviewing Delivery Order – (DO) #43 field boring logs, borings 06-31 and 06-43 soil strata information and the lab test results of each were utilized for an initial preliminary slope stability analyses for Pas 8 and 9 (Figure 1). Due to uncertain nature and individualistic of soil particles, slope stability analyses obtained from one or two boring locations with above minimum required factor of safety will not have guarantee of a foundation satisfactory for the rest of containment PAs. Additional slope stability analyses should be conducted during preconstruction design phase to investigate the stability factor of safety with the rest of the soil testing results.

Figure 1




Boring Locations for Containment Dike Stability Analyses at PAs 8 and 9

A two-phase construction was considered for the slope stability analysis for the new proposed PAs. "Phase I" consisted of constructing the dike to elevation of 23.0 feet MLT, about 18 feet lift from the assumed 5-foot natural ground elevation. "Phase II" containment dike construction was to raise from elevation 23 MLT to the final of dike elevation at elevation 34.0 feet. From the preliminary foundation analyses, the dike foundation is able to sustain a dike height greater than 34 feet MLT to provide an additional capacity for future dredge containment; however, a further foundation investigation is encouraged if such situations occur in the future.

The stability analysis results indicate that both Phase I and Phase II at the end of dike construction was above the required minimum factor of safety. However, in order to guarantee a longer service possibility and consolidate foundation material, an earthen berm at the outside toe of the dike was added to ensure the future containment dike raising probability. Minimum dimensions of the toe berm for Phase I and Phase II construction are 60 feet wide and 7 feet high, and 60 feet wide and 8 feet high, respectively. Table 10 summarizes the results.

Table 10
Results of Containment Dike Stability Analyses at PA 8 and PA 9

| Proposed Dike Construction | Worst Soil Conditions at Boring Location | Required Minimum Factor of Safety | Toe Berm Dimensions | Computed Minimum Factor of Safety |
|---|---|---|---|---|
| Phase I | 06-31 | 1.3 | 60' (W) x 7' (H) | 2.92 |
| | 06-43 | 1.3 | 60' (W) x 7' (H) | 2.86 |
| Phase II | 06-31 | 1.3 | 60' (W) x 8' (H) | 2.53 |
| | 06-43 | 1.3 | 60' (W) x 8' (H) | 2.22 |

## 4.10 CONTAINMENT DIKE AND CHANNEL TEMPLATES

A design slope of 3 to 1 (horizontal to vertical) for containment dike with 10-foot crown templates and channel cuts was selected for the feasibility level quantities computation. The design slope was analyzed and confirmed with preliminary stability analyses. Additional and more-detailed stability analyses are recommended and anticipated to be done during the PED phase. For the channel template, the 3:1 slope is consistent with the original plan presented in the General Design Memorandum No. 1 (dated April 1979).

## 4.11 JETTY SAND RETENTION

The core stone structure in the jetties has been designed to minimize sand transport directly through the structure, and any sand that makes it directly through the actual stone structure is likely very minor. Occasional damage incurred or repair work needed to the existing structure from time to time, to ensure the structure continues to function properly, is typically handled under the existing O&M budget/funding; thus, this would not be considered a new cost for the new channel deepening.

## 4.12 RECOMMENDED ADDITIONAL INVESTIGATIONS

### 4.12.1 Freeport Channel

Along Freeport Channel for the new project, during PED or prior to the final design for the initial construction contract, it is recommended that additional borings be taken at locations that include but are not limited to the following: (1) along the reach above the Upper Turning Basin and along Stauffer Channel at about 1,000-foot intervals to a depth below the depth of new cut, and at other channel locations where gaps or deficiencies are indentified from prior obtained foundation information; and (2) verification borings or investigations supplemental to prior work done in areas where channel cuts will encroach on critical features or structures such as the jetties.

### 4.12.2 Upland Placement Areas

At existing PA 1, prior to the next O&M construction contract under the new 50-year project, it is recommended that additional borings be taken at locations that include but are not limited to (1) areas where containment dike alignment adjustments have taken place since prior drilling work done at the site, (2) locations where results from prior drilling/testing are most critical for additional analyses, (3) locations where gaps or deficiencies in prior foundation information taken are identified, and (4) at select locations within the placement area to assess the latest crust levels from prior dredged fill placement or other soil materials for use as borrow for the initial mechanical containment dike work.

### 4.12.3 New Placement Areas 8 and 9

At new PAs 8 and 9, prior to the first O&M construction contract, when stockpiled new work material will be shaped to new containment dike height, recommend additional drilling be performed into containment dike foundations to verify extent of consolidation and foundation strength gain from surcharge of initial containment dike and new work stockpiles, and perform stability checks in critical foundation areas identified.

## 5.0 COST ENGINEERING

For this Feasibility Study of the deepening and selective widening of the Freeport Channel, two Mii estimates were developed: 1) National Economic Development (NED) Plan, and 2) Locally Preferred Plan (LPP). The current existing channel is 45 feet by 400 feet. See below for description of the NED Plan and the LPP.

The NED Alternative is referred to as the 60-foot by 540-foot project because the width of the Jetty Channel would be restricted to 540 feet. This alternative proposes to extend the Outer Bar Channel (Channel Extension) 3.2 miles farther into the Gulf of Mexico at a depth of 62 feet and

a width of 600 feet, deepen the existing Outer Bar Channel to 62 feet and the Jetty Channel to 60 feet, deepen the main channel from the Lower Turning Basin through Station 132+66 (just above the Brazosport Turning Basin) to 60 feet and widen the Brazosport Turning Basin to 1,200 feet, deepen the main channel from Station 132+66 through the Upper Turning Basin to 50 feet, deepen and widen the Lower Stauffer Channel to 50 feet by 300 feet, and dredge the Upper Stauffer Channel to 25 feet deep by 200 feet wide in lieu of restoring its previous dimensions of 30 feet by 200 feet.

The LPP Alternative is referred to as the 55-foot by 600-foot project. This alternative proposes to extend the Outer Bar Channel (Channel Extension) 1.3 miles farther into the Gulf of Mexico at a depth of 57 feet and a width of 600 feet, deepen the existing Outer Bar Channel to 57 feet and the Jetty Channel to 55 feet, deepen the main channel from the Lower Turning Basin through Station 132+66 (just above the Brazosport Turning Basin) to 55 feet and widen the Brazosport Turning Basin to 1,200 feet, deepen the main channel from Station 132+66 through the Upper Turning Basin to 50 feet, deepen and widen the Lower Stauffer Channel to 50 feet by 300 feet wide, and dredge the Upper Stauffer Channel to 25 feet deep by 200 feet wide in lieu of restoring its previous dimensions of 30 feet by 200 feet.

Quantities and design features were developed by the Galveston District (SWG) Engineering Branch.

This estimate was prepared using the latest Unit Price Books and labor rates for fiscal year 2012 (October 2011). The estimate was divided into eight contracts, with each contract being organized in accordance with the work breakdown structure. The midpoint dates of the construction contracts were developed in conjunction with 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 Engineering Regulation and EM 1110-2-1304, dated 31 March 2012. All this data was input into the Total Project Cost Summary Sheet (TPCS). The baseline estimate provides for all pertinent elements for a complete project ready for operations.

Since the project cost is over $40 million, a formal cost risk analysis using Crystal Ball software was done. It was performed with the cooperation of the PDT and Cost Engineering Directory of Expertise (DX) of the Walla Walla District in April 2012. The risks were quantified and a cost risk model developed to determine a contingency at 80 percent confidence level. The new contingencies along with the updated estimates were used to revise the TPCS.

The O&M estimates were prepared in April 2012.

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

**ACCOUNT CODE 06 – FISH AND WILDLIFE FACILITIES (MITIGATION):** Quantities and design features were provided by SWG Planning, Environmental, & Regulatory Division. Costs were generated to develop prairie into coastal prairie. This involved removing existing tallow tress (classified as weeds) and creating an irregular-shaped pond with an average depth of 12 inches in the middle, using a dozer to clear and form the depression, and planting 400 clumps, 10 feet apart on center, with appropriate wetland plants.

**ACCOUNT CODE 12 – NAVIGATION PORTS AND HARBORS**: Dredge quantities were developed by the design engineer. Two large hopper dredges were assumed to be used simultaneously for each contract Nos. 1 and 2; and that they would be owned by the same contractor to allow for better coordination of maritime traffic to the open-water disposal site, where dredge material would be discharged. The remainder of the channel was assumed to be dredged using a 30-inch pipeline, with the material discharged into existing PA 1 or into two new PAs (8 and 9), located along the waterway. The dredging costs were developed using CEDEP. The dredge production rates were reduced to account for the stiffer "new work" material to be encountered. The costs for mobilization and demobilization were developed using CEDEP, assuming the dredges were based in New Orleans. The dredge estimates were based on standard operation practices for the Galveston District, which assumed conventional contractual practices of large business Invitations for Bid.

The cost for Sea Turtle Protection is associated with hopper dredging and includes (1) cost for two trawlers per hopper, (2) a sea turtle protection device fitted to the hopper, and (3) 24-hour monitoring survey.

The cost for creating a PA was included under this code of account. Part of the cost for creating a PA included clearing, grubbing, and stripping the area, as well as turfing the outside of the new levees. Labor rates and overhead costs were adjusted to reflect Region 6. The PA levees would be built using 2-cubic yard (cy) dragline buckets, with an optimal production rate of 150 cy/hour. A total of three draglines would be working at the same time. Material characteristics were provided by SWG, Engineering Division, Structural and Geotechnical, sections 3.0 and 4.0.

Also, included under this account code were navigation aids. The navigations aids included additional buoys and the relocation of four existing rang towers. All the quantities and cost data were provide by the Coast Guard in New Orleans.

**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.

## 6.0 REFERENCES

Fugro Consultants LP. 2005. Fugro Consultants LP. Geotechnical Study - Jetty Stability and Channel Widening Project - Freeport Ship Channel - Port of Freeport - Freeport, Texas. February 2006.

PBS&J. 2007. PBS&J. November, 2007. Preliminary Draft Environmental Impact Statement, Freeport Harbor Deepening and Widening Channel Improvement Project, Brazoria County, Texas.

Professional Service Industries, Inc. 1996. Subsurface Exploration and Foundation Recommendations for the Proposed Confined Placement Site No. 1 – Port of Freeport – Freeport, Texas. June.

Shiner Moseley and Associates, Inc. 2007. Draft Feasibility Report – Freeport Entrance and Jetty Channel Widening Project, Freeport, Texas. June.

U.S. Army Corps of Engineers, Southwest Division (USACE SWG), Galveston District. 1979. General Design Memorandum No. 1 (Freeport Harbor, Texas, 45-foot Project, Phase II).

U.S. Army Corps of Engineers, SWG and ERDC. 2005. Desktop Sediment Study for Freeport Project. September.

**Attachment**

**Engineering Drawings and Soil Investigation Appendix**

List of attachments:

**Channel C-Drawings**
C00 Cover Sheet
C01 General Notes & Index
C02 Project Location
C03 Existing Plan View
C04 Enlarged Plan View Stauffer
C05 Enlarged Plan View Jetty Reach
C06 General LPP Cross Sections

**Geotechnical F-Drawings**
F01 Chan Boring Plan
F02 PA#1, 8, & 9 Boring Plan
F03 Channel Boring Logs
F04 Channel Boring Logs
F05 Channel Boring Logs
F06 PA 8 & 9 Boring Logs
F07 PA 8 & 9 Boring Logs
F08 PA 1 Boring Logs
F09 PA 1 Boring Logs
F10 PA 1 Boring Logs
F11 PA 1 Boring Logs
F12 PA 1 Boring Logs
F13 PA 1 Boring Logs
F14 Typical Containment Dike Detail

Freeport Channel, Texas
Channel Improvement Feasibility Study

## Pipeline/Hopper Dredging

# Freeport Navigation Channel Improvement, Stauffer Channel Reauthorization & New Upland Confined PA's #8 and #9

APPROVAL COPY
SUBJECT TO REVISION

## Coastal Navigation and Environmental Restoration

Office of the District Engineer
U. S. Army Engineer District, Galveston
Corps of Engineers
Galveston, Texas
March 2010

This project was designed by the Galveston District of the U.S. Army Corps of Engineers. The initials or signatures and registration designations of individuals appear on these project documents within the scope of their employment as required by ER 1110-1-8152.

TOTAL ARMY QUALITY

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## GENERAL CONSTRUCTION AND DREDGING NOTE(S):

1. HORIZONTAL CONTROL BASED ON TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE NAD83 IN FEET.
2. ALL ELEVATIONS SHOWN ON THESE PLANS ARE IN FEET REFERENCED TO NAVD88 OR MLT (MEAN LOW TIDE).
3. MLT DATUM IS 1.00' BELOW NAVD88 DATUM.

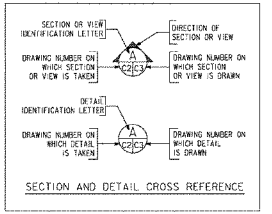
HORIZONTAL CONTROL MONUMENTS
N.A.D. - 83

| DESCRIPTION | EASTING | NORTHING |
|---|---|---|
| CAPTAIN | 3,151,802.03 | 13,542,617.36 |
| SMITH BURGER POINT | 3,151,763.35 | 13,554,272.97 |
| KBB-1 | 3,137,416.17 | 13,530,736.32 |
| WEST JETTY POINT #1 | 3,151,984.37 | 13,543,015.85 |
| WEST JETTY POINT #2 | 2,151,476.16 | 13,543,536.93 |
| SOUTHEAST CORNER D.A. #2 | 3,146,301.36 | 13,539,894.98 |
| E-6 | 3,156,924.73 | 13,548,366.59 |
| F.H.-3 | 3,149,745.88 | 13,544,667.91 |
| F.H.-6 | 3,144,294.30 | 13,541,164.37 |
| F.H.-7 | 3,142,151.04 | 13,541,280.05 |
| REDBUD | 3,146,162.21 | 13,543,511.69 |
| JM-2 | 3,140,824.37 | 13,546,303.41 |
| JM-3A | 3,142,439.40 | 13,542,550.49 |
| BPTB #4 | 3,144,877.76 | 13,544,585.26 |

4. CONTRACTOR SHALL CONTACT PIPELINE OWNERS AND VERIFY THE POSITION OF PIPELINES PRIOR TO PERFORMING WORK IN THE DESIGNATED WORK AREA.
5. CONTRACTOR SHALL VERIFY ACCURACY OF CONTROL MONUMENTS PRIOR TO CONSTRUCTION.
6. CONTRACTOR SHALL VERIFY ALL EXISTING CONDITIONS PRIOR TO COMMENCING CONSTRUCTION ACTIVITIES. CONTRACTOR SHALL TAKE MEASURES TO PROTECT ALL EXISTING IMPROVEMENTS WITHIN AND ADJACENT TO THE WORK AREA.
7. PRIOR TO COMMENCING DREDGING, CONTRACTOR SHALL PERFORM A PRE-DREDGE HAZARD SURVEY OVER WORK AREA TO LOCATE ANY BURIED OBSTRUCTIONS OR UNCHARTED PIPELINES THAT MAY BE PRESENT.
8. MATERIAL SHALL BE DEPOSITED WITHIN THE LIMITING LINES OF THE DESIGNATED PLACEMENT AREAS, AS PRESCRIBED IN THE SPECIFICATIONS.

## INDEX TO DRAWINGS


| PL NO. | TITLE |
|---|---|
| - | COVER SHEET |
| C01 | GENERAL NOTES AND INDEX TO DRAWINGS |
| | |
| | CHANNEL C-DRAWINGS |
| C02 | PROJECT LOCATION PLAN |
| C03 | EXISTING PLAN |
| C04 | ENLARGED PLAN VIEW STAUFFER |
| C05 | ENLARGED PLAN VIEW JETTY REACH |
| C06 | GENERAL LPP CROSS SECTIONS FOR REFERENCE |
| | |
| | |
| | |
| | GEOTECHNICAL F-DRAWINGS |
| F-1 | F01 Chan Boring Plan.dgn |
| F-2 | F02 PA 1 & 9 Boring Plan.dgn |
| F-3 | F03 Chan Boring Logs.dgn |
| F-4 | F04 Chan Boring Logs.dgn |
| F-5 | F05 Chan Boring Logs.dgn |
| F-6 | F06 PA 8 & 9 Boring Logs.dgn |
| F-7 | F07 PA 8 & 9 Boring Logs.dgn |
| F-8 | F08 PA 1 Boring Logs.dgn |
| F-9 | F09 PA 1 Boring Logs.dgn |
| F-10 | F10 PA 1 Boring Logs.dgn |
| F-11 | F11 PA 1 Boring Logs.dgn |
| F-12 | F12 PA 1 Boring Logs.dgn |
| F-13 | F13 PA 1 Boring Logs.dgn |
| F-14 | F14 Typ Levee.dgn |
| | |
| | |

SECTION AND DETAIL CROSS REFERENCE

US Army Corps of Engineers Galveston District

| No. | Date | By | Description |
|---|---|---|---|
| 1 | 2/10 | KJ | Updated Plan Views |
| 2 | 3/10 | KJ | Updated Plan Views |

Design Section

Approved for Construction: [illegible]
Date: [illegible]
Submitted by: [illegible]
Date: 3/10
Approved by: PETE C. PEREZ, P.E.
Chief, Engineering and Construction Division

USE ARMY ENGINEER DISTRICT, GALVESTON GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF DAVID E. WESTON, COL, E.C. DISTRICT COMMANDER

INDEX OF DRAWINGS
PROJECT CONSTRUCTION INFORMATION

Drawing No.: C01
Sheet of X
File No.

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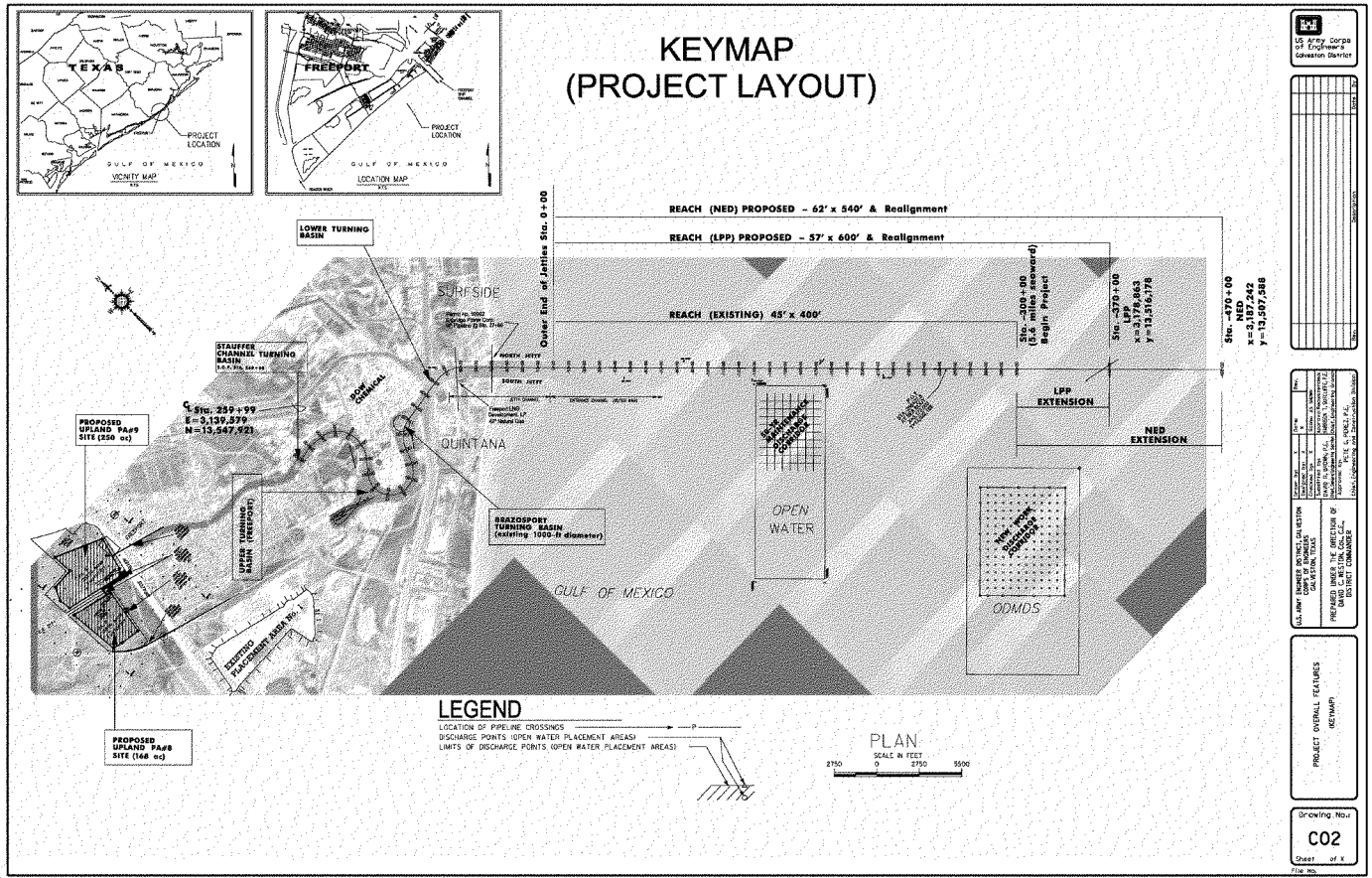
# KEYMAP
# (PROJECT LAYOUT)




US Army Corps of Engineers Galveston District

U.S. ARMY ENGINEER DISTRICT, GALVESTON
P.O. BOX 1229
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF
DAVID C. WESTON, COL, C.E.
DISTRICT COMMANDER

PETE S. PONCI, P.E.
Chief, Engineering and Construction Division

PROJECT OVERALL FEATURES
(KEYMAP)

Drawing No.: C02
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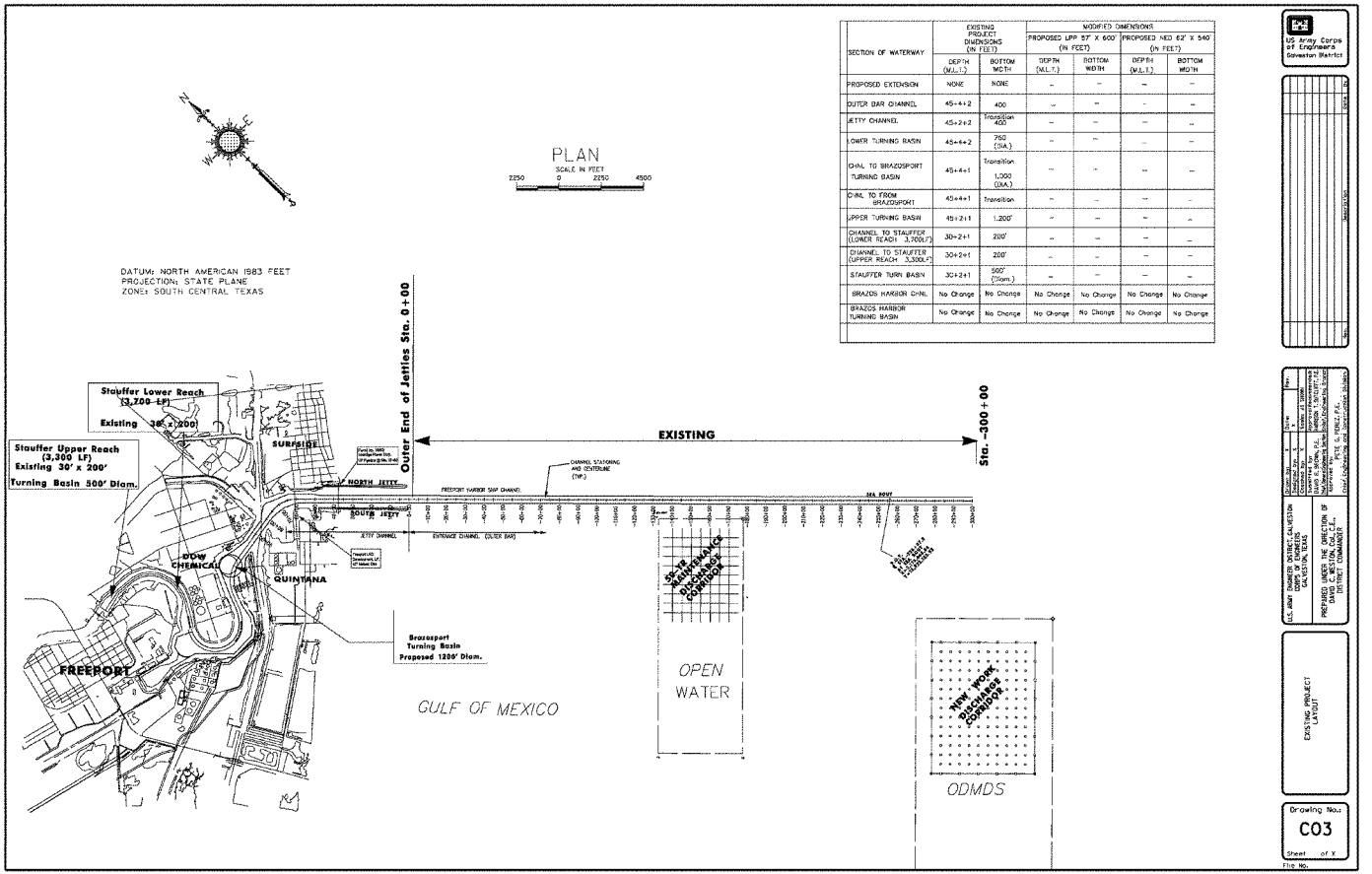
File No.

3/1/2




| SECTION OF WATERWAY | EXISTING PROJECT DIMENSIONS (IN FEET) | | MODIFIED DIMENSIONS PROPOSED UPP 57' X 600' (IN FEET) | | PROPOSED MID 62' X 540' (IN FEET) | |
|---|---|---|---|---|---|---|
| | DEPTH (M.L.T.) | BOTTOM WIDTH | DEPTH (M.L.T.) | BOTTOM WIDTH | DEPTH (M.L.T.) | BOTTOM WIDTH |
| PROPOSED EXTENSION | NONE | NONE | -- | -- | -- | -- |
| OUTER BAR CHANNEL | 45+4+2 | 400 | -- | -- | -- | -- |
| JETTY CHANNEL | 45+2+2 | Transition 400 | -- | -- | -- | -- |
| LOWER TURNING BASIN | 45+4+2 | 750 (DIA.) | -- | -- | -- | -- |
| CHNL TO BRAZOSPORT TURNING BASIN | 45+4+1 | Transition 1,000 (DIA.) | -- | -- | -- | -- |
| CHNL TO FROM BRAZOSPORT | 45+4+1 | Transition | -- | -- | -- | -- |
| UPPER TURNING BASIN | 45+2+1 | 1,200' | -- | -- | -- | -- |
| CHANNEL TO STAUFFER (LOWER REACH 3,700LF) | 30+2+1 | 200' | -- | -- | -- | -- |
| CHANNEL TO STAUFFER (UPPER REACH 3,300LF) | 30+2+1 | 200' | -- | -- | -- | -- |
| STAUFFER TURN BASIN | 30+2+1 | 500' (Diam.) | -- | -- | -- | -- |
| BRAZOS HARBOR CHNL | No Change | No Change | No Change | No Change | No Change | No Change |
| BRAZOS HARBOR TURNING BASIN | No Change | No Change | No Change | No Change | No Change | No Change |

US Army Corps of Engineers Galveston District

| Rev. | Date | By | Description |
|---|---|---|---|
| 1 | 5 MAY 09 | MBM | REVISED PER COMMENTS |

Designed by: DAVID E. BROWN, P.E.
Drawn by: MARSHA L. BERTOLETTE
Checked by: DAVID E. BROWN, P.E.
Approved by: PETE G. HENCH, P.E.
Project Engineering and Construction Branch

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

PREPARED UNDER THE DIRECTION OF DAVID C. WESTON, COL, C.E. DISTRICT COMMANDER

EXISTING PROJECT LAYOUT

Drawing No.: C03

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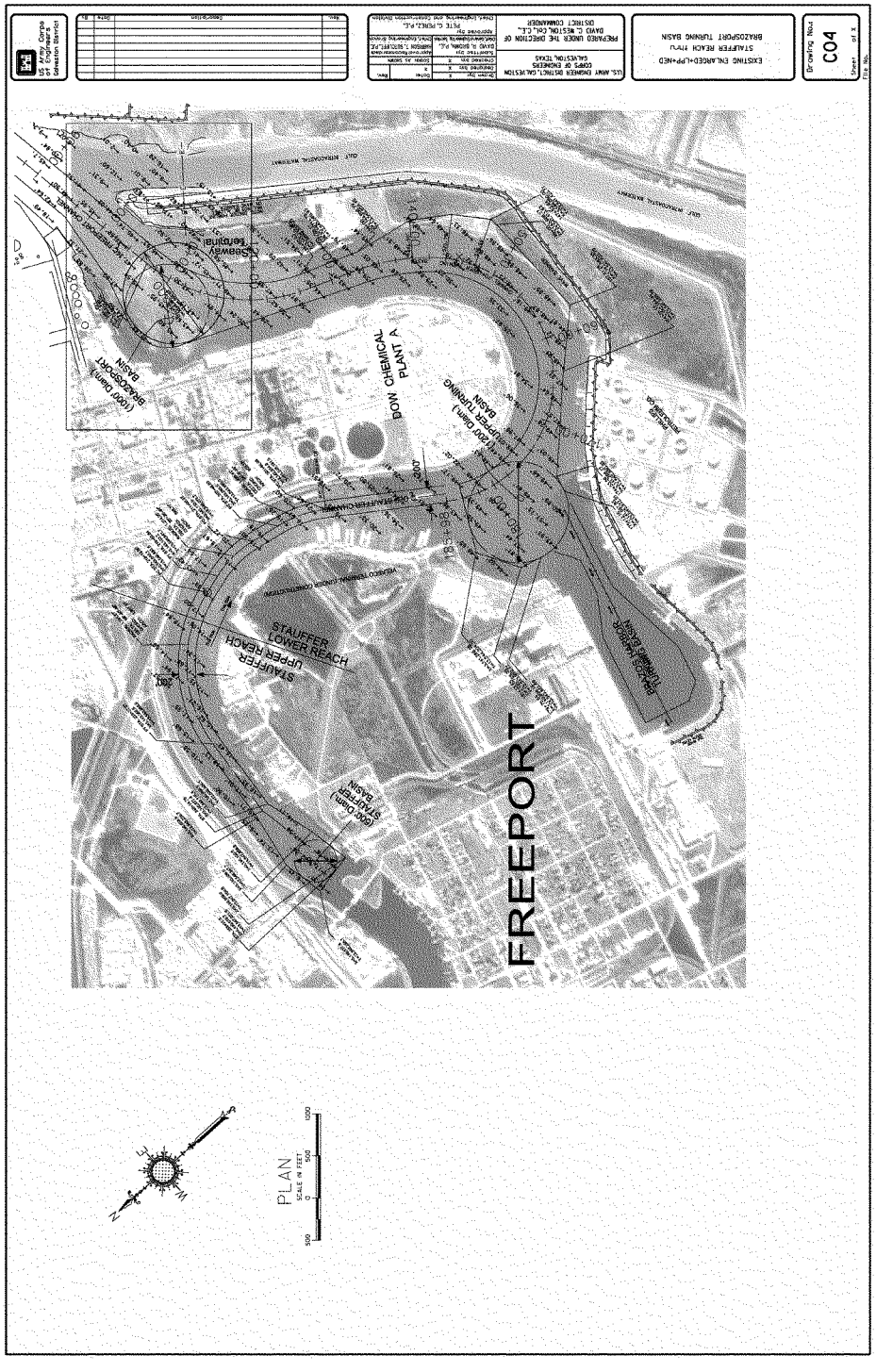
EXISTING ENLARGED-LPP+NED
STAUFFER REACH TRNU
BRAZOSPORT TURNING BASIN
C04
U.S. ARMY DISTRICT, GALVESTON
PREPARED UNDER THE DIRECTION OF
DAVID C. WESTON, COL, C.E.
DISTRICT COMMANDER
GALVESTON, TEXAS
CORPS OF ENGINEERS
U.S. Army Corps of Engineers
Galveston District
BOW CHEMICAL PLANT A
STAUFFER LOWER REACH
STAUFFER UPPER REACH
BRAZOSPORT BASIN
FREEPORT
PLAN
SCALE IN FEET
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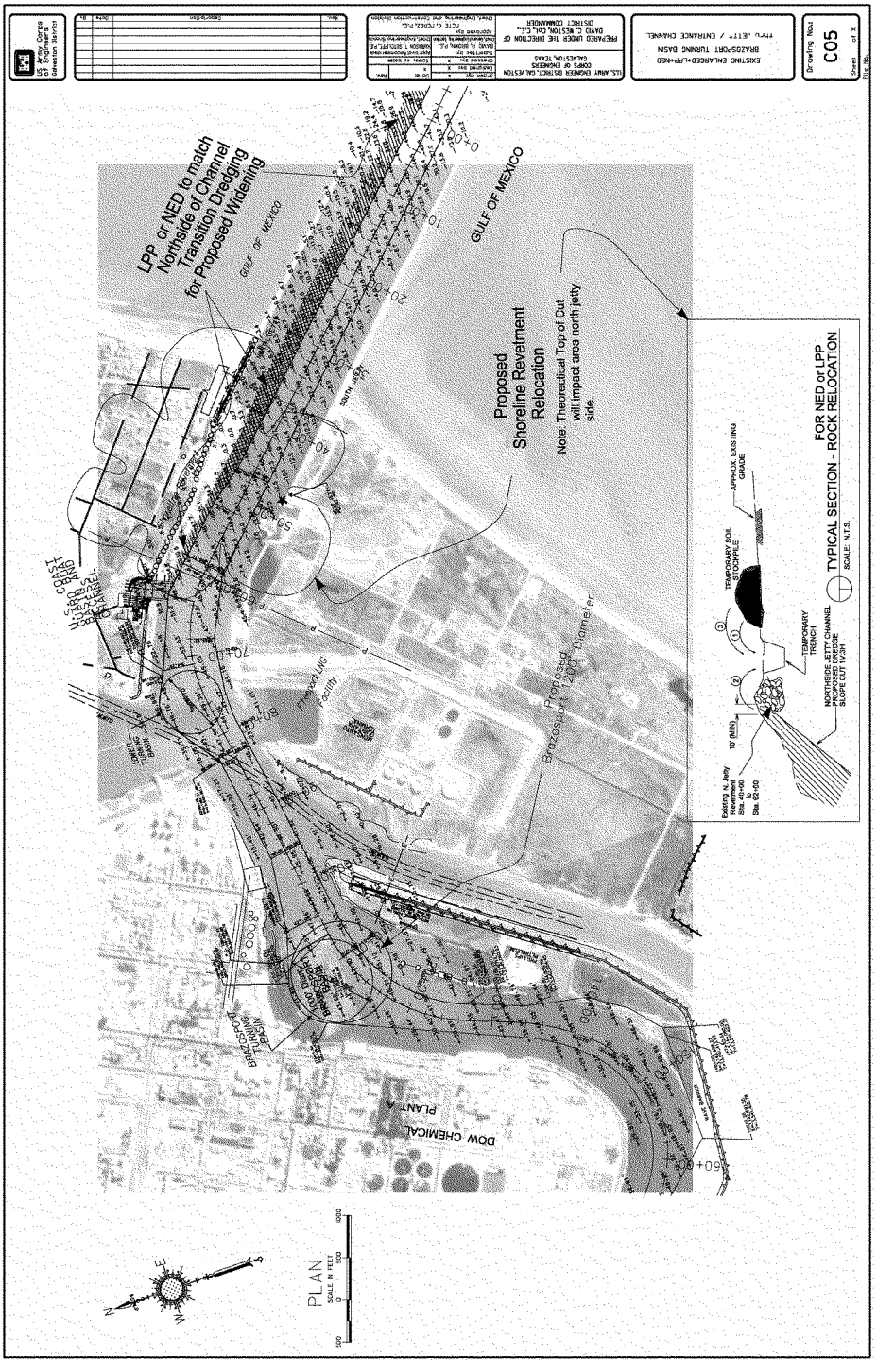
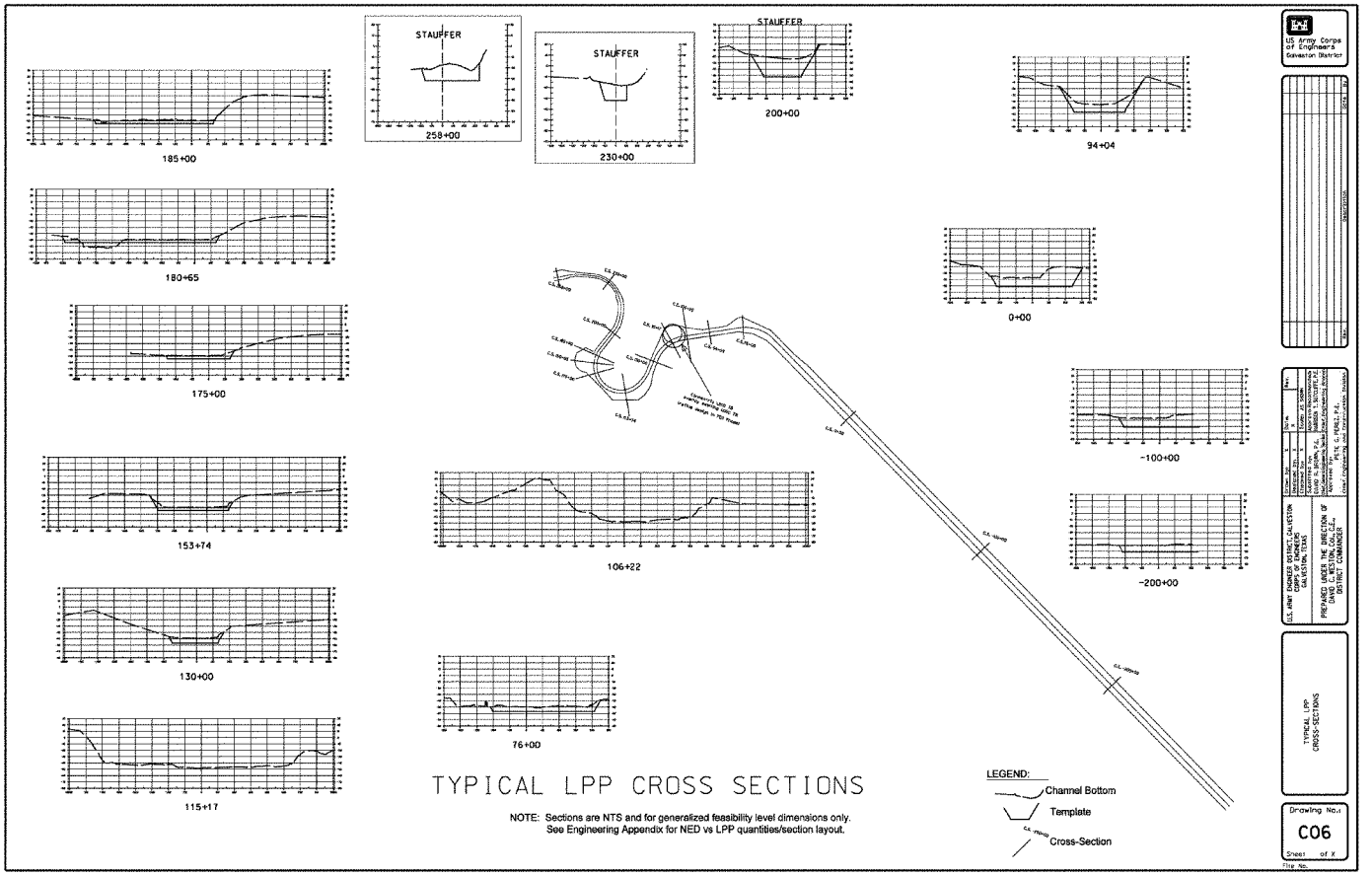

US Army Corps of Engineers Galveston District
EXISTING ENLARGED+LPP+NED BRAZOSPORT TURNING BASIN
PREPARED UNDER THE DIRECTION OF DAVID C. WESTON, COL.,C.E., DISTRICT COMMANDER
U.S. ARMY ENGINEER DISTRICT, GALVESTON CORPS OF ENGINEERS
Drawing No.: C05
LPP or NED to match Northside of Channel Transition Dredging for Proposed Widening
GULF OF MEXICO
Proposed Shoreline Revetment Relocation
Note: Theoretical Top of Cut will impact area north jetty side.
Proposed Brazosport 1200' Diameter
Freeport LNG Facility
DOW CHEMICAL PLANT A
BRAZOSPORT TURNING BASIN
COAST ROAD
U.S. 2ND AND BASIN CHANNEL
LOWER TURNING BASIN
PLAN
SCALE IN FEET
FOR NED or LPP
TYPICAL SECTION - ROCK RELOCATION
SCALE: N.T.S.
TEMPORARY SOIL STOCKPILE
APPROX. EXISTING GRADE
TEMPORARY TRENCH
NORTHSIDE JETTY CHANNEL PROPOSED DREDGE SLOPE CUT 1V:3H
Existing N. Jetty Revetment Sta. 40+00 to Sta. 62+00
10' (MIN)

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Existing ALG Sheet 1 of 2

# Freeport Harbor

Project Name: SWG Channel Alignments
Description: SP83TXSC Alignments
Horizontal Alignment Name: Freeport Harbor
Description: -300+00.000 to 184+19.880

| | STATION | NORTHING | EASTING |
|---|---|---|---|
| Element: Linear | | | |
| POB ( ) | -300+00.000000 | 13519041.994000 | 3176070.566000 |
| PC ( ) | 59+62.884289 | 13544785.945151 | 3150959.253299 |
| Tangent Direction: | N 44°17'14.202" W | | |
| Tangent Length: | 35962.884289 | | |
| Element: Circular | | | |
| PC ( ) | 59+62.884289 | 13544785.945151 | 3150959.253299 |
| PI ( ) | 68+19.753389 | 13545399.333000 | 3150360.939000 |
| CC ( ) | | 13543619.107799 | 3149763.019389 |
| PT ( ) | 75+46.419878 | 13545271.471713 | 3149513.663280 |
| Radius: | 1671.073000 | | |
| Delta: | 54°17'39.840" Left | | |
| Degree of Curve: | 3°25'43.255" | | |
| Length: | 1583.535589 | | |
| Tangent: | 856.869100 | | |
| Chord: | 1524.948047 | | |
| Middle Ordinate: | 184.090036 | | |
| External: | 206.880574 | | |
| Tangent Direction: | N 44°17'14.202" W | | |
| Radial Direction: | N 45°42'45.798" E | | |
| Chord Direction: | N 71°26'04.122" W | | |
| Radial Direction: | N 8°34'54.042" W | | |
| Tangent Direction: | N 81°25'05.958" E | | |
| Element: Linear | | | |
| PT ( ) | 75+46.419878 | 13545271.471713 | 3149513.663280 |
| PC ( ) | 106+74.254903 | 13544804.738798 | 3146420.847034 |
| Tangent Direction: | N 81°25'05.958" E | | |
| Tangent Length: | 3127.835025 | | |
| Element: Circular | | | |
| PC ( ) | 106+74.254903 | 13544804.738798 | 3146420.847034 |
| PI ( ) | 117+84.439399 | 13544639.078000 | 3145323.092000 |
| CC ( ) | | 13542916.241532 | 3146705.837723 |
| PT ( ) | 126+85.529503 | 13543603.193141 | 3144923.777370 |
| Radius: | 1909.880000 | | |
| Delta: | 60°20'15.304" Left | | |
| Degree of Cure: | 2°59'59.883" | | |
| Length: | 2011.274600 | | |
| Tangent: | 1110.184496 | | |
| Chord: | 1919.617031 | | |
| Middle Ordinate: | 258.695810 | | |
| External: | 299.226432 | | |
| Tangent Direction: | N 81°25'05.958" E | | |
| Radial Direction: | N 8°34'54.042" W | | |

Existing ALG Sheet 2 of 2

| | | | |
|---|---|---|---|
| Chord Direction: | N 51°14'58.305" E | | |
| Radial Direction: | N 68°55'09.347" W | | |
| Tangent Direction: | N 21°04'50.653" E | | |
| Element: Linear | | | |
| PT ( ) | 126+85.529503 | 13543603.193141 | 3144923.777370 |
| PC ( ) | 132+66.661899 | 13543060.953313 | 3144714.753853 |
| Tangent Direction: | N 21°04'50.653" E | | |
| Tangent Length: | 581.132396 | | |
| Element: Circular | | | |
| PC ( ) | 132+66.661899 | 13543060.953313 | 3144714.753853 |
| PI ( ) | 137+52.719878 | 13542607.425000 | 3144539.927000 |
| CC ( ) | | 13543996.879739 | 3142286.813723 |
| PCC ( ) | 142+27.702283 | 13542247.590734 | 3144213.167669 |
| Radius: | 2602.086000 | | |
| Delta: | 21°09'40.729" Right | | |
| Degree of Curve: | 2°12'06.902" | | |
| Length: | 961.040384 | | |
| Tangent: | 486.057979 | | |
| Chord: | 955.587455 | | |
| Middle Ordinate: | 44.242239 | | |
| External: | 45.007484 | | |
| Tangent Direction: | N 21°04'50.653" E | | |
| Radial Direction: | N 68°55'09.347" W | | |
| Chord Direction: | N 31°39'41.018" E | | |
| Radial Direction: | N 47°45'28.618" W | | |
| Tangent Direction: | N 42°14'31.382" E | | |
| Element: Circular | | | |
| PCC ( ) | 142+27.702283 | 13542247.590734 | 3144213.167669 |
| PI ( ) | 255+67.283993 | 13533852.769050 | 3136589.973965 |
| CC ( ) | | 13543223.825771 | 3143138.117058 |
| PT ( ) | 184+19.880284 | 13543897.655840 | 3141851.757192 |
| Radius: | 1452.160000 | | |
| Delta: | 165°24'16.963" Right | | |
| Degree of Curve: | 3°56'44.000" | | |
| Length: | 4192.178000 | | |
| Tangent: | 11339.581710 | | |
| Chord: | 2880.794039 | | |
| Middle Ordinate: | 1267.701085 | | |
| External: | 9980.026231 | | |
| Tangent Direction: | N 42°14'31.382" E | | |
| Radial Direction: | N 47°45'28.618" W | | |
| Chord Direction: | N 55°03'20.136" W | | |
| Radial Direction: | N 62°21'11.655" W | | |
| Tangent Direction: | N 27°38'48.345" E | | |

LPP and Stauffer ALG Sheet 1 of 2

Project Name: LPP Map Align
Description:
Horizontal Alignment Name: LPP Cntrln Mar18
Description:
Style: Default

| | STATION | NORTHING | EASTING |
|---|---|---|---|
| Element: Linear | | | |
| POB { } | -433+14.00 | 13509468.42 | 3185589.72 |
| PC { } | 60+81.63 | 13544828.57 | 3151099.30 |
| Tangent Direction: | N 44^17'12" W | | |
| Tangent Length: | 49395.63 | | |
| Non-collinear | | | |
| Element: Circular | | | |
| PC { } | 60+81.63 | 13544828.57 | 3151099.30 |
| PI { } | 69+69.41 | 13545370.24 | 3150395.93 |
| CC { } | | 13543087.16 | 3149758.25 |
| PT { } | 77+69.10 | 13545271.45 | 3149513.66 |
| Radius: | 2197.94 | | |
| Delta: | 43^59'20" Left | | |
| Degree of Curvature(Arc): | 2^36'24" | | |
| Length: | 1687.47 | | |
| Tangent: | 887.78 | | |
| Chord: | 1646.33 | | |
| Middle Ordinate: | 159.97 | | |
| External: | 172.52 | | |
| Tangent Direction: | N 52^24'00" W | | |
| Radial Direction: | N 37^36'00" E | | |
| Chord Direction: | N 74^23'40" W | | |
| Radial Direction: | N 6^23'20" W | | |
| Tangent Direction: | S 83^36'40" W | | |
| Non-collinear | | | |
| Element: Linear | | | |
| PT { } | 77+69.10 | 13545271.45 | 3149513.66 |
| PI { } | 95+22.99 | 13545009.73 | 3147779.41 |
| Tangent Direction: | S 81^25'06" W | | |
| Tangent Length: | 1753.89 | | |
| Element: Linear | | | |
| PI { } | 95+22.99 | 13545009.73 | 3147779.41 |
| PI { } | 108+96.93 | 13544804.72 | 3146420.85 |
| Tangent Direction: | S 81^25'07" W | | |
| Tangent Length: | 1373.94 | | |
| Element: Linear | | | |
| PI { } | 108+96.93 | 13544804.72 | 3146420.85 |
| PC { } | 108+96.94 | 13544804.72 | 3146420.85 |
| Tangent Direction: | S 39^31'29" E | | |
| Tangent Length: | 0.00 | | |
| Non-collinear | | | |
| Element: Circular | | | |
| PC { } | 108+96.94 | 13544804.72 | 3146420.85 |
| PI { } | 120+07.13 | 13544619.06 | 3145323.09 |
| CC { } | | 13542916.21 | 3146705.84 |
| PT { } | 129+08.22 | 13543603.17 | 3144923.77 |
| Radius: | 1909.89 | | |
| Delta: | 60^20'15" Left | | |
| Degree of Curvature(Arc): | 3^00'00" | | |
| Length: | 2011.28 | | |
| Tangent: | 1110.19 | | |
| Chord: | 1919.63 | | |
| Middle Ordinate: | 258.70 | | |
| External: | 299.23 | | |
| Tangent Direction: | S 81^25'07" W | | |
| Radial Direction: | N 8^34'53" W | | |
| Chord Direction: | S 51^14'59" W | | |
| Radial Direction: | N 68^55'09" W | | |
| Tangent Direction: | S 21^04'51" W | | |
| Non-collinear | | | |
| Element: Linear | | | |
| PT { } | 129+08.22 | 13543603.17 | 3144923.77 |
| PI { } | 129+08.22 | 13543603.17 | 3144923.77 |
| Tangent Direction: | S 47^31'20" W | | |
| Tangent Length: | 0.00 | | |
| Element: Linear | | | |
| PI { } | 129+08.22 | 13543603.17 | 3144923.77 |
| PI { } | 134+89.36 | 13543060.93 | 3144714.75 |
| Tangent Direction: | S 21^04'49" W | | |
| Tangent Length: | 581.13 | | |
| Element: Linear | | | |
| PI { } | 134+89.36 | 13543060.93 | 3144714.75 |
| PC { } | 134+89.36 | 13543060.93 | 3144714.75 |
| Tangent Direction: | N 66^04'02" W | | |
| Tangent Length: | 0.00 | | |
| Non-collinear | | | |
| Element: Circular | | | |
| PC { } | 134+89.36 | 13543060.93 | 3144714.75 |
| PI { } | 139+75.41 | 13542607.40 | 3144539.93 |
| CC { } | | 13543996.83 | 3142286.80 |
| PT { } | 144+50.40 | 13542247.56 | 3144213.17 |
| Radius: | 2602.09 | | |
| Delta: | 21^09'41" Right | | |
| Degree of Curvature(Arc): | 2^12'07" | | |
| Length: | 961.04 | | |
| Tangent: | 486.06 | | |
| Chord: | 955.59 | | |
| Middle Ordinate: | 44.24 | | |
| External: | 45.01 | | |
| Tangent Direction: | S 21^04'48" W | | |
| Radial Direction: | N 68^55'12" W | | |
| Chord Direction: | S 31^39'38" W | | |
| Radial Direction: | N 47^45'31" W | | |
| Tangent Direction: | S 42^14'29" W | | |
| Non-collinear | | | |
| Element: Linear | | | |
| PT { } | 144+50.40 | 13542247.56 | 3144213.17 |
| PC { } | 144+50.40 | 13542247.56 | 3144213.17 |
| Tangent Direction: | S 26^21'27" W | | |

```
           Tangent Length:              0.00

Non-collinear

Element: Circular
              PC (        )          144+50.40   13542247.56    3144213.17
              PI (        )          364+09.43   13525990.70    3129451.27
              CC (        )                      13543223.77    3143138.10
              PT (        )          188+20.70   13544049.91    3141943.84
                  Radius:              1452.16
                   Delta:          172^25'59" Right
  Degree of Curvature(Arc):             3^56'44"
                  Length:              4370.31
                 Tangent:             21959.04
                   Chord:              2897.99
          Middle Ordinate:              1356.34
                External:             20554.84
        Tangent Direction:      S 42^14'27" W
         Radial Direction:      N 47^45'33" W
          Chord Direction:      N 51^32'34" W
         Radial Direction:      S 55^19'34" E
        Tangent Direction:      N 34^40'26" E

Non-collinear

Element: Linear
              PT (        )          188+20.70   13544049.91    3141943.84
              PC (        )          202+75.07   13545193.01    3142843.02
        Tangent Direction:      N 38^11'22" E
           Tangent Length:              1454.37

Non-collinear

Element: Circular
              PC (        )          202+75.07   13545193.01    3142843.02
              PI (        )          205+75.21   13545438.26    3143016.03
              CC (        )                      13545951.30    3141768.05
              PT (        )          208+65.25   13545734.29    3143065.54
                  Radius:              1315.52
                   Delta:           25^42'15" Left
  Degree of Curvature(Arc):             4^21'19"
                  Length:               590.17
                 Tangent:               300.14
                   Chord:               585.24
          Middle Ordinate:                32.96
                External:                33.80
        Tangent Direction:      N 35^11'58" E
         Radial Direction:      S 54^48'02" E
          Chord Direction:      N 22^20'50" E
         Radial Direction:      S 80^30'18" E
        Tangent Direction:      N  9^29'42" E

Non-collinear

Element: Linear
              PT (        )          208+65.25   13545734.29    3143065.54
              PC (        )          212+15.69   13546078.74    3143130.02
        Tangent Direction:      N 10^36'10" E
           Tangent Length:               350.44

Non-collinear

Element: Circular
              PC (        )          212+15.69   13546078.74    3143130.02
              PI (        )          216+31.58   13546491.71    3143179.23
              CC (        )                      13546288.99    3141365.43
             PCC (        )          220+32.76   13546883.63    3143040.06
                  Radius:              1777.07
                   Delta:           26^20'38" Left
  Degree of Curvature(Arc):             3^13'27"
                  Length:               817.08
                 Tangent:               415.89
                   Chord:               809.90
          Middle Ordinate:                46.75
                External:                48.02
        Tangent Direction:      N  6^47'41" E
         Radial Direction:      S 83^12'19" E
          Chord Direction:      N  6^22'39" W
         Radial Direction:      N 70^27'02" E
        Tangent Direction:      N 19^32'58" W

Non-collinear

Element: Circular
             PCC (        )          220+32.76   13546883.63    3143040.06
              PI (        )          231+20.14   13547929.54    3142742.62
              CC (        )                      13546448.25    3141509.10
              PT (        )          239+40.67   13548032.73    3141660.14
                  Radius:              1591.67
                   Delta:           68^40'46" Left
  Degree of Curvature(Arc):             3^35'59"
                  Length:              1907.91
                 Tangent:              1087.38
                   Chord:              1795.72
          Middle Ordinate:               277.42
                External:               335.97
        Tangent Direction:      N 15^52'30" W
         Radial Direction:      N 74^07'30" E
          Chord Direction:      N 50^12'53" W
         Radial Direction:      N  5^26'44" E
        Tangent Direction:      N 84^33'16" W

Non-coincident

Element: Linear
              PT (        )          239+40.67   13548032.73    3141660.14
              PI (        )          249+27.91   13548126.42    3140677.36
        Tangent Direction:      N 84^33'16" W
           Tangent Length:               987.24

Element: Linear
              PI (        )          249+27.91   13548126.42    3140677.36
             POE (        )          260+44.46   13547921.90    3139579.70
        Tangent Direction:      S 79^26'44" W
           Tangent Length:              1116.55
```

NED and Stauffer ALG Sheet 1 of 3

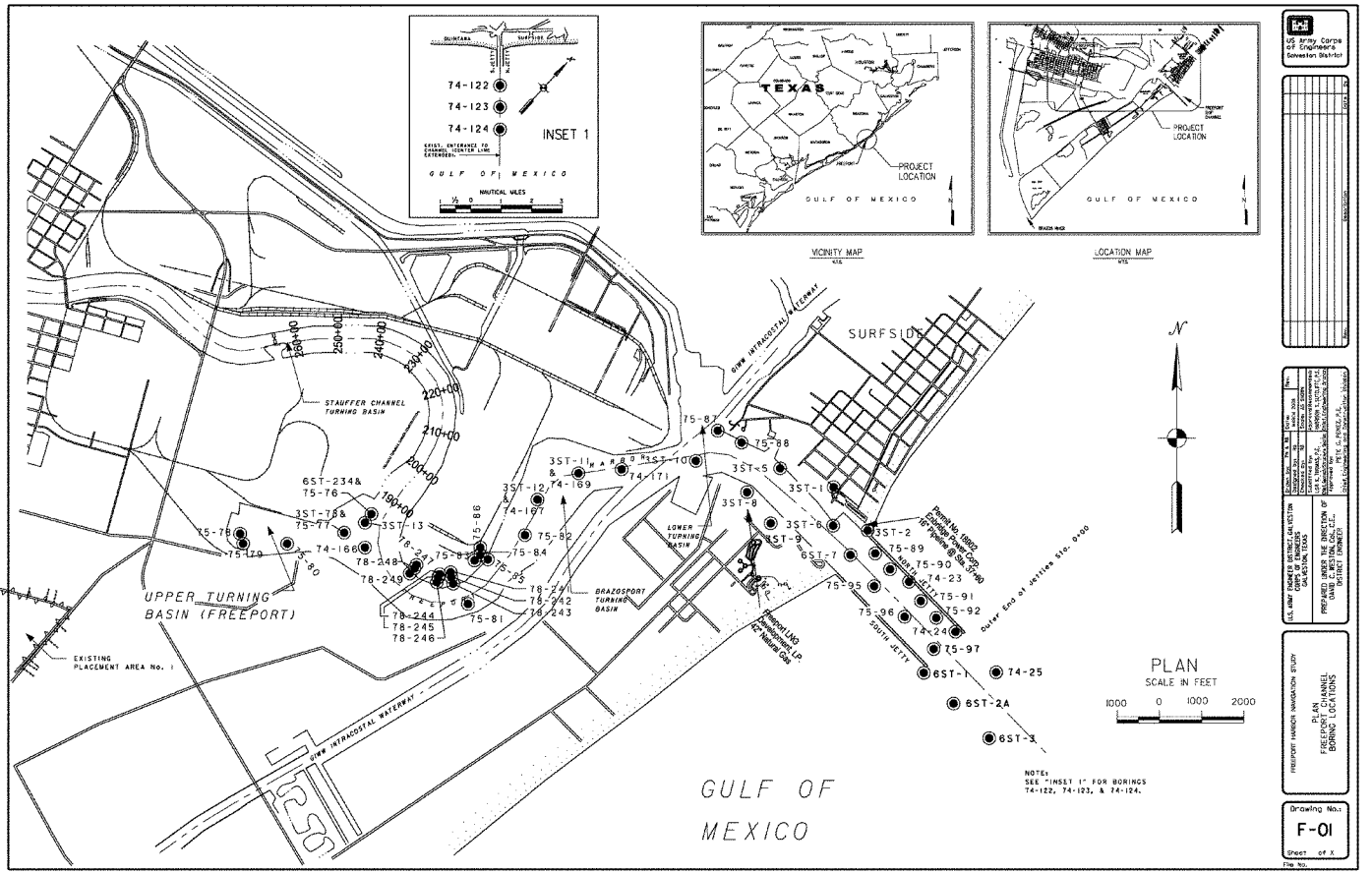
```
            Project Name: NED Map Jul19
             Description:
Horizontal Alignment Name: NED Cntrln Mar18
             Description:
                  Style: Default
                                    STATION      NORTHING       EASTING

Element: Linear
            POB (        )         -433+14.00   13509441.55    3185562.16
             PC (        )           57+41.59   13544557.88    3151308.78
        Tangent Direction:      N 44^17'14" W
           Tangent Length:           49055.59

Element: Circular
             PC (        )           57+41.59   13544557.88    3151308.78
             PI (        )           67+48.57   13545278.73    3150605.65
             CC (        )                      13542882.06    3149590.75
            PCC (        )           76+48.48   13545282.06    3149598.67
                  Radius:            2400.00
                   Delta:           45^31'24" Left
  Degree of Curvature(Arc):          2^23'14"
                  Length:            1906.89
                 Tangent:            1006.98
                   Chord:            1857.12
          Middle Ordinate:             186.91
                External:             202.69
        Tangent Direction:      N 44^17'14" W
         Radial Direction:      N 45^42'46" E
          Chord Direction:      N 67^02'56" W
         Radial Direction:      N  0^11'21" E
        Tangent Direction:      N 89^48'39" W

Non-collinear

Element: Circular
            PCC (        )           76+48.48   13545282.06    3149598.67
             PI (        )           76+91.33   13545277.84    3149556.03
             CC (        )                      13543619.09    3149763.02
             PT (        )           77+34.16   13545271.45    3149513.66
                  Radius:            1671.07
                   Delta:           2^56'16" Left
  Degree of Curvature(Arc):          3^25'43"
                  Length:              85.68
                 Tangent:              42.85
                   Chord:              85.67
          Middle Ordinate:               0.55
                External:               0.55
        Tangent Direction:      S 84^21'22" W
         Radial Direction:      N  5^38'38" W
          Chord Direction:      S 82^53'16" W
         Radial Direction:      N  8^34'54" W
        Tangent Direction:      S 81^25'06" W

Non-collinear

Element: Linear
             PT (        )           77+34.16   13545271.45    3149513.66
             PI (        )           94+88.05   13545009.73    3147779.41
        Tangent Direction:      S 81^25'06" W
           Tangent Length:            1753.89

Element: Linear
             PI (        )           94+88.05   13545009.73    3147779.41
             PI (        )          108+61.99   13544804.72    3146420.85
        Tangent Direction:      S 81^25'07" W
           Tangent Length:            1373.94

Element: Linear
             PI (        )          108+61.99   13544804.72    3146420.85
             PC (        )          108+61.99   13544804.72    3146420.85
        Tangent Direction:      S 39^31'29" E
           Tangent Length:               0.00

Non-collinear

Element: Circular
             PC (        )          108+61.99   13544804.72    3146420.85
             PI (        )          119+72.18   13544639.06    3145323.09
             CC (        )                      13542916.21    3146705.84
             PT (        )          128+73.28   13543603.17    3144923.77
                  Radius:            1909.89
                   Delta:           60^20'15" Left
  Degree of Curvature(Arc):          3^00'00"
                  Length:            2011.28
                 Tangent:            1110.19
                   Chord:            1919.63
          Middle Ordinate:             258.70
                External:             299.23
        Tangent Direction:      S 81^25'07" W
         Radial Direction:      N  8^34'53" W
          Chord Direction:      S 51^14'59" W
         Radial Direction:      N 68^55'09" W
        Tangent Direction:      S 21^04'51" W

Non-collinear

Element: Linear
             PT (        )          128+73.28   13543603.17    3144923.77
             PI (        )          128+73.28   13543603.17    3144923.77
        Tangent Direction:      S 47^31'20" W
           Tangent Length:               0.00

Element: Linear
             PI (        )          128+73.28   13543603.17    3144923.77
             PI (        )          134+54.41   13543060.93    3144714.75
        Tangent Direction:      S 21^04'49" W
           Tangent Length:             581.13

Element: Linear
             PI (        )          134+54.41   13543060.93    3144714.75
             PC (        )          134+54.41   13543060.93    3144714.75
        Tangent Direction:      N 66^04'02" W
           Tangent Length:               0.00

Non-collinear

Element: Circular
             PC (        )          134+54.41   13543060.93    3144714.75
             PI (        )          139+40.47   13542607.40    3144539.93
             CC (        )                      13543996.83    3142286.80
             PT (        )          144+15.45   13542247.56    3144213.17
                  Radius:            2602.09
```

NED and Stauffer ALG Sheet 2 of 3

```
                    Delta:          21^09'41" Right
  Degree of Curvature(Arc):          2^12'07"
                  Length:             961.04
                 Tangent:             486.06
                   Chord:             955.59
          Middle Ordinate:              44.24
                External:              45.01
        Tangent Direction:      S 21^04'48" W
         Radial Direction:      N 68^55'12" W
          Chord Direction:      S 31^39'38" W
         Radial Direction:      N 47^45'31" W
        Tangent Direction:      S 42^14'29" W

Non-collinear

Element: Linear
              PT (        )         144+15.45   13542247.56    3144213.17
              PC (        )         144+15.45   13542247.56    3144213.17
        Tangent Direction:      S 26^21'27" W
           Tangent Length:               0.00

Non-collinear

Element: Circular
              PC (        )         144+15.45   13542247.56    3144213.17
              PI (        )         363+74.49   13525990.70    3129451.27
              CC (        )                     13543223.77    3143138.10
              PT (        )         187+85.76   13546049.91    3141943.84
                  Radius:             1452.16
                   Delta:         172^25'59" Right
  Degree of Curvature(Arc):           3^56'44"
                  Length:             4370.31
                 Tangent:            21959.04
                   Chord:             2897.99
          Middle Ordinate:             1356.34
                External:            20554.84
        Tangent Direction:      S 42^14'27" W
         Radial Direction:      N 47^45'33" W
          Chord Direction:      N 51^32'34" W
         Radial Direction:      S 55^19'34" E
        Tangent Direction:      N 34^40'26" E

Non-collinear

Element: Linear
              PT (        )         187+85.76   13544049.91    3141943.84
              PC (        )         202+40.13   13545193.01    3142843.02
        Tangent Direction:      N 38^11'22" E
           Tangent Length:            1454.37

Non-collinear

Element: Circular
              PC (        )         202+40.13   13545193.01    3142843.02
              PI (        )         205+40.26   13545438.26    3143016.03
              CC (        )                     13545951.30    3141768.05
              PT (        )         208+30.30   13545734.29    3143065.54
                  Radius:             1315.52
                   Delta:          25^42'15" Left
  Degree of Curvature(Arc):           4^21'19"
                  Length:              590.17
                 Tangent:              300.14
                   Chord:              585.24
          Middle Ordinate:               32.96
                External:               33.80
        Tangent Direction:      N 35^11'58" E
         Radial Direction:      S 54^48'02" E
          Chord Direction:      N 22^20'50" E
         Radial Direction:      S 80^30'18" E
        Tangent Direction:      N  9^29'42" E

Non-collinear

Element: Linear
              PT (        )         208+30.30   13545734.29    3143065.54
              PC (        )         211+80.74   13546078.74    3143130.02
        Tangent Direction:      N 10^36'10" E
           Tangent Length:             350.44

Non-collinear

Element: Circular
              PC (        )         211+80.74   13546078.74    3143130.02
              PI (        )         215+96.63   13546491.71    3143179.23
              CC (        )                     13546208.99    3141365.43
             PCC (        )         219+97.82   13546883.63    3143040.06
                  Radius:             1777.07
                   Delta:          26^20'38" Left
  Degree of Curvature(Arc):           3^13'27"
                  Length:              817.08
                 Tangent:              415.89
                   Chord:              809.90
          Middle Ordinate:               46.75
                External:               48.02
        Tangent Direction:      N  6^47'41" E
         Radial Direction:      S 83^12'19" E
          Chord Direction:      N  6^22'39" W
         Radial Direction:      N 70^27'02" E
        Tangent Direction:      N 19^32'58" W

Non-collinear

Element: Circular
             PCC (        )         219+97.82   13546883.63    3143040.06
              PI (        )         230+85.20   13547929.54    3142742.62
              CC (        )                     13546648.25    3141509.10
              PT (        )         239+05.72   13548032.73    3141660.14
                  Radius:             1591.67
                   Delta:          68^40'46" Left
  Degree of Curvature(Arc):           3^35'59"
                  Length:             1907.91
                 Tangent:             1087.38
                   Chord:             1795.72
          Middle Ordinate:              277.42
                External:              335.97
        Tangent Direction:      N 15^52'30" W
         Radial Direction:      N 74^07'30" E
          Chord Direction:      N 50^12'53" W
         Radial Direction:      N  5^26'44" E
        Tangent Direction:      N 84^33'16" W

Non-coincident
```

NED and Stauffer ALG Sheet 3 of 3

```
Element: Linear
              PT (        )          239+05.72   13548032.73    3141660.14
              PI (        )          248+92.96   13548126.42    3140677.36
       Tangent Direction:       N 84^33'16" W
          Tangent Length:              987.24

Element: Linear
              PI (        )          248+92.96   13548126.42    3140677.36
             POE (        )          260+09.51   13547921.90    3139579.70
       Tangent Direction:       S 79^26'44" W
          Tangent Length:             1116.55
```

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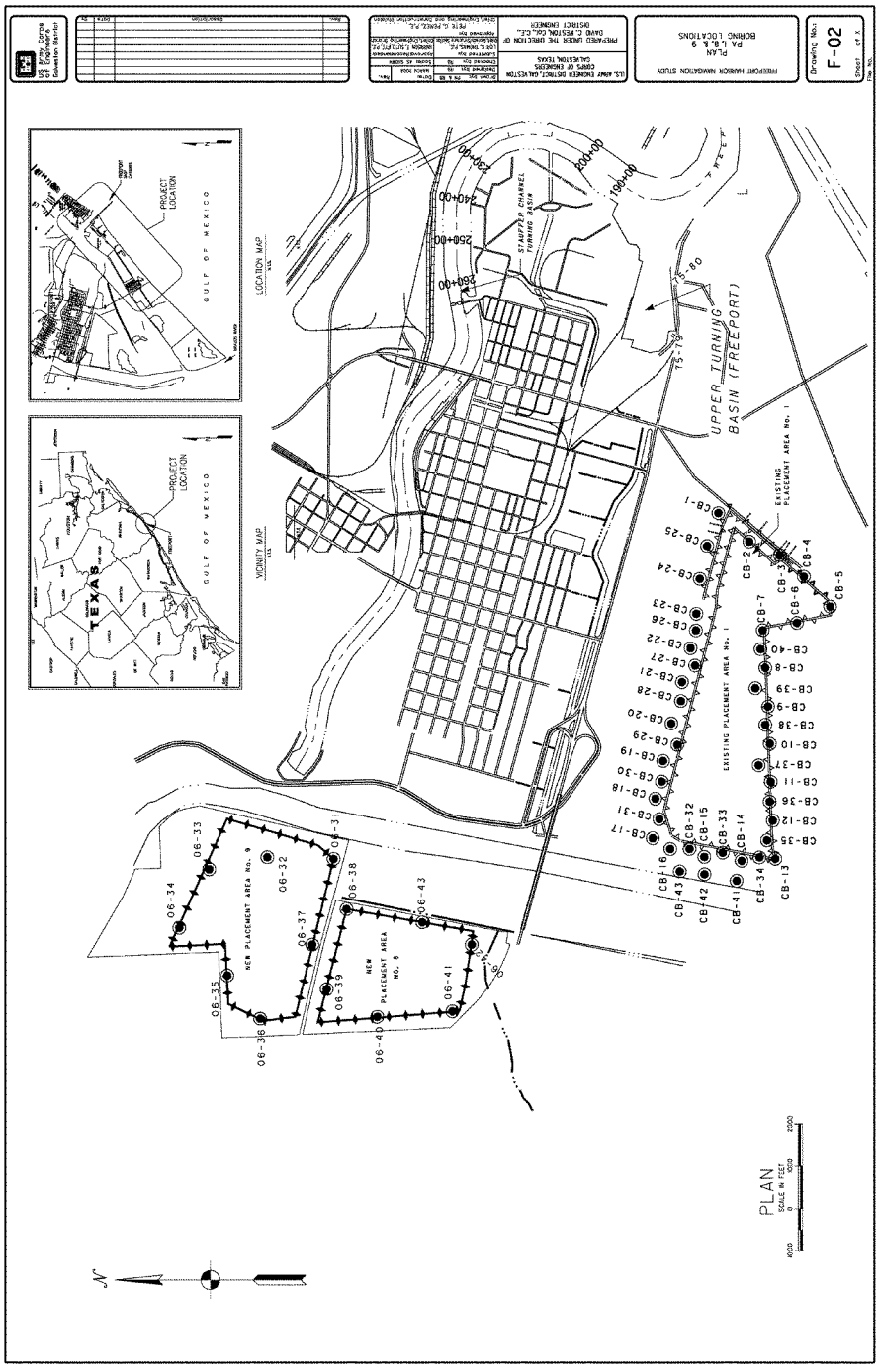


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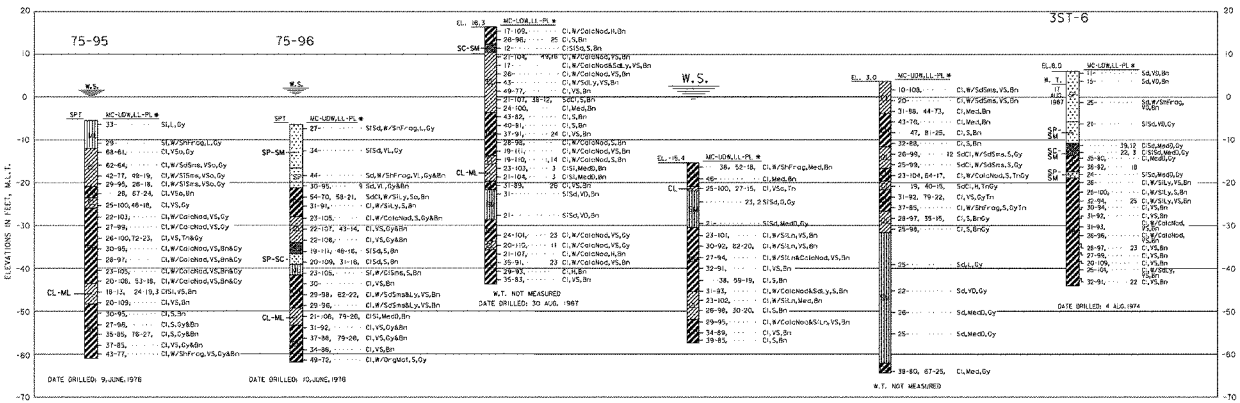


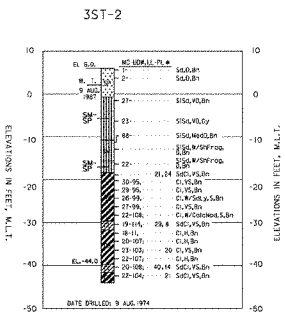


LABORATORY CLASSIFICATIONS:

CH INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
CL INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, LEAN CLAYS.
GC CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES.
GM SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES.
GP POORLY-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
GW WELL-GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
MH INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS.
ML INORGANIC SILTS AND VERY FINE SANDS, WITH SLIGHT PLASTICITY.
OH ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.
OL ORGANIC SILTS, AND ORGANIC SILT-CLAYS OF LOW PLASTICITY.
PT PEAT AND OTHER HIGHLY ORGANIC SOILS.
SC CLAYEY SANDS, SAND-CLAY MIXTURES.
SM SILTY SANDS, SAND-SILT MIXTURES.
SP POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES.
SW WELL-GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES.
CL-ML OR ML-CL CLAY AND SILT MIXTURES WITH SLIGHT PLASTICITY
SP-SM OR SM-SP SLIGHTLY SILTY SANDS, SANDS WITH SOME SILTS
SM-SC OR SC-SM SLIGHTLY SILTY AND CLAYEY SANDS, SANDS WITH SOME SILTS AND CLAYS

VISUAL CLASSIFICATIONS:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Asph Asphalt | Cl Clayley) | Dk Dark | Gyp Gypsum | Lt Light | | | | | |
| Agg Aggerate | Cli Caliche | Dr Dredge | H Hard | Meas Measured | | | | | |
| Ba Ballis) | Coa Coarse | F Firm | Hdbn Hydrocarbon | Mo Matter | | | | | |
| Bin Binder | Conc Concrete | Fer Ferrous | Hi Highly | Mat Material | | | | | |
| Bl Black | Coq Coquina | Fl Fine(s) | Ind Industrial | Med Medium | | | | | |
| Blk Blockey | Ch Chert | Fl Fill | Inor Inorganic | Mu Muck | Part Particle(s) | Rec Recorded | Sh Shell(y) | T.D. Total Depth | Wc Waste |
| Blu Blue | D-Odr Distinct Odor | Fk Flake(s) | Ir Iron | Mar Marsh | Peb Pebble(s) | R Red(dish) | Sl Silty | Th Thin | Wd Wood(en) |
| Bn Brown(ish) | | Frag Fragment(s) | L Loose | Mot Mottled | Pet Petroleum | Rk Rock(s) | Sli Slightly | Tk Thick | Wh White |
| Br Brick | D Dense | Fri Friable | Lg Large | Nod Nodules | Pl Plant | Rts Root(s) | Slks Slicken Sides | Tn Tan(nish) | Wed Weathered |
| Bs Base | Db Debris | Gl Glass | Lim Limonites | N.T. No Test | Poc Pocket(s) | Rub Rubble | Sm Small | Tr Trace(s) | W.T. Water Table |
| Bu Buff | D.C. Driller's Classification | Grs Grass | Ln Lense(s) | Nt Not | Prt Parting(s) | Ref Refinery | Sms Seams | Unde Undetermined | W.S. Water Surface |
| Calc Calcareous | Dec Decayed | Gr Green(ish) | Lp Lump(s) | N.Rec No Recovery | Pt Peat | S Stiff | So Soft | V Very | W With |
| Cem Cement(ed) | Dep Deposit(s) | Gv Gravel(ly) | Ly Layer(s) | Org Organic | Rd Road | Sd Sand(y) | St Stone(s) | Veg Vegetation | Y Yellow(ish) |
| Chem Chemical | | Gy Gray(ish) | Lims Limestone | Ol Olive | RdBd Road Bed | Sl Shale | Sur Surface | Vert Vertical | |

NOTES:

1. SOILS HAVE BEEN CLASSIFIED IN ACCORDANCE WITH ASTM 2487 "CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES (UNIFIED SOILS CLASSIFICATION SYSTEM)". CONSISTENCY OF SOILS SUCH AS SOFT, MEDIUM, HARD, LOOSE, DENSE, ETC., ARE RELATIVE TERMS BASED ON ESTIMATED UNDISTURBED SHEAR STRENGTH OF THE MATERIAL AS DETERMINED BY VISUAL CLASSIFICATION POCKET PENETROMETER TESTS AND PENETRATION RESISTANCE DURING SAMPLING.
2. FIGURES TO THE RIGHT OF BORING LOGS ARE WATER CONTENTS IN PERCENT OF THE DRY WEIGHT, DRY DENSITY, LIQUID LIMIT, PLASTIC LIMIT, AND BAR LINEAR SHRINKAGE. (MC-LOW,LL-PL,LB,L.S.)* FIGURES TO THE LEFT OF BORING LOGS UNDER COLUMN HEADING ENTITLED "SPT" ARE BLOWS PER FOOT OF PENETRATION FROM STANDARD PENETRATION TESTING. FIGURES BELOW COLUMN HEADINGS "P.P." AND "T." ARE POCKET PENETROMETER AND TORVANE TESTS RESPECTIVELY IN UNITS OF TONS PER SQUARE FEET.
3. BORINGS WERE DRILLED USING WET ROTARY DRILLING TECHNIQUES AND UNDISTURBED SAMPLES WERE RECOVERED WITH A 3-INCH DIAMETER THIN WALL SAMPLER WHERE COHESIVE MATERIALS WERE ENCOUNTERED.WHERE COHESIONLESS MATERIALS WERE ENCOUNTERED, DISTURBED SAMPLES WERE TAKEN WITH A SPLIT SPOON SAMPLER DURING PERFORMANCE OF STANDARD PENETRATION TESTING.
4. WATER LEVELS SHOWN ON BORING LOGS WERE DETERMINED AFTER DRILLING BORINGS BY MEASURING THE TOP OF FLUID LEVELS IN THE BORINGS. IN AS MUCH AS WET ROTARY DRILLING TECHNIQUES AND DRILLING MUD WERE USED TO DRILL THE HOLES, THE LEVEL OF DRILLING HOLES MAY NOT HAVE STABILIZED TO THE LEVEL OF THE ACTUAL WATER TABLE. ADDITIONALLY, WATER TABLES IN THE FIELD ARE LIKELY TO FLUCTUATE DEPENDING ON WEATHER CONDITIONS. THEREFORE, SOME VARIATION SHOULD BE ANTICIPATED BETWEEN WATER TABLES INDICATED AND WATER TABLES ENCOUNTERED IN THE FIELD.

US Army Corps of Engineers Galveston District

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

PREPARED UNDER THE DIRECTION OF DAVID J. WESTON, COL., C.E. DISTRICT ENGINEER

FREEPORT HARBOR NAVIGATION STUDY

FREEPORT CHANNEL LOG OF BORINGS

Drawing No.: F-03

Sheet of X

File No.

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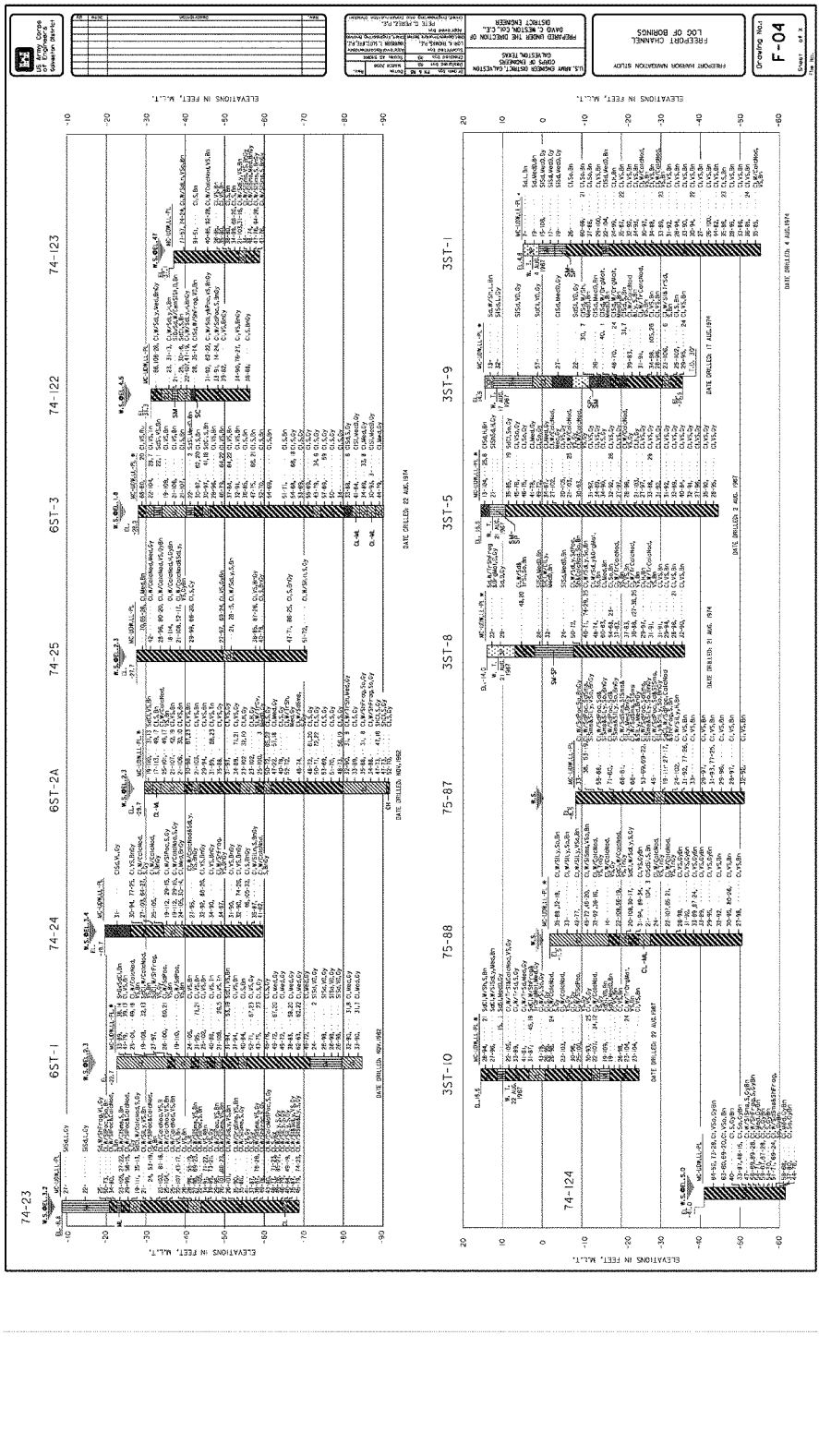
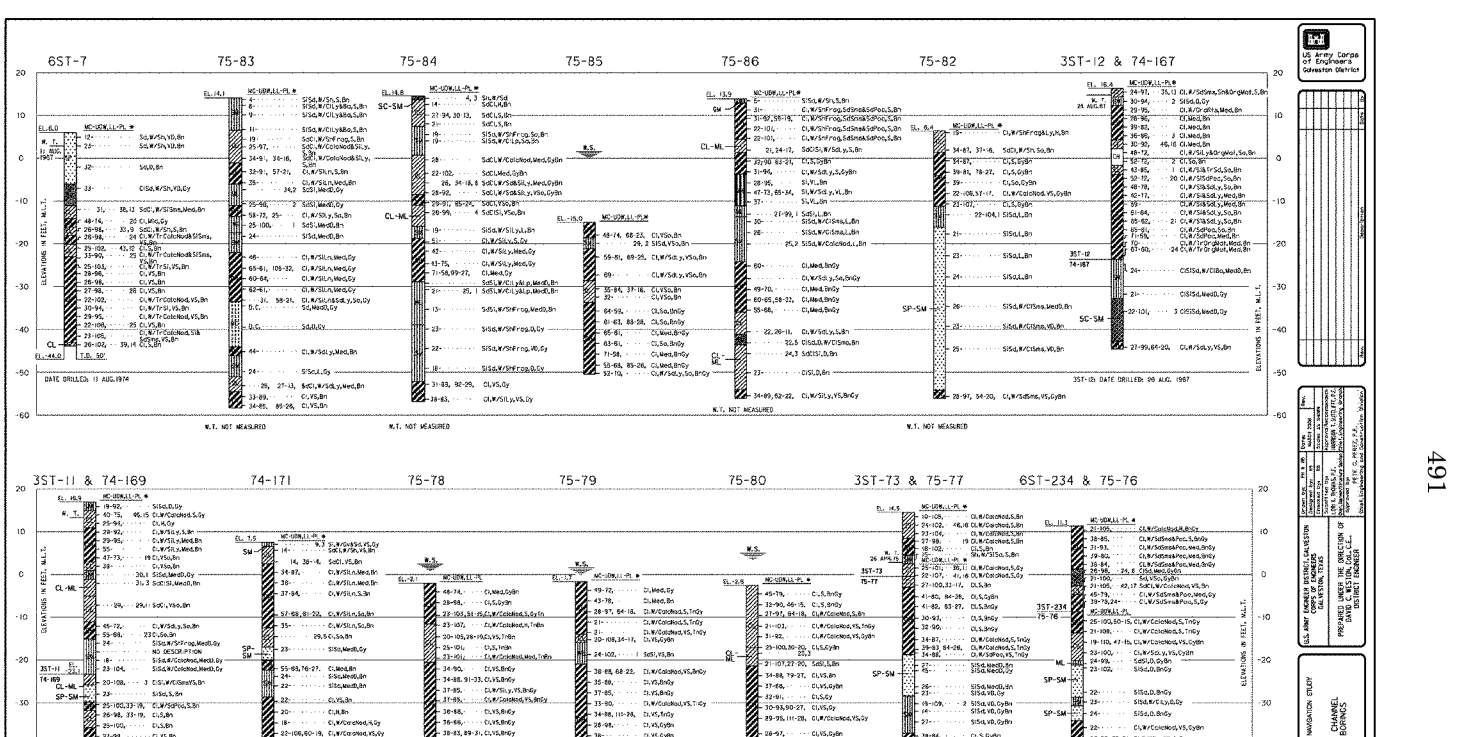



3/1/2019 9:45:00 AM W:\Caddd\Projects\BrazdFrport Nav Study\Latest Freeport\Drawings 24OCT07\EA V8 Frport Plates\F04 Chan Boring Logs.dgn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75-83
75-84
75-85
75-86
75-82
3ST-12 & 74-167
3ST-11 & 74-169
74-171
75-78
75-79
75-80
3ST-73 & 75-77
6ST-234 & 75-76
ELEVATIONS IN FEET, M.L.T.
W.T. NOT MEASURED
DATE DRILLED: 13 AUG. 1974
3ST-12: DATE DRILLED: 28 AUG. 1967
3ST-73: DATE DRILLED: 28 APR. 1975
6ST-234: DATE DRILLED: 24 AUG. 1968
US Army Corps of Engineers Galveston District
PREPARED UNDER THE DIRECTION OF DAVID C. WESTON, COL., CE, DISTRICT ENGINEER
U.S. ARMY ENGINEER DISTRICT, GALVESTON GALVESTON, TEXAS
FREEPORT HARBOR NAVIGATION STUDY
FREEPORT CHANNEL LOG OF BORINGS
Drawing No.: F-05
Sheet of X
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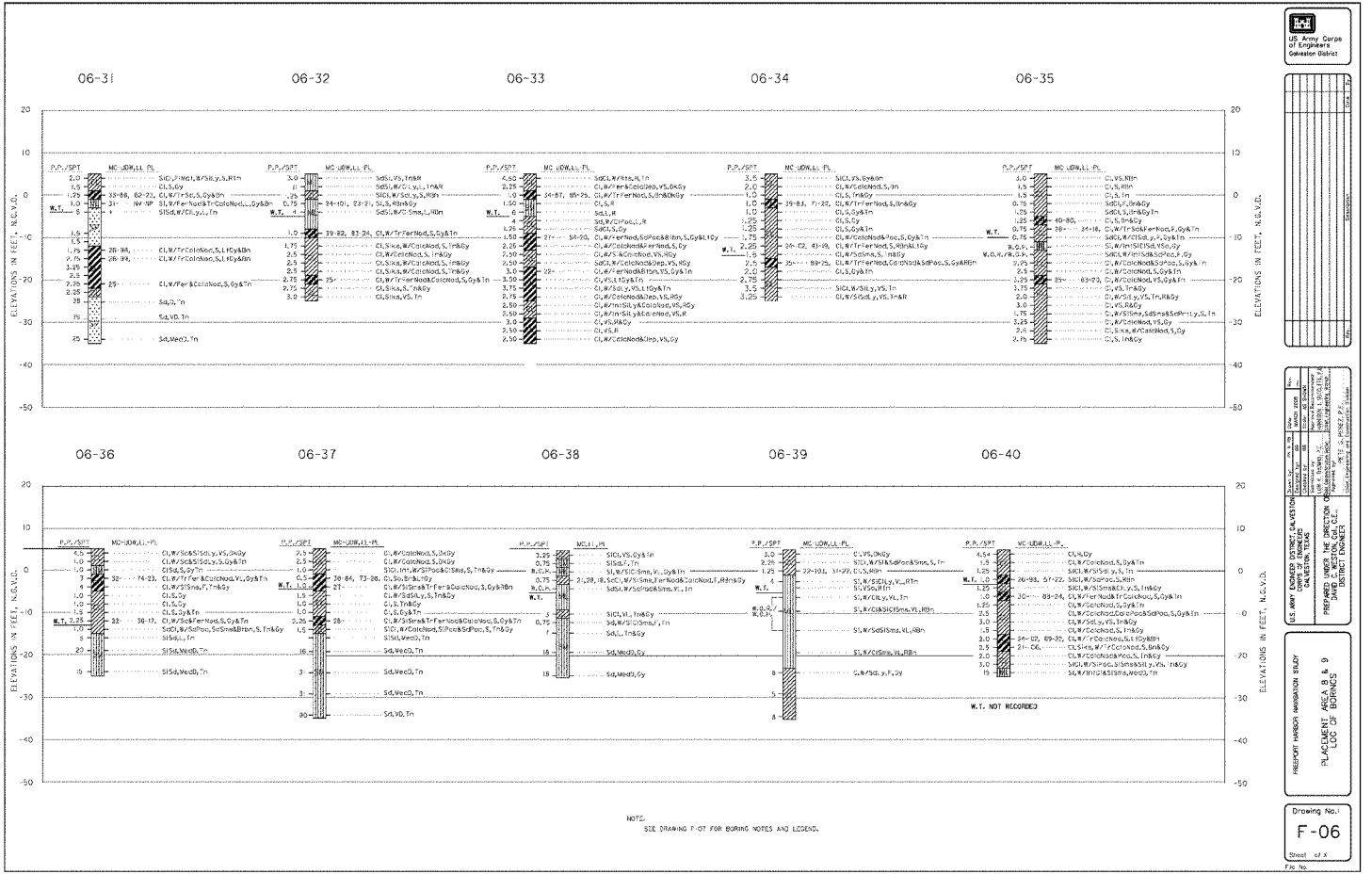
06-31
06-32
06-33
06-34
06-35
06-36
06-37
06-38
06-39
06-40
ELEVATIONS IN FEET, N.G.V.D.
P.P./SPT
MC-UDW,LL-PL
W.T. NOT RECORDED
NOTE:
SEE DRAWING F-07 FOR BORING NOTES AND LEGEND.
US Army Corps of Engineers
Galveston District
U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS
PREPARED UNDER THE DIRECTION OF
DAVID C. WESTON, Col., C.E.,
DISTRICT ENGINEER
FREEPORT HARBOR NAVIGATION STUDY
PLACEMENT AREA 8 & 9
LOG OF BORINGS
Drawing No.:
F-06
Sheet of X
File No.

NOTES;

1. SOILS HAVE BEEN CLASSIFIED IN ACCORDANCE WITH ASTM D-2487-93 "CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES (UNIFIED SOIL CLASSIFICATION SYSTEM) "." CONSISTENCY OF SOILS SUCH AS SOFT, MEDIUM, HARD, LOOSE, DENSE, ETC., ARE RELATIVE TERMS BASED ON ESTIMATED UNDISTURBED SHEAR STRENGTH OF THE MATERIAL AS DETERMINED BY VISUAL CLASSIFICATION POCKET PENETROMETER TESTS AND PENETRATION RESISTANCE DURING SAMPLING.
2. FIGURES TO THE RIGHT OF BORING LOGS ARE WATER CONTENTS IN IN PERCENT OF THE DRY WEIGHT, DRY DENSITY, LIQUID LIMIT, PLASTIC LIMIT AND BAR LINER SHRINKAGE. (MC-UDW,LL-PL) (B.L.S.*). FIGURES TO THE LEFT OF BORING LOGS ARE BLOWS PER FOOT PENETRATION FROM STANDARD PENETRATION TESTING.
3. BORINGS WERE DRILLED USING WET ROTARY DRILLING TECHNIQUES AND UNDISTURBED SAMPLES WHERE RECOVERED WITH A 3-INCH DIAMETER THIN WALL SAMPLER WHERE COHESIVE MATERIALS WERE ENCOUNTERED. WHERE COHESIONLESS MATERIALS WERE ENCOUNTERED, DISTURBED SAMPLES WERE TAKEN WITH A SPLIT SPOON SAMPLER DURING PERFORMANCE OF STANDARD PENETRATION TESTING.
4. WATER TABLE LEVELS SHOWN ON BORING LOGS WERE DETERMINED AFTER DRILLING BORINGS BY MEASURING THE TOP OF FLUID LEVELS IN THE BORINGS.INASMUCH AS WET ROTARY DRILLING TECHNIQUES AND DRILLING MUD WERE USED TO DRILL THE HOLES, THE LEVEL OF DRILLING FLUIDS IN THE BORE HOLES MAY NOT HAVE STABLILIZED TO THE LEVEL OF THE ACTUAL WATER TABLE. ADDITIONALLY, WATER TABLES IN THE FIELD ARE LIKELY TO FLUCTUATE DEPENDING ON WEATHER CONDITIONS. THEREFORE, SOME VARIATION SHOULD BE ANTICIPATED BETWEEN WATER TABLES INDICATED AND WATER TABLES ENCOUNTERED IN THE FIELD.

VISUAL CLASSIFICATIONS:

| | | |
|---|---|---|
| Bibn Bioturban | Int Interbedded | S Stiff |
| Bn Brown(ish) | L Loose | Sd Sand(y) |
| Calc Calcareous | Ly Layer(s) | Sl Silty |
| Cl Clay(ey) | Lt Light | Slks Slicken Sides |
| D Dense | Mat Material | Sms Seams |
| Dep Deposit(s) | Med Medium | So Soft |
| Dk Dark | N.P. | Tn Tan(nish) |
| F Firm | N.V. | Tr Trace(s) |
| Fer Ferrous | Nod Nodules | V Very |
| Fl Fill | Poc Pocket(s) | W With |
| Gy Gray(ish) | R Red(dish) | W.O.H. Weight Of Hammer |
| H Hard | Rts Root(s) | W.O.R. Weight Of Rod |
| | | W.T. Water Table |

LABORATORY CLASSIFICATION

CH INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.

CL INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, LEAN CLAYS.

ML INORGANIC SILTS AND VERY FINE SANDS, WITH SLIGHT PLASTICITY.

SM SILTY SANDS, SAND-SILT MIXTURES.

SP POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES.
SP-SM SLIGHTLY SILTY SANDS, SANDS WITH SOME SILTS.

US Army Corps of Engineers Galveston District

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

PREPARED UNDER THE DIRECTION OF DAVID C. WESTON, Col., C.E., DISTRICT ENGINEER

FREEPORT HARBOR NAVIGATION STUDY

PLACEMENT AREA 8 & 9 LOG OF BORINGS

Drawing No.: F-07

Sheet of X

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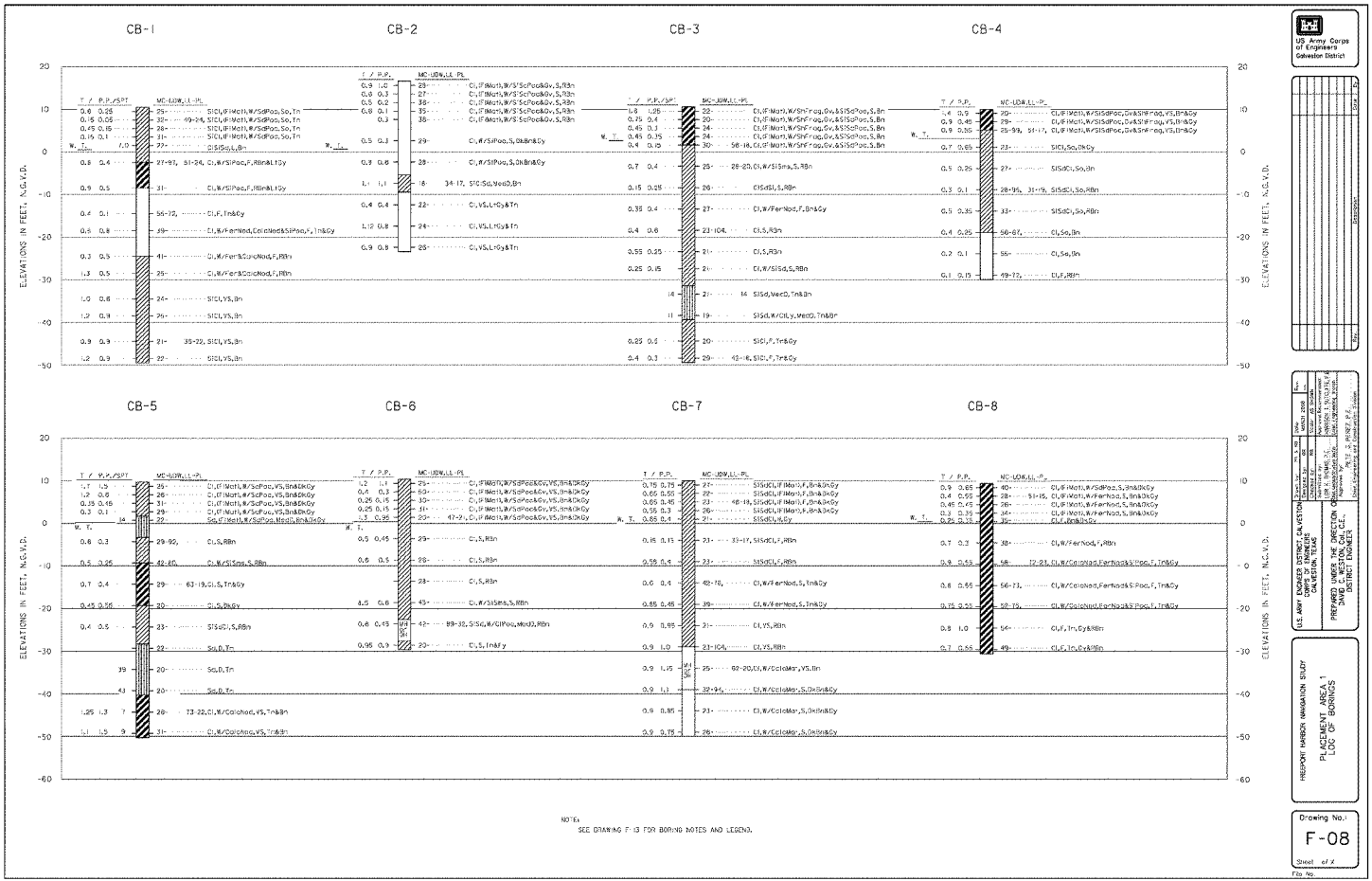
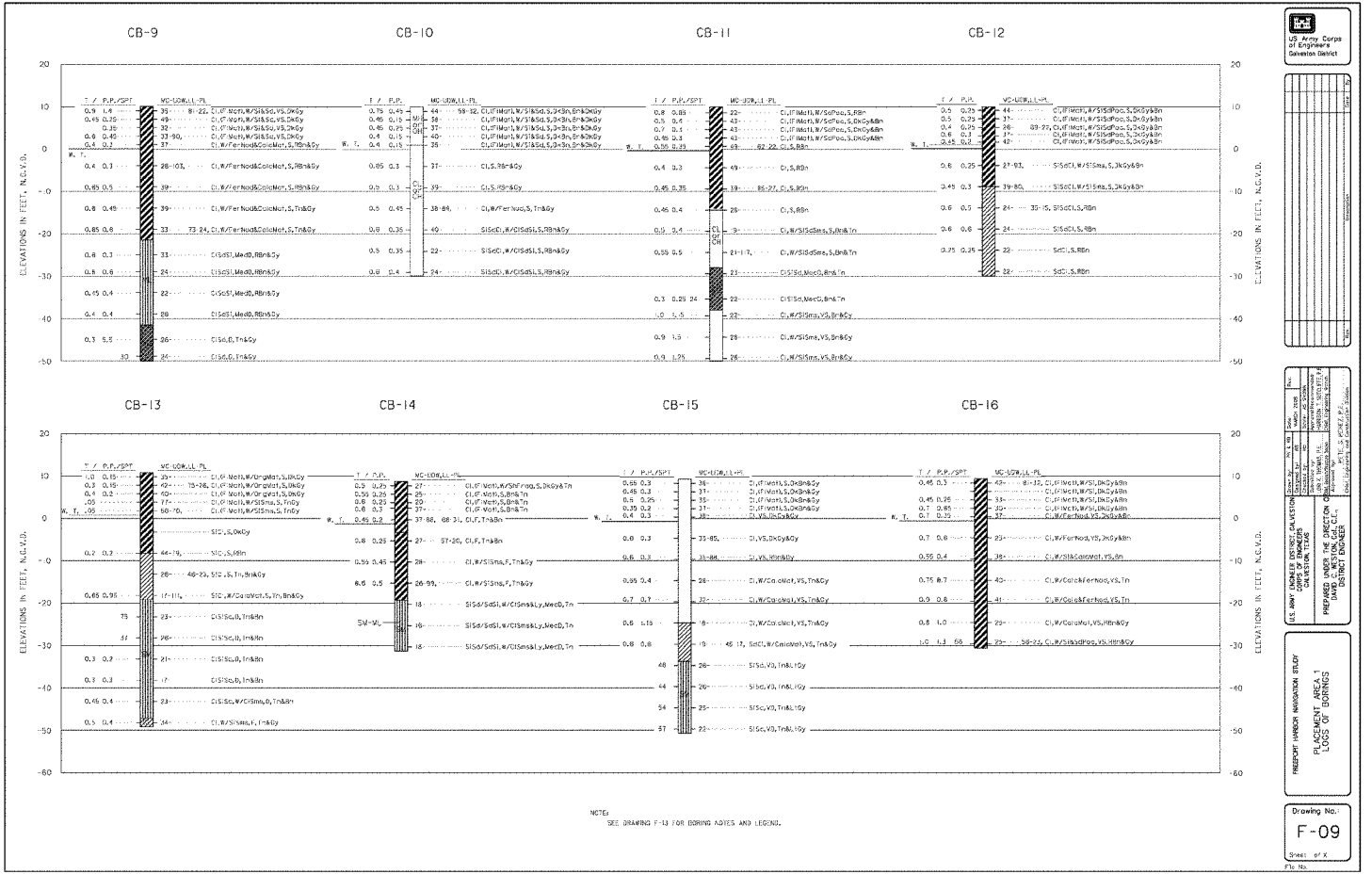
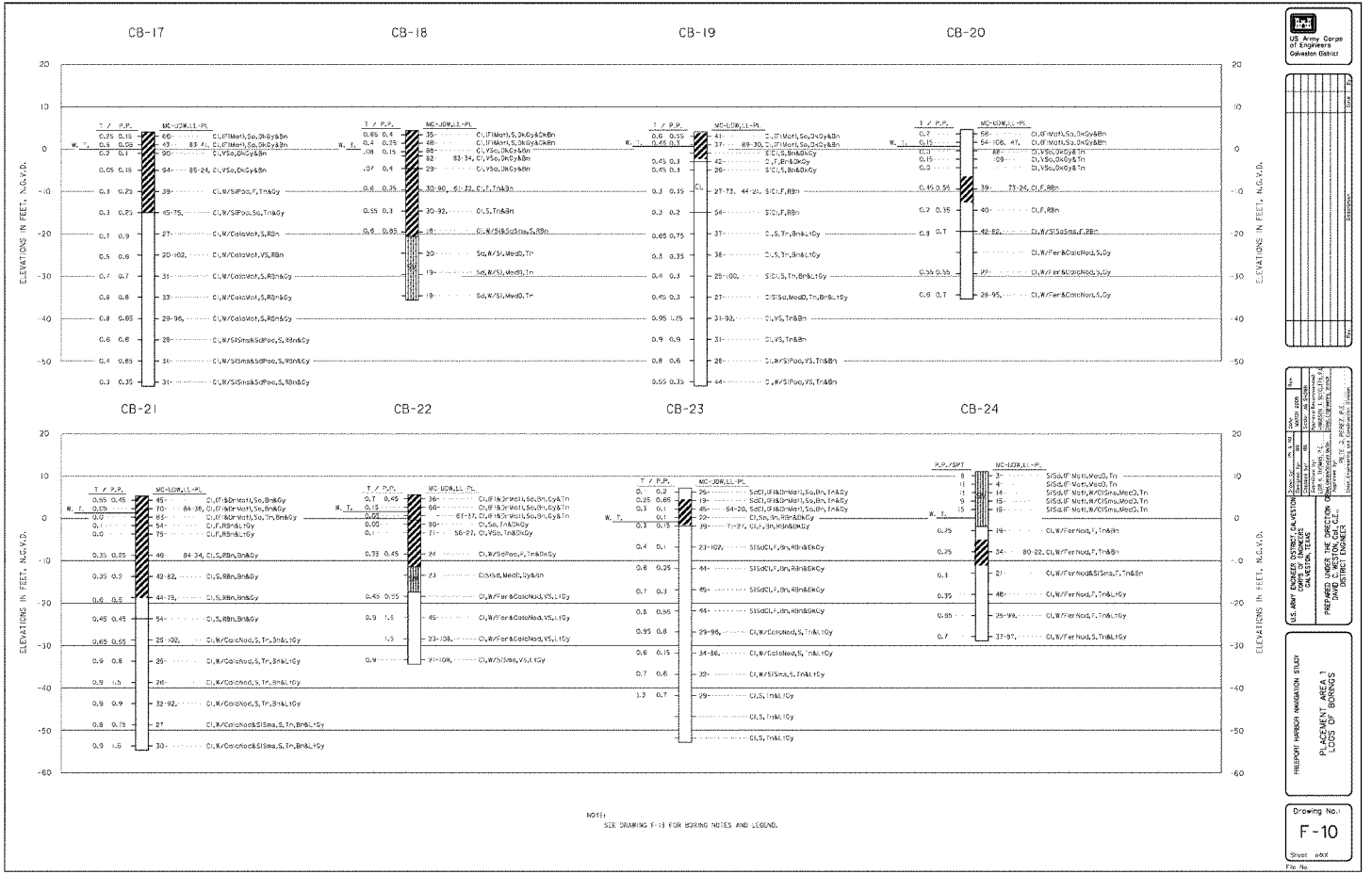

CB-1
CB-2
CB-3
CB-4
CB-5
CB-6
CB-7
CB-8
ELEVATIONS IN FEET, N.G.V.D.
US Army Corps of Engineers
Galveston District
U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS
PREPARED UNDER THE DIRECTION OF
DAVID C. WESTON, CIVIL C.E.
DISTRICT ENGINEER
PLACEMENT AREA 1
LOG OF BORINGS
Drawing No.:
F-08
Sheet of X
File No.
NOTE:
SEE DRAWING F-13 FOR BORING NOTES AND LEGEND.


CB-9
CB-10
CB-11
CB-12
CB-13
CB-14
CB-15
CB-16
ELEVATIONS IN FEET, N.G.V.D.
NOTES
SEE DRAWING F-13 FOR BORING NOTES AND LEGEND.
US Army Corps of Engineers Galveston District
FREEPORT HARBOR NAVIGATION STUDY
PLACEMENT AREA 1
LOGS OF BORINGS
PREPARED UNDER THE DIRECTION OF
DAVID C. WESTON, COL, C.E.,
DISTRICT ENGINEER
U.S. ARMY ENGINEER DISTRICT, GALVESTON
GALVESTON, TEXAS
Drawing No.
F-09
Sheet of X
File No.


CB-17
CB-18
CB-19
CB-20
CB-21
CB-22
CB-23
CB-24
ELEVATIONS IN FEET, N.G.V.D.
NOTE:
SEE DRAWING F-13 FOR BORING NOTES AND LEGEND.
US Army Corps of Engineers
Galveston District
FREEPORT HARBOR NAVIGATION STUDY
PLACEMENT AREA 1
LOGS OF BORINGS
PREPARED UNDER THE DIRECTION OF
DAVID C. WESTON, CW, C.E.
DISTRICT ENGINEER
U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS
Drawing No.
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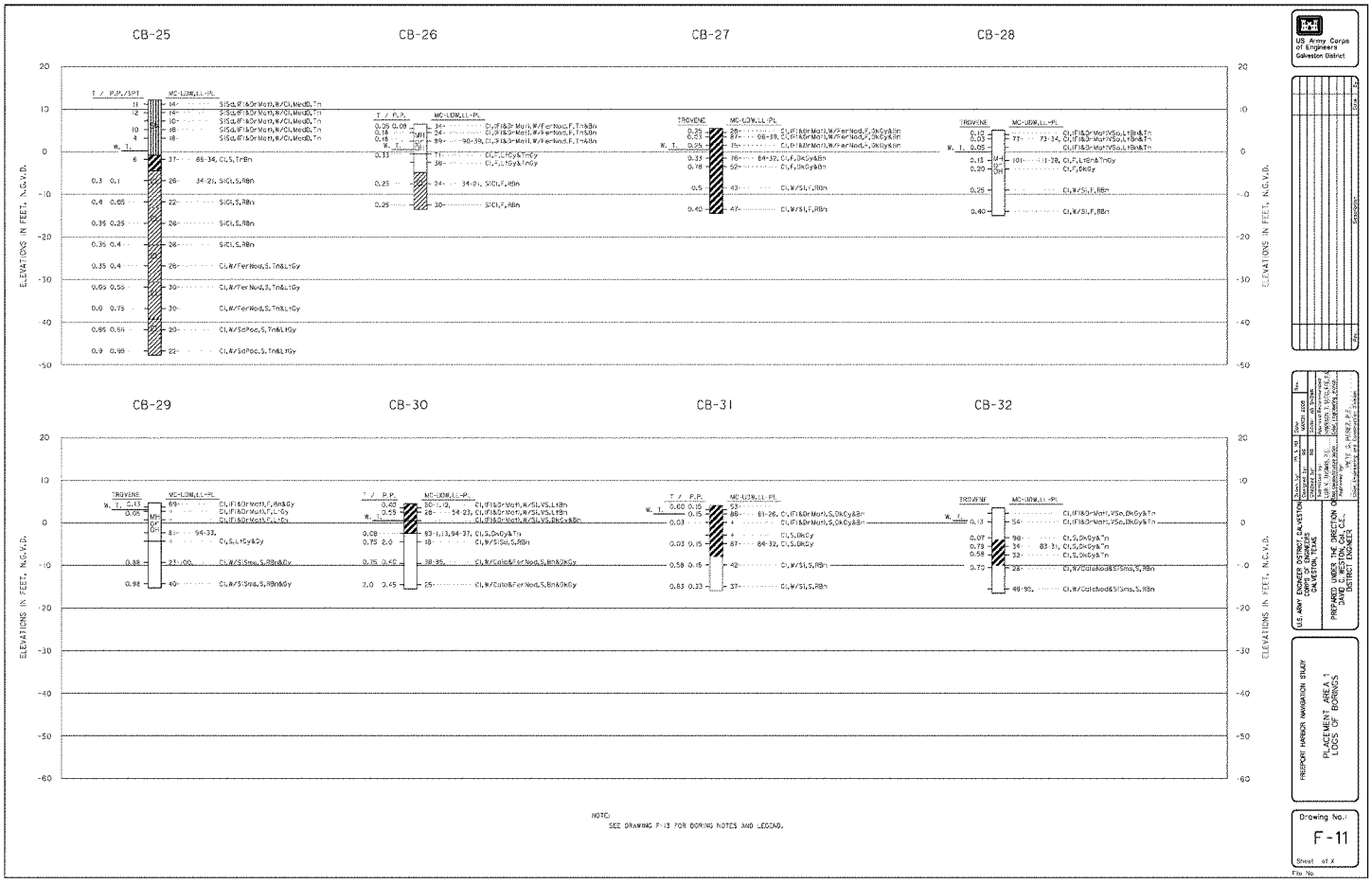
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CB-28
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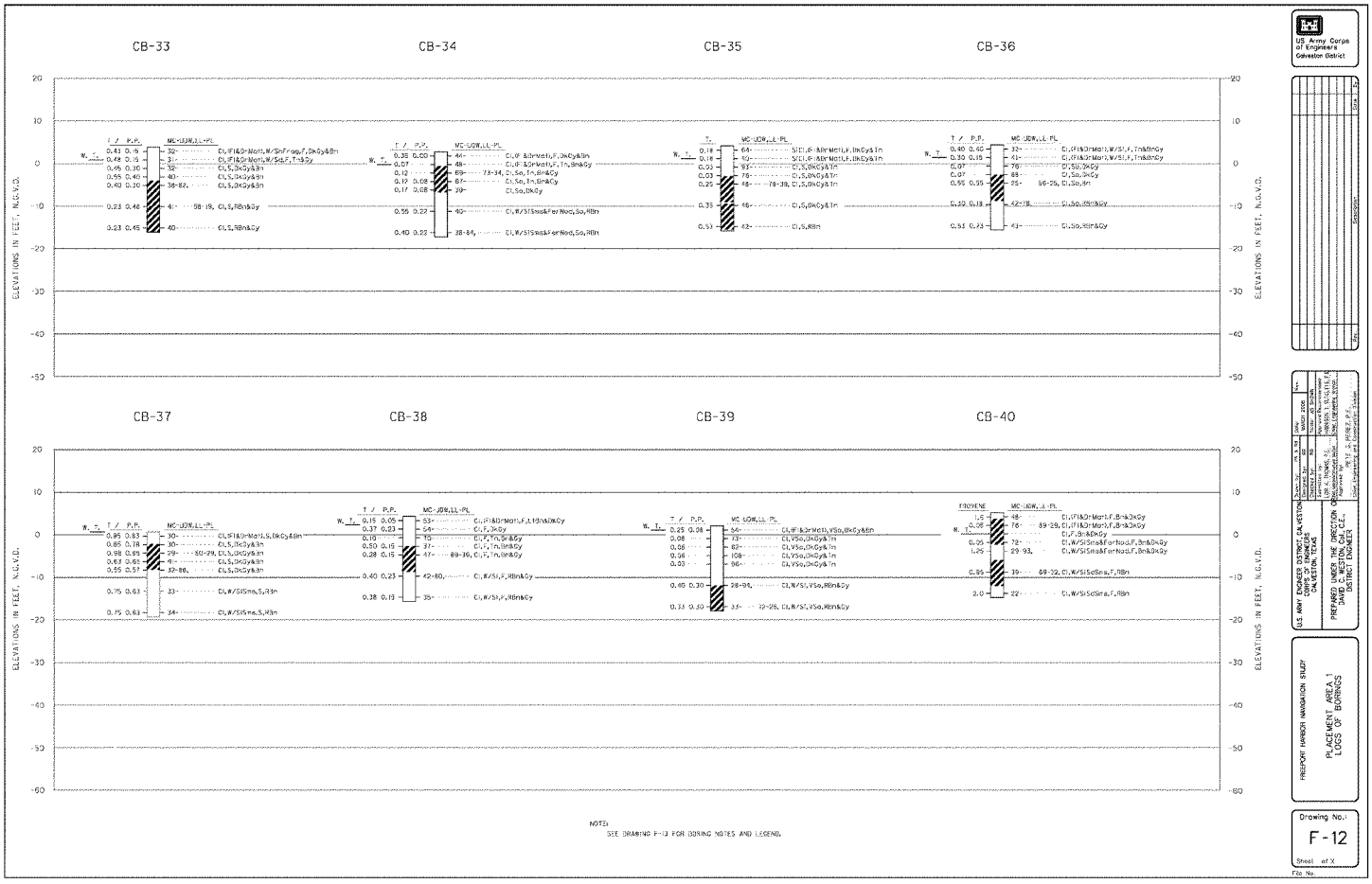
CB-30
CB-31
CB-32
ELEVATIONS IN FEET, N.G.V.D.
US Army Corps of Engineers Galveston District
US ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS
PREPARED UNDER THE DIRECTION OF
DAVID C. WESTON, Col. C.E.
DISTRICT ENGINEER
PREPARED BY
PETE G. PIERZ, P.E.
Chief, Engineering and Construction Division
FREEPORT HARBOR NAVIGATION STUDY
PLACEMENT AREA 1
LOGS OF BORINGS
Drawing No.:
F-11
Sheet of X
File No.
NOTE:
SEE DRAWING F-13 FOR BORING NOTES AND LEGEND.


CB-33
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CB-36
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CB-38
CB-39
CB-40
ELEVATIONS IN FEET, N.G.V.D.
NOTE:
SEE DRAWING F-13 FOR BORING NOTES AND LEGEND.
US Army Corps of Engineers
Galveston District
US. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS
GALVESTON, TEXAS
PREPARED UNDER THE DIRECTION OF
DAVID C. WESTON, Col., C.E.,
DISTRICT ENGINEER
FREEPORT HARBOR NAVIGATION STUDY
PLACEMENT AREA 1
LOGS OF BORINGS
Drawing No.:
F-12
Sheet of X
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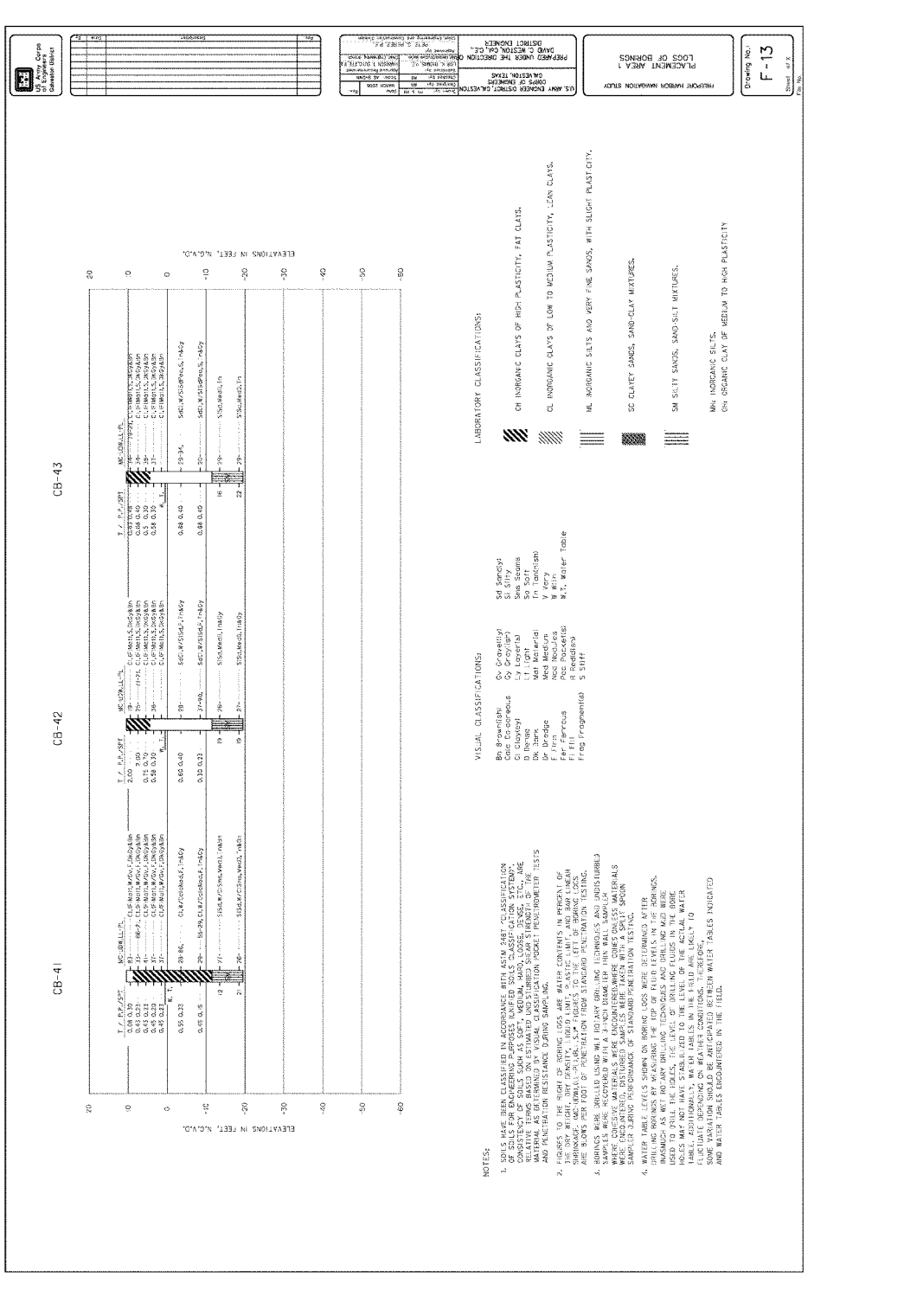
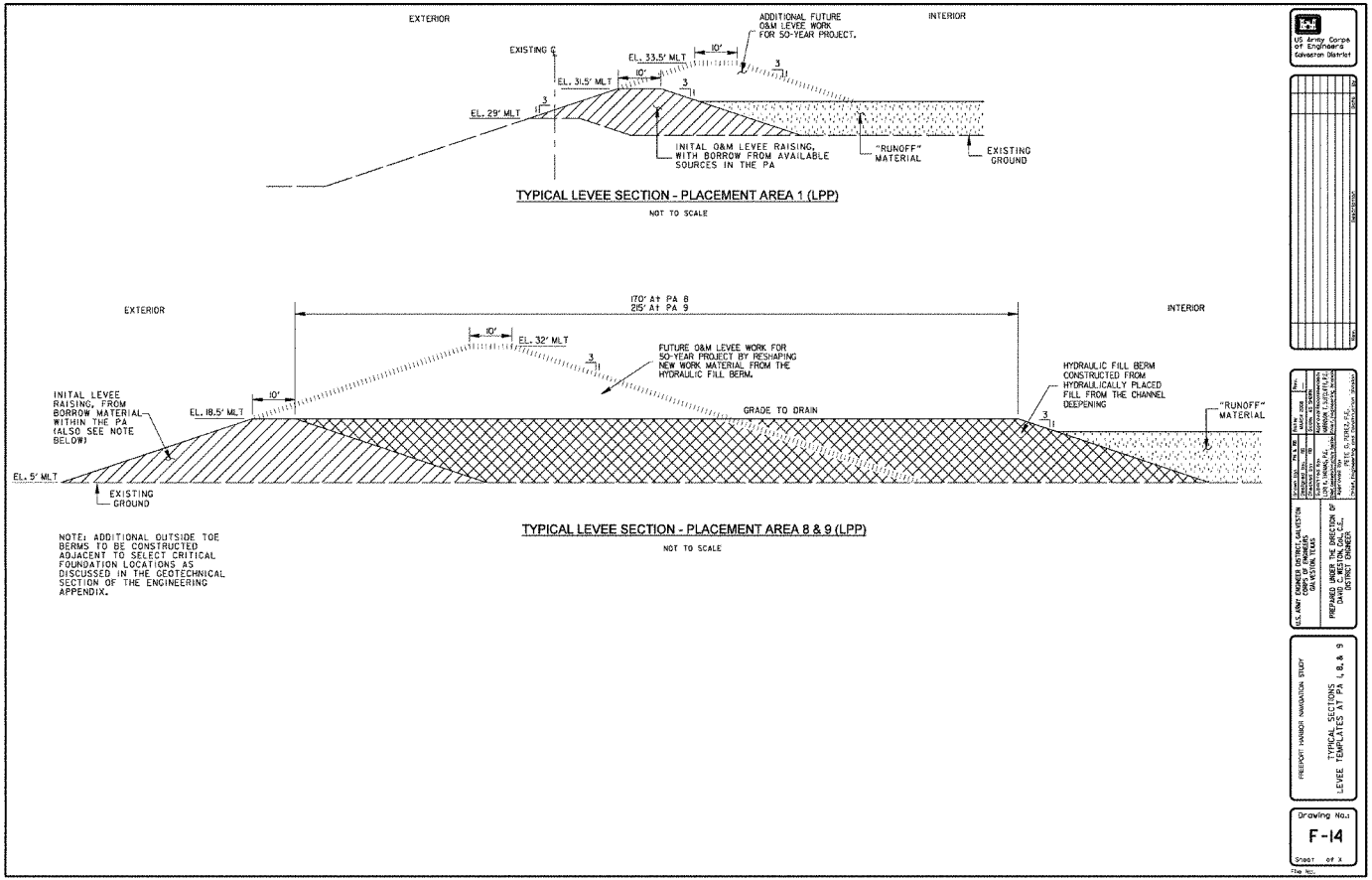

CB-41
CB-42
CB-43
ELEVATIONS IN FEET, N.G.V.D.
NOTES:
VISUAL CLASSIFICATIONS:
LABORATORY CLASSIFICATIONS:
CH INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
CL INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, LEAN CLAYS.
ML INORGANIC SILTS AND VERY FINE SANDS, WITH SLIGHT PLASTICITY,
SC CLAYEY SANDS, SAND-CLAY MIXTURES.
SM SILTY SANDS, SAND-SILT MIXTURES.
MH INORGANIC SILTS.
OH ORGANIC CLAY OF MEDIUM TO HIGH PLASTICITY
PLACEMENT AREA 1
LOOS OF BORINGS
F - 13


EXTERIOR
INTERIOR
ADDITIONAL FUTURE O&M LEVEE WORK FOR 50-YEAR PROJECT.
EXISTING ℄
EL. 33.5' MLT
EL. 31.5' MLT
EL. 29' MLT
10'
3
1
INITAL O&M LEVEE RAISING, WITH BORROW FROM AVAILABLE SOURCES IN THE PA
"RUNOFF" MATERIAL
EXISTING GROUND
TYPICAL LEVEE SECTION - PLACEMENT AREA 1 (LPP)
NOT TO SCALE
EXTERIOR
170' at PA 8
215' at PA 9
INTERIOR
10'
EL. 32' MLT
FUTURE O&M LEVEE WORK FOR 50-YEAR PROJECT BY RESHAPING NEW WORK MATERIAL FROM THE HYDRAULIC FILL BERM.
HYDRAULIC FILL BERM CONSTRUCTED FROM HYDRAULICALLY PLACED FILL FROM THE CHANNEL DEEPENING
INITAL LEVEE RAISING, FROM BORROW MATERIAL WITHIN THE PA (ALSO SEE NOTE BELOW)
EL. 18.5' MLT
GRADE TO DRAIN
"RUNOFF" MATERIAL
EL. 5' MLT
EXISTING GROUND
NOTE: ADDITIONAL OUTSIDE TOE BERMS TO BE CONSTRUCTED ADJACENT TO SELECT CRITICAL FOUNDATION LOCATIONS AS DISCUSSED IN THE GEOTECHNICAL SECTION OF THE ENGINEERING APPENDIX.
TYPICAL LEVEE SECTION - PLACEMENT AREA 8 & 9 (LPP)
NOT TO SCALE
US Army Corps of Engineers
Galveston District
FREEPORT HARBOR NAVIGATION STUDY
TYPICAL SECTIONS
LEVEE TEMPLATES AT PA 1, 8, & 9
Drawing No.:
F-14
Sheet of X

Project No. 03.14.859.44 Client: United States Army Corps of Engineers

Project: Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

| Boring No. | Sample No. | Depth (feet) | Soil Description | USCS | Water Content (%) | Dry Density (pcf) | Liquid Limit | Plastic Limit | Plast. Index | Finer than #200 Sieve (%) | Uc/UU. Compr. (tsf) | Cell Press. (psi) | Failure Strain (%) | Failure Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06-31 | | | | | | | | | | | | | | |
| | 3 | 4-6 | Gray and brown FAT CLAY; traces of sand | CH | 33.1 | 88.5 | 62 | 23 | 39 | 94.8 | 0.92 | | 10.0 | Multiple shear |
| | 4 | 6-8 | Gray and brown SILT; few ferrous nodules, traces of calcareous nodules | ML | 30.8 | | NV | NP | NP | 97.4 | | | | |
| | 8 | 17-19 | Light gray and brown FAT CLAY; traces of calcareous | CH | 26.0 | 96.4 | | | | | | | | 45 degree |
| | 9 | 19-21 | Light gray and brown FAT CLAY; traces of calcareous | CH | 26.0 | 99.4 | | | | | 0.90 | | 4.4 | Multiple shear |
| | 12 | 25-27 | Gray and tan FAT CLAY; few ferrous and calcareous nodules | CH | 25.1 | | | | | | | | | |
| 06-32 | | | | | | | | | | | | | | |
| | 4 | 6-8 | Reddish-brown and gray SILT | ML | 24.2 | 101.0 | 23 | 21 | 2 | 93.2 | | | | |
| | 6 | 13-15 | Gray and tan FAT CLAY; traces of ferrous | CH | 38.9 | 82.4 | 83 | 24 | 59 | 91.9 | 0.93 | | 14.5 | Bulge |
| | 11 | 24-26 | Gray and tan FAT CLAY; traces of ferrous nodules and few calcareous nodules | CH | 25.5 | | | | | | | | | |
| 06-33 | | | | | | | | | | | | | | |
| | 3 | 4-6 | Brown and dark gray FAT CLAY, traces of ferrous | CH | 34.3 | 86.3 | 85 | 25 | 60 | 94.8 | | | | |
| | 8 | 14-16 | Gray and light gray FAT CLAY; few ferrous nodules, sand pockets and bioturbation | CH | 27.1 | | 54 | 20 | 34 | 86.4 | | | | |
| | 13 | 24-26 | Gray and tan FAT CLAY; traces of ferrous nodules and bioturbation | CH | 21.9 | | | | | | | | | |
| 06-34 | | | | | | | | | | | | | | |
| | 4 | 6-8 | Brown and gray FAT CLAY; traces of ferrous | CH | 39.1 | 83.2 | 71 | 22 | 49 | 98.2 | 0.83 | | 9.0 | Multiple shear |
| | 9 | 16-18 | Reddish-brown and light gray LEAN CLAY; traces of ferrous | CL | 24.1 | 102.3 | 43 | 19 | 24 | 94.5 | 1.21 | | 4.2 | Verticle Shear |
| | 11 | 20-22 | Gray and reddish-brown FAT CLAY; traces of ferrous and calcareous nodules, sand pockets | CH | 34.9 | | 89 | 25 | 64 | 96.3 | | | | |
| 06-35 | | | | | | | | | | | | | | |
| | 6 | 10-12 | Brown and gray FAT CLAY | CH | 40.4 | 80.0 | | | | | 0.76 | | 5.5 | Slickensided |
| | 7 | 12-14 | Gray and tan LEAN CLAY; traces of sand and ferrous nodules | CL | 26.6 | | 34 | 18 | 16 | 90.5 | | | | |
| | 13 | 24-26 | Gray and tan FAT CLAY; few calcareous nodules | CH | 24.7 | | 63 | 20 | 43 | 90.6 | | | | |
| 06-36 | | | | | | | | | | | | | | |
| | 7 | 12-14 | Gray and tan FAT CLAY; traces of ferrous and calcareous nodules | CH | 32.2 | | 74 | 23 | 51 | 92.2 | | | | |
| | 9 | 16-18 | Gray and tan LEAN CLAY with SAND; few ferrous nodules | CL | 22.2 | | 36 | 17 | 19 | 71.7 | | | | |
| 06-37 | | | | | | | | | | | | | | |
| | 4 | 6-8 | Brown and light gray FAT CLAY | CH | 36.6 | 84.4 | 73 | 26 | 47 | 96.0 | 0.75 | | 8.0 | Bulge |
| | 5 | 8-10 | Gray and reddish brown FAT CLAY; silt seams, traces of ferrous and calcareous nodules | CH | 26.7 | | | | | | | | | |
| | 9 | 16-18 | Gray and tan FAT CLAY; traces of ferrous nodules and calcareous nodules | CH | 27.6 | | | | | | | | | |
| 06-38 | | | | | | | | | | | | | | |
| | 4 | 6-8 | Reddish-brown and gray SANDY LEAN CLAY; silt seams, few ferrous nodules and calcareous nodules | CL | 20.8 | | 28 | 18 | 10 | 69.0 | | | | |
| 06-39 | | | | | | | | | | | | | | |

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Project No. 03.14.859.44 Client: United States Army Corps of Engineers

Project: Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

| Boring No. | Sample No. | Depth (feet) | Soil Description | USCS | Water Content (%) | Dry Density (pcf) | Liquid Limit | Plastic Limit | Plast. Index | Finer than #200 Sieve (%) | Uc/UU. Compr. (tsf) | Cell Press. (psi) | Failure Strain (%) | Failure Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4-6 | Reddish-brown LEAN CLAY | CL | 21.9 | 103.3 | 31 | 22 | 9 | 91.7 | | | | |
| 06-40 | | | | | | | | | | | | | | |
| | 4 | 6-8 | Reddish-brown FAT CLAY; sand pockets | CH | 26.4 | 97.8 | 57 | 22 | 35 | 94.6 | 0.51 | | 14.5 | Bulge |
| | 6 | 10-12 | Gray and tan FAT CLAY; few ferrous nodules, traces of calcareous nodules | CH | 30.1 | | 68 | 24 | 44 | 88.5 | | | | |
| | 11 | 20-22 | Light gray and brown FAT CLAY; traces of calcareous | CH | 23.5 | 102.0 | 69 | 22 | 47 | 88.8 | | | | 45 degree |
| | 12 | 22-24 | Brown and gray FAT CLAY; traces of calcareous | CH | 22.1 | 105.5 | | | | | 2.00 | | 7.0 | Multiple shear |
| 06-41 | | | | | | | | | | | | | | |
| | 3 | 4-6 | Reddish-brown and gray LEAN CLAY; sandy silt seams, traces of ferrous nodules | CL | 24.6 | | | | | | | | | |
| | 4 | 6-8 | Gray and brown LEAN CLAY | CL | 27.0 | 98.8 | 33 | 21 | 12 | 89.1 | | | | |
| | 6 | 10-12 | Gray and tan FAT CLAY; sand pockets, traces of ferrous nodules | CH | 32.2 | | 72 | 24 | 48 | 85.8 | | | | |
| | 8 | 14-16 | Gray and tan FAT CLAY; sand seams and traces of ferrous nodules | CH | 34.3 | | | | | | | | | |
| 06-42 | | | | | | | | | | | | | | |
| | 4 | 6-8 | Brown FAT CLAY | CH | 30.1 | 90.0 | | | | | | | | |
| | 5 | 8-10 | Reddish-brown and gray LEAN CLAY; silt seams, traces of ferrous nodules | CL | 26.1 | | 42 | 19 | 23 | 90.1 | | | | |
| | 7 | 12-14 | Gray and tan FAT CLAY; traces of calcareous | CH | 39.4 | 81.0 | 79 | 24 | 55 | 93.2 | 0.55 | | 4.8 | Slickensided |
| | 9 | 16-18 | Reddish-brown and gray FAT CLAY; traces of ferrous nodules, calcareous nodules and sand | CH | 29.6 | | | | | | | | | |
| | 11 | 20-22 | Gray and tan FAT CLAY; few ferrous and calcareous nodules | CH | 24.3 | | | | | | | | | |
| 06-43 | | | | | | | | | | | | | | |
| | 6 | 10-12 | Gray and brown FAT CLAY; sand seams | CH | 27.9 | 94.5 | 62 | 22 | 40 | 75.1 | 0.77 | | 11.0 | Multiple shear |
| | 9 | 16-18 | Gray and tan FAT CLAY; traces of ferrous and calcareous nodules | CH | 24.9 | | 67 | 21 | 46 | 83.1 | | | | |
| | | 22-24 | Gray and tan FAT CLAY; traces of ferrous and calcareous nodules | CH | 25.9 | | | | | | | | | |

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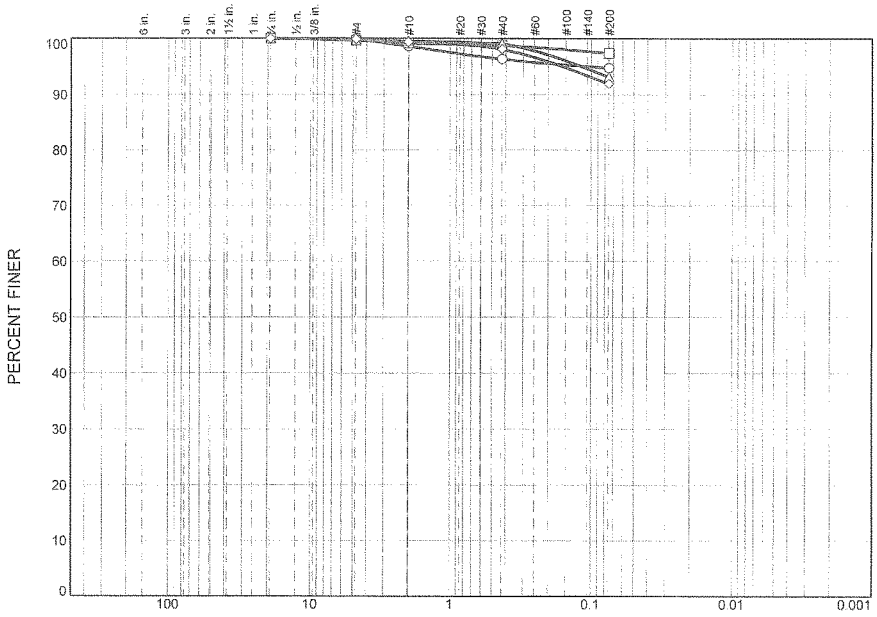
# Particle Size Distribution Report (ASTM D 1140)




| | % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|---|
| | | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| ○ | 0.0 | 0.0 | 0.0 | 1.4 | 2.3 | 1.5 | 94.8 | |
| □ | 0.0 | 0.0 | 0.4 | 0.4 | 0.4 | 1.4 | 97.4 | |
| △ | 0.0 | 0.0 | 0.2 | 0.2 | 0.5 | 5.9 | 93.2 | |
| ◇ | 0.0 | 0.0 | 0.1 | 0.5 | 1.3 | 6.2 | 91.9 | |

## SOIL DATA

| SYMBOL | SOURCE | SAMPLE NO. | DEPTH (ft.) | Material Description | USCS |
|---|---|---|---|---|---|
| ○ | 06-31 | 3 | 4-6 | Gray and brown FAT CLAY; traces of sand | CH |
| □ | 06-31 | 4 | 6-8 | Gray and brown SILT; few ferrous nodules, traces of calcareous | ML |
| | | | | nodules | |
| △ | 06-32 | 4 | 6-8 | Reddish-brown and gray SILT | ML |
| ◇ | 06-32 | 6 | 13-15 | Gray and tan FAT CLAY; traces of ferrous | CH |

**Tolunay-Wong Engineers, Inc.**
**Houston, Texas**

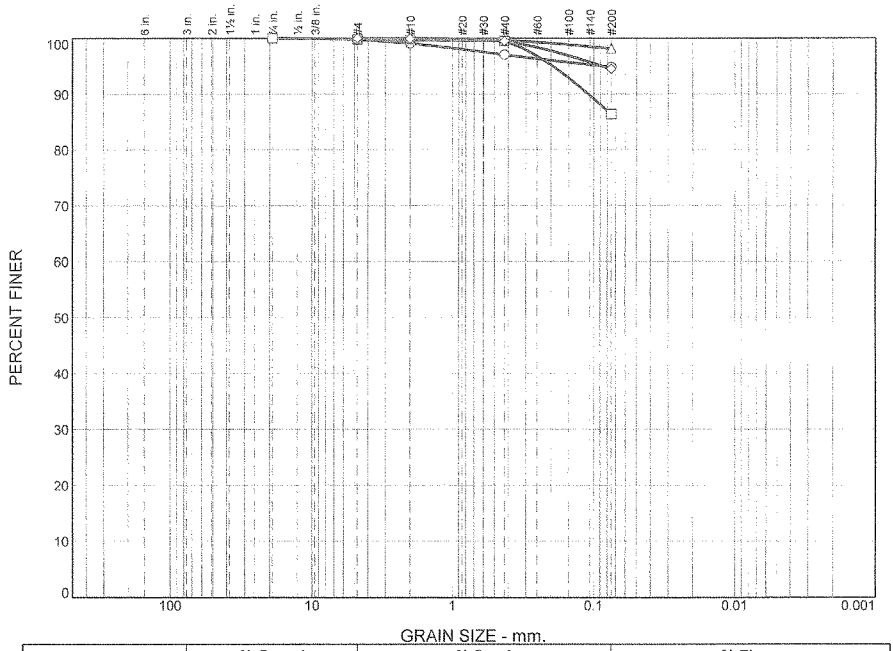
**Client:** United States Army Corps of Engineers

**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

**Project No.:** 03.14.859.44

Figure B-1

# Particle Size Distribution Report (ASTM D 1140)




| | % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|---|
| | | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| ○ | 0.0 | 0.0 | 0.3 | 0.6 | 2.0 | 2.3 | 94.8 | |
| □ | 0.0 | 0.0 | 0.2 | 0.1 | 0.2 | 13.1 | 86.4 | |
| △ | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 1.5 | 98.2 | |
| ◇ | 0.0 | 0.0 | 0.0 | 0.1 | 0.4 | 5.0 | 94.5 | |

## SOIL DATA

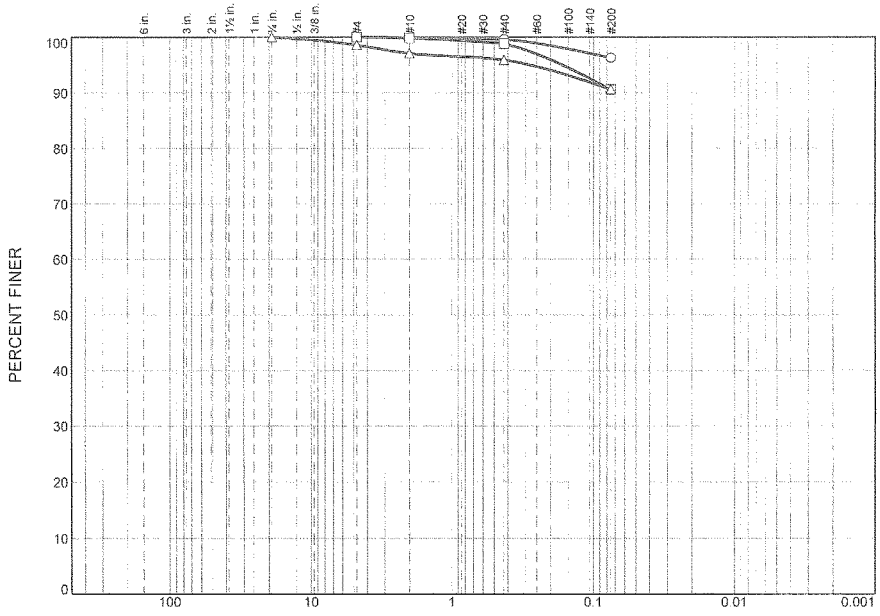
| SYMBOL | SOURCE | SAMPLE NO. | DEPTH (ft.) | Material Description | USCS |
|---|---|---|---|---|---|
| ○ | 06-33 | 3 | 4-6 | Brown and dark gray FAT CLAY; traces of ferrous | CH |
| □ | 06-33 | 8 | 14-16 | Gray and light gray FAT CLAY; few ferrous nodules, sand | CH |
| | | | | pockets and bioturbation | |
| △ | 06-34 | 4 | 6-8 | Brown and gray FAT CLAY; traces of ferrous | CH |
| ◇ | 06-34 | 9 | 16-18 | Reddish-brown and light gray LEAN CLAY; traces of ferrous | CL |

**Tolunay-Wong Engineers, Inc.**
**Houston, Texas**

**Client:** United States Army Corps of Engineers
**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044
**Project No.:** 03.14.859.44

Figure B-2

# Particle Size Distribution Report (ASTM D 1140)




| | % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|---|
| | | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| ○ | 0.0 | 0.0 | 0.0 | 0.1 | 0.3 | 3.3 | 96.3 | |
| □ | 0.0 | 0.0 | 0.0 | 0.2 | 1.0 | 8.3 | 90.5 | |
| △ | 0.0 | 0.0 | 1.4 | 1.5 | 1.2 | 5.3 | 90.6 | |
| | | | | | | | | |
| | | | | | | | | |

**SOIL DATA**

| SYMBOL | SOURCE | SAMPLE NO. | DEPTH (ft.) | Material Description | USCS |
|---|---|---|---|---|---|
| ○ | 06-34 | 11 | 20-22 | Gray and reddish-brown FAT CLAY; traces of ferrous and | CH |
| | | | | calcareous nodules, sand pockets | |
| □ | 06-35 | 7 | 12-14 | Gray and tan LEAN CLAY; traces of sand and ferrous nodules | CL |
| △ | 06-35 | 13 | 24-26 | Gray and tan FAT CLAY; few calcareous nodules | CH |
| | | | | | |

**Tolunay-Wong Engineers, Inc.**
**Houston, Texas**

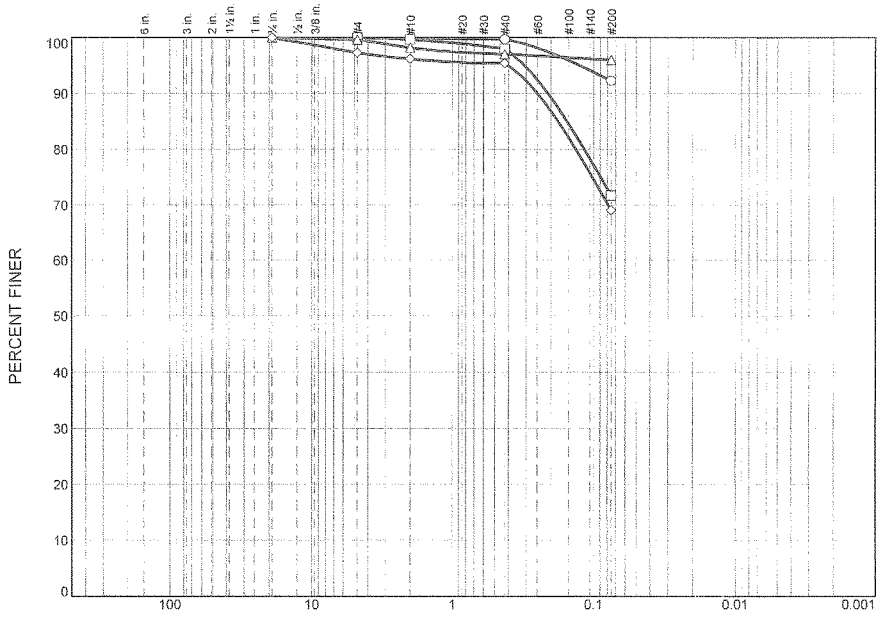
**Client:** United States Army Corps of Engineers

**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

**Project No.:** 03.14.859.44

Figure B-3

# Particle Size Distribution Report (ASTM D 1140)




| | % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|---|
| | | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| ○ | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 7.5 | 92.2 | |
| □ | 0.0 | 0.0 | 0.0 | 0.3 | 1.7 | 26.3 | 71.7 | |
| △ | 0.0 | 0.0 | 0.4 | 1.4 | 1.2 | 1.0 | 96.0 | |
| ◇ | 0.0 | 0.0 | 2.7 | 1.1 | 0.8 | 26.4 | 69.0 | |

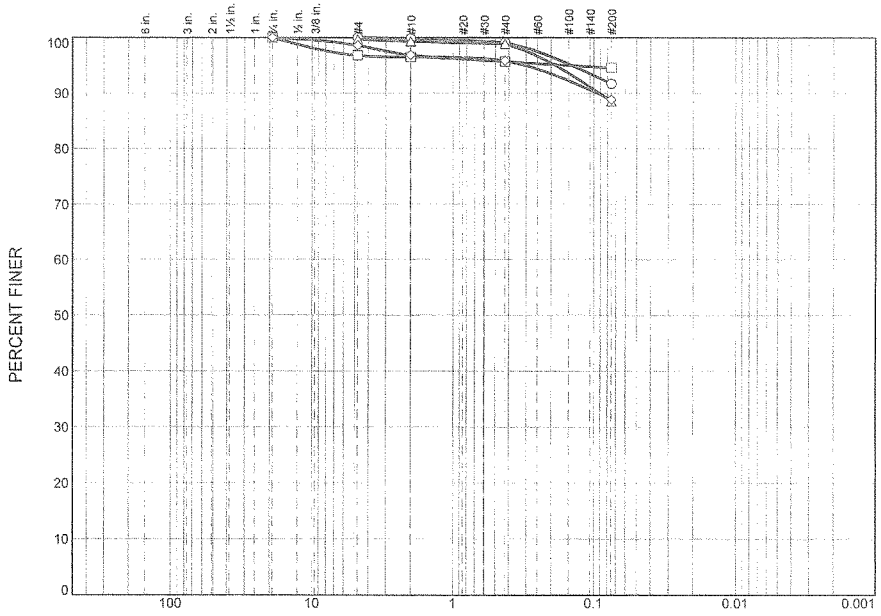
## SOIL DATA

| SYMBOL | SOURCE | SAMPLE NO. | DEPTH (ft.) | Material Description | USCS |
|---|---|---|---|---|---|
| ○ | 06-36 | 7 | 12-14 | Gray and tan FAT CLAY; traces of ferrous and calcareous | CH |
| | | | | nodules | |
| □ | 06-36 | 9 | 16-18 | Gray and tan LEAN CLAY with SAND; few ferrous nodules | CL |
| △ | 06-37 | 4 | 6-8 | Brown and light gray FAT CLAY | CH |
| ◇ | 06-38 | 4 | 6-8 | Reddish-brown and gray SANDY LEAN CLAY; silt seams, few | CL |

**Tolunay-Wong Engineers, Inc.**
**Houston, Texas**

**Client:** United States Army Corps of Engineers
**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044
**Project No.:** 03.14.859.44 Figure B-4

# Particle Size Distribution Report (ASTM D 1140)




| | % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|---|
| | | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| ○ | 0.0 | 0.0 | 0.0 | 0.1 | 0.7 | 7.5 | 91.7 | |
| □ | 0.0 | 0.0 | 3.2 | 0.3 | 0.8 | 1.1 | 94.6 | |
| △ | | | | 0.4 | 0.4 | 10.4 | 88.5 | |
| ◇ | 0.0 | 0.0 | 1.4 | 1.8 | 1.0 | 7.0 | 88.8 | |
| | | | | | | | | |

## SOIL DATA

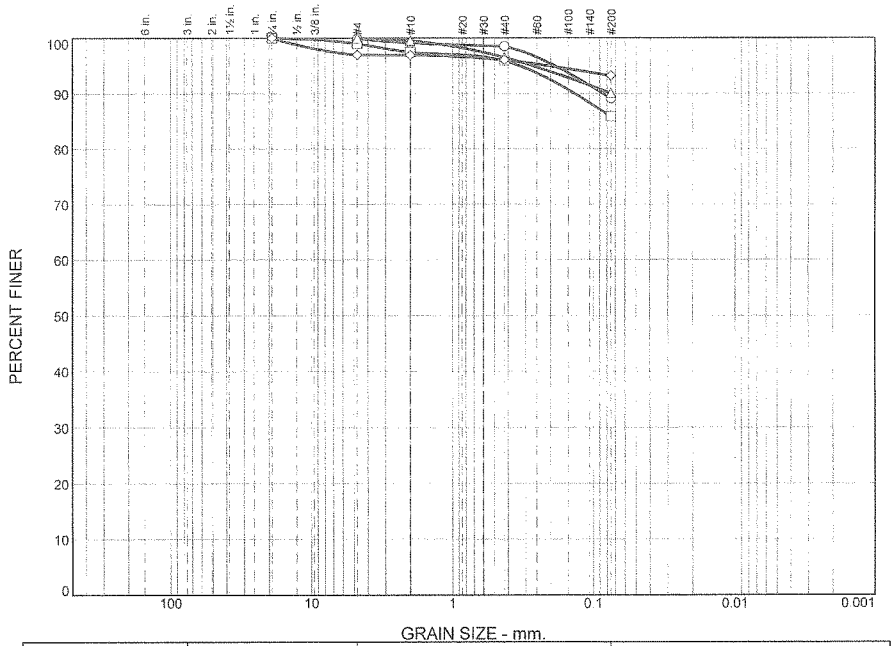
| SYMBOL | SOURCE | SAMPLE NO. | DEPTH (ft.) | Material Description | USCS |
|---|---|---|---|---|---|
| ○ | 06-39 | 3 | 4-6 | Reddish-brown LEAN CLAY | CL |
| □ | 06-40 | 4 | 6-8 | Reddish-brown FAT CLAY; sand pockets | CH |
| △ | 06-40 | 6 | 10-12 | Gray and tan FAT CLAY; few ferrous nodules, traces of | CH |
| | | | | calcareous nodules | |
| ◇ | 06-40 | 11 | 20-22 | Light gray and brown FAT CLAY; traces of calcareous | CH |

**Tolunay-Wong Engineers, Inc.**
**Houston, Texas**

**Client:** United States Army Corps of Engineers
**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044
**Project No.:** 03.14.859.44

Figure B-5

# Particle Size Distribution Report (ASTM D 1140)




| | % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|---|
| | | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| ○ | | | | 0.7 | 0.6 | 9.5 | 89.1 | |
| □ | 0.0 | 0.0 | 1.0 | 1.5 | 1.6 | 10.1 | 85.8 | |
| △ | 0.0 | 0.0 | 0.0 | 0.5 | 3.0 | 6.4 | 90.1 | |
| ◇ | 0.0 | 0.0 | 3.0 | 0.1 | 0.9 | 2.8 | 93.2 | |

## SOIL DATA

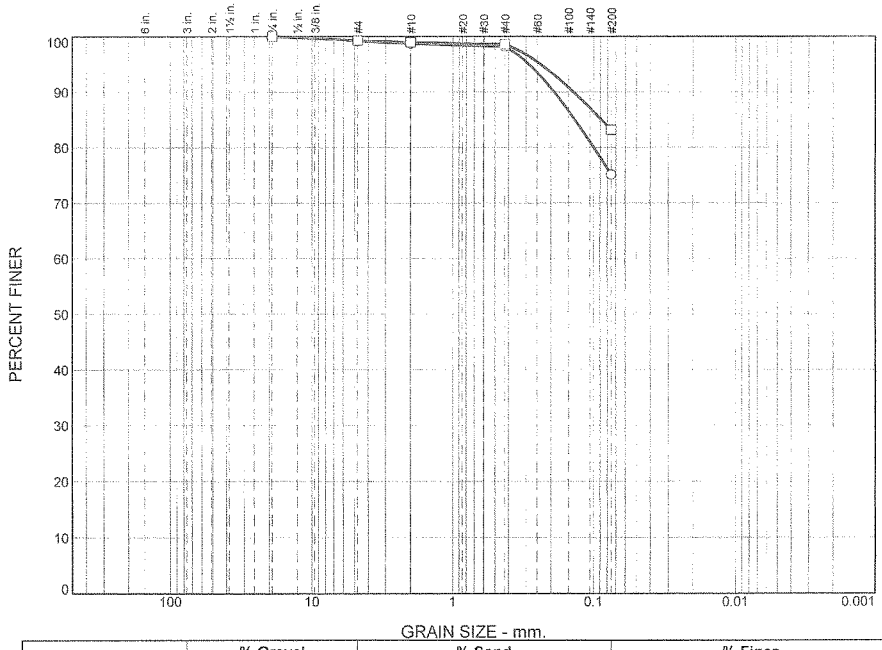
| SYMBOL | SOURCE | SAMPLE NO. | DEPTH (ft.) | Material Description | USCS |
|---|---|---|---|---|---|
| ○ | 06-41 | 4 | 6-8 | Gray and brown LEAN CLAY | CL |
| □ | 06-41 | 6 | 10-12 | Gray and tan FAT CLAY; sand pockets, traces of ferrous nodules | CH |
| △ | 06-42 | 5 | 8-10 | Reddish-brown and gray LEAN CLAY; silt seams, traces of | CL |
| | | | | ferrous nodules | |
| ◇ | 06-42 | 7 | 12-14 | Gray and tan FAT CLAY; traces of calcareous | CH |

**Tolunay-Wong Engineers, Inc.**
**Houston, Texas**

**Client:** United States Army Corps of Engineers
**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044
**Project No.:** 03.14.859.44

Figure B-6

# Particle Size Distribution Report (ASTM D 1140)




| | % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|---|
| | | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| ○ | 0.0 | 0.0 | 0.8 | 0.4 | 0.6 | 23.1 | 75.1 | |
| □ | 0.0 | 0.0 | 0.7 | 0.3 | 0.3 | 15.6 | 83.1 | |

## SOIL DATA

| SYMBOL | SOURCE | SAMPLE NO. | DEPTH (ft.) | Material Description | USCS |
|---|---|---|---|---|---|
| ○ | 06-43 | 6 | 10-12 | Gray and brown FAT CLAY; sand seams | CH |
| □ | 06-43 | 9 | 16-18 | Gray and tan FAT CLAY; traces of ferrous and calcareous nodules | CH |

**Tolunay-Wong Engineers, Inc.**
**Houston, Texas**

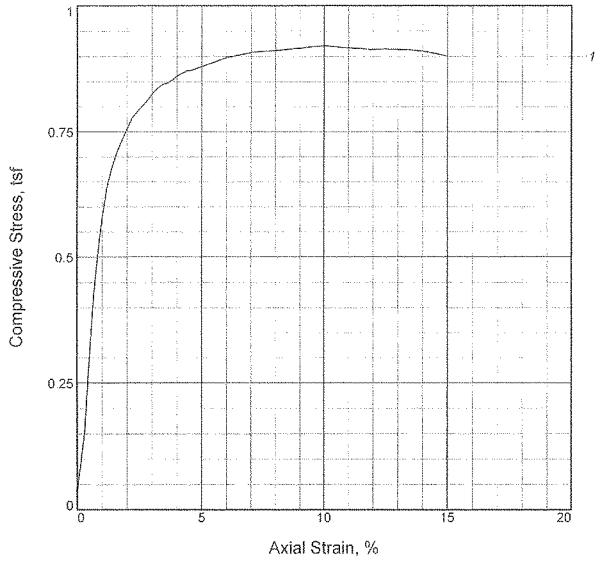
**Client:** United States Army Corps of Engineers

**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

**Project No.:** 03.14.859.44

Figure B-7

## UNCONFINED COMPRESSION TEST




| Sample No. | 1 | | | |
|---|---|---|---|---|
| Unconfined strength, tsf | 0.921 | | | |
| Undrained shear strength, tsf | 0.460 | | | |
| Failure strain, | 10.0 | | | |
| Strain rate, %/min. | 1.00 | | | |
| Water content, % | 33.1 | | | |
| Wet density, pcf | 117.8 | | | |
| Dry density, pcf | 88.5 | | | |
| Saturation, % | 96.8 | | | |
| Void ratio | 0.9396 | | | |
| Specimen diameter, in. | 2.83 | | | |
| Specimen height, in. | 5.92 | | | |
| Height/diameter ratio | 2.09 | | | |

**Description:** Gray and brown FAT CLAY; traces of sand

| LL = 62 | PL = 23 | PI = 39 | Assumed GS= 2.75 | Type: Undisturbed |
|---|---|---|---|---|

Project No.: 03 14 859.44

**Date:** 12/21/05

**Remarks:**

Test Method: ASTM D 2166
Pocket pen; tsf: 1.75
Failure type: Multiple shear
Figure C-1

**Client:** United States Army Corps of Engineers

**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

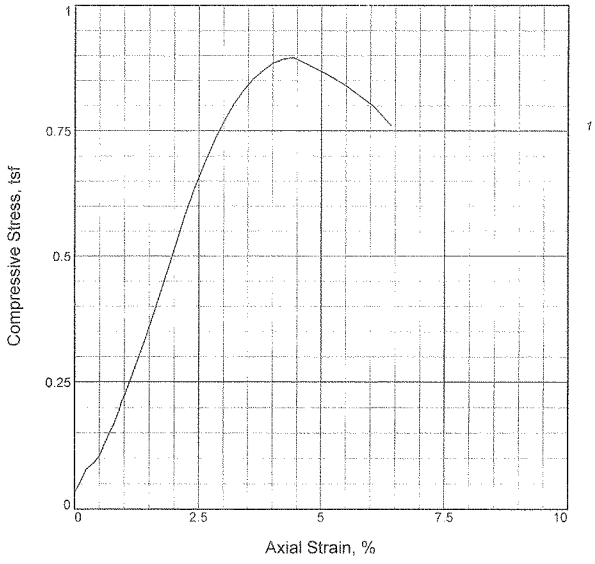
**Source of Sample:** 06-31 **Depth:** 4-6

**Sample Number:** 3

UNCONFINED COMPRESSION TEST

Tolunay-Wong Engineers, Inc.

# UNCONFINED COMPRESSION TEST




| Sample No. | 1 | | | |
|---|---|---|---|---|
| Unconfined strength, tsf | 0.896 | | | |
| Undrained shear strength, tsf | 0.448 | | | |
| Failure strain, | 4.4 | | | |
| Strain rate, %/min. | 1.00 | | | |
| Water content, % | 26.0 | | | |
| Wet density, pcf | 125.3 | | | |
| Dry density, pcf | 99.4 | | | |
| Saturation, % | 98.3 | | | |
| Void ratio | 0.7265 | | | |
| Specimen diameter, in. | 2.85 | | | |
| Specimen height, in. | 4.36 | | | |
| Height/diameter ratio | 1.53 | | | |

**Description:** Light gray and brown FAT CLAY; traces of calcareous

| LL = | PL = | PI = | Assumed GS= 2.75 | Type: Undisturbed |
|---|---|---|---|---|

Project No.: 03.14.859.44

**Date:** 12/21/05

**Remarks:**

Test Method: ASTM D 2166
Pocket pen; tsf: 2.00
Failure type: Multiple shear
Figure C-2

**Client:** United States Army Corps of Engineers

**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

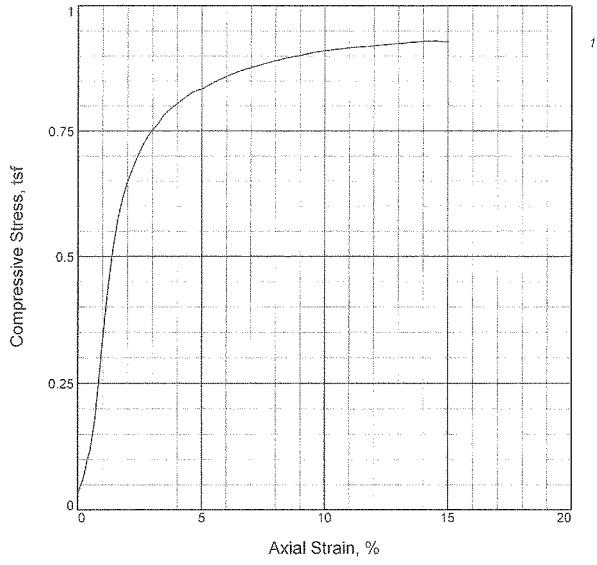
**Source of Sample:** 06-31 **Depth:** 19-21

**Sample Number:** 9

UNCONFINED COMPRESSION TEST

Tolunay-Wong Engineers, Inc.

# UNCONFINED COMPRESSION TEST




| Sample No. | 1 | | | |
|---|---|---|---|---|
| Unconfined strength, tsf | 0.930 | | | |
| Undrained shear strength, tsf | 0.465 | | | |
| Failure strain, | 14.5 | | | |
| Strain rate, %/min. | 1.00 | | | |
| Water content, % | 38.9 | | | |
| Wet density, pcf | 114.4 | | | |
| Dry density, pcf | 82.4 | | | |
| Saturation, % | 98.6 | | | |
| Void ratio | 1.0836 | | | |
| Specimen diameter, in. | 2.83 | | | |
| Specimen height, in. | 5.91 | | | |
| Height/diameter ratio | 2.09 | | | |

**Description:** Gray and tan FAT CLAY; traces of ferrous

| **LL** = 83 | **PL** = 24 | **PI** = 59 | **Assumed GS**= 2.75 | **Type:** Undisturbed |
|---|---|---|---|---|

Project No.: 03 14 859 44

**Date:** 12/21/05

**Remarks:**

Test Method: ASTM D 2166
Pocket pen; tsf: 1.25
Failure type: Bulge
Figure C-3

**Client:** United States Army Corps of Engineers

**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

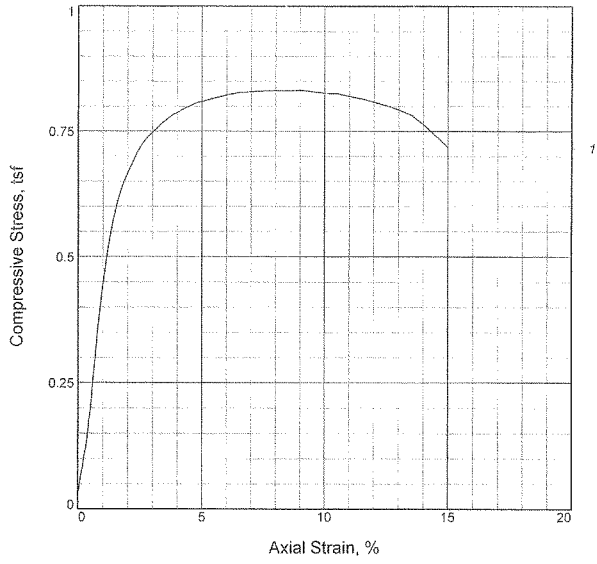
**Source of Sample:** 06-32 **Depth:** 13-15

**Sample Number:** 6

UNCONFINED COMPRESSION TEST

Tolunay-Wong Engineers, Inc.

## UNCONFINED COMPRESSION TEST




| Sample No. | 1 | | | |
|---|---|---|---|---|
| Unconfined strength, tsf | 0.832 | | | |
| Undrained shear strength, tsf | 0.416 | | | |
| Failure strain, | 9.0 | | | |
| Strain rate, %/min. | 1.00 | | | |
| Water content, % | 39.1 | | | |
| Wet density, pcf | 115.7 | | | |
| Dry density, pcf | 83.2 | | | |
| Saturation, % | 101.1 | | | |
| Void ratio | 1.0638 | | | |
| Specimen diameter, in. | 2.83 | | | |
| Specimen height, in. | 5.91 | | | |
| Height/diameter ratio | 2.09 | | | |

**Description:** Brown and gray FAT CLAY; traces of ferrous

| LL = 71 | PL = 22 | PI = 49 | Assumed GS= 2.75 | Type: Undisturbed |
|---|---|---|---|---|

Project No.: 03.14.859.44

**Date:** 12/21/05

**Remarks:**

Test Method: ASTM D 2166
Pocket pen; tsf: 1.00
Failure type: Multiple shear
Figure C-4

**Client:** United States Army Corps of Engineers

**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

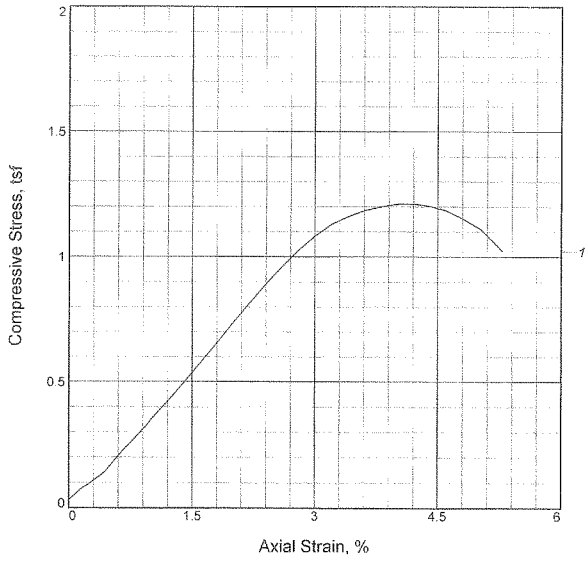
**Source of Sample:** 06-34 **Depth:** 6-8

**Sample Number:** 4

UNCONFINED COMPRESSION TEST

Tolunay-Wong Engineers, Inc.

# UNCONFINED COMPRESSION TEST




| Sample No. | 1 | | | |
|---|---|---|---|---|
| Unconfined strength, tsf | 1.211 | | | |
| Undrained shear strength, tsf | 0.606 | | | |
| Failure strain, | 4.2 | | | |
| Strain rate, %/min. | 1.00 | | | |
| Water content, % | 24.1 | | | |
| Wet density, pcf | 126.9 | | | |
| Dry density, pcf | 102.3 | | | |
| Saturation, % | 97.6 | | | |
| Void ratio | 0.6782 | | | |
| Specimen diameter, in. | 2.83 | | | |
| Specimen height, in. | 5.90 | | | |
| Height/diameter ratio | 2.08 | | | |

**Description:** Reddish-brown and light gray LEAN CLAY; traces of ferrous

| **LL** = 43 | **PL** = 19 | **PI** = 24 | **Assumed GS=** 2.75 | **Type:** Undisturbed |
|---|---|---|---|---|

Project No.: 03.14.859.44

**Date:** 12/21/05

**Remarks:**

Test Method: ASTM D 2166
Pocket pen; tsf: 1.00
Failure type: Vertical shear
Figure C-5

**Client:** United States Army Corps of Engineers

**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

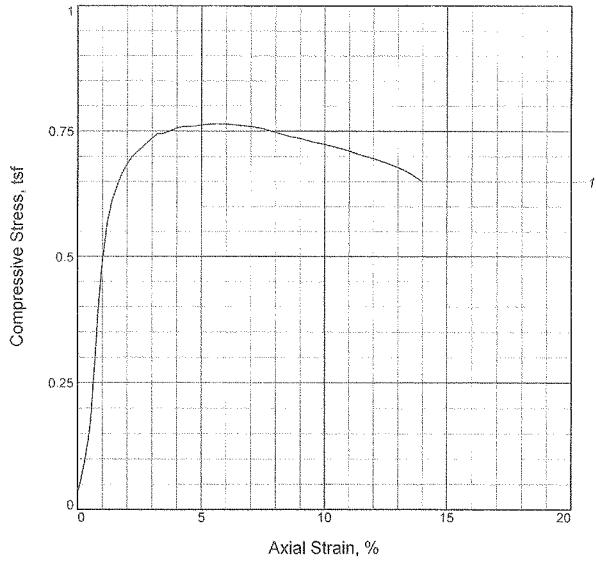
**Source of Sample:** 06-34 **Depth:** 16-18

**Sample Number:** 9

UNCONFINED COMPRESSION TEST

Tolunay-Wong Engineers, Inc.

# UNCONFINED COMPRESSION TEST




| Sample No. | 1 | | | |
|---|---|---|---|---|
| Unconfined strength, tsf | 0.764 | | | |
| Undrained shear strength, tsf | 0.382 | | | |
| Failure strain, | 5.5 | | | |
| Strain rate, %/min. | 1.00 | | | |
| Water content, % | 40.4 | | | |
| Wet density, pcf | 112.3 | | | |
| Dry density, pcf | 80.0 | | | |
| Saturation, % | 96.8 | | | |
| Void ratio | 1.1470 | | | |
| Specimen diameter, in. | 2.83 | | | |
| Specimen height, in. | 5.92 | | | |
| Height/diameter ratio | 2.09 | | | |

**Description:** Brown and gray FAT CLAY

| LL = | PL = | PI = | **Assumed GS=** 2.75 | **Type:** Undisturbed |
|---|---|---|---|---|

Project No.: 03.14.859.44

**Date:** 12/21/05

**Remarks:**

Test Method: ASTM D 2166
Pocket pen; tsf: 1.00
Failure type: Slickensided
Figure C-6

**Client:** United States Army Corps of Engineers

**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

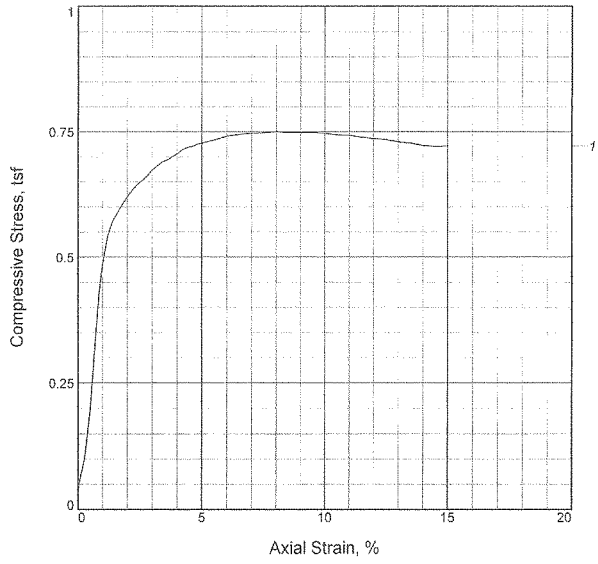
**Source of Sample:** 06-35 **Depth:** 10-12

**Sample Number:** 6

UNCONFINED COMPRESSION TEST

Tolunay-Wong Engineers, Inc.

## UNCONFINED COMPRESSION TEST




| Sample No. | 1 | | | |
|---|---|---|---|---|
| Unconfined strength, tsf | 0.750 | | | |
| Undrained shear strength, tsf | 0.375 | | | |
| Failure strain, | 8.0 | | | |
| Strain rate, %/min. | 1.00 | | | |
| Water content, % | 36.6 | | | |
| Wet density, pcf | 115.2 | | | |
| Dry density, pcf | 84.4 | | | |
| Saturation, % | 97.2 | | | |
| Void ratio | 1.0348 | | | |
| Specimen diameter, in. | 2.80 | | | |
| Specimen height, in. | 5.93 | | | |
| Height/diameter ratio | 2.12 | | | |

**Description:** Brown and light gray FAT CLAY

| LL = 73 | PL = 26 | PI = 47 | Assumed GS= 2.75 | Type: Undisturbed |
|---|---|---|---|---|

Project No.: 03.14.859.44

**Date:** 12/21/05

**Remarks:**

Test Method: ASTM D 2166
Pocket pen; tsf: 0.75
Failure type: Bulge
Figure B-7

**Client:** United States Army Corps of Engineers

**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

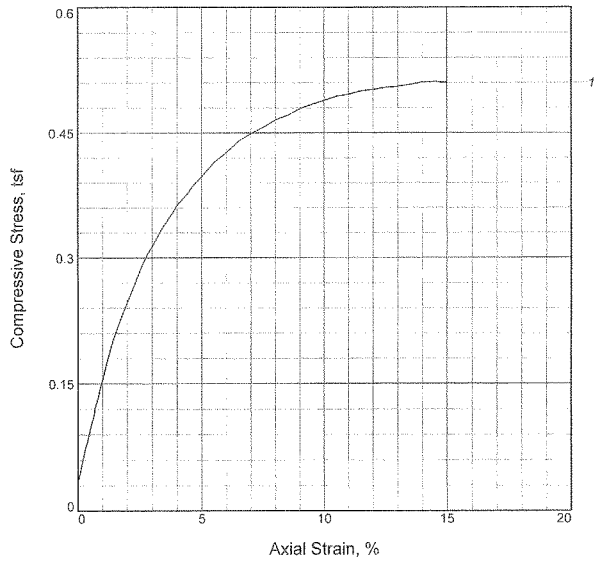
**Source of Sample:** 06-37 **Depth:** 6-8

**Sample Number:** 4

UNCONFINED COMPRESSION TEST

Tolunay-Wong Engineers, Inc.

# UNCONFINED COMPRESSION TEST




| Sample No. | 1 | | | |
|---|---|---|---|---|
| Unconfined strength, tsf | 0.512 | | | |
| Undrained shear strength, tsf | 0.256 | | | |
| Failure strain, | 14.5 | | | |
| Strain rate, %/min. | 1.00 | | | |
| Water content, % | 26.4 | | | |
| Wet density, pcf | 123.6 | | | |
| Dry density, pcf | 97.8 | | | |
| Saturation, % | 96.2 | | | |
| Void ratio | 0.7558 | | | |
| Specimen diameter, in. | 2.83 | | | |
| Specimen height, in. | 5.70 | | | |
| Height/diameter ratio | 2.02 | | | |

**Description:** Reddish-brown FAT CLAY; sand pockets

| LL = 57 | PL = 22 | PI = 35 | Assumed GS= 2.75 | Type: Undisturbed |
|---|---|---|---|---|

Project No.: 03.14.859.44

**Date:** 12/21/05

**Remarks:**

Test Method: ASTM D 2166
Pocket pen; tsf: 1.00
Failure type: Bulge
Figure B-8

**Client:** United States Army Corps of Engineers

**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

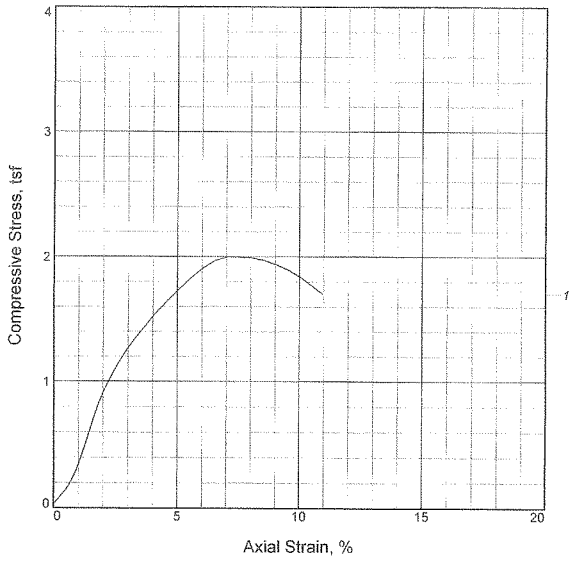
**Source of Sample:** 06-40 **Depth:** 6-8

**Sample Number:** 4

UNCONFINED COMPRESSION TEST

Tolunay-Wong Engineers, Inc.

# UNCONFINED COMPRESSION TEST




| Sample No. | 1 | | | |
|---|---|---|---|---|
| Unconfined strength, tsf | 1.998 | | | |
| Undrained shear strength, tsf | 0.999 | | | |
| Failure strain, | 7.0 | | | |
| Strain rate, %/min. | 1.00 | | | |
| Water content, % | 22.1 | | | |
| Wet density, pcf | 128.8 | | | |
| Dry density, pcf | 105.6 | | | |
| Saturation, % | 96.8 | | | |
| Void ratio | 0.6262 | | | |
| Specimen diameter, in. | 2.81 | | | |
| Specimen height, in. | 5.76 | | | |
| Height/diameter ratio | 2.05 | | | |

**Description:** Brown and gray FAT CLAY; traces of calcareous

| LL = | PL = | PI = | **Assumed GS=** 2.75 | **Type:** Undisturbed |
|---|---|---|---|---|

Project No.: 03.14.859.44

**Date:** 12/21/05

**Remarks:**

Test Method: ASTM D 2166
Pocket pen; tsf: 3.25
Failure type: Multiple shear
Figure C-9

**Client:** United States Army Corps of Engineers

**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

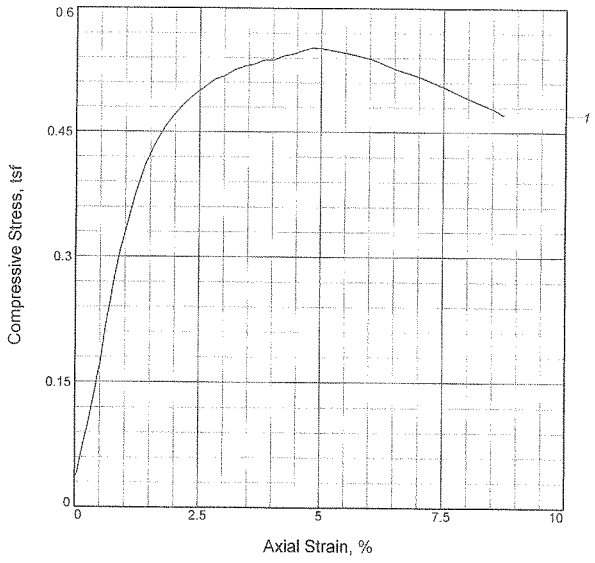
**Source of Sample:** 06-40 **Depth:** 22-24

**Sample Number:** 12

UNCONFINED COMPRESSION TEST

Tolunay-Wong Engineers, Inc.

# UNCONFINED COMPRESSION TEST




| Sample No. | 1 | | | |
|---|---|---|---|---|
| Unconfined strength, tsf | 0.552 | | | |
| Undrained shear strength, tsf | 0.276 | | | |
| Failure strain, | 4.8 | | | |
| Strain rate, %/min. | 1.00 | | | |
| Water content, % | 39.4 | | | |
| Wet density, pcf | 113.0 | | | |
| Dry density, pcf | 81.0 | | | |
| Saturation, % | 96.9 | | | |
| Void ratio | 1.1190 | | | |
| Specimen diameter, in. | 2.83 | | | |
| Specimen height, in. | 5.91 | | | |
| Height/diameter ratio | 2.09 | | | |

**Description:** Gray and tan FAT CLAY; traces of calcareous

| LL = 79 | PL = 24 | PI = 55 | **Assumed GS=** 2.75 | **Type:** Undisturbed |
|---|---|---|---|---|

Project No.: 03.14.859 44

**Date:** 12/21/05

**Remarks:**

Test Method: ASTM D 2166
Pocket pen; tsf: 0.75
Failure type: Slickensided
Figure B-10

**Client:** United States Army Corps of Engineers

**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

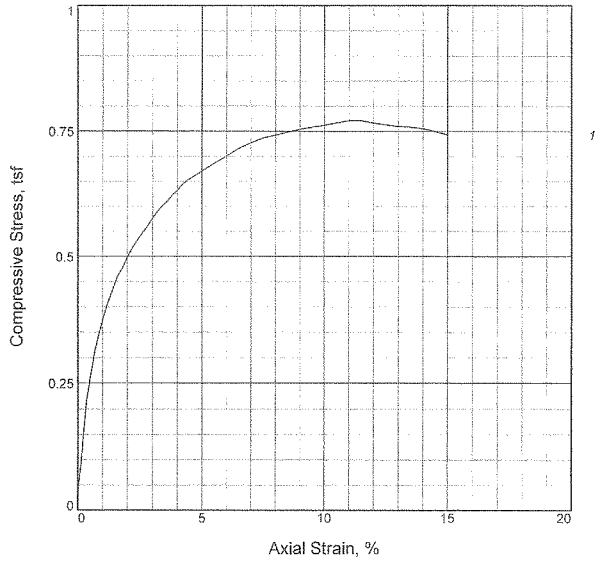
**Source of Sample:** 06-42 **Depth:** 12-14

**Sample Number:** 7

UNCONFINED COMPRESSION TEST

Tolunay-Wong Engineers, Inc.

# UNCONFINED COMPRESSION TEST




| Sample No. | 1 | | | |
|---|---|---|---|---|
| Unconfined strength, tsf | 0.771 | | | |
| Undrained shear strength, tsf | 0.386 | | | |
| Failure strain, | 11.0 | | | |
| Strain rate, %/min. | 1.00 | | | |
| Water content, % | 27.9 | | | |
| Wet density, pcf | 120.9 | | | |
| Dry density, pcf | 94.5 | | | |
| Saturation, % | 94.1 | | | |
| Void ratio | 0.8163 | | | |
| Specimen diameter, in. | 2.83 | | | |
| Specimen height, in. | 5.89 | | | |
| Height/diameter ratio | 2.08 | | | |

**Description:** Gray and brown FAT CLAY; sand seams

| **LL =** 62 | **PL =** 22 | **PI =** 40 | **Assumed GS=** 2.75 | **Type:** Undisturbed |
|---|---|---|---|---|

Project No.: 03.14.859.44

**Date:** 12/21/05

**Remarks:**

Test Method: ASTM D 2166
Pocket pen; tsf: 0.75
Failure type: Multiple shear
Figure B-11

**Client:** United States Army Corps of Engineers

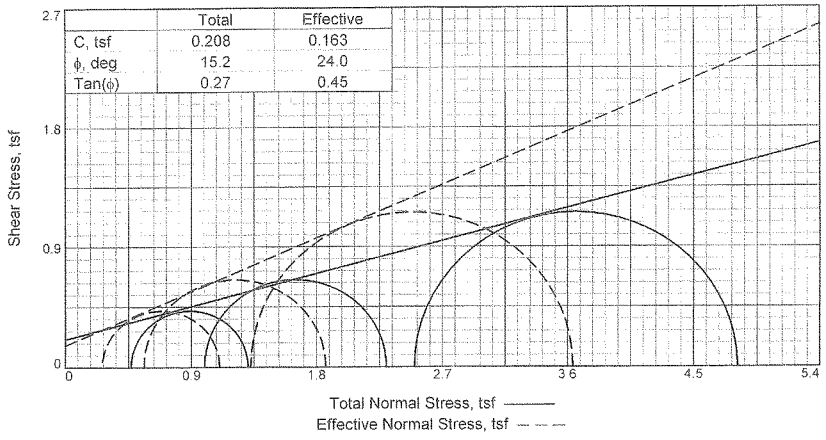
**Project:** Freeport Placement Area; Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044

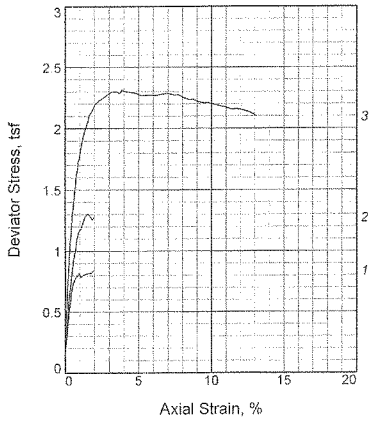
**Source of Sample:** 06-43 **Depth:** 10-12

**Sample Number:** 6

UNCONFINED COMPRESSION TEST

Tolunay-Wong Engineers, Inc.




| Sample No. | | 1 | 2 | 3 |
|---|---|---|---|---|
| Initial | Water Content, | 26.0 | 26.0 | 26.0 |
| | Dry Density, pcf | 96.4 | 96.4 | 96.4 |
| | Saturation, | 93.7 | 93.7 | 93.7 |
| | Void Ratio | 0.7484 | 0.7484 | 0.7484 |
| | Diameter, in. | 1.98 | 1.98 | 1.98 |
| | Height, in. | 4.16 | 4.16 | 4.16 |
| At Test | Water Content, | 25.2 | 25.2 | 25.2 |
| | Dry Density, pcf | 96.9 | 98.3 | 101.4 |
| | Saturation, | 92.0 | 95.3 | 102.6 |
| | Void Ratio | 0.7400 | 0.7141 | 0.6630 |
| | Diameter, in. | 1.97 | 1.98 | 1.97 |
| | Height, in. | 4.16 | 4.07 | 3.99 |
| Strain rate, %/min. | | 0.02 | 0.02 | 0.01 |
| Eff. Cell Pressure, tsf | | 0.47 | 0.99 | 2.50 |
| Fail. Stress, tsf | | 0.84 | 1.31 | 2.31 |
| Excess Pore Pr., tsf | | 0.20 | 0.43 | 1.17 |
| Strain, % | | 2.0 | 1.6 | 3.8 |
| Ult. Stress, tsf | | 0.84 | 1.31 | 2.31 |
| Excess Pore Pr., tsf | | 0.20 | 0.43 | 1.17 |
| Strain, % | | 2.0 | 1.6 | 3.8 |
| $\bar{\sigma}_1$ Failure, tsf | | 1.10 | 1.87 | 3.64 |
| $\bar{\sigma}_3$ Failure, tsf | | 0.26 | 0.56 | 1.33 |

**Type of Test:**
CU with Pore Pressures
**Sample Type:** Undisturbed
**Description:** Light gray and brown FAT CLAY; traces of calcareous

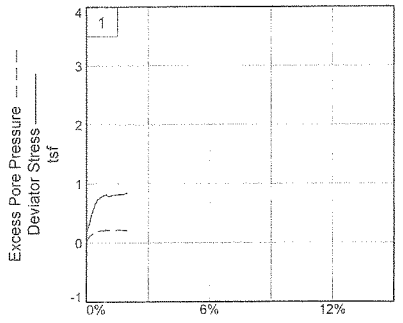
**Assumed Specific Gravity=** 2.70
**Remarks:**
Test Method: ASTM D4767
Pocket pen; tsf: 1.75
Failure type: 45 degree

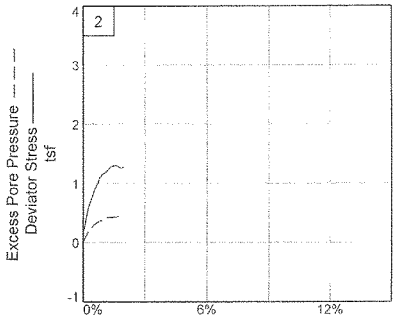
**Client:** United States Army Corps of Engineers

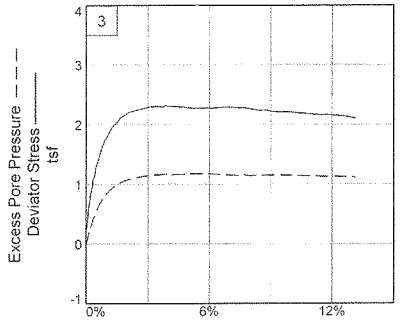
**Project:** Freeport Placement Area
Contract No. DACW64-03-D-0008 (FY 06); Delivery Order No. 0044
**Source of Sample:** 06-31 **Depth:** 17-19
**Sample Number:** 8
Proj. No.: 03 14 859 44 **Date:** 12/20/05

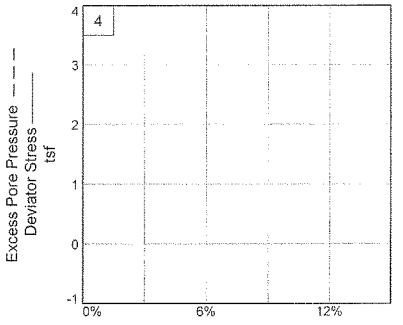
TRIAXIAL SHEAR TEST REPORT

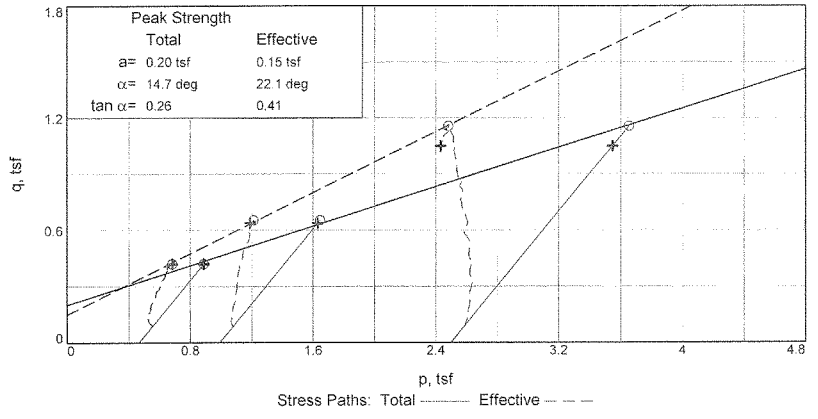
Tolunay-Wong Engineers, Inc.



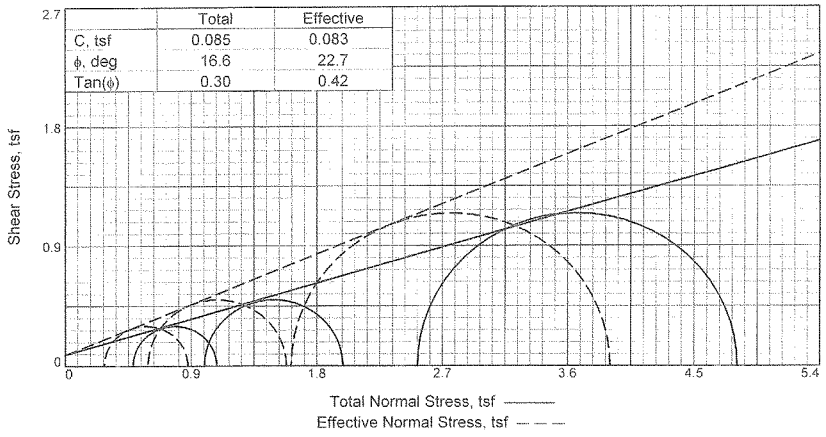



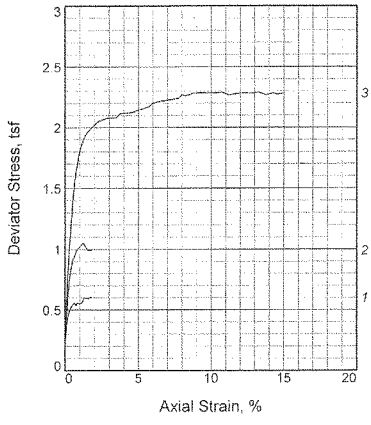




**Client:** United States Army Corps of Engineers
**Project:** Freeport Placement Area
**Source of Sample:** 06-31 **Depth:** 17-19 **Sample Number:** 8
**Project No.:** 03.14.859.44

TOLUNAY-WONG ENGINEERS, INC.




| Sample No. | | 1 | 2 | 3 |
|---|---|---|---|---|
| Initial | Water Content, | 25.6 | 25.6 | 25.6 |
| | Dry Density, pcf | 99.0 | 99.0 | 99.0 |
| | Saturation, | 98.3 | 98.3 | 98.3 |
| | Void Ratio | 0.7022 | 0.7022 | 0.7022 |
| | Diameter, in. | 1.92 | 1.92 | 1.92 |
| | Height, in. | 4.05 | 4.05 | 4.05 |
| At Test | Water Content, | 24.9 | 24.9 | 24.9 |
| | Dry Density, pcf | 98.9 | 99.9 | 101.7 |
| | Saturation, | 95.4 | 97.6 | 102.1 |
| | Void Ratio | 0.7039 | 0.6880 | 0.6579 |
| | Diameter, in. | 1.92 | 1.93 | 1.94 |
| | Height, in. | 4.05 | 3.97 | 3.89 |
| Strain rate, %/min. | | 0.01 | 0.02 | 0.02 |
| Eff. Cell Pressure, tsf | | 0.48 | 0.99 | 2.52 |
| Fail. Stress, tsf | | 0.60 | 0.99 | 2.29 |
| Excess Pore Pr., tsf | | 0.21 | 0.40 | 0.90 |
| Strain, % | | 1.7 | 1.8 | 9.3 |
| Ult. Stress, tsf | | 0.61 | 0.99 | 2.28 |
| Excess Pore Pr., tsf | | 0.20 | 0.40 | 0.79 |
| Strain, % | | 1.8 | 1.5 | 15.0 |
| $\bar{\sigma}_1$ Failure, tsf | | 0.88 | 1.58 | 3.90 |
| $\bar{\sigma}_3$ Failure, tsf | | 0.28 | 0.59 | 1.62 |

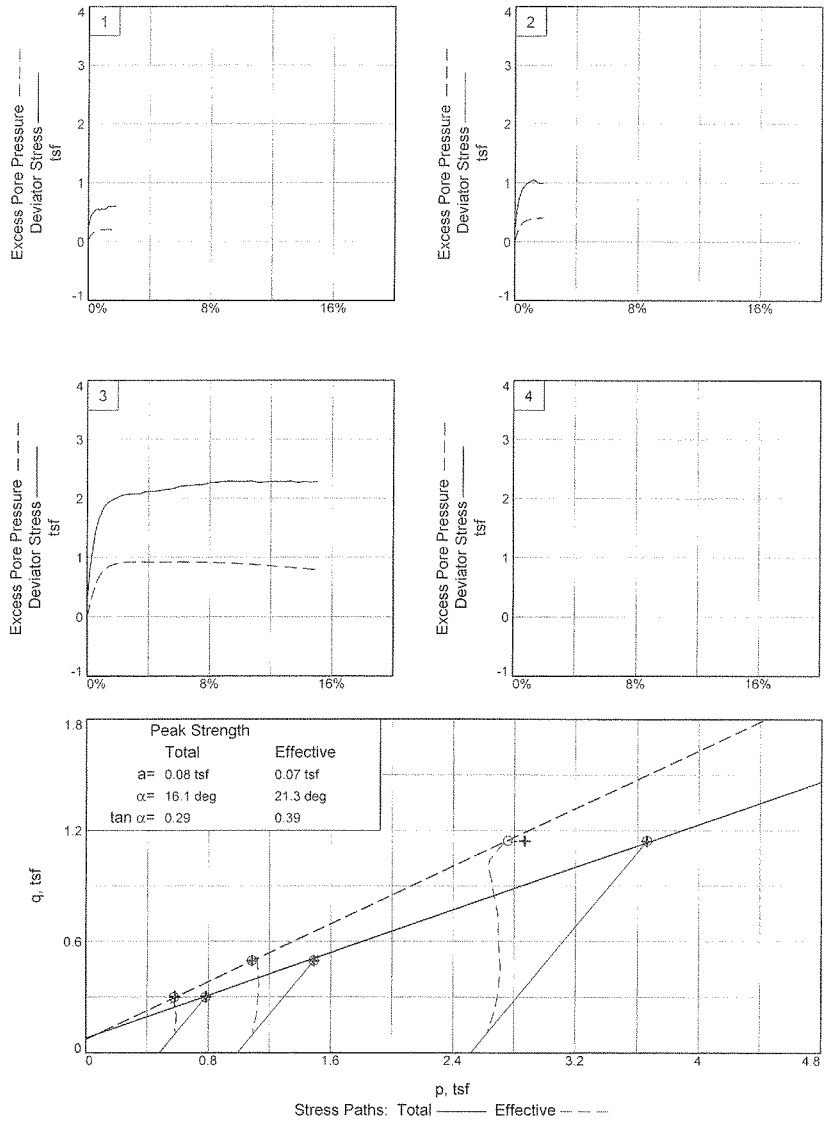
**Type of Test:**
CU with Pore Pressures
**Sample Type:** Undisturbed
**Description:** Light gray and brown FAT CLAY; traces of calcareous
**LL=** 69 **PL=** 22 **PI=** 47
**Assumed Specific Gravity=** 2.70
**Remarks:**
Test Method: ASTM D4767
Pocket pen; tsf: 3.50
Failure type: 45 degree

**Client:** United States Army Corps of Engineers

**Project:** Freeport Placement Area
Contract No. DACW64-03-D-0008 (FY 06); Delivery Order No. 0044
**Source of Sample:** 06-40 **Depth:** 20-22
**Sample Number:** 11
Proj. No.: 03 14.859 44 **Date:** 12/20/05

TRIAXIAL SHEAR TEST REPORT

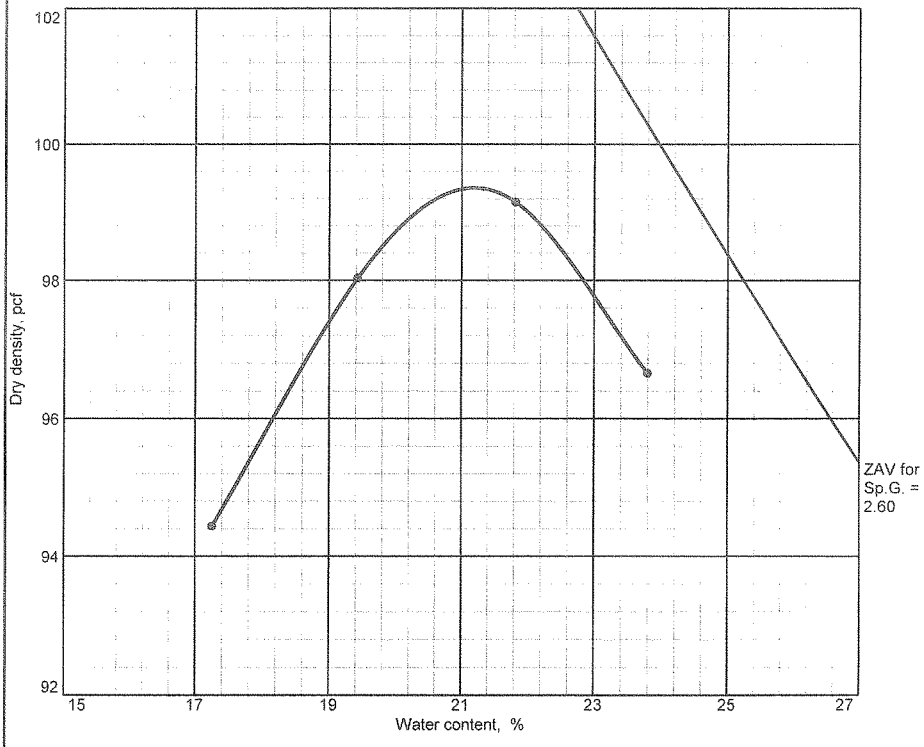
Tolunay-Wong Engineers, Inc.




**Client:** United States Army Corps of Engineers
**Project:** Freeport Placement Area
**Source of Sample:** 06-40 **Depth:** 20-22 **Sample Number:** 11
**Project No.:** 03.14.859.44

TOLUNAY-WONG ENGINEERS, INC.

# COMPACTION TEST REPORT




Test specification: ASTM D 698-00a Method A Standard

| Elev/ Depth | Classification | | Nat. Moist. | Sp.G. | LL | PI | % > No.4 | % < No.200 |
|---|---|---|---|---|---|---|---|---|
| | USCS | AASHTO | | | | | | |
| | CH | | | 2.60 | | | 0.0 | |

| TEST RESULTS | MATERIAL DESCRIPTION |
|---|---|
| Maximum dry density = 99.4 pcf<br>Optimum moisture = 21.2 % | Dark gray and tan FAT CLAY |

**Project No.** 03.14.859.44 **Client:** United States Army Corps of Engineers
**Project:** Freeport Placement Area
Contract No. DACW64-03-D-0008 (FY06); Delivery Order No. 0044 **Date:** 01-12-06
● **Source:** Boring Location 40

**Remarks:**
Preparation Method: Wet
Specific Gravity: Assumed

**Tolunay-Wong Engineers, Inc.**
**Houston, Texas**

List of attachments:

**Channel C-Drawings**
C00 Cover Sheet
C01 General Notes & Index
C02 Project Location
C03 Existing Plan View
C04 Enlarged Plan View Stauffer
C05 Enlarged Plan View Jetty Reach
C06 General LPP Cross Sections

**Geotechnical F-Drawings**
F01 Chan Boring Plan
F02 PA#1, 8, & 9 Boring Plan
F03 Channel Boring Logs
F04 Channel Boring Logs
F05 Channel Boring Logs
F06 PA 8 & 9 Boring Logs
F07 PA 8 & 9 Boring Logs
F08 PA 1 Boring Logs
F09 PA 1 Boring Logs
F10 PA 1 Boring Logs
F11 PA 1 Boring Logs
F12 PA 1 Boring Logs
F13 PA 1 Boring Logs
F14 Typical Containment Dike Detail

**Attachment**

**Cost Engineering Documentation**

NED PLAN - FREEPORT HARBOR, TEXAS
Channel Deepening and Selective Widening
Feasibility Study
October 2011 Price Level



| | |
|---|---|
| Estimated by | J. Lockhart |
| Designed by | CESWG-EC-PS |
| Prepared by | U.S. Army Corps of Engineers - Galveston District |
| Preparation Date | 3/28/2012 |
| Effective Date of Pricing | 3/28/2012 |
| Estimated Construction Time | Days |

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| Description | UOM | Quantity | DirectCost | ContractCost | ProjectCost |
|---|---|---|---|---|---|
| **Project Cost Summary Report** | | | **234,256,228** | **239,321,320** | **239,321,320** |
| **01 Contract 1 - Future Ch & half of Outer Bar Ch** | **LS** | **1.00** | **66,050,025** | **67,546,887** | **67,546,887** |
| **012 Federal Costs** | **LS** | **1.00** | **66,050,025** | **67,546,887** | **67,546,887** |
| **01212 Navigation Ports and Harbors** | **LS** | **1.00** | **66,050,025** | **67,546,887** | **67,546,887** |
| **0121201 Mobilization & Demobilization** | **LS** | **1.00** | **1,658,000** | **1,658,000** | **1,658,000** |
| **0121202 Hopper Dredging** | **CY** | **7,220,000.00** | **58,847,600** | **58,847,600** | **58,847,600** |
| **0121204 Navigation Aids** | **LS** | **1.00** | **90,000** | **90,000** | **90,000** |
| **0121203 Sea Turtle Protection** | **EA** | **1.00** | **5,454,425** | **6,951,287** | **6,951,287** |
| **02 Contract 2 - Half Outer Bar Ch & Jetty Ch** | **LS** | **1.00** | **70,539,585** | **72,118,447** | **72,118,447** |
| **022 Federal Costs** | **LS** | **1.00** | **70,539,585** | **72,118,447** | **72,118,447** |
| **02212 Navigation Ports and Harbors** | **LS** | **1.00** | **70,539,585** | **72,118,447** | **72,118,447** |
| **0221201 Mobilization & Demobilization** | **LS** | **1.00** | **1,726,000** | **1,726,000** | **1,726,000** |
| **0221202 Hopper Dredging** | **CY** | **7,737,000.00** | **62,060,360** | **62,060,360** | **62,060,360** |
| **0221203 Sea Turtle Protection** | **EA** | **1.00** | **5,753,225** | **7,332,087** | **7,332,087** |
| **0221204 Navigation Aids** | **LS** | **1.00** | **1,000,000** | **1,000,000** | **1,000,000** |
| **03 Contract 3 - Lower TB** | **LS** | **1.00** | **12,480,200** | **12,480,200** | **12,480,200** |
| **031 Non-Federal Costs** | **LS** | **1.00** | **9,488,000** | **9,488,000** | **9,488,000** |
| **03112 NavigationPorts & Harbor** | **LS** | **1.00** | **9,488,000** | **9,488,000** | **9,488,000** |
| **031201 Dredging for Berthing Areas** | **CY** | **99,000.00** | **1,188,000** | **1,188,000** | **1,188,000** |
| **031202 Upgrade Berthing Area** | **EA** | **1.00** | **8,300,000** | **8,300,000** | **8,300,000** |
| **032 Federal Costs** | **LS** | **1.00** | **2,992,200** | **2,992,200** | **2,992,200** |
| **03212 Navigation Ports and Harbors** | **LS** | **1.00** | **2,992,200** | **2,992,200** | **2,992,200** |
| **0321201 Mobilization & Demobilization** | **LS** | **1.00** | **480,000** | **480,000** | **480,000** |
| **0321202 Pipeline Dredging** | **CY** | **318,000.00** | **2,512,200** | **2,512,200** | **2,512,200** |
| **05 Cont 5 - Ch to BRZPT through BRZPT TB and PA 8** | **LS** | **1.00** | **44,674,731** | **45,629,065** | **45,629,065** |
| **051 Non-Federal Costs** | **LS** | **1.00** | **16,428,000** | **16,428,000** | **16,428,000** |

| Description | UOM | Quantity | DirectCost | ContractCost | ProjectCost |
|---|---|---|---|---|---|
| 05112 NavigationPorts & Harbor | LS | 1.00 | 16,428,000 | 16,428,000 | 16,428,000 |
| 0511201 Dredging for Berthing Areas | CY | 144,000.00 | 1,728,000 | 1,728,000 | 1,728,000 |
| 0511202 Upgrade Berthing Area | EA | 2.00 | 14,700,000 | 14,700,000 | 14,700,000 |
| 052 Federal Costs | LS | 1.00 | 28,246,731 | 29,201,065 | 29,201,065 |
| 05212 Navigation Ports and Harbors | LS | 1.00 | 28,246,731 | 29,201,065 | 29,201,065 |
| 0521201 Mobilization & Demobilization | LS | 1.00 | 600,000 | 600,000 | 600,000 |
| 0521202 Pipeline Dredging | CY | 2,316,000.00 | 24,179,040 | 24,179,040 | 24,179,040 |
| 0521203 PA 8 | EA | 1.00 | 3,467,691 | 4,422,025 | 4,422,025 |
| 06 Cont 6 - Ch to Upper TB throught Uper TB and, PA 9 | LS | 1.00 | 29,180,010 | 30,186,930 | 30,186,930 |
| 061 Non-Federal Costs | LS | 1.00 | 19,104,000 | 19,104,000 | 19,104,000 |
| 06112 NavigationPorts & Harbor | LS | 1.00 | 19,104,000 | 19,104,000 | 19,104,000 |
| 0611201 Dredging for Berthing Areas | CY | 317,000.00 | 3,804,000 | 3,804,000 | 3,804,000 |
| 0611202 Upgrade Berthing Area | EA | 2.00 | 15,300,000 | 15,300,000 | 15,300,000 |
| 062 Federal Costs | LS | 1.00 | 10,076,010 | 11,082,930 | 11,082,930 |
| 06212 Navigation Ports and Harbors | LS | 1.00 | 10,076,010 | 11,082,930 | 11,082,930 |
| 0621201 Mobilization & Demobilization | LS | 1.00 | 550,000 | 550,000 | 550,000 |
| 0621202 Pipeline Dredging | CY | 1,037,000.00 | 5,867,240 | 5,867,240 | 5,867,240 |
| 0621203 PA 9 | EA | 1.00 | 3,658,770 | 4,665,690 | 4,665,690 |
| 07 Contract 7 -Stauffer Ch | LS | 1.00 | 11,229,520 | 11,229,520 | 11,229,520 |
| 071 Non-Federal Costs | LS | 1.00 | 1,092,000 | 1,092,000 | 1,092,000 |
| 03112 NavigationPorts & Harbor | LS | 1.00 | 1,092,000 | 1,092,000 | 1,092,000 |
| 031201 Dredging for Berthing Areas | CY | 91,000.00 | 1,092,000 | 1,092,000 | 1,092,000 |
| 072 Federal Costs | LS | 1.00 | 10,137,520 | 10,137,520 | 10,137,520 |
| 07212 Navigation Ports and Harbors | LS | 1.00 | 10,137,520 | 10,137,520 | 10,137,520 |
| 0721201 Mobilization & Demobilization | LS | 1.00 | 550,000 | 550,000 | 550,000 |
| 0721202 Pipeline Dredging | CY | 1,814,000.00 | 9,587,520 | 9,587,520 | 9,587,520 |

| Description | UOM | Quantity | DirectCost | ContractCost | ProjectCost |
|---|---|---|---|---|---|
| **08 Contract 8- Mitigation** | **LS** | **1.00** | **102,157** | **130,271** | **130,271** |
| **082 Federal Costs** | **LS** | **1.00** | **102,157** | **130,271** | **130,271** |
| **08206 Fish & Wildlife Facilities** | **ACR** | **12.00** | **102,157** | **130,271** | **130,271** |
| **0820601 Tallow Removal** | **ACR** | **12.00** | **10,052** | **12,818** | **12,818** |
| **0820603 Planting Forest Seedlings** | **EA** | **1,800.00** | **18,000** | **22,954** | **22,954** |
| **0820604 Grassland** | **ACR** | **8.00** | **34,877** | **44,475** | **44,475** |
| **0820602 Pond Creation** | **ACR** | **3.00** | **39,229** | **50,025** | **50,025** |

| Description | Page |
|---|---|
| **Project Cost Summary Report** | **1** |
| 01 Contract 1 - Future Ch & half of Outer Bar Ch | 1 |
| 012 Federal Costs | 1 |
| 01212 Navigation Ports and Harbors | 1 |
| 0121201 Mobilization & Demobilization | 1 |
| 0121202 Hopper Dredging | 1 |
| 0121204 Navigation Aids | 1 |
| 0121203 Sea Turtle Protection | 1 |
| 02 Contract 2 - Half Outer Bar Ch & Jetty Ch | 1 |
| 022 Federal Costs | 1 |
| 02212 Navigation Ports and Harbors | 1 |
| 0221201 Mobilization & Demobilization | 1 |
| 0221202 Hopper Dredging | 1 |
| 0221203 Sea Turtle Protection | 1 |
| 0221204 Navigation Aids | 1 |
| 03 Contract 3 - Lower TB | 1 |
| 031 Non-Federal Costs | 1 |
| 03112 NavigationPorts & Harbor | 1 |
| 031201 Dredging for Berthing Areas | 1 |
| 031202 Upgrade Berthing Area | 1 |
| 032 Federal Costs | 1 |
| 03212 Navigation Ports and Harbors | 1 |
| 0321201 Mobilization & Demobilization | 1 |
| 0321202 Pipeline Dredging | 1 |
| 05 Cont 5 - Ch to BRZPT through BRZPT TB and PA 8 | 1 |
| 051 Non-Federal Costs | 1 |
| 05112 NavigationPorts & Harbor | 1 |
| 05112 NavigationPorts & Harbor | 2 |
| 0511201 Dredging for Berthing Areas | 2 |
| 0511202 Upgrade Berthing Area | 2 |
| 052 Federal Costs | 2 |
| 05212 Navigation Ports and Harbors | 2 |
| 0521201 Mobilization & Demobilization | 2 |
| 0521202 Pipeline Dredging | 2 |
| 0521203 PA 8 | 2 |
| 06 Cont 6 - Ch to Upper TB throught Uper TB and, PA 9 | 2 |
| 061 Non-Federal Costs | 2 |
| 06112 NavigationPorts & Harbor | 2 |
| 0611201 Dredging for Berthing Areas | 2 |
| 0611202 Upgrade Berthing Area | 2 |
| 062 Federal Costs | 2 |
| 06212 Navigation Ports and Harbors | 2 |

| Description | Page |
|---|---|
| 0621201 Mobilization & Demobilization | 2 |
| 0621202 Pipeline Dredging | 2 |
| 0621203 PA 9 | 2 |
| 07 Contract 7 -Stauffer Ch | 2 |
| 071 Non-Federal Costs | 2 |
| 03112 NavigationPorts & Harbor | 2 |
| 031201 Dredging for Berthing Areas | 2 |
| 072 Federal Costs | 2 |
| 07212 Navigation Ports and Harbors | 2 |
| 0721201 Mobilization & Demobilization | 2 |
| 0721202 Pipeline Dredging | 2 |
| 08 Contract 8- Mitigation | 2 |
| 08 Contract 8- Mitigation | 3 |
| 082 Federal Costs | 3 |
| 08206 Fish & Wildlife Facilities | 3 |
| 0820601 Tallow Removal | 3 |
| 0820603 Planting Forest Seedlings | 3 |
| 0820604 Grassland | 3 |
| 0820602 Pond Creation | 3 |

# LPP PLAN - FREEPORT HARBOR, TEXAS
Channel Deepening and Widening
Feasibility Study
October 2011 Price Level



| | |
|---|---|
| Estimated by | J. Lockhart |
| Designed by | CESWG-EC-PS |
| Prepared by | U.S. Army Corps of Engineers - Galveston District |
| Preparation Date | 3/29/2012 |
| Effective Date of Pricing | 3/29/2012 |
| Estimated Construction Time | Days |

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| Description | UOM | Quantity | DirectCost | ContractCost | ProjectCost |
|---|---|---|---|---|---|
| **Project Cost Summary Report** | | | **181,261,468** | **185,396,562** | **185,396,562** |
| **01 Contract 1 - Future Ch & Half of Outer Bar Ch** | **LS** | **1.00** | **36,638,300** | **37,626,474** | **37,626,474** |
| **012 Federal Costs** | **LS** | **1.00** | **36,638,300** | **37,626,474** | **37,626,474** |
| **01212 Navigation Ports and Harbors** | **LS** | **1.00** | **36,638,300** | **37,626,474** | **37,626,474** |
| **0121201 Mobilization & Demobilization** | **LS** | **1.00** | **1,900,000** | **1,900,000** | **1,900,000** |
| **0121202 Hopper Dredging** | **CY** | **3,940,000.00** | **31,055,150** | **31,055,150** | **31,055,150** |
| **0121204 Navigation Aids** | **LS** | **1.00** | **90,000** | **90,000** | **90,000** |
| **0121203 Sea Turtle Protection** | **EA** | **1.00** | **3,593,150** | **4,581,324** | **4,581,324** |
| **02 Contract 2 - Half Outer Bar Ch & Jetty Ch** | **LS** | **1.00** | **54,041,660** | **55,231,847** | **55,231,847** |
| **022 Federal Costs** | **LS** | **1.00** | **54,041,660** | **55,231,847** | **55,231,847** |
| **02212 Navigation Ports and Harbors** | **LS** | **1.00** | **54,041,660** | **55,231,847** | **55,231,847** |
| **0221201 Mobilization & Demobilization** | **LS** | **1.00** | **1,900,000** | **1,900,000** | **1,900,000** |
| **0221202 Hopper Dredging** | **CY** | **5,793,000.00** | **46,813,960** | **46,813,960** | **46,813,960** |
| **0221203 Sea Turtle Protection** | **EA** | **1.00** | **4,327,700** | **5,517,887** | **5,517,887** |
| **0221204 Navigation Aids** | **LS** | **1.00** | **1,000,000** | **1,000,000** | **1,000,000** |
| **03 Contract 3 - Lower TB** | **LS** | **1.00** | **11,812,840** | **11,812,840** | **11,812,840** |
| **031 Non-Federal Costs** | **LS** | **1.00** | **9,488,000** | **9,488,000** | **9,488,000** |
| **03112 NavigationPorts & Harbor** | **EA** | **1.00** | **9,488,000** | **9,488,000** | **9,488,000** |
| **031201 Dredging for Berthing Areas** | **CY** | **99,000.00** | **1,188,000** | **1,188,000** | **1,188,000** |
| **031202 Upgrade Berthing Area** | **EA** | **1.00** | **8,300,000** | **8,300,000** | **8,300,000** |
| **032 Federal Costs** | **LS** | **1.00** | **2,324,840** | **2,324,840** | **2,324,840** |
| **03212 Navigation Ports and Harbors** | **LS** | **1.00** | **2,324,840** | **2,324,840** | **2,324,840** |
| **0321201 Mobilization & Demobilization** | **LS** | **1.00** | **665,000** | **665,000** | **665,000** |
| **0321202 Pipeline Dredging** | **CY** | **208,000.00** | **1,659,840** | **1,659,840** | **1,659,840** |
| **05 Cont 5 - Ch to BRZPT through BRZPT TB and PA 8** | **LS** | **1.00** | **38,527,891** | **39,466,569** | **39,466,569** |
| **051 Non-Federal Costs** | **LS** | **1.00** | **16,428,000** | **16,428,000** | **16,428,000** |

| Description | UOM | Quantity | DirectCost | ContractCost | ProjectCost |
|---|---|---|---|---|---|
| 05112 NavigationPorts & Harbor | EA | 1.00 | 16,428,000 | 16,428,000 | 16,428,000 |
| 0511201 Dredging for Berthing Areas | CY | 144,000.00 | 1,728,000 | 1,728,000 | 1,728,000 |
| 0511202 Upgrade Berthing Area | EA | 2.00 | 14,700,000 | 14,700,000 | 14,700,000 |
| 052 Federal Costs | LS | 1.00 | 22,099,891 | 23,038,569 | 23,038,569 |
| 05212 Navigation Ports and Harbors | LS | 1.00 | 22,099,891 | 23,038,569 | 23,038,569 |
| 0521201 Mobilization & Demobilization | LS | 1.00 | 700,000 | 700,000 | 700,000 |
| 0521202 Pipeline Dredging | CY | 2,916,000.00 | 17,932,200 | 17,932,200 | 17,932,200 |
| 0521203 PA 8 | EA | 1.00 | 3,467,691 | 4,406,369 | 4,406,369 |
| 06 Cont 6 - Ch to Upper TB throught Uper TB and PA 9 | LS | 1.00 | 28,909,100 | 29,899,502 | 29,899,502 |
| 061 Non-Federal Costs | LS | 1.00 | 19,104,000 | 19,104,000 | 19,104,000 |
| 06112 NavigationPorts & Harbor | EA | 1.00 | 19,104,000 | 19,104,000 | 19,104,000 |
| 0611201 Dredging for Berthing Areas | CY | 317,000.00 | 3,804,000 | 3,804,000 | 3,804,000 |
| 0611202 Upgrade Berthing Area | EA | 2.00 | 15,300,000 | 15,300,000 | 15,300,000 |
| 062 Federal Costs | LS | 1.00 | 9,805,100 | 10,795,502 | 10,795,502 |
| 06212 Navigation Ports and Harbors | LS | 1.00 | 9,805,100 | 10,795,502 | 10,795,502 |
| 0621201 Mobilization & Demobilization | LS | 1.00 | 550,000 | 550,000 | 550,000 |
| 0621202 Pipeline Dredging | CY | 881,000.00 | 5,596,330 | 5,596,330 | 5,596,330 |
| 0621203 PA 9 | EA | 1.00 | 3,658,770 | 4,649,172 | 4,649,172 |
| 07 Contract 7 -Stauffer Ch | LS | 1.00 | 11,229,520 | 11,229,520 | 11,229,520 |
| 071 Non-Federal Costs | LS | 1.00 | 1,092,000 | 1,092,000 | 1,092,000 |
| 03112 NavigationPorts & Harbor | LS | 1.00 | 1,092,000 | 1,092,000 | 1,092,000 |
| 031201 Dredging for Berthing Areas | CY | 91,000.00 | 1,092,000 | 1,092,000 | 1,092,000 |
| 072 Federal Costs | LS | 1.00 | 10,137,520 | 10,137,520 | 10,137,520 |
| 07212 Navigation Ports and Harbors | LS | 1.00 | 10,137,520 | 10,137,520 | 10,137,520 |
| 0721201 Mobilization & Demobilization | LS | 1.00 | 550,000 | 550,000 | 550,000 |
| 0721202 Pipeline Dredging | CY | 1,814,000.00 | 9,587,520 | 9,587,520 | 9,587,520 |

| Description | UOM | Quantity | DirectCost | ContractCost | ProjectCost |
|---|---|---|---|---|---|
| **08 Contract 8- Mitigation** | **LS** | **1.00** | **102,157** | **129,810** | **129,810** |
| **082 Federal Costs** | **LS** | **1.00** | **102,157** | **129,810** | **129,810** |
| **08206 Fish & Wildlife Facilities** | **ACR** | **12.00** | **102,157** | **129,810** | **129,810** |
| **0820601 Tallow Removal** | **ACR** | **12.00** | **10,052** | **12,772** | **12,772** |
| **0820603 Planting Forest Seedlings** | **EA** | **1,800.00** | **18,000** | **22,872** | **22,872** |
| **0820604 Grassland** | **ACR** | **8.00** | **34,877** | **44,318** | **44,318** |
| **0820602 Pond Creation** | **ACR** | **3.00** | **39,229** | **49,848** | **49,848** |

| Description | Page |
|---|---|
| **Project Cost Summary Report** | **1** |
| 01 Contract 1 - Future Ch & Half of Outer Bar Ch | 1 |
| 012 Federal Costs | 1 |
| 01212 Navigation Ports and Harbors | 1 |
| 0121201 Mobilization & Demobilization | 1 |
| 0121202 Hopper Dredging | 1 |
| 0121204 Navigation Aids | 1 |
| 0121203 Sea Turtle Protection | 1 |
| 02 Contract 2 - Half Outer Bar Ch & Jetty Ch | 1 |
| 022 Federal Costs | 1 |
| 02212 Navigation Ports and Harbors | 1 |
| 0221201 Mobilization & Demobilization | 1 |
| 0221202 Hopper Dredging | 1 |
| 0221203 Sea Turtle Protection | 1 |
| 0221204 Navigation Aids | 1 |
| 03 Contract 3 - Lower TB | 1 |
| 031 Non-Federal Costs | 1 |
| 03112 NavigationPorts & Harbor | 1 |
| 031201 Dredging for Berthing Areas | 1 |
| 031202 Upgrade Berthing Area | 1 |
| 032 Federal Costs | 1 |
| 03212 Navigation Ports and Harbors | 1 |
| 0321201 Mobilization & Demobilization | 1 |
| 0321202 Pipeline Dredging | 1 |
| 05 Cont 5 - Ch to BRZPT through BRZPT TB and PA 8 | 1 |
| 051 Non-Federal Costs | 1 |
| 05112 NavigationPorts & Harbor | 1 |
| 05112 NavigationPorts & Harbor | 2 |
| 0511201 Dredging for Berthing Areas | 2 |
| 0511202 Upgrade Berthing Area | 2 |
| 052 Federal Costs | 2 |
| 05212 Navigation Ports and Harbors | 2 |
| 0521201 Mobilization & Demobilization | 2 |
| 0521202 Pipeline Dredging | 2 |
| 0521203 PA 8 | 2 |
| 06 Cont 6 - Ch to Upper TB throught Uper TB and PA 9 | 2 |
| 061 Non-Federal Costs | 2 |
| 06112 NavigationPorts & Harbor | 2 |
| 0611201 Dredging for Berthing Areas | 2 |
| 0611202 Upgrade Berthing Area | 2 |
| 062 Federal Costs | 2 |
| 06212 Navigation Ports and Harbors | 2 |

| Description | Page |
|---|---|
| 0621201 Mobilization & Demobilization | 2 |
| 0621202 Pipeline Dredging | 2 |
| 0621203 PA 9 | 2 |
| 07 Contract 7 -Stauffer Ch | 2 |
| 071 Non-Federal Costs | 2 |
| 03112 NavigationPorts & Harbor | 2 |
| 031201 Dredging for Berthing Areas | 2 |
| 072 Federal Costs | 2 |
| 07212 Navigation Ports and Harbors | 2 |
| 0721201 Mobilization & Demobilization | 2 |
| 0721202 Pipeline Dredging | 2 |
| 08 Contract 8- Mitigation | 2 |
| 08 Contract 8- Mitigation | 3 |
| 082 Federal Costs | 3 |
| 08206 Fish & Wildlife Facilities | 3 |
| 0820601 Tallow Removal | 3 |
| 0820603 Planting Forest Seedlings | 3 |
| 0820604 Grassland | 3 |
| 0820602 Pond Creation | 3 |

US Army Corps
of Engineers®

# FREEPORT HARBOR, TEXAS
# CHANNEL IMPROVEMENT PROJECT
# (WIDENING AND DEEPENING)

## FEASIBILITY RISK ANALYSIS REPORT
## FOR
## GALVESTON DISTRICT, TEXAS

## REPORT UPDATE - 2012

DRAFT

*Prepared for:*

*U.S. Army Corps of Engineers, Galveston District*

*Prepared by:*

*U.S. Army Corps of Engineers, Walla Walla District*
*Cost Engineering Branch*

Date: April 27, 2012

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DRAFT

# EXECUTIVE SUMMARY

## REPORT PURPOSE

The purpose of this risk analysis report is to document the results of the Cost and Schedule Risk Analysis (CSRA) performed for the Freeport Harbor Widening and Deepening Feasibility Study under development by the U.S. Army Corps of Engineers (USACE), Galveston District.

## PROJECT BACKGROUND

The purpose of the feasibility study is to develop and evaluate alternatives for navigation problems that directly affect the Freeport Harbor channel. To allow for a more effective, safe, and efficient waterway, the study focused on eliminating the major problems contributing to inefficiencies on the waterway, such as insufficient depth and width, as determined by fleet forecasts and the requirement for one-way traffic in the channel. The study also identified new economic benefits associated with proposed channel modifications and recommends alternatives that maximize these benefits. The study was conducted to determine if navigation problems currently being experienced at Freeport Harbor are in the Federal interest and to provide documentation needed to recommend Congressional authorization and funding for construction of that project.

The feasibility study resulted in choosing the Locally Preferred Plan (LPP). The chosen project reaches were then placed into separate contracts that equate to an approximate 1-year duration each. Those separate contracts were then studied within the CSRA framework. Note that the choice to establish acquisition strategy and contract duration at this stage greatly diminished certain risks. Those contracts studied are:

- Contract 1: Future Channel Extension and One-Half of the Outer Bar Channel
- Contract 2: One-Half Outer Bar Channel and Jetty Channel
- Contract 3: Lower Turning Basin
- Contract 4: Real Estate PA8
- Contract 5: Channel to Brazosport through Turning Basin
- Contract 6: Channel to Upper Turning Basin through Upper Turning Basin
- Contract 7: Stauffer Channel - Lower and Upper Reach
- Contract 8: Environmental Mitigation

## REPORT SCOPE

The scope of the risk analysis report is to reflect the feasibility study and to calculate and present the cost contingencies at the 80 percent (P80) confidence level using the risk analysis processes as mandated by USACE Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating

Guide for Civil Works. The report presents the contingency results for both cost and schedule risks for all construction features at feasibility level development.

## RISK ANALYSIS PROCESS

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball), which is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes.

Since the dredging estimates for this project were developed within the USACE Cost Engineering Dredge Estimating Program (CEDEP), which is Excel based, the risk analysis process used the CEDEP as the risk model basis, incorporating both cost and schedule. Contracts 4 and 8 (Real Estate and Environmental Mitigation) are minimal costs and were transferred into Excel to support the risk analyses, respectively.

Specifically related to this project, it became apparent that the contracts related to dredging carried similar risks (Contracts 1, 2, 3, 5, 6, and 7). For this reason, the dredging contracts utilized the same risk events identified within the risk register to support the risk models and resulting contingencies. A separate risk register was developed for Contract 8 (Environmental Mitigation).

## CONTINGENCY RESULTS

The USACE Cost Engineering Technical Center of Expertise (TCX) for Civil Works recommends risk analyses output reflect the P80 confidence level in successfully completing the project. The following table reflects those results for the eight specific contracts. It is these contingencies that are reflected within the Total Project Cost Summary.

**Table ES-1. Contract Contingency Results - 80 Percent Confidence**

| Contract No. | Contract Description/Title | Type of Work | Contingency |
|---|---|---|---|
| Contract 1 | Future Channel Extension and One-Half Outer Bar Channel | Dredging | 24% |
| Contract 2 | One-Half Outer Bar Channel and Jetty Channel | Dredging | 24% |
| Contract 3 | Lower Turning Basin | Dredging | 24% |
| Contract 4 | Real Estate for PA8 | | 24% |
| Contract 5 | Channel to Brazosport through Turning Basin | Dredging | 24% |
| Contract 6 | Channel to Upper Turning Basin through Upper Turning Basin | Dredging | 24% |
| Contract 7 | Stauffer Channel - Lower and Upper Reach | Dredging | 24% |
| Contract 8 | Environmental Mitigation | Mitigation | 24% |

Note: Contingency % reflects an 80% confidence level.

Dredging Risks: While dredging risks varied between the six contracts, similar risks were found:

- Fuel price fluctuations and volatility.
- Contractor overhead assumptions and bidding climate/competition.
- Uncertain dredge material classifications, which can impact productivity assumptions.
- Dredging prism that defines the quantities dredged.

Environmental Mitigation Risks: The four most common risk concerns related to the Environmental Mitigation contract, carrying the greater risks were:

- Bidding climate and competition.
- Inflation rates in the local area potentially exceeding the annual Office of Management and Budget rates.
- Potential for scope changes before and after construction contract award.
- Work in the out years subject to cost variances not captured within the estimate or the risk analysis.

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## 1. PURPOSE

The purpose of this report is to document the results of the Cost and Schedule Risk Analysis (CSRA) performed for the Freeport Harbor Widening and Deepening Feasibility Study under development by the U.S. Army Corps of Engineers (USACE), Galveston District.

## 2. BACKGROUND

The original project for Federal channel improvement at Freeport Harbor was authorized by the River and Harbor Act (RHA), approved June 14, 1880, which provided for construction of jetties for controlling and improving the channel over the bar at the mouth of the Brazos River. Work was started in 1881 and continued to 1886 when operations were suspended due to lack of funds. In March 1899, the Brazos River Channel and Dock Company, under authority granted by the Act of August 21, 1888, began rework on the navigation channel. The company was unable to finance completion of the work and in April, the works, rights, and privileges were transferred to the United States. This constituted the initial authorization for the existing project for Freeport Harbor.

The existing Freeport Harbor Project was authorized by the RHAs of May 1950 and July 1958. The RHAs provided for an entrance channel 38 feet deep and 300 feet wide from the Gulf of Mexico to a point inside the jetties and for inside channels 36 feet deep and 200 feet wide to and including the upper turning basin. Greater depth and width were authorized by Congress in 1970 (Section 101 of RHA of 1970, Public Law 91-611; House Document 289, 93rd Congress – 2nd Session, 31 Dec 1975) and by the President in 1974. These authorizations were for the jetty channel to be relocated and deepened to 45 feet, widened to 400 feet, and the north jetty relocated northward. The relocated entrance channel (outer bar) was authorized to a 400-foot width, to a 47-foot depth, and to extend approximately 4.6 miles into the Gulf of Mexico. A final environmental impact statement for the project was prepared by USACE in 1978. In 1978, Seaway Pipeline, Inc., under a Department of Army permit, widened the entrance (outer bar) channel to 400 feet and the jetty channel to 230 feet.

The purpose of the feasibility study was to develop and evaluate alternatives for navigation problems that directly affect the Freeport Harbor Channel. To allow for a more effective, safe, and efficient waterway, the study focused on eliminating the major problems contributing to inefficiencies on the waterway, such as insufficient depth and width, as determined by fleet forecasts and the requirement for one-way traffic in the channel. The study also identified new economic benefits associated with proposed channel modifications and recommends alternatives that maximize these benefits. The study was conducted to determine if navigation problems currently being experienced at Freeport Harbor are in the Federal interest and to provide documentation needed to recommend Congressional authorization and funding for construction of that project.

## 3. REPORT SCOPE

The scope of the risk analysis report is to calculate and present the cost contingencies at the 80 percent confidence level using the risk analysis processes as mandated by USACE Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The report presents the contingency results for both cost and schedule risks for all construction features.

### 3.1 Project Scope

For this feasibility study of the widening and deepening of the Freeport Harbor channel, two project estimates were developed: (1) National Economic Development Plan (NED) and (2) Locally Preferred Plan (LPP). The current existing channel is 45 feet by 400 feet. See table 1 for a description of the project channel reaches for the differences between both proposed plans.

**Table 1. Project Channel Reaches**

| |
|---|
| A. **Future Channel Extension for LPP (Sta. -300+00 to Sta. -350+00).** Should the LPP be selected, this proposed future reach will extend from the present offshore terminus out further into the Gulf of Mexico until the 57-foot contour is encountered. |
| B. **Future Channel Extension for NED (Sta. -300+00 to Sta. -435+00).** Should the NED be selected, this proposed future reach will extend from the present offshore terminus out further into the Gulf of Mexico until the 62-foot contour is encountered. |
| C. **Outer Bar (Sta. -300+00 to Sta. 0+00).** This offshore channel reach under present authorization extends 30,000 feet out into the Gulf of Mexico from its juncture with the jetty channel. Vessels in the entrance channel are completely exposed to cross-currents and waves from the open Gulf. The proposed plans provide for widening the channel 200 feet and 140 feet for the LPP (55'x600') and NED (60'x540'), respectively. |
| D. **Jetty Channel (Sta. 0+00 to Sta. 70+00).** This offshore channel reach under present authorization extends 6,346 feet landward from its juncture with the entrance channel. Vessels in the jetty channel are sheltered from cross-currents and waves by the jetties. The proposed plans provide for transition taper after widening the channel 200 feet and 140 feet for the LPP (55'x600') and NED (60'x540'), respectively |
| E. **Lower Turning Basin (Sta.71+52 to Sta.78+52).** This turning basin reach under present authorization is 750 feet in diameter and is located at the intersection of the GIWW and Freeport Harbor channel adjacent the future LNG facility. The proposed plans provide for no change other than deepening as required per LPP or NED. |
| F. **Channel to New Brazosport Turning Basin (Sta.78+52 to Sta. 101+00).** This reach under present authorization varies in width 400 feet and extends west from the intersection of the GIWW and Freeport Harbor channel adjacent the future LNG facility. The proposed plans provide for no change other than deepening as required per LPP or NED |
| G. **New Brazosport Turning Basin (Sta. 101+00 to Sta. 115+00).** This turning basin reach under present authorization is 1,000 feet in diameter and is located at the terminus of seaway terminal adjacent the GIWW. The proposed plans provide for increasing the footprint to a 1,350-foot diameter and associated deepening as required per LPP or NED. |
| H. **Channel from New Brazosport Turning Basin (Sta. 115+00 to 132+66).** This reach under present authorization varies in width 250-400 feet and extends west from the existing Brazosport Turning Basin |

parallel to seaway terminal. The proposed plans provide for no change other than deepening as required per LPP or NED.

I. **Channel Upper Reach from Station (132+66 to Sta. 174+00).** This reach under present authorization varies in width 275-550 feet and extends west from the existing Brazosport Turning Basin parallel seaway terminal. The proposed plans provide for no change other than deepening as required per LPP or NED.

J. **Upper Turning Basin (Sta. 174+00 to 184+20).** This turning basin reach under present authorization is 1,200 feet in diameter and is the existing project terminus offset the Brazos Harbor channel. The proposed plans provide for no change other than deepening as required per LPP or NED.

K. **Stauffer Channel, Lower Reach (184+20 to 222+00).** This lower existing 200-foot-wide reach adjacent Dow Chemical under present authorization is de-authorized. The proposed plans provide for re-authorizing and improving the channel reach to 40 by 300 feet for the NED or 50 by 300 feet for the LPP.

L. **Stauffer Channel, Upper Reach (222+00 to 260+00).** This upper existing reach, which includes a 500-foot-wide turning basin, is currently de-authorized. The proposed plans provide for re-authorizing and improving the channel reach to 30 by 200 feet to include the 500- by 500-foot-diameter turning basin for both the NED and LPP.

The feasibility study resulted in choosing the LPP. The above reaches were then placed into separate contracts that equate to an approximate 1-year duration. Those separate contracts were then studied within the CSRA framework. Note that the District's choice to establish acquisition strategy and contract duration at this stage greatly diminished certain risks. Those contracts, as compared to the above table and under risk study, are:

- Contract 1: Future Channel Extension and One-Half Outer Bar Channel
- Contract 2: One-Half Outer Bar Channel and Jetty Channel
- Contract 3: Lower Turning Basin
- Contract 4: Real Estate PA8
- Contract 5: Channel to Brazosport through Turning Basin
- Contract 6: Channel to Upper Turning Basin through Upper Turning Basin
- Contract 7: Stauffer Channel - Lower and Upper Reach
- Contract 8: Environmental Mitigation

### 3.2 USACE Risk Analysis Process

The risk analysis process reflected within the risk analysis report uses probabilistic CSRA methods within the framework of the Crystal Ball software. The risk analysis results are intended to serve several functions, one being the establishment of reasonable contingencies reflective of an 80 percent confidence level to successfully accomplish the project work within that established contingency amount. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as provide

tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, CSRA should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting, and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, the risk analysis is performed to meet the requirements and recommendations of the following documents and sources:

- CSRA process guidance prepared by the USACE Cost Engineering TCX.
- Memorandum from Major General Don T. Riley (U.S. Army Director of Civil Works), dated July 3, 2007.
- Engineering and Construction Bulletin issued by James C. Dalton, P.E. (Chief, Engineering and Construction, Directorate of Civil Works), dated September 10, 2007.
- ER 1110-2-1150, dated August 31, 1999.
- ER 1110-2-1302, dated September 15, 2008.
- Engineering Technical Letter 1110-2-573, dated September 30, 2008.

## 4. METHODOLOGY/PROCESS

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve any desired level of cost confidence. A parallel process is also used to determine the probability of various project schedule duration outcomes and quantify the required schedule contingency (i.e., float) needed in the schedule to achieve any desired level of schedule confidence.

In simple terms, contingency is an amount added to an estimate (cost or schedule) to allow for items, conditions, or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed in a probabilistic context using confidence levels.

The USACE Cost Engineering TCX for Civil Works guidance for CSRA generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk-adverse approach (whereas the use of P50 would be a risk-neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a

commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes.

Since the dredging estimates for this project were developed within the USACE Cost Engineering Dredge Estimating Program (CEDEP), which is Excel based, the risk analysis used the CEDEP as the risk model basis, incorporating both cost and schedule. Contracts 4 and 8 (Jet Grouting and Environmental Mitigation) costs were transferred into Excel to support the risk analysis.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in section 5.

### 4.1 Identify and Assess Risk Factors

Identifying the risk factors via the project development team (PDT) are considered a qualitative process that results in establishing a risk register document. The risk register document then serves to support the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

The qualitative risks were captured and placed within the risk register format. This format is the basis used for establishing the quantitative risks and developing the Crystal Ball risk model.

Specifically related to this project, it became apparent that the contracts related to dredging carried similar risks (Contracts 1, 2, 3, 5, 6, and 7). For this reason, the dredging contracts utilized the same risk events identified within the risk register to support the risk models and resulting contingencies. Separate risk registers were developed for Contract 4 (Jet Grouting) and Contract 8 (Environmental Mitigation).

### 4.2 Risk Registers

A risk register is a tool commonly used in project planning and risk analysis. The risk register reflects the results of risk factor identification and assessment, risk factor quantification, and contingency analysis. It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of

project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting risk analysis feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

The summary risk registers in tables 2 and 3 make distinction between two primary categories: dredging and environmental mitigation. Once established, the risk registers serve as the risk analysis model per contract. In the cases studied, the schedule analysis was incorporated into the cost analysis as another risk event.

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**Table 2. Dredging Risk Register**

| Risk No. | Risk/Opportunity Event | Discussion and Concerns | Likelihood* | Impact* | Risk Level* | Measurement / Adjustments | Risk Applied to |
|---|---|---|---|---|---|---|---|
| 1 | Bidding Climate | Corps studies have resulted in an expected dredge shortage as compared to the many anticipated projects in the Gulf region. Less competition is likely, resulting in longer mobilizations, higher bids. Acquisition planning may help alleviate some of this concern. | VERY LIKELY | SIGNIFICANT | HIGH | Limited Bid Competition impacting Mobilization distance and contractor markups. | Contractor |
| 2 | Dredge Material | Inadequate Geotechnical data of the dredged material may result in a more difficult material, such as stiff clays, that would impact productivity. | LIKELY | MARGINAL | MODERATE | Productivity - Duration | Production |
| 3 | Dredged Quantity (prism) | Dredging commonly results in changed quantities resulting from inadequate underwater surveys. There is potential that the dredging material prism could change. | UNLIKELY | SIGNIFICANT | MODERATE | Volume - CY | Production |
| 4 | Scope Changes | As the designs are further developed, there is potential that the scope could change. | UNLIKELY | SIGNIFICANT | MODERATE | Volume - CY | Dredge quantity |
| 5 | Weather | Severe weather in the Gulf region can cause delays and possible remobilizations. To impact dredging, weather would have to be very severe. | UNLIKELY | SIGNIFICANT | MODERATE | Productivity - Duration | Equipment |

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## Dredging Risk Register (Continued)

| Risk No. | Risk/Opportunity Event | Discussion and Concerns | Likelihood* | Impact* | Risk Level* | Measurement / Adjustments | Risk Applied to |
|---|---|---|---|---|---|---|---|
| 6 | Schedule Constraints | Contract and environmental schedule constraints can cause delays, force acceleration, require larger dredges that may be unavailable due to competing needs. The greater schedule concern would be funding availability which studied under a different risk. | UNLIKELY | MARGINAL | LOW | Duration | Equipment |
| 7 | Labor Availability/Pricing | Gulf region labor is fairly low when compared to national rates. Slower economy should keep the rates reasonable with little impact. Travel and per diem could be an issue. | UNLIKELY | SIGNIFICANT | MODERATE | Hourly Wage Rates | Labor |
| 8 | Equipment Availability/Pricing | Corps studies suggest a possible dredge shortage, but this concern has lessened 6 years post-Katrina in the Gulf region. A shortage and lost competition could still impact bids. | UNLIKELY | SIGNIFICANT | MODERATE | Equipment Rates | Contractor |
| 9 | Fuel Prices | Fuel price fluctuations continue. Dredge operations are significantly impacted by fuel usage and cost. Current estimate is based on current fuel prices. | VERY LIKELY | SIGNIFICANT | HIGH | Fuel $/Gal | Fuel |
| 10 | Potential savings due to innovation, streamlining, and gains in efficiency | There seems to be little potential for efficiency gains with the dredging projects. "It is what it is." | VERY UNLIKELY | NEGLIGIBLE | LOW | Volume - CY | N/A |
| 11 | Inflation Increases | Inflationary costs could impact project costs in the long term. Volatile fuel pricing on a dredge project could exceed standard Office of Management and Budget (OMB) inflation rates. | LIKELY | MARGINAL | MODERATE | Escalation comparisons | Contract |

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**Table 3. Environmental Mitigation Risk Register**

| Risk No. | Risk/Opportunity Event | Discussion and Concerns | Likelihood* | Impact* | Risk Level* | Measurement / Adjustments | Risk Applied to |
|---|---|---|---|---|---|---|---|
| 1 | Bidding Climate | There is some concern that bidding climate may result in less competitive bids. Current market in the area seems fairly robust and is supported by large industry in the vicinity. | UNLIKELY | SIGNIFICANT | MODERATE | +or- 20% | Contract |
| 2 | Quotes - Estimate Confidence | Mitigation estimate totals approximately $100,000 which is a very small part of the project. Of the $100,000, 25% is supported by a quote. The remaining costs are structured as unit prices similar to historical values. Estimate confidence is more related to quantity of acres involved. | LIKELY | MARGINAL | MODERATE | Scope Changes | Contract |
| 3 | Scope Changes | Feasibility level design, resulting in potential that quantities could change. Cost to overall project is minimal (less than one %). | LIKELY | MARGINAL | MODERATE | Scope Changes | Contract |
| 4 | Weather | Severe weather in the Gulf region can cause delays and possible remobilizations. This impacts productivity. Weather impacts of severity would be somewhat unlikely for plantings. | UNLIKELY | MARGINAL | LOW | Unstudied | Quotes |
| 5 | Labor Availability/Pricing | Gulf region labor is fairly low when compared to national rates. Slower economy should keep the rates reasonable with little impact. Travel and per diem could be an issue. | UNLIKELY | MARGINAL | LOW | Unstudied | N/A |
| 6 | Fuel Prices | Fuel price fluctuations continue. Fuel more greatly impacts dredging costs. This part of the work is not dredging. | UNLIKELY | MARGINAL | LOW | Unstudied | N/A |
| 7 | Savings Opportunities | There seems to be little potential for efficiency gains with the jet grouting. It must be done. | UNLIKELY | NEGLIGIBLE | LOW | Unstudied | N/A |
| 8 | Inflation Increases | Inflationary costs could impact project costs in the long term. Volatile fuel pricing on a dredge project could exceed standard OMB inflation rates. Current estimate fuel pricing is considered conservative. | LIKELY | MARGINAL | MODERATE | Applied in CSRA model | Contract |

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### 4.3 Quantify Risk Factor Impacts

The quantitative impacts of risk factors on project plans are analyzed using a combination of professional judgment, empirical data, and analytical techniques. Risk factor impacts are quantified using probability distributions (density functions), because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involves multiple project team disciplines and functions. However, the quantification process relies more extensively on collaboration between cost engineering, designers, and risk analysis team members with lesser inputs from other functions and disciplines.

The following is an example of the PDT quantifying risk factor impacts by using an iterative, consensus-building approach to estimate the elements of each risk factor:

- Maximum possible value for the risk factor.
- Minimum possible value for the risk factor.
- Most likely value (the statistical mode), if applicable.
- Nature of the probability density function used to approximate risk factor uncertainty.
- Mathematical correlations between risk factors.
- Affected cost estimate and schedule elements.

In this study, the risk discussions focused on the dredging contracts since they were similar in nature of risks, as well as comprised the bulk of the project costs. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions are meant to support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

For the six dredge contracts, the estimates were developed using USACE's CEDEP, which is Excel based and can also be used to support the Crystal Ball model. The CEDEP model allowed risk study at the detailed estimate level by incorporating variances for direct and indirect costs that support the risk register concerns. The study went even further, considering items such contractor markups, mobilization, quantities, and productivities. Within that same CEDEP, schedule variance is also included since it relates to the productivity factors found within CEDEP.

### 4.4 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software (an add-in to the Microsoft Excel format of the cost estimate and schedule). *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks

identified for each option (i.e., low-level risks are typically not considered but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the base cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

For schedule contingency within this analysis, noting that the contracts were separated into an approximate 1-year construction duration, the schedule risk of escalation was applied within the cost risk model.

## 5. RISK ANALYSIS RESULTS

### 5.1 Contingency Results at 80 Percent Confidence

The Cost Engineering TCX recommends risk analyses output reflect the P80 confidence level in successfully completing the project. The following table reflects those results for the eight specific contracts. It is these contingencies that are reflected within the Total Project Cost Summary.

**Table 4. Contract Contingency Results - 80 Percent Confidence**

| Contract No. | Contract Description/Title | Type of Work | Contingency |
|---|---|---|---|
| Contract 1 | Future Channel Extension and One-Half Outer Bar Channel | Dredging | 24% |
| Contract 2 | One-Half Outer Bar Channel and Jetty Channel | Dredging | 24% |
| Contract 3 | Lower Turning Basin | Dredging | 24% |
| Contract 4 | Real Estate for PA8 | | 24% |
| Contract 5 | Channel to Brazosport through Turning Basin | Dredging | 24% |
| Contract 6 | Channel to Upper Turning Basin through Upper Turning Basin | Dredging | 24% |
| Contract 7 | Stauffer Channel - Lower and Upper Reach | Dredging | 24% |
| Contract 8 | Environmental Mitigation | Mitigation | 24% |

Note: Contingency % reflects an 80% confidence level. While the Mitigation contingency was less, the District chose 24% to remain consistent with the dredging contingency.

### 5.2 Model Sensitivity Analysis and Output

The sensitivity analysis output indicates the risk events carrying the greatest potential variance in cost and schedule that also result in the greatest risks. For this report, the sensitivity results are presented for a sample of the dredging projects and environmental mitigation.

### 5.2.1 Dredging Sensitivity

The four most common risk concerns related to dredging, carrying the greater risks noted in the figure below were concern for:

- Fuel price fluctuations and volatility.
- Contractor overhead assumptions and bidding climate/competition.
- Uncertain dredge material classifications, which can impact productivity assumptions.
- Dredging prism, which defines the quantities dredged.

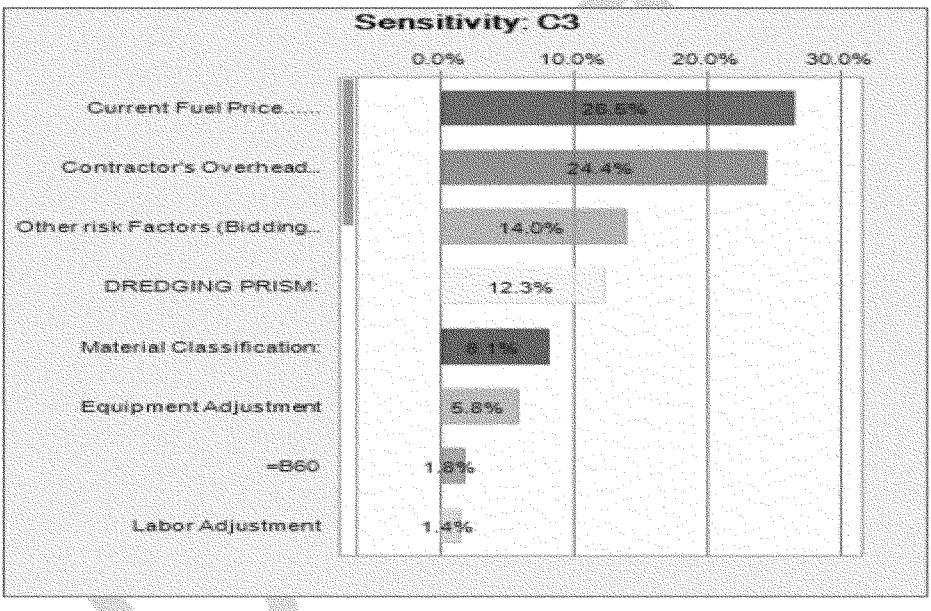


**Figure 1. Dredging Sensitivity**

Fuel Price Fluctuations: Within the past decade, fuel prices have fluctuated dramatically, but continue to creep higher as each price rise settles. While the previous risk of Inflation would seem to capture this issue, the two were studied separately. Fuel pricing is an element of the estimate, while inflation and funding are elements of the program. Fuel pricing fluctuations are currently unavoidable; however, contract solicitations may benefit from timely award during low fuel season.

Contractor Overhead and Bidding Climate/Competition: USACE studies of future dredging needs have indicated that there is a potential shortage of dredges to support the dredging programs in the Gulf regions. To further complicate, differences in assumed estimate overheads can vary between small and large businesses within that competition. The risk may be mitigated depending on acquisition strategy, dredging season as related to severe weather, fuel costs, any wildlife implications, and contract duration.

Uncertain Dredge Material Classifications: As geotechnical investigations continue during PED phase, better understanding of the dredged materials will be obtained. Until then, limited geotechnical data results in a less confident estimated productivity of that dredged material.

Dredging Prism: Dredging Prism equates to quantities dredged. As better survey information is obtained and designs mature, this risk is reduced; however, until that occurs, confidence and quantity variance remains a concern. The other main concern is related to the construction activities in the way of quantity impacts and modifications, resulting in further quantity variance.

### 5.2.2 Environmental Mitigation

Studies indicate that the environmental mitigation risks are less than the dredging risks and resulted in a lower contingency. With the minimal overall project cost to the project, the PDT chose to apply the same 24% contingency as calculated in the dredging contracts. Though small, the four most common risk concerns related to the environmental mitigation, carrying the greater risks noted in the figure below were concerned for:

- Bidding climate and competition.
- Inflation rates in the local area potentially exceeding the annual OMB rates.
- Potential for scope changes before and after construction contract award.
- Work in the out years subject to cost variances not captured within the estimate or the risk analysis.

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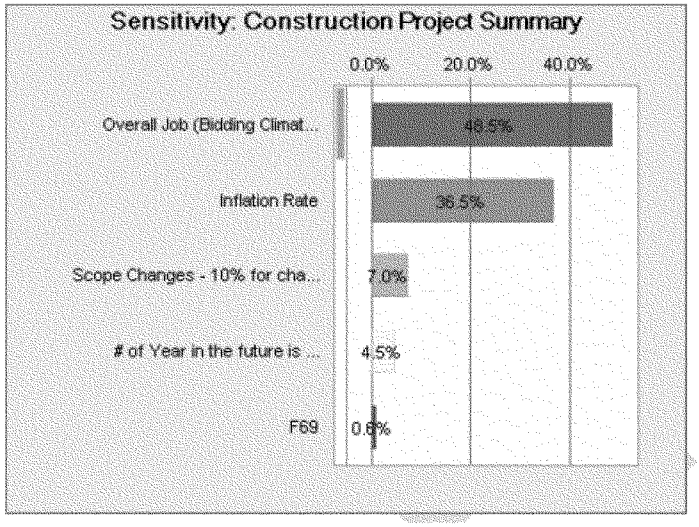


**Figure 2. Environmental Mitigation Sensitivity**

Bidding Climate: Bidding climate is a concern related to the current market conditions but also the risks carried within the quality of the acquisition strategy and contract package. Bidding climate can also be a reflection of the contract acquisition strategy such as small business, sole source procurement, etc. These methods commonly increase construction contract costs in the form of less competition, higher contractor markups, etc.

Inflation: There is a concern that over time, while waiting for Federal funding, the OMB escalation rates may not fully adjust for the local market. In the case of jet grouting, as compared to dredging activities, this risk is less. Yet the risk remains and is a common risk when the program is accomplished over a lengthy period of time.

Scope Changes: Generally speaking, feasibility designs typically lack adequate geotechnical information that can impact the quantities greatly. As better survey information is obtained and designs mature, this risk is reduced; however, until that occurs, confidence and quantity variance remains a concern. The other main concern is related to the construction activities in the way of quantity impacts and modifications, resulting in further quantity variance.

Work in the Out Years: The environmental mitigation work is scheduled in the out years. Over time, there is greater risk related to scope changes and unit cost variances. This item addresses the potential for unit cost variances.

**EXHIBIT "A"**

MAP SHEETS DEPICTING VICINITY OF PROJECT, PLACEMENT AREAS, PIPELINE EASEMENTS, CHANNEL IMPROVEMENT EASEMENTS AND MITIGATION SITES REQUIRED FOR REAL ESTATE INTEREST.

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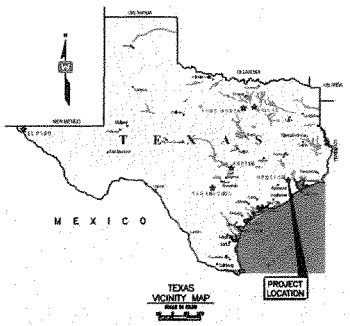
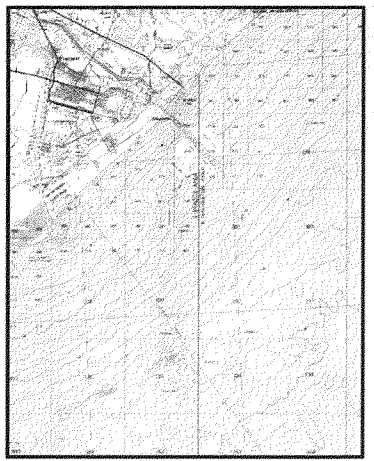
# FREEPORT JETTIES NED PLAN
# BRAZORIA COUNTY, TEXAS
# REAL ESTATE MAPS 2008



TEXAS VICINITY MAP



TABLE

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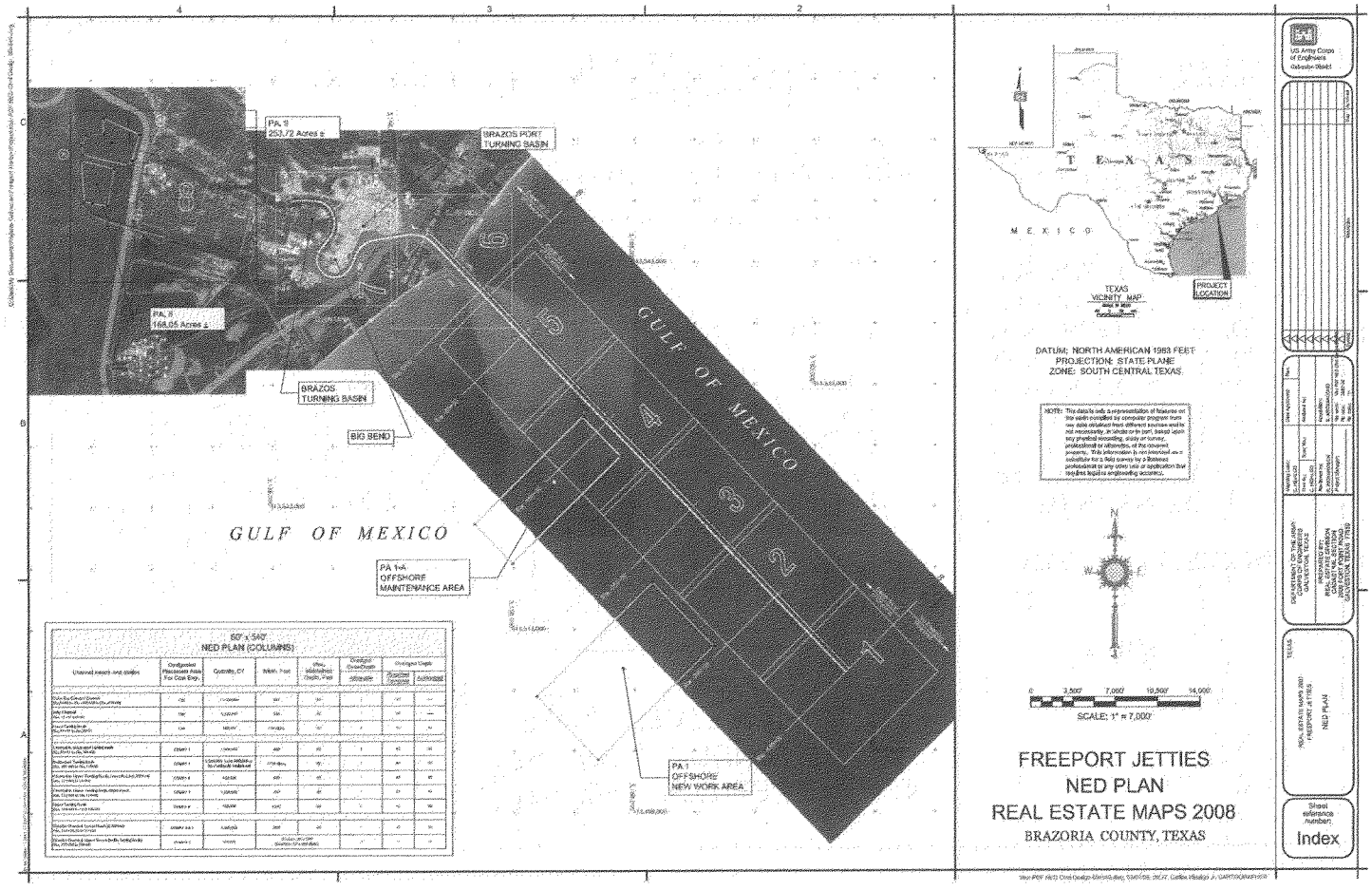
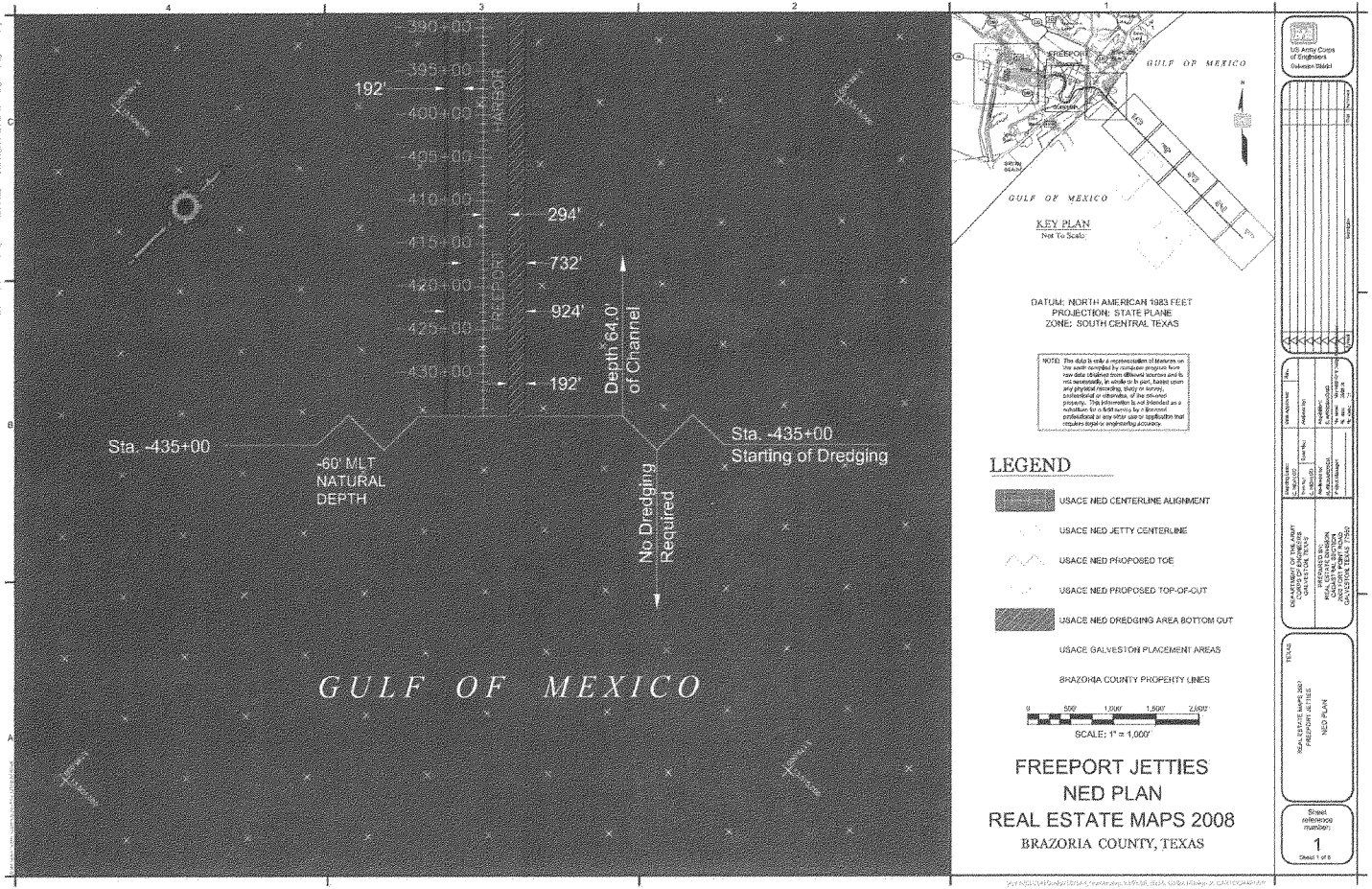
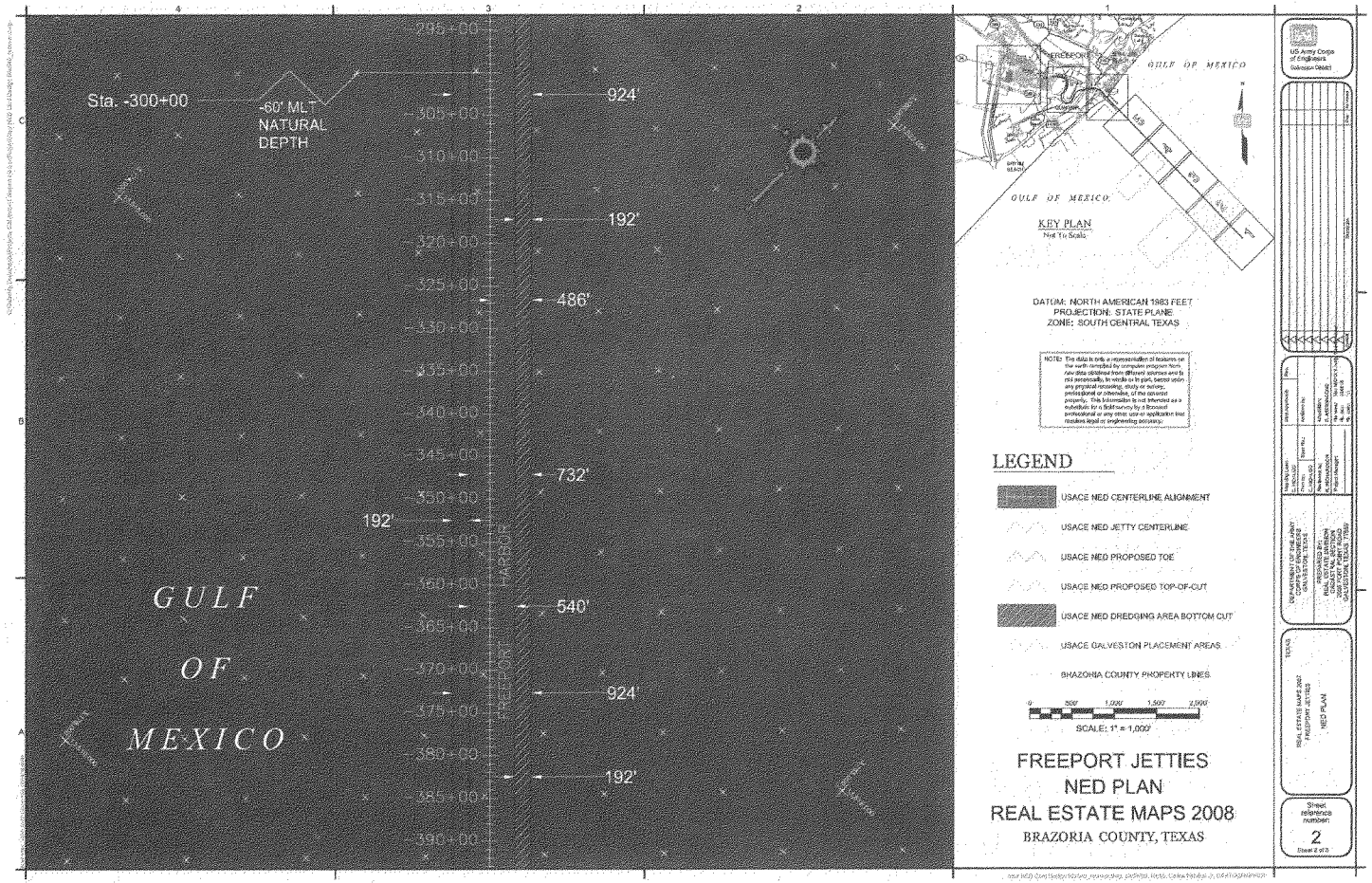
| MAP SHEET | 3 |
| MAP SHEET | 4 |
| MAP SHEET | 5 |
| MAP SHEET | 6 |
| MAP SHEET | 7 |
| MAP SHEET | 8 |

UNITED STATES ARMY CORPS
OF
ENGINEERS
GALVESTON DISTRICT

PLACE TITLE OF PROJECT HERE


PA 9
253.72 Acres ±
BRAZOS PORT
TURNING BASIN
PA 8
168.05 Acres ±
BRAZOS
TURNING BASIN
BIG BEND
GULF OF MEXICO
GULF OF MEXICO
PA 1-A
OFFSHORE
MAINTENANCE AREA
PA 1
OFFSHORE
NEW WORK AREA
60' x 540'
NED PLAN (COLUMNS)
TEXAS
VICINITY MAP
PROJECT
LOCATION
DATUM: NORTH AMERICAN 1983 FEET
PROJECTION: STATE PLANE
ZONE: SOUTH CENTRAL TEXAS
SCALE: 1" = 7,000'
FREEPORT JETTIES
NED PLAN
REAL ESTATE MAPS 2008
BRAZORIA COUNTY, TEXAS
US Army Corps
of Engineers
Galveston District
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
GALVESTON, TEXAS
REQUESTED BY:
REAL ESTATE DIVISION
CONSTRUCTION SECTION
2000 FORT POINT ROAD
GALVESTON, TEXAS 77550
TEXAS
REAL ESTATE MAPS 2008
FREEPORT JETTIES
NED PLAN
Sheet
reference
number
Index


390+00
395+00
400+00
405+00
410+00
415+00
420+00
425+00
430+00
HARBOR
FREEPORT
192'
294'
732'
924'
192'
Depth 64.0' of Channel
Sta. -435+00
-60' MLT NATURAL DEPTH
Sta. -435+00
Starting of Dredging
No Dredging Required
GULF OF MEXICO
FREEPORT
GULF OF MEXICO
GULF OF MEXICO
KEY PLAN
Not To Scale
DATUM: NORTH AMERICAN 1983 FEET
PROJECTION: STATE PLANE
ZONE: SOUTH CENTRAL TEXAS
NOTE: This data is only a representation of features on the earth compiled by computer programs from raw data obtained from different sources and is not necessarily, in whole or in part, based upon any physical recording, survey or survey, professional or otherwise, of the relevant property. This information is not intended as a substitute for a field survey by a licensed professional or any other use or application that requires legal or engineering accuracy.
LEGEND
USACE NED CENTERLINE ALIGNMENT
USACE NED JETTY CENTERLINE
USACE NED PROPOSED TOE
USACE NED PROPOSED TOP-OF-OUT
USACE NED DREDGING AREA BOTTOM CUT
USACE GALVESTON PLACEMENT AREAS
BRAZORIA COUNTY PROPERTY LINES
0 500' 1,000' 1,500' 2,000'
SCALE: 1" = 1,000'
FREEPORT JETTIES
NED PLAN
REAL ESTATE MAPS 2008
BRAZORIA COUNTY, TEXAS
US Army Corps of Engineers
Galveston District
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
GALVESTON, TEXAS
PREPARED BY:
REAL ESTATE DIVISION
GALVESTON DISTRICT
2000 FORT POINT ROAD
GALVESTON, TEXAS 77550
REAL ESTATE MAPS 2007
FREEPORT JETTIES
NED PLAN
Sheet reference number:
1
Sheet 1 of 6


Sta. -300+00
-60' MLT
NATURAL
DEPTH
924'
192'
486'
732'
192'
540'
924'
192'
GULF
OF
MEXICO
FREEPORT HARBOR
-305+00
-310+00
-315+00
-320+00
-325+00
-330+00
-335+00
-340+00
-345+00
-350+00
-355+00
-360+00
-365+00
-370+00
-375+00
-380+00
-385+00
-390+00
FREEPORT
GULF OF MEXICO
GULF OF MEXICO
KEY PLAN
Not To Scale
DATUM: NORTH AMERICAN 1983 FEET
PROJECTION: STATE PLANE
ZONE: SOUTH CENTRAL TEXAS
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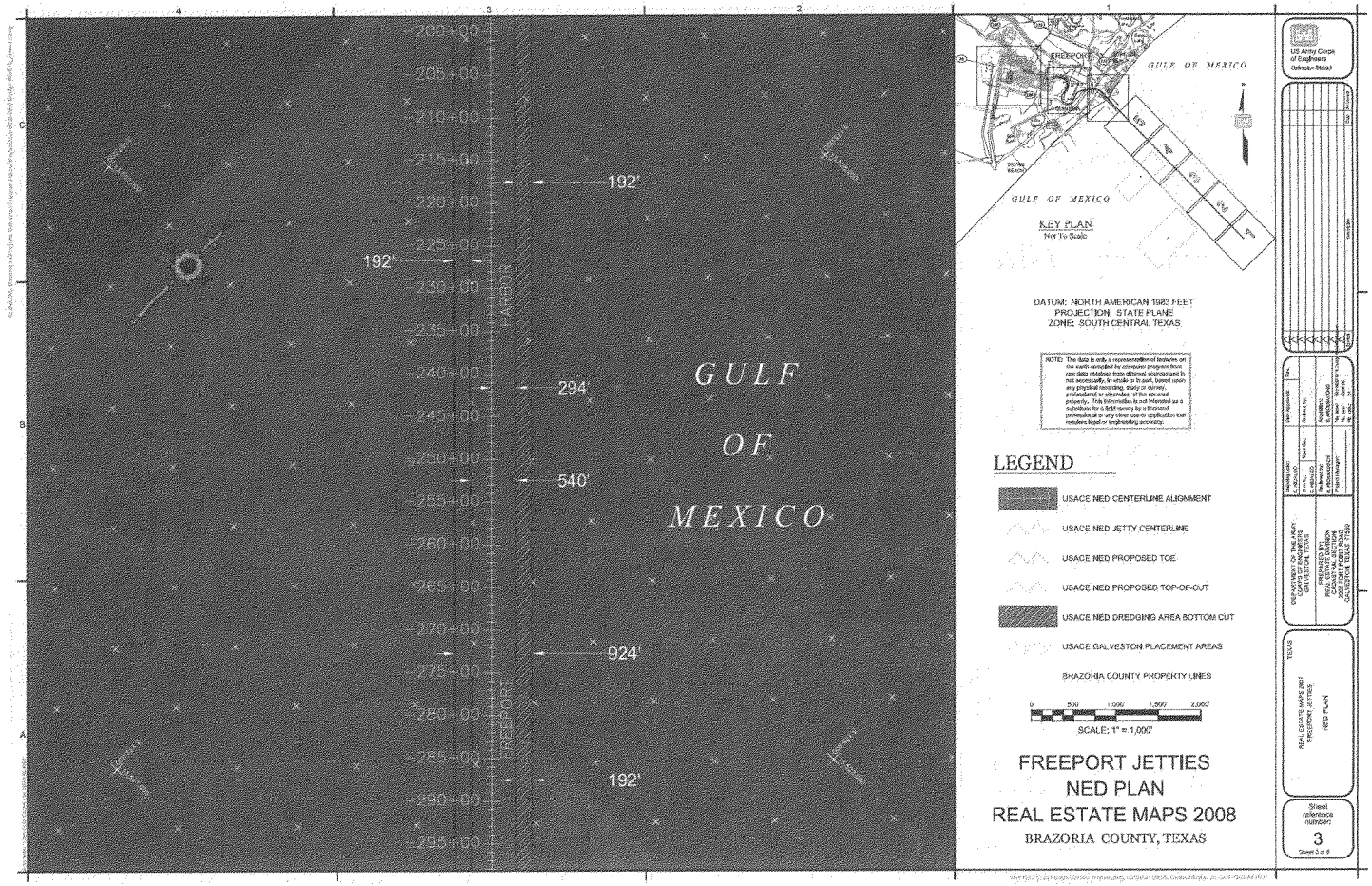
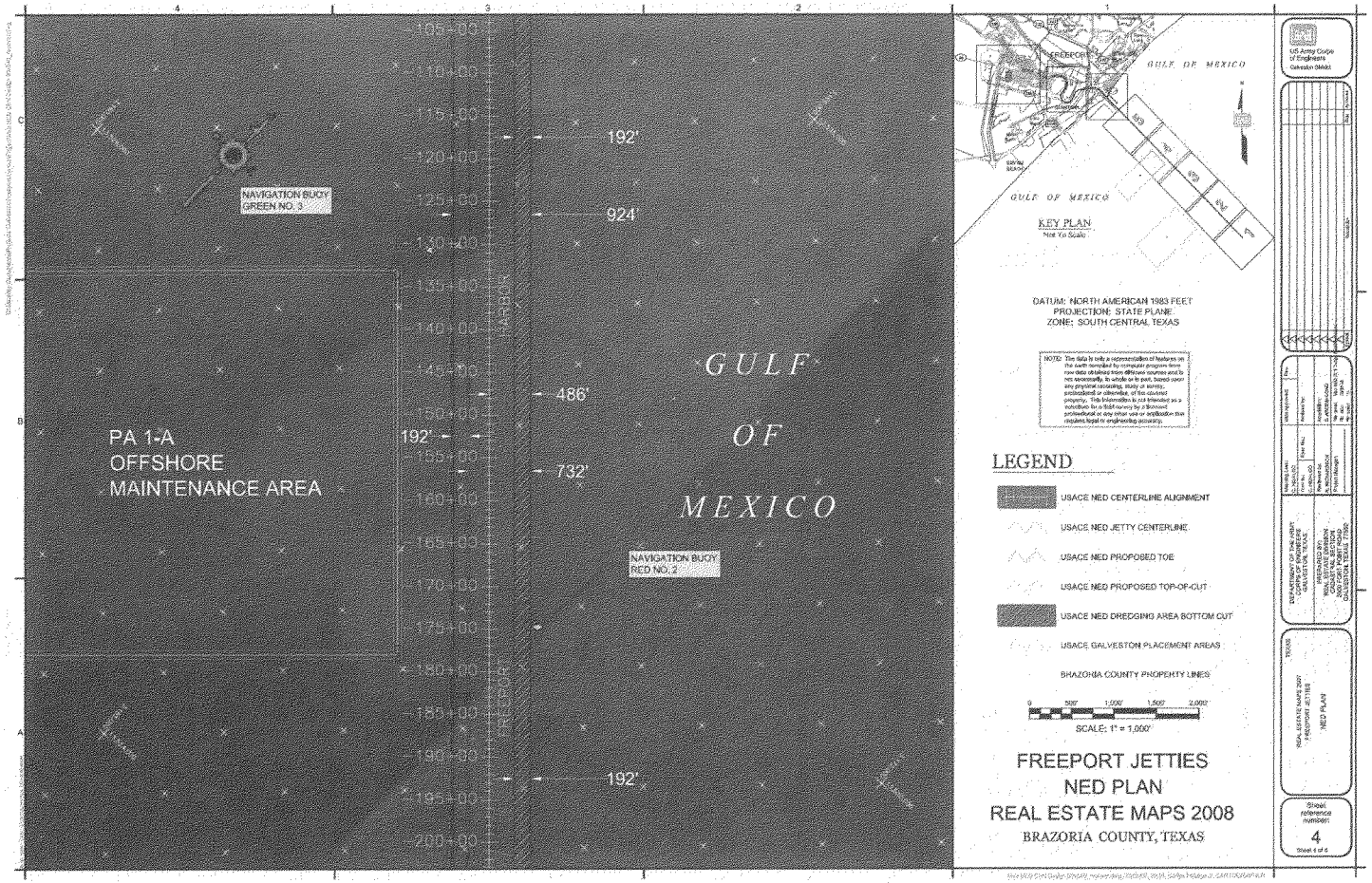
LEGEND
USACE NED CENTERLINE ALIGNMENT
USACE NED JETTY CENTERLINE
USACE NED PROPOSED TOE
USACE NED PROPOSED TOP-OF-CUT
USACE NED DREDGING AREA BOTTOM CUT
USACE GALVESTON PLACEMENT AREAS
BRAZORIA COUNTY PROPERTY LINES
0 500' 1,000' 1,500' 2,000'
SCALE: 1" = 1,000'
FREEPORT JETTIES
NED PLAN
REAL ESTATE MAPS 2008
BRAZORIA COUNTY, TEXAS
US Army Corps of Engineers
Galveston District
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
GALVESTON DISTRICT
PREPARED BY:
REAL ESTATE DIVISION
2000 FORT POINT ROAD
GALVESTON, TEXAS 77550
TEXAS
REAL ESTATE MAPS 2007
FREEPORT JETTIES
NED PLAN
Sheet reference number
2
Sheet 2 of 3



GULF OF MEXICO
FREEPORT
HARBOR
192'
294'
540'
924'
192'
KEY PLAN
Not To Scale
DATUM: NORTH AMERICAN 1983 FEET
PROJECTION: STATE PLANE
ZONE: SOUTH CENTRAL TEXAS
LEGEND
USACE NED CENTERLINE ALIGNMENT
USACE NED JETTY CENTERLINE
USACE NED PROPOSED TOE
USACE NED PROPOSED TOP-OF-CUT
USACE NED DREDGING AREA BOTTOM CUT
USACE GALVESTON PLACEMENT AREAS
BRAZORIA COUNTY PROPERTY LINES
SCALE: 1" = 1,000'
FREEPORT JETTIES
NED PLAN
REAL ESTATE MAPS 2008
BRAZORIA COUNTY, TEXAS
US Army Corps of Engineers
Galveston District
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
GALVESTON, TEXAS
PREPARED BY:
REAL ESTATE DIVISION
CADASTRAL SECTION
2007 FORT POINT ROAD
GALVESTON, TEXAS 77550
TEXAS
REAL ESTATE MAPS 2007
FREEPORT JETTIES
NED PLAN
Sheet reference number:
3


NAVIGATION BUOY GREEN NO. 3
PA 1-A
OFFSHORE
MAINTENANCE AREA
192'
924'
486'
732'
192'
GULF
OF
MEXICO
NAVIGATION BUOY RED NO. 2
192'
FREEPORT
105+00
110+00
115+00
120+00
125+00
130+00
135+00
140+00
145+00
150+00
155+00
160+00
165+00
170+00
175+00
180+00
185+00
190+00
195+00
200+00
FREEPORT
GULF OF MEXICO
GULF OF MEXICO
KEY PLAN
Not To Scale
DATUM: NORTH AMERICAN 1983 FEET
PROJECTION: STATE PLANE
ZONE: SOUTH CENTRAL TEXAS
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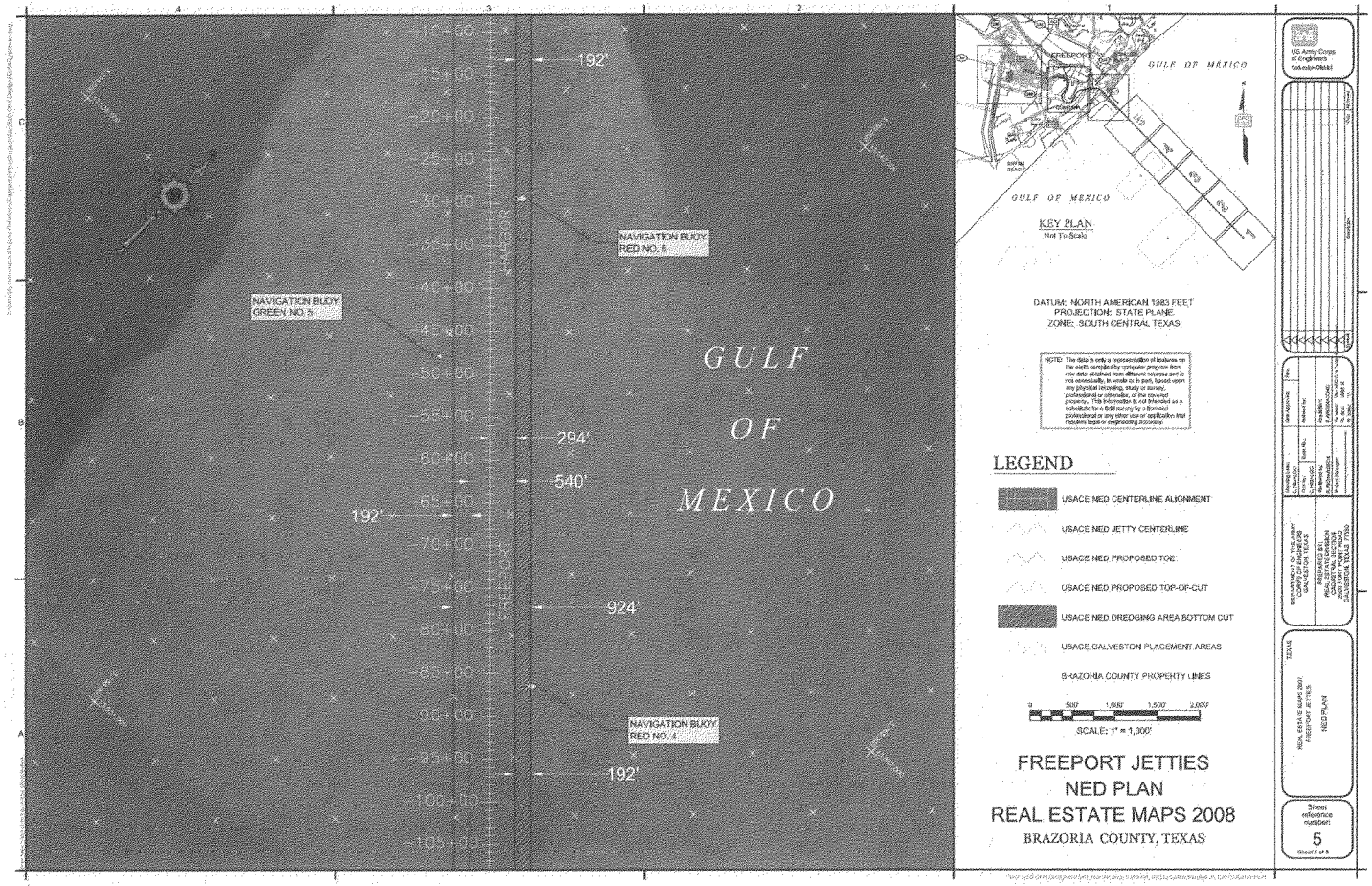
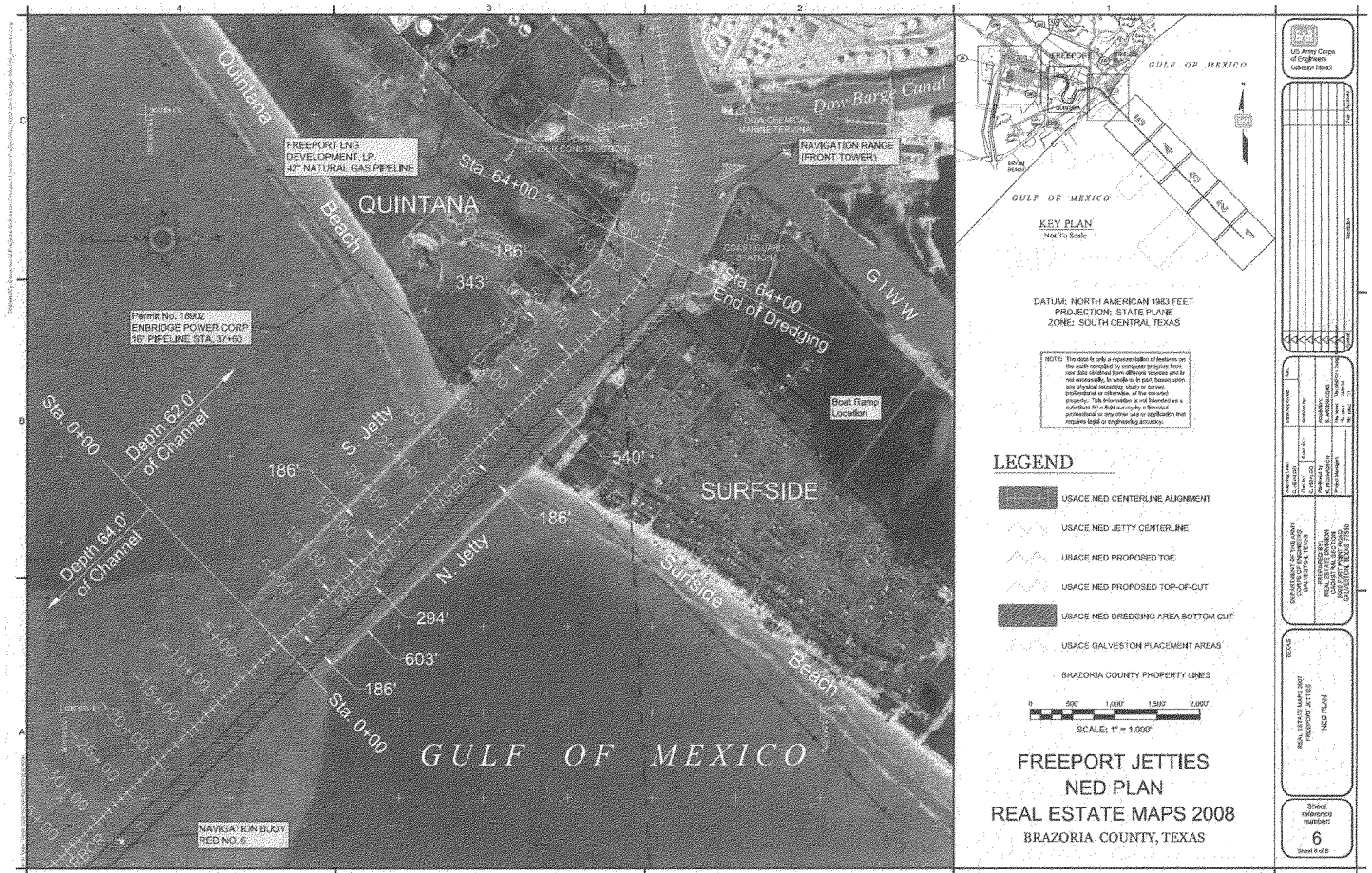
LEGEND
USACE NED CENTERLINE ALIGNMENT
USACE NED JETTY CENTERLINE
USACE NED PROPOSED TOE
USACE NED PROPOSED TOP-OF-CUT
USACE NED DREDGING AREA BOTTOM CUT
USACE GALVESTON PLACEMENT AREAS
BRAZORIA COUNTY PROPERTY LINES
0 500' 1,000' 1,500' 2,000'
SCALE: 1" = 1,000'
FREEPORT JETTIES
NED PLAN
REAL ESTATE MAPS 2008
BRAZORIA COUNTY, TEXAS
US Army Corps of Engineers
Galveston District
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
GALVESTON, TEXAS
PREPARED BY:
REAL ESTATE DIVISION
GALVESTON DISTRICT
2000 FORT POINT ROAD
GALVESTON, TEXAS 77550
REAL ESTATE MAPS 2007
FREEPORT JETTIES
NED PLAN
Sheet reference number:
4
Sheet 4 of 6


NAVIGATION BUOY GREEN NO. 3
NAVIGATION BUOY RED NO. 6
NAVIGATION BUOY RED NO. 4
GULF OF MEXICO
192'
294'
540'
192'
924'
192'
GULF OF MEXICO
KEY PLAN
Not To Scale
DATUM: NORTH AMERICAN 1983 FEET
PROJECTION: STATE PLANE
ZONE: SOUTH CENTRAL TEXAS
LEGEND
USACE NED CENTERLINE ALIGNMENT
USACE NED JETTY CENTERLINE
USACE NED PROPOSED TOE
USACE NED PROPOSED TOP-OF-CUT
USACE NED DREDGING AREA BOTTOM CUT
USACE GALVESTON PLACEMENT AREAS
BRAZORIA COUNTY PROPERTY LINES
SCALE: 1" = 1,000'
FREEPORT JETTIES
NED PLAN
REAL ESTATE MAPS 2008
BRAZORIA COUNTY, TEXAS


QUINTANA
SURFSIDE
Quintana Beach
Surfside Beach
Dow Barge Canal
FREEPORT LNG DEVELOPMENT, LP
42" NATURAL GAS PIPELINE
Permit No. 18902
ENBRIDGE POWER CORP
16" PIPELINE STA. 37+90
NAVIGATION RANGE (FRONT TOWER)
NAVIGATION BUOY RED NO. 6
Sta. 64+00
Sta. 0+00
End of Dredging
Boat Ramp Location
S. Jetty
N. Jetty
GIWW
Depth 62.0' of Channel
Depth 64.0' of Channel
186'
343'
540'
294'
603'
GULF OF MEXICO
FREEPORT
GULF OF MEXICO
KEY PLAN
Not To Scale
DATUM: NORTH AMERICAN 1983 FEET
PROJECTION: STATE PLANE
ZONE: SOUTH CENTRAL TEXAS
NOTE: This data is only a representation of features on the earth compiled by computer programs from raw data obtained from different sources and is not necessarily, in whole or in part, based upon any physical recording, study or survey, professional or otherwise, of the denoted property. This information is not intended as a substitute for a field survey by a licensed professional or any other use or application that requires legal or engineering accuracy.
LEGEND
USACE NED CENTERLINE ALIGNMENT
USACE NED JETTY CENTERLINE
USACE NED PROPOSED TOE
USACE NED PROPOSED TOP-OF-CUT
USACE NED DREDGING AREA BOTTOM CUT
USACE GALVESTON PLACEMENT AREAS
BRAZORIA COUNTY PROPERTY LINES
0 500 1,000' 1,500' 2,000'
SCALE: 1" = 1,000'
FREEPORT JETTIES
NED PLAN
REAL ESTATE MAPS 2008
BRAZORIA COUNTY, TEXAS
US Army Corps of Engineers Galveston District
TEXAS
REAL ESTATE MAPS 2007
FREEPORT JETTIES
NED PLAN
Sheet reference number
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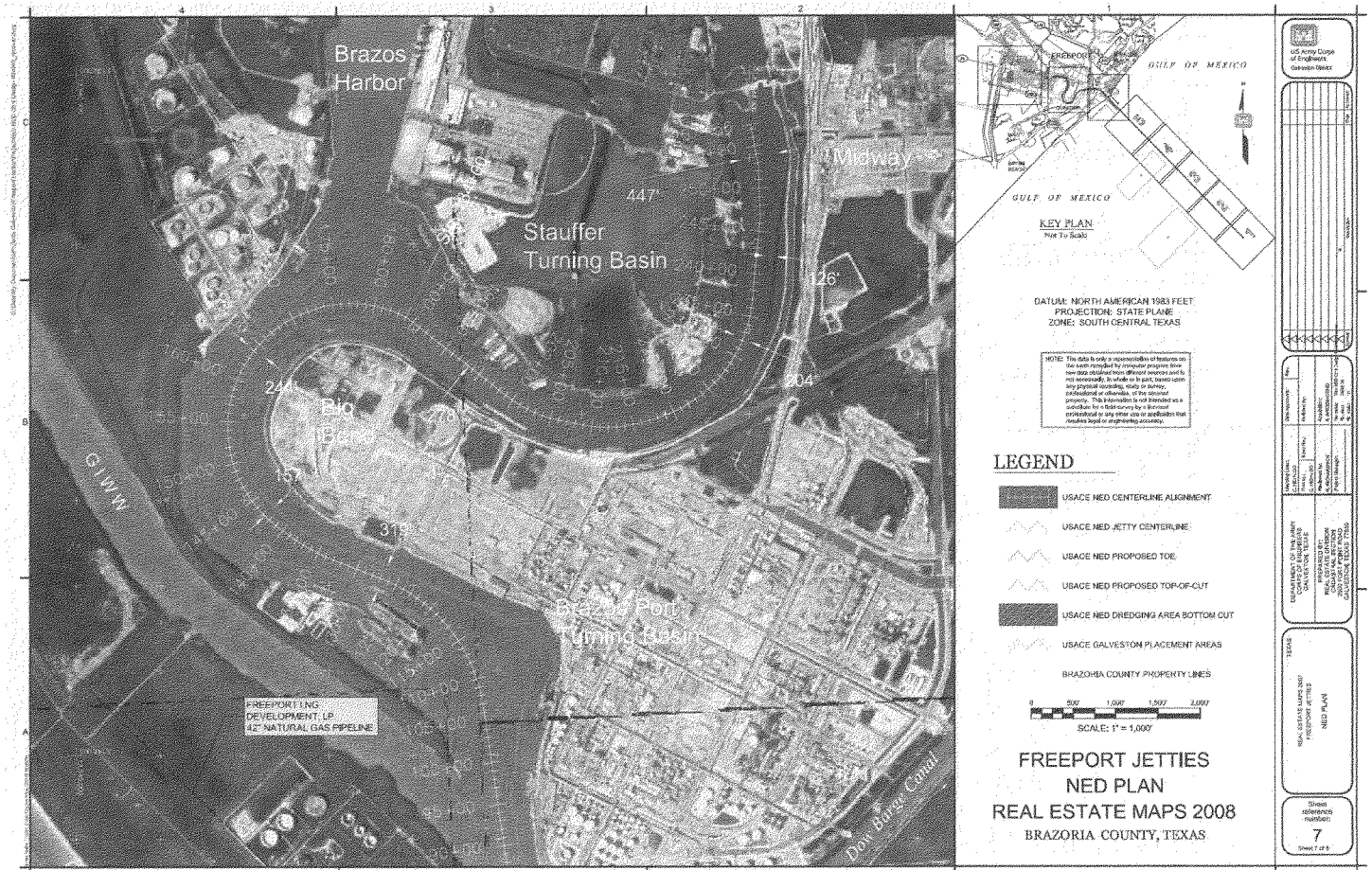
Sheet 6 of 6


Brazos Harbor
Midway
447'
Stauffer Turning Basin
126'
244'
Big Barge
204'
157'
315'
GIWW
Brazos Port Turning Basin
FREEPORT LNG DEVELOPMENT, LP
42" NATURAL GAS PIPELINE
Dow Barge Canal
FREEPORT
GULF OF MEXICO
KEY PLAN
Not To Scale
DATUM: NORTH AMERICAN 1983 FEET
PROJECTION: STATE PLANE
ZONE: SOUTH CENTRAL TEXAS
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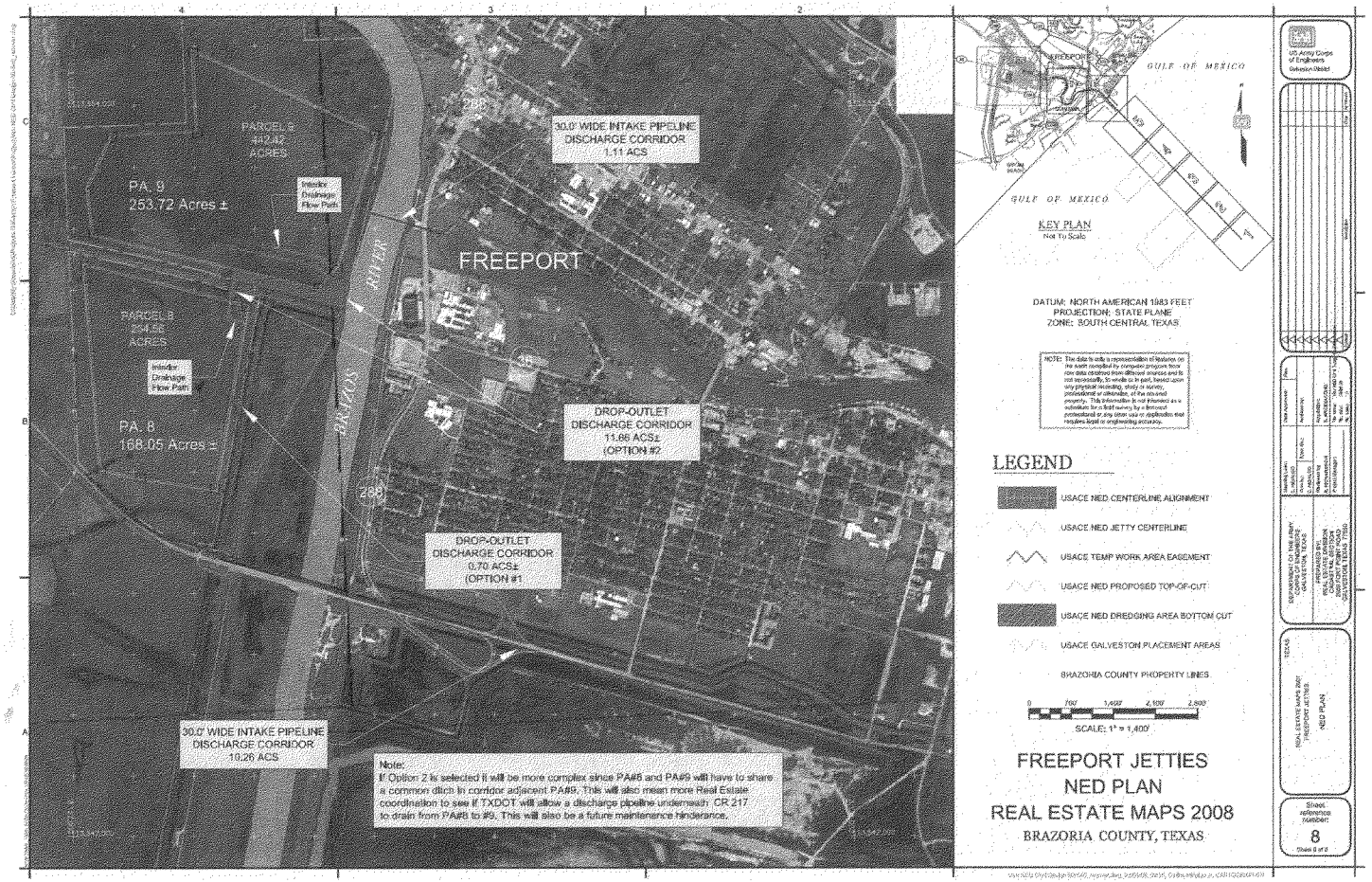
LEGEND
USACE NED CENTERLINE ALIGNMENT
USACE NED JETTY CENTERLINE
USACE NED PROPOSED TOE
USACE NED PROPOSED TOP-OF-CUT
USACE NED DREDGING AREA BOTTOM CUT
USACE GALVESTON PLACEMENT AREAS
BRAZORIA COUNTY PROPERTY LINES
0 500 1,000 1,500 2,000
SCALE: 1" = 1,000'
FREEPORT JETTIES
NED PLAN
REAL ESTATE MAPS 2008
BRAZORIA COUNTY, TEXAS
US Army Corps of Engineers
Galveston District
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
GALVESTON, TEXAS
PREPARED BY:
REAL ESTATE DIVISION
2000 FORT POINT ROAD
GALVESTON, TEXAS 77550
REAL ESTATE MAPS 2007
FREEPORT JETTIES
NED PLAN
Sheet reference number:
7
Sheet 7 of 9


PARCEL 9
442.42
ACRES
PA. 9
253.72 Acres ±
Interior
Drainage
Flow Path
PARCEL 8
234.33
ACRES
Interior
Drainage
Flow Path
PA. 8
168.05 Acres ±
BRAZOS RIVER
FREEPORT
30.0' WIDE INTAKE PIPELINE
DISCHARGE CORRIDOR
1.11 ACS
DROP-OUTLET
DISCHARGE CORRIDOR
11.66 ACS±
(OPTION #2
DROP-OUTLET
DISCHARGE CORRIDOR
0.70 ACS±
(OPTION #1
30.0' WIDE INTAKE PIPELINE
DISCHARGE CORRIDOR
10.26 ACS
Note:
If Option 2 is selected it will be more complex since PA#8 and PA#9 will have to share a common ditch in corridor adjacent PA#9. This will also mean more Real Estate coordination to see if TXDOT will allow a discharge pipeline underneath CR 217 to drain from PA#8 to #9. This will also be a future maintenance hinderance.
GULF OF MEXICO
GULF OF MEXICO
KEY PLAN
Not To Scale
DATUM: NORTH AMERICAN 1983 FEET
PROJECTION: STATE PLANE
ZONE: SOUTH CENTRAL TEXAS
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LEGEND
USACE NED CENTERLINE ALIGNMENT
USACE NED JETTY CENTERLINE
USACE TEMP WORK AREA EASEMENT
USACE NED PROPOSED TOP-OF-CUT
USACE NED DREDGING AREA BOTTOM CUT
USACE GALVESTON PLACEMENT AREAS
BRAZORIA COUNTY PROPERTY LINES
0 700' 1,400' 2,100' 2,800'
SCALE: 1" = 1,400'
FREEPORT JETTIES
NED PLAN
REAL ESTATE MAPS 2008
BRAZORIA COUNTY, TEXAS
US Army Corps of Engineers
Galveston District
DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS
PREPARED BY:
REAL ESTATE DIVISION
2000 FORT POINT ROAD
GALVESTON, TEXAS 77550-1229
REAL ESTATE MAPS 2007
FREEPORT JETTIES
NED PLAN
Sheet reference number
8
Sheet 8 of 8

# Appendix D

# Baseline Cost Estimate

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

PROJECT: NED - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

This Estimate reflects the scope and schedule in report; Project Feasibility Report

Program Year (Budget EC): 2014
Effective Price Level Date: 1 OCT 13

| WBS NUMBER | Civil Works Feature & Sub-Feature Description | ESTIMATED COST COST ($K) | CNTG ($K) | CNTG (%) | TOTAL ($K) | ESC (%) | PROJECT FIRST COST COST ($K) | CNTG ($K) | TOTAL ($K) | TOTAL PROJECT COST (FULLY FUNDED) 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 |
| 12 | NAVIGATION PORTS & HARBORS | | - | | | - | | | | | | | | |
| 12 | Non- Federal | $46,112 | $11,067 | 24% | $57,179 | 3.0% | $47,482 | $11,396 | **$58,878** | | | $49,959 | $11,990 | $61,949 |
| 12 | Federal | $219,834 | $52,760 | 24% | $272,594 | 3.0% | $226,366 | $54,328 | **$280,694** | | | $238,040 | $57,130 | $295,169 |
| 06 | FISH & WILDLIFE FACILITIES | $130 | $31 | 24% | $161 | 3.0% | $134 | $32 | **$166** | | | $145 | $35 | $180 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $266,076 | $63,858 | | **$329,934** | 3.0% | $273,982 | $65,756 | **$339,737** | | | $288,143 | $69,154 | $357,298 |
| 01 | LANDS AND DAMAGES | $1,491 | $162 | 11% | $1,653 | 3.0% | $1,535 | $167 | **$1,702** | | | $1,605 | $175 | $1,780 |
| 30 | PROJECT EXPENDITURES | | | | | | | | | | | | | |
| | Non-Federal Cost | | | | | | | | | 4,050 | | | | $4,050 |
| | Federal Cost | | | | | | | | | 4,050 | | | | $4,050 |
| 30 | PLANNING, ENGINEERING & DESIGN | $29,486 | $7,094 | 24% | $36,580 | 4.1% | $30,689 | $7,384 | **$38,073** | | | $32,786 | $7,891 | $40,677 |
| 31 | CONSTRUCTION MANAGEMENT | $18,636 | $4,473 | 24% | $23,109 | 4.1% | $19,396 | $4,655 | **$24,051** | | | $21,608 | $5,186 | $26,793 |
| | **PROJECT COST TOTALS:** | $315,689 | $75,587 | 24% | **$391,276** | 3.1% | $325,602 | $77,961 | **$403,564** | 8,100 | | $344,143 | $82,405 | $434,648 |

| | |
|---|---|
| ESTIMATED FEDERAL COST: | **$366,869** |
| ESTIMATED NON-FEDERAL COST: | **$67,779** |
| **ESTIMATED TOTAL PROJECT COST:** | **$434,648** |

_____ CHIEF, COST ENGINEERING, Willie Joe Honza

_____ PROJECT MANAGER, Sharon Tirpak

_____ CHIEF, REAL ESTATE, Orlando Rosa

_____ CHIEF, PLANNING, Dolan Dunn

_____ CHIEF, ENGINEERING, Robert Howell

_____ CHIEF, OPERATIONS, Joe Hrametz

_____ CHIEF, CONSTRUCTION, Don Carelock

_____ CHIEF, CONTRACTING, John Eugino

_____ CHIEF, PM-J, Valerie Miller

_____ CHIEF, DPM, Pete Perez

Filename: TPCS NED 2012_04_30.xlsm
TPCS

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

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

PROJECT: NED - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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 | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *I* | *J* | *P* | *L* | *M* | *N* | *O* |
| | Cont #1 - Future Ch Extension & Half of Outer Bar Ch | | | | | | | | | | | | | |
| 12 | NAVIGATION PORTS & HARBORS | | | | | | | | | | | | | |
| 12 | Hopper Dredge | $76,232 | $18,296 | 24% | $94,528 | 3.0% | $78,497 | $18,839 | $97,336 | 2016Q2 | 4.0% | $81,655 | $19,597 | $101,253 |
| 12 | Navigation Aids | $90 | $22 | 24% | $112 | 3.0% | $93 | $22 | $115 | 2016Q2 | 4.0% | $96 | $23 | $120 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $76,322 | $18,317 | 24% | **$94,639** | | $78,590 | $18,862 | $97,451 | | | $81,752 | $19,620 | $101,372 |
| 01 | LANDS AND DAMAGES | | | | | | | | | | | | | |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| *1.0%* | Project Management | $763 | $183 | 24% | $946 | 4.1% | $794 | $191 | $985 | 2014Q4 | 2.8% | $817 | $196 | $1,013 |
| *1.0%* | Planning & Environmental Compliance | $763 | $183 | 24% | $946 | 4.1% | $794 | $191 | $985 | 2014Q4 | 2.8% | $817 | $196 | $1,013 |
| *5.0%* | Engineering & Design | $3,816 | $916 | 24% | $4,732 | 4.1% | $3,972 | $953 | $4,925 | 2014Q4 | 2.8% | $4,084 | $980 | $5,064 |
| *1.0%* | Engineering Tech Review ITR & VE | $763 | $183 | 24% | $946 | 4.1% | $794 | $191 | $985 | 2014Q4 | 2.8% | $817 | $196 | $1,013 |
| *1.0%* | Contracting & Reprographics | $763 | $183 | 24% | $946 | 4.1% | $794 | $191 | $985 | 2014Q4 | 2.8% | $817 | $196 | $1,013 |
| | Real Estate In-House Labor | | | 26% | | | | | | | | | | |
| *2.0%* | Engineering During Construction | $1,526 | $366 | 24% | $1,892 | 4.1% | $1,588 | $381 | $1,969 | 2016Q2 | 8.9% | $1,730 | $415 | $2,145 |
| | | | | 24% | | | | | | | | | | |
| | Project Operations | | | 24% | | | | | | | | | | |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| *6.0%* | Construction Management | $4,579 | $1,099 | 24% | $5,678 | 4.1% | $4,766 | $1,144 | $5,910 | 2016Q2 | 8.9% | $5,190 | $1,246 | $6,436 |
| | Project Operation: | | | 24% | | | | | | | | | | |
| *1.0%* | Project Management | $763 | $183 | 24% | $946 | 4.1% | $794 | $191 | $985 | 2016Q2 | 8.9% | $865 | $208 | $1,072 |
| | **CONTRACT COST TOTALS:** | $90,058 | $21,614 | | **$111,672** | | $92,886 | $22,293 | $115,179 | | | $96,887 | $23,253 | **$120,140** |



Filename: TPCS NED 2012_04_30.xlsm
TPCS

**** CONTRACT COST SUMMARY ****

PROJECT: NED - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | P | L | M | N | O |
| | Contract #2 - Half of Outer Bar Ch & Jetty Ch | | | | | | | | | | | | | |
| 12 | NAVIGATION PORTS & HARBORS | | | | | | | | | | | | | |
| 12 | Hopper Dredge | $89,099 | $21,384 | 24% | $110,483 | 3.0% | $91,746 | $22,019 | $113,765 | 2017Q2 | 5.9% | $97,155 | $23,317 | $120,473 |
| 12 | Navigation Aids | $1,000 | $240 | 24% | $1,240 | 3.0% | $1,030 | $247 | $1,277 | 2017Q2 | 5.9% | $1,090 | $262 | $1,352 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $90,099 | $21,624 | 24% | **$111,723** | | $92,776 | $22,266 | $115,042 | | | $98,246 | $23,579 | $121,825 |
| 01 | LANDS AND DAMAGES | | | | | | | | | | | | | |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| 1.0% | Project Management | $901 | $216 | 24% | $1,117 | 4.1% | $938 | $225 | $1,163 | 2015Q2 | 4.8% | $983 | $236 | $1,219 |
| 1.0% | Planning & Environmental Compliance | $901 | $216 | 24% | $1,117 | 4.1% | $938 | $225 | $1,163 | 2015Q2 | 4.8% | $983 | $236 | $1,219 |
| 5.0% | Engineering & Design | $4,505 | $1,081 | 24% | $5,586 | 4.1% | $4,689 | $1,125 | $5,814 | 2015Q2 | 4.8% | $4,915 | $1,180 | $6,095 |
| 1.0% | Engineering Tech Review ITR & VE | $901 | $216 | 24% | $1,117 | 4.1% | $938 | $225 | $1,163 | 2015Q2 | 4.8% | $983 | $236 | $1,219 |
| 1.0% | Contracting & Reprographics | $901 | $216 | 24% | $1,117 | 4.1% | $938 | $225 | $1,163 | 2015Q2 | 4.8% | $983 | $236 | $1,219 |
| | Real Estate In-House Labor | | | 26% | | | | | | | | | | |
| 2.0% | Engineering During Construction | $1,802 | $432 | 24% | $2,234 | 4.1% | $1,876 | $450 | $2,326 | 2017Q2 | 13.0% | $2,119 | $509 | $2,628 |
| | | | | 24% | | | | | | | | | | |
| | Project Operations | | | 24% | | | | | | | | | | |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| 6.0% | Construction Management | $5,406 | $1,297 | 24% | $6,703 | 4.1% | $5,627 | $1,350 | $6,977 | 2017Q2 | 13.0% | $6,358 | $1,526 | $7,884 |
| | Project Operation: | | | 24% | | | | | | | | | | |
| 1.0% | Project Management | $901 | $216 | 24% | $1,117 | 4.1% | $938 | $225 | $1,163 | 2017Q2 | 13.0% | $1,060 | $254 | $1,314 |
| | **CONTRACT COST TOTALS:** | $106,317 | $25,516 | | **$131,833** | | $109,656 | $26,317 | $135,973 | | | $116,830 | $27,991 | **$144,621** |

PROJECT: NED - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *I* | *J* | *P* | *L* | *M* | *N* | *O* |
| | Contract #3 -Lower TB | | | | | | | | | | | | | |
| 12 | NAVIGATION PORTS & HARBORS | | | | | | | | | | | | | |
| 12 | Non-Fed Costs | $9,488 | $2,277 | 24% | $11,765 | 3.0% | $9,770 | $2,345 | $12,115 | 2015Q3 | 2.6% | $10,028 | $2,407 | $12,435 |
| 12 | Federal Cost | $2,992 | $718 | 24% | $3,710 | 3.0% | $3,081 | $739 | $3,820 | 2015Q3 | 2.6% | $3,162 | $759 | $3,921 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $12,480 | $2,995 | 24% | **$15,475** | | $12,851 | $3,084 | $15,935 | | | $13,191 | $3,166 | $16,356 |
| 01 | LANDS AND DAMAGES | $63 | $7 | 11% | $70 | 3.0% | $65 | $7 | $72 | 2015Q2 | 2.2% | $66 | $7 | $74 |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| *1.0%* | Project Management | $125 | $30 | 24% | $155 | 4.1% | $130 | $31 | $161 | 2015Q2 | 4.8% | $136 | $33 | $169 |
| *1.0%* | Planning & Environmental Compliance | $125 | $30 | 24% | $155 | 4.1% | $130 | $31 | $161 | 2015Q2 | 4.8% | $136 | $33 | $169 |
| *5.0%* | Engineering & Design | $624 | $150 | 24% | $774 | 4.1% | $649 | $156 | $805 | 2015Q2 | 4.8% | $681 | $163 | $844 |
| *1.0%* | Engineering Tech Review ITR & VE | $125 | $30 | 24% | $155 | 4.1% | $130 | $31 | $161 | 2015Q2 | 4.8% | $136 | $33 | $169 |
| *1.0%* | Contracting & Reprographics | $125 | $30 | 24% | $155 | 4.1% | $130 | $31 | $161 | 2015Q2 | 4.8% | $136 | $33 | $169 |
| *2.0%* | Engineering During Construction | $250 | $60 | 24% | $310 | 4.1% | $260 | $62 | $323 | 2015Q3 | 5.8% | $275 | $66 | $342 |
| | Real Estate In-House Labor | $10 | $2 | 20% | $12 | 4.1% | $10 | $2 | $12 | 2015Q3 | 5.8% | $11 | $2 | $13 |
| | Project Operations | | | 24% | | | | | | | | | | |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| *6.0%* | Construction Management | $749 | $180 | 24% | $929 | 4.1% | $780 | $187 | $967 | 2015Q3 | 5.8% | $825 | $198 | $1,023 |
| | Project Operation: | | | 24% | | | | | | | | | | |
| *1.0%* | Project Management | $125 | $30 | 24% | $155 | 4.1% | $130 | $31 | $161 | 2015Q3 | 5.8% | $138 | $33 | $171 |
| | **CONTRACT COST TOTALS:** | $14,801 | $3,544 | | **$18,345** | | $15,266 | $3,655 | $18,921 | | | $15,733 | $3,767 | **$19,499** |



Filename: TPCS NED 2012_04_30.xlsm
TPCS

**** CONTRACT COST SUMMARY ****

PROJECT: NED - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *I* | *J* | *P* | *L* | *M* | *N* | *O* |
| | Contract #4 - Real Estate for PA 8 | | | | | | | | | | | | | |
| 11 | LEVEES & FLOODWALLS | | | | | | | | | | | | | |
| 04 | DAMS | | | | | | | | | | | | | |
| 05 | LOCKS | | | | | | | | | | | | | |
| 06 | FISH & WILDLIFE FACILITIES | | | | | | | | | | | | | |
| 07 | POWER PLANT | | | | | | | | | | | | | |
| | **CONSTRUCTION ESTIMATE TOTALS:** | | | | | | | | | | | | | |
| 01 | LANDS AND DAMAGES | $480 | $48 | 10% | $528 | 3.0% | $494 | $49 | $544 | 2015Q1 | 1.7% | $503 | $50 | $553 |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| *1.0%* | Project Management | | | | | | | | | | | | | |
| *1.0%* | Planning & Environmental Compliance | | | | | | | | | | | | | |
| *5.0%* | Engineering & Design | | | | | | | | | | | | | |
| *1.0%* | Engineering Tech Review ITR & VE | | | | | | | | | | | | | |
| *1.0%* | Contracting & Reprographics | | | | | | | | | | | | | |
| | Real Estate In-House Labor | $10 | $2 | 20% | $12 | 4.1% | $10 | $2 | $12 | 2015Q1 | 3.8% | $11 | $2 | $13 |
| *2.0%* | Engineering During Construction | | | | | | | | | | | | | |
| | Project Operations | | | | | | | | | | | | | |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| *6.0%* | Construction Management | | | | | | | | | | | | | |
| | Project Operation: | | | | | | | | | | | | | |
| *1.0%* | Project Management | | | | | | | | | | | | | |
| | **CONTRACT COST TOTALS:** | $490 | $50 | | **$540** | | $505 | $52 | $556 | | | $514 | $52 | **$566** |

**** CONTRACT COST SUMMARY ****

PROJECT: NED - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | P | L | M | N | O |
| | Contract #5 - Dredge Ch to BRZPT through BRZPT TB | | | | | | | | | | | | | |
| 12 | NAVIGATION PORTS & HARBORS | | | | | | | | | | | | | |
| 12 | Non-Fed Costs | $16,428 | $3,943 | 24% | $20,371 | 3.0% | $16,916 | $4,060 | $20,976 | 2016Q2 | 4.0% | $17,597 | $4,223 | $21,820 |
| 12 | Federal Cost | $29,201 | $7,008 | 24% | $36,209 | 3.0% | $30,069 | $7,216 | $37,285 | 2016Q2 | 4.0% | $31,278 | $7,507 | $38,785 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $45,629 | $10,951 | 24% | **$56,580** | | $46,985 | $11,276 | $58,261 | | | $48,875 | $11,730 | $60,605 |
| 01 | LANDS AND DAMAGES | $28 | $3 | 11% | $31 | 3.0% | $29 | $3 | $32 | 2015Q2 | 2.2% | $29 | $3 | $33 |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| 1.0% | Project Management | $456 | $109 | 24% | $565 | 4.1% | $475 | $114 | $589 | 2015Q2 | 4.8% | $497 | $119 | $617 |
| 1.0% | Planning & Environmental Compliance | $456 | $109 | 24% | $565 | 4.1% | $475 | $114 | $589 | 2015Q2 | 4.8% | $497 | $119 | $617 |
| 5.0% | Engineering & Design | $2,281 | $547 | 24% | $2,828 | 4.1% | $2,374 | $570 | $2,944 | 2015Q2 | 4.8% | $2,489 | $597 | $3,086 |
| 1.0% | Engineering Tech Review ITR & VE | $456 | $109 | 24% | $565 | 4.1% | $475 | $114 | $589 | 2015Q2 | 4.8% | $497 | $119 | $617 |
| 1.0% | Contracting & Reprographics | $456 | $109 | 24% | $565 | 4.1% | $475 | $114 | $589 | 2015Q2 | 4.8% | $497 | $119 | $617 |
| | Real Estate In-House Labor | $11 | $2 | 18% | $13 | 4.1% | $11 | $2 | $14 | 2015Q2 | 4.8% | $12 | $2 | $14 |
| 2.0% | Engineering During Construction | $913 | $219 | 24% | $1,132 | 4.1% | $950 | $228 | $1,178 | 2016Q2 | 8.9% | $1,035 | $248 | $1,283 |
| | Project Operations | | | | | | | | | | | | | |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| 6.0% | Construction Management | $2,738 | $657 | 24% | $3,395 | 4.1% | $2,850 | $684 | $3,534 | 2016Q2 | 8.9% | $3,104 | $745 | $3,848 |
| | Project Operation: | | | 24% | | | | | | | | | | |
| 1.0% | Project Management | $456 | $109 | 24% | $565 | 4.1% | $475 | $114 | $589 | 2016Q2 | 8.9% | $517 | $124 | $641 |
| | **CONTRACT COST TOTALS:** | $53,880 | $12,927 | | **$66,807** | | $55,572 | $13,333 | $68,905 | | | $58,051 | $13,928 | **$71,978** |

PROJECT: NED - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-12
Effective Price Level: 1-Oct-11

Program Year (Budget EC): 2014
Effective Price Level Date: 1 OCT 13

| WBS | Civil Works | COST | CNTG | CNTG | TOTAL | ESC | COST | CNTG | TOTAL | FULLY FUNDED PROJECT ESTIMATE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NUMBER | Feature & Sub-Feature Description | ($K) | ($K) | (%) | ($K) | (%) | ($K) | ($K) | ($K) | Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
| A | B | C | D | E | F | G | H | I | J | P | L | M | N | O |
| | Contract #6 - Dredge Ch to Upper TB through Upper TB | | | | | | | | | | | | | |
| 12 | NAVIGATION PORTS & HARBORS | | | | | | | | | | | | | |
| 12 | Non-Fed Costs | $19,104 | $4,585 | 24% | $23,689 | 3.0% | $19,672 | $4,721 | $24,393 | 2018Q1 | 7.3% | $21,111 | $5,067 | $26,177 |
| 12 | Federal Cost | $11,083 | $2,660 | 24% | $13,743 | 3.0% | $11,412 | $2,739 | $14,151 | 2018Q1 | 7.3% | $12,247 | $2,939 | $15,187 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $30,187 | $7,245 | 24% | **$37,432** | | $31,084 | $7,460 | $38,544 | | | $33,358 | $8,006 | $41,364 |
| 01 | LANDS AND DAMAGES | $785 | $79 | 10% | $864 | 3.0% | $808 | $81 | $890 | 2017Q2 | 5.9% | $856 | $86 | $942 |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| 1.0% | Project Management | $302 | $72 | 24% | $374 | 4.1% | $314 | $75 | $390 | 2017Q2 | 13.0% | $355 | $85 | $440 |
| 1.0% | Planning & Environmental Compliance | $302 | $72 | 24% | $374 | 4.1% | $314 | $75 | $390 | 2017Q2 | 13.0% | $355 | $85 | $440 |
| 5.0% | Engineering & Design | $1,509 | $362 | 24% | $1,871 | 4.1% | $1,571 | $377 | $1,948 | 2017Q2 | 13.0% | $1,775 | $426 | $2,201 |
| 1.0% | Engineering Tech Review ITR & VE | $302 | $72 | 24% | $374 | 4.1% | $314 | $75 | $390 | 2017Q2 | 13.0% | $355 | $85 | $440 |
| 1.0% | Contracting & Reprographics | $302 | $72 | 24% | $374 | 4.1% | $314 | $75 | $390 | 2017Q2 | 13.0% | $355 | $85 | $440 |
| | Real Estate In-House Labor | $27 | $3 | 11% | $30 | 4.1% | $28 | $3 | $31 | 2017Q2 | 13.0% | $32 | $4 | $35 |
| 2.0% | Engineering During Construction | $604 | $145 | 24% | $749 | 4.1% | $629 | $151 | $780 | 2018Q1 | 16.1% | $730 | $175 | $905 |
| | Project Operations | | | 24% | | | | | | | | | | |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| 6.0% | Construction Management | $1,811 | $435 | 24% | $2,246 | 4.1% | $1,885 | $452 | $2,337 | 2018Q1 | 16.1% | $2,188 | $525 | $2,713 |
| | Project Operation: | | | 24% | | | | | | | | | | |
| 1.0% | Project Management | $302 | $72 | 24% | $374 | 4.1% | $314 | $75 | $390 | 2018Q1 | 16.1% | $365 | $88 | $452 |
| | **CONTRACT COST TOTALS:** | $36,433 | $8,631 | | **$45,064** | | $37,576 | $8,902 | $46,478 | | | $40,723 | $9,650 | **$50,373** |



Filename: TPCS NED 2012_04_30.xlsm
TPCS

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

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

PROJECT: NED - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *I* | *J* | *P* | *L* | *M* | *N* | *O* |
| | Contract #7 -Dredge Stauffer Ch | | | | | | | | | | | | | |
| 12 | NAVIGATION PORTS & HARBORS | | | | | | | | | | | | | |
| 12 | Non-Fed Costs | $1,092 | $262 | 24% | $1,354 | 3.0% | $1,124 | $270 | $1,394 | 2018Q4 | 8.8% | $1,223 | $294 | $1,517 |
| 12 | Lower Stauffer Ch | $7,612 | $1,827 | 24% | $9,439 | 3.0% | $7,838 | $1,881 | $9,719 | 2018Q4 | 8.8% | $8,526 | $2,046 | $10,572 |
| 12 | Upper Stauffer Ch | $2,525 | $606 | 24% | $3,131 | 3.0% | $2,600 | $624 | $3,224 | 2018Q4 | 8.8% | $2,828 | $679 | $3,507 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $11,229 | $2,695 | 24% | **$13,924** | | $11,563 | $2,775 | $14,338 | | | $12,577 | $3,019 | $15,596 |
| 01 | LANDS AND DAMAGES | $135 | $25 | 19% | $160 | 3.0% | $139 | $26 | $165 | 2018Q3 | 8.3% | $151 | $28 | $178 |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| *1.0%* | Project Management | $112 | $27 | 24% | $139 | 4.1% | $117 | $28 | $145 | 2018Q3 | 18.1% | $138 | $33 | $171 |
| *1.0%* | Planning & Environmental Compliance | $112 | $27 | 24% | $139 | 4.1% | $117 | $28 | $145 | 2018Q3 | 18.1% | $138 | $33 | $171 |
| *5.0%* | Engineering & Design | $561 | $135 | 24% | $696 | 4.1% | $584 | $140 | $724 | 2018Q3 | 18.1% | $690 | $166 | $855 |
| *1.0%* | Engineering Tech Review ITR & VE | $112 | $27 | 24% | $139 | 4.1% | $117 | $28 | $145 | 2018Q3 | 18.1% | $138 | $33 | $171 |
| *1.0%* | Contracting & Reprographics | $112 | $27 | 24% | $139 | 4.1% | $117 | $28 | $145 | 2018Q3 | 18.1% | $138 | $33 | $171 |
| | Real Estate In-House Labor | $115 | $50 | 43% | $165 | 4.1% | $120 | $52 | $172 | 2018Q3 | 18.1% | $141 | $61 | $203 |
| *2.0%* | Engineering During Construction | $225 | $54 | 24% | $279 | 4.1% | $234 | $56 | $290 | 2018Q4 | 19.1% | $279 | $67 | $346 |
| | Project Operations | | | 24% | | | | | | | | | | |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| *6.0%* | Construction Management | $674 | $162 | 24% | $836 | 4.1% | $702 | $168 | $870 | 2018Q4 | 19.1% | $836 | $201 | $1,036 |
| | Project Operation: | | | 24% | | | | | | | | | | |
| *1.0%* | Project Management | $112 | $27 | 24% | $139 | 4.1% | $117 | $28 | $145 | 2018Q4 | 19.1% | $139 | $33 | $172 |
| | **CONTRACT COST TOTALS:** | $13,499 | $3,255 | | **$16,754** | | $13,924 | $3,357 | $17,281 | | | $15,363 | $3,706 | **$19,069** |



Filename: TPCS NED 2012_04_30.xlsm
TPCS

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

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

PROJECT: NED - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *I* | *J* | *P* | *L* | *M* | *N* | *O* |
| | Contract #8 - PA Mitigation | | | | | | | | | | | | | |
| 06 | FISH & WILDLIFE FACILITIES | $130 | $31 | 24% | $ 161 | 3.0% | $134 | $32 | $166 | 2018Q3 | 8.3% | $145 | $35 | $180 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $130 | $31 | 24% | **161** | | $134 | $32 | $166 | | | $145 | $35 | $180 |
| 01 | LANDS AND DAMAGES | | | | | | | | | | | | | |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| *5.0%* | Project Management | $7 | $2 | 24% | 9 | 4.1% | $7 | $2 | $9 | 2018Q1 | 16.1% | $8 | $2 | $10 |
| *5.0%* | Planning & Environmental Compliance | $7 | $2 | 24% | 9 | 4.1% | $7 | $2 | $9 | 2018Q1 | 16.1% | $8 | $2 | $10 |
| *20.0%* | Engineering & Design | $26 | $6 | 24% | 32 | 4.1% | $27 | $6 | $34 | 2018Q1 | 16.1% | $31 | $8 | $39 |
| *5.0%* | Engineering Tech Review ITR & VE | $7 | $2 | 24% | 9 | 4.1% | $7 | $2 | $9 | 2018Q1 | 16.1% | $8 | $2 | $10 |
| *5.0%* | Contracting & Reprographics | $7 | $2 | 24% | 9 | 4.1% | $7 | $2 | $9 | 2018Q1 | 16.1% | $8 | $2 | $10 |
| *5.0%* | Engineering During Construction | $7 | $2 | 24% | 9 | 4.1% | $7 | $2 | $9 | 2018Q3 | 18.1% | $9 | $2 | $11 |
| | Real Estate In-House Labor | | | | | | | | | | | | | |
| | Project Operations | | | | | | | | | | | | | |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| *10.0%* | Construction Management | $13 | $3 | 24% | 16 | 4.1% | $14 | $3 | $17 | 2018Q3 | 18.1% | $16 | $4 | $20 |
| *5.0%* | Project Management | $7 | $2 | 24% | 9 | 4.1% | $7 | $2 | $9 | 2018Q3 | 18.1% | $9 | $2 | $11 |
| | **CONTRACT COST TOTALS:** | $211 | $51 | | **262** | | $218 | $52 | $271 | | | $243 | $58 | **$302** |



Filename: TPCS NED 2012_04_30.xlsm
TPCS

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

PROJECT: LPP - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

This Estimate reflects the scope and schedule in report; Project Feasibility Report

Program Year (Budget EC): 2014
Effective Price Level Date: 1 OCT 13

| WBS NUMBER | Civil Works Feature & Sub-Feature Description | ESTIMATED COST COST ($K) | CNTG ($K) | CNTG (%) | TOTAL ($K) | ESC (%) | PROJECT FIRST COST COST ($K) | CNTG ($K) | TOTAL ($K) | TOTAL PROJECT COST (FULLY FUNDED) Spent Thru: 31-Mar-12 ($K) | | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
| 12 | NAVIGATION PORTS & HARBORS | | - | | | - | | | | | | | | |
| 12 | Non- Federal | $46,112 | $11,067 | 24% | $57,179 | 3.0% | $47,482 | $11,396 | **$58,878** | | | $49,862 | $11,967 | $61,829 |
| 12 | Federal | $165,113 | $39,627 | 24% | $204,740 | 3.0% | $170,019 | $40,805 | **$210,823** | | | $178,086 | $42,741 | $220,826 |
| 06 | FISH & WILDLIFE FACILITIES | $130 | $31 | 24% | $161 | 3.0% | $134 | $32 | **$166** | | | $145 | $35 | $180 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $211,355 | $50,725 | | **$262,080** | 3.0% | $217,635 | $52,232 | **$269,867** | | | $228,093 | $54,742 | $282,835 |
| 01 | LANDS AND DAMAGES | $1,491 | $162 | 11% | $1,653 | 3.0% | $1,535 | $167 | **$1,702** | | | $1,581 | $172 | $1,753 |
| 30 | PROJECT EXPENDITURES | | | | | | | | | | | | | |
| | Non-Federal Cost | | | | | | | | | 4,050 | | | | $4,050 |
| | Federal Cost | | | | | | | | | 4,050 | | | | $4,050 |
| 30 | PLANNING, ENGINEERING & DESIGN | $14,281 | $3,445 | 24% | $17,726 | 4.1% | $14,864 | $3,585 | **$18,449** | | | $15,793 | $3,812 | $19,606 |
| 31 | CONSTRUCTION MANAGEMENT | $7,413 | $1,779 | 24% | $9,192 | 4.1% | $7,715 | $1,852 | **$9,567** | | | $8,544 | $2,051 | $10,595 |
| | **PROJECT COST TOTALS:** | $234,540 | $56,111 | 24% | **$290,651** | 3.1% | $241,749 | $57,836 | **$299,586** | 8,100 | | $254,011 | $60,777 | $322,888 |

CHIEF, COST ENGINEERING, Willie Joe Honza

PROJECT MANAGER, Sharon Tirpak

CHIEF, REAL ESTATE, Orlando Rosa

CHIEF, PLANNING, Dolari Dunn

CHIEF, ENGINEERING, Robert Howell

CHIEF, OPERATIONS, Joe Hrametz

CHIEF, CONSTRUCTION, Don Carelock

CHIEF, CONTRACTING, John Eugino

CHIEF, PM-J, Valerie Miller

CHIEF, DPM, Pete Perez

ESTIMATED FEDERAL COST: **$255,256**
ESTIMATED NON-FEDERAL COST: $67,632
**ESTIMATED TOTAL PROJECT COST: $322,888**

Filename: TPCS LPP 2012_04_30.xlsm
TPCS

**** CONTRACT COST SUMMARY ****

PROJECT: LPP - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | P | L | M | N | O |
| | Cont #1 - Future Ch Ext &Half of Outer Bar Ch | | | | | | | | | | | | | |
| 12 | NAVIGATION PORTS & HARBORS | | | | | | | | | | | | | |
| 12 | Hopper Dredge | $45,415 | $10,900 | 24% | $56,315 | 3.0% | $46,764 | $11,223 | $57,988 | 2015Q4 | 3.1% | $48,217 | $11,572 | $59,789 |
| 12 | Navigation Aids | $90 | $22 | 24% | $112 | 3.0% | $93 | $22 | $115 | 2015Q4 | 3.1% | $96 | $23 | $118 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $45,505 | $10,921 | 24% | **$56,426** | | $46,857 | $11,246 | $58,103 | | | $48,312 | $11,595 | $59,907 |
| 01 | LANDS AND DAMAGES | | | | | | | | | | | | | |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| 0.5% | Project Management | $228 | $55 | 24% | $283 | 4.1% | $237 | $57 | $294 | 2014Q4 | 2.8% | $244 | $59 | $303 |
| 0.8% | Planning & Environmental Compliance | $364 | $87 | 24% | $451 | 4.1% | $379 | $91 | $470 | 2014Q4 | 2.8% | $390 | $93 | $483 |
| 3.0% | Engineering & Design | $1,365 | $328 | 24% | $1,693 | 4.1% | $1,421 | $341 | $1,762 | 2014Q4 | 2.8% | $1,461 | $351 | $1,811 |
| 0.8% | Engineering Tech Review ITR & VE | $341 | $82 | 24% | $423 | 4.1% | $355 | $85 | $440 | 2014Q4 | 2.8% | $365 | $88 | $453 |
| 0.8% | Contracting & Reprographics | $364 | $87 | 24% | $451 | 4.1% | $379 | $91 | $470 | 2014Q4 | 2.8% | $390 | $93 | $483 |
| 0.8% | Engineering During Construction | $364 | $87 | 24% | $451 | 4.1% | $379 | $91 | $470 | 2015Q4 | 6.9% | $405 | $97 | $502 |
| | Real Estate In-House Labor | | | 24% | | | | | | | | | | |
| | Project Operations | | | 24% | | | | | | | | | | |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| 3.0% | Construction Management | $1,365 | $328 | 24% | $1,693 | 4.1% | $1,421 | $341 | $1,762 | 2015Q4 | 6.9% | $1,518 | $364 | $1,883 |
| | Project Operation: | | | 24% | | | | | | | | | | |
| 0.5% | Project Management | $228 | $55 | 24% | $283 | 4.1% | $237 | $57 | $294 | 2015Q4 | 6.9% | $254 | $61 | $314 |
| | **CONTRACT COST TOTALS:** | $50,124 | $12,030 | | **$62,154** | | $51,665 | $12,399 | $64,064 | | | $53,338 | $12,801 | **$66,139** |

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

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

PROJECT: LPP - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | Mid-Point Date | ESC (%) | FULLY FUNDED PROJECT ESTIMATE COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | P | L | M | N | O |
| | Contract #2 - Half of Outer Bar Ch & Jetty Ch | | | | | | | | | | | | | |
| 12 | NAVIGATION PORTS & HARBORS | | | | | | | | | | | | | |
| 12 | Hopper Dredge | $72,311 | $17,355 | 24% | $89,666 | 3.0% | $74,460 | $17,870 | $92,330 | 2017Q1 | 5.4% | $78,494 | $18,839 | $97,332 |
| 12 | Navigation Aids | $1,000 | $240 | 24% | $1,240 | 3.0% | $1,030 | $247 | $1,277 | 2017Q1 | 5.4% | $1,086 | $261 | $1,346 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $73,311 | $17,595 | 24% | **$90,906** | | $75,489 | $18,117 | $93,607 | | | $79,579 | $19,099 | $98,678 |
| 01 | LANDS AND DAMAGES | | | | | | | | | | | | | |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| 0.5% | Project Management | $367 | $88 | 24% | $455 | 4.1% | $382 | $92 | $474 | 2015Q2 | 4.8% | $400 | $96 | $496 |
| 0.8% | Planning & Environmental Compliance | $586 | $141 | 24% | $727 | 4.1% | $610 | $146 | $756 | 2015Q2 | 4.8% | $639 | $153 | $793 |
| 3.0% | Engineering & Design | $2,199 | $528 | 24% | $2,727 | 4.1% | $2,289 | $549 | $2,838 | 2015Q2 | 4.8% | $2,399 | $576 | $2,975 |
| 0.8% | Engineering Tech Review ITR & VE | $550 | $132 | 24% | $682 | 4.1% | $572 | $137 | $710 | 2015Q2 | 4.8% | $600 | $144 | $744 |
| 0.8% | Contracting & Reprographics | $586 | $141 | 24% | $727 | 4.1% | $610 | $146 | $756 | 2015Q2 | 4.8% | $639 | $153 | $793 |
| 0.8% | Engineering During Construction | $586 | $141 | 24% | $727 | 4.1% | $610 | $146 | $756 | 2017Q1 | 12.0% | $683 | $164 | $847 |
| | Real Estate In-House Labor | | | | | | | | | | | | | |
| | Project Operations | | | 24% | | | | | | | | | | |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| 3.0% | Construction Management | $2,199 | $528 | 24% | $2,727 | 4.1% | $2,289 | $549 | $2,838 | 2017Q1 | 12.0% | $2,563 | $615 | $3,178 |
| | Project Operation: | | | 24% | | | | | | | | | | |
| 0.5% | Project Management | $367 | $88 | 24% | $455 | 4.1% | $382 | $92 | $474 | 2017Q1 | 12.0% | $428 | $103 | $530 |
| | **CONTRACT COST TOTALS:** | $80,751 | $19,380 | | **$100,131** | | $83,233 | $19,976 | $103,209 | | | $87,931 | $21,103 | **$109,034** |



Filename: TPCS LPP 2012_04_30.xlsm
TPCS

PROJECT: LPP - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *I* | *J* | *P* | *L* | *M* | *N* | *O* |
| | Contract #3 -Lower TB | | | | | | | | | | | | | |
| 12 | NAVIGATION PORTS & HARBORS | | | | | | | | | | | | | |
| 12 | Non-Fed Costs | $9,488 | $2,277 | 24% | $11,765 | 3.0% | $9,770 | $2,345 | $12,115 | 2015Q3 | 2.6% | $10,028 | $2,407 | $12,435 |
| 12 | Federal Cost | $2,325 | $558 | 24% | $2,883 | 3.0% | $2,394 | $575 | $2,969 | 2015Q3 | 2.6% | $2,457 | $590 | $3,047 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $11,813 | $2,835 | 24% | **$14,648** | | $12,164 | $2,919 | $15,083 | | | $12,486 | $2,997 | $15,482 |
| 01 | LANDS AND DAMAGES | $63 | $7 | 11% | $70 | 3.0% | $65 | $7 | $72 | 2015Q2 | 2.2% | $66 | $7 | $74 |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| *0.5%* | Project Management | $59 | $14 | 24% | $73 | 4.1% | $61 | $15 | $76 | 2015Q2 | 4.8% | $64 | $15 | $80 |
| *0.8%* | Planning & Environmental Compliance | $95 | $23 | 24% | $118 | 4.1% | $99 | $24 | $123 | 2015Q2 | 4.8% | $104 | $25 | $129 |
| *3.0%* | Engineering & Design | $354 | $85 | 24% | $439 | 4.1% | $368 | $88 | $457 | 2015Q2 | 4.8% | $386 | $93 | $479 |
| *0.8%* | Engineering Tech Review ITR & VE | $89 | $21 | 24% | $110 | 4.1% | $93 | $22 | $115 | 2015Q2 | 4.8% | $97 | $23 | $120 |
| *0.8%* | Contracting & Reprographics | $95 | $23 | 24% | $118 | 4.1% | $99 | $24 | $123 | 2015Q2 | 4.8% | $104 | $25 | $129 |
| *0.8%* | Engineering During Construction | $95 | $23 | 24% | $118 | 4.1% | $99 | $24 | $123 | 2015Q3 | 5.8% | $105 | $25 | $130 |
| | Real Estate In-House Labor | $10 | $2 | 20% | $12 | 4.1% | $10 | $2 | $12 | 2015Q3 | 5.8% | $11 | $2 | $13 |
| | Project Operations | | | 24% | | | | | | | | | | |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| *3.0%* | Construction Management | $354 | $85 | 24% | $439 | 4.1% | $368 | $88 | $457 | 2015Q3 | 5.8% | $390 | $94 | $484 |
| *0.5%* | Project Management | $59 | $14 | 24% | $73 | 4.1% | $61 | $15 | $76 | 2015Q3 | 5.8% | $65 | $16 | $81 |
| | **CONTRACT COST TOTALS:** | $13,086 | $3,132 | | **$16,218** | | $13,488 | $3,228 | $16,717 | | | $13,878 | $3,322 | **$17,199** |



Filename: TPCS LPP 2012_04_30.xlsm
TPCS

**** CONTRACT COST SUMMARY ****

PROJECT: LPP - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H | I | J | P | L | M | N | O |
| | Contract #4 - Real Estate PA 8 | | | | | | | | | | | | | |
| 11 | LEVEES & FLOODWALLS | | | | | | | | | | | | | |
| 04 | DAMS | | | | | | | | | | | | | |
| 05 | LOCKS | | | | | | | | | | | | | |
| 06 | FISH & WILDLIFE FACILITIES | | | | | | | | | | | | | |
| 07 | POWER PLANT | | | | | | | | | | | | | |
| | **CONSTRUCTION ESTIMATE TOTALS:** | | | | | | | | | | | | | |
| 01 | LANDS AND DAMAGES | $480 | $48 | 10% | $528 | 3.0% | $494 | $49 | $544 | 2014Q1 | | $494 | $49 | $544 |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| 0.5% | Project Management | | | | | | | | | | | | | |
| 0.8% | Planning & Environmental Compliance | | | | | | | | | | | | | |
| 3.0% | Engineering & Design | | | | | | | | | | | | | |
| 0.8% | Engineering Tech Review ITR & VE | | | | | | | | | | | | | |
| 0.8% | Contracting & Reprographics | | | | | | | | | | | | | |
| 0.8% | Real Estate In-House Labor | $10 | $2 | 20% | $12 | 4.1% | $10 | $2 | $12 | 2014Q1 | | $10 | $2 | $12 |
| 0.8% | Engineering During Construction | | | | | | | | | | | | | |
| | Project Operations | | | | | | | | | | | | | |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| 3.0% | Construction Management | | | | | | | | | | | | | |
| | Project Operation: | | | | | | | | | | | | | |
| 0.5% | Project Management | | | | | | | | | | | | | |
| | **CONTRACT COST TOTALS:** | $490 | $50 | | **$540** | | $505 | $52 | $556 | | | $505 | $52 | **$556** |

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

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

PROJECT: LPP - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | Mid-Point Date | ESC (%) | FULLY FUNDED PROJECT ESTIMATE COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *I* | *J* | *P* | *L* | *M* | *N* | *O* |
| | Contract #5 - Dredge Ch to BRZPT through BRZPT TB | | | | | | | | | | | | | |
| 12 | NAVIGATION PORTS & HARBORS | | | | | | | | | | | | | |
| 12 | Non-Fed Costs | $16,428 | $3,943 | 24% | $20,371 | 3.0% | $16,916 | $4,060 | $20,976 | 2016Q2 | 4.0% | $17,597 | $4,223 | $21,820 |
| 12 | Federal Cost | $23,039 | $5,529 | 24% | $28,568 | 3.0% | $23,724 | $5,694 | $29,417 | 2016Q2 | 4.0% | $24,678 | $5,923 | $30,601 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $39,467 | $9,472 | 24% | **$48,939** | | $40,640 | $9,754 | $50,393 | | | $42,275 | $10,146 | $52,421 |
| 01 | LANDS AND DAMAGES | $28 | $3 | 11% | $31 | 3.0% | $29 | $3 | $32 | 2015Q2 | 2.2% | $29 | $3 | $33 |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| *0.5%* | Project Management | $197 | $47 | 24% | $244 | 4.1% | $205 | $49 | $254 | 2015Q2 | 4.8% | $215 | $52 | $267 |
| *0.8%* | Planning & Environmental Compliance | $316 | $76 | 24% | $392 | 4.1% | $329 | $79 | $408 | 2015Q2 | 4.8% | $345 | $83 | $427 |
| *3.0%* | Engineering & Design | $1,184 | $284 | 24% | $1,468 | 4.1% | $1,232 | $296 | $1,528 | 2015Q2 | 4.8% | $1,292 | $310 | $1,602 |
| *0.8%* | Engineering Tech Review ITR & VE | $296 | $71 | 24% | $367 | 4.1% | $308 | $74 | $382 | 2015Q2 | 4.8% | $323 | $78 | $400 |
| *0.8%* | Contracting & Reprographics | $316 | $76 | 24% | $392 | 4.1% | $329 | $79 | $408 | 2015Q2 | 4.8% | $345 | $83 | $427 |
| *0.8%* | Engineering During Construction | $316 | $76 | 24% | $392 | 4.1% | $329 | $79 | $408 | 2016Q2 | 8.9% | $358 | $86 | $444 |
| | Real Estate In-House Labor | $11 | $2 | 18% | $13 | 4.1% | $11 | $2 | $14 | 2016Q2 | 8.9% | $12 | $2 | $15 |
| | Project Operations | | | | | | | | | | | | | |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| *3.0%* | Construction Management | $1,184 | $284 | 24% | $1,468 | 4.1% | $1,232 | $296 | $1,528 | 2016Q2 | 8.9% | $1,342 | $322 | $1,664 |
| *0.5%* | Project Management | $197 | $47 | 24% | $244 | 4.1% | $205 | $49 | $254 | 2016Q2 | 8.9% | $223 | $54 | $277 |
| | **CONTRACT COST TOTALS:** | $43,512 | $10,439 | | **$53,951** | | $44,849 | $10,759 | $55,609 | | | $46,759 | $11,218 | **$57,977** |



Filename: TPCS LPP 2012_04_30.xlsm
TPCS

PROJECT: LPP - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *I* | *J* | *P* | *L* | *M* | *N* | *O* |
| | Contract #6 - Dredge Ch to Upper TB through Upper TB | | | | | | | | | | | | | |
| 12 | NAVIGATION PORTS & HARBORS | | | | | | | | | | | | | |
| 12 | Non-Fed Costs | $19,104 | $4,585 | 24% | $23,689 | 3.0% | $19,672 | $4,721 | $24,393 | 2017Q4 | 6.9% | $21,019 | $5,045 | $26,064 |
| 12 | Federal Cost | $10,796 | $2,591 | 24% | $13,387 | 3.0% | $11,117 | $2,668 | $13,785 | 2017Q4 | 6.9% | $11,878 | $2,851 | $14,729 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $29,900 | $7,176 | 24% | **$37,076** | | $30,788 | $7,389 | $38,178 | | | $32,898 | $7,895 | $40,793 |
| 01 | LANDS AND DAMAGES | $785 | $79 | 10% | $864 | 3.0% | $808 | $81 | $890 | 2016Q3 | 4.5% | $845 | $85 | $930 |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| *0.5%* | Project Management | $150 | $36 | 24% | $186 | 4.1% | $156 | $37 | $194 | 2016Q3 | 9.9% | $172 | $41 | $213 |
| *0.8%* | Planning & Environmental Compliance | $239 | $57 | 24% | $296 | 4.1% | $249 | $60 | $308 | 2016Q3 | 9.9% | $273 | $66 | $339 |
| *3.0%* | Engineering & Design | $897 | $215 | 24% | $1,112 | 4.1% | $934 | $224 | $1,158 | 2016Q3 | 9.9% | $1,026 | $246 | $1,273 |
| *0.8%* | Engineering Tech Review ITR & VE | $224 | $54 | 24% | $278 | 4.1% | $233 | $56 | $289 | 2016Q3 | 9.9% | $256 | $62 | $318 |
| *0.8%* | Contracting & Reprographics | $239 | $57 | 24% | $296 | 4.1% | $249 | $60 | $308 | 2016Q3 | 9.9% | $273 | $66 | $339 |
| | Real Estate In-House Labor | $27 | $3 | 11% | $30 | 4.1% | $28 | $3 | $31 | 2016Q3 | 9.9% | $31 | $3 | $34 |
| *0.8%* | Engineering During Construction | $239 | $57 | 24% | $296 | 4.1% | $249 | $60 | $308 | 2017Q4 | 15.0% | $286 | $69 | $355 |
| | | | | | | | | | | | 15.0% | | | |
| | Project Operations | | | | | | | | | | | | | |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| *3.0%* | Construction Management | $897 | $215 | 24% | $1,112 | 4.1% | $934 | $224 | $1,158 | 2017Q4 | 15.0% | $1,074 | $258 | $1,332 |
| *0.5%* | Project Management | $150 | $36 | 24% | $186 | 4.1% | $156 | $37 | $194 | 2017Q4 | 15.0% | $180 | $43 | $223 |
| | **CONTRACT COST TOTALS:** | $33,747 | $7,986 | | **$41,733** | | $34,784 | $8,232 | $43,015 | | | $37,314 | $8,834 | **$46,148** |

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

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

PROJECT: LPP - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *I* | *J* | *P* | *L* | *M* | *N* | *O* |
| | Contract #7 -Dredge Stauffer Ch | | | | | | | | | | | | | |
| 12 | NAVIGATION PORTS & HARBORS | | | | | | | | | | | | | |
| 12 | Non-Fed Costs | $1,092 | $262 | 24% | $1,354 | 3.0% | $1,124 | $270 | $1,394 | 2018Q3 | 8.3% | $1,218 | $292 | $1,510 |
| 12 | Lower Stauffer Ch | $7,612 | $1,827 | 24% | $9,439 | 3.0% | $7,838 | $1,881 | $9,719 | 2018Q3 | 8.3% | $8,488 | $2,037 | $10,525 |
| 12 | Upper Stauffer Ch | $2,525 | $606 | 24% | $3,131 | 3.0% | $2,600 | $624 | $3,224 | 2016Q1 | 3.6% | $2,692 | $646 | $3,339 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $11,229 | $2,695 | 24% | **$13,924** | | $11,563 | $2,775 | $14,338 | | | $12,398 | $2,975 | $15,373 |
| 01 | LANDS AND DAMAGES | $135 | $25 | 19% | $160 | 3.0% | $139 | $26 | $165 | 2017Q1 | 5.4% | $147 | $27 | $174 |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| *0.5%* | Project Management | $56 | $13 | 24% | $69 | 4.1% | $58 | $14 | $72 | 2017Q1 | 12.0% | $65 | $16 | $81 |
| *0.8%* | Planning & Environmental Compliance | $90 | $22 | 24% | $112 | 4.1% | $94 | $22 | $116 | 2017Q1 | 12.0% | $105 | $25 | $130 |
| *3.0%* | Engineering & Design | $337 | $81 | 24% | $418 | 4.1% | $351 | $84 | $435 | 2017Q1 | 12.0% | $393 | $94 | $487 |
| *0.8%* | Engineering Tech Review ITR & VE | $84 | $20 | 24% | $104 | 4.1% | $87 | $21 | $108 | 2017Q1 | 12.0% | $98 | $23 | $121 |
| *0.8%* | Contracting & Reprographics | $90 | $22 | 24% | $112 | 4.1% | $94 | $22 | $116 | 2017Q1 | 12.0% | $105 | $25 | $130 |
| | Real Estate In-House Labor | $115 | $50 | 43% | $165 | 4.1% | $120 | $52 | $172 | 2017Q1 | 18.1% | $141 | $61 | $203 |
| *0.8%* | Engineering During Construction | $90 | $22 | 24% | $112 | 4.1% | $94 | $22 | $116 | 2018Q3 | 18.1% | $111 | $27 | $137 |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| *3.0%* | Construction Management | $337 | $81 | 24% | $418 | 4.1% | $351 | $84 | $435 | 2018Q3 | 18.1% | $414 | $99 | $514 |
| *0.5%* | Project Management | $56 | $13 | 24% | $69 | 4.1% | $58 | $14 | $72 | 2018Q3 | 18.1% | $69 | $17 | $85 |
| | **CONTRACT COST TOTALS:** | $12,619 | $3,044 | | **$15,663** | | $13,008 | $3,138 | $16,145 | | | $14,045 | $3,390 | **$17,436** |



Filename: TPCS LPP 2012_04_30.xlsm
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****** TOTAL PROJECT COST SUMMARY ******

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

PROJECT: LPP - Freeport Harbor, Deepening and Selective Widening
LOCATION: Freeport, Texas
This Estimate reflects the scope and schedule in report; Project Feasibility Report

DISTRICT: Galveston District PREPARED: 3/30/2012
POC: CHIEF, COST ENGINEERING, Willie Joe Honza

Estimate Prepared: 30-Mar-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) | CNTG (%) | TOTAL ($K) | ESC (%) | COST ($K) | CNTG ($K) | TOTAL ($K) | FULLY FUNDED PROJECT ESTIMATE Mid-Point Date | ESC (%) | COST ($K) | CNTG ($K) | FULL ($K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *I* | *J* | *P* | *L* | *M* | *N* | *O* |
| | Contract #8 - PA Mitigation | | | | | | | | | | | | | |
| 06 | FISH & WILDLIFE FACILITIES | $130 | $31 | 24% | $ 161 | 3.0% | $134 | $32 | $166 | 2018Q3 | 8.3% | $145 | $35 | $180 |
| | **CONSTRUCTION ESTIMATE TOTALS:** | $130 | $31 | 24% | **161** | | $134 | $32 | $166 | | | $145 | $35 | $180 |
| 01 | LANDS AND DAMAGES | | | | | | | | | | | | | |
| 30 | PLANNING, ENGINEERING & DESIGN | | | | | | | | | | | | | |
| *5.0%* | Project Management | $7 | $2 | 24% | 9 | 4.1% | $7 | $2 | $9 | 2017Q1 | 12.0% | $8 | $2 | $10 |
| *5.0%* | Planning & Environmental Compliance | $7 | $2 | 24% | 9 | 4.1% | $7 | $2 | $9 | 2017Q1 | 12.0% | $8 | $2 | $10 |
| *20.0%* | Engineering & Design | $26 | $6 | 24% | 32 | 4.1% | $27 | $6 | $34 | 2017Q1 | 12.0% | $30 | $7 | $38 |
| *5.0%* | Engineering Tech Review ITR & VE | $7 | $2 | 24% | 9 | 4.1% | $7 | $2 | $9 | 2017Q1 | 12.0% | $8 | $2 | $10 |
| | Real Estate In-House Labor | | | | | | | | | | | | | |
| *5.0%* | Contracting & Reprographics | $7 | $2 | 24% | 9 | 4.1% | $7 | $2 | $9 | 2017Q1 | 12.0% | $8 | $2 | $10 |
| *5.0%* | Engineering During Construction | $7 | $2 | 24% | 9 | 4.1% | $7 | $2 | $9 | 2018Q3 | 18.1% | $9 | $2 | $11 |
| 31 | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | | |
| *10.0%* | Construction Management | $13 | $3 | 24% | 16 | 4.1% | $14 | $3 | $17 | 2018Q3 | 18.1% | $16 | $4 | $20 |
| | Project Operation: | | | 24% | | | | | | | | | | |
| *5.0%* | Project Management | $7 | $2 | 24% | 9 | 4.1% | $7 | $2 | $9 | 2018Q3 | 18.1% | $9 | $2 | $11 |
| | **CONTRACT COST TOTALS:** | $211 | $51 | | **262** | | $218 | $52 | $271 | | | $241 | $58 | **$299** |



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FOR CONTINUATION OF HOUSE DOCUMENT 113-44

FINAL REPORT FREEPORT HARBOR,
TEXAS CHANNEL IMPROVEMENT PROJECT

SEE PART 2