FINAL FEASIBILITY REPORT
FOR
SABINE-NECHES WATERWAY
CHANNEL IMPROVEMENT PROJECT
SOUTHEAST TEXAS AND SOUTHWEST LOUISIANA

VOLUME I

PREPARED BY:

U.S. ARMY CORPS OF ENGINEERS
GALVESTON DISTRICT
SOUTHWESTERN DIVISION

March 2011

INTRODUCTION

This Feasibility Report was prepared as a final response to the study authorization contained in the Senate Committee on Environment and Public Works Resolution adopted on June 5, 1997. The report presents the results of studies investigating the need to deepen and widen the Sabine-Neches Waterway (SNWW) along the border of Texas and Louisiana. In response to the study authority, the reconnaissance phase of the study was initiated in September 1998. The reconnaissance investigations resulted in a finding that there was an interest in continuing the study into the feasibility phase. The Jefferson County Navigation District, as the non-Federal sponsor (Sponsor), and the U.S. Army Corps of Engineers (USACE) initiated the feasibility phase of the study on March 6, 2000. The feasibility phase study cost was shared equally between the USACE and the Sponsor. In 2002, the Jefferson County Navigation District was renamed the Jefferson County Waterway and Navigation District (JCWND), and in 2007 the JCWND was renamed the Sabine Neches Navigation District (SNND); the latter designation is used throughout the remainder of this document.

This syllabus is intended to inform the reader of the major factors that were considered in the investigation and influenced the decisions documented in the Final Feasibility Report (FFR) and Final Environmental Impact Statement (FEIS).

MAJOR CONCLUSIONS AND FINDINGS

Planning Objectives

The water resources problems to be solved with this study are the navigational and safety issues that have developed on the SNWW because of the growth in the area. The investigation of the problems and opportunities in the study area led to the establishment of the following planning objectives:

- Improve the navigational efficiency along the SNWW waterway; and
- Maintain the ecological value of coastal and estuarine resources within the project area.

Alternatives

Over 120 alternatives at nine different depths (43, 45, 46, 47, 48, 49, 50, 53, and 55 feet) in combination with several different width scenarios were evaluated in order to address the planning objectives and the problems and opportunities identified by the Sponsor and the public.

Identification of the National Economic Development Plan

The Federal objective in water resources planning is to contribute to the National Economic Development (NED) consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other planning requirements. Through thorough investigation and analysis, deepening the SNWW to 49 feet (with selective widening) is the best plan to meet the NED objective. However, the Sponsor has indicated that the 48-foot plan is preferred because the cost of the NED and deeper plans would make the project unaffordable. The 48-foot plan is the Locally Preferred Plan (LPP) and is the Recommended Plan.

Recommended Plan and Locally Preferred Plan

The alternative plan selected for recommendation is the 48-foot plan that is also the LPP. The Recommended Plan calls for the following modifications to the existing SNWW:

- Deepening the SNWW from 40 to 48 feet and offshore channel from 42 to 50 feet in depth from offshore to the Port of Beaumont Turning Basin;
- Extending the 50-foot-deep offshore channel by 13.2 miles, increasing the total length of the channel from 64 to 77 miles;
- Decreasing the width of the Sabine Bank Channel from 800 to 700 feet;
- Tapering and marking the Sabine Bank Channel from 800 feet wide (Station 23+300) to 700 feet wide (Station 25+800 through the end of the channel);
- Deepening and widening of Taylor Bayou channels and turning basins;
- Easing selected bends on the Sabine-Neches Canal and Neches River Channel; and
- Constructing new and enlarging/deepening existing turning and anchorage basins on the Neches River Channel.

Features of the Recommended Plan

The Recommended Plan consists of navigation channel improvements (see following table), marsh mitigation, and a 50-year Dredged Material Management Plan (DMMP) with beneficial use (BU) areas, upland placement areas (PAs), and Ocean Dredged Material Disposal Sites (ODMDS).

Sixteen existing and two expanded upland PAs are proposed for use with the Recommended Plan. Offshore placement consists of four existing and four new ODMDSs. As part of the DMMP, dredged material would be used beneficially to restore degraded marsh areas on the Neches River and nourish the Gulf shoreline along the Texas and Louisiana coasts. Both BU features are least-cost plans and as such are considered General Navigation Features (GNF) of the Recommended Plan. The Neches River and Gulf Shore BU features would offset all direct and indirect marsh impacts in Texas by creating 2,853 acres of emergent marsh vegetation, improving 871 acres of open water habitat, and nourishing 1,234 acres of existing marsh in Texas. Benefits of the Neches River BU Feature more than offset the direct

impact of conversion of 86 acres of fresh marsh to a confined placement area (PA 24A) and the indirect impact of the increase in salinity over approximately 39,000 wetland acres in Texas. The Gulf Shore BU Feature offsets minor erosion impacts by periodically nourishing 6 miles of Texas and Louisiana Gulf shorelines.

Project Dimensions for Recommended Plan

Reach	Station	to	Station	Bottom Width (feet)	Project Depth (feet)
Extension Channel	165+443		95+734	700	50
Sabine Bank Channel	95+734		25+800	700	50
Sabine Bank Channel	25+800		23+300	700–800*	50
Sabine Pass Outer Bar Channel	23+300		0+000	800	50
Sabine Pass Jetty Channel	–214+88		0+00	800–500	48
Sabine Pass Channel	0+00		296+25	500	48
Port Arthur Canal	0+00		325+84	500	48
Sabine-Neches Canal	0+00		592+94	400	48
Neches River Channel	0+00		980+00	400	48
Taylor Bayou					
Entrance Channel	0+00		25+27	406–764	48
East Turning Basin	0+00		17+65	532–354	48
West Turning Basin	25+27		41+30	776	48
Connecting Channel	41+30		71+50	470–250	48
Taylor Bayou Turning Basin	71+50		106+25	1,000	48

*Sabine Pass Outer Bar Channel would be 800 feet wide to address maneuverability issues caused by current velocities around end of jetties

The primary impact of the Recommended Plan is an indirect impact associated with a small increase in salinity and an associated reduction in biological productivity over approximately 182,000 acres of intertidal marsh in Louisiana, and the potential loss of 691 acres of marsh in Louisiana as some marsh converts to open water. The mitigation plan compensates for all impacts by restoring 2,783 acres of emergent marsh, improving 957 acres of shallow-water habitat, and stabilizing and nourishing 4,355 acres of existing marsh in the Willow and Black Bayou areas, Louisiana.

Environmental Compliance

All project components were evaluated for environmental impacts, and an FEIS has been prepared in accordance with Council on Environmental Quality requirements. A mitigation plan was developed to compensate for all unavoidable environmental impacts. USACE has evaluated the proposed SNWW Channel Improvement Project (CIP) for consistency with the Texas and Louisiana coastal management programs, and concluded that the Recommended Plan is fully consistent to the maximum extent practicable with the enforceable policies of both state programs. The Texas Coastal Coordination Council has concurred with the USACE consistency determination. The Louisiana Department of Natural Resources, Office of Coastal Management (LDNR-OCM), found that the SNWW CIP is conditionally

consistent with their state program. Since conditional consistency as proposed by LDNR-OCM is not acceptable, LDNR-OCM has been notified that USACE will proceed with the project. Additional information on this matter is presented in FEIS Section 6.0. Clean Water Act §401 State Water Quality certification has been received from Texas and Louisiana for this action. Short-term increases in turbidity may be caused by the unconfined flow of dredged material during construction of BU features and mitigation measures. There would be temporary, minor impacts from ocean placement at the new ODMDSs. Proposed channel improvements should increase safety, thus decreasing the probability of a spill. A Clean Water Act §404(b)(1) evaluation of the proposed action, provided in the FEIS (Appendix E), describes the effects of the proposed discharges. The Recommended Plan is the least environmentally damaging practicable alternative. Coordination with the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) regarding potential endangered species impacts has been concluded. Critical Habitat for wintering piping plovers is present in the Louisiana portion of the Gulf Shore BU Feature. The USFWS has concurred that the BU feature may affect, but is not likely to adversely affect, the species or its Critical Habitat because the Gulf Shore BU Feature would protect existing Critical Habitat. Hopper dredging of the Entrance Channel is likely to adversely affect but not jeopardize the continued existence of loggerhead, Kemp's ridley, and green sea turtles. In the Biological Opinion, the NMFS authorizes the incidental lethal take of four sea turtles and has identified reasonable and prudent measures to be adopted during construction. Based upon recent chemical analyses of water and sediment collected from within the channels, the potential for encountering hazardous material during dredging operations is considered minimal. Shoaled sediments and new work material that would be dredged from the SNWW during construction has been determined to be of sufficient quality to be used for beneficial uses. In compliance with requirements of the Clean Air Act and the State of Texas, the TCEQ has provided written concurrence that emissions from the Recommended Plan are conformant with the Texas State Implementation Plan for the Beaumont-Port Arthur area, and the USACE has prepared a Final General Conformity Determination. Potential impacts to historic properties will be addressed in accordance with the terms of the Historic Properties Programmatic Agreement with the SNND.

Benefits and Costs of the Recommended Plan

Project Benefits

The basic economic benefits from a navigation improvement project are the reduction in transportation costs for commodities and the increase in the value of output for goods and services. Specific transportation savings may result from the use of larger vessels, more-efficient use of large vessels, more-efficient use of existing vessels, reductions in transit time, and lower cargo handling and tug assistance costs. Based on the economic analyses performed during the study, total average annual project benefits are estimated at $115,074,000. Transportation cost savings are expected to occur for the following:

- Crude Petroleum Imports
- Petroleum and Chemical Products
- Grain Exports

- Steel Slab and Iron Ore
- Limestone and Rock
- Liquefied Natural Gas (LNG) traffic (benefits stop at 43 feet)

Project Costs (October 2009 Price Levels)

The First Cost of all project components in current dollars totals $1,071,877,000. Based on Budget Year 2012, the first cost would be $1,100,935,000. The Fully Funded Cost for the project (e.g., First Costs and escalation in current dollars) totals $1,161,372,000. The LPP investment cost of all components totals $1,191,259,000 in current dollars, and includes $119,382,000 in interest during construction (IDC). The total average annual LPP investment cost for the project is $91,341,000. The LPP cost includes average annual incremental costs for operations and maintenance (O&M) ($32,067,000) and deferred construction for fish and wildlife mitigation ($215,000).

Benefit-Cost Ratio

Based on the annualized project benefits estimated at $115,074,000 and annualized project costs estimated at $91,341,000, the benefit-cost ratio for the Recommended Plan is 1.3.

Cost Sharing

General navigation features (GNF) costs for deepening from the existing authorized depth of 40 feet down to 45 feet are cost shared at 25 percent non-Federal and 75 percent Federal; costs for deepening below 45 feet (recommended authorized depth of 48 feet) are cost shared at 50 percent non-Federal and 50 percent Federal. Fish and wildlife mitigation to compensate for project impacts is considered a GNF and is cost shared in the same manner as other GNF costs. The Sponsor also must pay an additional 10 percent of the GNF costs in cash over a period not to exceed 30 years. This additional 10 percent cash contribution is offset by credit for Lands, Easements, and Rights of Way (LER) and relocations (including utility relocations) pursuant to Section 101(a)(2) of Water Resources Development Act of 1986, as amended. Owners of berth and dock facilities that would require modification are responsible for 100 percent of those associated costs. The U.S. Coast Guard (USCG) is responsible for 100 percent of the cost for new channel markers (aids to navigation).

PUBLIC COORDINATION

The USACE and SNND developed a public involvement plan as part of the study process to ensure responsiveness to the needs and concerns of stakeholders and to ensure public involvement through an open, interactive process. Extensive coordination with State and Federal resource agencies was conducted throughout the study process, primarily through an Interagency Coordination Team (ICT) and workgroup meetings. Over 30 workgroup meetings and 11 ICT meetings were held during the study process.

NON-FEDERAL SPONSOR SUPPORT

SNND fully supports the project and is willing to sponsor project construction in accordance with the items of local cooperation set forth in this report. The Sponsor has indicated financial capability to satisfy its obligations for the construction of the Recommended Plan. A self certification has been prepared by the Sponsor and provided to the USACE.

AREAS OF CONTROVERSY AND UNRESOLVED ISSUES

The USACE has evaluated the proposed SNWW CIP for consistency with the Louisiana coastal management program, and concluded that the Recommended Plan is fully consistent to the maximum extent practicable with the enforceable policies of the state's coastal management program. The Louisiana Department of Natural Resources, Office of Coastal Management, found that the SNWW CIP is conditionally consistent with their state program. Since conditional consistency as proposed by LDNR-OCM is not acceptable, LDNR-OCM has been notified that USACE will proceed with the project. See FEIS Section 6.0 for further details.

Coordination with the Louisiana Department of Wildlife and Fisheries (LDWF) has not been able to resolve issues related to the offset of project impacts to Federal lands using benefits from BU features in Texas, LDWF requirements that the Recommended Plan include additional BU features, and royalty, license, and further assessment requirements concerning areas in Sabine Lake that would be affected by the removal of fill material for use in marsh mitigation. The USACE has proposed that an assessment survey be completed, following the protocol established by the LDWF, during the Preconstruction Engineering and Design phase of the SNWW CIP.

In order for the four new ODMDSs to be approved for use, the Environmental Protection Agency (EPA) must publish a final rulemaking in the *Federal Register*. An FEIS for the proposed ODMDS and a Final Site Management and Monitoring Plan have been prepared and accepted by EPA for use in this rulemaking at a later date (FEIS, Appendix B).

Issues related to contaminated materials in PA 17 (a capped landfill and other waste disposal areas within the PA) must be resolved by the non-Federal sponsor before the PA can be used as part of the Recommended Plan. Alternative placement areas are available should this not be resolved in time for use.

Table of Contents

The Final Feasibility Report (FFR) and Final Environmental Impact Statement (FEIS) for the Sabine-Neches Waterway Channel Improvement Project are contained in four volumes. Volume 1 contains the FFR and FFR Appendices 1 through 4. Volume II contains the FEIS Main Report. Volume III contains FEIS Appendices A and B. Volume IV contains FEIS Appendices C through K.

Page

Syllabus S-1
List of Figures ix
List of Plates x
List of Tables xi
Acronyms and Abbreviations xv

I. STUDY INFORMATION I-1
I.A OVERVIEW I-1
I.B STUDY AUTHORITY I-1
I.C PURPOSE AND SCOPE I-1
I.D PROJECT AREA DESCRIPTION I-1
Physical Description of Study Area I-1
Study Area I-5
Environmental Setting I-5
Terrain I-5
Tides I-10
Salinity I-11
Geology I-11
Fish and Wildlife Resources I-12
Aquatic Resources I-12
Freshwater Resources I-13
Marine Resources I-13
Coastal Wetland Resources I-14
Sensitive Areas I-17
Upland Resources I-18
Threatened and Endangered Species I-18
Plants I-18
Wildlife I-18
Significant Habitats I-19
Cultural Resources I-19
Socioeconomic Considerations I-19
Population I-20
Employment and Income I-20
Commercial and Recreation Fishing I-20
Outdoor Recreation I-21
I.E NON-FEDERAL SPONSOR AND COORDINATION I-21
I.F PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS I-22
I.G STUDY AND REPORT PROCESS I-24

Page

II. PROBLEMS AND OPPORTUNITIES II-1
II.A OVERVIEW II-1
II.B NAVIGATION AND COMMERCE II-1
General II-1
Commerce II-3
Safety II-9
National Security II-10
II.C ENVIRONMENTAL II-10

III. FORMULATION OBJECTIVES, CONSTRAINTS, AND CRITERIA III-1
III.A OVERVIEW III-1
III.B FEDERAL OBJECTIVES III-1
III.C PUBLIC CONCERNS III-1
III.D PLANNING OBJECTIVES III-2
III.E PLANNING CONSTRAINTS III-2
III.F TECHNICAL CRITERIA III-3
III.G VALUE MANAGEMENT III-3
III.H ECONOMIC CRITERIA III-4
III.I ENVIRONMENTAL CRITERIA III-5
III.J SOCIAL CRITERIA III-6
III.K OTHER USACE INITIATIVES III-6
USACE Campaign Plan III-6
Goal 2: Engineering Sustainable Water Resources III-6
Goal 3: Delivering Effective, Resilient, Sustainable Solutions III-7

IV. FORMULATION AND EVALUATION OF ALTERNATIVES IV-1
IV.A OVERVIEW IV-1
IV.B PLAN FORMULATION PROCESS IV-1
IV.C PRELIMINARY SCREENING OF ALTERNATIVES IV-2
Future Without-Project Condition (No-Action Alternative) IV-2
Preliminary Screening of Alternatives IV-5
Nonstructural Alternatives IV-5
Structural Alternatives IV-5
Plans Eliminated During Preliminary Screening IV-6
IV.D SECOND SCREENING IV-6
Technical Studies IV-6
Nonstructural Alternatives IV-8
Vessel Traffic Service IV-8
Relaxation of Existing Pilot Rules IV-9
Alternative Mode of Commodity Transport IV-10
Louisiana Offshore Oil Port IV-10
Bulk Oil Offshore Transfer System IV-12
Structural Alternatives IV-14
Evaluation of Alternatives IV-15
Second Screening Costs IV-16
Second Screening Economic Analysis IV-17
Project Benefits IV-17
Second Screening Net Excess Benefits IV-19
Evaluation of Structural Alternatives IV-20

Page

Deepening and Widening IV-20
Turning Basins and Anchorage Basins IV-21
Barge Lanes IV-21
Plans Eliminated During Second Screening IV-22
IV.E FINAL SCREENING OF ALTERNATIVES IV-23
Final Screened Alternatives IV-23
IV.F IDENTIFICATION OF THE RECOMMENDED PLAN IV-26
IV.G PRINCIPLES AND GUIDELINES EVALUATION ACCOUNTS IV-26
National Economic Development IV-26
Effects on Environmental Quality IV-27
Regional Economic Development (RED) IV-29
Other Social Effects IV-29

V. ECONOMIC EVALUATION OF ALTERNATIVES V-1
V.A OVERVIEW V-1
V.B SCREENING PROCESS V-1
Total Tonnage V-1
Crude Petroleum V-3
Port Arthur and Beaumont Tonnage Bases V-6
Expansion of the Deep-Draft Traffic Historical Base V-10
Liquefied Natural Gas Traffic V-10
V.C COMMODITY AND FLEET FORECASTS V-13
Vessel Utilization Trends V-15
Crude Petroleum Fleet V-16
Petroleum Product Carriers V-19
Chemical Product Carriers V-22
Grain Carriers V-24
Steel Slab and Iron Ore Carriers V-26
Limestone and Rock Carriers V-27
Wood Product Carriers V-28
Liquefied Natural Gas Fleet V-28
V.D CHANNEL DEEPENING BENEFITS V-28
Vessel Operating Costs V-30
Transportation Savings Benefits for Channel Deepening V-32
Crude Petroleum Imports Transportation Savings Benefits V-32
Petroleum and Chemical Product Transportation Savings Benefits V-38
Grain Exports Transportation Savings Benefits V-38
Limestone and Rock Transportation Savings Benefits V-47
Liquefied Natural Gas Transportation Savings Benefits V-50
Summary of Channel Deepening Benefits V-51
V.E CHANNEL WIDENING BENEFITS V-52
Vessel Traffic V-54
Entrance Channel Widening Benefits V-61
Neches River Holding Areas V-62
Summary of Widening Benefits V-69
V.F NED BENEFIT SUMMARY V-71
Incremental Analysis V-71
Benefit-Cost Ratio at 7 Percent V-77

Page

Sensitivity Analysis for Additional Advanced Maintenance V-77
V.G REGIONAL BENEFITS V-78

VI. DESCRIPTION OF RECOMMENDED PLAN VI-1
VI.A OVERVIEW VI-1
VI.B DESCRIPTION OF RECOMMENDED PLAN VI-1
General Navigation Features of the Recommended Plan VI-2
Sabine Bank Extension Channel VI-3
Sabine Bank Channel VI-3
Sabine Pass Outer Bar Channel VI-11
Sabine Pass Jetty Channel VI-12
Sabine Pass Channel VI-12
Port Arthur Canal (including Taylor Bayou Channels and Turning Basins) VI-13
Sabine-Neches Canal VI-14
Neches River Channel VI-15
Management of Dredged Material VI-16
Beneficial Use Features of the DMMP VI-17
Upland Placement Areas VI-19
Ocean Dredged Material Disposal Sites VI-19
Compensatory Mitigation VI-19
Aids to Navigation – USCG Channel Markers VI-20
Bridge Reinforcements and Fenders VI-20
Lands, Easements and Rights-of-Way VI-20
Relocations VI-21
Impact Analysis and Mitigation Needs Summary for the Recommended Plan VI-22
Critical Assumptions VI-22
VI.C RECOMMENDED PLAN AND RECENT USACE INITIATIVES VI-22
USACE Environmental Operating Principles VI-22
USACE Actions for Change as Reflected in the Campaign Plan VI-29

VII. DREDGED MATERIAL MANAGEMENT PLAN (DMMP) VII-1
VII.A OVERVIEW VII-1
VII.B REGIONAL SEDIMENT MANAGEMENT OBJECTIVES AND SCOPE VII-1
VII.C EXISTING SHOALING AND SEDIMENT TRANSPORT CONDITIONS VII-2
Shoreline Descriptions VII-2
Historical Shoreline Change in the Study Area VII-3
Sabine Pass Sediment Budget VII-4
Existing Project Shoaling and Sediment Transport Conditions VII-4
Neches River Channel VII-4
Sabine-Neches and Port Arthur Canals VII-5
Sabine Pass Channel VII-6
Sabine Pass Jetty Channel VII-6
Sabine Pass Outer Bar Channel VII-6
Sabine Bank Channel VII-7
Adjacent Gulf Shorelines VII-7
VII.D ANALYSIS OF SEDIMENT-RELATED PROBLEMS AND OPPORTUNITIES VII-7
Preliminary Screening – Features Eliminated from Consideration VII-8
Detailed Evaluation of Disposal Features VII-12
Neches River Beneficial Use Feature VII-12

Page

Gulf Shore Beneficial Use Feature VII-15
Upland Placement Features VII-19
Existing Active PAs VII-19
Existing Inactive PAs VII-19
Areas Considered for PA Expansion VII-20
ODMDS Features VII-21
VII.E IDENTIFYING THE LEAST-COST PLACEMENT ALTERNATIVE VII-21
Description of Placement Alternatives VII-21
Cost Comparison of Placement Alternatives VII-23
Selection of the DMMP VII-25
VII.F DESCRIPTION OF THE DMMP FOR THE RECOMMENDED PLAN VII-25
DMMP BU Features VII-25
Upland PA Features VII-25
Offshore Placement Features VII-27
VII.G INCREMENTAL ENVIRONMENTAL IMPACTS AND BENEFITS OF THE DMMP VII-28
Incremental Environmental Impacts of the DMMP VII-28
Incremental Ecological Benefits of the DMMP VII-28
Methods and Objectives VII-28
Offsetting Ecological Impacts VII-29
VII.H BASE PLAN FOR THE EXISTING 40-FOOT PROJECT VII-29
VII.I INCREMENTAL O&M COST OF THE PROPOSED 48-FOOT PROJECT VII-34
Description of O&M Activities for the Recommended Plan VII-34
Incremental O&M Cost of the Recommended Plan VII-34

VIII. DEVELOPMENT OF THE MITIGATION PLAN VIII-1
VIII.A OVERVIEW VIII-1
VIII.B ECOSYSTEM IMPACTS SUMMARY VIII-1
VIII.C PROCEDURES FOR THE FORMULATION AND ASSESSMENT OF MITIGATION MEASURES VIII-2
Compliance with Federal Requirements VIII-2
Mitigation Planning Objectives VIII-4
Models Used to Evaluate Environmental Effects and Mitigation Measures VIII-6
HS Modeling VIII-6
Ecological Modeling VIII-7
Consideration of Environmental Mitigation Costs During Plan Formulation VIII-8
VIII.D SELECTION OF THE BEST BUY MITIGATION PLAN VIII-8
VIII.E RECOMMENDED ECOLOGICAL MITIGATION PLAN VIII-10
Monitoring and Contingency Plans VIII-13
VIII.F FULFILLMENT OF MITIGATION PLANNING OBJECTIVES VIII-14
VIII.G CULTURAL RESOURCES MITIGATION VIII-14

IX. RISK AND UNCERTAINTY ANALYSIS IX-1
IX.A OVERVIEW IX-1
IX.B GUIDANCE AND CONCEPTS IX-1
IX.C UNCERTAINTY IN TECHNICAL EVALUATIONS IX-3
Forecasting Tools and Analyses IX-3
Engineering Data and Models IX-4
Data IX-4
Hydrologic Data IX-4

Page

New Work and Maintenance Material Data IX-4
Models IX-5
Ship Simulation Model IX-5
HS Model IX-6
Storm Surge Model IX-6
Sediment Model IX-7
Vessel Effects Study Model IX-8
Shoreline Impacts Model IX-8
Other Analyses IX-9
Relative Sea Level Rise IX-9
Stability Analyses (Bridges and Port Arthur Hurricane Protection Levee) IX-13
Cost Risk Analysis IX-14
Economic Data and Models IX-15
Data IX-15
Risk and Uncertainty IX-15
Models IX-16
Environmental Data and Models IX-16
WVA Model IX-16
Salinity Sensitivity Analysis IX-18
Percent Emergent Marsh Sensitivity Analysis IX-18
Cultural Resources IX-19
Real Estate Data IX-19
IX.D COMMUNICATION OF RISK IX-20

X. RECOMMENDED PLAN X-1
X.A OVERVIEW X-1
X.B GENERAL NAVIGATION FEATURES OF RECOMMENDED PLAN X-1
Sabine Bank Extension Channel X-1
Sabine Bank Channel X-2
Sabine Pass Outer Bar Channel X-2
Sabine Pass Jetty Channel X-4
Sabine Pass Channel X-4
Port Arthur Canal X-4
Taylor Bayou Channels and Turning Basins X-4
Sabine-Neches Canal X-5
Neches River Channel X-6
DMMP X-6
Ecological Mitigation for the Recommended Plan X-8
Marsh Mitigation X-8
X.C LANDS, EASEMENTS, AND RIGHTS-OF-WAY X-9
X.D RELOCATIONS X-9
X.E AIDS TO NAVIGATION X-10
Channel Markers X-10
X.F BRIDGE REINFORCEMENTS AND FENDERS X-10

XI. PLAN IMPLEMENTATION XI-1
XI.A OVERVIEW XI-1
XI.B DIVISION OF PLAN RESPONSIBILITIES AND COST SHARING REQUIREMENTS XI-1
XI.C DESIGN PHASE COSTS FOR ALTERNATIVES SCREENING XI-1

Page

XI.D PROJECT COSTS XI-2
Costs for the Recommended Plan XI-2
Total First Cost and Annualized O&M Costs XI-2
Deferred Construction Costs XI-2
Federal O&M Costs XI-3
Non-Federal O&M Costs XI-4
National Economic Development Investment Cost XI-4
Fully Funded Cost XI-5
XI.E COST SHARING ALLOCATION XI-5
XI.F ADDITIONAL NON-FEDERAL SPONSOR CASH CONTRIBUTION XI-10
XI.G NON-FEDERAL SPONSOR VIEWS XI-10

XII. SUMMARY OF COORDINATION XII-1
XII.A OVERVIEW XII-1
XII.B COORDINATION XII-1
XII.C PUBLIC/AGENCY COMMENTS XII-1
Saltwater Intrusion XII-2
Threatened and Endangered Species XII-2
Contaminated Sediments XII-2
Essential Fish Habitat XII-3
Storm Surge and Erosion XII-3
Cultural Resources XII-3
Socioeconomic and Project Costs XII-3
Public Infrastructure XII-4

XIII. RECOMMENDATIONS XIII-1
XIII.A PROJECT COSTS (OCTOBER 2009 PRICE LEVELS) XIII-1
XIII.B REQUIREMENTS XIII-1
XIII.C MAINTENANCE OF NEW CHANNEL AND EXISTING CHANNEL XIII-4
XIII.D RECOMMENDATION XIII-4

XIV. LITERATURE CITED XIV-1

Appendices

1 Engineering Plates
2 Economic Appendix
3 Baseline Cost Estimate
4 Real Estate Plan

VOLUME II – FEIS MAIN REPORT

VOLUME III – FEIS APPENDICES A AND B

VOLUME IV – FEIS APPENDICES C THROUGH K

List of Figures

Page

I-1 Sabine-Neches Waterway Project Area I-3
I-2 Sabine-Neches Waterway Project and Study Area I-7
I-3 Hydrologic Units and Vegetative Coverages I-15
I-4 History of Channel Deepening of Sabine-Neches Waterway I-24
II-1 Port of Beaumont II-2
II-2 Maritime and Petrochemical Use of Sabine-Neches Waterway near Port Arthur, Texas II-2
II-3 Sabine-Neches Waterway Facility Sites within the Study Area II-5
II-4 Increasing Vessel Sizes II-8
II-5 Widening to Address Safety II-9
II-6 Rose City Marsh II-11
IV-1 Planning Process IV-2
V-1 U.S. and Sabine-Neches Crude Oil Imports, 1980–2007 ..... V-5
V-2 SNWW Foreign Imports and Exports by Major Group (Excluding Crude Petroleum), 1990–1992 to 2005–2007 Distribution V-10
V-3 U.S. LNG Imports 2006–2030 ..... V-14
V-4 U.S. and Beaumont Bulk Grain Exports, 1990–2007 ..... V-25
V-5 Sabine-Neches Waterway, 1965–2007, Average Tonnage per Trip for Ocean-Going Vessels V-55
VI-1 Sabine-Neches Waterway – Extension Channel VI-4
VI-2 Sabine Pass Outer Bar and Sabine Pass Bank Channel VI-5
VI-3 Sabine Pass Jetty Channel VI-6
VI-4 Sabine Pass Channel VI-7
VI-5 Sabine-Neches Waterway – Port Arthur Canal (including Taylor Bayou) VI-8
VI-6 Sabine-Neches Waterway – Sabine-Neches Canal VI-9
VI-7 Sabine-Neches Waterway – Neches River VI-10
VII-1 Components of the Neches River BU Feature VII-13
VII-2 Gulf Shore Beneficial Use Feature VII-17
VII-3 Map of Existing and New ODMDS VII-22
VIII-1 Results of the CE/ICA Analysis VIII-9
VIII-2 Sabine-Neches Waterway Recommended Mitigation Plan VIII-11
X-1 Recommended Plan – Project Map X-3

List of Plates

C-01R	Dredging Plan (Neches River Channel), Sta. 980+00 to Sta. 730+00
C-02R	Dredging Plan (Neches River Channel), Sta. 730+00 to Sta. 450+00
C-03R	Dredging Plan (Neches River Channel), Sta. 450+00 to Sta. 201+00
C-04	Dredging Plan (Neches River Channel), Sta. 201+00 to Sta. 520+00
C-05	Dredging Plan (Sabine-Neches Canal), Sta. 520+00 to 290+00
C-06	Dredging Plan (Sabine-Neches Canal), Sta. 290+00 to Sta. 80+00
C-07R	Dredging Plan (Sabine-Neches Canal), Sta. 80+00 to Port Arthur Canal Sta. 230+00
C-08R	Dredging Plan (Port Arthur Canal), Sta. 230+00 to Sabine Pass Channel Sta. 280+00
C-09R	Dredging Plan (Sabine Pass Channel), Sta. 280+00 to Sta. 60+00
C-10R	Dredging Plan (Sabine Pass Channel), Sta. 60+00 to Sabine Pass Jetty Channel Sta. -140+00
C-11R	Dredging Plan (Sabine Pass Jetty Channel), Sta. -140+00 to Sabine Bank Channel Sta. 110+000
C-12	Dredging Plan (Sabine Bank Channel Extension), Sta. 110+000 to Sta. 165+000
C-24R	Bessie Heights Plan
C-25	Old River Cove Plan
C-27R	Shoreline Nourishment Plan
G-02R	Location Plan Proposed Waterway

List of Tables

Page

I-1 Existing Sabine-Neches Waterway Channel Dimensions I-2
I-2 Summary of Habitat Acreages by State, 2004 ..... I-14
I-3 Sabine-Neches Waterway Interagency Coordination Team Participants I-22
I-4 Congressional Authorizations for Sabine-Neches Waterway Channel Improvements I-23
IV-1 Structural Alternatives IV-14
IV-2 SNWW (including Taylor Bayou Channel and Neches River Channel) Alternative First Cost IV-17
IV-3 Average Annual Benefits, Neches River Channel IV-18
IV-4 Average Annual Benefits, Taylor Bayou Channel and Basin – Accommodates Limited Range of Aframax Vessels IV-18
IV-5 Average Annual Benefits, Taylor Bayou Channel and Basin – Accommodates Limited Range of Aframax and Suezmax Vessels IV-18
IV-6 SNWW (Taylor Bayou and Neches River Channels) First Cost and Average Annual Costs and Benefits IV-19
IV-7 Sabine Pass Channel and Port Arthur Canal Widening Only, Economic Summary Data IV-22
IV-8 Alternatives for Final Screening IV-24
IV-9 SNWW Economic Summary Data, Cost and Benefits by Channel Alternative IV-24
IV-10 Comparison of P&G Evaluation Criteria IV-25
V-1 SNWW Total Tonnage and Major Commodity Tonnage V-2
V-2 SNWW Shallow-Draft Port and GIWW Through Tonnage, Deep-Draft Total Tonnage, and Shallow-Draft Percentage of Total Tonnage V-3
V-3 Comparison of SNWW and Regional and National Totals, Crude Petroleum Imports V-4
V-4 SNWW Atmospheric Crude Oil Distillation Capacity V-6
V-5 Port Arthur Total Tonnage and Major Commodity Tonnage, 1999–2007 ..... V-7
V-6 Beaumont Total Tonnage and Major Commodity Tonnage, 1999–2007 ..... V-8
V-7 SNWW Economic Analysis, U.S. Liquefied Natural Gas Facility Expansions and New Construction V-12
V-8 LNG Existing and Under Construction Terminals V-13
V-9 U.S. and SNWW Liquefied Natural Gas Imports, 2005–2030 ..... V-14
V-10 Port Arthur Tonnage Evaluated for Channel Deepening V-16
V-11 Beaumont Tonnage Evaluated for Channel Deepening V-17
V-12 SNWW Crude Petroleum Imports by Loaded Draft, 2002–2007 ..... V-18
V-13 Port Arthur Crude Petroleum Imports 2002–2007, Percentage of Imports by Vessel DWT and Design Draft and Year Built V-18
V-14 Beaumont Crude Petroleum Imports 2002–2007, Percentage of Imports by Vessel DWT and Design Draft and Year Built V-18
V-15 SNWW Petroleum Product Import Tonnage, by Vessel DWT V-19
V-16 SNWW Petroleum Products 2002–2007 Imports and Exports by Vessel Design Draft V-20
V-17 Percentage of Imports and Exports Shipped in Vessels of 60,000 DWT or Larger, SNWW Petroleum Product Imports, 1998–2007 ..... V-21
V-18 SNWW Petroleum Product Exports, 1998–2007 ..... V-21
V-19 SNWW and U.S. Chemical Products, Foreign Imports and Exports V-23
V-20 Chemical Product Carrier Fleet, World Fleet as of January 2009 ..... V-23
V-21 Beaumont Bulk Grain Export, Distribution of Tonnage by Grain Type and Loaded Vessel Draft V-25
V-22 LoLo Bulk Dry Cargo Carriers V-26

List of Tables, cont'd

Page

V-23 SNWW Building Material Imports V-27
V-24 SNWW Aggregate Tonnage Fleet, 2002–2007 ..... V-28
V-25 World Liquefied Natural Gas Fleet V-29
V-26 Adjustments for Estimating Actual Vessel Capacity V-29
V-27 Representative Round Trip Mileage to SNWW V-30
V-28 Tanker Characteristics and Hourly Operating Cost, Double-Hull Tankers, December 2008 IWR Release V-31
V-29 Dry Bulk Carrier Characteristics and Hourly Operation Costs, Foreign Flag Dry Bulk Carriers, December 2008 IWR Release V-31
V-30 Liquefied Natural Gas Carriers Characteristics and Hourly Operating Cost V-32
V-31 Transportation Cost Calculation (South America to SNWW) V-33
V-32 SNWW Crude Petroleum Imports Transportation Cost and Savings, Most Likely Transportation Mode Trade Route and Channel Depth V-34
V-33 SNWW Crude Petroleum Imports, Lightening Cost per Ton by Channel Depth and Trade Route V-35
V-34 SNWW Crude Petroleum Imports, Lightering Cost per Ton by Channel Depth Alternative and Trade Route V-35
V-35 Beaumont Crude Petroleum Imports, Annual Transportation Savings by Trade Route and Decade V-36
V-36 Port Arthur Crude Petroleum Imports, Annual Transportation Savings by Trade Route and Decade V-37
V-37 Beaumont Petroleum and Chemical Product Imports and Exports, Annual Transportation Cost by Trade Route and Decade V-39
V-38 Port Arthur Petroleum and Chemical Product Imports and Exports, Annual Transportation Cost by Trade Route and Decade V-40
V-39 SNWW Petroleum and Chemical Products Annual Savings by Channel Depth Alternative, 2019–2069 ..... V-41
V-40 SNWW Petroleum Product Coastwise Shipments and Receipts, Vessel Data, Base Tonnage, and Transportation Savings Benefit Summary V-42
V-41 Beaumont Wheat Exports, Shipments to Europe, Mediterranean, and Far East, Total Cost per Ton by Channel Depth V-43
V-42 Beaumont Wheat Exports, Shipments to Europe, Mediterranean, and Far East, Total Cost ($1,000s) by Channel Depth V-43
V-43 Beaumont Steel Slab and Iron Ore from South America, Mediterranean, and the Far East V-44
V-44 Beaumont Steel Slab and Iron Ore from South America, Mediterranean, and the Far East Tonnage and Annual Transportation Cost by Ton V-45
V-45 Port Arthur Steel Slab and Iron Ore from South America, Mediterranean, and the Far East Tonnage and Annual Transportation Cost by Ton V-46
V-46 SNWW Crude Material Imports and Exports via Mexico, South America, Mediterranean, and Far East Cost per Ton V-47
V-47 Beaumont Imports and SNWW Exports of Crude Materials, Mexico, South America, Mediterranean and the Far East Tonnage and Annual Transportation Cost by Ton V-48
V-48 Port Arthur Crude Material Imports from, Mexico, South America, Mediterranean, and the Far East Tonnage and Annual Transportation Cost by Ton V-49
V-49 SNWW Liquefied Natural Gas Trade Route Forecast, Short Tons V-50
V-50 Liquefied Natural Gas Transportation Cost per Ton by Channel Depth, Vessel DWT, and Shipment Origin V-50

List of Tables, cont'd

Page

V-51 SNWW Liquefied Natural Gas Annual Transportation Savings by Trade Route V-50
V-52 Total Average Annual Deepening Benefits by Project Depth Alternative V-51
V-53 Total Average Annual Benefits by Channel Reach and Alternative V-51
V-54 SNWW Pilot's Rules V-53
V-55 SNWW Crude Petroleum Imports, Percentage of Imports by Vessel DWT, and Design Draft and Year Built V-55
V-56 SNWW Trips by Loaded Draft V-56
V-57 SNWW Total Vessel Trips for Piloted Vessels V-57
V-58 HarborSym Vessel Classes V-58
V-59 SNWW 2000–2004 Base Tonnage V-59
V-60 SNWW 2030–2040 Tonnage V-59
V-61 SNWW 2030–2040 Tonnage V-60
V-62 SNWW 2030–2040 Vessel Trips Without Deepening V-60
V-63 SNWW 2030–2040 Vessel Trips With Deepening V-60
V-64 Sabine Pass Channel and Port Arthur Canal Average Annual Benefits V-62
V-65 Sabine Pass Channel and Port Arthur Canal, Widening Only, Economic Summary Data V-62
V-66 Neches River Turning Basin and Anchorage Features V-63
V-67 Neches River Anchorage Basins V-66
V-68 Average Annual Cost, Transportation Savings Benefits, Net Excess Benefits, and BCRs V-67
V-69 Average Annual Cost, Transportation Savings Benefits, Net Excess Benefits, and BCRs V-68
V-70 SNWW Neches River Anchorage Analysis, Basins 1, 4, and 8, Economic Summary Data V-69
V-71 Sabine Pass Channel and Port Arthur Canal Average Annual Benefits V-70
V-72 Sabine Pass Channel and Port Arthur Canal Economic Summary Data V-70
V-73 Total Average Annual Benefits by Channel Reach and Alternative V-72
V-74 SNWW Economic Summary Data, Cost and Benefits by Channel Alternative V-73
V-75 Sabine Pass, Port Arthur Canal, and Sabine-Neches Canal Incremental Analysis Cost and Benefits by Channel Alternative V-73
V-76 Taylor Bayou Incremental Analysis Cost and Benefits by Channel Alternative V-74
V-77 Project Improvements through Port Arthur (including Taylor Bayou) Cost and Benefits by Channel Alternative V-74
V-78 Neches River Incremental Economic Analysis Cost and Benefits by Channel Alternative V-75
V-79 SNWW Improvements (excludes Taylor Bayou) Cost and Benefits by Channel Alternative V-75
V-80 Neches River Project Improvements (excludes Transportation Benefits for All Other Reaches) Cost and Benefits by Channel Alternative V-76
V-81 SNWW Improvements (excludes LNG) Cost and Benefits by Channel Alternative V-76
V-82 SNWW Economic Summary Data at 7 Percent Cost and Benefits by Channel Alternative V-77
V-83 SNWW Economic Summary Data Without Additional Advanced O&M Cost and Benefits by Channel Alternative V-78
VI-1 New Work and 50-Year Maintenance Quantities for the Recommended Plan VI-2
VI-2 Project Details of Sabine Bank Extension VI-3
VI-3 Project Details for Sabine Bank Channel Reach VI-11
VI-4 Project Details for Sabine Pass Outer Bar Channel Reach VI-11
VI-5 Project Details for Sabine Pass Jetty Channel Reach VI-12
VI-6 Project Details for Sabine Pass Channel Reach VI-13
VI-7 Project Details for Port Arthur Canal Reach (including Taylor Bayou) VI-14

List of Tables, cont'd

Page

VI-8 Project Details for Sabine-Neches Canal Reach VI-15
VI-9 Project Details for the Neches River Channel Reach VI-16
VI-10 Existing and Proposed Maintenance Dredging Quantities VI-17
VI-11 Real Estate Requirements for Placement Areas VI-21
VI-12 SNWW WVA Impacts Summary-Before DMMP Benefits and Mitigation, Louisiana Impacts VI-23
VI-13 SNWW WVA Impacts Summary-Before DMMP Benefits and Mitigation, Texas Impacts VI-24
VI-14 Impact Analysis and Mitigation Need VI-26
VI-15 Critical Assumptions VI-27
VII-1 Annual Sediment Budget for Sabine Pass VII-5
VII-2 Preliminary Screening: Dredged Material Beneficial Use Features Eliminated from Consideration VII-10
VII-3 Acreage Restored by Neches River BU Feature VII-15
VII-4 Average Annual Cost Comparison of Placement Plan Alternatives for the Proposed 48-foot Project VII-24
VII-5 DMMP BU Features VII-26
VII-6 Dredged Material Management Plan Upland Placement Areas VII-27
VII-7 Existing and New ODMDSs VII-27
VII-8 Texas – FWP Impacts and Benefits by Habitat Type VII-30
VII-9 Louisiana – FWP Impacts and Benefits by Habitat Type VII-31
VII-10 Net FWP Impacts for Project as a Whole VII-32
VII-11 Cost Comparison of Gulf Shore Beneficial Use Feature to Base Plan PA 5 ..... VII-33
VII-12 Incremental O&M Cost for the Recommended Plan VII-35
VIII-1 Net Project Impacts and Benefits by Average Annual Habitat Units VIII-2
VIII-2 FWP Compensatory Mitigation Target for Louisiana VIII-5
VIII-3 Best Buy Plans Identified by Incremental Cost Analysis VIII-9
VIII-4 Recommended Mitigation Plan VIII-10
VIII-5 Recommended Mitigation Plan – Acreage Analysis VIII-13
IX-1 RSLR Sensitivity of Project Alternatives IX-11
IX-2 Primary Data Used for SNWW Economic Analysis IX-15
IX-3 Quality of Data Used in Ecological Analyses IX-17
X-1 Project Dimensions for Recommended Plan X-2
X-2 Upland Placement Areas for the Recommended Plan X-7
X-3 Ocean Dredged Material Disposal Sites for Recommended Plan X-7
X-4 GNF Beneficial Use Features in the Recommended Plan X-8
X-5 Mitigation for Recommended Plan X-9
XI-1 Total First Cost and Annualized O&M for the Recommended Plan XI-3
XI-2 Total Investment Cost for the Recommended Plan XI-4
XI-3 Recommended Plan First Costs Allocation by Depth XI-6
XI-4 Recommended Plan Fully Funded Costs Allocation by Depth XI-7
XI-5 Recommended Plan – First Costs Allocation XI-8
XI-6 Recommended Plan – Fully Funded Costs Allocation XI-9
XI-7 Total General Navigation Features Costs and Credits XI-10

Acronyms and Abbreviations

3-D	three-dimensional
AAHU	average annualized habitat units
AB	anchorage basins
ADV	Acoustic Doppler Velocity
AIS	Automatic Identification System
ATR	Agency Technical Review
Bcf	billion cubic feet
Bcf/d	billion cubic feet/day
BCR	Benefit-to-Cost Ratio
BOOTS	Bulk Oil Offshore Transfer System
BU	Beneficial Use
CAP	Continuing Authorities Project
CAR	Coordination Act Report
CE/ICA	cost-effectiveness analysis and incremental cost analysis
CEPRA	Coastal Erosion Planning and Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHL	Coastal and Hydraulics Laboratory
CIP	Channel Improvement Project
CWPPRA	Coastal Wetlands Planning, Protection and Restoration Act
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Plan
DAMP	Dewatering Management Practices
DMMP	Dredged Material Management Plan
DWT	deadweight tons
EC	Engineering Circular
EFH	Essential Fish Habitat
EGM	Economic Guidance Memorandum
EIA	Energy Information Administration
EIS	Environmental Impact Statement
EMCM	Emergent Marsh Community Model
EOP	Environmental Operating Principles
EPA	Environmental Protection Agency
ER	Engineering Regulation
ERDC	Engineer, Research and Development Center
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission

FFR	Final Feasibility Report
FWOP	future without project
FWP	future with project
GEC	Gulf Engineers and Consultants, Inc.
GICA	Gulf Intracoastal Canal Association
GIWW	Gulf Intracoastal Waterway
GLO	General Land Office
GMFMC	Gulf of Mexico Fisheries Management Council
GNF	General Navigation Features
HEP	Habitat Evaluation Procedure
HFP	Hurricane Flood Protection
HS model	hydrodynamic-salinity modeling
ICT	Interagency Coordination Team
IDC	interest during construction
IH	Interstate Highway
IPCC	Intergovernmental Panel on Climate Change
IWR	Institute of Water Resources
JCWND	Jefferson County Waterway and Navigation District
LACPRA	Louisiana Coastal Protections and Restoration Authority
LBG/TEA	Louis Berger Group and Toxicological and Environmental Associates
LCWCR/WCRA	Louisiana Coastal Wetlands Conservation and Restoration/Wetlands Conservation and Restoration Authority
LDNR	Louisiana Department of Natural Resources
LDNR-OCM	Louisiana Department of Natural Resources, Office of Coastal Management
LDWF	Louisiana Department of Wildlife and Fisheries
LER	Lands, Easements, and Rights of Way
LNG	liquefied natural gas
LOOP	Louisiana Offshore Oil Port
LPP	Locally Preferred Plan
mcy	million cubic yards
mcy/yr	million cubic yards per year
MLK	Martin Luther King
mm	millimeters
msl	mean sea level
MW	Hydrodynamic and Salinity Modeling Workgroup
NAWMP	North American Waterfowl Plan
NDC	Navigation Data Center
NED	National Economic Development

NEPA	National Environmental Policy Act
NMFS	U.S. National Marine Fisheries Service
NRC	National Research Council
NRHP	National Register of Historic Places
NWR	National Wildlife Refuge
O&M	operations and maintenance
ODMDS	Ocean Dredged Material Disposal Sites
P&G	Principles and Guidelines
PA	placement area
PADD	Petroleum Administration Defense District
PED	Preconstruction Engineering and Design
PGL	Policy Guidance Letters
PIE	Pacific International Engineering
ppt	parts per thousand
RED	Regional Economic Development
RHA	River and Harbor Act
RSLR	relative sea level rise
RSM	Regional Sediment Management
SCM	Swamp Community Model
SH	State Highway
SI	Suitability Indices
SNND	Sabine Neches Navigation District
SNWW	Sabine-Neches Waterway
SPA	Sabine Pilots Association
STWAVE	Steady State Spectral Wave Model
TB	turning basins
TBA	turning basin anchorage
Tcf	trillion cubic feet
TDH	Texas Department of Health
TPCS	Total Project Cost Summary
TPWD	Texas Parks and Wildlife Department
TWDB	Texas Water Development Board
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDA	U.S. the Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VLCC	Very Large Crude Carriers

VTS	Vessel Traffic Service
WMA	Wildlife Management Area
WRDA	Water Resources Development Act
WVA	wetland value assessment model

I. STUDY INFORMATION

I.A OVERVIEW

This Feasibility Report was prepared to determine the feasibility of modifying the portion of the existing Sabine-Neches Waterway (SNWW) that serves the ports of Beaumont and Port Arthur, Texas. The Port of Orange was not interested in participating in the study; therefore, modifications to the Channel to Orange were not considered in this study. To allow for a more effective, safe, and efficient waterway, the study focused on eliminating the major problems contributing to the inefficiencies on the waterway. The study reviewed and analyzed alternatives to address the insufficient channel depth and width, as determined by fleet forecasts. The possibility of conducting two-way traffic in portions of the channel, and ways of maintaining a safe waterway for all commercial and public users were also investigated. Economic benefits and costs were identified for proposed channel modifications, and recommendations were made that would maximize project benefits.

I.B STUDY AUTHORITY

This Feasibility Report was conducted in response to the June 5, 1997, Senate resolution from the Committee on Environment and Public Works. The resolution states:

> The Secretary of the Army shall review previous reports on the Sabine-Neches Waterway published as Senate Document No. 80, 83rd Congress, Second Session; House Document No. 553, 87th Congress, Second Session; and other pertinent reports to determine the feasibility of modifying the channels serving the ports of Beaumont, Port Arthur, and Orange, Texas, in the interest of commercial navigation.

I.C PURPOSE AND SCOPE

This report presents the findings of a feasibility investigation conducted to determine whether there is a Federal interest in providing channel improvements to the SNWW. This report analyzes the problems and opportunities, and expresses desired outcomes as planning objectives. Alternatives were then developed to address these objectives. These alternatives include a plan of no action and various combinations of structural and nonstructural measures. The economic and environmental impacts of the alternatives were then evaluated to identify the Recommended Plan. The report also presents details on U.S. Army Corps of Engineers (USACE) and Sponsor participation needed to implement the plan. The report concludes with a plan that is recommended for Congressional authorization (the Recommended Plan).

I.D PROJECT AREA DESCRIPTION

Physical Description of Study Area

The SNWW is an approximately 64-mile federally authorized and maintained waterway located in Jefferson and Orange counties in southeast Texas and Cameron Parish, Louisiana. The area surrounding

the waterway is generally referred to as the "Golden Triangle" and is delineated by the three major Texas seaports of Port Arthur, Beaumont, and Orange. Sabine Pass, Sabine Lake, and the Sabine River together form part of the boundary between the states of Texas and Louisiana (Figure I-1). Improvements to the 30-foot Sabine River Channel to Orange were not evaluated due to the expectation of continued low utilization of the existing project depth.

The SNWW is a system of navigation channels that has been superimposed upon the Sabine-Neches estuary in Texas and Louisiana. The estuary includes Sabine Lake, tidal portions of the Sabine and Neches rivers, and a number of tidally influenced bayous and shallow coastal lakes. The only connection with the Gulf of Mexico is a long narrow pass called Sabine Pass through which all tidal interchange occurs. Sabine Pass is stabilized by jetties that extend 4.1 miles into the Gulf of Mexico. The jetties were initially constructed for navigational purposes in the late 1880s.

The existing SNWW is made up of seven reaches as shown in Table I-1, beginning with the Sabine Bank Channel in the Gulf of Mexico and working upstream to the Neches River Channel.

Table I-1
Existing Sabine-Neches Waterway Channel Dimensions

Channel Reach	Authorized Depth (feet)	Bottom Width (feet)	Length (miles)
Sabine Bank Channel	42	800	14.7
Sabine Pass Outer Bar Channel	42	800	3.4
Sabine Pass Jetty Channel	40	800–500	4.0
Sabine Pass Channel	40	500–1,133	5.6
Port Arthur Canal (including Taylor Bayou)	40	500–1,788	6.2
Sabine-Neches Canal	40	400–1,060	11.3
Neches River Channel	40	400	18.6

The SNWW enters from deep water in the Gulf through the Entrance Channel, which is divided into the Sabine Bank Channel and the Sabine Pass Outer Bar Channel. It enters into Sabine Pass through the Sabine Pass Jetty and Sabine Pass channels, and follows the west bank of Sabine Lake to Port Arthur in the Port Arthur Canal. The project includes Taylor Bayou Channels and Turning Basins (TB) at the confluence of the Port Arthur Junction Area. On the west side of Sabine Lake, the Sabine-Neches Canal is separated from the lake by an artificially created band of land called Pleasure Island, that extends to the near the mouth of the Neches River. From the northwestern to the northeastern corner of Sabine Lake, another section of the Sabine-Neches Canal connects the mouths of two rivers, the Neches River (to Beaumont, Texas) and the Sabine River to the east (to Orange, Texas). The Neches River Channel ends at the Beaumont TB just south of the Interstate Highway (IH) 10 Bridge. The deep-draft portion of the authorized Federal project generally provides for a channel 42 feet deep and 800 feet wide at the entrance to the Gulf of Mexico, a channel 40 feet deep and 500 feet wide to Port Arthur, and a channel 40 feet deep

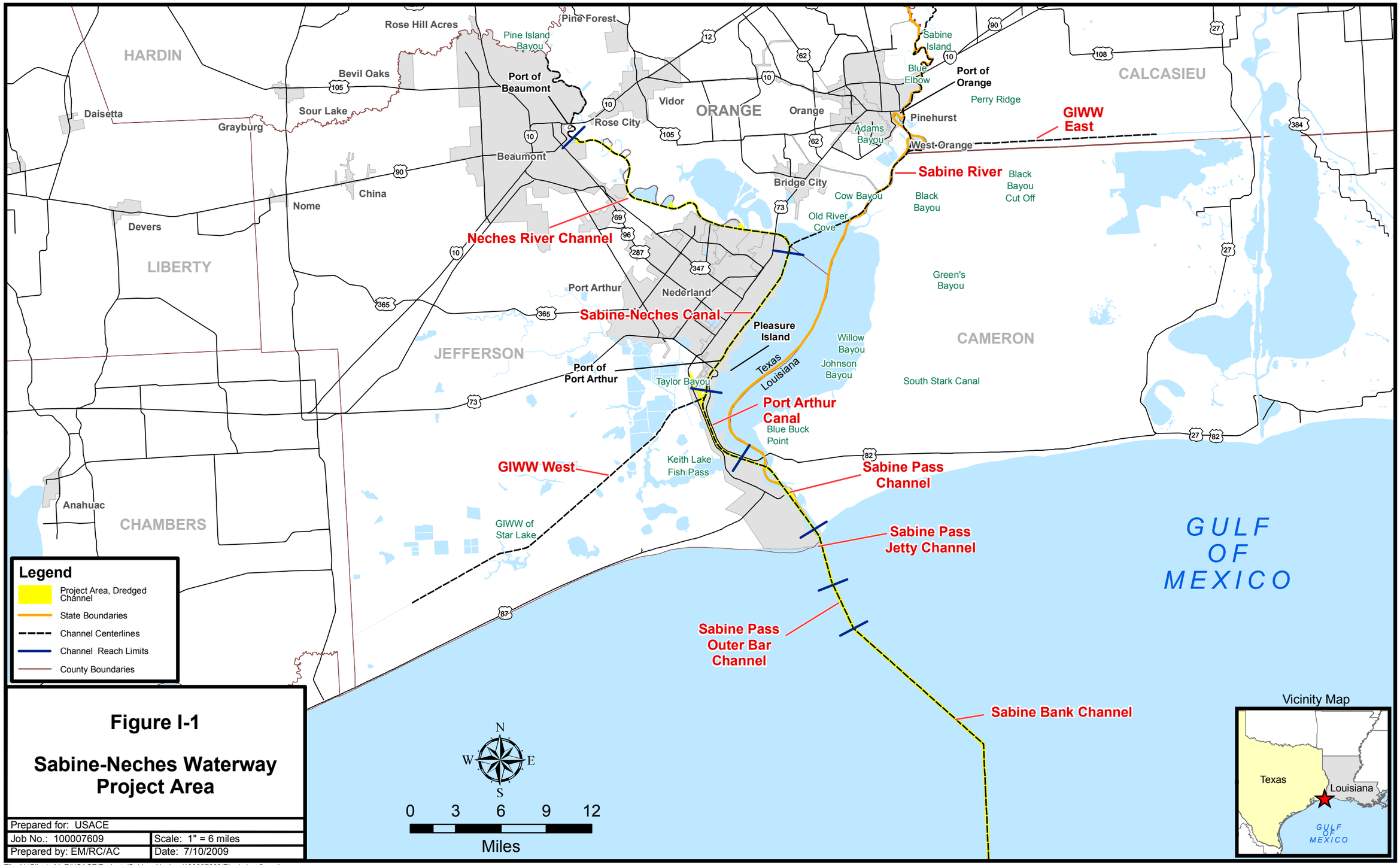


Figure I-1

Sabine-Neches Waterway Project Area

Prepared for: USACE	
Job No.: 100007609	Scale: 1" = 6 miles
Prepared by: EM/RC/AC	Date: 7/10/2009

File: N:/Clients/U_Z/USACE/Projects/Sabine_Neches/100007609/Fig_I_1_vr2.mxd

This page intentionally left blank.

and 400 feet wide to Beaumont by way of the Neches River. The existing SNWW channel has four open-water dredged material placement areas (PAs) and 24 upland confined PAs.

Shallow- and deep-draft vessels use the same channel where the routes of the Gulf Intracoastal Waterway (GIWW) and SNWW overlap. The GIWW coincides with parts of the SNWW, entering from the west just south of Port Arthur, extending through the confined channel reach at Pleasure Island, crossing the more exposed northern edge of Sabine Lake, and following the Sabine River Channel north to just south of the City of Orange, where the GIWW turns eastward and continues into Louisiana.

Study Area

The study area includes the area for which environmental effects of alternatives have been analyzed (Figure I-2) and encompasses a 2,000-square-mile area, which contains the smaller area referred to as the "project area." The project area includes those areas that would be directly affected by construction of the Channel Improvement Project (CIP) (i.e., dredging footprint, existing and proposed PAs, and mitigation areas). The study area includes the following water bodies and adjacent coastal wetlands: Sabine Lake and adjacent marshes in Texas and Louisiana, the Neches River channel up to the new Neches River Saltwater Barrier, the Sabine River channel to the Sabine Island Wildlife Management Area (WMA), the GIWW west to Star Bayou, the GIWW east to Gum Cove Ridge, the Gulf shoreline extending to 10 miles either side of Sabine Pass, and 35 miles offshore into the Gulf of Mexico.

The major rivers within the study area are the Sabine and Neches rivers, and smaller streams such as Taylor, Adam, Cow, and Little Cypress bayous on the Texas side. Major bayous flowing into Sabine Lake from Louisiana include Lighthouse, Johnson's, Madame Johnson's, Willow, Three, and Black bayous. Approximately 80 percent of the freshwater drainage bypasses Sabine Lake, traveling down the SNWW and flowing into the Gulf of Mexico or southwestward into the GIWW (Gosselink et al., 1979).

Environmental Setting

Terrain

The coastline of the study area differs from most of the Texas coast in that there are no barrier islands or lagoons. The study area is characterized by a diversity of features that are a result of the natural transition between marine and freshwater environments and anthropogenic impacts. The mainland portion of the study area can be classified as either coastal-marsh or coastal-prairie. These extensive wetland areas occur in areas less than 5 feet above mean sea level (msl) and extend inland 4 to 15 miles along the entire Gulf shoreline. Expansive marsh borders Sabine Lake on the southeast side, PAs on the west and north sides of the lake, and swamps and bottomland hardwoods extend up the lower reaches of the Neches and Sabine rivers.

This page intentionally left blank.

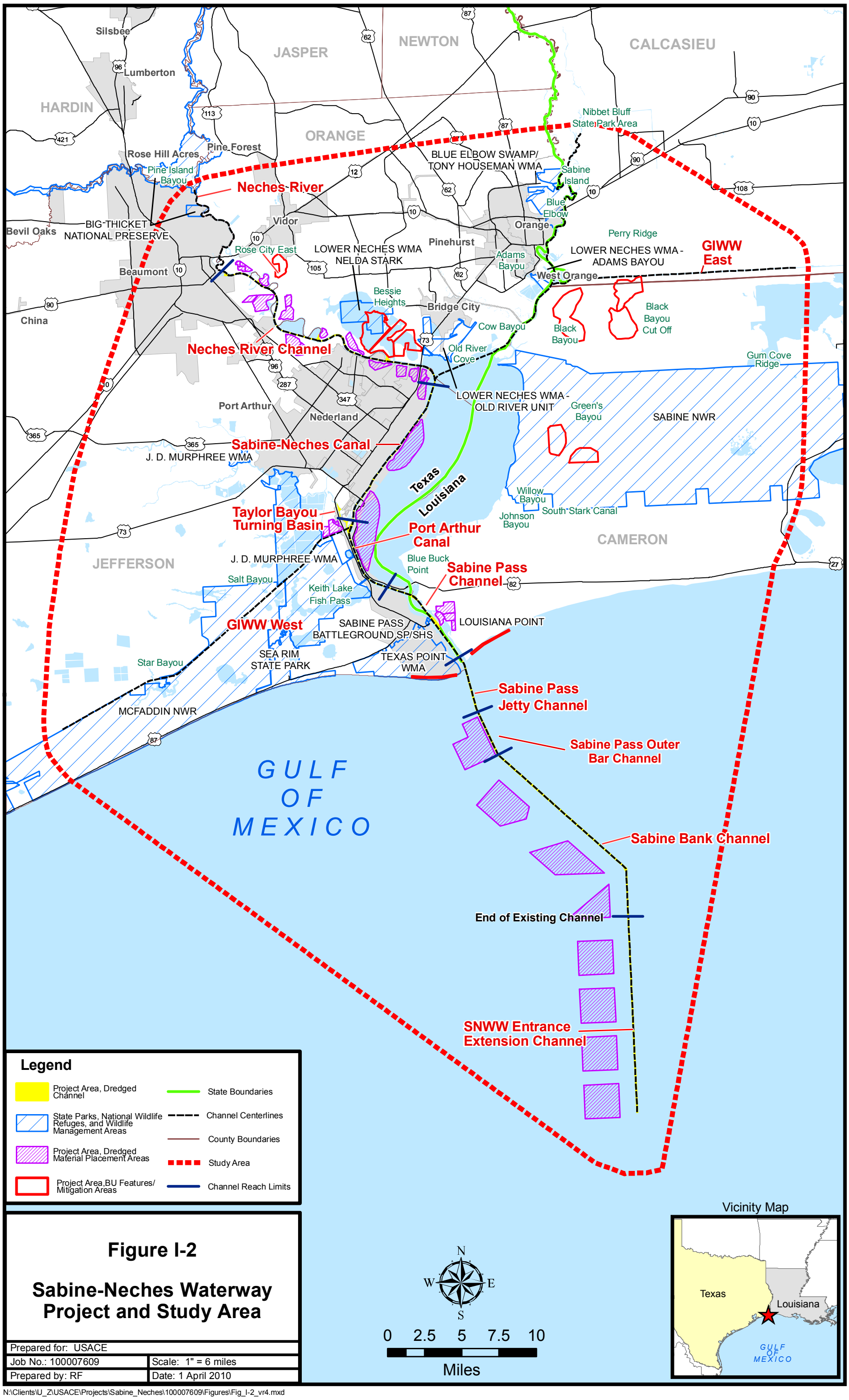


Figure I-2

Sabine-Neches Waterway Project and Study Area

Prepared for: USACE	
Job No.: 100007609	Scale: 1" = 6 miles
Prepared by: RF	Date: 1 April 2010

N:\Clients\U_Z\USACE\Projects\Sabine_Neches\100007609\Figures\Fig_I-2_vr4.mxd

This page intentionally left blank.

The gentle sloping coastal prairie lies landward of the coastal marshes and is broken into smaller prairie segments by belts of pine and hardwood trees and by small meandering coastal streams with their associated wetlands. Farmers and ranchers are the principal users in the higher marsh areas. Cities and industries cover most of the higher elevations, and this is largely restricted to the west bank of Sabine Pass and Sabine Lake, and between the mouth of the Sabine and Neches rivers, northwest of Sabine Lake.

The timberlands in the flood-prone areas were commercially lumbered in the past but have experienced only small-scale lumbering in the twentieth century. Topography of the study area is essentially featureless, except for the surface expression of salt domes (Big Hill, Fannett, and Spindletop in Texas and Hackberry in Louisiana). These salt domes are still producing limited quantities of oil and gas.

Sabine Lake has a water surface area of approximately 100 square miles and a maximum natural depth of 9 feet. Due to the abundance of rainfall in this region, the rivers and bayous of this reach provide substantial freshwater inflow into Sabine Lake. However, instream flows to this reach have been altered from their natural hydrograph due to major impoundments in the middle and upper Sabine and Neches River basins. The combined discharges of the Sabine and Neches rivers into the northern part of Sabine Lake constitute the greatest freshwater input to any Texas bay. These rivers discharge large quantities of fine sediments into the lake but do not form deltas at their mouths because most of this material remains in suspension and is dispersed over the northern portion of the lake. During flood flows, these fine sediments are dispersed over the entire lake, and some are expelled through the Sabine Pass into the Gulf of Mexico.

The Gulf in the study area consists of open seas, coastline, and a dredged channel extending from the jettied Sabine Pass seaward. This area is heavily influenced by the Mississippi River Delta located to the east. When the Mississippi River occupied one of its western courses, sediment deposits were carried westward by littoral currents that built the Chenier Plain (Davis, 1996). The Chenier Plain is a unique salt marsh area on the extreme eastern edge of the Texas Gulf Coast, and is part of a much larger chenier plain in western Louisiana. A chenier plain is a series of sandy or shelly ridges or “cheniers,” many more than 10 feet high, separated by clayey or silty marsh deposits. The distance from chenier to chenier may be as much as 1 or 2 miles or more.

Chronic erosion is believed to be associated with the diversion of sand and other sediment resulting from channelization and regulation of the Mississippi and Atchafalaya rivers to the east, and the Sabine and Neches rivers in Texas. The Sabine Pass jetties intercept sediment moving westward in the littoral drift, creating a wide, muddy, tidal flat next to the east jetty (PBS&J, 2006; USACE, 2004). Texas Point is undergoing severe beach erosion, with shoreline retreat of up to 1,150 feet between 1974 and 2000 (King, 2007; Morang, 2006). This is the highest rate of shoreline loss on the upper Texas coast, and a Texas Coastal Erosion Planning and Response Program (CEPRA) has identified several parts of the study areas as “critical erosion areas” (Texas General Land Office [GLO], 2004, 2005). In Louisiana, persistent erosion along the shoreline between Ocean View and Holly Beach, on the order of –4.3 feet/year between 1985 and 1998, was recorded here prior to Hurricane Rita (USACE, 1971a, 2004). Nearer to Louisiana

Point, significant accretion over the last 100 years has slowed to +1.2 feet/year, and the behavior of this shoreline has become erratic, with some areas eroding and some accreting (USACE, 2004).

The study area lies in the easternmost portion of the humid climatological zone of Texas and usually has mild summers and winters. Winds generally are from the south or southeast except during the winter when polar fronts (northers) move across the state. Winds from these northers are important in lowering water levels and help to flush coastal estuaries. Temperatures are moderated by the influence of the winds from the Gulf, resulting in mild winters and relatively cool summer nights. The mean daily temperature ranges from the mid-50s (degrees Fahrenheit, °F) in December and January to the mid-80s in the summer months. The temperature rarely drops below 22°F or rises above 98°F. Relative humidity levels average approximately 78 percent throughout the year (USACE, 1975). Freezing temperatures occasionally occur during the winter but rarely last more than a few days. The historical temperature variance has been from a low of 11°F to a high of 107°F. The growing season, or the average period from the last frost in spring to the first frost in fall, is about 294 days.

The study area is also subject to dense fog throughout the year, but such conditions are most prevalent during the fall and winter months. Heavy fog occurring on an average of 29 days per year tends to hamper navigation by producing limited-visibility conditions along the waterway. Clear days during the year average about 117; partly cloudy days, 191; and cloudy days, 57.

Another effect of the nearness of the Gulf is abundant rainfall distributed throughout the year. The average annual rainfall is about 52 inches, with monthly precipitation averaging from 3.2 inches to about 6.6 inches. The area is occasionally subject to periods of intense rainfall, which may occur during any time of the year, but are usually associated with tropical storms, which typically occur from June through October.

Tides

The Sabine Lake area is a dynamic estuary only recently subject to the extensive mixing of fresh and seawater due to tidal currents. The tidal inlet at Sabine Pass differs from the other Texas tidal passes in that it is very long, 7 miles, and narrow, 0.4 mile, and is solidly entrenched in earlier geologic deposits. Normal tidal fluctuation in the area is relatively small with a diurnal range of 1 to 2 feet. A tidal range varying from 1.03 at Sabine Pass to 0.65 foot at Orange can be derived from the tide records. These ranges are typical of the Gulf coast area. Water levels in the SNWW are also influenced by the prevailing winds from the south-southeast direction. Water levels generally rise slightly with winds out of the south and south-southeast and fall, sometimes significantly, with winds from the north or northwest. Water surface elevations in the SNWW can vary greatly when driven by wind and storm activity. Water levels as low as –4 feet during strong northwesterly winds and as high as +16 to +18 feet during hurricane surges have been observed.

Salinity

The SNWW estuarine system exhibits very complicated circulation and salinity patterns (Brown and Stokes, 2009). Fresh water enters the system via several tributaries, including the Sabine River, the Neches River, and other smaller inflows. The Neches River flows directly into Sabine Lake and the Sabine-Neches Canal. The Sabine River flows into Sabine Lake, the Sabine National Wildlife Refuge (NWR) and into Calcasieu Lake via the GIWW. During times of low flow, the direction of this flow is reversed and higher salinity Calcasieu waters flow westward into the Sabine basin (Gammill et al., 2002).

The Sabine-Neches Canal connects the Neches River Channel to Sabine Pass, flowing through a narrow, confined channel between Pleasure Island on the east and the Port Arthur area on the west. This canal acts as a flow pathway for both fresh water from the inflowing rivers, and saline waters intruding via tidal propagation through Sabine Pass. This combination results in highly stratified conditions in the Sabine-Neches Canal. The stratification contributes to saltwater intrusion migrating up the Sabine-Neches Canal and into the northwest corner of Sabine Lake and the lower reaches of the Neches River. To combat these conditions, a saltwater barrier (Neches River Saltwater Barrier) has been installed approximately 30 stream-miles upstream of Rainbow Bridge to prevent saltwater intrusion north of the Port of Beaumont. As a result of the intrusion, the observed salinity in Sabine Lake is highest at both the southern end (where the lake connects to Sabine Pass) and at the northern end (where the lake connects to the Sabine-Neches Canal). The lowest salinities are observed in the central and eastern portions of Sabine Lake, which are farthest from the hydraulic connection to sources of saline water.

The estuary experiences wide swings in salinity levels that are associated with periods of drought and high freshwater inflows. During periods of drought, the flow in the Neches and Sabine rivers can drop drastically and a saltwater wedge can proceed farther upstream of both the Sabine and Neches rivers from the Gulf (Lower Neches Valley Authority, 2002; Sabine River Authority of Texas, 2002). The strength and intensity of winds and intensity of rainfall influences salinity levels in the SNWW, Sabine Lake, and Calcasieu Lake. The salinity of the waterway ranges from open Gulf levels of about 34 parts per thousand (ppt) to 0 ppt in the upper reaches of the Neches and Sabine River channels. Sabine Lake is predominantly a brackish-water estuary with salinity content ranging from 15 ppt at Sabine Pass to 0 ppt at times at the northern end of the lake. During periods of normal rainfall, high-salinity water transported by the SNWW is buffered by inflows from the Sabine and Neches rivers, direct rainfall, and coastal watershed inflows that have little effect on the salinity levels of Sabine Lake and the surrounding marshes. On the other hand, during periods of high flows, the SNWW and Sabine Lake can experience occasional freshwater conditions (very low salinity levels) due to large quantities of fresh water entering the system from the Sabine and Neches rivers (Coalition to Restore Coastal Louisiana, 2002).

Geology

The soils of Jefferson and Orange counties, Texas, and Cameron Parish, Louisiana, are separated mainly into Holocene and Pleistocene sediments with modern river sediments in the vicinity of the Neches and Sabine River channels. The coastal zone in the study area has evolved to its present condition by erosion,

deposition, compaction, and subsidence, all of which are still active. Gradual faulting continues as Pleistocene and older Gulf basin muds continue to compact.

The site geology is characterized by modern marine deposits overlaying recent Holocene deposits that in turn overlay Beaumont and Lissie formations of the Pleistocene Series (Bureau of Economic Geology, 1982). The modern deposits are generally normally consolidated clays, silts, and fine sands that were deposited through natural overwash and sedimentation processes or through man-made depositional processes. The recent deposits of the Holocene consist of silts, clays, silty sands, clayey sands, and clayey silts that exhibit the characteristics of normally to lightly overconsolidated materials. These deposits are generally encountered to depths of 30 to 40 feet. Beaumont Clay is the predominant Pleistocene formation whose eroded surface forms the upper limit of stiff to very stiff clay material. Lenses of fine-grained, poorly graded sand and silt, and a few calcareous nodules are sometimes encountered in this formation. The clay fraction is composed of montmorillonite, kaolinite, illite, and finely ground quartz, in that order of prevalence, and it has a high shrink-swell potential.

Sabine Lake was formed from the flooding of an ancient river valley (Kane, 1959) and was later separated from the Gulf by the advancement of the Gulf shoreline and deposition of the beach ridge/mudflat complex known as the Chenier Plain (Gould and McFarlan, 1959). Two types of landforms characterize the Chenier Plain: broad marshes containing organic clays and peat, and long narrow relict beach features called cheniers that appear as ridges parallel to the coast. The Chenier Plain fronts the entire study area on the Gulf shoreline in both Texas and Louisiana.

High-volume freshwater inflow into Sabine Lake helped maintain Sabine Pass as a narrow and relatively shallow link between the Gulf and Sabine Lake (Morton, 1996). Filling of Sabine Lake with sediment continues from the Sabine and Neches rivers and the Gulf of Mexico. Muddy river deposits slowly fill the upper parts of the estuarine systems and are responsible for much of the muddy sediment that fills the upper part of Sabine Lake. Only small amounts of bedload sand have been deposited in the estuarine system.

Fish and Wildlife Resources

The SNWW 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.

Aquatic Resources

The study area consists of both freshwater and marine ecosystems. The Sabine and Neches rivers and their tributaries were dominated by fresh water prior to the late 1800s, before Sabine Lake was opened for navigation. It is likely that Sabine Lake was almost entirely fresh, with the exception of saltwater intrusions that emanated from tidal surges during storms or during severe droughts. Thus, the biological communities have changed significantly within the past century due to the encroachment of saltwater.

The salinity extremes that often occur in Sabine Lake preclude lasting colonization of stenohaline species (tolerating narrow salinity ranges). Most of the tributaries adjacent to Sabine Lake are also influenced by salt water to some extent. A general overview of the freshwater and marine resources is described below. For a more detailed description of the biological resources within the study area, see Section 3.10 of the Final Environmental Impact Statement (FEIS).

Freshwater Resources

Freshwater fauna typically occur in the tributaries of Sabine Lake including the Sabine and Neches rivers, Taylor, Cow, Adams, and Little Cypress bayous in Texas, Black and Johnson's bayous in Louisiana, as well as numerous other smaller tributaries. In addition, freshwater fauna can be found in the multitude of wetlands, oxbows, ponds, canals, and ditches within the study area.

Due to the variety of habitats and the typical diversity of southeastern U.S. streams, the study area has an exceptionally diverse fish community consisting of approximately 56 freshwater and 25 estuarine species (Hubbs, 1982; USACE, 1975). The Louisiana Department of Wildlife and Fisheries (LDWF), Inland Fisheries Division, monitors fish populations and has identified a variety of freshwater species from this area including largemouth bass, spotted bass, bowfin, black crappie, spotted sucker, golden shiner, sunfish, blue catfish, channel catfish, spotted gar, shad, and striped mullet (LDWF, n.d.).

Both benthic macroinvertebrates and plankton support the food chain in the freshwater zones. Food chains in the larger, slow-moving rivers, bayous, and backwater areas are similar to that found in lakes. In these systems, the food chain consists primarily of plankton, including microscopic algae (phytoplankton) and crustaceans (zooplankton) that are suspended in the water column. Diverse communities of plankton occur throughout the freshwater system, but gradually shift to marine taxa as the water enters the estuarine areas.

Marine Resources

Sabine Lake, when compared to the other estuarine ecosystems in Texas, covers the smallest surface area (43,978 acres/68.6 square miles) and volume; however, it has the largest surrounding marshland (over 185,000 acres/288.6 square miles) (Armstrong et al., 1987; Blackburn et al., 2001). Phytoplankton (microscopic algae) are the major plant life in the open-bay, taking up carbon through photosynthesis and nutrients for growth. Phytoplankton are fed upon by zooplankton (small crustaceans), fish, and benthic consumers. Zooplankton are most abundant when the salinities are higher. Sabine Lake supports a diverse nekton population including fish, shrimp, and crabs such as Atlantic croaker, white and brown shrimp, Gulf menhaden, bay anchovy, red drum, blue crab, and southern flounder. These species are present all along the Texas and Louisiana coast and are unaffected by changes in salinity. Sabine Lake sustains an important blue crab fishery in Texas and Louisiana. Eastern oyster reefs are located in the southern part of Sabine Lake near Blue Buck Point, in Sabine Pass, and in Keith Lake. Oysters are not commercially harvested from Sabine Lake. The Texas Department of Health (TDH) has prohibited the harvesting of molluscan shellfish from this system since the late 1970s (Heideman, 2002; TDH, 2002). Louisiana has

designated Sabine Lake as a "Public Oyster Area." However, no harvesting is currently allowed due to water quality issues.

Coastal Wetland Resources

The SNWW study area contains a high concentration of significant coastal wetlands. Approximately 109,175 acres (171 square miles) in Texas and 197,530 acres (309 square miles) in Louisiana were identified as coastal marsh, bottomland hardwood, or cypress-tupelo swamp habitats. Coastal marshes occur in four distinct types within the study area: (1) salt marsh, (2) brackish marsh, (3) intermediate marsh, and (4) freshwater marsh. A summary of the habitat acreage by state is provided in Table I-2, and a distribution of these habitats is presented on Figure I-3.

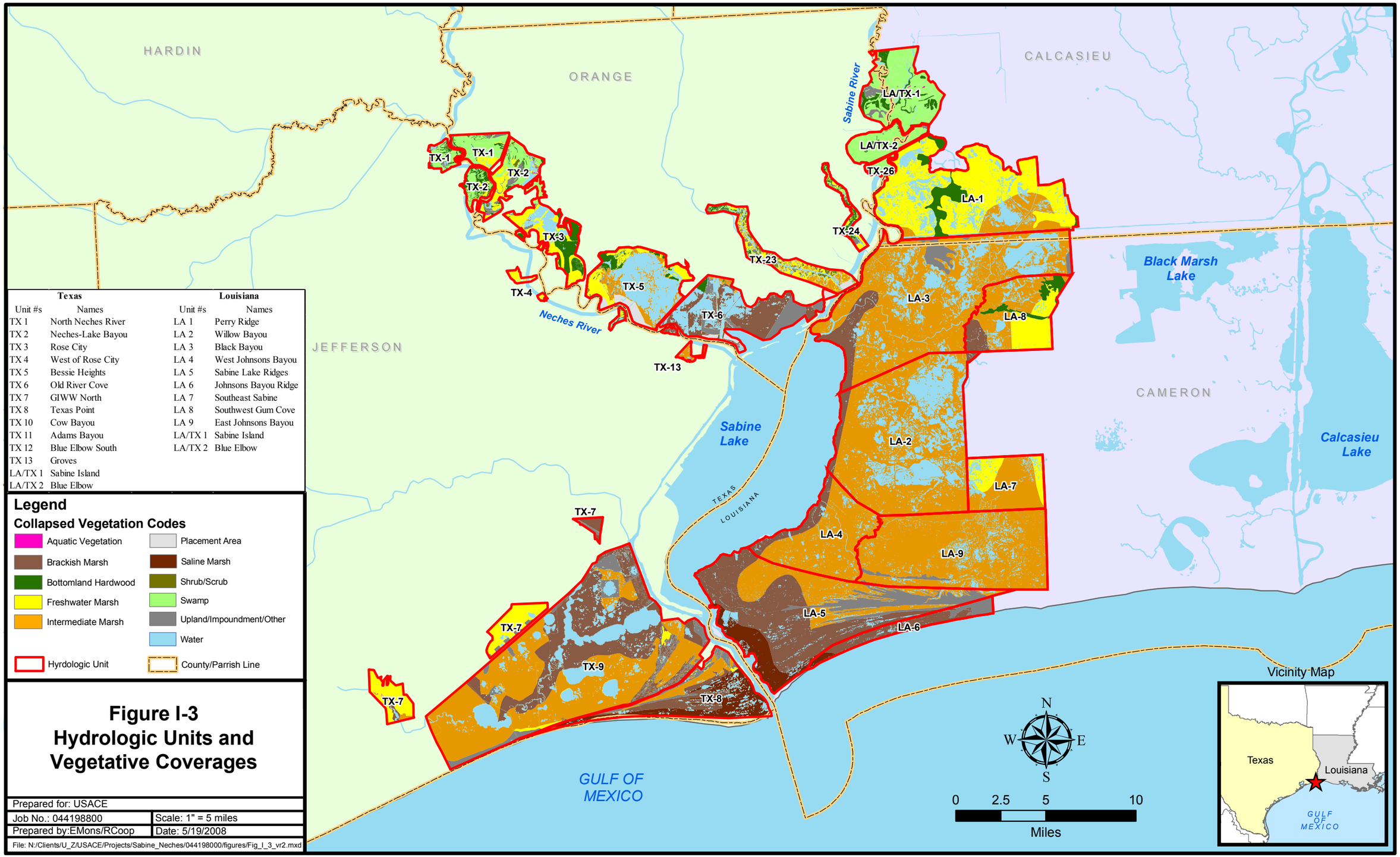
Table I-2
Summary of Habitat Acreages by State, 2004

	Fresh	Inter-mediate	Brackish	Saline	Total Marsh	Bottomland Hardwood	Swamp	Total Wetlands
Texas								
Acreage	13,580	30,336	24,047	4,898	72,861	5,458	10,157	88,476
Water	2,117	9,240	8,254	810	20,421	0	0	20,421
Totals	15,697	39,576	32,301	5,708	93,282	5,458	10,157	108,897
Louisiana								
Acreage	20,336	101,405	23,112	3,551	148,404	3,206	6,641	158,251
Water	4,772	31,872	2,049	586	39,279	0	0	39,279
Totals	25,108	133,277	25,161	4,137	187,683	3,206	6,641	197,530
Total								
Acreage	33,916	131,741	47,159	8,449	221,265	8,664	16,798	246,727
Water	6,889	41,112	10,303	1,396	59,700	0	0	59,700
Totals	40,805	172,853	57,462	9,845	280,965	8,664	16,798	306,427

Salt marsh is located along the Gulf shoreline of Texas and Louisiana, and the shores of Sabine Pass. Subjected to regular tidal inundation, low saline marsh is dominated with smooth cordgrass/oystergrass, seashore saltgrass, and marshbay cordgrass/wiregrass. The dominant species in high salt marsh subject to less frequent tidal inundation is glasswort. Relative to other marsh types, salt marsh typically supports fewer terrestrial vertebrates although some shorebird species are common.

Brackish marsh in the study area is located inland from salt marsh along the Gulf shoreline and in the Sabine Pass area, lines the Salt Bayou/Keith Lake watershed south of the GIWW, and fringes the northern and eastern shores of Sabine Lake in Louisiana. The dominant species in high brackish marshes are saltmarsh bulrush, seashore saltgrass, and marshbay cordgrass. Brackish marshes are extremely important as nurseries for fish and shellfish.

Intermediate marshes are subjected to periodic pulses of salt water. In the SNWW study area, these areas grade inland from brackish marshes in the Salt Bayou/Keith Lake watershed, are the major marsh type along the lower Neches River, and dominate the interior marshes of Louisiana east of Sabine Lake.



Texas		Louisiana	
Unit #s	Names	Unit #s	Names
TX 1	North Neches River	LA 1	Perry Ridge
TX 2	Neches-Lake Bayou	LA 2	Willow Bayou
TX 3	Rose City	LA 3	Black Bayou
TX 4	West of Rose City	LA 4	West Johnsons Bayou
TX 5	Bessie Heights	LA 5	Sabine Lake Ridges
TX 6	Old River Cove	LA 6	Johnsons Bayou Ridge
TX 7	GIWW North	LA 7	Southeast Sabine
TX 8	Texas Point	LA 8	Southwest Gum Cove
TX 10	Cow Bayou	LA 9	East Johnsons Bayou
TX 11	Adams Bayou	LA/TX 1	Sabine Island
TX 12	Blue Elbow South	LA/TX 2	Blue Elbow
TX 13	Groves		
LA/TX 1	Sabine Island		
LA/TX 2	Blue Elbow		

Legend

Collapsed Vegetation Codes

- Aquatic Vegetation
- Brackish Marsh
- Bottomland Hardwood
- Freshwater Marsh
- Intermediate Marsh
- Placement Area
- Saline Marsh
- Shrub/Scrub
- Swamp
- Upland/Impoundment/Other
- Water
- Hyrdologic Unit
- County/Parrish Line

Figure I-3
Hydrologic Units and Vegetative Coverages

Prepared for: USACE	
Job No.: 044198800	Scale: 1" = 5 miles
Prepared by:EMons/RCoop	Date: 5/19/2008

File: N:/Clients/U_Z/USACE/Projects/Sabine_Neches/044198000/figures/Fig_I_3_vr2.mxd

This page intentionally left blank.

Freshwater marshes are heterogeneous, with local species composition governed by frequency and duration of flooding, topography, substrate, hydrology, and salinity. A large expanse of fresh marsh is located between the GIWW and the Neches River, and in the riparian zone of the Neches and Sabine rivers. Freshwater marsh is also present in most interior portions of the Louisiana marshes east of Sabine Lake. Species range from maidencane, giant cutgrass, and bulltongue in lower areas to squarestem spikerush and marshbay cordgrass in the higher areas.

Sensitive Areas

Sensitive habitat generally refers to the vulnerability of a habitat. Areal extent, uniqueness, endemic quality, or vulnerability to ongoing pressures or imminent changes may make a habitat environmentally sensitive (e.g., large historical losses as with the coastal prairie or fresh marsh losses due to saltwater intrusions). They may be unique to the region and/or historical losses have made them less common or rare. They may be particularly vulnerable to changes in the landscape. The following areas were identified as part of the vegetative mapping in the study area and are described in more detail in the Wetland Value Assessment (WVA) Ecological Modeling Report found in Appendix C of the FEIS.

In Texas, beginning at the coast and working inland, the following protected and sensitive habitat areas are present within the study area:

- Approximately 10,000 acres of fresh to salt marsh in the chenier plain west of Sabine Pass, the majority of which consists of the Texas Point NWR.
- 55,700 acres of fresh to salt marsh located west of the Sabine River between Texas Point and the mouth of the Neches River. Much of this area is protected by the J.D. Murphree WMA.
- 22,100 acres of fresh, intermediate, and brackish marshes and 2,850 acres of cypress-tupelo swamp and bottomland hardwoods on the Neches River from the mouth of the river where it empties into Sabine Lake to the City of Beaumont.
- 6,490 acres of Neches River cypress-tupelo swamp and bottomland hardwoods and 1,970 acres of fresh marsh between the City of Beaumont and the new Neches River Saltwater Barrier near Pine Island Bayou.
- 4,771 acres of cypress-tupelo swamps, bottomland hardwood, and fresh and intermediate marshes on Cow and Adams bayous.
- 689 acres of cypress-tupelo swamp west of the Sabine River and south of IH 10.
- 2,737 acres of cypress-tupelo swamp and bottomland hardwoods in the Blue Elbow Swamp.
- 2,277 acres of cypress-tupelo swamp and bottomland hardwoods west of the Sabine River, across from the Sabine Island WMA in Louisiana.
- 6,000 acres of cypress-tupelo swamp, bottomland hardwood forest, and freshwater marshes, acquired by the Big Thicket National Preserve in 2009, located upstream of I 10.

In Louisiana, beginning at the coast and working inland, the following protected and sensitive habitat areas are present within the study area (Louisiana Coastal Wetlands Conservation and Restoration/

Wetlands Conservation and Restoration Authority [LCWCR/WCRA], 1999; U.S. Geological Survey [USGS]-National Wetlands Resource Center, 2004).

- 71,470 acres of saline, brackish, and intermediate marshes in the Louisiana Chenier Plain habitat at Louisiana Point, Blue Buck Point, and Johnson Bayou areas.
- 44,325 acres of brackish, intermediate, and fresh coastal marsh in the western half of the Sabine NWR.
- 46,511 acres of brackish, intermediate, and fresh marsh in the area north of Willow Bayou and south of the GIWW.
- 25,721 acres of fresh and intermediate marsh and bottomland hardwood habitat in the Perry Ridge mapping unit, north of the GIWW and east of the Sabine River.
- 650 acres of cypress-tupelo swamp and bottomland hardwoods in the Blue Elbow Swamp, east of the Sabine River and north IH 10.
- 7,039 acres of cypress-tupelo swamp and bottomland hardwoods in the Sabine Island WMA, north of the Blue Elbow Swamp and east of the Sabine River.

Upland Resources

The study area supports a diverse population of wildlife species. According to Blair (1950), at least 47 species of mammals, 29 species of snakes, 10 lizards, 2 land turtles, 17 anurans, and 18 urodeles occur or have occurred there. Common mammals include, but are not limited to rabbits, rats, raccoons, coyotes, mice, bats, armadillos, and bobcats. Virtually all of the original Gulf Coastal Prairies community has been converted to agricultural, industrial, or other uses although some remnants still exist (Smeins et al., 1991). Agricultural areas typically have sparse ground cover and provide poor-quality habitat for wildlife.

Threatened and Endangered Species

Plants

There are no Federal or State-listed threatened, endangered, or candidate plant species potentially occurring in Jefferson and Orange counties of Texas, and Cameron and Calcasieu parishes of Louisiana (National Diversity Database, 2005; U.S. Fish and Wildlife Service [USFWS], 2005).

Wildlife

There are a total of 32 State and/or federally listed threatened and endangered fish and wildlife species, and 9 listed by the U.S. National Marine Fisheries Service (NMFS) as Species of Concern—species that may potentially occur in Orange and Jefferson counties, Texas, and Cameron and Calcasieu parishes, Louisiana. Some of the species listed as threatened and endangered include brown pelican, piping plover, interior least tern, West Indian manatee, black bear, Louisiana black bear, red wolf, hawksbill sea turtle, green sea turtle, leatherback sea turtle, Kemp's ridley sea turtle, and loggerhead sea turtle. The West Indian manatee, black bear, Louisiana black bear, and red wolf formerly occurred along the Gulf Coast; however, it is unlikely that they would occur within the study area. Designated Critical Habitat for the

wintering populations of the piping plover is present in the study area on the Louisiana shoreline beginning at the east jetty and extending eastward into Louisiana beyond our study area.

Essential Fish Habitat (EFH) is present in the study area for adult and juvenile brown and white shrimp, red drum, red snapper, lane snapper, greater amberjack, king mackerel, Spanish mackerel, cobia, Gulf stone crab, gag grouper, scamp, and adult gray snapper. The EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." When referring to estuaries, it is further defined as "all waters and substrates (mud, sand, shell, rock, and associated biological communities) within these estuarine boundaries, including the sub-tidal vegetation (seagrasses and algae) and adjacent tidal vegetation (marshes and mangroves)" (Gulf of Mexico Fisheries Management Council [GMFMC], 2004).

Significant Habitats

The State of Louisiana also includes a ranking of natural areas it deems as imperiled or threatened due to one or more reasons. Cameron and Calcasieu parishes contain 10 such habitats. These significant habitats include bottomland hardwood forest, brackish marsh, coastal prairie, coastal dune grassland, coastal live oak-hackberry forest, freshwater marsh, migratory bird staging/stopover sites, waterbird nesting colony, western longleaf pine savannah, and western saline longleaf pine savannah. While none of these habitats are federally designated as threatened or endangered, some of them are significant due to their losses during the past century and their value as habitat to fish and wildlife.

Cultural Resources

Within the study area, the National Register of Historic Places (NRHP) for Texas and Louisiana identifies 6 NRHP-listed architectural properties for Orange County, 19 such properties for Jefferson County, and 1 property, the Sabine Pass Lighthouse, for Cameron Parish. Two of the National Register-listed sites are located adjacent to the proposed CIP: the Rainbow Bridge and the Sabine Pass Lighthouse. The Rainbow Bridge is the cantilever bridge crossing the Neches River just upstream from Sabine Lake. The Sabine Pass Lighthouse is located on the Louisiana side of Sabine Pass. The lighthouse was constructed in 1856 and began operation in 1857.

These National Register-listed properties represent civic, commercial, religious, and private residential properties that span the history of the study area from the mid-nineteenth century to the mid-twentieth century. In addition to these National Register-listed properties, there are many other eligible, recorded, and reported resources in the study area. Numerous potentially eligible historic sites and shipwrecks are present in the project area. These include the Sabine Pass Battleground Park, Fort Griffin, and shipwrecks associated with important battles during the U.S. Civil War.

Socioeconomic Considerations

The following counties and parishes were used as units of socioeconomic analysis: Hardin, Jefferson, and Oranges counties in Texas, and Cameron and Calcasieu parishes in Louisiana. The following cities were

reviewed: Beaumont, Port Arthur, Port Neches, Nederland, Vidor, Orange, and Bridge City in Texas and Lake Charles in Louisiana. The study area for the socioeconomic review included areas within a 1-mile-wide corridor of the areas proposed for channel improvement.

Population

From 1980 to 1990, population growth within the study area was negative largely due to high unemployment rates and economic problems within the region due to the 1980s "oil bust," when manufacturing and construction industries within the study area suffered heavy economic losses and layoffs. From 1990 to 2000, population growth was slow to moderate (at 7.4 percent), with the greatest population growth in Bridge City and Nederland. Population growth from 2000 to 2050 is expected to be slow to moderate if the socioeconomic trends continue as they have over the past 30 years. The greatest population growth rates in the study area during this period are anticipated in Hardin County (average decade growth rate of 8.1 percent) and in Calcasieu Parish (average decade growth rate of 5.9 percent).

Employment and Income

Total employment in the port, manufacturing, and industrial industries is currently 30,000 with approximately 13.7 percent of the population in port-related jobs (estimated one member per family works in industries directly or indirectly linked to waterborne commerce). Since the "oil bust" in the 1980s, the area relies to a greater extent on industries such as service, Federal, State, and local government, retail and wholesale trade, medical services, education, and Federal and state jails for its livelihood. It is estimated that 25 percent of the study area population depends on these port-related industries.

The highest median family income within the study area is found in Hardin County (at $37,612), while the lowest median family income is found in Cameron Parish (at $34,232). All median family income figures for the study area counties and parishes are higher than that of Louisiana (at $32,566), and lower than that of Texas (at $39,927).

Commercial and Recreation Fishing

Commercial fishing within the Sabine Lake system and adjacent offshore waters of the Gulf of Mexico is a relatively small contributor to the study area economy. Commercial harvesting of oysters in Sabine Lake and Sabine Pass is prohibited due to public health concerns. A small offshore commercial shrimp fleet operates out of Sabine Pass.

The largest total value for all finfish and shellfish landings was $6.0 million in 1992. Recreational fishing continues to be a major outdoor recreational activity with a large variety of fresh- and saltwater species in the area. Sabine Lake, numerous wetlands, and the Gulf of Mexico are sources of recreational fishing within the study area. Between 1991 and 2001, saltwater fishing increased by 22 percent, and freshwater fishing decreased by 6 percent (USFWS, 2002a). Recreational fishing in this area is a year-round activity. Largemouth bass in the inland waters and speckled trout in the Gulf of Mexico and Sabine Lake are

favorites among anglers in the area. Although most species are commercially exploited, recreational anglers contributed more than $400 million to the local economy in 2005, with more than half a million people involved in this leisure-time activity (USFWS, 2003).

Outdoor Recreation

One of the benefits of outdoor recreation is the economic impact it has on a state and its region. In Louisiana, over $3.0 billion was spent on wildlife-associated activities (hunting and fishing yielded over $1.4 billion and associated activities yielded over $1.6 billion), and in Texas, almost $9.4 billion was spent on wildlife-related activities (hunting and fishing yielded over $5.3 billion and wildlife-associated activities yielded almost $4.1 billion) (USFWS, 2002a).

The economic impact of hunting in Texas resulted in $1.5 billion spent in Texas in 2001. Hunting within the Louisiana portion of the study area is equally popular, with numerous seasonally occupied camps located primarily on private land, and leased to club members who often travel from metropolitan areas of Louisiana and Texas to hunt waterfowl and deer, among other game.

Wildlife-watching, particularly birding, is an extremely popular activity within the study area and in the nearby vicinity. The Great Coastal Birding Trail is a series of trails that links bird-watching sites and many communities along the entire Gulf Coast. Several sections are located in or nearby the project study area, in both Texas and Louisiana. Participation in the Texas portion of the trail has grown over 33 percent overall between 2001 and 2002 (Scroggs, 2002; USFWS, 2002a).

I.E NON-FEDERAL SPONSOR AND COORDINATION

The USACE District Engineer, Galveston District is responsible for the overall management of the study and the report preparation. The Sabine Neches Navigation District (SNND) is the Sponsor for the study. The Sponsor was previously known as the Jefferson County Navigation District or the Jefferson County Waterway and Navigation District. In 2007, the SNND name was adopted. An Interagency Coordination Team (ICT) comprised of the Federal and State resource agency representatives from Louisiana and Texas was established to:

1) Involve agencies in scoping and identifying environmental issues and concerns;
2) Evaluate the significance of fish and wildlife resources and select resources to be evaluated;
3) Recommend and review necessary environmental studies;
4) Evaluate anticipated impacts; and
5) Recommend and evaluate potential mitigation measures.

The ICT agencies are listed in Table I-3. Representatives from other local and State agencies or governments also participated in the ICT in an advisory capacity: Jefferson and Orange counties, Texas; Cameron and Calcasieu parishes, Louisiana. While the ICT was a true decision-making body for issues related specifically to the environmental impact review, the USACE did retain final decision-making

authority on issues related to compliance with USACE policy. The USACE ICT members ensured that decisions were made within the framework of the USACE planning process and in compliance with Federal Law and policy, including guidance such as Planning in a Collaborative Environment (Engineering Circular [EC] 1105-2-409) and the Environmental Principles (Engineering Regulations [ER] 200-1-5). Important decisions related to identifying and studying potential ecological impacts and identifying alternatives for compensatory mitigation measures were made by consensus within the ICT. The ICT meetings were open to the public, and public comments were taken either before or after some of the meetings. Technical work addressing specific environmental concerns or planning objectives was performed by several smaller workgroups (whose members were taken from the ICT). Each of the workgroups and their purpose are identified below:

- **Restoration and Beneficial Uses Workgroup** was created to develop ideas for ecosystem restoration and the Beneficial Use (BU) of dredged material in the study area.
- **Hydrodynamic and Salinity Modeling Workgroup (MW)** provided data to assist the hydrodynamic salinity modeling (HS model) and verification process, and reviewed modeling results as part of the impacts evaluation.
- **Contaminants Workgroup** evaluated water and sediment quality associated with the proposed CIP, including characterization of existing conditions in the project area and the results of physical and chemical analyses conducted.
- **Ocean Dredged Material Disposal Sites (ODMDSs) Workgroup** was created to provide advice in the preparation of the Site Designation FEIS for the proposed ODMDSs.
- **Habitat Evaluation Workgroup** reviewed and classified existing habitat, performed field evaluations to document existing conditions, and developed procedures for the prediction of without- and with-project conditions.

Table I-3
Sabine-Neches Waterway Interagency Coordination Team Participants

U.S. Army Corps of Engineers	Louisiana Department of Wildlife and Fisheries
Sabine Neches Navigation District	Sabine River Authority of Texas
U.S. Environmental Protection Agency	Texas General Land Office
U.S. Fish and Wildlife Service	Texas Parks and Wildlife Department
U.S. Natural Resource Conservation Service	Texas Water Development Board
National Marine Fisheries Service	Texas Commission on Environmental Quality
Louisiana Department of Natural Resources	Texas Department of Transportation
Louisiana Department of Environmental Quality	

I.F PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

Federal involvement in navigation improvements along the SNWW began with the River and Harbor Act (RHA) of 1885. This authorization provided for improvements to the mouth of the Sabine River. On March 3, 1905, the RHA authorized the first major improvement to the waterway, the construction of a

channel 9 feet deep and 100 feet wide through Sabine Lake from the mouth of the Sabine and Neches rivers to the mouth of Taylor Bayou. Major channel improvements continued to occur along the SNWW. Table I-4 shows the congressional authorizations and the authorized channel improvements.

Table I-4
Congressional Authorizations for Sabine-Neches Waterway Channel Improvements

RHA 1885	Improvements to mouth of Sabine River.
RHA 1905	Construction of a channel 9 feet deep and 100 feet wide through Sabine Lake from the mouth of Sabine and Neches rivers to the mouth of Taylor Bayou.
RHA 1912	Construction of a channel 25 feet deep, repair of jetties, enlarge Port Arthur Canal to a depth of 26 feet and a width of 150 feet, and dredge Port Arthur Turning Basin 26 feet deep, 600 feet wide, and 1,700 feet long.
RHA 1927	Enlargement of Sabine Pass and jetty channels to 300-foot width, Port Arthur Canal to a width of 200 feet, and the Sabine-Neches Canal up to the mouth of the Neches River to a width of 150 feet, provide two passing places in the Sabine-Neches Canal.
RHA 1935	Enlargement of the project to depths of 35 feet on the outer bar, 35 to 32 in jetty channel, and 32 feet up to and including turning basins at Port Arthur and Beaumont. Widen to widths of 450 feet on the outer bar, 450 feet to 300 feet through the jetties, 250 feet up to Port Arthur, and 200 feet up to the mouth of the Neches River.
RHA 1946	Deepen Sabine Pass outer bar channel to 37 feet, Sabine Pass jetty channel to 36 feet at the inner end, deepen to 36 feet Sabine Pass Channel, Port Arthur Canal, Port Arthur East and West Turning Basins, and widen to 400 feet the Sabine-Neches Canal from Port Arthur Canal to the mouth of the Neches River, except through Port Arthur Bridge; deepen Neches River channel from mouth to Beaumont Turning Basin to 36 feet, widening to 350 feet from Smith's Bluff to Beaumont Turning Basin, widen Sabine-Neches Canal between Neches and Sabine rivers to 150 feet.
RHA 1962	Deepen Outer Bar Channel to 42 and 40 feet for all inland channels to Port Arthur and Beaumont; width of 500 feet in Port Arthur Canal and 400 feet in Neches River Channel to Beaumont with three turning points in Neches River; a channel, 12 by 125 feet, extending in Sabine River to Echo; Deauthorization of uncompleted portion of channel between Port Arthur West Turning Basin and Taylor Bayou Turning Basin and enlargement of entrance channel to Port Arthur Turning Basins.

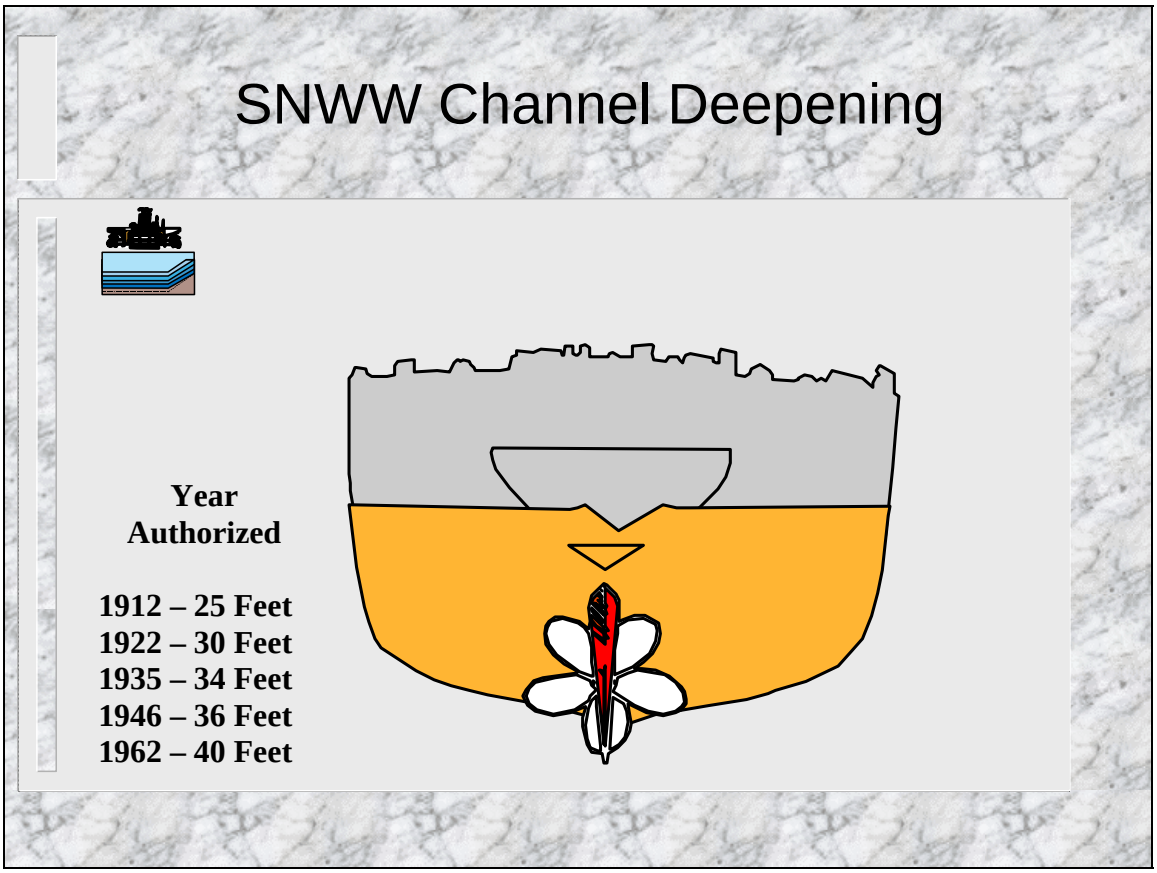
Major deepening efforts on the SNWW were authorized in 1912 resulting in a channel depth of 25 feet. Under the RHA of 1962, the waterway was authorized to be deepened to its current depth of 40 feet (Figure I-4).

On December 11, 1969, the Committee on Public Works House of Representatives adopted a resolution authorizing a review of the SNWW project. The resolution requested review of the report of the Chief of Engineers on the SNWW, published as House Document No. 553, 87th Congress, 2nd Session, and prior reports, with a view to determining whether the existing project should be modified in any way at this time, with particular reference to providing increased depths in the channel and basins.

As a result, a feasibility study was initiated and a Draft Feasibility Report was completed in April 1982. The report determined that it was feasible and advisable to deepen and widen the SNWW. The Recommended Plan recommended a channel depth of 52 feet at the Gulf of Mexico entrance channel and

a channel 50 feet deep for the Sabine Pass Channel, Port Arthur Canal, Sabine-Neches Canal, and the lower 12 miles of the Neches River Channel.

Figure I-4. History of Channel Deepening of Sabine-Neches Waterway



The plan also included widening of the Sabine-Neches Canal, located adjacent to Port Arthur, from 400 feet wide to 500 feet in width to reduce traffic congestion and delays in this reach of the waterway, which also serves as part of the GIWW. The Recommended Plan was not implemented because the Sponsor withdrew their support for the project.

I.G STUDY AND REPORT PROCESS

In September 1998, the USACE completed a Reconnaissance Report for the SNWW. The reconnaissance concluded that deepening and widening of the SNWW offers sufficient opportunity for navigation improvements with potential benefits outweighing the anticipated project costs. Without the increase of channel depths and widths to accommodate the anticipated increase in commodity transportation, more vessels would need to make lighter-drafting trips, increasing vessel delays and decreasing the efficiency of movement of bulk commodities along the waterway.

The USACE planning process involves a six-step, iterative process. This process provided for systematic preparation and evaluation of alternative plans to address problems and opportunities for the SNWW. The feasibility study process involved all of the six functional planning steps:

1) Specification of water and related land resources future without-project (FWOP) problems and opportunities;
2) Inventory, forecast, and analysis of water and related land resources conditions within the study area;
3) Formulation of alternative plans;
4) Evaluation of the effects of the alternative plans;
5) Comparison of the alternative plans; and
6) Selection of the Recommended Plan.

The Reconnaissance Report emphasized problem identification and formulation of alternatives. The emphasis of this Feasibility Report is on the evaluation of alternatives, assessment of impacts, and selection of a Recommended Plan. The goal of a feasibility study is to identify the plan that contributes to the National Economic Development (NED) consistent with protecting the Nation's environment.

This page intentionally left blank.

II. PROBLEMS AND OPPORTUNITIES

II.A OVERVIEW

This chapter covers the first step of the planning process and identifies the problems with the existing SNWW and potential opportunities available if the existing SNWW channel is deepened and widened. The SNWW continues to play a significant role in the growth and economic development of the Golden Triangle area of Port Arthur, Beaumont, and Orange, Texas. As growth and economic development of the study area continues, the increasing use of the SNWW intensifies the need for more-efficient movement of commodities, particularly crude petroleum, by vessels traveling the waterway.

The amount of the vessel traffic along the waterway also increases concerns for the safety of the users and the local communities and businesses all along the waterway. With the current channel dimensions, the tonnage is not being moved as efficiently due to the size restrictions of the larger tankers utilizing the channel. These tankers are either limited by the current channel depth of 40 feet or by the physical and safety limitations of the channel.

The water resources problems to be solved with this project are the navigational and safety issues that have developed on the SNWW because of the growth in the area. Existing water resource problems and needs in the study area were identified through coordination with Federal, State, and local agencies; area residents; waterway users; and the USACE and SNND. Numerous concerns were raised during the public scoping meetings, letters received in response to those meetings, and a series of workshops with local public agencies and private organizations. The major issues and concerns identified through this process are discussed below. Summaries of the scoping meetings and copies of public comment letters are provided in Appendix A of the FEIS.

II.B NAVIGATION AND COMMERCE

General

The SNWW serves the ports of Port Arthur, Beaumont, and Orange. Channel improvements are needed to support the SNWW's critically important role in the Nation's economy. In 2007, the SNWW ranked first in the nation in crude oil imports, importing 56.2 million tons (Institute of Water Resources [IWR], 2007). In 2006, the SNWW (ports of Beaumont, Port Arthur and Orange) was ranked 4th in the nation for domestic and total tonnage with Beaumont (Figure II-1) ranked 5th and Port of Port Arthur (Figure II-2) ranked 28th in the nation (IWR, 2007).

The Port of Beaumont's public docks are located on the Neches River Channel, as well as several crude petroleum and product terminals. Port Arthur's general cargo facilities are located on the Sabine-Neches Canal, and its crude petroleum and product terminals are in the Taylor Bayou Basins. The Taylor Bayou Basins are located immediately south of Port Arthur at the junction of the Sabine-Neches Canal with the GIWW. In addition to its deep-draft traffic, the Sabine-Neches Canal serves as a through channel for

Figure II.1. Port of Beaumont

Figure II.2. Maritime and Petrochemical Use of Sabine-Neches Waterway
near Port Arthur, Texas

shallow-draft barge traffic on the GIWW. The locations of the facilities along the SNWW are identified on Figure II-3.

Commerce

Sixty percent of the SNWW tonnage total is deep-draft movements, and the remaining 40 percent is shallow-draft GIWW traffic. Crude petroleum imports and petrochemical product imports and exports comprised approximately 95 percent of Beaumont's and 85 percent of Port Arthur's oceangoing tonnage. Other significant commodities and breakbulk cargoes that are handled by the SNWW ports include petroleum coke, ammonia, sulphuric acid, metallic salts, liquid sulphur, grain, manufactured iron and steel products, limestone, sand, and gravel. Twenty percent of 2005–2007 U.S. metallic salts were exported from Port Arthur.

Domestic refineries on the Gulf Coast, the East Coast, and in the Midwest rely on the SNWW for 12–16 percent of waterborne crude oil deliveries (Martin Associates, 2006). The SNWW's four local refineries represent 6 percent of the U.S. total. SNWW refining capacity levels for 2007 are presently 9.4 percent higher than in 2004, and 29 percent higher than in 1994. In 2007, Motiva announced plans for a major refinery expansion in Port Arthur that would make it the largest refinery in the U.S. and one of the largest in the world. The ExxonMobil Beaumont refinery on the Neches River Channel is presently the third largest refinery in the world. As a result of these additions, SNWW's combined capacity would be the largest concentration in the State of Texas. Refined petroleum products are shipped from the SNWW via three major pipeline systems to 21 states east of the Rockies, including states as far away as Delaware, New York, and Pennsylvania (Martin Associates, 2006).

The existing SNWW navigation channel system is congested. The existing 40-foot project depth was designed to efficiently and safely accommodate much smaller vessels than are being used today. The current channel was completed in the late 1960s, and at that time, crude oil tankers averaging 40,000 deadweight tons (DWT) with loaded drafts of 36 feet were common. Vessels over 90,000 DWT are now used routinely for crude oil imports to both Beaumont and Port Arthur. In addition to larger vessels, the amount of vessel traffic on the SNWW has also increased. Both SNWW and U.S. crude oil imports have steadily risen since the 1970s, and this trend is projected to continue into the foreseeable future. The 2005–2007 crude oil import volume is nearly three times the average 1990–1992 levels. In the short term, it is expected that SNWW imports would grow at rates comparable to or higher than regional and national trends, and long-term expectations are for growth equal to regional and national trends. From 2005 to 2007, SNWW volumes of crude petroleum imports exceeded other Texas Gulf Coast ports by nearly 35 percent. Recent increases in SNWW refinery capacity indicate that the region would gain an increasing share of U.S. totals.

In addition to the large base of existing crude oil and petrochemical product facilities on the SNWW, three Liquefied Natural Gas (LNG) terminals have been proposed at Sabine Pass. LNG is expected to play an increasingly important role in the natural gas industry and global energy markets in the next several years and in the long-term future. Construction of the Sabine Pass Terminal is complete, and the

This page intentionally left blank.

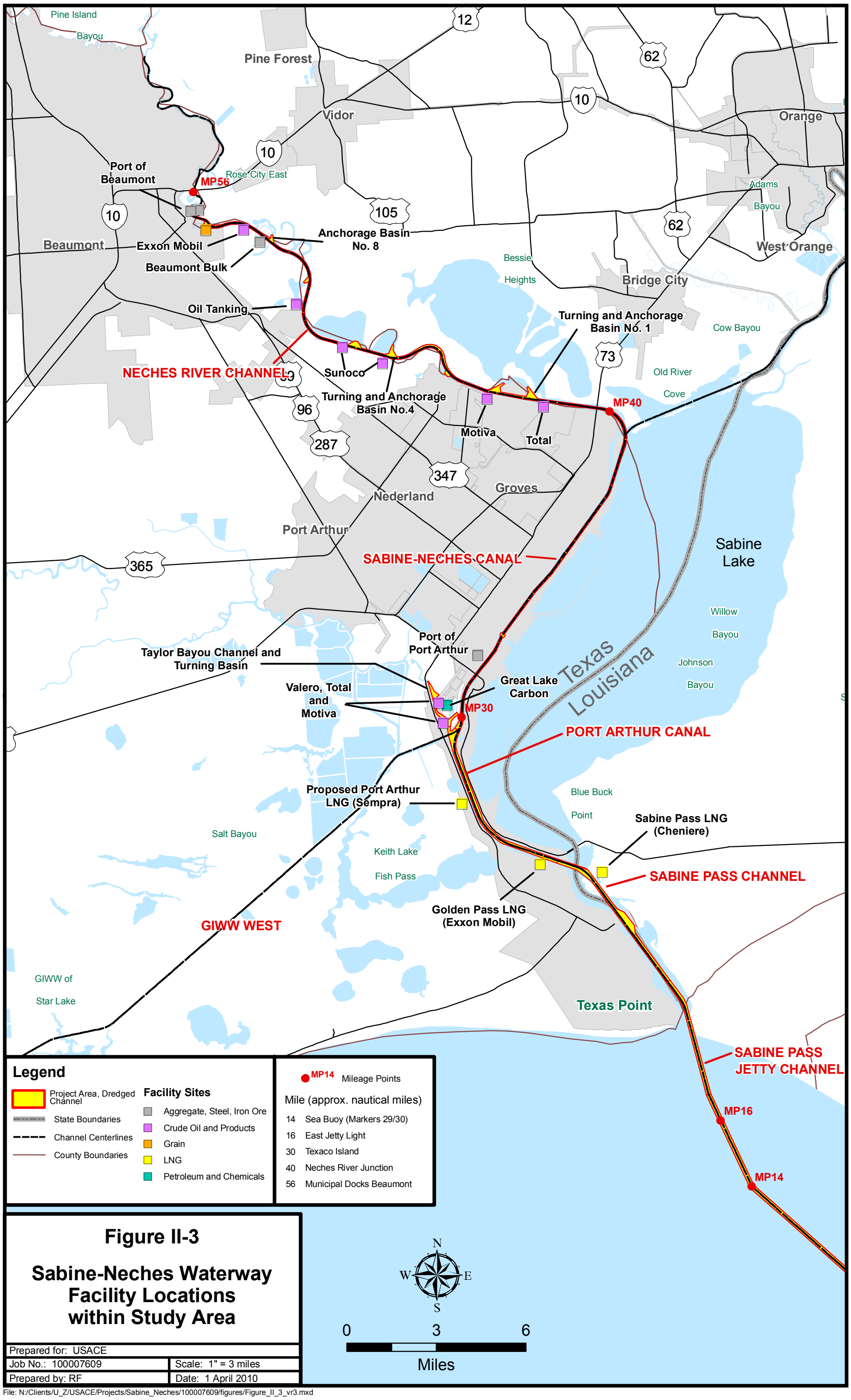


Figure II-3

Sabine-Neches Waterway Facility Locations within Study Area

Prepared for: USACE	
Job No.: 100007609	Scale: 1" = 3 miles
Prepared by: RF	Date: 1 April 2010

File: N:/Clients/U_Z/USACE/Projects/Sabine_Neches/100007609/figures/Figure_II_3_vr3.mxd

This page intentionally left blank.

first vessels arrived in April 2008. Construction is ongoing at the Golden Pass Terminal; the Port Arthur Terminal has received regulatory approval. The SNWW LNG facilities are located in the Sabine Pass Channel and Port Arthur Canal; these reaches are presently 500 feet wide and would remain so under the without-project future. LNG vessels using the SNWW would be subject to strict U.S. Coast Guard (USCG) regulations and to local pilot rules, and all LNG vessel movements would be subject to one-way traffic.

With the current channel depth, there are draft restrictions on large vessels currently utilizing the channel. The majority of the tonnage carried on the SNWW is in deep-draft vessels, and the vast majority of the deep-draft traffic is comprised of crude oil and petrochemical products. However, LNG, grain, and aggregate products, such as iron ore, steel slab, limestone, sand, and gravel, are also carried in draft-constrained deep-draft vessels. For the period 2002–2007, 89 percent and 64 percent of crude petroleum imports to Beaumont and Port Arthur, respectively, were transported in vessels with design drafts over 40 feet.

Currently at the SNWW, Very Large Crude Carriers (VLCC) transfer tonnage at an offshore location onto one or more shuttle vessels in a process called lightering. These very large carriers cannot enter the SNWW because of their size and draft. In addition, other large crude tankers presently offload a partial load to a shuttle vessel or vessels and then enter the SNWW with the shuttle vessels as they are small enough to navigate the SNWW with a lighter load. This process is called lightening.

The SNWW experienced strong growth over the past decade, with total tonnage increasing from an average of 108 million short tons for 1995–1997 to 138 million for 2005–2007. As imports have increased, the number of lightered and lightened vessels and product carriers has also increased, adding to shipping delays and congestion. The total number of inbound vessels on the SNWW is projected to increase in the short-term at rates comparable to or higher than regional and national trends. Recent increases in SNWW refinery capacity indicate the region would regain an increasing share of U.S. totals.

Ships are not only requiring deeper drafts, but the sizes of the vessels are wider (Figure II-4). The vessel beams of both Port Arthur's and Beaumont's vessels cause them to be regularly impacted by the present 500-foot width of the Sabine Pass Jetty Channel and Port Arthur Canal. The most common crude oil tankers unloading at the Taylor Bayou Basins have design drafts of 45 feet and beams of approximately 124 feet. Tankers using the Taylor Bayou Basins are smaller than those offloading at terminals on the Neches River Channel because existing width at the mouth of Taylor Bayou and the configuration of the docks within Taylor Bayou limit the allowable vessel size. The maximum size vessels unloading at Port of Beaumont facilities on the Neches River Channel are approximately 900 feet long, with a beam width of 164 feet.

The Sabine Pilots Association (SPA, or Sabine Pilots) has adopted self-imposed transit rules for safety in the narrow channel; these rules result in navigation constraints. These rules are presented in Table V-54 later in this report. These constraints include daylight-only and one-way sailing restrictions in specific reaches. The main restrictions place limitations on the combined beam widths and drafts for vessel

meetings on the waterway. A major restriction is that vessels with combined beam widths in excess of 50 percent of the channel width cannot meet. The effects of these and other navigation restrictions cause significant delays along the waterway.

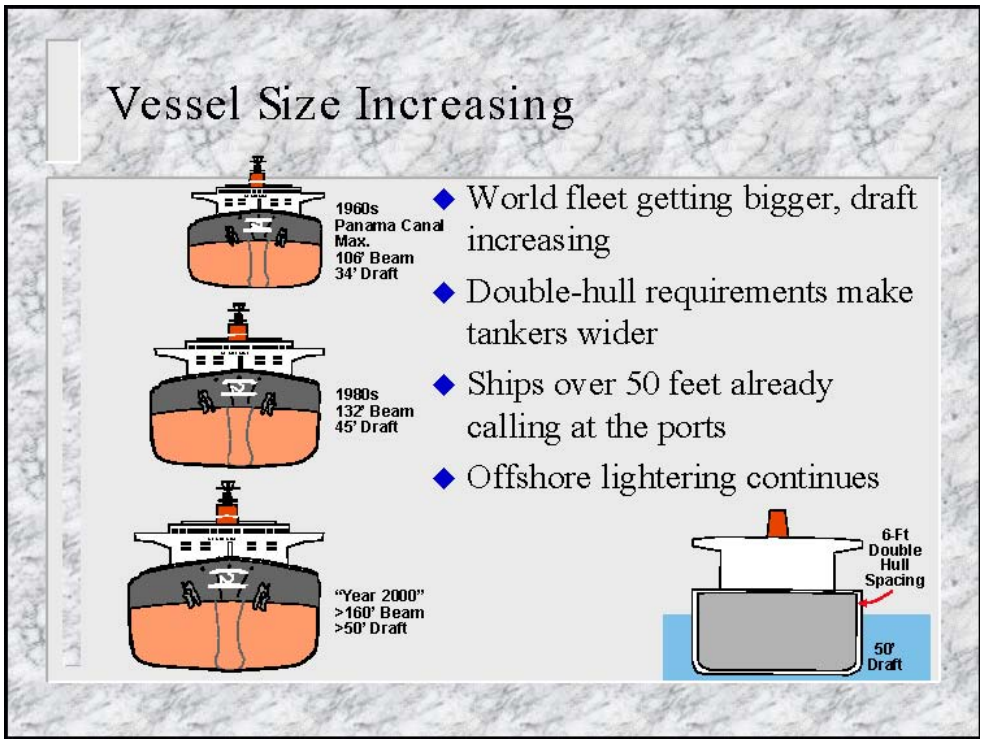


Figure II-4. Increasing Vessel Sizes

As a result of these rules, inbound vessels intending to use a specific dock must wait offshore until the outbound vessel at that dock sets sail, resulting in considerable delays because of the length of the inshore channel. In addition, vessels are now wider due to new double-hull requirements and to industry changes to wider but shorter vessels, which makes vessel-meetings more difficult. The probability of accidents and other safety problems may increase with increases in both inland barge and deep-draft vessel traffic along the waterway. Channel deepening and/or widening could alleviate some of these congestion and safety problems by enhancing the maneuverability and control of deep-draft vessels, and permitting two-way traffic in the widened SNWW reaches and providing additional TB and anchorage basins (AB) on the Neches River Channel.

The CIP would provide benefits by reducing the number of vessel trips needed for crude oil imports. Vessel trips would be reduced since the mother vessels could enter the waterway more-heavily loaded and fewer shuttle vessels would be used for lightening. In addition, shuttle vessels used in lightering the VLCC could be more-heavily loaded, which would reduce the number of shuttle vessels required. Some petroleum products and other commodities would also be able to take advantage of increased channel depths by loading additional tonnage; however, crude oil is expected to be the principal beneficiary of the deeper channel. Widening of the inshore channels below Taylor Bayou would allow more vessels to meet under existing rules, and increase efficient utilization of the channel. Additional TB and anchorages on

the Neches River Channel would allow some vessels to wait at nearby docks rather than waiting offshore, significantly reducing delays associated with one-way traffic restrictions.

Safety

Navigational safety on the SNWW is a concern given the SNWW's large existing traffic base, the number of crude oil and dangerous cargo transits, and the 2008 introduction of LNG vessels to the vessel mix. Vessels are now wider due to new double-hull requirements and to industry changes to wider but shorter vessels. Wider vessels make meetings more difficult and, therefore, more dangerous (Figure II-5). Historically, however, casualty incidents on the SNWW channel are very low, due in large part to existing pilot rules that minimize the probability of incidents involving deep-draft vessels. A list of the transit rules is provided in Section V.E (see Table V-54.) of this report. The pilot rules would continue to limit the vessel sizes that can meet in each portion of the channel. Recent installation of the Port Arthur Vessel Traffic Service (VTS) would allow the USCG to assist vessel operators in managing their transits in relation to other traffic on the waterway, reducing potential interactions between deep-draft vessels and tows or barges on the congested Sabine-Neches Canal. LNG vessels using the SNWW would be subject to strict USCG regulations and to local pilot rules and, therefore, would not have the opportunity to meet other vessels. Under current pilot rules, the wide beams of LNG tankers would make them subject to one-way traffic restrictions.

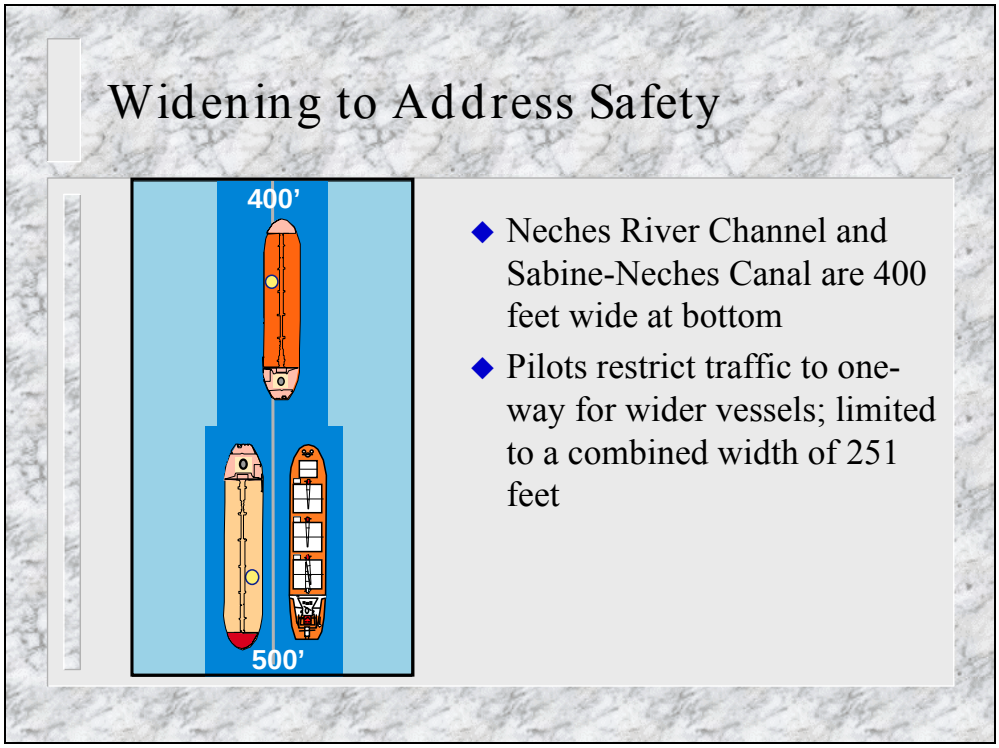


Figure II-5. Widening to Address Safety

Channel improvements would allow more deep-draft cargo to be carried with fewer vessel trips. Associated reductions in deep-draft vessel traffic would thereby serve to reduce the probability of casualties. However, since casualty occurrences in the SNWW are rare, the proposed improvements would not have a discernible effect on casualty rates.

National Security

Congestion is increased during times when the SNWW serves an important military function. One of the busiest ports for military cargo in the world is located on the SNWW. The Port of Beaumont is the Nation's busiest Strategic Port of Embarkation, and it is the second largest commercial military out-load port worldwide. For the war in Iraq, it has handled approximately one-third of all the military cargo deployed to and from the war, which is more military cargo than any other U.S. port (Military Surface Deployment and Distribution Command, 2004, 2006). The SNWW must accommodate the military's increased use of newer and larger transport ships, which are three times the size of transport ships used in 1990. Improved transportation efficiency on the SNWW is vital in maintaining the Port of Beaumont's ability to provide critical support to U.S. military operations. The SNWW contributes to national security in one other key aspect. Two terminals on the Neches River are connected by pipelines to underground storage facilities of the U.S. Department of Energy's Strategic Petroleum Reserve at Big Hill, Texas, and West Hackberry, Louisiana.

II.C ENVIRONMENTAL

The most significant trend adversely affecting the study area is the high rate of wetland loss that has occurred over the last century. In Louisiana, a net land loss of 21 percent between 1978 and 2000 has been reported in the Chenier Plain subregion of coastal Louisiana, which includes the Sabine estuary. In Texas, the most extensive losses of interior coastal wetlands in the state have occurred in the Neches River delta, an example of which is shown in Figure II-6. These losses total 12,632 acres between 1930 and 1978. In total, over 90 percent of the emergent marshes in the Lower Neches River delta have been converted to open water, which is more than half of the total wetland loss in the State of Texas.

While the future rate of relative sea level rise (RSLR) at the Sabine-Neches estuary is very uncertain, it must be considered in project planning. RSLR consists of two components: global (eustatic) sea level rise and local subsidence. The uncertainty 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 2007 Intergovernmental Panel on Climate Change (IPCC). A similar degree of uncertainty exists with the rate of local subsidence.

A detailed review of both eustatic and local subsidence rates was performed by the Engineer Research and Development Center (ERDC) in fulfillment of requirements of Circular No. 1165-2-211, Water Resources Policies and Authorities Incorporating Sea-level Change Considerations in Civil Works Programs (USACE, 2009a). This review found the eustatic rate estimates range from 1.8 millimeters per year (mm/year) to 6.45 mm/year for the next 50 years. This study employs an estimate for eustatic rise of

Figure II-6. Rose City Marsh (Historical Cypress Swamp to Open Water)

4.5 mm/year. This estimate is in the middle of the range projected by NRC (1987) and in the high middle range of that predicted by IPCC. In coastal Louisiana, estimates of the local subsidence component of RSLR were found to range from 0.4 to 0.6 mm/year based on basal peat measurements (Törnquist et al., 2006), to 2 to 5 mm/year as averaged from 48 years of tide gage data (Morton et al., 2005), and 10 to 15 mm/year measured from settling rates of established benchmarks (Shinkle and Dokka, 2004). The ERDC's review concluded that the lower rates (0.4 to 0.6 mm/year) were the most technically valid. These lower rates represent long-term trends in the subsidence rate, and seem to be the closest approximation of consensus concerning the local subsidence rate that is currently available.

Adding these to the NRC II projections for eustatic sea level rise yields a value for the RSLR in the SNWW study area over 50 years of 4.9 to 5.1 mm/year. The average of these, 5.0 mm/year, is used for modeling purposes.

Therefore, the "most likely" value of RSLR to be used for the SNWW deepening study's 50-year period of analysis is 0.82 foot. Adjusting this to account for the period of analysis beginning in 2019 and ending in 2069, the period of analysis for the SNWW reformulation, the "most likely" amount of RSLR by the year 2069 is 1.1 feet.

Potential for increased Gulf shoreline erosion is also a concern. In recent years, high shoreline erosion has caused substantial wetland losses on the Gulf of Mexico shoreline from Texas Point westward to the

vicinity of Sea Rim State Park. Inland shoreline erosion due partly from the passage of large vessels occurs along the waterway, especially in the narrow portions of the channel. Inland shoreline erosion results in thousands of dollars being spent every year to provide bank stabilization and maintain roads, some of which are critical for evacuation during hurricanes.

Since the devastating hurricane season in 2005, concerns have increased regarding the potential for channel-deepening projects such as the SNWW CIP to exacerbate the adverse effects of tropical storms like hurricanes Rita and Katrina on environment and infrastructure in the study area. These concerns are also related to recent forecasts of more intense tropical storms in the future due to global climate change.

There is an increasing potential for environmental harm as a result of an increase in the probability of shipping accidents due to predicted increases in vessel traffic. Environmentally sensitive areas that could be affected by spills resulting from shipping actions are located along both sides of Sabine Pass, west of the Port Arthur Canal, and along portions of the Neches River Channel. The need to protect environmental resources in the study area is related to the high concentration of significant coastal wetland habitats (see Figure I-3).

As part of the feasibility study process and as required by the National Environmental Policy Act (NEPA), the public and State and Federal resource agencies were coordinated with to obtain their comments and concerns regarding the proposed project. These comments are summarized in Section XII of this report. Detailed comments are located in Appendix A of the FEIS.

III. FORMULATION OBJECTIVES, CONSTRAINTS, AND CRITERIA

III.A OVERVIEW

This chapter addresses the remainder of step one in the planning process by identifying the Federal objectives for the study, identifying public concerns, planning objectives and potential constraints, and developing the criteria to be used for evaluating plan formulation alternatives.

III.B FEDERAL OBJECTIVES

The fundamental objective of Federal participation in water resource 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 NEPA of 1969 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 NED is the primary Federal 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. The NED Plan is the plan that reasonably maximizes net NED benefits. 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.

III.C PUBLIC CONCERNS

A number of public concerns have been identified during the course of the study. Input was received through coordination with the Sponsor, coordination with Federal and State agencies, public review of draft and interim products, and public meetings. A discussion of public involvement is included in Section XII of this document. The majority of the concerns/comments from the public that are related to the establishment of planning objectives and planning constraints are:

- Potential saltwater intrusion impacts on the adjacent marshes in Texas and Louisiana;
- Potential increase in water levels, including tidal movements;
- Potential impacts to the eastern shore of Sabine Lake;
- Natural resources (e.g., ducks, freshwater marsh birds, alligators, etc.) that would likely be affected by the proposed project;
- Impact of doing nothing that would result in economic reductions, loss of jobs, and reduction of property values; and

- Utilize the dredged material beneficially to improve the coastal shoreline by increasing vegetative dune structure and replenishing eroding beaches.

III.D PLANNING OBJECTIVES

The Federal objectives are general statements and not specific enough for direct use in plan formulation. The water and related land resource problems and opportunities identified in this study are stated as specific planning objectives to provide focus for the formulation of alternatives. 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, regulations, and executive orders.

These planning objectives reflect the problems and opportunities expressed by the Sponsor and the public, and represent the desired positive changes to the existing project conditions. The following planning objectives were used in formulation and evaluation of alternative plans:

- Improve the navigational efficiency along the waterway; and
- Maintain the ecological values of coastal and estuarine resources within the project area.

III.E PLANNING CONSTRAINTS

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that should not be violated. Plans must be formulated with regard to addressing the problems and needs of the area, taking into consideration 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 requires that impacts of the proposed action be measured and results displayed or accounted for in terms of contributions to NED, environmental quality, regional economic development, and other social effects.

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:

- The study process and plans developed must comply with Federal and State laws and policies;
- Fish and wildlife habitat affected by a project plan should be minimized as much as possible and preserved, if possible; and
- Alternative plans that resolve problems in one area should not create or amplify problems in other areas.

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 and have generally guided the formulation of the study. Technical, economic, environmental, and social criteria have been established to guide the project development process. These criteria are discussed below.

III.F TECHNICAL CRITERIA

Technical criteria require the preservation of adequate project dimensions to provide safe passage of commercial navigation traffic through a reach of 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 a portion of the waterway and to provide a long-term plan for the placement of dredged material in order to continue maintenance of the waterway in the future.

The 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) and analyses used during the study included, but was not limited to:

- Hydrodynamic/salinity study
- Ship simulation study
- Gulf shoreline study
- Vessel effects study
- Sediment and water quality analyses
- Aerial photography
- Historical dredging records
- Previously published scientific reports related to the project area
- Stability analyses
- 50-year Dredged Material Management Plan (DMMP)
- Pipeline identification and relocation analysis
- Marine and estuarine resource investigations
- Threatened and endangered species assessment.

III.G VALUE MANAGEMENT

Following the guidance in ER 1110-2-1150 Paragraph 13.14 Value Engineering, "A value engineering study shall be performed on the earliest document available that satisfies the functional requirements of the project and includes a MII cost estimate. The Project Delivery Team (PDT) shall determine if the

initial value engineering study shall occur during the feasibility phase or be delayed until the Pre-Construction Engineering and Design (PED) phase." Galveston District received approval for a delay of the Value Engineering Study until the PED phase is completed from Southwestern Division.

The inherent nature of a feasibility study process involves considerable value analysis and management efforts within all aspects of the study. This section summarizes the value management efforts that were utilized in this phase of the study. Various nonstructural alternatives were investigated throughout the feasibility phase as a means to solve the navigational problems. Some of these nonstructural measures included vessel traffic systems to alleviate transportation inefficiency and safety concerns, changes in pilot rules, and alternative modes of commodity transport. Structural alternatives were evaluated and included channel deepening and widening.

Standard dredging practice utilizes pipeline and hopper dredges, the only applicable method of construction for deepening the channel. Because the type of equipment to be used as part of the construction was limited, the value analysis efforts concentrated on the other construction aspects. These included construction of new placement areas, rehabilitation of existing placement areas, mitigation features, and BU sites. Identifying cost-saving alternatives that used resources more efficiently and decreased project costs, as well as operation and maintenance costs, played a major part in the feasibility study's value management.

Beneficial use of the dredged material, new work, and maintenance material, was investigated to find the most economical and practical placement within the project constraints. The "life-cycle" of the waterway was considered with emphasis on practical placement of new work within the placement areas for use in future levee construction. Additionally maintenance material was used beneficially for marsh creation, which was an economical advantage over standard placement practices.

The public was afforded an opportunity to provide input regarding more-cost-effective alternatives that could be used to accomplish the project purpose. The plan was presented to the public at industry group meetings, public workshops, and public meetings.

During the PED phase, the construction contracts will undergo value management and value techniques following guidance found in the ER 11-1-321- Army Programs Value Engineering.

III.H ECONOMIC CRITERIA

The economic criteria require that tangible benefits attributable to projects exceed project costs. Project benefits and costs are presented as average annual equivalent values and related in a ratio of benefits to costs (Benefit-to-Cost Ratio or BCR). This ratio must exceed unity to meet the NED objective. Recommended 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, which may impact on project proposals. The USACE planning guidelines required that the alternative that most reasonably maximizes net economic benefits, consistent

with protecting the Nation's environment, be identified as the NED Plan. This NED Plan may be selected as the Recommended Plan. However, for a navigation project, if a plan with lesser benefits is preferred by the sponsor due to financial constraints, guidance allows for a categorical exemption to be granted and this lesser plan to be selected as the Recommended Plan. This process is addressed in more detail later in this report.

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, and major replacements, as well as amortization and interest on the investment.

III.I ENVIRONMENTAL CRITERIA

The general environmental standards for navigation projects are identified in Federal laws, executive orders, and the USACE planning guidance. It is Federal policy that conservation of fish and wildlife resources be given equal consideration with other study purposes in the formulation and evaluation of alternatives. Care must be taken to preserve and protect significant ecological, aesthetic, and cultural values and to conserve natural resources. These efforts should provide the means to maintain and restore, as applicable, the desirable quality of the human and natural environments.

Throughout the study process, the USACE Environmental Operating Principles (EOP) should be considered. The EOP principles ensure conservation, environmental preservation, and restoration are considered at the same level as economic issues. The seven EOP principles are (1) strive for 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.

Consistent with laws and policy, alternative plans formulated to improve navigation should avoid damaging the environment to the extent practicable and contain measures to minimize or mitigate unavoidable environmental impacts. The following criteria were used to address environmental impacts during the evaluation of alternatives:

- Protection, preservation, and improvement of the existing fish and wildlife resources along with the protection and preservation of estuarine and wetland habitats and water quality;
- Consideration in the project design of the least disruptive construction techniques and methods;
- Mitigation for project-related impacts by minimizing, rectifying, reducing, or eliminating impacts, or compensating for unavoidable impacts by replacing or substituting resources;
- Protection and preservation of endangered and/or threatened species, Critical Habitat, and EFH; and
- Preservation of significant historical and archeological resources through avoidance, if possible, or data recovery if destruction of the resource is necessary.

III.J SOCIAL CRITERIA

Plans proposed for implementation should have an overall favorable impact on the social well-being of affected interests (e.g., community impacts, health and safety, displacement, energy conservation, and others) and have an 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.

III.K OTHER USACE INITIATIVES

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 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 (USACE, 2009b).

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 the 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 SNWW 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 the USACE will provide innovative, resilient, and sustainable infrastructure solutions for the Nation today and in the future. The 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.

This page intentionally left blank.

IV. FORMULATION AND EVALUATION OF ALTERNATIVES

IV.A OVERVIEW

Navigational and safety issues that have developed on the SNWW because of the growth in the area are the water resources problems to be solved with this project. The ultimate objective of a feasibility study is to arrive at a recommended plan after a full range of alternatives has been analyzed. This involves a comparison between each alternative and the FWOP condition consequences, considering economic, environmental, and social impacts.

This chapter provides a summary of the screening processes and evaluations conducted on the project alternatives. Structural and nonstructural alternatives were identified based on their ability to address the planning objectives, as well as the project problems, needs, concerns, and opportunities.

IV.B PLAN FORMULATION PROCESS

The planning framework requires a systematic preparation and evaluation of alternative ways of addressing the project problems, needs, concerns, and opportunities while considering environmental factors. The criteria and planning objectives previously identified form the basis for subsequent plan formulation, alternative screening, and ultimately identification of the Recommended Plan. Planning for Federal water resources projects constructed by the USACE, as well as other agencies, is based on the Principles and Guidelines (P&G) adopted by the Water Resources Council. Based on the Economic and Environmental Principles for Water and Related Land Resources Implementation Studies, there are four accounts that have been established to facilitate evaluation and display of the effects of alternative plans (ER 1105-2-100). The rationale for the Recommended Plan as it relates to these four accounts is presented later in this chapter.

The planning process for this feasibility study has been driven by the overall objective of developing a comprehensive plan that would allow for safe and efficient barge and ship traffic along the SNWW while protecting the Nation's environmental resources. Secondary objectives have been to address other related water resources problems within the study area.

The first phase of the study process was to determine the magnitude and extent of the problems along the SNWW, then to develop and evaluate an array of alternative solutions to meet the existing and long-range future needs of the Sponsor and the public. During the feasibility phase of the project, 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 occurred 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 identified earlier in this report. For the structural plans, a variety of channel modifications and dredged material placement alternatives were developed, evaluated, and screened. The various channel modifications were investigated as to a possible

means to satisfy the objectives of constructing a safer, more-efficient waterway. Through a two-phased (preliminary and detailed) screening process, a recommended channel modification plan for the SNWW was selected. Figure IV-1 presents the process used to identify and evaluate project alternatives.

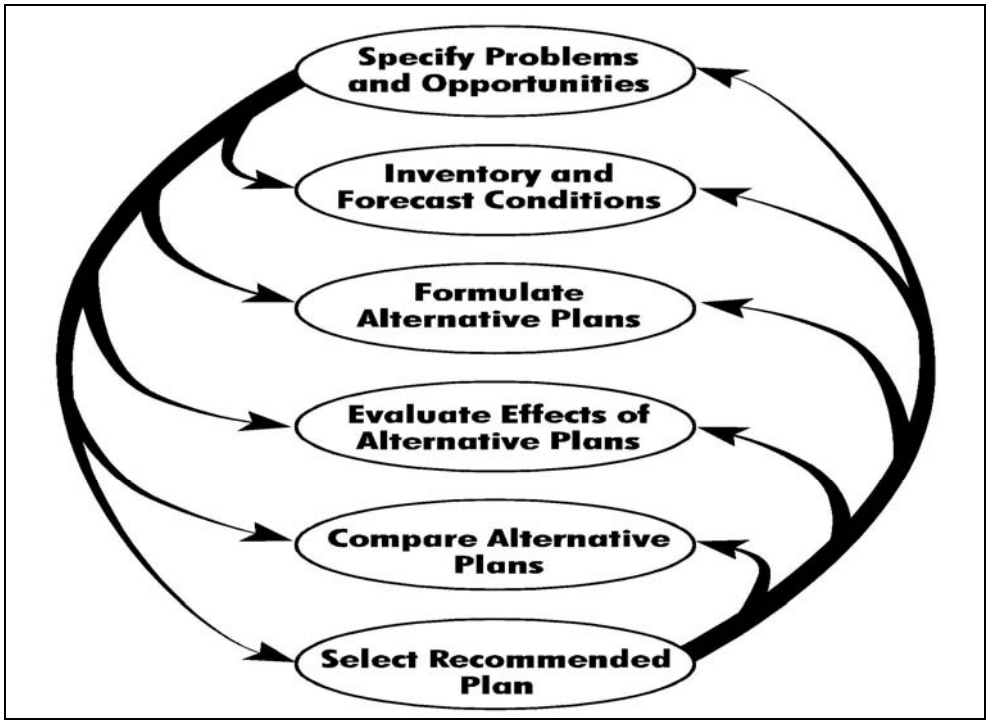


Figure IV-1. Planning Process

IV.C PRELIMINARY SCREENING OF ALTERNATIVES

During preliminary screening, the expected "No Action" Alternative was developed for comparison with other alternatives. Nonstructural and structural alternatives that could address planning objectives were also developed.

Future Without-Project Condition (No-Action Alternative)

The USACE is required to consider the option of "No Action" as one of the alternatives in order to comply with ER 1105-2-100 and the requirements of NEPA. With the No-Action Alternative, which is synonymous with the FWOP condition, it is assumed that no project would be implemented by the Federal Government or by local interests to achieve the planning objectives of improving the navigational efficiency and safety of the waterway. The No-Action Alternative forms the basis against which all other alternative plans are measured.

The No-Action Alternative would retain the existing 40-foot-deep SNWW navigation channel with its various widths along the waterway. The current dimensions would continue to limit the efficient

movement of commodities by vessels traveling the waterway and the safety limitations that result in one-way and daylight-only sailing restrictions. Under the FWOP condition, safety would continue to be a concern for the waterway users and the local communities adjacent to the waterway.

The waterway is often congested because of frequent movements of lightered vessels carrying petroleum products from the Gulf to refineries on the Neches River Channel, and because of barge through-traffic using the GIWW. Vessels are now wider, placing limitations on the combined beam widths and drafts for vessel meetings on the waterway. As vessels increase in draft and beam width, the restrictive depth and width in certain reaches of the waterway would prevent some vessels from entering with full loads or prevent larger vessels from even utilizing the waterway. The potential for accidents on the waterway and their effects on users and the local communities adjacent to the waterway would remain the same. The need to lighter products and/or light load vessels would increase, thereby increasing overall project costs and decreasing the efficiency of the vessels using the waterway.

Methods of shipping crude oil are direct, lightered, and lightened. Direct shipment, as the name implies, is the transfer of tonnage by vessel between two coastal ports. Lightering involves the transfer of tonnage at an offshore location from a larger vessel, called a VLCC, onto one or more shuttle vessels. U.S. Gulf Coast lightering occurs in the international waters of the Gulf of Mexico and is extremely cost effective for long-haul bulk freight. With lightering, the VLCC does not enter the coastal receiving port. A frequent alternative to either direct shipment or lightering is lightening. The term lightening describes the process where enough cargo is offloaded from a tanker to permit the light-loaded vessel to enter a confined channel system.

It is expected that imports of crude oil and petroleum products would continue to expand to keep pace with the predicted national need for these products and the projected continuing declines in U.S. production. Vessel trips would increase to accommodate the higher imports, and higher costs associated with the current lightering and vessel movement limitations would continue. In addition to increasing petroleum imports, continued growth of petroleum and chemical exports is expected. The need for dock reinforcement and stabilization necessary to realize project-deepening benefits was recognized in the plan formulation process. The costs associated with berth stabilization necessary due to channel deepening are included in the project construction cost calculations. Crude petroleum refinery expansion was initiated by Motiva in 2007 due to current refinery limitations and future throughput needs. Dock improvements on both the Neches River and Taylor Bayou were recently completed by industry to accommodate larger crude oil vessels. The results of the plan formulation analyses indicated that berth and terminal capacities were not a constraint to realizing benefits from using larger and more-fully loaded vessels.

Increased vessel trips associated with higher tonnage and increasing concentration of larger vessels would exacerbate the existing channel bank erosion caused by vessel wakes in the confined channel reaches of the SNWW. It is projected that the existing trend in wetland losses would continue due to the combined effect of sea level rise and subsidence, and altered hydrology and salinity levels caused by the existing SNWW navigation channels, the GIWW, and canals, levees, and water control structures associated with oil and gas exploration and production, logging, fishing, and hunting lands.

The No-Action Alternative would continue disposal activities for maintenance material from the 40-foot project in conformance with most, but not all, existing practices. In this Final Feasibility Report (FFR), the DMMP for the No-Action Alternative (the FWOP) is referred to as the Base Plan. The Base Plan forecasts disposal facility needs for all material that would be generated by maintenance dredging of the existing 40-foot project over a 50-year period of analysis. The 50-year analysis determined that additional capacity in upland PAs would be required, and it identified a least-cost BU feature that should be adopted as part of the Base Plan.

No differences from existing offshore placement activities were identified for the Base Plan. The offshore channels (Sabine Bank Channel, Sabine Pass Outer Bar, and Sabine Pass Jetty Channel) would be maintained with a hopper dredge, and approximately 162 million cubic yards (mcy) of material would be placed in the four existing ODMDSs (sites 1–4). Bed sediments in the offshore channels vary from 4.3 percent sand and 95.7 percent silt plus clay in the Sabine Pass Outer Bar Channel to 24.3 percent sand and 75.7 percent silt plus clay in the Sabine Bank Channel (Parchure et al., 2005). These ODMDSs have sufficient capacity for the 50-year period of analysis as they are located in a dispersive environment where dredged material does not accumulate.

For the inshore Sabine Pass Channel, a cost analysis of placement alternatives (presented in Chapter VII) resulted in a change from traditional upland placement practices involving PA 5. Rather than placing all of the maintenance material from this channel into upland PA 5, the BU of material from the channel section closest to the coast (Sabine Pass Channel, Section 5) was evaluated to determine whether it could be used to nourish the Gulf shoreline on both sides of Sabine Pass. Material from Sabine Pass Channel would continue to be placed into PA 5 because the longer pumping distance to the coast makes shore nourishment cost prohibitive. The cost analysis determined that the Gulf Shore BU Feature is more cost effective than placing the material in the upland PA 5, and therefore it was adopted as part of the Base Plan.

Under the Base Plan, all of the inshore channels of the existing project (Sabine Pass Channel, Port Arthur Canal, Sabine-Neches Canal, and the Neches River Channel) would continue to be maintained by hydraulic pipeline dredge. Material from non-Federal dredging of private mooring and dock facilities would also continue to be placed in upland PAs along with the material from the Federal project. Existing management practices that utilize 16 upland PAs located adjacent to the channel from Sabine Pass to the Beaumont TB would continue. To contain 231.6 mcy of material over the 50-year period of analysis, the heights of existing PAs would be raised on a regular, recurring schedule in accordance with existing SNWW management practices. One new PA in the middle reach of the Neches River Channel (an expansion cell at PA 24A) would be needed to provide sufficient capacity for the period of analysis. On average, bed sediments vary in the inland channels from 38.3 percent sand and 61.7 percent silt plus clay in the Neches River Channel, to 16.2 percent sand and 83.8 percent silt plus clay in the Port Arthur Canal (Parchure et al., 2005). BU features are not included in the Base Plan for the inland channels because the lack of suitable material makes construction and maintenance of containment levees more expensive than placing the material in existing PAs. However, BU of dredged material (Section 204) projects would be

considered on a project-by-project basis if non-Federal sponsors express an interest in paying the incremental cost for such projects.

Preliminary Screening of Alternatives

Based on the problems and opportunities identified by the Sponsor and the public comments received at the May 2000 public scoping meeting, a wide variety of management measures (alternatives) were identified to address one or more of the planning objectives. A preliminary (first) screening of the alternatives was conducted to eliminate any alternatives that did not meet the study objectives. This screening focused on whether deepening, and perhaps widening, would be cost effective, and whether any nonstructural alternatives to deepening and/or widening could be identified.

In order to evaluate the preliminary alternatives, screening criteria that would likely have the most influence in determining the viability of the alternatives were identified. The following criteria were used to evaluate and screen the alternatives:

- Dredging Quantities
- Cultural Resource Concerns
- Real Estate Issues
- Project Benefits
- Safety Issues
- Environmental Considerations
- Hazardous, Toxic, and Radioactive Waste Concerns
- Construction Costs
- Sponsor's Preferences

Each of the following alternatives was assessed and a determination made regarding whether it should be retained for the second screening of alternative plans. The following is a list of the preliminary alternatives considered:

Nonstructural Alternatives

- Alternate mode of commodity transport,
- Vessel traffic service, and
- Modification of existing pilot rules on the waterway.

Structural Alternatives

- Deepening only (43-, 45-, 48-, 50-, 53-, 55-foot depths)
- Widening only, along the entire channel (widths varying from 500 to 700 feet) from Sabine Pass to the Port of Beaumont
- Deepening and widening (combinations of six depths and various widths for entire channel length)
- Selective widening only (widening only certain reaches of the channel)
- Deepening with selective widening (combination of depths and widening options)

- Expansion of existing and construction of new TB and/or AB
- Construction of barge lanes (for passing)

Plans Eliminated During Preliminary Screening

All of the nonstructural plans were advanced into the second screening because it was determined that these alternatives could potentially meet one or more of the planning objectives, but a more in-depth analysis would be necessary for a full assessment. In addition, most of the structural alternatives were also advanced into the second screening. It was found that deepening and widening the existing 40-foot channel would allow for existing ships to more fully utilize the channel and potentially reduce traffic delays, without prohibitive costs.

Two of the preliminary structural alternatives considered were found to be infeasible due to technical, economic, and environmental constraints, and were therefore not advanced into the second screening:

- Widening the entire existing channel from Sabine Pass to the Port of Beaumont, at widths varying from 500 to 700 feet, was found to be infeasible based upon a number of criteria. The length of the widening would generate a tremendous quantity of dredged material, resulting in greatly increased costs for construction and placement facilities. A number of large commercial docks and berthing facilities are located along the channel, and these would be disrupted or displaced by widening activities. The Martin Luther King (MLK) Bridge that crosses the Port Arthur Canal would need to be relocated as the existing span is not wide enough to accommodate channel widening. The widening would affect a large amount of emergent land, especially along the narrow confined Port Arthur Canal and narrower sections of the Neches River. Landfills containing hazardous materials would be affected by the widening, as well as some wetland areas. And perhaps most pertinent, widening only would not provide the additional draft needed to increase navigation efficiency for the largest number of waterway users.
- Selective widening only (widening only certain reaches of the channel) would reduce or eliminate some of the environmental, real estate, and cost concerns discussed above. However, selective widening would provide even fewer navigation benefits than the widening for the entire channel and also would not increase navigation efficiency for the largest number of waterway users.

IV.D SECOND SCREENING

The alternatives remaining from the preliminary screening underwent more-detailed analyses. These analyses were conducted on three nonstructural plans and over 120 structural combinations of the alternative depths and widths (including seven TBs and anchorage features). Alternatives were evaluated for a 50-year period of analysis.

Technical Studies

To evaluate the depth alternatives with selective widening options, TBs, and barge lanes, several technical studies were conducted by the ERDC and IWR. The additional study efforts included:

- Hydrodynamic/Salinity Modeling Study (ERDC)
- Ship Simulation Study (ERDC)
- Sediment Study and Velocity Analysis (ERDC)
- Vessel Effects Study (ERDC)
- Gulf Shoreline Desktop Study (ERDC)
- Harbor Simulation Model (Widening Analysis) (IWR)

The reports from these studies are available upon request from the USACE. The following is a brief overview of each of the studies:

Hydrodynamic-Salinity Model. The HS model study was conducted to determine the hydrodynamics (water levels and current velocities) of the SNWW and the potential salinity impacts due to the proposed deepening and widening of the existing channel (Brown and Stokes, 2009). The model was originally developed by Resources Management Associates (King, 1993) and extensively modified by the ERDC staff. The model has been used extensively over the past decade on such projects including the Houston-Galveston Navigation Channels; New York Harbor; St. Johns River, Florida; and Atchafalaya Bay, Louisiana. The model was performed for the 48- and 50-foot channel depths. The 45-foot channel depth was not modeled since the salinity differences between 45-foot and 48-foot depths were expected to be similarly small (FEIS, Section 2.3.2)

Ship Simulation. The ship simulation was used to determine navigation and safety impacts due to anticipated changes in vessel sizes as a result of the proposed channel widening (Webb, 2003). The main objective of the study was to determine whether the "design" ship could safely operate within the width and depth of the proposed channel dimensions. The simulation was conducted on a channel depth of 50 feet with varying widths and proposed barge lanes, including simulation of Taylor Bayou. Additional ship simulation was conducted to determine the navigation and safety implications of reducing the offshore entrance channel from its existing 800-foot width to a 700-foot width.

Sediment Study and Velocity Analysis. To determine anticipated shoaling rates (sediment build-up) along the waterway and estimate any increases in channel erosion, a sediment study was conducted (Parchure et al., 2005). Erosion concerns along Pleasure Island and East Sabine Lake were also addressed by the analysis. An additional study effort was performed along the Pleasure Island reach and Sabine-Neches Canal to determine whether the channel velocities in these areas would result in increased channel erosion.

Vessel Effects Study. A vessel effects study was conducted to determine the potential erosional effects to Pleasure Island from vessel traffic in the Port Arthur and Sabine-Neches canals (Maynord, 2005). Project vessel traffic was modeled with HIVEL2D, a two-dimensional (2-D) finite element model designed specifically to simulate flow in typical high-velocity channels. The model has been used since the mid-1980s and is maintained by the ERDC-Coastal and Hydraulics Laboratory (CHL).

Gulf Shoreline Study. This ERDC-CHL study was conducted 10 miles on either side of the SNWW entrance channel to determine potential erosion impacts to the existing shoreline at the Gulf of Mexico, on the Texas and Louisiana sides of the channel (Gravens and King, 2003). The spectral nearshore wave transformation model, Steady State Spectral Wave (STWAVE), was applied to examine wave conditions within a bathymetry grid extending 20 miles along the shoreline. The STWAVE model has been used on studies at Willapa Bay and Grays Harbor, Washington, and Ponce de Leon, Florida.

Harbor Simulation Model. The HarborSym model was used to evaluate widening of the entrance channel. HarborSym is a planning-level model developed by the IWR to assist in economic analyses of channel-widening improvements. The model creates an event-driven simulation based on empirical data and includes data from user-specified transit rules that the model processes with each vessel call in order to calculate delays within the system. More-detailed information on the model results can be found in the Economic Appendix of this report.

Nonstructural Alternatives

The nonstructural alternatives were evaluated during the preliminary screening process to determine their ability to meet some or all of the planning objectives for the project. The nonstructural alternatives evaluated the use of a VTS to alleviate transportation inefficiency and safety concerns, the relaxation of existing pilot rules, and an alternative mode of commodity transport.

Vessel Traffic Service

The existing VTS along the SNWW was evaluated as a nonstructural alternative. Although this service is managed by the USCG and thus is not within the jurisdiction of the USACE, it was evaluated because it appeared to be a potential alternative to structural plans. The VTS was authorized by certain sections of the Ports and Waterways Safety Act of 1972; the Oil Pollution Act of 1990 made participation mandatory in areas serviced by existing and future VTS (USCG, 2008a). The purpose of VTS is to provide active monitoring and navigational advice for vessels in particularly confined and busy waterways. VTS is designed to expedite ship movements, increase transportation system efficiency, improve all-weather operating capability, and enhance vessel safety and marine environmental protection (USCG, 2007, 2008b).

The VTS Center in Port Arthur monitors every ship, vessel, or boat that attempts to enter or leave the SNWW and the GIWW in the Port Arthur service area. Infrared cameras, along with radar, radio-telephone reports from vessel operators, and satellite surveillance sensors on towers along the SNWW, allow VTS controllers to zoom-in on vessel activity at a moment's notice. The satellite-based Automatic Identification System (AIS), required by the Maritime Transportation Security Act of 2002, assists the VTS by determining exactly what a specific commercial vessel is carrying, along with its speed, dimensions, and destination. Most commercial vessels using the waterway were required to have AIS equipment installed by the end of 2004 (USCG, 2004). These include power-driven vessels 66 feet in length or longer, power-driven vessels of 100 gross tons or more carrying one or more passengers for hire, towing vessels 26 feet or longer while navigating, all dredges and floating plant likely to restrict or

affect the navigation of other vessels, and all vessels required to participate in the Vessel Movement Reporting System. However, not all vessels are required to carry AIS; in particular, pleasure crafts, fishing boats, and warships are exempt.

Currently, the VTS Port Arthur is a voluntary system operated in accordance with existing VTS regulations. Until rules regarding VTS Port Arthur are published, vessels are exempt from all VTS and vessel movement reporting system requirements, except the requirement for AIS continuous broadcasts. When VTS Port Arthur is included in the VTS regulation, participation will become mandatory. At that time, VTS Port Arthur would be authorized to designate temporary reporting points and procedures, impose vessel-operating requirements, or establish vessel traffic routing schemes. During conditions of vessel congestion, restricted visibility, adverse weather, or other hazardous circumstances, VTS may control or manage traffic by specifying times of entry, movement, or departure to, from, or within a VTS area.

While the VTS would help congestion and improve safety to some degree, the USCG's traffic management role is limited to specific circumstances when the SNWW is congested or experiencing hazardous conditions. The VTS assists vessel operators in making independent decisions regarding the safe navigation of their vessels, for which they retain complete responsibility. In this sense, VTS should be considered primarily a navigational aid, a tool for mariners to use along with numerous other tools to facilitate safe navigation (USCG, 2008b), and thus would not improve deep-draft navigation inefficiencies created by the need for lightering and associated vessel delays.

Relaxation of Existing Pilot Rules

The SNWW is currently subject to transit rules that are needed for the pilots to safely guide large tankers through the existing, narrow channel. Relaxation of these rules as an alternative to channel improvements was evaluated. These transit rules or restrictions are agreed upon by the shipping industry, supported by the USCG Captain of the Port Orders under the Ports and Waterways Safety Act of 1978, as amended, and administered by the Sabine Pilots (2007). The agreement, dated January 12, 1981, will remain in force until the Sabine shipping industries, SPA, and USCG agree to its revision or modification.

The existing 700-foot-wide reach of the SNWW channel does not have vessel-meeting restrictions; however, in the narrower channel reaches vessel-meeting restrictions are currently imposed. The specific rules posted by the Sabine Pilots are displayed in Table VI-54. A general overview of the transit rules are:

- Daylight-only sailing restrictions applied in specific reaches for vessels that exceed certain DWT, length, and breadth criteria.
- No meeting during nighttime sailing for vessels exceeding a given draft limitation.
- No meeting during either day or night, applied to vessels by DWT, length, breadth, and draft combinations.

Relaxation of the existing pilot rules for the waterway was considered as a nonstructural alternative. However, given concerns about vessel handling and associated safety issues and that vessels utilizing the

waterway are wider than those using the channel even 5 to 10 years ago, the Sabine Pilots would not consider relaxing the rules. The expectation for the with- and without-project future is that pilot rules would continue to limit the possibility of vessel meetings in the Sabine-Neches Canal reach and that both vessel and shallow-draft tow movements would be scheduled through both VTS and communication between vessel pilots. More discussion of the transit rules and coordination with the SPA can be found in Chapter V, Economic Evaluation of Alternatives.

Alternative Mode of Commodity Transport

Offshore oil terminals were evaluated as an alternative mode of commodity transport to determine whether it was economically more effective for the primary users of the waterway (crude oil tankers) to utilize this mode of transportation than it would be to construct a deeper and wider channel. Two offshore terminal alternatives were considered in the analysis, one existing and one proposed. The decision to use an offshore terminal instead of lightering or constructing a deeper channel is complicated but largely depends on the relative cost per ton, relative market volumes, and facility accessibility.

Louisiana Offshore Oil Port

Louisiana Offshore Oil Port (LOOP) is America's first and only deepwater (offshore) port and has been operating at capacity since 2005. The LOOP is located offshore of Grande Isle, Louisiana, in 110 feet of water. Grande Isle is 302 miles east of Port Arthur and Beaumont. The LOOP was organized in 1972 as a Delaware corporation and converted to a limited liability company in 1996. Marathon Ashland Pipe Line LLC, Murphy Oil Corporation, and Shell Oil Company are the LOOP's owners. The LOOP is the only port in the U.S. capable of offloading deep-draft tankers known as Ultra Large Crude Carriers and VLCC. Along with offloading crude from VLCC, the LOOP also offloads smaller tankers. The LOOP consists of three single-point mooring buoys used for the offloading of crude tankers and a marine terminal consisting of a two-level pumping platform and a three-level control platform.

Access to the LOOP for the SNWW market would require substantial investment as SNWW crude oil import volume nearly equals LOOP's capacity. The LOOP's design capacity of 1.4 to 1.8 million barrels per day is marginally higher than SNWW 2004–2006 crude petroleum import volume, which ranged from 1.2 to 1.4 million barrels per day (USACE, 2007a). The investment necessary for LOOP to process SNWW's entire crude petroleum throughput would require a doubling of capacity

A 48-inch-diameter pipeline connects the LOOP Marine Terminal located 23 miles offshore in the Gulf of Mexico to the Clovelly, Louisiana, storage facilities. Clovelly is approximately 260 miles east of the SNWW Port Arthur and Beaumont facilities. Four pipelines connect the onshore storage facility to refineries in Louisiana and along the Gulf Coast. The Clovelly facility provides interim storage for crude oil before it is delivered via connecting pipelines to refineries on the Gulf Coast and in the Midwest. The oil is stored in eight underground caverns leached out of a naturally occurring salt dome. In 1996, one cavern was dedicated to the production streams coming in from the deepwater Gulf of Mexico.

The domestic offshore crude oil system uses the same distribution system used by the foreign barrels. The caverns are capable of storing approximately 50 million barrels of crude oil (a barrel of oil is equal to 42 U.S. gallons). In addition, LOOP has an aboveground tank farm consisting of six 600,000-barrel tanks. LOOP operates the 53-mile, 48-inch LOCAP pipeline that connects the LOOP to CAPLINE (Amoco Cushing-Chicago Pipeline Company) at St. James, Louisiana. CAPLINE is a 40-inch pipeline that transports crude oil to several Midwest refineries. St. James is 227 miles east of Port Arthur and Beaumont. LOOP is connected to over 50 percent of the U.S. refinery capacity and has offloaded over 7 billion barrels of foreign crude oil since its inception.

Present users of LOOP consist of Louisiana-based refineries and U.S. Gulf Coast state domestic offshore production interests. In addition to new customers brought on due to infrastructure damages associated with the 2005 hurricanes, recent increase in the LOOP is tied to utilization associated with domestic production in the U.S. Gulf. It was noted that LOOP's existing base of customers uses it as one of several options for delivering crude oil to their Gulf Coast refineries (personal communication with Kathleen Jackson, Exxon, 2007). While all of SNWW's crude oil could not currently transfer to LOOP, additional tonnage could potentially be diverted. SNWW users continue to consider LOOP along with other alternatives; however, continued practices suggest that LOOP is not a cost-effective alternative to the existing SNWW practice of its land-based ports. The large fixed cost of expansion, and associated financing costs, necessitates participation by a consortium of companies. SNWW industries have not found the option of investing in LOOP, and the necessary associated infrastructure expansions, to be a cost-effective alternative to existing practices of either direct shipment or offshore lightering. The lack of incentive has remained since the 1970s. An additional variable pertinent to the current evaluation is that LOOP would appear to be a less-attractive cost option when compared to lower shipping costs that the SNWW improvement project is expected to provide.

LOOP is designed to handle 1.4 million barrels per day, but depending on the sizes of ships being serviced, it can handle 1.8 million barrels per day. The variance relates to the pumping rates of the tankers using the facility. Larger tankers tend to have faster pumping rates with some capable of pumping 80,000 barrels per hour. Smaller tankers may only be able to pump 35,000 barrels per hour. When fully operational, LOOP is generally the largest point of entry for crude oil imports into the U.S. About 13 percent of all waterborne foreign imports pass through LOOP each day. Again, LOOP's design capacity of 1.4 to 1.8 million barrels per day is only marginally higher than SNWW 2004–2006 crude petroleum import volume, which ranged from 1.2 to 1.4 million barrels per day. Of SNWW's approximately 1.3 million barrels per day import volume, terminals on the SNWW transport approximately 400,000 barrels per day of waterborne crude oil via pipelines to inland refineries including refineries in Texas, Louisiana, Oklahoma, Ohio, Arkansas, and Kentucky (Martin Associates, 2006). In total, the SNWW delivers approximately 12 to 16 percent of the crude oil supplied to domestic refineries east of the Rockies. Refineries supplied via the SNWW provide transportation fuels and other products to consumers along the Gulf Coast, East Coast, and Midwest regions. The SNWW ports presently receive about 1 percent of their daily input through LOOP. Additional offshore and landside infrastructure would be necessary for an increase in volume to take place.

Although there are some competing markets, the SNWW and LOOP generally serve parallel markets with LOOP consistently processing very large volumes and SNWW serving relatively smaller parcels. The sizes of the VLCC using LOOP typically exceed 300,000 DWT, whereas the maximum sized vessels using the SNWW are 175,000 DWT. The maximum design draft of these vessels is 55 feet or less. The minimum sized crude oil tankers using SNWW are in the 70,000 to 80,000 DWT range and have design drafts between 40 and 48 feet. LOOP's foreign petroleum imports are from the Middle East, whereas SNWW's market consists of direct shipments from Mexico and Venezuela and lightened mother vessels and shuttles. It has been noted that the cost effectiveness of LOOP lessens for small vessel sizes. The SNWW has the ability to serve a more general market and range of users. In discussions with local port and oil industry personnel, it is noted that LOOP and similar proposals serve crude petroleum but do not serve a full range of petroleum and bulk cargoes that use the SNWW.

The most-immediate obstacle to increased use of LOOP or a new offshore facility is major limitations for direct connection from LOOP to SNWW. A marginal increase in SNWW use of LOOP from its present 1 percent share would require LOOP pipeline connection modifications involving multiple pipelines and multiple companies. Such an investment may generate the necessity for higher throughput charges, which in turn may make access less cost effective than in the past. An industry analyst noted that, to a large extent, the companies demand that each segment, including pipeline transportation, stand on its own economically (Rabinow, 2004). The long-term availability of LOOP since the 1970s and low participation by SNWW companies indicate that LOOP and new offshore terminal proposals have not provided the market utilization incentives for significant shares of SNWW crude oil to shift towards these alternatives. The long-term trend is for domestic refining capacity to become more concentrated in regional centers and for imports of petroleum products to grow. This trend is evident with SNWW with crude oil import tonnage exceeding that of any other U.S. port and being equal to LOOP. Imports of refined products and partial refined crude oil have grown significantly as have the use of draft-constrained vessels for transporting these cargoes.

Bulk Oil Offshore Transfer System

Consideration of a Texas offshore oil terminal was also recognized as an alternative. In 2001, construction of a new terminal (called the Bulk Oil Offshore Transfer System, or BOOTS) offshore of Sabine Pass, Texas, was proposed. The relatively long distance from LOOP to SNWW and the need for additional infrastructure suggest that a facility closer to SNWW would be an attractive alternative to LOOP for SNWW channel improvements. However, the BOOTS facility has not yet been constructed and the regulatory permit application is inactive. The USCG has had no update on the proposal and does not expect a submittal. At the present time, the potential user of the proposed project is the terminal proponent. They noted that their participation as sole supporter is not feasible financially. It was specifically noted that their feedstock needs were not sufficient to finance the expansions to LOOP.

The BOOTs project proponent was contacted, and it was found that a new location farther down the Texas Coast near Freeport is presently being considered. The Freeport, Texas, site is about 100 miles southwest of the previous BOOTS location. Access by the SNWW refineries to a Freeport site involves

longer distances than the previous BOOTS location but it has advantages over LOOP. There is an existing pipeline from Freeport to Texas City; however, its connection to Port Arthur would necessitate a new pipeline from Texas City to SNWW, a distance of approximately 95 miles. Construction of a Freeport offshore facility could help serve the Freeport, Houston, and Texas City markets. Freeport's annual crude oil import volumes for the most recent 3-year period equate to approximately 0.4 million barrels per day; Houston's imports equate to about 1.0 million barrels per day; and Texas City's imports equate to about 0.9 million barrels per day. Industry indications are that the use of an offshore Freeport terminal would not serve as the exclusive supplier, just as LOOP is not the exclusive supplier for the Louisiana markets. Foreign imports by vessels into Louisiana and Mississippi are presently about 0.8 million barrels per day.

In a general discussion with industry, a representative noted that offshore oil terminal projects surface periodically, but the cost of these alternatives keeps them from moving beyond the initial planning stage. It is noted that the attractiveness of offshore alternatives over existing use of the SNWW is diminished by its ability to only serve one commodity (i.e., crude petroleum). It was added that the various crude oil blends and grades of oil introduce a range of additional concerns that add to throughput costs. The pipelines and associated infrastructure requirements vary between potential users and mingling of products and grades of crude is complex and difficult to facilitate. The construction of an offshore terminal that can meet the needs of various users is a challenge with the costs to realize multiparty usage creating an impasse to these proposals moving beyond the initial planning stage. Recognition of the cost of multiple pipelines necessary to meet the needs of the large base of customers necessary to finance these project alternatives has resulted in a stalemate in the decision process.

Expansion of LOOP, construction of a new offshore facility such as BOOTS, or an unloading terminal along the Sabine Pass or Port Arthur Canal reaches would reduce the vessel traffic on the Neches River. The reduction in ship traffic resulting from LOOP or BOOTS would reduce the economic viability of the SNWW deepening and widening project. However, past and present trends in infrastructure and fleet investments indicate that industry intends to continue using the Neches River Channel. An increase in the number of specially designed SNWW vessels was recently completed by one company, and another has invested in Neches River dock modifications for the larger "Aframax" and "Suezmax" vessels. The focus of immediate private sector petroleum vessel investments is concentrated on SNWW improvements rather than offshore or on the Sabine Pass Channel or Port Arthur Canal.

SNWW industry evaluation of offshore alternatives remains a reality; however, specific investments and commitments have not been made during a period when industry has invested in construction of new crude petroleum docks on the Neches River and in Port Arthur. Ongoing consultation with industry continues to show that commitments to offshore terminal investment have not materialized. During the 30 years since LOOP has become operational, several Texas Gulf Coast channel improvement projects have been completed and the benefits have been accrued. Offshore terminals would not accommodate products other than crude oil, and a significant proportion of benefits for the SNWW project improvement are from refined petroleum products. The offshore terminal was not found to meet the efficiency objective for all waterway users as it addressed the needs of only one user and commodity (crude oil). For these reasons, this alternative was eliminated from further consideration.

Structural Alternatives

In order to reach the appropriate depths offshore, all deepening alternatives would involve an increase in the Entrance Channel ranging from 5 to 25 miles in length. Deepening and widening alternatives that were evaluated during this second screening analysis are listed in Table IV- 1.

Table IV-1
Structural Alternatives

Alternative	Depths (feet) Evaluated	Section/Reach to be Widened	Widths (feet) Evaluated
No Action	40	None	Existing – Sabine Bank Channel to Outer Bar Channel – 800 Jetty Channel to Port Arthur Canal – 500 Sabine-Neches Canal/Neches River Channel – 400
Deepen only	43, 45, 48, 50, 53, 55	None	Existing
Deepen and Widen	43, 45, 48, 50, 53, 55	Sabine-Neches Canal/Neches River Channel to Beaumont	Widen to match lower reach – 500
Deepen and Widen	43, 45, 48, 50, 53, 55	Sabine Pass Channel – Sta. 180+00 to Port Arthur Canal – Sta. 275+00	600 or 700
Deepen and Widen	43, 45, 48, 50, 53, 55	Sabine Pass Channel – Sta. 265+00 to Port Arthur Canal – Sta. 85+00	600 or 700
Deepen and Widen	43, 45, 48, 50, 53, 55	Sabine Pass Jetty Channel	600 or 700
Deepen and Widen	43, 45, 48, 50, 53, 55	Sabine-Neches Canal	500, 600, 700, selective widening, or barge lanes
Deepen and Widen	43, 45, 48, 50, 53, 55	Neches River Channel	600, 700 or Turning Basins/Anchorages
Deepen and Widen	45, 48, 50	Sabine Pass Jetty Channel to Port Arthur Canal, selective widening on Taylor Bayou	700

Additional engineering and environmental analyses were conducted to identify the specific channel modifications and environmental impacts for the various depths. Modifications to these alternatives were considered in an effort to decrease costs and identify an economically justified project. As part of the iterative plan formulation process, the following alternatives were added:

- Deepening the SNWW to Beaumont to 48 feet, widening to 700 feet width through the end of the Port Arthur Canal, and deepening and widening the Taylor Bayou Channel and TBs, but with a modification (narrowing) of the Outer Bank and Sabine Bank channels to 700 feet width through the end of the channel.
- Deepening the SNWW to Beaumont to 48 feet, widening to 700 feet width through the end of the Port Arthur Canal, deepening and widening the Taylor Bayou Channel and TBs, and tapering Sabine Bank Channel from 800 feet wide (Station 23+300) to 700 feet wide (Station 25+800 through end of the channel).

- Deepening the SNWW to Beaumont to 47 feet, widening to 700 feet width through the end of the Port Arthur Canal, deepening and widening the Taylor Bayou Channel and TBs, and narrowing of the Outer Bar and Sabine Bank channels to 700 feet width through the end of the channel. The 47-foot depth alternative was considered later in plan formulation phase in an attempt to reduce project costs and find an economically justified project. This alternative was later dropped since a modification to the original 48-foot depth alternative was found to be economically justified.

Evaluation of Alternatives

As a result of the second screening, detailed evaluations were conducted on channel depths of 45, 48, and 50 feet in order to identify the optimal depth. Analysis of additional depths of 46, 47, and 49 feet were conducted later in the study to further optimize the NED depth. Along with these above-mentioned studies, various analyses including benefit and cost analyses, were conducted on the three alternative depths including the selective widening and TB/anchorage area options.

Incremental analyses of separable elements were also performed to determine if each was economically justified on its own. These separable elements included deepening to Port Arthur, deepening to Beaumont, and deepening Taylor Bayou with selective widening to ease navigation problems.

Second screening costs for the three depths were revised to include additional estimates developed for dock modifications, dock dredging, bridge pier replacement, costs for TBs and AB, and operations and maintenance (O&M) (including extension of the channel into the Gulf of Mexico to reach the proposed depth alternatives). Mitigation costs were assumed to be the same for each alternative for the reasons described below. Throughout this detailed analysis, environmental coordination and evaluation efforts were being conducted with the State and Federal resource agencies to identify mitigation requirements and BU locations for the estimated new work and maintenance material for the 50-year period of analysis.

Ecological mitigation costs for the six depth alternatives were estimated using the HS model salinity projection for the 40-, 45-, and 48-foot channel depths. Salinity was chosen as the best factor on which to base interpolation of mitigation costs because it is the primary driver in the ecological modeling that was used to determine the compensatory mitigation plan. The cost interpolation assumed that there would be a linear relationship between predicted salinities for each channel depth at the end of the period of analysis and the cost of mitigation.

Direct ecological effects associated with the navigation channel improvements under all proposed alternatives and the placement of dredged material consist of:

- Impacts to benthic organisms and their Gulf, estuarine, and riverine water-bottom habitats would be similar for all alternatives. Benthic organisms are expected to quickly rebound from the short-term impacts of channel dredging, the use of offshore PAs, and the Sabine Lake borrow trench/access channel associated with compensatory mitigation in Louisiana.
- Dredging impacts to bottom-feeding and pelagic organisms such as sea turtles may occur with hopper dredging of offshore channel reaches for all alternatives; reasonable and prudent measures to avoid impacts would be instituted with an avoidance plan.

- Impacts to marsh would result from the enlargement of one PA under the No-Action Alternative, and two PAs under all other alternatives. The new PAs would be small and the incremental cost associated with one additional PA are too small to affect alternative selection. Most PAs would be enlarged by raising levee heights, which means that the footprint of the PA impacts would be similar for all alternatives.
- Impacts to shorebirds and their habitat would result from the regular placement of maintenance material on the Gulf shoreline under all alternatives, including the No-Action Alternative. Birds would be temporarily displaced to nearby habitat during each placement episode. These impacts would be minor and temporary, and the number and footprint of each placement episode would be the same for each alternative.

Indirect effects provide the primary ecological impacts of all structural alternatives. Although the SNWW channel is located primarily in Texas, large indirect impacts may occur in both Texas and Louisiana due to small increases in salinity levels causing an increase in wetland loss rates and a decrease in biological productivity in aquatic habitats of the study area. HS modeling indicates that none of the depth alternatives would result in significant impacts to swamp and fresh marsh habitats in the upper reaches of the Sabine and Neches rivers. Salinity impacts of the six depth alternatives to the vast saline through intermediate marshes would be similar, with an average difference between the 45- and 50-foot alternatives of less than 0.5 ppt.

Second Screening Costs

Second screening costs were prepared for the existing channel width (500 feet) at the six alternative depths. These costs are included in Table IV-2. These estimates included costs for relocations (including utility relocations), dredging, levee construction, engineering and design, and construction management. Costs for selective widening to 700-foot widths were determined for two channel reaches for all six alternative depths and the existing 40-foot depth. Costs for O&M for each of the structural alternatives were not included in this second screening evaluation of the alternatives, but would be considered later in the screening process. Costs for real estate lands and damages, mitigation, and BU features were not calculated for the 120 plus variations during this screening. Project benefits were based on reductions in transportation costs generated from more-efficient vessel loading and from reduction in vessel delays for the channels to Port Arthur and Beaumont. With the high number of alternatives to be screened, the results of the economic analysis, specifically the BCRs and the net excess benefits, were used as the main screening tool.

Ecological benefits and mitigation costs were not calculated for the nonstructural and 120-plus variations of structural alternatives for channel improvements during the screening process. However, all alternatives, including the No-Action Alternative, were informally reviewed for potential effects to the environment in a nonquantitative manner, and this information was evaluated along with cost data in determining which plans would advance into detailed evaluation.

Table IV-2
SNWW (including Taylor Bayou and Neches River Channels)
Alternative First Cost
(2002 Calculations)

Channel Depth (feet)	First Cost Deepening ($)
43	134,295,000
45	191,843,000
48	297,787,000
50	373,275,000
53	496,691,000
55	575,436,000

Second Screening Economic Analysis

Project Benefits

An economic evaluation of various deepening and widening alternatives was conducted to identify alternatives that maximized NED benefits. This evaluation is presented in detail in Chapter V of this report. Benefits were calculated for Port Arthur and Beaumont depth alternatives of 43, 45, 48, 50, 53, and 55 feet, and for other separable elements of the proposed CIP. Based on the BCRs, the screening analyses indicated that the improvements through the Neches River Channel to Beaumont were economically justified. It was found that 65 percent of the project benefits were associated with the upstream Beaumont area and 35 percent with the Port Arthur area; therefore, continuing improvements up the Neches River to Beaumont was economically justified. Alternative depths of 45 feet and greater had higher net excess benefits than depths less than 45 feet. In addition, the non-Federal sponsor did not wish to pursue depths less than 45 feet; therefore, depth alternatives less than 45 feet were dropped from further analysis.

Preliminary benefit calculations prepared for the early screenings were limited to crude petroleum and refined petroleum products. These groups represent over 88 percent of 2000–2006 total deep-draft tonnage. Tables IV-3 to IV-5 display the transportation savings benefits calculated for the second screening. The benefits for the Neches River Channel to Beaumont deepening are shown in Table IV-3, and the benefits for the Taylor Bayou reach are shown in tables IV-4 and IV-5. The benefits presented in Table IV-4 assume deepening Taylor Bayou, widening at the mouth of the Bayou and the west TB bottleneck curve, and placement of a structural wall that would protect local railroad tracks. The widening associated with the Table IV-4 scenario would facilitate the existing fleet and reduce the level of maneuvering necessary. The second set of Taylor Bayou benefits (Table IV-5) assumes major reconfiguration of the Taylor Bayou channel so that larger Aframax and Suezmax vessels (i.e., 120,000 to 175,000 DWT) could access the facilities. Facilitating the full range of Aframax and Suezmax vessels would require moving the railroad tracks rather than just constructing a retaining wall. The maximum sized tankers presently using the Taylor Bayou channel are in the 80,000 to 115,000 DWT range.

Table IV-3
Average Annual Benefits ($), Neches River Channel
(2002 Calculations at 6.375%, 50-Year Period)

Channel Depth (feet)	Crude Oil Imports	Petroleum Products		Total Benefits
		Imports	Exports	
43	11,192,741	2,673,782	1,034,112	14,900,635
45	13,905,184	3,429,983	1,327,696	18,662,863
48	21,048,641	5,396,346	2,090,369	28,535,356
50	23,182,977	6,448,183	2,497,512	32,128,672
53	26,816,688	7,580,793	2,929,141	37,326,622
55	29,047,523	8,067,929	3,114,431	40,229,883

Table IV-4
Average Annual Benefits ($), Taylor Bayou Channel and Basin
Accommodates Limited Range of Aframax Vessels
(2002 Calculations at 6.375%, 50-Year Period)

Channel Depth (feet)	Crude Oil Imports	Petroleum Products		Total Benefits
		Imports	Exports	
43	5,415,881	653,569	855,527	6,924,977
45	6,715,426	836,923	1,096,613	8,648,962
48	10,147,206	1,314,065	1,723,108	13,184,379
50	10,918,029	1,567,326	2,035,245	14,520,600
53	11,216,492	1,567,326	2,035,245	14,819,063
55	11,216,492	1,567,326	2,035,245	14,819,063

Table IV-5
Average Annual Benefits ($), Taylor Bayou Channel and Basin
Accommodates Limited Range of Aframax and Suezmax Vessels
(2002 Calculations at 6.375%, 50-Year Period)

Channel Depth (feet)	Crude Oil Imports	Petroleum Products		Total Benefits
		Imports	Exports	
43	6,546,410	789,997	1,034,112	8,370,519
45	9,130,533	1,013,283	1,327,696	10,471,512
48	12,309,970	1,594,143	2,090,369	15,994,482
50	13,526,683	1,904,115	2,497,512	17,928,310
53	15,641,626	2,255,707	2,929,141	20,826,474
55	18,999,767	2,398,070	3,114,431	24,512,268

Table IV-6 summarizes the results of the screening depth optimization. The Taylor Bayou construction cost contained in Table IV-6 assumes deepening of the existing channel framework and limited widening. The widening associated with the cost shown would facilitate the upper end of the existing fleet and reduce the level of maneuvering necessary but it would not accommodate the full range of Aframax and Suezmax tankers.

Table IV-6
SNWW (Taylor Bayou and Neches River Channels)
First Cost and Average Annual Costs and Benefits
(2002 Calculations at 6.375%, 50 Years)

Channel Depth (feet)	First Cost Deepening ($)	Average Annual Cost ($)	Average Annual Benefits ($)	Net Excess Benefits ($)	BCR
SNWW Total					
43	134,295,000	8,969,424	21,825,612	12,856,188	2.4
45	191,843,000	12,812,996	27,311,825	14,498,829	2.1
48	297,787,000	19,888,886	41,719,734	21,830,848	2.1
50	373,275,000	24,930,652	46,599,463	21,668,811	1.9
53	496,691,000	33,173,479	51,797,413	18,623,934	1.6
55	575,436,000	38,432,776	54,700,674	16,267,898	1.4
Deepening to Neches River (No Improvements to Taylor Bayou)					
43	128,073,368	8,553,888	14,900,635	6,346,747	1.7
45	184,192,994	12,302,060	18,662,863	6,360,803	1.5
48	287,681,639	19,213,960	28,535,356	9,321,396	1.5
50	360,546,301	24,080,515	32,128,672	8,048,157	1.3
53	480,142,477	32,068,220	37,326,622	5,258,402	1.2
55	556,384,575	37,160,351	40,229,883	3,069,532	1.1
Taylor Bayou Deepening Increment (Limited Aframax, no Suezmax)					
43	6,221,632	415,536	6,924,977	6,509,441	16.7
45	7,650,006	510,936	8,648,962	8,138,026	16.9
48	10,105,361	674,927	13,184,378	12,509,451	19.5
50	12,728,699	850,137	14,520,600	13,670,463	17.1
53	16,548,523	1,105,259	14,819,063	13,713,534	13.4
55	19,051,425	1,272,425	14,819,063	13,546,638	11.6

Second Screening Net Excess Benefits

As indicated in Table IV-6, the results of the initial formulation showed that the 48- to 50-foot channel depth produced the highest net excess benefits. While additional commodities, specifically aggregate, grain, chemicals, and LNG, were not included in the initial formulation, it was anticipated, based on analyses conducted for other studies, that inclusion of these additional groups would push the formulation closer to 48 feet rather than 50 feet. Consideration of LNG came later in the plan formulation process after the Federal Energy Regulatory Commission (FERC) approval and construction commencement. However, its inclusion also had the effect of pushing the depth optimization below 50 feet.

Consideration of relatively flat net excess benefits between the 48- and 50-foot depth, as well as the anticipated effects on the formulation from additional commodities as discussed above, and the Sponsor's interest in minimizing the construction costs suggested that the focus of the detailed formulation should be on depths between 45 and 50 feet. The NED plan is the plan that reasonably maximizes net NED benefits. This second screening analyses indicated that the 48-foot depth had the highest net excess benefits and would be the probable NED depth. More-detailed analysis was conducted to confirm the identification of the NED depth. Analysis of additional depths, such as 46, 47, and 49 feet, was conducted

later in the study in order to determine potential changes to NED depth optimization based on 1-foot depth increments.

Evaluation of Structural Alternatives

Deepening and Widening

Interest in the project was driven by two factors: (1) allow the existing fleet to carry additional cargo, and (2) reduce congestion and associated risk along the waterway. For a given volume of traffic, channel deepening results in fewer trips and reduces congestion. With this in mind, the optimization initially focused on depth and then looked for widening options. Determination of channel width alternatives was driven by pilot input and followed up with the ERDC vessel (ship) simulation modeling. During the screening, channel widening was evaluated for all of the channel reaches from Sabine Pass Channel, inland through the Neches River Channel. With the exception of the Entrance Channel reaches, widening alternatives were limited because of physical structures, including docks on the Neches River and Sabine-Neches Canal reaches and the Port Arthur Hurricane Protection Levee in the Sabine-Neches Canal reach. The widening alternatives were subsequently screened based on comparison of associated vessel delay costs and initial project construction cost estimates.

The ERDC model results, transportation cost outputs, project construction costs, and anticipated environmental effects helped in identifying the optimal choice of plans. The results of the ERDC ship simulation showed that a channel width of 700 feet through the Sabine Pass Channel and Port Arthur Canal would be necessary for the Suezmax and Aframax vessels to meet smaller vessels in these channel reaches. The project design vessel is 899 feet long and 164 feet wide. These dimensions correspond to a 158,000 DWT Suezmax crude petroleum tanker. A loaded and a ballast design vessel could not successfully meet in the ERDC test of the 600-foot channel, nor could the design vessel and a smaller 110,000 DWT tanker meet.

As noted, the ERDC ship simulation showed that a width of 700 feet was necessary for the largest combinations of vessels. While the results of the ERDC ship simulation modeling showed that a minimum width of 700 feet was necessary for inbound and outbound vessel meeting for many vessels in the existing and future fleet, economic analysis of alternative widths was also included as part of the HarborSym economic widening model. Preliminary estimates of the widening benefits were calculated during the preliminary screening; however, a width optimization analysis was not performed until the second screening.

Numerous widening scenarios were evaluated in the various alternatives in the second screening. Narrowing of the entrance channel from the existing 800-foot width to a 700-foot width was investigated in the phase for cost reduction purposes. The Ship Simulation studies verified that these channels could be narrowed from 800 to 700 feet, with the exception of the Sabine Pass Outer Bar Channel where the 800-foot width was necessary because of crosscurrents in that area. Based on the analysis, the Sabine Outer Bar Channel would maintain the existing 800-foot width. For the Sabine Bank Channel and Extension, the channel would taper down to a 700-foot width after the first ½ mile. The Sabine Pass Jetty Channel

would transition from 800-foot to 500-foot width going upstream through the jetties. No impacts to the existing jetties would occur as a result of the modifications. The Sabine Pass Channel and the Port Arthur Canal would remain 500 feet wide with the Sabine-Neches Canal remaining 400 feet wide. The Neches River Channel would maintain the 400-foot width with new and existing TBs/AB. Pilots expressed concern that widening the Neches River Channel would prove too costly and would raise numerous environmental issues that would prevent completion of the widening project. They preferred the use of TBs and AB to help traffic efficiency. Ship simulation confirmed that no widening was necessary and TBs and AB were acceptable navigation modifications to improve navigation efficiency.

Turning Basins and Anchorage Basins

As an additional structural alternative, modifications to existing TBs and AB or creation of new TBs and/or AB along the waterway were considered, coordinated with the SPA, and modeled by the ERDC. The proposed Neches River TB anchorages were identified as a less costly alternative to channel widening. The anchorages would be used to facilitate vessel passing. Preliminary estimates of the TB and AB benefits were not calculated during the preliminary screening but later in the study process.

Barge Lanes

Another structural alternative evaluated was the construction of a barge shelf in a portion of the Sabine-Neches Canal. Interest in the barge shelf was prompted by the large volume of tow-barges using the Sabine-Neches Canal reach, along with a high flow of deep-draft traffic. The mix of deep- and shallow-draft traffic in this reach raised safety concerns and prompted interest in evaluation of a barge shelf through the canal reach between the east and west junctions with the GIWW. Initial responses to the barge shelf alternative revealed large variances in expectations about potential effects, with some tow operators questioning the usefulness and safety of the proposed project feature. For these reasons, in 2005 the Gulf Intracoastal Canal Association (GICA) withdrew their support for the barge shelf. The GICA is an organization created to ensure that the GIWW is maintained, operated, and improved to provide the safest, most efficient, economical, and environmentally sound water transportation route in our Nation. Part of their mission is to identify existing physical hazards and other opportunities to improve the safety and efficiency of the GIWW (GICA, 2008).

The initial indication from some of the deep-draft and shallow-draft operators was that a barge shelf could provide an increased degree of safety; however, benefits from casualty reductions were not calculated because the without-project condition is “avoidance behavior” in the form of pilot rules, radio, VTS communication, and transit delays. The indication from some vessel operators was that if a barge shelf was available, vessel operators would only use it in an emergency but that avoidance of tow-vessel and tow-tow meetings in the Sabine-Neches Canal would continue as the most likely future.

Anticipated and continued success of the VTS, as a nonstructural alternative, contributed to the vessel operators’ decision to forgo the barge shelf. Overall, improved deep-draft and barge vessel communication was initiated by the USCG and user safety board that resulted in questions concerning the need for the barge shelf. Ongoing improvements to the VTS system are expected to result in accelerated

safety and communication improvements. The VTS nonstructural initiative made by the USCG, SPA, and GICA represent alternatives to the barge shelf proposal.

Plans Eliminated During Second Screening

For evaluation of the nonstructural alternatives, the alternative mode of commodity transport (LOOP and BOOTS) and the VTS alternatives would help with improving safety along the existing channel (by reducing vessel traffic or better managing the traffic). However, these alternatives do not address the navigational efficiency of the waterway and would not allow the vessels utilizing the channel to load more fully. The potential relaxation of the current transit rules by the pilots was evaluated but screened out as not implementable because the pilots do not support this course of action. Therefore, all nonstructural alternatives were eliminated from further consideration.

The widening alternatives included widening of the Sabine Pass Channel and Port Arthur Canal from 500 to 700 feet. Although the widening in combination with the deepening of the channel was economically justified, the widening alone resulted in a BCR of 0.4. The economic summary of this channel widening is included in Table IV-7. Therefore, the widening alternative for this reach was not an incrementally justified feature and was eliminated from further evaluation.

Table IV-7
Sabine Pass Channel and Port Arthur Canal
Widening Only (700 feet)
Economic Summary Data (2008 Dollars at 4.375%)

Item	Sabine Pass and Port Arthur Canal ($)
First Cost	78,448,000
Mitigation Cost	48,484,500
Interest During Construction	36,282,311
Total First Cost	163,241,841
Average Annual Construction Cost	8,091,727
Incremental Average Annual O&M Cost	9,587,005
Total Average Annual Cost	17,678,732
Average Annual Benefits	6,379,579
BCR	0.4

As previous shown in Table IV-6, net excess benefits were relatively flat from depths of 48 to 50 feet. However, construction costs increased significantly between those depths. The results of this screening analysis indicated that NED depth was between 48 and 50 feet, with the highest net excess benefits being at the 48-foot depth. Due to cost-sharing requirements for deep-draft channels (depths greater than 45 feet) and the Sponsor's uncertainty of the preferred depth, the 45-foot depth alternative was also carried forward for further analysis. Continuous widening of the Sabine-Neches Canal and Neches River Channel to 500 feet throughout their lengths was eliminated when the ship simulation determined that a 700-foot width was necessary for safe two-way traffic.

In summary, since structural alternatives (e.g., deepening the channel) were the only alternatives that would fully address the project objective of navigational efficiency, only the No-Action Alternative and some structural alternatives for improvements to the SNWW navigation system were carried forward for detailed analysis. Among all of the structural alternatives, only six depths (45, 46, 47, 48, 49, and 50 feet) were carried forward into detailed evaluation.

IV.E FINAL SCREENING OF ALTERNATIVES

During detailed evaluation of screened alternatives, the identification of the Recommended Plan was based upon technical, economic, and environmental factors. Operation and maintenance costs for extending the entrance channel for the deeper depth alternatives were developed to better estimate project costs of each proposed depth.

Final Screened Alternatives

Based on additional information from the traffic analysis, the revised BCRs, net excess benefits, and the Sponsor's lack of support for depths greater than 50 feet, the deepening alternatives were screened to a 5-foot range from 45 to 50 feet, focusing on those depths with the highest net excess benefits. Selective widening and TBs were also carried forward for more-detailed analysis and formulation with the deepening alternatives.

This selective widening included sections in the Sabine-Neches Canal and the Neches River Channel. The Sabine-Neches Canal included realignment in the section adjacent to Port of Port Arthur to place the centerline directly in the center of the channel width. This change shifted the channel over approximately 10 feet while keeping the same bottom width. This allowed for additional berthing space in the area while avoiding impacts to the Hurricane Protection Levee and Pleasure Island properties. Additionally, bend easings were included to improve ship maneuverability and eliminate a wiggle in the alignment. The Neches River Channel was widened at the mouth of the Neches River prior to the State Highway (SH) 87 twin bridges. Additional TB/AB or enlargement of existing TB/AB on the Neches River Channel were also included in the final screening.

The structural alternatives evaluated during this final screening phase of the study are listed in Table IV-8.

Since the deepening alternatives would result in the existing project channel extending in the Gulf of Mexico (potentially an additional 17 miles), consideration of O&M costs, in addition to other detailed evaluations and analyses, was deemed necessary in conducting the further screening.

The identification of the Recommended Plan from the various alternatives was based upon economic and environmental factors. Costs were estimated for all of the alternatives and compared to the project benefits. Included in the costs were dredging, levee construction, relocations (including utility relocations), and O&M costs for the 50-year period of analysis. Costs for ecosystem mitigation were estimated using HS model salinity projections.

Table IV-8
Alternatives for Final Screening

Alternative	Depths (feet)	Sections	Width (feet)
Deepening	45, 46, 47, 48, 49, 50	Extension Channel	700
		Sabine Bank Channel	700 (tapers to 800)
		Sabine Pass Outer Bar Channel	800 (existing)
		Sabine Pass Jetty Channel	500 (existing)
		Sabine Pass Channel	500 (existing)
		Port Arthur Canal	500 (existing)
		Taylor Bayou	selective widening
		Sabine-Neches Canal	400 (existing)
		Neches River Channel	400 (existing)
Turning Basins/ Anchorage Basins (various combinations)	48	Neches River Channel	

Table IV-9 presents the economic summary of the final screening of alternatives and includes BCRs and net excess benefits for the 45- to 50-foot plans, including TBs and AB. From these data, the 49-foot depth produced the most net excess benefits compared to the cost of the proposed project modifications. Therefore, the 49-foot alternative was identified as the NED Plan. The sponsor has indicated a preference for the 48-foot project because of cost savings. Therefore, the 48-foot project is the locally preferred plan (LPP).

Table IV-9
SNWW Economic Summary Data
Cost and Benefits ($1,000s) by Channel Alternative
(50-Year Period of Analysis at 4.375%)
(December 2008 Vessel Costs)

	45 feet	46 feet	47 feet	48 feet	49 feet	50 feet
First Cost of Construction ($)	798,920	889,906	980,891	1,071,877	1,152,079	1,232,280
Total Annual Cost ($)	70,217	77,258	84,299	91,341	96,626	101,911
Average Annual Benefits ($)	83,844	95,856	104,303	115,074	122,875	127,696
Net Excess Benefits ($)	13,627	18,598	20,004	23,733	26,249	25,785
BCR	1.2	1.2	1.2	1.3	1.3	1.3

Finally, the abbreviated array of alternatives was compared against the four primary evaluation criteria specified in the P&G: acceptability, completeness, efficiency, and effectiveness (Table IV-10). To meet the first criterion, plans should be acceptable to State and Federal resource agencies and local governments; they should also be able to show evidence of broad-based public support. To be considered complete, plans must provide and account for all investments necessary to implement the plan. For the third criteria, plans must be cost effective. For the final criterion, effectiveness, the plan must make a significant contribution to addressing the specific planning objectives addressed by the study.

Table IV-10
Comparison of P&G Evaluation Criteria

Item	No Action	45 feet	NED – 49 feet	LPP – 48 feet
Criteria	Maintain existing 40-foot-deep x 800-foot-wide x 22-mile-long Sabine Bank and Outer Bar channels, transitioning to 500 feet wide in the Sabine Pass Jetty Channel, and 400-foot x 40-foot-deep channel to Beaumont	45-foot-deep x 8.45-foot-deep x 8.3-mile-long x 800-foot-wide Extension, Sabine Bank, and Outer Bar channels, transitioning to 500-foot-wide channel to end of Port Arthur Canal, and 400-foot x 45-foot-deep channel to Beaumont; deepening and widening of Taylor Bayou Channels and Basins	4- foot-deep x 16.5-mile-long x 800-foot-wide Extension, Sabine Bank, and Outer Bar channels, transitioning to 500-foot-wide channel to end of Port Arthur Canal, and 400-foot x 49-foot-deep channel to Beaumont; deepening and widening of Taylor Bayou Channels and Basins	48-foot-deep x 13.2-mile-long x 700-foot-wide Extension and Sabine Bank channels, 800-foot-wide Outer Bar Channel, then 500-foot-wide channel to end of Port Arthur Canal, and 400-foot x 48-foot-deep channel to Beaumont; deepening and widening of Taylor Bayou Channels and Basins
Acceptability (meets all laws, regulations and guidance)	Acceptable	Acceptable	Acceptable	Acceptable
Completeness (provides and accounts for all necessary investments or other actions to ensure the realization of the planning objectives)	No Action is an incomplete solution to all planning objectives	Plan is an incomplete solution; it provides some improvement in navigation efficiency over No Action but does not maximize transportation benefits	Plan is a complete solution; it maximizes navigation efficiency over other plans; no impacts to bridges and Hurricane Flood Protection (HFP) Plan	Plan is more complete than others, but does not maximize transportation benefits, no impacts to bridges and HFP Plan
Efficiency (extent to which an alternative plan is the most cost effective means of achieving the objectives)	No Action does not address the planning objectives	Less costly than Recommended Plan but does not address objectives as effectively; net excess benefits are not maximized	More costly than Recommended Plan; achieves all objectives; net excess benefits are maximized	Cost-effective; achieves all objectives; net excess benefits are not maximized; Sponsor indicated this plan is LPP
Effectiveness (extent to which the alternative plans contribute to achieve the planning objectives)	Ineffective for improving navigational efficiencies	Not as effective as Recommended Plan for improving navigation efficiency or maintaining environmental quality	Most effective plan for improving navigation efficiency and maintaining environmental quality; Sponsor has indicated this plan is not affordable	Not as effective as NED Plan for improving navigation efficiency; Sponsor has indicated this plan is LPP

IV.F IDENTIFICATION OF THE RECOMMENDED PLAN

The detailed evaluation of screened alternatives concluded with the identification of a Recommended Plan. The identification of the Recommended Plan was based upon a comparison of economic, engineering, environmental, and socioeconomic factors, as well as the Sponsor's preference. The alternative described below has been identified as the Recommended Plan:

> *Deepening of the SNWW to Beaumont to 48 feet with an extension of the Entrance Channel 13.2 miles in length, deepening and widening of Taylor Bayou Channel and turning basins, and tapering the Sabine Bank Channel from 800 feet wide (Station 23+300) to 500 feet wide (Station 25+800 through the end of Sabine Bank Channel). Turning and anchorage basins would be added and/or enlarged along the Neches River Channel and bend easing performed on the Sabine-Neches Canal and Neches River Channel.*

Detailed evaluations of alternatives for the management of dredged material and the mitigation of ecological impacts were then performed for the Recommended Plan. This evaluation concluded with the development of a DMMP and a mitigation plan. The DMMP includes measures in which dredged material is used to restore wetland habitat, offsetting impacts of the Recommended Plan. The evaluation of alternatives for the management of dredged material and the recommended placement plan are described in Chapter VII of this report and in Section 2.5 of the FEIS. The evaluation of mitigation alternatives that compensate for remaining unavoidable impacts to significant habitats and resources and the recommended mitigation plan are described in Chapter 5 of the FEIS. Least cost analyses of dredged material placement and an incremental cost analysis of mitigation alternatives were conducted to select recommended placement and mitigation measures. These analyses are presented in Chapter VIII of this report.

IV.G PRINCIPLES AND GUIDELINES EVALUATION ACCOUNTS

The four P&G evaluation accounts were used throughout the planning process to evaluate the effects of the project alternatives. Each of the four accounts is identified below as well as an explanation of how the Recommended Plan complies with these evaluation accounts.

National Economic Development

The NED account shows the changes in the economic value of the national output of goods and services. The main economic benefit from a navigation project is the reduction in the value of the resources required to transport the various commodities associated with the waterway. National benefits can result from any of the following: increased efficiency of moving commodities resulting in cost reductions in commodities, savings from using a more-cost-effective mode of transportation (alternate mode of transportation), a shift in origin and destination of commodities thereby reducing the costs of transport, new

movements of commodities, and/or commodities delivered either at less cost or additional commodities being transported due to lower transportation costs.

The Recommended Plan is the culmination of the various benefit analyses mentioned above. The 49-foot depth including TBs and AB was found to produce the most net excess benefits compared to the cost of the proposed project modifications. Therefore, the 49-foot alternative was identified as the NED Plan. However, the Sponsor has indicated that the 48-foot plan is preferred because the cost of the NED and deeper plans would make the project unaffordable. The 48-foot plan is the LPP, the plan preferred by the sponsor.

The USACE guidance requires that the NED plan be recommended unless there are believed to be overriding reasons favoring the selection of another alternative. Planning guidance (ER 1105-2-100) states that if the non-Federal sponsor identifies a financial constraint due to limited resources, and if net benefits are increasing as the constraint is reached, a categorical exemption may be granted and the constrained plan recommended. Categorical exemptions for plans that are lesser projects than the NED plan are cost shared on the same basis as the NED and become a federally supportable plan.

In this study's selection of the Recommended Plan, the sponsor has indicated a preference of the 48-foot LPP due to cost restraints. This plan is a justified plan that is less costly that the NED plan. This LPP still meets the policies for the high-priority outputs and has greater benefits than the smaller scale plans (see Table IV-9). Since the 48-foot plan is the Sponsor's preference due to financial constraints and fits all of the criteria regarding categorical exemptions for navigation projects, this plan has been identified as the Recommended Plan. This LPP is less costly than the NED plan; therefore, cost sharing will be the same as the NED plan.

Effects on Environmental Quality

The Environmental Quality account identifies the nonmonetary effects on significant natural and cultural resources (ER 1105-2-100). The primary impact of the Recommended Plan is an indirect impact associated with an increase in salinity intrusion and an associated reduction in biological productivity over 182,000 acres of intertidal marsh and swamps within the area of tidal influence in the Sabine-Neches study area. As quantified by the WVA model, the net decrease in productivity for the project as a whole is –843 average annualized habitat units, or AAHUs, after application of benefits from the Recommended Plan. Later in this report, Table VIII-2 summarizes the calculations made resulting in these –843 AAHUs. Minor impacts to cypress-tupelo swamp or bottomland hardwood productivity are projected. The ICT considered this to be acceptable since the loss in function is negligible. No adverse impacts to threatened or endangered species or Critical Habitat would result from the indirect effects of salinity increases or land losses.

Most of the direct effects of the Recommended Plan on ecological systems and resources are minor and temporary. These impacts are associated with navigation channel improvements and the placement of dredged material. They include (1) impacts to benthic organisms and their Gulf, estuarine, and riverine

water-bottom habitats resulting from dredging to construct the navigation improvements, offshore PAs, borrow areas for mitigation measures, and marsh restoration in shallow, open-water areas; (2) potential dredging impacts to bottom-feeding and pelagic organisms such as sea turtles; and (3) impacts to shoreline birds and their habitat from the placement of maintenance material on the Gulf shoreline.

The Recommended Plan would have no long-term adverse environmental effects, after benefits of the DMMP and compensatory mitigation are taken into account. The Recommended Plan is expected to produce beneficial effects that would contribute to the long-term sustainability of valuable habitat in the SNWW area as described below. A detailed discussion of the effects of the Recommended Plan and the mitigation plan are presented in the FEIS.

BU features of the DMMP (Neches River and Gulf Shore BU Features) would minimize and offset all direct and indirect marsh impacts in Texas by creating 2,853 acres of emergent marsh vegetation, improving 871 acres of open water habitat, and nourishing 1,234 acres of existing marsh in Texas. Benefits of the Neches River BU Feature also more than offset the direct impact of conversion of 86 acres of fresh marsh to a confined PA (PA 24A) and the indirect impact of the increase in salinity over 39,000 wetland acres in Texas. The Gulf Shore BU Feature offsets minor erosion impacts by periodically nourishing 6 miles of Texas and Louisiana Gulf shorelines.

Since the DMMP offsets all impacts of the Recommended Plan in Texas, no compensating mitigation would be required for Recommended Plan effects in this state. It is important to note that the impacts presented here do not include all impacts of the Preferred Alternative in Texas as future with project (FWP) impacts in Texas's Salt Bayou (TX 9) hydro-unit are not included. Jefferson County, Texas, and USACE, with support from the Texas Parks and Wildlife Department (TPWD), GLO, and Texas Water Development Board (TWDB), have been studying ways to reduce the amount of saltwater intrusion, decrease high-energy inflows, and minimize impacts to larval fish access in an on-going Section 1135 Continuing Authorities Project (CAP) study for the Salt Bayou hydrologic unit. When the Keith Lake Section 1135 CAP study was begun in 2003, it seemed likely that the CAP study and construction would be completed before the SNWW CIP could be authorized and constructed. The Keith Lake Section 1135 study was therefore considered separable from the SNWW CIP, and for planning purposes, it was assumed that a water control structure at the Fish Pass would be part of the future without-project condition for the SNWW CIP. Incremental impacts of the SNWW CIP will be calculated for the Salt Bayou unit of the SNWW study area when WVA modeling is completed for the Keith Lake Section 1135 study. It is possible that the excess DMMP benefits (316 AAHUs) of the SNWW CIP will cover all incremental project impacts. However, if it is determined that additional mitigation is needed, then USACE and the non-Federal sponsor of the SNWW CIP will initiate consultation with resource agencies, identify and incrementally justify additional compensatory mitigation for the Salt Bayou unit, and prepare a supplemental environmental impact statement (EIS).

Unavoidable losses to marshes in Louisiana, which remain after application of all DMMP benefits, are fully mitigated by marsh creation in the Willow Bayou and Black Bayou watersheds east of Sabine Lake.

Potential adverse effects to threatened and endangered sea turtles from the use of hopper dredges to construct the Entrance Channel in the Gulf of Mexico would be avoided by the adoption of reasonable and prudent measures recommended by the USFWS Biological Opinion. No long-term impacts to air quality or noise levels are expected, and temporary impacts to air quality during construction have been determined to be in general conformity with the Texas State Implementation Plan. No impacts to historic properties have been identified at this time. However, should adverse effects to historic properties be identified in the future, mitigation plans would be developed and implemented in accordance with the Historic Properties Programmatic Agreement for the Treatment of Historic Properties (FEIS, Appendix H).

DMMP BU features on the Neches River and compensatory mitigation east of Sabine Lake are expected to have long-term beneficial effects on water quality and terrestrial and aquatic habitats. Both entail the restoration of large-scale areas of degraded marsh. Restored marshes would filter runoff from surrounding uplands, and improved shallow-water habitat would encourage the growth of additional submerged aquatic vegetation. The restored marshes would increase available habitat for bird and wildlife species, and the improved shallow-water habitat would provide additional nursery areas and nutrients for aquatic organisms. Gulf shore nourishment is expected to have a long-term beneficial effect on piping plover Critical Habitat at Louisiana Point, by replacing shoreline habitat predicted to be lost as a result of plan implementation.

Regional Economic Development (RED)

The RED account identifies changes in the distribution of regional economic activity. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output, and population (ER 1105-2-100). With the value of the current 40-foot SNWW channel to the region, it is expected that the Recommended Plan of deepening the channel for navigational efficiency and safety would increase benefits to the region. Even with the implementation of the Recommended Plan, the study area would continue to have large industrial facilities and would not result in negative impacts to the local economy. During project construction, the study area may have a slight increase in construction employment and local purchases of construction materials but would be temporary, if any change at all. The primary economic bases of the study area include petrochemical processing, construction, mineral extraction, tourism, commercial fishing, and agriculture. As a result of the Recommended Plan, the positive economic effects to the study area would be moderate at the least and substantial at best. A detailed overview of RED is included in the Economic Appendix.

Other Social Effects

The other social effects account identifies the plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts (ER 1105-2-100). The Recommended Plan would likely not have an effect on population growth trends within the study area. As a result of the Recommended Plan, demand for community facilities, services, and housing would not increase in the study area. The population living within the study area is primarily composed of White persons (59.6 percent), followed by Black or African American persons (26.7 percent), and Hispanic or Latino

persons (9.6 percent). The proposed project would not be located within a minority area. The minority and low-income populations living within the study area would likely experience no adverse changes to the demographic, economic, or community cohesion characteristics within their respective neighborhoods as a result of the Recommended Plan.

The construction of the Recommended Plan would have minimal negative effects on recreation within the study area, and proposed BU of dredged material from the construction of the Recommended Plan are expected to have beneficial impacts to recreational activities by providing additional habitats important to current sportfishing, recreational fishing, wildlife watching, and hunting.

V. ECONOMIC EVALUATION OF ALTERNATIVES

V.A OVERVIEW

This chapter presents the economic analysis for proposed project modifications to the existing 40-foot SNWW channel. The project benefits were evaluated for deepening and widening the channels to Port Arthur and Beaumont and are based on reductions in transportation costs generated from more-efficient vessel loading and from reductions in vessel delays. Improvements to the 30-foot Sabine River Channel to Orange were not evaluated at this time due to the expectation of continued low utilization of the existing project depth.

V.B SCREENING PROCESS

Deepening benefits were calculated for SNWW depth alternatives of 45, 46, 47, 48, 49, and 50 feet. Determination of the depths evaluated was based on the cost-benefit results of the alternative screening and input from the Sponsor. Widening benefits for deep-draft traffic were also evaluated. Evaluation of widening alternatives was based on data obtained from vessel simulation modeling conducted by the ERDC. The alternatives were subsequently screened based on comparison of associated vessel delay costs and the initial project construction cost estimates. The ERDC model results, transportation cost outputs, project construction costs, and anticipated environmental effects identified the optimal choice of plans. Benefits were calculated for incremental widening and for holding area alternatives and are based on comparison of transit times between project alternatives. The calculations were made using the HarborSym economic traffic model.

Total Tonnage

The SNWW experienced strong growth over the past decade, with total tonnage increasing from an average of 108 million short tons for 1995–1997 to 138 million for 2005–2007. In 2007, the SNWW ranked 4th in the U.S. in terms of total tonnage. As individual ports, Beaumont ranked 5th with 81.4 million short tons. Port Arthur's 2007 tonnage totaled 29.3 million short tons with a ranking of 28th. Channel to Orange tonnage totaled 682,000 in 2007. Table V-1 presents SNWW 1970–2007 total tonnage and principal deep-draft movements. Approximately 60 percent of the SNWW tonnage total consists of deep-draft movements. The remaining 40 percent consists of shallow-draft GIWW-related traffic. Table V-2 displays Sabine-Neches Canal 1970–2007 shallow-draft GIWW tonnage and the relative percentage of shallow-draft to total tonnage. For 2007, nearly 30 million short tons of the 59.7 million shallow-draft total (Table V-2) were transported through SNWW facilities. Beaumont's shallow-draft barge tonnage totaled 21.2 million short tons with Port Arthur's 8.3 million, Orange's 0.7 million, and Sabine Pass 0.9 million. The remaining 30.3 million short tons of 2007 shallow-draft barge traffic consisted of "through movements" between the Lower Mississippi River and Houston and points westward. In reviewing trends for commodities presently or anticipated to be constrained, the initial focus was on the commodity groups displayed in Table V-1.

Table V-1
SNWW Total Tonnage and Major Commodity Tonnage
(1,000s of Short Tons)

Year	Total Tonnage	Total Deep-Draft Tonnage*	Principal Deep-Draft Commodities						
			Crude Petroleum		Petroleum Products		Chemical Products		Bulk Grain Exports
			Imports	Coastwise	Imports	Exports	Imports	Exports	
1970	79,291	35,696	9	9,217	280	827	72	336	1,786
1975	79,296	41,134	13,820	3,102	177	256	42	310	2,926
1980	108,124	52,560	28,640	3,082	715	2,359	648	634	1,843
1985	70,239	39,169	22,627	1,835	2,516	1,514	267	707	1,642
1990	90,819	36,175	20,348	2,921	2,198	1,635	34	546	2,090
1993	95,418	46,990	32,639	81	2,656	3,260	25	537	3,471
1994	99,675	49,775	37,226	225	1,859	3,092	49	577	2,303
1995	103,254	52,959	38,743	187	1,304	4,258	33	725	1,712
1996	103,262	54,863	40,930	971	1,473	3,930	48	777	1,038
1997	116,012	67,553	51,142	81	2,470	4,595	33	1,101	1,370
1998	115,935	70,351	53,877	38	3,491	4,329	140	966	910
1999	114,393	69,259	53,834	86	3,627	3,307	449	753	936
2000	126,285	83,385	67,187	149	3,051	4,043	619	1,469	894
2001	128,944	80,950	64,226	127	2,734	5,120	754	1,296	858
2002	135,088	87,081	66,383	133	5,028	5,635	683	1,587	835
2003	143,923	92,563	70,158	195	5,187	6,573	434	1,555	1,125
2004	150,297	94,823	69,875	134	6,002	7,152	656	2,104	1,329
2005	134,695	82,925	59,691	165	5,349	6,354	1,084	1,891	1,081
2006	138,065	81,640	57,616	139	3,819	6,823	1,244	2,904	1,214
2007	140,967	81,282	56,088	217	3,744	6,608	955	3,169	1,632

Source: USACE, *Waterborne Commerce of the U.S., Part 2*, 1970–2007 (USACE, 2007a).
*Includes commodities in addition to what is shown.

Table V-2
SNWW Shallow-Draft Port and GIWW Through Tonnage,
Deep-Draft Total Tonnage, and Shallow-Draft Percentage of Total Tonnage
(1,000s of short tons)*

Year	Shallow-Draft Port Tonnage and GIWW Through Tonnage	Deep-Draft Tonnage	SNWW Total	Shallow-Draft Percent of Total Tonnage (%)
1970	43,595	35,696	79,291	55
1975	38,162	41,134	79,296	48
1980	55,564	52,560	108,124	51
1985	31,070	39,169	70,239	44
1990	54,644	36,175	90,819	60
1995	50,295	52,959	103,254	49
1996	48,399	54,863	103,262	47
1997	48,459	67,553	116,012	42
1998	45,584	70,351	115,935	39
1999	45,134	69,259	114,393	39
2000	42,900	83,385	126,285	34
2001	47,902	81,998	128,944	37
2002	48,007	87,081	135,088	36
2003	51,360	92,563	143,923	36
2004	55,474	94,823	150,297	37
2005	51,770	82,925	134,695	38
2006	56,646	81,421	138,067	41
2007	59,685	81,282	140,967	42

Source: USACE, *Waterborne Commerce of the U.S., Part 2*, 1970–2007 (USACE, 2007a).
*Includes intraport movements.

Crude Petroleum

SNWW's 2002–2006 crude petroleum waterborne imports comprised 12 percent of U.S. and 18 percent of Petroleum Administration Defense District (PADD III) imports. The SNWW is contained in the U.S. Gulf Coast (PADD III), which includes the states of Texas, Louisiana, Arkansas, Mississippi, Alabama, and New Mexico. The U.S. Gulf Coast leads the Nation in refinery capacity, with 41 percent of the Nation's crude oil distillation capacity, and one-half of the Gulf Coast refinery capacity is in Texas and the remainder is in Louisiana. The Gulf Coast is also the Nation's leading supplier of refined products. Table V-3 displays SNWW 1985–2007 crude petroleum imports and its share of the national and regional totals.

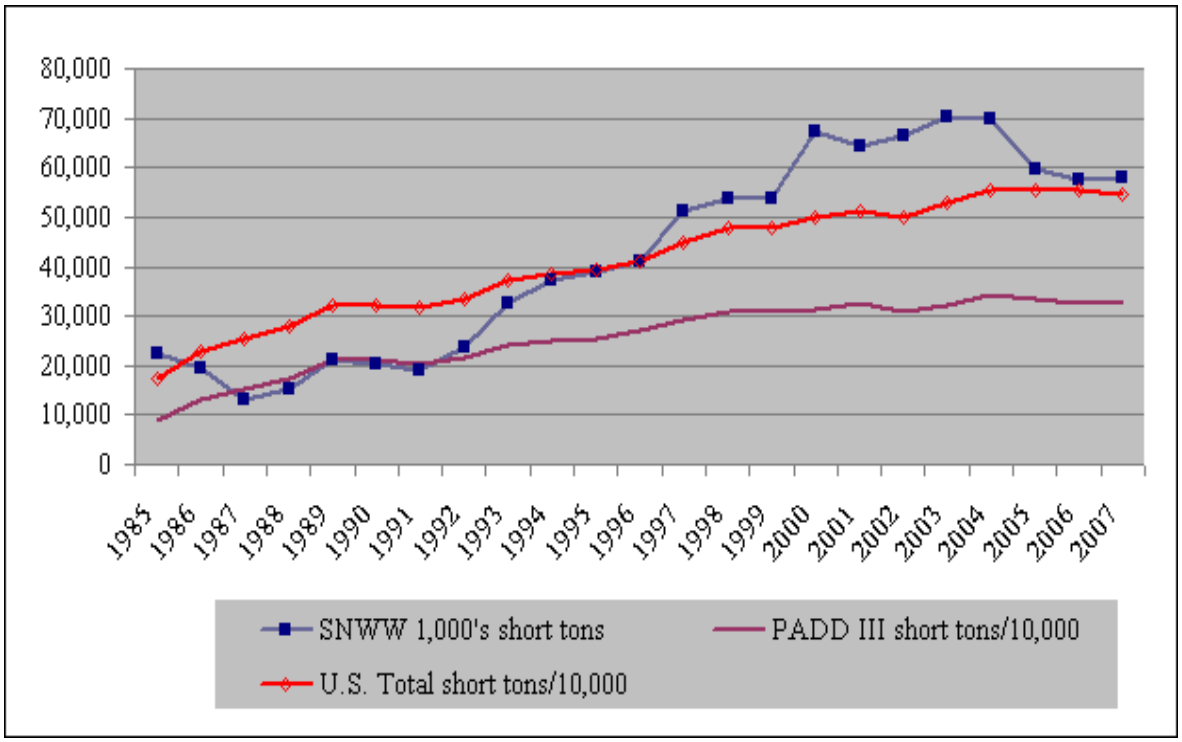
Table V-3
Comparison of SNWW and Regional and
National Totals, Crude Petroleum Imports
(1,000s of short tons)

Year	SNWW Imports	PADD III Imports	U.S. Total Imports	SNWW Percentage of PADD III	SNWW Percentage of U.S. Total
1985	22,627	90,372	175,095	25.0	12.9
1986	19,576	133,107	228,552	14.7	8.6
1987	13,119	153,901	255,670	8.5	5.1
1988	15,173	172,256	280,112	8.8	5.4
1989	21,224	209,622	319,641	10.1	6.6
1990	20,348	212,613	322,433	9.6	6.3
1991	19,245	203,992	316,310	9.4	6.1
1992	23,613	216,745	333,666	10.9	7.1
1993	32,639	241,614	371,267	13.5	8.8
1994	37,226	251,394	386,381	14.8	9.6
1995	38,743	253,200	395,484	15.3	9.8
1996	40,930	272,769	411,824	15.0	9.9
1997	51,142	292,282	449,961	17.5	11.4
1998	53,877	309,147	476,231	17.4	11.3
1999	53,834	308,707	477,592	17.4	11.3
2000	67,187	312,288	497,547	21.5	13.5
2001	64,226	324,094	510,298	19.8	12.6
2002	66,383	310,218	499,999	21.4	13.3
2003	70,158	323,123	528,703	21.7	13.3
2004	69,875	342,238	553,337	20.4	12.7
2005	59,691	335,075	553,923	17.8	10.8
2006	57,615	327,715	553,489	17.6	10.4
2007	56,078	305,732	548,742	18.3	10.2

Source: USACE (2007a) and Energy Information Administration (EIA, 2008). The U.S., PADD III, and SNWW percentages were compiled from EIA 2008.

Although SNWW tonnage exhibits more variance than the region and the Nation, short-term expectations are that SNWW imports would grow at rates comparable to or higher than regional and national trends. Long-term expectations are that SNWW imports would grow at rates comparable to the regional and national trends. These expectations are based on analysis of long-term historical trends and the study area's established infrastructure of regional and national pipeline distribution links. While SNWW 2005–2007 import volumes are down, Figure V-1 shows that SNWW imports from 1992 through 2007 grew at higher rates than the region or the Nation. In comparison to other Texas Gulf Coast ports, SNWW 2000–2007 crude petroleum imports volumes exceeded other ports by nearly 35 percent. Additionally, recent increases in SNWW refinery capacity indicate the region would regain an increasing share of U.S. and PADD III totals.

Figure V-1
U.S. and Sabine-Neches Crude Oil Imports, 1980–2007



SNWW refinery capacity presently represents 6 percent of the U.S. total. Specific capacities are 572,000 barrels per calendar day for Port Arthur and 577,000 for Beaumont (Table V-4). SNWW capacity levels for 2009 are presently 12 percent higher than in 2004, and 31 percent higher than in 1994. In December 2007, Motiva announced plans for a 325,000-barrel-per-day refinery expansion in Port Arthur. The expansion would increase the refinery's crude oil throughput capacity to 600,000 barrels per day, making it the largest refinery in the U.S. and one of the largest in the world. The ExxonMobil Beaumont refinery is presently the third largest refinery in the world. As a result of these additions, SNWW's combined capacity would represent the largest concentration in the State of Texas

The SNWW terminals transport 400,000 barrels per day of waterborne crude oil via pipelines to inland refineries including refineries in Texas, Louisiana, Oklahoma, Ohio, Arkansas, and Kentucky (Martin Associates, 2006). Colonial Pipeline delivers over two million barrels per day of refined products via pipeline serving Louisiana, Alabama, Mississippi, Georgia, Tennessee, South Carolina, North Carolina, Virginia, Maryland, Delaware, and New Jersey. Explorer Pipeline delivers 650,000 barrels per day of refined products via pipeline serving Texas, Oklahoma, Missouri, Illinois, and Indiana. Products, such as gasoline, heating oil, diesel, and jet fuel, are transported from the Gulf Coast to the East Coast and the Midwest through existing pipeline networks. Product traffic also moves between U.S. ports by coastwise tankers and inland waterway barges. The SNWW refineries supply 15 percent of the product on Colonial's system and 13 percent of the product on Explorer's system.

Table V-4
SNWW Atmospheric Crude Oil Distillation Capacity
(1,000s of Barrels per Calendar Day)

Period	Beaumont	Port Arthur	Percent of Texas	Percent of U.S.	U.S. Total
1994	420.5	454.0	19.6	5.8	15,034
1999	438.5	513.5	22.7	5.9	16,261
2000	450.0	523.0	23.0	5.9	16,512
2001	500.0	521.0	23.8	6.2	16,595
2002	500.0	527.0	22.9	6.1	16,785
2003	510.0	523.6	23.8	6.1	16,757
2004	505.0	523.6	22.9	6.1	16,974
2005	540.0	582.0	24.2	6.5	17,196
2006	545.0	580.5	24.0	6.5	17,383
2007	545.0	590.5	24.0	6.5	17,436
2008	574.0	576.5	24.0	6.5	17,436
2009	572.0	576.5	24.0	6.5	17,436

Source: USACE (2007a) and EIA (2008).
*Variations occur in annual volumes due to temporary shutdowns and routine maintenance

Port Arthur and Beaumont Tonnage Bases

Distributions of Port Arthur's and Beaumont's 1999–2007 deep-draft tonnages are displayed in tables V-5 and V-6. Port specific data for years prior to 1999 are not included in these tables due to Navigation Data Center (NDC) reporting problems which resulted in a portion of Beaumont tonnage being attributed to Port Arthur. Crude petroleum imports and petroleum and chemical product imports and exports comprised 80 percent of Port Arthur's 2007 total oceangoing tonnage. The 1999–2007 average was 83 percent. The remaining percent of tonnage consisted of imports of crude material and manufactured goods and domestic coastwise shipment of gasoline and chemical shipments.

As shown in Table V-5, Port Arthur's highest growth rates were for product exports and domestic coastwise. Analysis of the commodity-specific data showed that 81 percent of Port Arthur's 2005–2007 petroleum product exports were comprised of petroleum coke. Port Arthur's petroleum coke exports make up 11 percent of the U.S. total.[1] Plans for a new 45,000 barrels-per-day "delayed coker" in Port Arthur were announced in February 2008, with construction anticipated to be complete by 2011 (*Port Arthur News*, 2008). Delayed cokers are used to convert residual oils into gasoline and diesel oil. Delayed coker feed originates from the crude oil, and the effect of new construction would be used to produce residual fuel and other products. Demand for petroleum coke has been noted to be increasing due to growing use of heavy crude oil.

[1] EIA website data shows Port Arthur's 2007 annual petroleum coke imports exceeding 250,000 short tons.

Table V-5
Port Arthur Total Tonnage and Major Commodity Tonnage, 1999–2007
(1,000s of short tons)

Year	Total	Total Deep-Draft	Total Coastwise	Crude Petroleum Imports	Petroleum Products		Chemical Products		Crude Materials Except Fuels		Primary Manufactured Goods		Major Group Total	% of Deep-Draft
					Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports		
1999	18,308	12,073	659	7,977	604	1,136	5	349	566	21	617	107	12,041	100
2000	21,387	13,730	817	8,862	1,121	1,502	0	307	206	7	743	107	13,672	100
2001	22,802	16,173	1,043	11,064	641	2,327	25	136	131	0	665	101	16,133	100
2002	22,676	16,640	1,422	9,013	997	3,143	89	176	919	2	641	194	16,596	100
2003	27,170	21,044	2,577	11,987	1,152	3,734	60	210	481	20	557	128	20,906	99
2004	27,570	20,758	1,804	10,015	2,150	4,255	225	889	531	41	564	106	20,580	99
2005	26,385	19,856	1,803	9,320	2,205	3,858	194	998	558	14	710	84	19,744	99
2006	28,403	21,209	2,323	10,627	1,144	4,391	111	1,330	566	54	542	46	21,134	100
2007	29,067	20,977	3,330	10,334	792	3,978	97	1,525	513	64	122	35	20,790	99
Average Annual Growth Rate (1999–2007)														
	5.9%	7.1%	22.4%	3.3%	3.4%	17.0%	44.9%	20.2%	–1.2%	14.9%	–18.3%	–13.0%	7.1%	–0.1%

Source: USACE (2007a).

Table V-6
Beaumont Total Tonnage and Major Commodity Tonnage, 1999–2007
(1,000s of short tons)

Year	Total Tonnage	Deep-Draft	Coastwise	Crude Petroleum Imports	Petroleum Products Imports	Petroleum Products Exports	Chemical Products Imports	Chemical Products Exports	Crude Materials, Except Fuels Imports	Crude Materials, Except Fuels Exports	Primary Manufactured Goods Imports	Primary Manufactured Goods Exports	Grain Exports	Major Group Total	% of Deep Draft
1999	69,406	57,186	3,330	45,857	3,023	2,170	444	404	115	446	281	8	936	57,014	100
2000	76,894	69,655	3,046	58,325	1,930	2,541	619	1,162	413	410	133	1	894	69,474	100
2001	79,131	64,777	2,793	53,162	2,093	2,793	729	1,160	622	165	103	6	858	64,484	100
2002	85,911	70,441	2,712	57,370	4,031	2,492	594	1,411	394	14	204	14	835	70,071	99
2003	87,541	71,519	2,732	58,171	4,035	2,839	374	1,345	583	73	115	36	1,125	71,428	100
2004	91,968	74,065	3,191	59,860	3,852	2,897	431	1,215	559	104	420	1	1,329	73,859	100
2005	78,887	63,069	2,967	50,371	3,144	2,496	890	893	624	106	471	12	1,082	63,056	100
2006	79,486	60,431	3,115	46,988	2,676	2,432	1,133	1,574	550	243	364	8	1,214	60,296	100
2007	80,062	60,305	3,261	45,776	2,952	2,713	858	1,644	617	421	173	86	1,632	60,133	100
Average Annual Growth Rate (1998–2007)															
	1.8%	0.7%	–0.3%	0.0%	–0.3%	2.8%	8.6%	19.2%	23.4%	–0.7%	–5.9%	34.5%	7.2%	0.7%	0.0%

Source: USACE (2007a).

Analysis of Port Arthur tonnage also shows significant increases in chemical imports and exports. Import growth is associated with ammonia and sulphuric acid. Increases in exports are associated with metallic salts and hydrocarbons. Twenty percent of 2005–2007 U.S. metallic salts export tonnage was exported from Port Arthur. Metallic salts and organic compounds are used in the production of paints and solvents, paper and wood products, cleaning products, and various chemical products, and more recently in the production of nylon in Latin America and China. The increase in Port Arthur's metallic salt exports experienced since 2004 is associated with the completion of a 266,000-metric-ton-per-year cyclohexane facility in the Taylor Bayou section of Port Arthur in early 2004. Port Arthur's steady volume of coastwise tonnage shown in Table V-5 is associated with continuing shipments of gasoline, distillate fuel oil, and petroleum coke between Port Arthur and other deep-draft U.S. ports.

Port Arthur's crude petroleum imports remained relatively flat since 2001 but steady. In 2009, Port Arthur's refinery capacity was nearly 13 percent higher than in 2004. Additionally, Motiva announced plans for a 325,000 barrels-per-day refinery expansion in Port Arthur in December 2007. Port Arthur's other commodity movements include imports of crude materials and primary manufactured goods. In 2007, crude material imports consisted of 513,000 short tons of limestone, sand, and gravel. For the most recent 10-year period, crude material volumes averaged nearly 500,000 short tons annually. In 2007, imports of primary manufactured goods were down from 1999–2006 annual volumes that exceeded 500,000. Port Arthur's crude material and primary manufacturing facilities are located on the Sabine-Neches Canal near mile 32, and its crude petroleum and product terminals are in the Taylor Bayou basin.

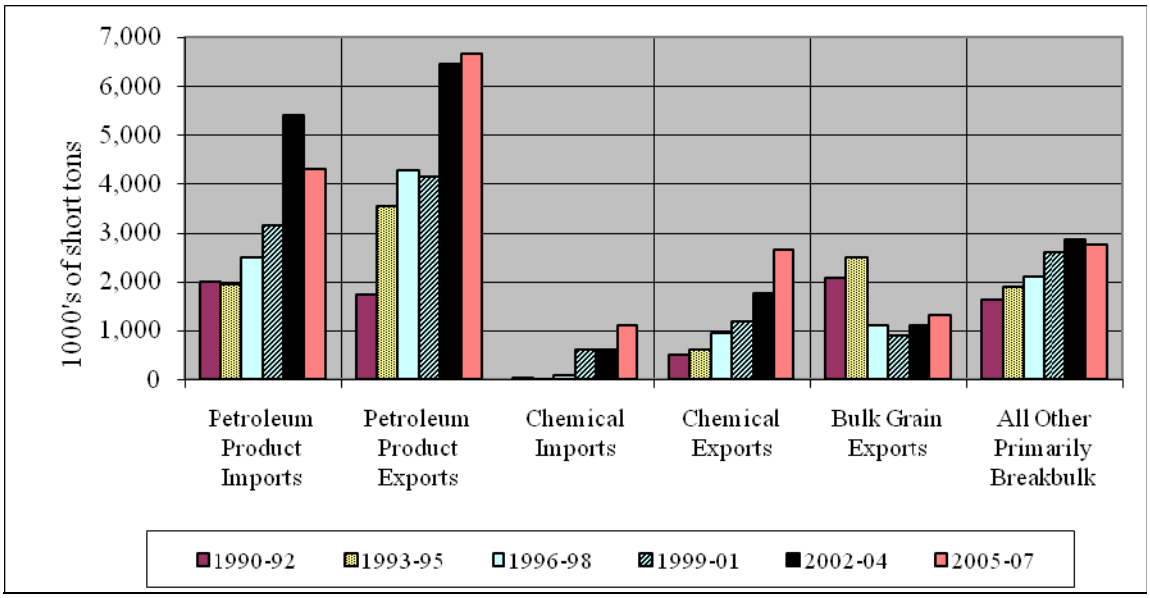
Examination of Beaumont's tonnage showed that crude petroleum imports and imports and exports of petrochemical products comprised 89 percent of Beaumont's 2007 total oceangoing tonnage. For 2005–2007, 4 percent of U.S. nitrogenous, potassic, and fertilizer mixes were exported from Beaumont. For 2005–2007, the Beaumont share of fertilizer exports increased to 12.5 percent. Beaumont's other commodity movements include grain exports, gasoline and liquid sulphur coastwise shipments, and imports and exports of crude material and manufactured goods. Beaumont's crude material imports, which include limestone, sand, and gravel, comprised 1 percent of the 2005–2007 U.S. total. Beaumont's imports of manufactured goods for 2005–2007 consisted of 336,000 short tons of iron and steel products, representing 1 percent of the U.S. total. Coastwise shipments for 2005–2007 averaged 2.4 million short tons and included 1.3 million short tons of gasoline and 720,000 short tons of chemicals. Liquid sulphur comprised 85 percent of coastwise chemical shipments. For the period 1999–2007, sulphur shipments ranged from a low of 506,000 short tons in 2004 to a high of 679,000 in 2001. In 2007, Beaumont's sulphur shipments totaled 553,000 short tons.

While crude petroleum growth dominates SNWW total tonnage, significant increases in other commodities are notable. Figure V-2 displays comparison of SNWW 1990–1992 through 2005–2007 volumes by major commodity group.[2] Petroleum and chemical product imports and exports, breakbulk

[2] Data for the years prior to 1999 are not presented for the individual ports. The Bureau of Census data contained in the *Waterborne Commerce of the United States* does not reflect correct allocation of Port Arthur and Beaumont traffic between the ports. Some of Beaumont's traffic was recorded under Port Arthur due to a Bureau of Census error. Total tonnage values were found to be correct for the SNWW, but the individual counts for years prior to 1999 were found to be unreliable.

imports and exports, and bulk grain exports are shown. Tonnage increased for all groups except grain. In spite of declines, grain exports have increased marginally since the middle 1990s, and Beaumont's 2005–2007 wheat exports represent 5 percent of total U.S. wheat exports. The U.S. Department of Agriculture (USDA) forecast shows a constant export level of 1,075 million bushels for 2014–2015 through 2018–2019, with the forecast volume down by 17 percent from the 2007/2008 high of 1,264 million bushels.

Figure V-2
SNWW Foreign Imports and Exports by Major Group (Excluding Crude Petroleum),
1990–1992 to 2005–2007 Distribution



Expansion of the Deep-Draft Traffic Historical Base

In addition to its large existing base of crude petroleum, petroleum and chemical products, and dry bulk deep-draft cargoes, the without-project future condition includes operation of three LNG terminals. LNG is expected to play an increasingly important role in the natural gas industry and global energy markets in the next several years and in the long-term future. The combination of higher natural gas prices, lower LNG costs, rising gas import demand, and the desire of gas producers to monetize their gas reserves is setting the stage for increased global LNG trade. *The Global Liquefied Natural Gas Market: Status & Outlook*, which characterizes the global LNG market, recent trends, and future prospects in the LNG market, was evaluated in relationship to national trends and anticipated market shares.

Liquefied Natural Gas Traffic

LNG will play an increasingly important role in the natural gas industry and global energy markets in the next several years. In 2007, the U.S. imported an estimated 771 billion cubic feet (Bcf) or 21.2 million short tons of LNG. Shipments to existing U.S. facilities in 2006–2008 came from Trinidad (64 percent), North Africa (22 percent), Western Africa (11 percent), Norway (2 percent), and Middle East (1 percent).

During the early 2000s, LNG permits were approved for the Sabine Pass, Golden Pass, and Port Arthur terminals. The SNWW LNG facilities are located in the Sabine Pass Channel and Port Arthur Canal reaches; these reaches are presently 500 feet and would remain so under the without-project future. LNG vessels using the SNWW would be subject to strict USCG regulations and to local pilot rules and, therefore, would not have the opportunity to meet other vessels or barges. The USCG regulations require that a safety zone is in place 2 miles ahead of a loaded LNG vessel and 1 mile astern of the vessel while transiting. LNG vessels using the SNWW would be subject to this rule. Even in the absence of the safety concerns inherent to LNG, the beams of LNG tankers would result in vessel meeting restrictions; however, all LNG vessel movements would be subject to one-way traffic. Operation of the LNG terminals is part of the without-project future condition.

Phase I of the Sabine Pass terminal, which is operated by Cheniere, is complete and the first vessels arrived in April 2008. Phase 1 consists of 10.1 Bcf of LNG storage in three tanks, each with an LNG capacity of 160,000 cubic meters, and a maximum continuous regasification rate of 2.6 billion cubic feet per day (Bcf/d). Phase 2 will be built in stages. The first stage of Phase 2 includes the addition of a fourth and fifth storage tank, additional vaporizers that would bring the maximum continuous regasification rate up to 4.0 Bcf/d with a peak sendout capacity of 4.3 Bcf/d. In the future stages of Phase 2, a sixth storage tank may be added and related facilities would bring the total LNG storage volume to 20.2 Bcf.

Construction of the Golden Pass LNG terminal is currently in progress and is scheduled for completion by 2011. The Golden Pass facility, which is being constructed by ExxonMobil and Conoco Phillips, will consists of a dock and unloading facilities, five LNG storage tanks (≈17 Bcf), and vaporization capacity of 2.7 Bcf/d. The Port Arthur project consists of two ship berths, three to six storage tanks (160,000 cubic meters), and vaporization capacity of 1.5–3 Bcf/d. The LNG for the Golden Pass terminal is anticipated to be supplied primarily from the Ras Laffan 3 and the Qatargas 3 projects in Qatar, which will produce and process natural gas from Qatar's offshore North Field.

Construction of the Port Arthur terminal has not started but is anticipated after 2012. The Port Arthur LNG terminal, constructed and operated by Sempra Energy, would be capable of delivering between 1.5 and 3 Bcf/d of natural gas. The terminal will include two unloading docks for ships and three to six full containment storage tanks and associated equipment in order to transform the LNG back to its gaseous state. As noted, construction of this third facility is planned for after 2012. At full utilization, Sabine Pass and Golden Pass could handle 2.05 trillion cubic feet (Tcf) annually. The Port Arthur terminal annual capacity would increase regional capacity by 2.97 Tcf without pushing peak capacity. Table V-7 shows SNWW current and future capacity volumes.

Table V-7
SNWW Economic Analysis, U.S. Liquefied Natural Gas
Facility Expansions and New Construction
(Given Current FERC Approval and Existing Facility Status)

Facility	Storage Capacity (Bcf)	Output Capacity (Bcf/d)	Completion Date
Sabine Pass			
Phase I	10.1	2.6	2008
Phase II	10.1	1.4	-
Total	20.2	4.0	
Golden Pass	17.0	2.7	2010
Port Arthur	20.0	3.0	2012
Total SNWW	57.2	9.7	

There are about 40 LNG terminals that are before the FERC being discussed by the LNG industry for North America. Six terminals are already operating on the East Coast, Puerto Rico, and Alaska. There are seven onshore LNG terminals in the continental U.S. These are located in Everett, Massachusetts; Lake Charles, Louisiana; Elba Island, Georgia; Cove Point, Maryland; Cameron, Louisiana; Sabine, Texas; and Freeport, Texas. The Cameron, Sabine, and Freeport terminals are new. In addition to these three terminals, the Northeast Gateway port offshore Massachusetts received its first supplies in 2008. With these four terminals now operational, U.S. capacity to receive LNG imports has increased from approximately 5.0 Bcf/d at the end of 2007 to 14.5 Bcf/d per day at the end of 2008. The Sabine Pass facility adds 2.6 Bcf and about 18 percent to U.S. Bcf capacity. Table V-8 displays 2007–2008 U.S. LNG capacity and shows 2003–2009 imports. The Energy Information Administration (EIA) reported total LNG import shipments of 771 Bcf in 2007 to these terminals, with each importing similar volumes – each between 20 and 30 percent of the total. Imports in 2008 only reached 351 Bcf.

Despite declines in 2008, the EIA expects U.S. LNG imports to increase to about 500 Bcf in 2009, up from 352 Bcf in 2008, and rise to about 740 Bcf in 2010. The 2008 fall in imported natural gas to the U.S. reflects the increased need for natural gas in other countries willing to compete for available global supplies. While U.S. imports increased in 2009 over 2008 levels, U.S. LNG import growth this year has been constrained because of increased LNG demand in Europe and delays and maintenance to new and existing LNG liquefaction capacity. With limited natural gas storage availability, recent data suggest that European inventory levels are now nearing capacity. The expectation is that LNG shipments may be redirected to U.S. ports in the coming months as prices in the European market become less attractive to LNG suppliers.

The *2009 Annual Energy Outlook* (AEO2009) forecast shows U.S. LNG imports reaching 2007 levels again in 2014 and peaking at 1,380 Bcf in 2020. Between 2020 and 2030, imports are forecasted to turn down once again. Figure V-3 shows the Department of Energy's 2006–2030 U.S. LNG import forecast. Identification of the region's future share of the LNG market is obviously subject to uncertainty. The SNWW facilities have the advantage of the FERC approval, relatively high levels of public and political

support, and locational advances in terms of access to the U.S. Gulf. For the analysis, 25 percent of U.S. waterborne LNG imports market was used for SNWW. The SNWW forecast is included in Table V-9.

Table V-8
LNG Existing and Under Construction Terminals

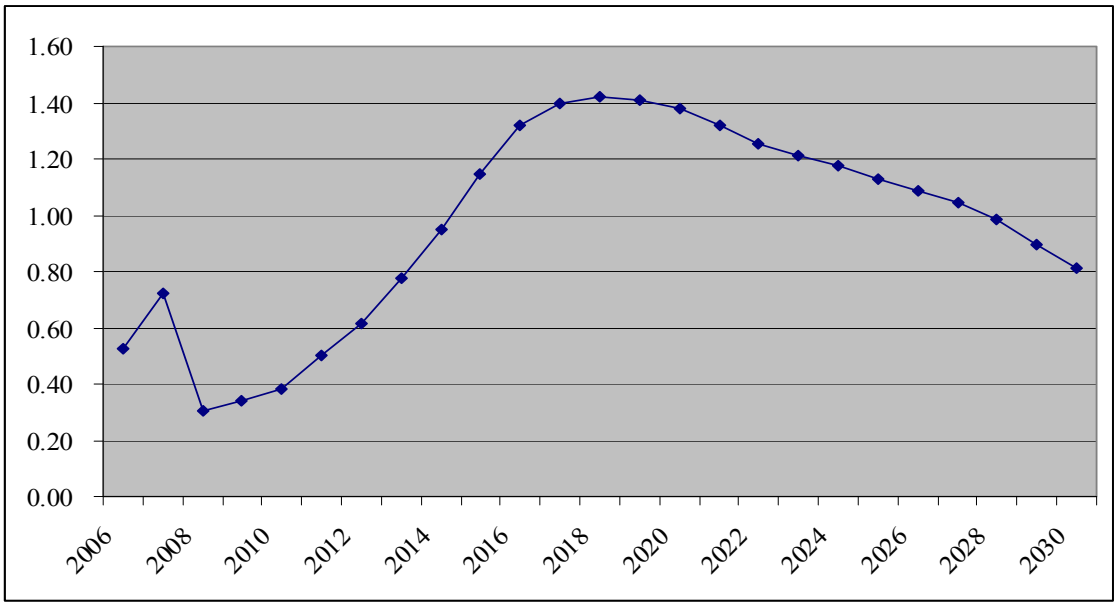
	Total Capacity (Bcf/d)			Total Throughput (Imports Bcf)					
Location	2007	2008	2012	2003	2004	2005	2006	2007	2008
Everett		0.7		158.3	173.8	168.5	176.1	183.6	165.3
Cove Point		1.8		66.1	209.3	221.7	116.6	148.2	25.9
Elba Island		0.8		43.9	105.2	132.1	146.8	170.2	135.7
Lake Charles		1.8		238.2	163.7	103.8	143.6	251.5	8.9
NE Gateway		0.4		–	–	5.2	0.5	17.3	–
Gulf Gateway		0.4		–	–	–	–	–	0.9
Altamira		0.7		–	–	–	–	–	–
Sabine Pass		2.6	4.0	–	–	–	–	–	9.2
Cameron		1.8		–	–	–	–	–	–
Freeport		1.5		–	–	–	–	–	–
Golden Pass		–	2	–	–	–	–	–	–
Gulf LNG		–	1.5	–	–	–	–	–	–
Neptune		–	0.5	–	–	–	–	–	–
Canaport		1.0		–	–	–	–	–	–
Costa Azul		1.0	2.6	–	–	–	–	–	–
Total		14.5	21.5*	506.5	652.0	631.3	583.5	770.8	345.9
Short Tons (millions)		n/a	n/a	15.6	22.2	16.6	18.6	21.2	10.7

Source: Compiled from U.S. Department of Energy data.
*Reflects inclusion of 2008 capacity.

V.C COMMODITY AND FLEET FORECASTS

Commodity and fleet forecasts were prepared for SNWW crude petroleum, petroleum and chemical products, grain, iron and steel products, limestone and building materials, and LNG. The crude petroleum, petroleum, and chemical products forecasts are presented first, followed by discussion of the new LNG market and its tonnage forecast. Finally the grain, iron, metal products, and aggregate are presented. The remaining oceangoing commodity groups, which were found either not to be transported in draft constrained vessels at the current time or were of limited volumes, were analyzed in the aggregate. Estimation of total traffic was needed for the widening analysis and also provided critical input for the shore erosion effects evaluation performed by the ERDC.

Figure V-3
U.S. LNG Imports 2006–2030
Trillion of Cubic Feet



Source: U.S. Department of Energy (2009a).

Table V-9
U.S. and SNWW Liquefied Natural Gas Imports, 2005–2030
Updated June 2009

	U.S. Total LNG Imports		SNWW
Year	Trillion Cubic Feet	Waterborne Short Tons	LNG Forecast Short Tons
2005	0.5661	16,566,000	–
2006	0.5840	18,617,000	–
2007	0.7708	21,238,000	–
2015	1.1460	31,575,957	3,157,596
2019	1.4101	38,852,755	5,827,913
2020	1.3808	38,045,447	9,511,362
2025	1.1269	31,049,691	7,008,843
2029	0.8964	24,698,681	6,174,670
2030	0.8097	22,309,819	6,174,670
2039	n/a	n/a	6,174,670
2049	n/a	n/a	6,174,670
2059	n/a	n/a	6,174,670
2069	n/a	n/a	6,174,670

Source for U.S. Imports: U.S. Department of Energy (2009b).

National crude petroleum and petrochemical forecast data and general indicators were assessed in relationship to the study area's historical commodity-specific tonnage flows for the purpose of evaluating the relationship between historical U.S. tonnage volumes and study area tonnage. Assessment of the statistical variables associated with the U.S. and study area tonnage provides the analytical support needed to determine which forecasts furnish the best long-term estimation of future study area tonnage flows. The vessel fleet forecasts incorporate recent historical practices, which reflect continued and increased utilization of draft-constrained vessels, regardless of the proposed channel enlargement alternatives.

The outputs of the commodity and fleet projections were based on forecasts published in the EIA AEO2008 and AEO2009; Global Insight, *The U.S. Economy, The 30-Year Focus*, First Quarter 2008 and Second Quarter 2009; USDA *Agricultural Baseline Projection Tables, USDA Baseline Projections Report to 2019*, February 2009; and from indices developed from historical trend data. The forecasting methodologies, the distribution of tonnage by vessel class, and the determination of the number of vessel trips are discussed in the sections that follow.

Tables V-10 and V-11 summarize the forecasts for the major commodity groups evaluated for channel deepening. The Port Arthur forecast is shown in Table V-10 and Beaumont's forecast in Table V-11. Detailed discussions of the commodity forecasts are presented in the Economic Appendix. The following section presents SNWW vessel fleet data.

Vessel Utilization Trends

The existing 40-foot project depth was designed to efficiently and safely accommodate vessels of approximately 40,000 DWT with loaded drafts of 36 feet. Since the authorization of the existing project, the size and draft of vessels using the waterway increased to meet the competitive demand for more-efficient movements. Table V-1 displays SNWW 1970–2007 total tonnage and principal deep-draft movements by major commodity group. Examination of SNWW historic traffic data showed that if deeper depths were available, a significant share of the vessels used in the transport of crude petroleum and petroleum products could be loaded to drafts over 40 feet. In addition, but to a lesser extent, examination of the 1995–2007 vessel sizes, loaded drafts, design drafts, and parcel sizes revealed that some of the vessels used to transport grain, chemical products, and breakbulk cargo, such as iron ore, metal products, and limestone and other aggregate, warranted additional analysis.

Analysis of the vessel fleets and utilization, and existing and future constraints associated with crude petroleum; petrochemical products, including LNG; grain; and aggregate products, such as iron ore, steel slab, limestone, and sand and gravel, provided the basis for identifying the commodities expected to be transported in vessels loaded to channel depths over 40 feet and estimating specific percentage utilization for channel depths over 40 feet. Additional considerations were foreign port depths and constraints such as the Panama Canal. Completion of the Panama Canal expansion, from its present width restriction of 106 feet and approximate loaded draft limit of 39.6 feet, in the year 2014 would allow for more fully loaded vessel movements from deepwater ports in Western Mexico, South America, and the Far East. The

canal expansion would accommodate maximum loaded drafts of 48 feet. Port depth, trade route, and historical vessel utilization data were used to identify the percentage of tonnage anticipated to benefit from the proposed SNWW depth increases.

Table V-10
Port Arthur Tonnage Evaluated for Channel Deepening*
(1,000s of short tons)

Year	Crude Petroleum Imports	Petrochemicals					Breakbulk		Liquefied Natural Gas Imports
		Petroleum Products		Chemical Products		Coastwise*	Crude	Primary Manuf.	
		Imports	Exports	Imports	Exports	Products	Materials	Goods	
2001	11,064	641	2,327	25	136	1,043	131	665	0
2002	9,013	997	3,143	89	176	1,422	921	641	0
2003	11,987	1,152	3,734	60	210	2,577	501	557	0
2004	10,015	2,150	4,255	225	889	1,804	572	564	0
2005	9,320	2,205	3,858	194	998	1,803	572	710	0
2006	10,627	1,144	4,391	111	1,330	2,323	620	542	0
2007	10,334	772	3,978	97	1,525	3,330	577	122	0
Port Arthur Tonnage Forecast**									
2019	12,248	1,811	6,879	223	1,462	3,002	751	524	5,828
2029	13,663	2,027	9,013	246	1,872	3,754	873	608	6,175
2039	14,509	2,312	10,255	272	2,396	4,506	1,016	705	6,175
2040	14,800	2,589	11,619	301	2,647	4,977	1,181	818	6,175
2059	15,100	2,901	13,124	332	2,924	5,498	1,374	949	6,175
2069	15,469	3,250	14,850	367	3,229	6,073	1,598	1,102	6,175

*Includes coastwise crude petroleum shipments and receipts.

**Deepening benefits were calculated for a percentage of the tonnage presented in this table.
Discussion of the commodity-specific percentages is contained in the Economic Appendix (Appendix 2).

Crude Petroleum Fleet

Crude petroleum growth dominates total tonnage for both Beaumont and Port Arthur. In a comparison of the relative port statistics, a greater percentage of crude tonnage is loaded to drafts of 38 feet or more for Port Arthur than for Beaumont. This is due to Port Arthur receiving a higher share of direct shipments from Mexico than Beaumont does. Generally, vessels would be loaded to deeper drafts for longer distance direct routes. In comparison, Beaumont receives a higher share of lightered tonnage from both lightened mother vessels and shuttles. While there are obvious cost incentives to load to the maximum allowable depth, in looking at average loaded drafts, the lightened mother vessels and shuttles were lighter than vessels associated with direct shipments. Port Arthur's petroleum refineries are located inside the Taylor Bayou complex. The maximum size using the Taylor Bayou facilities are in the 110,000 to 116,000 DWT range. While Port Arthur vessels are loaded to deeper draft, the Port Arthur fleet is smaller than Beaumont's in terms of DWT because the existing width at the mouth of Taylor Bayou and the configuration of the docks within Taylor Bayou limit the allowable vessel size.

Table V-11
Beaumont Tonnage Evaluated for Channel Deepening
(1,000s of short tons)

Year	Crude Petroleum Imports	Petrochemicals					Grain Exports	Breakbulk	
		Petroleum Products		Chemical Products		Coastwise* Products		Crude Materials	Primary Manuf. Goods
		Imports	Exports	Imports	Exports				
2001	53,162	2,093	2,793	729	1,160	2,793	858	787	103
2002	57,370	4,031	2,492	594	1,411	2,712	835	408	204
2003	58,171	4,035	2,839	374	1,345	2,732	1,125	656	115
2004	59,860	3,852	2,897	431	1,215	3,191	1,329	663	420
2005	50,371	3,144	2,496	890	893	2,967	1,082	730	471
2006	46.988	2,676	2,432	1,133	1,574	3,115	1,214	793	364
2007	47,776	2,948	2,713	858	1,644	3,261	1,632	1,038	173
Beaumont Tonnage Forecast**									
2019	81,980	3,362	4,586	967	1,787	4,899	2,129	1,106	428
2029	91,463	3,765	6,008	1,068	2,288	6,125	2,351	1,285	498
2039	97,152	4,293	7,458	1,180	2,928	7,351	2,597	1,495	579
2049	99,136	4,809	8,450	1,303	3,235	8,120	2,869	1,738	674
2059	101,149	5,387	10,738	1,439	3,573	8,970	3,169	2,022	784
2069	103,189	6,036	12,150	1,590	3,947	9,908	3,501	2,352	911

*Includes coastwise crude petroleum shipments and receipts.

**Deepening benefits were calculated for a percentage of the tonnage presented in this table.

Discussion of the commodity-specific percentages is contained in the Economic Appendix (Appendix 2).

Widening of the mouth of the entrance to Taylor Bayou would occur under the with-project future condition and this would allow better vessel maneuverability. Widening of the mouth was recommended as a result of the ERDC vessel simulation modeling. Port Arthur's breakbulk docks and new LNG facilities are located outside of the Taylor Bayou complex and are not subject to similar vessel beam and length restrictions. The maximum sized vessels using the Channel to Beaumont are in the 150,000 to 175,000 DWT class. The maximum length for that group is approximately 900 feet, with a corresponding beam width of 164 feet. Five percent of Beaumont's 2006 crude petroleum imports are associated with this group. Table V-12 displays Port Arthur's and Beaumont's 2002–2006 port-specific distributions by loaded draft. Distributions of Port Arthur and Beaumont crude oil imports by vessel DWT range are shown in tables V-13 and V-14.

Table V-12
SNWW Crude Petroleum Imports by Loaded Draft, 2002–2007

Loaded Draft (feet)	Port Arthur Crude Petroleum Imports (%)					
	2002	2003	2004	2005	2006	2007
<35	7.6	2.6	0.3	9.5	5.0	4.6
35–37	10.5	8.6	0.0	47.6	56.7	3.2
>37	81.9	88.8	99.7	42.9	38.3	92.2
Total	100.0	100.0	100.0	100.0	100.0	100.0
	Beaumont Crude Petroleum Imports (%)					
<35	10.5	10.5	12.7	10.3	17.2	7.3
35–37	27.3	27.0	23.5	19.1	19.3	22.6
>37	62.2	62.5	63.8	70.6	63.5	70.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: USACE (2007a). The Lloyd's Register-Fairplay was used to obtain the vessel DWT and associated characteristics.

Table V-13
Port Arthur Crude Petroleum Imports 2002–2007, Percentage of Imports
by Vessel DWT and Design Draft and Year Built

DWT	2002	2003	2004	2005	2006	2007
≤50,000	0.1	0.7	0.7	1.5	0.0	0.9
50,000–74,500	55.5	6.2	3.0	3.1	4.5	7.9
75,000–84,900	14.5	75.8	93.7	66.0	93.1	82.2
85,000–89,900	5.3	0.7	0.0	0.0	0.0	0.0
90,000–119,900	21.9	15.2	2.6	26.0	2.4	4.4
120,000–149,900	0.8	0.0	0.0	0.8	0.0	1.0
150,000–175,000	1.9	1.4	0.0	2.6	0.0	3.6
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: USACE (2007a). The Lloyd's Register-Fairplay was used to obtain the vessel DWT and associated characteristics.

Table V-14
Beaumont Crude Petroleum Imports 2002–2007, Percentage of Imports
by Vessel DWT and Design Draft and Year Built

DWT	2002	2003	2004	2005	2006	2007
≤50,000	0.6	0.4	0.8	1.6	1.1	0.7
50,000–74,500	2.3	2.5	1.5	1.6	3.2	2.8
75,000–84,900	8.1	6.2	8.2	9.1	9.6	9.7
85,000–89,900	9.8	5.4	0.5	0.0	0.4	0.0
90,000–119,900	71.2	76.2	78.8	80.2	77.6	80.2
120,000–149,900	2.9	3.3	3.9	3.5	2.5	1.9
150,000–175,000	5.2	6.1	6.5	4.0	5.7	4.7
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: USACE (2007a). The Lloyd's Register-Fairplay was used to obtain the vessel DWT and associated characteristics.

Petroleum Product Carriers

Examination of the vessel characteristics and geographic routings associated with SNWW products indicates that some vessels could be more fully loaded. Table V-15 presents a percentage distribution of SNWW petroleum product imports and exports by vessel DWT class. This table shows that 32 to 54 percent of 1998–2007 imports and 5 to 27 percent of exports were transported in vessels of 60,000 DWT or more.

Table V-15
SNWW Petroleum Product Import Tonnage by Vessel DWT

SNWW Percentage of Imports by DWT Range						
DWT Range	1998	2001	2004	2005	2006	2007
<10,000	4.3	0.0	0.4	0.0	0.4	1.3
10,000 to 29,999	12.1	6.2	2.8	4.4	1.1	4.4
30,000 to 49,999	45.8	48.9	41.3	48.7	58.1	45.6
50,000 to 59,999	5.5	3.0	1.4	1.1	2.2	7.1
60,000 to 69,999	3.8	15.1	16.7	9.3	12.8	6.9
70,000 to 79,999	2.7	0.0	15.2	18.4	17.0	21.2
80,000 to 89,999	4.0	8.9	5.4	7.3	0.0	0.0
90,000 to 99,999	15.8	5.4	3.7	3.3	2.1	0.5
100,000 to 116,000	6.0	12.6	13.2	7.5	6.4	13.1
Total	100.0	100.0	100.0	100.0	100.0	100.0
SNWW Percentage of Exports by DWT Range						
DWT Range	1998	2001	2004	2005	2006	2007
<10,000	2.9	2.5	3.0	1.0	1.4	1.7
10,000 to 29,999	14.3	11.9	9.5	15.5	7.2	8.6
30,000 to 49,999	67.3	57.0	69.0	72.9	77.6	61.2
50,000 to 59,999	7.2	1.4	10.0	4.2	8.7	14.5
60,000 to 69,999	4.1	12.1	4.4	1.7	2.7	5.5
70,000 to 79,999	1.9	11.4	4.0	4.7	0.6	8.5
80,000 to 89,999	2.2	0.0	0.0	0.0	1.7	0.0
90,000 to 99,999	0.1	1.2	0.0	0.0	0.0	0.0
100,000 to 116,000	0.0	2.4	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: USACE (2007a).

The Lloyd's Register-Fairplay was used to obtain the vessel DWT and associated characteristics.

Table V-16 presents the percentage of Port Arthur and Beaumont tonnage for design drafts greater than and less than 40 feet and shows that in 2007, an average of 59 percent of Port Arthur and 46 percent of Beaumont petroleum product imports were transported in vessels with design drafts over 40 feet. For exports, the 38 percent of Port Arthur and 20 percent of Beaumont tonnage were transported in vessels with design drafts over 40 feet. Comparison of the 2002–2007 statistics shows that the percentage of Port

Arthur and Beaumont exports transported in vessels with design drafts over 40 feet experienced relatively large increases; however, the annual rates are subject to variability based on annual changes in trade routes and commodity mixes.

Tables V-17 and V-18 show product totals by commodity and the corresponding percentage of imports and exports shipped in vessels of 60,000 DWT or more. As shown, the annual percentages vary greatly and discernible patterns are not apparent. As also shown in Table V-17, higher percentages of imports are associated with vessels of 60,000 DWT than are exports.

Table V-16
SNWW Petroleum Products 2002–2007 Imports and Exports by Vessel Design Draft

Design Draft (feet)	2002	2003	2004	2005	2006	2007	2002–2007 Average Annual Growth Rate
Port Arthur Percentage of Petroleum Product Imports							
≤40	60	62	62	54	40	41	–7.3
>40	40	38	38	46	60	59	8.1
Total	100	100	100	100	100	100	n/a
Beaumont Percentage of Petroleum Product Imports							
≤40	49	45	48	66	63	54	2.0
>40	51	55	52	34	37	46	–2.0
Port Arthur Percentage of Petroleum Product Exports							
≤40	94	70	89	91	92	62	–8.0
>40	6	30	11	9	8	44.7	44.7
Total	100	100	100	100	100	n/a	n/a
Beaumont Percentage of Petroleum Product Exports							
≤40	89	83	83	85	86	80	–2.1
>40	11	17	17	15	14	20	12.7
Total	100	100	100	100	100	100	n/a

Source: USACE (2007a). The Lloyd's Register-Fairplay was used to obtain the vessel DWT and associated characteristics.

While it is anticipated that this variance would continue to remain high, the use of draft-constrained vessels for several markets served by the SNWW is also anticipated to continue. While published forecasts of specific trade routes are not available, the SNWW presently serves markets that can accommodate more fully loaded product carriers, and it was assumed that some cargo movements would transition to more fully loaded vessels based on the economics of scale of loading to increased depths and availability of channel depths in excess of 40 feet at some trading ports. As shown in tables V-16 and V-17, larger product carriers are used for high volume commodities such as distillate and residual fuel imports and petroleum coke exports

Table V-17
Percentage of Imports and Exports Shipped in Vessels of 60,000 DWT or Larger
SNWW Petroleum Product Imports
1998–2007 (select years)

Major Commodity Group	Total Imports by Commodity Group (1,000s of short tons)						Percent of Imports Transported in Vessels ≥60,000 DWT					
	1998	2001	2004	2005	2006	2007	1998	2001	2004	2005	2006	2007
Gasoline	–	33	1,613	2,213	1,678	1,096	–	0	6	14	8	15
Distillate Fuel	102	572	728	1,286	1,267	1,872	40	75	73	73	78	67
Residual Fuel	57	25	810	804	351	355	100	100	59	94	74	16
Lube Oil and Greases	2,140	700	619	50	71	2	83	90	80	0	39	39
Naphtha and Solvents	808	1,138	1,977	595	368	719	21	5	81	49	16	16
Asphalt, Tar, and Pitch	11	–	–	7	–	–	–	–	–	–	–	–
Petroleum Coke	250	266	255	365	84	276	10	–	21	48	–	10
Other	124	–	–	29	–	–	6	–	–	–	–	–
Total Imports	3,492	2,734	6,003	5,349	3,819	3,744	58	42	54	46	39	40

Table V-18
SNWW Petroleum Product Exports
1998–2007 (select years)

Major Commodity Group	Total Exports by Commodity Group (1,000s of short tons)						Percent of Exports Transported in Vessels ≥60,000 DWT					
	1998	2001	2004	2005	2006	2007	1998	2001	2004	2005	2006	2007
Gasoline	1,376	1,258	1,949	1,778	1,777	1,970	1	–	3	–	1	10
Distillate Fuel	602	179	449	371	371	345	42	–	–	11	9	58
Residual Fuel	206	12	0	51	68	–	12	–	–	–	50	–
Lube Oil and Greases	41	63	57	99	117	60	10	–	–	–	10	10
Naphtha and Solvents	0	146	8	58	94	22	4	–	–	–	4	–
Petroleum Coke	1,622	3,447	4,688	4,362	4,362	4,210	13	35	13	14	6	9
Other	463	17	0	104	33	–	–	–	–	–	–	–
Total Imports	4,328	5,122	7,151	6,823	6,822	6,607	8	23	9	9	5	15

Source (Tables 40–41): USACE (2007a).

The Lloyd's Register-Fairplay was used to obtain the vessel DWT and associated characteristic

Examination of the data in tables V-13 through V-17 shows that there are large annual variances in the percentage of annual tonnage associated with the draft and parcel criteria, and, therefore, depths at trading ports and comparable operations at similar ports were also evaluated. Examination of petroleum product imports and exports through other U.S. Gulf Coast ports with channel depths over 40 feet shows that 34 percent of distillate imports from Russia, North Africa, and Venezuela were shipped in vessels with loaded drafts of 42 feet or more.

The use of the Panama Canal for all of the Far East and over half of the South America destinations would limit the sizes of vessels used for that trade until the Panama Canal expansions are complete. Completion of the Panama Canal deepening and widening is expected to occur before 2014. In addition to foreign flag product carriers, a steady volume of domestic coastwise product tankers use Port Arthur and Beaumont. Domestic coastwise movements primarily consist of gasoline and distillate and residual fuel shipments. These products are refined at the SNWW ports and shipped to the U.S. East Coast, specifically eastern Florida. In 2006, coastwise shipments totaled 3.6 million short tons. Coastwise receipts totaled 978,000 short tons. Examination of vessel specifics showed that approximately 10 percent of outbound coastwise shipments were transported in draft-restricted tankers. These product carriers generally are between 60,000 and 70,000 DWT with design drafts in the 41- to 43-foot range.

Chemical Product Carriers

For the period 2002–2007, chemical imports represented approximately 3 percent of both SNWW and U.S. total foreign tonnage. Both U.S. and SNWW imports exhibited consistent upward growth from the mid-1990s through 2007, with SNWW overall rates increasing at nearly five times the U.S. rate but also exhibiting higher annual variances. As with imports, SNWW chemical exports exhibited significantly higher overall growth than the national rates, with overall rates increasing at nearly five times the U.S. rate. Chemical product growth can be attributed to diversification of the SNWW product base and the development of new markets. Table V-19 shows SNWW and U.S. total tonnage for 1990–2007, with recent tonnage representing record highs.

Evaluation of 1998–2007 chemical product exports showed that the percentage of tonnage associated with design drafts between 40 and 44 feet ranged from zero to 14 percent, averaging 4 percent annually. An average of 16 percent of 1998–2006 export tonnage was transported in loaded drafts between 36 and 40 feet. In 2007, 18 percent of SNWW chemical exports were transported in vessels with loaded drafts between 36 and 40 feet. Approximately two-thirds of 2002–2007 exports were shipped from Beaumont and the remainder from Port Arthur. Seventy-nine percent of 2002–2007 imports were shipped into Beaumont and the remainder to Port Arthur.

Review of the Lloyd's Register-Fairplay showed that 21.6 percent of the chemical tankers on order in 2009 have design drafts of 43 feet or more and 1.6 percent of chemical tankers on order have design drafts of 47 feet or more. Table V-20 presents the distribution of the world chemical carrier fleet as of January 2009.

Table V-19
SNWW and U.S. Chemical Products (1,000s of short tons)
Foreign Imports and Exports

	Chemical Product Imports		Chemical Product Exports	
Year	SNWW	U.S.	SNWW	U.S.
1990	34	15,943	547	40,419
1991	35	15,293	455	44,418
1992	46	16,404	489	42,216
1993	25	18,954	537	39,781
1994	49	23,479	577	44,934
1995	33	24,069	724	49,466
1996	48	24,597	777	47,476
1997	33	25,054	1,101	50,538
1998	140	27,443	979	51,343
1999	449	28,141	753	52,199
2000	619	38,477	1,469	57,886
2001	754	43,833	1,296	54,746
2002	683	39,572	1,587	54,961
2003	434	42,010	1,555	53,575
2004	656	43,810	2,104	60,734
2005	1,084	45,517	1,891	56,684
2006	1,133	48,013	2,904	58,699
2007	955	46,881	3,169	60,188
1990–1998 Average	49	21,248	686	45,626
1999–2007 Average	752	41,806	1,859	56,630
Average Annual Growth % Rate	35.4	7.8	11.7	2.4

Source: USACE (2007a).

Table V-20
Chemical Product Carrier Fleet
World Fleet as of January 2009

		Percentage of Total DWT	
Design Draft (feet)	Median DWT	Built 1985–2004	On Order as of January 2009
<36	13,000	36.1	34.1
36–38	38,500	23.6	18.6
39–40	46,000	24.2	17.7
41–42	47,000	6.6	6.2
43–44	50,000	3.5	21.8
45–46	85,000	0.9	–
47–49	95,000	5.1	1.6
50–51	n/a	–	–
	Total	100	100

Source: Lloyd's' Register-Fairplay (2009).

Current vessel usage and general indicators, such as depths at trading ports, overall tonnage, and the design drafts for the current fleet of vessels, suggest that some future chemical movements would benefit from channel depths up to 48 feet. Of the vessels on order, 1.8 percent of vessels have design drafts of 48 feet. Review of existing cargo loads suggests that the draft-constrained tonnage would likely consist of metallic salt exports and acyclic hydrocarbon exports. Project benefits were calculated assuming that 5 to 10 percent of future chemical export tonnage would be transported in vessels with loaded drafts between 40 and 49 feet. Eight percent of 2019–2069 chemical export tonnage was assumed to be loaded to drafts over 40 feet. Deepening benefits were not calculated for chemical imports due to current limited utilization of larger vessels and loaded drafts over 36 feet and uncertainty about future trends towards the use of either larger or more fully loaded vessels.

Grain Carriers

Grain is exported from the Beaumont elevator located just below the Port of Beaumont main TB. While exports have exceeded 1 million short tons since 2003, recent volumes are less than one-half the 1993 peak volume of 3.5 million short tons. In 2007, Beaumont's wheat exports totaled 1.6 million short tons. While relatively low in comparison to the Pacific Northwest and the Lower Mississippi, Beaumont has maintained a 1.4 to 1.7 percent share of the U.S. waterborne bulk grain export market. Table V-21 displays Beaumont's 2001–2007 grain export tonnage by grain type and loaded draft. Wheat presently comprises 100 percent of Beaumont's grain exports for the most recent 5-year period. Beaumont's 2007 wheat exports composed 5 percent of the U.S. wheat export total. Figure V-4 provides a comparison of Beaumont and U.S. wheat exports. During earlier years, wheat represented 85 percent, sorghum 10 percent, and corn 5 percent.

The maximum DWT presently used for grain exports is in the 60,000 to 70,000 DWT range. These vessels have design drafts between 42 and 43 feet. The specific type of bulk carriers used for grain is "load-on/load off" or "LoLo" vessels. Table V-22 displays the existing fleet of "LoLo" vessels in the world fleet and LoLo vessels on order. The median year of construction for the range of vessels transporting grain from Beaumont is 1985, which is older than the median of 1998 associated with the world fleet. Review of the distribution of vessels on order and the port 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.

The USDA's February 2009 forecast shows modest growth in wheat exports between 2006 and 2018/2019. U.S. 2006–2018/2019 exports are forecasted to increase from approximately 990 million bushels in 2006 to 1,075 million bushels by 2014/2015 and remain constant at that level through the end of the forecast period in 2018/2019.

Table V-21
Beaumont Bulk Grain Export
Distribution of Tonnage by Grain Type and Loaded Vessel Draft

	2001	2002	2003	2004	2005	2006	2007
Bulk Grain Export Totals by Year (1,000s of Short Tons)							
Total Exports	831	835	1,125	1,329	1,080,	1,214	1,632
% by Grain Type							
Wheat	79.0	88.8	100.0	100.0	100.0	100.0	100.0
Corn	6.5	8.4	0.0	0.0	0.0	0.0	0.0
Sorghum	14.5	2.8	0.0	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% by Loaded Draft (feet)							
≤35	56.8	65.8	65.3	67.8	62.8	35.5	50.8
36–37	6.7	5.5	11.6	9.0	15.2	25.7	18.5
38–40	36.5	28.7	23.1	23.2	22.0	38.8	30.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: USACE (2007a).

Figure V-4. U.S. and Beaumont Bulk Grain Exports, 1990–2007 (Short Tons)

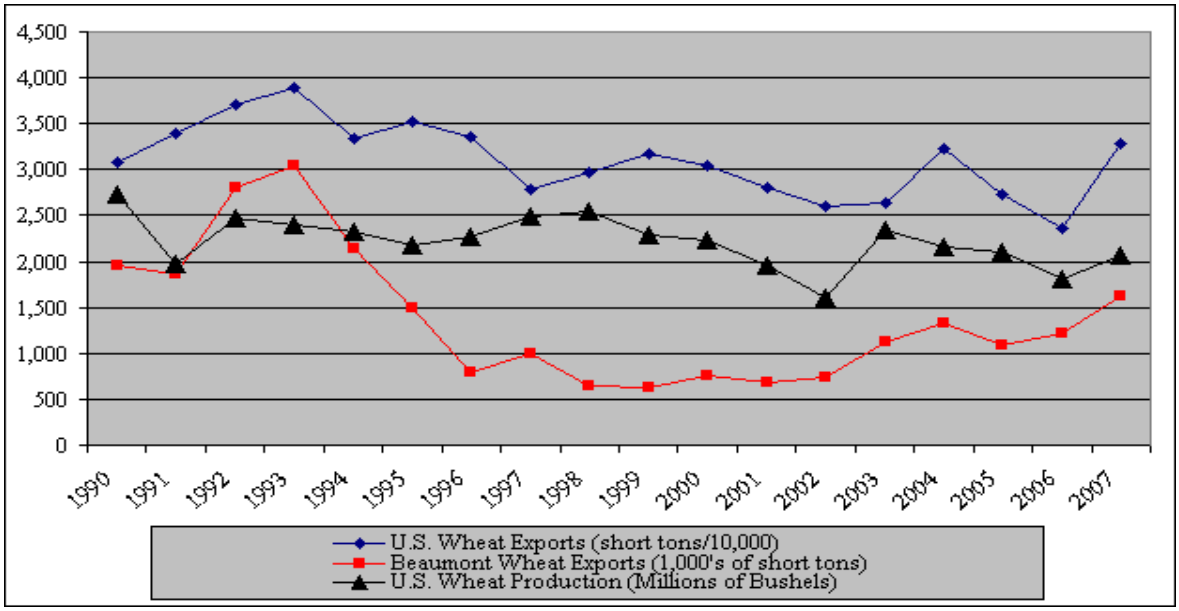


Table V-22
LoLo Bulk Dry Cargo Carriers (World Fleet)

Vessels in Operation					
DWT Range	Total DWT	Percent DWT	Median DWT	Design Draft (feet)	Year Built
<25,000	5,825,500	3	20,035	30	1996
25,000 to 44,000	31,009,518	14	32,755	34	1994
45,000 to 64,000	33,235,975	15	49,061	39	2000
65,000 to 79,000	58,832,687	27	73,445	45	1998
80,000 to 94,000	3,716,652	2	88,405	43	2000
95,000 to 106,999	414,221	0	105,712	50	2001
107,000 to 169,999	38,252,170	18	151,257	57	1994
170,000 to 260,000	45,324,613	21	172,964	58	2000
Total	216,611,336	100			

Vessels on Order				
DWT Range	Total DWT	Percent DWT	Median DWT	Design Draft (feet)
<25,000	775,191	2	18,500	28
25,000 to 44,000	4,430,571	8	34,525	34
45,000 to 64,000	11,825,398	21	54,500	41
65,000 to 79,000	9,044,747	16	75,750	46
80,000 to 94,000	9,382,833	17	82,788	47
95,000 to 106,999	815,150	2	100,000	44
170,000 to 199,999	18,990,990	34	177,015	59
Total	55,264,880	100		

Source: Tables 47 and 48: Lloyd's Register-Fairplay (2006).

Steel Slab and Iron Ore Carriers

For the period, 2002–2006, an average of 2.5 percent of U.S. iron ore and steel slab imports were transported through the SNWW ports. For the period 2002–2007, imports ranged from a low of 240,000 short tons in 2007 and a high of 1,136,000 short tons in 2005. In 2006, SNWW imports totaled 859,000 short tons. The 2002–2006 average annual import volume of 783,000 short tons is over 100 percent higher than 1990–1993 average levels.

Steel slab is transported in LoLo bulkers in the 45,000 to 53,000 DWT range, with a maximum vessel size of 78,000 DWT. Review of the Lloyd's Register-Fairplay (2003) showed that 23 percent of bulk carriers constructed over the past decade are in the 66,000 to 78,000 DWT range. This is same vessel type used for grain; however, the specific vessels are different with each cargo having dedicated carriers.

Examination of the foreign ports of call for 1998–2007 SNWW tonnage showed that an average of 8 percent of tonnage was transported through world ports with channel depths of 44 to 47 feet. Current

vessel usage and general indicators, such as depths at trading ports and the design drafts for new vessel orders, suggests that, in the short term, a minimum of 10 percent of present iron ore movements would utilize channel depths over 40 feet. Expansion of the Panama Canal is expected to increase the percentage to 50 percent by the year 2014. Project benefits were calculated assuming that 10 percent of 2015–2020 tonnage and 50 percent of 2020–2069 would be transported in vessels with loaded drafts between 40 and 49 feet.

Limestone and Rock Carriers

SNWW aggregate tonnage primarily consists of imports of limestone, rock, and other raw building materials. For the period 2005–2007, 3 percent of U.S. limestone and rock imports were transported through the SNWW ports. Table V-23 displays SNWW aggregate tonnage. Presently, the most common carriers used on the SNWW are in the 46,000 to 77,000 DWT range. Table V-24 displays the fleet used for SNWW 2002–2007 aggregate imports. Presently, nearly all tonnage is transported in vessels with design drafts over 40 feet. Current vessel usage and general indicators, such as depths at trading ports and the design drafts for new vessel orders, suggests that some 50 percent of iron ore movements would utilize channel depths over 40 feet due to the expansion of the Panama Canal. The shipments of clay and refractory materials are associated with vessels with loaded drafts over 37 feet and design drafts over 40 feet.

Table V-23
SNWW Building Material Imports
(1,000s of short tons)

	Sand, Gravel, and Limestone Imports (Total Imports and Estimated Port Share)			Sulphur and Refractory Material Exports (Total Imports and Estimated Port Share)			Estimated Percentage of Tonnage Transported in Vessels with Design Drafts ≅40 feet		
Year	Total	Port Arthur (%)	Beaumont (%)	Total	Port Arthur (%)	Beaumont (%)	Sand and Gravel	Limestone	Sulphur and Refractory Materials
1999	617	90	10	0	0	0	100	0	0
2000	495	36	64	13	0	100	99	60	0
2001	635	18	82	40	0	100	99	37	0
2002	1,117	20	80	16	12	88	99	78	0
2003	658	40	60	46	2	100	99	57	0
2004	642	35	65	104	28	72	99	100	0
2005	815	36	64	91	12	88	100	100	21
2006	816	44	56	261	18	82	99	100	0
2007	829	41	59	463	12	88	99	99	11

Source: USACE (2007a).

Table V-24
SNWW Aggregate Tonnage Fleet, 2002–2007

Vessel DWT	Loaded Draft (feet)	Estimated % of 2002–2006 Imports	Vessel Characteristics			
			Length (feet)	Beam (feet)	Design Draft (feet)	Year Built
46,606	33	11	615	106	37	1995
62,594	40	4	747	106	44	1982
67,044	35–40	54	753	106	43	1984
77,499	40	26	804	106	46	1991
<40,000	n/a	5	n/a	n/a	n/a	n/a
	Total	100				

Source: USACE (2007a).

Wood Product Carriers

For the period 1998–2006, approximately 1 percent of U.S. wood product tonnage was transported through the SNWW ports. Wood products also represent 1 percent of the SNWW 1998–2006 foreign total. The largest wood product carriers used on the SNWW are in the 50,000 to 60,000 DWT range. The design drafts of these ships are right at 40 feet; and it was found that wood chip carriers, like container vessels, characteristically reach capacity in terms of volume before they reach their design drafts. Review of 2002–2006 data showed that the load patterns were the same as for 1998–2001. The nature of wood chip cargo suggests it is unlikely that the current fleet could be loaded to depths greater than 40 feet, and therefore, deepening benefits were not calculated for wood products. Discussion with industry representatives confirmed this.

Liquefied Natural Gas Fleet

Discussion with industry representatives and review of the vessels on order revealed that LNG vessels with design drafts of 40 feet or more are being constructed. Table V-25 displays the world LNG fleet, including vessels on order.

V.D 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 based on review from IWR Report 91-R-13, *National Economic Development Procedures Manual Deep-draft Navigation* (1991) and consultation with SNWW industry and pilots association. The IWR (1991) cargo capacity factors published in the deep-draft manual

for dry bulk carriers and tankers are shown in Table V-26. Consultation with industry and the pilots revealed that these estimates are reasonable. Table V-27 presents representative round trip mileage for the trade routes or junction points used for the transportation savings computations.

Table V-25
World Liquefied Natural Gas Fleet

Year Built	DWT Total	Percent of DWT	DWT	Length of Ship (feet)	Beam (feet)	Design Draft feet)
Constructed Between 1980–2002 (Average Vessel Dimensions)						
1980–1990	1,742,877	25.6	69,715	910	142	38
1991–2002	5,064,932	74.4	67,532	889	144	37
Total	6,807,809	100.0				
Vessels Constructed After 2002 (Average Vessel Dimensions)						
Design Draft Range (feet)	Total DWT	Percent of DWT	DWT	Length of Ship (feet)	Beam (feet)	Design Draft (feet)
36.6 to 39.9	2,868,168	66	74,852	927	147	38
40.0 to 41.1	1,453,796	34	77,750	930	144	41
Total	4,321,964	100.0				
Vessels on Order 2007 (Average Vessel Dimensions)						
Design Draft Range (feet)	Total DWT	Percent of DWT	DWT	Length of Ship (feet)	Beam (feet)	Design Draft (feet)
21 to 30	83,242	0.7	8,200	450	98	24
35 to 41	230,250	1.8	58,900	825	127	38
37 to 41	5,516,514	43.9	74,400	945	145	39
37 to 40	2,102,350	16.7	83,000	928	142	38
39 to 45	3,129,719	24.9	100,000	1,033	164	45
39 to 45	1,499,200	11.9	125,600	1,132	176	39
Total	12,561,275	100.0				

Table V-26
Adjustments for Estimating Actual Vessel Capacity

Vessel DWT	Dry Bulk	Tanker
<20,000	0.90	0.90
20,000–70,000	0.92	0.92
70,000–120,000	0.95	0.95
120,000	0.97	0.97

Source: USACE (1991).

Table V-27
Representative Round Trip Mileage to SNWW

Location	Total Miles
Coatzacoalcos, Mexico	1,376
U.S. Gulf Coast Lightering/Lightening Zone	160
Venezuela	3,612
Panama Canal	3,120
Brazil (Maceio/Sao Paulo weighted average)	9,422
Rotterdam, Netherlands	10,040
Sture, Norway	10,528
North Africa, Algiers	10,294
West Africa (Nigeria and Angola)	12,500
Persian Gulf and Indian Subcontinent via Suez Canal	19,704
Persian Gulf and Indian Subcontinent via Cape of Good Hope	25,112
Singapore via Panama Canal	24,248
Singapore via Cape of Good Hope	26,304

Vessel Operating Costs

The vessel operating costs are shown in tables V-28 through V-30. Table V-28 displays the hourly operating costs for tankers. The hourly operating costs include fuel, labor, and maintenance. The costs used were obtained from deep-draft vessel operating cost Economic Guidance Memorandum (EGM) December 2008 update (USACE, 2008a). The tanker costs were used for the crude petroleum, petroleum product, and chemical product transportation cost calculations. The maximum sized vessels using the channel to Beaumont on a regular basis are in the 150,000 DWT class. The maximum size using the Taylor Bayou Port Arthur facilities are in the 110,000 to 116,000 DWT range. As previously noted, the Port Arthur fleet is smaller, in terms of DWT, because the existing width at the mouth of Taylor Bayou limits the allowable vessel size. The U.S. flag tanker costs contained in Table V-28 were used for U.S. coastwise product movements. Table V-29 displays the foreign flag bulk carrier operating costs that were used for the grain exports and imports of iron ore, metal products, limestone, and rock. Table V-30 displays the LNG vessel operating costs. The LNG costs were estimated in consultation with the IWR.

The LNG design vessel used by the ERDC for the ship simulations consisted of a 140,000 cubic meter spherical-tank-type vessel 920 feet long, 142 feet wide, and 37.4 feet in draft, and a proposed 250,000-cubic-meter membrane-type tanker 1,126 feet long, 177 feet wide, and 39.4 feet in draft. The LNG facilities are in the Sabine Pass Channel and Port Arthur reaches. The project design vessel for crude petroleum tankers using the Entrance Channel and going to Beaumont is 899 feet long and 164 feet wide. These dimensions correspond to a 158,000 DWT crude petroleum tanker.

Table V-28
Tanker Characteristics and Hourly Operating Cost
Double-Hull Tankers, December 2008 IWR Release

Vessel DWT	Design Draft (feet)	Immersion Factor	Hourly Cost ($) Foreign-Flag At Sea	Foreign-Flag In Port	U.S. Flag At Sea	U.S. Flag In Port
20,000	32.3	78.7	659	403	1,470	1,214
25,000	33.4	90.8	696	430	1,565	1,300
35,000	35.6	112.6	766	481	1,747	1,463
50,000	38.7	141.4	865	554	2,005	1,693
60,000	40.7	158.9	952	622	2,239	1,909
70,000	42.6	175.4	1,001	653	2,354	2,007
80,000	44.6	191.0	1,058	692	2,496	2,130
90,000	46.4	205.9	1,107	724	2,610	2,226
110,000	50.0	234.1	1,192	772	2,793	2,374
150,000	56.4	285.4	1,369	878	3,190	2,700
165,000	58.6	303.4	1,439	922	3,350	2,833
175,000	70.3	410.7	1,485	951	4,400	3,707
265,000	73.2	444.5	1,900	1,207	4,764	4,010
320,000	74.5	463.3	2,061	1,306	4,971	4,182

Source: USACE (2008a).

Table V-29
Dry Bulk Carrier Characteristics and Hourly Operating Cost
Foreign Flag Dry Bulk Carriers, December 2008 IWR Release

Vessel DWT	Design Draft (feet)	Immersion Factor	Hourly Cost ($) At Sea	Hourly Cost ($) In Port
60,000	42.1	153.5	807	552
70,000	44.1	168.6	847	578
80,000	46.0	183.7	886	603
90,000	47.7	197.4	940	643
100,000	49.4	211.1	994	683
120,000	52.3	236.5	1,092	754
135,000	54.2	254.2	1,236	857
150,000	56.1	271.8	1,236	857
175,000	58.9	299.2	1,355	942

Source: USACE (2008a).

Table V-30
Liquefied Natural Gas Carriers
Characteristics and Hourly Operating Cost (December 2008 Vessel Costs)

Vessel DWT	Design Draft (feet)	Cubic Meters Capacity	Immersion Factor	Hourly Cost ($)	
				At Sea	At Sea
76,500	37	145,000	248.7	1,773	1,506
100,000	39	210,000	315.2	2,073	1,753
125,000	40	250,000	358.1	2,302	1,937
125,000	40	265,000	372.4	2,423	2,039

For the transportation cost calculations, an average of 1 foot of underkeel clearance was used for petroleum vessels. Based on industry input, a 4- to 6-foot underkeel clearance was used for LNG vessel. The indication from pilot discussion was that an absolute minimum of 4 feet underkeel clearance would be required; and the preference was for 6 feet. The effects of varying underkeel clearance are addressed in detail in the sensitivity section of the Economic Appendix (Appendix 2).

Transportation Savings Benefits for Channel Deepening

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. As previously noted, long-term fleet selection would continue to reflect goals of minimizing vessel operating costs. The basic procedure used to calculate transportation costs using 110,000- and 150,000-DWT foreign flag tankers as an example is illustrated in Table V-31. Similar computations were made for appropriate distances and vessel sizes for each of the channel depth alternatives. The resulting costs-per-ton computations were calculated over the relevant range of vessels projected for each channel depth improvement, and the associated savings per ton were measured using the net differences in costs between the existing 40-foot channel and the depth alternative. Unless otherwise noted, the 2019–2069 tonnage forecasts used for the benefit calculations were summarized in tables V-10 and V-11.

Crude Petroleum Imports Transportation Savings Benefits

The transportation costs used to calculate the benefits for crude petroleum imports are presented in Table V-32. The per-ton transportation costs correspond to the least-cost method of shipment associated with the particular trade route. Review of the depths at trading ports and significant savings per ton indicates that a large share of crude petroleum tonnage from Mexico, Venezuela, and Trinidad would be loaded to vessel drafts over 40 feet. Expectations concerning the percentage of Middle East and Africa movements are subject to greater uncertainty. Nearly all Middle East tonnage is lightered and nearly all West Africa crude is lightened. The logistics associated with these offshore transfers introduces higher degrees of uncertainty than with direct shipment and, therefore, generates large cost variances.

Table V-31
Transportation Cost Calculation (South America to SNWW)

Channel Depth (feet)	40	45	50	40	45	50
Vessel Deadweight Tons	110,000	110,000	110,000	150,000	150,000	150,000
Design Draft (feet)	50.0	50.0	50.0	56.4	56.4	56.4
Cargo Capacity (%)*	95	95	95	97	97	97
Cargo Capacity (short tons)*	104,500	104,500	104,500	145,500	145,500	145,500
Immersion Factor (tons per inch)	234.1	234.1	234.1	285.4	285.4	285.4
Hourly Cost at Sea (from EGM) ($)	1,192	1,192	1,192	1,369	1,369	1,369
Underkeel Clearance (feet)**	1	1	1	1	1	1
Hourly Cost in Port (from EGM) ($)	772	772	772	878	878	878
Round Trip Mileage from South America**	5,627	5,627	5,627	5,627	5,627	5,627
Speed (Knots)	15	15	15	15	15	15
Total Voyage Cost ($)	447,127	447,127	447,127	513,521	513,521	513,521
Other Components (Loading and Unloading and Port Time)						
Maximum Load at Channel Depth	73,599	87,645	101,691	85,908	103,032	120,156
Cost Per Ton for Sea Voyage ($)	6.08	5.10	4.40	5.98	4.98	4.27
Loading/Unloading Rate (short tons/hour)	5,250	5,250	5,250	5,250	5,250	5,250
Hours in Port	30	30	30	30	30	30
Total Loading Cost at Foreign Port ($)	23,160	23,160	23,160	26,340	26,340	26,340
Total Unloading Cost SNWW ($)	23,160	23,160	23,160	26,340	26,340	26,340
Pilot and Tug Costs ($)	45,501	48,624	51,031	56,923	60,331	62,908
Total Loading, Unloading, and Port Costs ($)	91,821	94,944	97,351	109,603	113,011	115,588
Total Cost Sum ($)	538,948	542,072	544,478	623,124	626,532	629,109
Total Cost Per Ton ($)	7.32	6.18	5.35	7.25	6.08	5.24

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

**Weighted mileage based on distance from Venezuela and Brazil. The weight factor of 0.7 was used for Venezuela, and a factor of 0.3 was used for Brazil. The weights were determined based on the expected percentage of tonnage by origin.

Additionally, and as Table V-32 illustrates, the cost savings for offshore transfer is lower than with direct shipment; however, distinct cost savings are apparent. The savings for lightering results from increases in shuttle loads due to greater channel depth in SNWW. For lightering, the effect of increasing channel depths at SNWW allows for the reduction in the number of shuttles necessary to totally lighter VLCC. The savings for lightened movements results from decreases in offshore unloading time from the mother vessel to shuttles. For lightening, the mother vessel is substituting offshore unloading time for dock-side unloading time. Additionally, the shuttle vessel reduces its overall loading and unloading time.

Table V-32
SNWW Crude Petroleum Imports Transportation Cost and Savings
Most Likely Transportation Mode Trade Route and Channel Depth (December 2008 Vessel Costs)

Trade Route/Depth (feet) and Method of Shipment	40	45	46	47	48	49	50
Mexico	Direct	Direct	Direct	Direct	Direct	Direct	Direct
Cost/ton Beaumont	2.76	2.34	2.28	2.21	2.15	2.11	2.07
Cost/ton Port Arthur	2.77	2.37	2.30	2.23	2.18	2.14	2.11
Savings/ton Beaumont		0.41	0.48	0.55	0.60	0.65	0.69
Savings/ton Port Arthur		0.41	0.47	0.54	0.59	0.63	0.67
Venezuela	Direct	Direct	Direct	Direct	Direct	Direct	Direct
Cost/ton Beaumont	7.22	6.09	5.91	5.73	5.58	5.45	5.34
Cost/ton Port Arthur	7.28	6.17	5.98	5.81	5.67	5.55	5.47
Savings/ton Beaumont		1.13	1.31	1.49	1.64	1.77	1.88
Savings/ton Port Arthur		1.11	1.30	1.47	1.62	1.73	1.81
Africa/North Sea	Lightered	Lightered	Lightered	Lightered	Lightered	Lightered	Lightered
Cost/ton Beaumont	8.41	8.18	8.13	8.12	8.05	8.01	8.01
Cost/ton Port Arthur	8.46	8.19	8.13	8.12	8.12	8.11	8.08
Savings/ton Beaumont		0.23	0.28	0.30	0.36	0.40	0.40
Cost/ton Port Arthur		0.27	0.33	0.34	0.35	0.35	0.39
Middle East	Lightered	Lightered	Lightered	Lightered	Lightered	Lightered	Lightered
Cost/ton Beaumont	14.43	14.20	14.15	14.13	14.06	14.03	14.03
Cost/ton Port Arthur	14.48	14.19	14.13	14.11	14.11	14.10	14.06
Savings/ton Beaumont		0.23	0.28	0.30	0.36	0.40	0.40
Savings/ton Port Arthur		0.29	0.35	0.36	0.37	0.38	0.42

Lightening generates comparatively lower savings than lightering because the latter produces the possibility of reducing the number of shuttles needed. Examination of the cost data also revealed that as channel depth increases the resulting savings may provide incentive to switch from lightening to direct shipment for movements from Africa and the North Sea. Table V-33 presents the lightening costs and Table V-34 presents the lightering costs. Historically, lightening was the most common choice for Africa and the North Sea movements; however, lightering has become more common for this route in recent years due to structural changes in oil production of the coast off West Africa. Lightering has always been

the method of choice for Middle East movements. The small percentage of North Sea using SNWW tends to be lightered, and an increasing portion of West Africa crude is lightered. Lightering was assumed to represent the without- and with-project future choice for West Africa crude due to its relative low cost and increasing popularity.

Table V-33
SNWW Crude Petroleum Imports
Lightened Cost per Ton by Channel Depth and Trade Route (December 2008 Vessel Costs)

	Channel Depth and Vessel DWT						
	40 feet	45 feet	46 feet	47 feet	48 feet	49 feet	50 feet
Mother Vessels (DWT)							
Minimum	150,000	150,000	162,500	162,500	162,500	162,500	162,500
Maximum	175,000	175,000	175,000	175,000	175,000	175,000	175,000
Shuttle Vessels (DWT)							
Minimum	72,000	57,000	57,000	57,000	57,000	57,000	57,000
Maximum	85,000	68,000	65,000	65,000	65,000	65,000	65,000
Africa and North Sea	Per Ton Transportation Cost ($) to SNWW						
Minimum	10.10	10.08	10.08	10.08	10.08	10.08	10.08
Mean	10.56	10.49	10.49	10.49	10.49	10.49	10.49
Maximum	11.02	10.90	10.90	10.90	10.90	10.90	10.90
Middle East	Per Ton Transportation Cost ($) to SNWW						
Minimum	14.70	14.68	14.68	14.68	14.68	14.68	14.68
Mean	15.17	15.10	15.10	15.10	15.10	15.10	15.10
Maximum	15.63	15.51	15.51	15.51	15.51	15.51	15.51

Table V-34
SNWW Crude Petroleum Imports
Lightering Cost per Ton by Channel Depth Alternative and Trade Route (December 2008 Vessel Costs)

Depth	40 feet	45 feet	46 feet	47 feet	48 feet	49 feet	50 feet
Africa and North Sea per Ton Transportation Cost ($)							
Minimum	8.31	8.16	8.04	8.02	8.00	7.90	7.89
Mean	8.41	8.18	8.13	8.12	8.05	8.01	8.01
Maximum	8.66	8.53	8.51	8.28	8.26	8.26	8.26
Middle East per Ton Transportation Cost ($)							
Minimum	14.33	14.17	14.06	14.04	14.02	13.92	13.91
Mean	14.43	14.20	14.15	14.13	14.06	14.03	14.03
Maximum	14.68	14.55	14.52	14.30	14.27	14.27	14.27

Tables V-35 and V-36 display Beaumont and Port Arthur's transportation cost savings based on the least-cost shipping methods displayed in Table V-32. For Port Arthur, the maximum vessel DWT used for the benefit calculations is less than 120,000 DWT. As previously noted, deepening of the channel leading to the Taylor Bayou terminal would enable the existing fleet to be more fully loaded but it would not result in transition to larger vessels. The transportation savings calculation costs shown in tables V-35 and V-36 reflect continuation of this limitation. As previously noted, the 2019–2069 tonnage forecasts used in the

benefit calculations are presented in tables V-10 and V-11. The specific tonnage volumes used for the benefit calculations are presented in the Economic Appendix.

Table V-35
Beaumont Crude Petroleum Imports
Annual Transportation Savings ($1,000s) by Trade Route and Decade (December 2008 Vessel Costs)

Channel Depth Alternative/ Trade Route	2002/2004	2019	2029	2039	2049	2059	2069
			(all costs in dollars)				
45-foot Channel							
Mexico	6,065	3,227	3,597	3,808	3,870	3,945	4,235
Central/South America	8,348	14,216	15,850	16,779	17,052	17,380	18,660
Europe and Africa	2,021	6,842	7,629	8,076	8,207	8,365	8,981
Middle East	5,879	6,402	7,138	7,556	7,679	7,827	8,403
Total Savings	22,313	30,686	34,214	36,219	36,808	37,516	40,280
46-foot Channel							
Mexico	7,089	3,771	4,205	4,451	4,524	4,611	4,950
Central/South America	9,724	16,558	18,461	19,543	19,861	20,243	21,735
Europe and Africa	2,431	8,230	9,176	9,714	9,872	10,062	10,803
Middle East	7,071	7,700	8,585	9,088	9,236	9,414	10,107
Total Savings	26,315	36,259	40,427	42,796	43,493	44,329	47,595
47-foot Channel							
Mexico	8,051	4,283	4,775	5,055	5,137	5,236	5,622
Central/South America	11,016	18,758	20,914	22,140	22,500	22,933	24,623
Europe and Africa	2,566	8,687	9,685	10,253	10,420	10,620	11,403
Middle East	7,464	8,128	9,062	9,593	9,749	9,937	10,669
Total Savings	29,097	39,856	44,437	47,041	47,807	48,726	52,316
48-foot Channel							
Mexico	8,867	4,717	5,259	5,567	5,658	5,767	6,192
Central/South America	12,147	20,684	23,062	24,413	24,810	25,288	27,151
Europe and Africa	3,162	10,705	11,935	12,635	12,840	13,087	14,052
Middle East	9,198	10,016	11,167	11,821	12,014	12,245	13,147
Total Savings	33,373	46,121	51,423	54,437	55,323	56,387	60,541
49-foot Channel							
Mexico	9,549	5,080	5,664	5,996	6,093	6,210	6,668
Central/South America	13,093	22,295	24,858	26,315	26,743	27,258	29,266
Europe and Africa	3,490	11,816	13,175	13,947	14,174	14,447	15,511
Middle East	10,153	11,056	12,327	13,049	13,261	13,516	14,512
Total Savings	36,285	50,247	56,023	59,307	60,272	61,431	65,957
50-foot Channel							
Mexico	10,171	5,411	6,033	6,386	6,490	6,615	7,102
Central/South America	13,900	23,669	26,390	27,937	28,391	28,937	31,069
Europe and Africa	3,490	11,816	13,175	13,947	14,174	14,447	15,511
Middle East	10,153	11,056	12,327	13,049	13,261	13,516	14,512
Total Savings	37,714	51,952	57,924	61,319	62,317	63,515	68,195

Table V-36
Port Arthur Crude Petroleum Imports
Annual Transportation Savings ($1,000s) by Trade Route and Decade
(December 2008 Vessel Costs)

Channel Depth Alternative/ Trade Route	2002/2004	2019	2029	2039	2049	2059	2069
			(all costs in dollars)				
45-foot Channel							
Mexico	3,355	484	539	573	584	596	611
Central/South America	399	2,128	2,370	2,514	2,560	2,611	2,745
Europe and Africa	128	1,214	1,353	1,437	1,466	1,496	1,532
Middle East	299	1,194	1,331	1,414	1,442	1,471	1,507
Total Savings	4,180	5,020	5,594	5,937	6,053	6,174	6,395
46-foot Channel							
Mexico	3,928	567	631	670	684	698	715
Central/South America	465	2,481	2,764	2,931	2,985	3,044	3,201
Europe and Africa	154	1,467	1,635	1,736	1,771	1,807	1,851
Middle East	365	1,461	1,628	1,729	1,764	1,800	1,844
Total Savings	4,913	5,976	6,659	7,067	7,205	7,349	7,611
47-foot Channel							
Mexico	4,468	644	718	763	778	794	813
Central/South America	527	2,813	3,134	3,324	3,385	3,452	3,629
Europe and Africa	160	1,527	1,702	1,807	1,843	1,881	1,927
Middle East	382	1,528	1,703	1,808	1,845	1,882	1,928
Total Savings	5,537	6,512	7,256	7,701	7,851	8,008	8,297
48-foot Channel							
Mexico	4,908	708	789	838	855	872	893
Central/South America	580	3,094	3,446	3,655	3,722	3,796	3,991
Europe and Africa	163	1,550	1,728	1,835	1,872	1,910	1,957
Middle East	389	1,554	1,732	1,840	1,877	1,915	1,962
Total Savings	6,039	6,906	7,695	8,167	8,325	8,492	8,802
49-foot Channel							
Mexico	5,242	756	843	895	913	931	954
Central/South America	620	3,306	3,683	3,906	3,978	4,057	4,265
Europe and Africa	165	1,567	1,746	1,854	1,891	1,930	1,977
Middle East	393	1,573	1,753	1,861	1,899	1,937	1,985
Total Savings	6,420	7,201	8,024	8,516	8,681	8,855	9,181
50-foot Channel							
Mexico	5,501	793	884	939	958	977	1,001
Central/South America	649	3,461	3,856	4,089	4,165	4,247	4,465
Europe and Africa	182	1,730	1,928	2,048	2,089	2,131	2,184
Middle East	439	1,756	1,958	2,079	2,121	2,164	2,217
Total Savings	6,771	7,741	8,626	9,155	9,332	9,519	9,866

Petroleum and Chemical Product Transportation Savings Benefits

Reductions in the vessel operating costs for SNWW foreign petroleum product import and exports and coastwise shipments 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 were calculated for vessels that minimize transportation costs given trade route constraints. Again, long-term fleet selection would continue to reflect goals of minimizing vessel-operating costs. Table V-37 displays the annual transportation costs for Beaumont's petroleum and chemical product imports and exports. Table V-38 summarizes the annual transportation savings benefits for Port Arthur's petroleum and chemical product imports and exports. Table V-39 summarizes the annual transportation savings benefits for Beaumont's and Port Arthur's petroleum and chemical product imports and exports.

Table V-40 summarizes the benefit calculations for coastwise product shipments. As noted, deepening of the channel leading to the Taylor Bayou terminal would enable the existing fleet to be more fully loaded, but it would not result in transition to larger vessels. The transportation savings shown in Table V-40 reflect continuation of this limitation. The maximum sized coastwise vessels do not exceed Taylor Bayou's limitation.

Grain Exports Transportation Savings Benefits

Beaumont wheat exports comprise 5 percent of the current U.S. total. Forecast of future exports were estimated based on analysis of USDA's February 2009 forecast. Per ton transportation costs were estimated based on exports shipped from Beaumont to Europe and the Mediterranean. The per ton transportation costs are presented in Table V-41. The transportation costs by channel depth alternative are presented in Table V-42.

Reductions in the vessel-operating costs for SNWW steel slab and iron ore imports were calculated based on the relative difference in transportation costs between the without- and with-project conditions. As with the previous presentations, transportation costs and savings were calculated for vessels that minimize transportation costs given trade route constraints. Again, long-term fleet selection would continue to reflect goals of minimizing vessel-operating costs. Port Arthur's breakbulk terminal is located outside the Taylor Bayou reach and the bulk carriers are not subject to the beam and length limitations. However, the maximum beam width for the bulk carrier fleet is 106 feet. The design drafts for these vessels are generally less than 45 feet. The DWT range of bulk carriers used for the benefit calculations is 60,000 to 99,999. Larger vessels could be used but are not anticipated over the next 20 years. The maximum size presently being used is 78,000 DWT. The transportation savings calculations were based on average costs for the anticipated 60,000 to 99,999 DWT range. As previously noted, the tonnage forecast and average annual growth rate for 2002–2004 to 2069 tonnage growth was displayed in tables V-10 and V-11.

Table V-37
Beaumont Petroleum and Chemical Product Imports and Exports
Annual Transportation Cost ($1,000) by Trade Route and Decade
(December 2008 Vessel Costs)

	2004/2006	2019	2029	2039	2049	2059	2069
40-foot Channel							
Imports	12,810	14,840	24,440	27,850	31,205	34,967	39,187
Exports	17,347	28,367	43,489	54,111	61,328	69,310	78,463
Total Cost	30,157	43,207	67,928	81,962	92,533	104,278	117,650
45-foot Channel							
Imports	10,795	12,506	20,595	23,469	26,296	29,467	33,023
Exports	14,618	23,905	36,648	45,599	51,681	58,408	66,121
Total Cost	25,413	36,411	57,243	69,069	77,977	87,874	99,143
46-foot Channel							
Imports	10,465	12,123	19,965	22,752	25,492	28,565	32,013
Exports	14,171	23,174	35,527	44,205	50,100	56,621	64,098
Total Cost	24,636	35,297	55,492	66,956	75,592	85,186	96,111
47-foot Channel							
Imports	10,155	11,764	19,374	22,077	24,737	27,719	31,064
Exports	13,751	22,487	34,474	42,895	48,615	54,943	62,199
Total Cost	23,906	34,251	53,848	64,972	73,352	82,662	93,263
48-foot Channel							
Imports	9,885	11,451	18,859	21,491	24,080	26,983	30,239
Exports	13,386	21,890	33,558	41,755	47,324	53,484	60,547
Total Cost	23,271	33,341	52,418	63,246	71,404	80,467	90,786
49-foot Channel							
Imports	9,646	11,174	18,403	20,971	23,497	26,330	29,507
Exports	13,062	21,360	32,746	40,745	46,179	52,189	59,081
Total Cost	22,708	32,534	51,149	61,716	69,676	78,519	88,588
50-foot Channel							
Imports	9,438	10,933	18,005	20,518	22,989	25,761	28,869
Exports	12,779	20,899	32,039	39,864	45,181	51,062	57,805
Total Cost	22,217	31,831	50,044	60,382	68,170	76,822	86,674

Table V-38
Port Arthur Petroleum and Chemical Product Imports and Exports
Annual Transportation Cost ($1,000) by Trade Route and Decade (December 2008 Vessel Costs)

	2004/2006	2019	2029	2039	2049	2059	2069
40-foot Channel							
Imports	5,956	6,887	11,616	13,244	14,835	16,619	18,620
Exports	17,563	28,722	44,032	54,788	62,094	70,176	79,444
Total Cost	23,519	35,609	55,648	68,032	76,930	86,796	98,064
45-foot Channel							
Imports	5,039	5,826	9,826	11,204	12,550	14,059	15,751
Exports	14,858	24,297	37,249	46,347	52,529	59,366	67,205
Total Cost	19,896	30,123	47,075	57,551	65,079	73,425	82,957
46-foot Channel							
Imports	4,887	5,651	9,531	10,867	12,173	13,637	15,278
Exports	14,411	23,567	36,130	44,955	50,950	57,582	65,186
Total Cost	19,298	29,218	45,661	55,822	63,123	71,219	80,464
47-foot Channel							
Imports	4,745	5,486	9,253	10,551	11,818	13,240	14,833
Exports	13,991	22,881	35,077	43,645	49,466	55,905	63,287
Total Cost	18,736	28,367	44,331	54,196	61,285	69,144	78,121
48-foot Channel							
Imports	4,627	5,351	9,025	10,290	11,526	12,912	14,466
Exports	13,646	22,315	34,210	42,567	48,244	54,523	61,723
Total Cost	18,273	27,666	43,235	52,856	59,770	67,435	76,189
49-foot Channel							
Imports	4,529	5,237	8,832	10,071	11,281	12,637	14,158
Exports	13,355	21,840	33,481	41,659	47,215	53,361	60,408
Total Cost	17,884	27,076	42,314	51,730	58,496	65,998	74,566
50-foot Channel							
Imports	4,453	5,149	8,684	9,901	11,091	12,425	13,920
Exports	13,130	21,472	32,918	40,959	46,422	52,464	59,392
Total Cost	17,583	26,621	41,602	50,861	57,513	64,888	73,312

Table V-39
SNWW Petroleum and Chemical Products Annual Savings by Channel Depth Alternative, 2019–2069
($1,000s)

	2004–2006	2019	2030	2040	2050	2060	2069
SNWW Total Petroleum Product Imports							
45-foot	2,932.7	3,395.3	5,633.8	6,421.2	7,194.1	8,060.7	9,032.6
46-foot	3,414.3	3,952.9	6,559.0	7,475.7	8,375.5	9,384.5	10,516.0
47-foot	3,866.7	4,476.8	7,428.3	8,466.5	9,485.5	10,628.2	11,909.7
48-foot	4,253.7	4,924.8	8,171.6	9,313.7	10,434.6	11,691.6	13,101.4
49-foot	4,591.6	5,316.0	8,820.4	10,053.1	11,263.1	12,619.9	14,141.5
50-foot	4,876.2	5,645.5	9,366.5	10,675.5	11,960.4	13,401.2	15,017.1
SNWW Total Petroleum Product Exports							
45-foot	5,434.3	8,886.9	13,624.2	16,952.0	19,212.9	21,713.5	24,581.0
46-foot	6,327.9	10,348.1	15,864.3	19,739.3	22,371.9	25,283.7	28,622.7
47-foot	7,167.6	11,721.3	17,969.5	22,358.7	25,340.7	28,638.9	32,421.0
48-foot	7,878.6	12,884.2	19,752.2	24,576.9	27,854.6	31,480.1	35,637.3
49-foot	8,493.4	13,889.5	21,293.5	26,494.6	30,028.1	33,936.5	38,418.1
50-foot	9,000.1	14,718.2	22,563.8	28,075.3	31,819.6	35,961.1	40,710.2

Table V-40
SNWW Petroleum Product Coastwise Shipments and Receipts
Vessel Data, Base Tonnage, and Transportation Savings Benefit Summary
(December 2008 Vessel Costs)

Origin-Destination Data: U.S. East Coast to/from SNWW

Initial % of total outbound shipments:	10
Round trip mileage	3,000
Hourly Cost at Sea:	2,425
Hourly Cost in Port:	2,007
Vessel Speed (Knots)	14

Vessel Input Data and Transportation Cost

Channel Depth (feet)	Design Draft (feet)	Vessel DWT	No. of feet Light-Loaded	Cargo by Channel Depth	Round Trip Voyage Cost ($)	Loading, Unloading and Port Cost ($)	Total Cost ($)	Cost Per Ton ($)
40	45	75,000	6	58,571	519,643	124,110	643,753	10.99
45 to 50	45	75,000	1	69,173	519,643	124,110	641,908	9.64
							Saving/ton	1.36

SNWW Domestic Coastwise Petroleum Product Tonnage

Year	Total Short Tons	Short Tons Used for Benefits
2004–2006 Average	5,068,000	506,800

SNWW Domestic Coastwise Petroleum Product Annual Transportation Benefits

Year	Total Tonnage	Used for Benefits	Percentage Used for Benefits	Annual Savings ($)
2002–2004	5,067,667	506,767	10	687,121
2019	7,901,200	790,120	10	1,071,317
2029	9,878,897	987,890	10	1,339,472
2039	11,856,594	1,185,659	10	1,607,626
2049	13,834,291	1,383,429	10	1,875,781
2059	15,811,988	1,581,199	10	2,143,935
2069	17,789,685	1,778,968	10	2,412,089

Table V-41
Beaumont Wheat Exports, Shipments to Europe, Mediterranean, and Far East
Total Cost per Ton by Channel Depth (December 2008 Vessel Costs)
(All costs in dollars)

	Channel Depth (feet)						
DWT	40	45	46	47	48	49	50
70,000	20.07	16.83	16.83	15.80	15.80	15.80	15.80
80,000	19.58	16.39	16.39	15.38	14.92	14.49	14.49
90,000	17.97	15.24	14.78	14.35	13.94	13.56	13.20
100,000	18.01	15.25	14.79	14.36	13.95	13.56	13.20
120,000	17.32	14.73	14.31	13.92	13.49	13.13	12.78

Table V-42
Beaumont Wheat Exports, Shipments to Europe, Mediterranean, and Far East
Total Cost ($1,000s) by Channel Depth (December 2008 Vessel Costs)

		Transportation Cost ($1,000s) by Channel Depth (feet)						
DWT	% by Vessel DWT	40	45	46	47	48	49	50
70,000	2.0	7,883	6,610	6,610	6,208	6,208	6,208	6,208
80,000	15.0	7,691	6,437	6,437	6,040	5,860	5,690	5,690
90,000	55.0	7,059	5,984	5,805	5,636	5,477	5,327	5,184
100,000	20.0	7,074	5,991	5,811	5,642	5,479	5,327	5,184
120,000	8.0	6,802	5,786	5,621	5,466	5,298	5,156	5,019
Weighted Cost		7,153	6,050	5,902	5,696	5,535	5,385	5,267
2005/2007 Savings			1,103	1,251	1,457	1,618	1,768	1,886

Annual Transportation Savings

	Transportation Savings ($1,000s) by Channel Depth (feet)					
Year	45	46	47	48	49	50
2005/2007	1,103	1,251	1,457	1,618	1,768	1,886
2019	1,793	2,033	2,369	2,630	2,874	3,065
2029	1,980	2,246	2,617	2,905	3,174	3,386
2039	2,187	2,480	2,890	3,209	3,506	3,740
2049	2,416	2,740	3,193	3,545	3,873	4,132
2059	2,669	3,027	3,527	3,916	4,278	4,564
2069	2,948	3,343	3,896	4,325	4,726	5,041

Table V-43 presents the cost-per-ton transportation cost for steel slab and iron ore. The costs shown are for Beaumont tonnage. The costs for Port Arthur would be approximately 1 percent less. Based on existing port depths and vessel utilization, an estimated 15 percent of tonnage was projected to use channel depths over 40 feet for the years prior to 2014. By 2014, the expansion of the Panama Canal is expected to result in the existing base tonnage from the deepwater port of Lazaro Cardenas on the West Coast of Mexico to load to vessel drafts over 40 feet. At that time, an estimated 50 percent of tonnage is anticipated to be loaded to vessel drafts over 40 feet. As outlined in the Economic Appendix (Table 48) 99 percent of sand and gravel 1999–2007 imports, 70 percent of limestone 1999–2007 imports, and 15 percent of 2005–2007 dry sulphur exports were shipped in vessels with design drafts of 40 feet or more. Review of the Lloyd's Register-Fairplay (2003) showed that 23 percent of bulk carriers constructed over the past decade are in the 66,000 to 78,000 DWT range. Table V-44 summarizes the annual transportation savings benefits for Beaumont's steel slab and iron ore import tonnage. Table V-45 summarizes the annual transportation savings benefits for Port Arthur's tonnage.

Table V-43
Beaumont Steel Slab and Iron Ore from South America, Mediterranean, and the Far East
(December 2008 Vessel Costs)

DWT	40	45	46	47	48	49	50
Transportation Cost ($)/Ton to Port Arthur							
60,000	17.63	14.60	14.13	13.66	13.66	13.66	13.66
70,000	15.60	13.08	12.68	12.29	12.29	12.29	12.29
80,000	15.22	12.74	12.35	11.96	11.60	11.26	11.26
90,000	14.12	11.95	11.60	11.25	10.94	10.63	10.35
Transportation Cost ($)/Ton to Beaumont							
60,000	18.35	15.22	14.73	14.23	14.23	14.23	14.23
70,000	16.23	13.63	13.22	12.80	12.80	12.80	12.80
80,000	15.84	13.29	12.89	12.49	12.12	11.77	11.77
90,000	14.70	12.47	12.12	11.77	11.44	11.14	10.84

The transportation cost calculations are based on a representative weighted mileage for the applicable South America, Mediterranean, and Far East routes. The weighted mileage is approximately 14,000 miles round trip. One of its greatest impacts would be felt in the breakbulk trade where expansion would enable larger vessels to transit the canal. Expansion of the canal project is expected to be completed in 2014. Completion of the Panama Canal expansion, from its present width restriction of 106 feet and approximate loaded draft limit of 39.6 feet, by the year 2014 would allow for more fully loaded vessel movements from deepwater ports in the Asia and the western coasts of Mexico and South America. The canal expansion would accommodate maximum loaded drafts of 15 meters or approximately 49 feet. Completion of the canal will coincides with port expansion projects in India and Chile. Steel is imported to SNWW from Dhamra. The Dhamra channel expansion will provide a channel depth of 18 meters, which can accommodate super cape-size vessels up to 180,000 DWT. Dhamra's master plan provides for 13 berths, capable of handling more than 83 million metric tons per annum of dry bulk, liquid bulk, breakbulk, and containerized cargo.

Table V-44
Beaumont Steel Slab and Iron Ore from South America, Mediterranean, and the Far East Tonnage and Annual Transportation Cost by Ton ($1,000) (December 2008 Vessel Costs)

Year	Total Exports	Used for Benefit Calculations
2001	103,000	
2002	204,000	
2003	115,000	
2004	420,000	
2005	471,000	
2006	364,000	
2007	173,000	
2019	428,221	213,254
2029	498,041	248,025
2039	579,247	288,465
2049	673,692	335,499
2059	783,537	390,201
2069	911,292	453,823

Transportation Cost ($) by Vessel Size and Channel Depth Using 2005–2007 Average Tonnage*							
	40	45	46	47	48	49	50
60,000	616	511	495	478	478	478	478
70,000	545	458	444	430	430	430	430
80,000	532	446	433	420	407	395	395
90,000	494	419	407	395	385	374	364
Average Cost	547	459	445	431	425	419	417
Average Savings		88	102	116	122	128	130

Transportation Savings ($) by Year*						
	45	46	47	48	49	50
2005/2007	88	102	116	122	128	130
2019	560	649	737	774	809	825
2029	652	755	857	900	941	960
2039	869	1,006	1,143	1,200	1,254	1,279
2049	1,175	1,360	1,546	1,623	1,697	1,730
2059	1,589	1,840	2,091	2,196	2,295	2,341
2069	2,150	2,489	2,828	2,970	3,105	3,166

*The costs are based on the 2005–2007 average tonnage volume multiplied by the cost per ton shown in Table V-43 for Beaumont.

Note: Application of data as presented may produce some differences due to rounding.

Table V-45
Port Arthur Steel Slab and Iron Ore from South America, Mediterranean, and the Far East Tonnage and Annual Transportation Cost by Ton ($1,000) (December 2008 Vessel Costs)

Year	Total Exports	Used for Benefit Calculations
2001	665,000	
2002	641,000	
2003	557,000	
2004	564,000	
2005	710,000	
2006	542,000	
2007	122,000	
2019	523,626	262,651
2029	607,630	304,787
2039	705,110	353,683
2049	818,228	410,423
2059	949,493	476,266
2069	1,101,817	552,671

Transportation Cost ($) by Vessel Size and Channel Depth Using 2005–2007 Average Tonnage*							
	40	45	46	47	48	49	50
60,000	616	511	495	478	478	478	478
70,000	545	458	444	430	430	430	430
80,000	532	446	433	420	407	395	395
90,000	494	419	407	395	385	374	364
Average Cost	547	459	445	431	425	419	417
Average Savings		88	102	116	122	128	130

Transportation Savings ($) by Year*						
	45	46	47	48	49	50
2005–2007	88	102	116	122	128	130
2019	560	649	737	774	809	825
2029	652	755	857	900	941	960
2039	869	1,006	1,143	1,200	1,254	1,279
2049	1,175	1,360	1,546	1,623	1,697	1,730
2059	1,589	1,840	2,091	2,196	2,295	2,341
2069	2,150	2,489	2,828	2,970	3,105	3,166

*The costs are based on the 2005–2007 average tonnage volume multiplied by the cost per ton shown in Table V-43 for Port Arthur.

Note: Application of data as presented may produce some differences due to rounding.

Limestone and Rock Transportation Savings Benefits

As with steel slab and iron ore, the DWT range of bulk carriers used for the aggregate rock benefit calculations are in the 60,000 to 90,000 DWT range. Larger vessels could be used but are not anticipated over the next 20 years. The maximum size presently being used is 78,000 DWT. The transportation savings calculations were based on average costs for the anticipated 60,000 to 90,000 DWT range. As with the previous presentations, transportation costs and savings were calculated for vessels that minimize transportation costs given trade route constraints. The DWT range of bulk carriers used for the benefit calculations are in the 60,000 to 90,000 range.

The applicable tonnage forecast and average annual growth rate for 2002–2004 to 2069 was contained in tables V-10 and V-11. Based on existing port depths and vessel utilization, an estimated 50 percent of tonnage was projected to use channel depths over 40 feet. A representative weighted mileage for the applicable Mexico, South America, Mediterranean, and Far East routes was used. The weighted mileage is approximately 14,000 miles round trip. Table V-46 presents the cost-per-ton transportation costs. The costs shown are for Port Arthur tonnage. The costs for Beaumont would be approximately 1 percent higher. Table V-47 summarizes the annual transportation savings benefits for Beaumont's import and SNWW export tonnage. Table V-48 summarizes the annual transportation savings benefits for Port Arthur's import tonnage. Port Arthur's share of bulk material exports has historically been low in comparison to Beaumont's, with Beaumont's recent historical share representing approximately 90 percent of the SNWW total. Due to the recent historical distribution, the benefit calculations were estimated using the average mileage for Beaumont and Port Arthur. For presentation purposes, the benefit calculations for exports are presented in Table V-47.

Table V-46
SNWW Crude Material Imports and Exports via Mexico, South America, Mediterranean, and Far East Cost per Ton (December 2008 Vessel Costs)

DWT	40	45	46	47	48	49	50
Transportation Cost ($)/Ton to Beaumont							
60,000	17.93	14.85	14.37	13.89	13.89	13.89	13.89
70,000	15.86	13.30	12.90	12.49	12.49	12.49	12.49
80,000	15.48	12.96	12.56	12.16	11.80	11.46	11.46
90,000	14.36	12.14	11.80	11.45	11.12	10.82	10.52
Transportation Cost ($)/Ton to Port Arthur							
60,000	17.85	14.78	14.31	13.83	13.83	13.83	13.83
70,000	15.79	13.25	12.84	12.44	12.44	12.44	12.44
80,000	15.41	12.90	12.51	12.11	11.75	11.41	11.41
90,000	14.30	12.09	11.75	11.40	11.08	10.77	10.48

Table V-47
Beaumont Imports and SNWW Exports of Crude Materials
Mexico, South America, Mediterranean and the Far East Tonnage and
Annual Transportation Cost by Ton
($1,000) (December 2008 Vessel Costs)

Year	Beaumont Imports	SNWW Exports	Total	Imports	Used for Benefit Calculations	
					Exports	Total
2001	622,000	165,000	787,000			
2002	394,000	16,000	410,000			
2003	583,000	93,000	676,000			
2004	559,000	145,000	704,000			
2005	624,000	120,000	744,000			
2006	550,000	297,000	847,000			
2007	617,000	485,000	1,102,000			
2019	760,862	383,193	1,144,055	364,453	57,287	728,906
2029	884,920	444,711	1,329,631	423,877	66,484	847,754
2039	1,029,206	517,220	1,546,426	492,990	77,324	985,980
2049	1,197,017	601,552	1,798,569	573,371	89,932	1,146,742
2059	1,392,189	699,635	2,091,824	666,858	104,595	1,333,716
2069	1,619,184	813,710	2,432,894	775,589	121,650	1,551,178

Transportation Cost ($) by Vessel Size and Channel Depth Using
2005–2007 Average Tonnage*

	40	45	46	47	48	49	50
60,000	807	669	647	625	625	625	625
70,000	714	599	581	563	563	563	563
80,000	697	584	566	548	531	516	516
90,000	647	547	531	515	501	487	474
Average Cost	716	600	581	563	555	548	544
Average Savings		117	135	154	161	169	172

Transportation Savings ($) by Year*

	45	46	47	48	49	50
2005/2007	117	135	154	161	169	172
2019	669	775	881	925	967	986
2029	777	899	1,022	1,073	1,122	1,144
2039	901	1,044	1,186	1,246	1,302	1,328
2049	1,046	1,211	1,376	1,446	1,511	1,541
2059	1,214	1,405	1,597	1,677	1,754	1,788
2069	1,408	1,631	1,853	1,947	2,035	2,075

*The costs are based on the 2005–2007 average tonnage multiplied by the cost per ton shown in Table V-46.

Note: Application of data as presented may produce some differences due to rounding.

Table V-48
Port Arthur Crude Material Imports from Mexico, South America, Mediterranean, and the Far East Tonnage and Annual Transportation Cost by Ton
($1,000) (December 2008 Vessel Costs)

Year	Total Imports	Used for Benefit Calculations
2001	131,000	
2002	919,000	
2003	481,000	
2004	531,000	
2005	558,000	
2006	566,000	
2007	513,000	
2019	712,739	356,370
2029	828,951	414,475
2039	964,110	482,055
2049	1,121,308	560,654
2059	1,304,136	652,068
2069	1,516,661	758,330

Transportation Cost ($) by Vessel Size and Channel Depth Using 2005–2007 Average Tonnage*

	40	45	46	47	48	49	50
60,000	1,022	846	819	792	792	792	792
70,000	904	758	735	712	712	712	712
80,000	882	739	716	693	672	653	653
90,000	819	692	672	653	634	617	600
Average Cost	907	759	736	712	703	693	689
Average Savings		148	171	194	204	213	218

Transportation Savings ($) by Year*

	45	46	47	48	49	50
2005–2007	148	171	194	204	213	218
2019	999	1,156	1,313	1,393	1,469	1,515
2029	999	1,156	1,313	1,393	1,469	1,515
2039	1,162	1,344	1,527	1,620	1,708	1,762
2049	1,352	1,564	1,776	1,884	1,987	2,049
2059	1,572	1,819	2,065	2,191	2,311	2,383
2069	1,828	2,115	2,402	2,548	2,687	2,772

*The costs are based on the 2005–2007 average tonnage multiplied by the cost per ton shown in Table V-46.

Note: Application of data as presented may produce some differences due to rounding.

Liquefied Natural Gas Transportation Savings Benefits

Table V-49 presents the trade route forecast used for the benefit calculations, Table V-50 presents the per-ton transportation cost, and Table V-51 presents the annual savings. The maximum loaded draft for LNG vessels is anticipated to be 40 to 42 feet. The majority of vessels would be loaded to 39 feet. The vessels will need from 3 to 6 feet of underkeel clearance. While the deepening benefits were believed to stop at an approximate channel depth of 43 feet, construction of LNG vessels with design drafts of 45 feet has taken place since 2007. The design drafts associated with 12 of the new vessels are identified to be in the 45-foot draft range (i.e., 13.6 meters).

Table V-49
SNWW Liquefied Natural Gas Trade Route Forecast, Short Tons

Year	Middle East	Trinidad	Algeria	Total
2019	1,946,522	1,940,695	1,940,695	5,827,913
2029	2,062,339	2,056,165	2,056,165	6,174,669
2039	2,062,340	2,056,165	2,056,165	6,174,670
2049	2,062,340	2,056,165	2,056,165	6,174,670
2059	2,062,340	2,056,165	2,056,165	6,174,670
2069	2,062,340	2,056,165	2,056,165	6,174,670

Table V-50
Liquefied Natural Gas Transportation Cost ($) per Ton by Channel Depth
Vessel DWT, and Shipment Origin (December 2008 Vessel Costs)

Vessel DWT	Middle East		Trinidad		Algeria	
	40	43	40	43	40	43
76,500	26.70	26.70	5.83	5.83	14.12	14.12
100,000	24.14	20.78	5.28	4.61	12.77	11.03
125,000	22.11	19.22	4.82	4.25	11.69	10.20

	Savings/Ton for 43 feet for SNWW Fleet		
DWT	Qatar	Trinidad	Algeria
100,000	3.36	0.67	1.74
125,000	2.89	0.57	1.49
Average	3.12	0.62	1.62

Table V-51
SNWW Liquefied Natural Gas Annual Transportation Savings ($) by Trade Route*
(December 2008 Vessel Costs)

Year	Middle East	Trinidad	Algeria	Total
2019	6,080,341	1,209,365	3,137,311	10,427,016
2029	6,442,118	1,281,321	3,323,978	11,047,417
2039	6,442,121	1,281,321	3,323,978	11,047,420
2049	6,442,121	1,281,321	3,323,978	11,047,420
2059	6,442,121	1,281,321	3,323,978	11,047,420
2069	6,442,121	1,281,321	3,323,978	11,047,420

*Savings are multiplied by tonnage (Table V-49) and savings (Table V-50). Totals are subject to rounding.

Summary of Channel Deepening Benefits

Table V-52 presents the transportation cost savings by major commodity group for channel deepening. The majority of benefits are associated with imports of crude petroleum, LNG, and petroleum product and exports of petroleum products. Crude petroleum and petroleum products represent 84 percent of the benefits at the 45-foot depth and 89 percent at the 50-foot depth. The LNG composes 7 percent of benefits at the 45-foot depth and 4 percent at 50 feet. The LNG benefits are for facilities in the Sabine Pass Channel and Port Arthur Canal reaches. Distributions of the Taylor Bayou, Port Arthur, and Neches River deepening benefits are presented in Tables V-53.

Table V-52
Total Average Annual Deepening Benefits ($1,000s)
(50-Year Period of Analysis at 4.375%)
by Project Depth Alternative
(December 2008 Vessel Costs)

	45	46	47	48	49	50
Crude Petroleum Imports	41,130	48,650	53,411	61,081	66,173	68,759
Petroleum Products Imports	5,923	6,896	7,810	8,591	9,273	9,848
Petroleum Products Exports	15,309	17,826	20,191	22,194	23,926	25,354
Coastwise	1,481	1,481	1,481	1,481	1,481	1,481
Grain Exports	2,172	2,463	2,870	3,187	3,482	3,714
Breakbulk	4,536	5,247	5,247	5,247	5,247	5,247
LNG	11,140	11,140	11,140	11,140	11,140	11,140
Deepening Benefits	81,691	93,703	102,150	112,921	120,722	125,543

Table V-53
Total Average Annual Benefits ($1,000s)
by Channel Reach and Alternative
(50-Year Period of Analysis at 4.375%) (December 2008 Vessel Costs)

Reach and Commodity	45	46	47	48	49	50
Sabine Pass LNG	3,676	3,676	3,676	3,676	3,676	3,676
Port Arthur LNG	7,464	7,464	7,464	7,464	7,464	7,464
Taylor Bayou						
Crude Petroleum Imports	5,790	6,892	7,510	7,964	8,305	8,928
Petroleum Product Imports	2,369	2,758	3,124	3,436	3,709	3,939
Petroleum & Chemical Product Exports	7,348	8,556	9,692	10,653	11,485	12,170
Coastwise Petro Products	563	563	563	563	563	563
Taylor Bayou Total	16,070	18,769	20,889	22,616	24,062	25,600
Sabine-Neches Canal						
Breakbulk and Aggregate	2,065	2,387	2,387	2,387	2,387	2,387
Neches River Channel to Beaumont						
Crude Petroleum Imports	35,340	41,759	45,901	53,117	57,868	59,832
Petroleum Product Imports	3,554	4,138	4,686	5,155	5,564	5,909
Petroleum & Chemical Product Exports	7,961	9,269	10,499	11,541	12,442	13,184
Coastwise Petroleum Products	918	918	918	918	918	918
Grain Exports	2,172	2,463	2,870	3,187	3,482	3,714
Breakbulk and Aggregate	2,471	2,860	2,860	2,860	2,860	2,860
Neches River Total	52,416	61,407	67,734	76,777	83,134	86,417

V.E CHANNEL WIDENING BENEFITS

The SNWW is currently subject to transit rules that are needed for the pilots to safely guide large tankers through the narrow channel. The waterway's high volume of inland barge and deep-draft vessel traffic exacerbates congestion and results in increased delays and accident probabilities. To address these problems, a range of alternatives was evaluated, including channel widening and sidings. The effect of the project alternatives would be to reduce delay frequencies and durations. An additional expectation would be reductions in accident probabilities. Benefits were not quantified for reductions in accidents because, while accident probabilities are high, rates are low. Traffic increases and associated congestion recognizably increase the probability of accidents; however, "avoidance behavior," in the form of delays characterized by the existing conditions, keeps accident rates low. This behavior provides the basis for the monetary benefits associated with the proposed project alternatives as the proposed modifications would reduce the duration and frequency of delays.

Reduction in delay benefits were calculated for channel widening and for holding area alternatives. The benefit estimates are based on comparison of transit times between project alternatives. Transportation costs for existing conditions, the without-project condition, and the project alternatives were calculated using 2004 SNWW traffic base. Vessel characteristics and related details were obtained from the USACE NDC detailed records.

In terms of channel width, there are three main traffic rules presently affecting vessel traffic. The traffic rules, which affect movements in the 400- and 500-foot project reaches, are instituted by the SPA for the purpose of helping to ensure safe navigation. The general categorization of the transit rules are daylight-only sailing restrictions applied in specific reaches for vessels that exceed certain DWT, length, and breadth criteria. There is no meeting during nighttime sailing for vessels exceeding a given draft limitation. No meeting during either day or night applied to vessels by DWT, length, breadth, draft combinations. The specific rules posted by the Sabine Pilots are displayed in Table V-54. The results of these rules provide for a safe channel and a relatively low accident rate. The rules also affect a significant portion of traffic in the form of vessel delays.

The HarborSym model was used in evaluation of the entrance channel widening and the Neches River TB and anchorage features. HarborSym is a planning-level model developed by IWR to assist in economic analyses of channel widening improvements. HarborSym is an event-driven simulation model and includes data from user-specified transit rules that the model processes with each vessel call in order to calculate delays within the system. The model is presently in the model certification process. While not yet certified, the model is scheduled for review under the USACE certification system. The model is presently being used by several USACE district offices for channel widening studies, and the outputs of these studies have undergone Agency Technical Review (ATR) and USACE headquarters review.

HarborSym outputs were crucial for aggregation and understanding of base condition delays. Pilot interviews were used to identify a wide range of information, including delay times. Vessel class-specific

delay times were obtained from the model output, with these inputs having been defined using pilot logs and extensive pilot interviews. The key element in modeling the harbor system was replicating transit rules as listed in Table V-54.

Table V-54
SNWW Pilot's Rules

General: Vessels 85,000 DWT or over, or greater than 875 feet in length and 125 feet in beam width will move during daylight hours only above the Texas Island intersection with the GIWW West. In the event that meeting situations are applicable but circumstances will not permit the utilization of turning basins, the following criteria will prevail:

1. Vessels with combined beam widths that equal or exceed one-half of the channel width will not meet day or night.
2. Vessels 48,000 metric DWT or more with a draft of 30 feet or more will not meet above Buoys 29 and 30.
3. Vessels ≥85,000 DWT will not meet vessels of either ≥30,000 DWT or ≥30-foot draft above Buoys 29 and 30.
4. Vessels ≥85,000 DWT will not meet vessels of either ≥30,000 DWT or ≥25-foot draft above the Texas Island intersection.
5. Vessels with a combined draft of 70 feet or more will not meet between the Neches River intersection and Day Beacon #40 (Smith Bluff) at night. Vessels with a combined draft of 65 feet or more will not meet above Day Beacon #40 at night.

Source: SPA (2007).

Benefits from reductions in delays were calculated for widening the 500-foot entrance channel sections to a project width of 700 feet. A 700-foot project width up to the junction of the Sabine-Neches Canal with Taylor Bayou would provide a consistent series of reaches for vessels to meet. Specifically, it would allow two-way traffic for vessels that cannot presently meet in the 500-foot sections of the reaches. The 700-foot reach does not presently cause the pilots to impose vessel-meeting restrictions. The portions of the channel that are presently 500 feet do result in vessel meeting restrictions. The delays associated with the 500-foot width are a problem.

Two-way traffic is not allowed for LNG tankers under either the without- or with-project future. Construction of the Sabine Pass terminal is presently complete and the first vessels arrived in April 2008. Construction of the Golden Pass LNG terminal is scheduled for completion in September 2010. Construction of the third permitted facility, Port Arthur, is anticipated after 2012. All LNG tankers would be subject to one-way traffic rules in spite of channel widening. The LNG facilities are located in the Sabine Pass Channel and Port Arthur Canal reaches; these reaches are presently 500 feet. The ERDC modeling that was performed under the direction of the permit applicants showed that 500 feet is adequate for one-way transits of LNG vessels. The LNG traffic would be affected by USCG rules limiting the distance of other vessels traveling before and after the LNG tanker. Delays resulting from LNG traffic would occur under both the without- and with-project conditions. Channel deepening and widening would decrease the duration and frequency of delays for LNG and all vessels affected by either pilot or USCG rules. The beam widths for the smallest LNG (i.e., 76,000 DWT) are in the 142- to 158-foot range.

In addition to widening the entrance channel reaches, widening of the Neches River Channel to Beaumont was also evaluated and modeled by the ERDC. The results of the ERDC modeling showed increasing the Neches River channel width from 400 to 500 feet was not sufficient for safe negotiation of vessel meeting. Furthermore, both the 500-foot width and more optimal widths necessary for two-way traffic would necessitate extensive dock modifications and land acquisition, and this cost was anticipated to greatly exceed the reduction in delays that it would afford.

As a less costly and more practical alternative to the Neches River widening, the Sabine Pilots suggested the use of "sidings" or "channel pull-overs" to help facilitate vessel meeting. At the present time, suggested sites are commonly referred to and used as TB. The TBs are presently used as "holding" or "waiting areas"; however, the depth and width of these areas do not accommodate the full range of larger tankers common on the SNWW. Again, the "holding areas" serve the dual function of TB. In spite of their depth and width limitations, the TB are presently used to facilitate turning small vessels and are also used to "tuck small vessels away" while other vessels move along the channel.

Vessel Traffic

Over 70 percent of SNWW's 1998–2007 crude petroleum tonnage was shipped in vessels of 90,000 DWT or larger, up by 30 percent since the early 1990s. The largest concentration of SNWW crude petroleum tonnage is in vessels between 90,000 and 119,999 DWT. Table V-55 displays SNWW's 1990–2004 crude oil import by vessel class.

Table V-56 presents 1990–2007 vessel trips by loaded draft for vessels. Analysis of the data showed that trips increased at an annual rate of 3.7 percent, with the highest rates of growth for 36 feet and greater. Total trips for drafts over 35 feet greater at an average annual rate of 7.3 percent, while trips for loaded drafts of 35 feet or less grew at 3.7 percent. For the period 1990–2007, total deep-draft tonnage grew at an average annual rate of 5.2 percent.

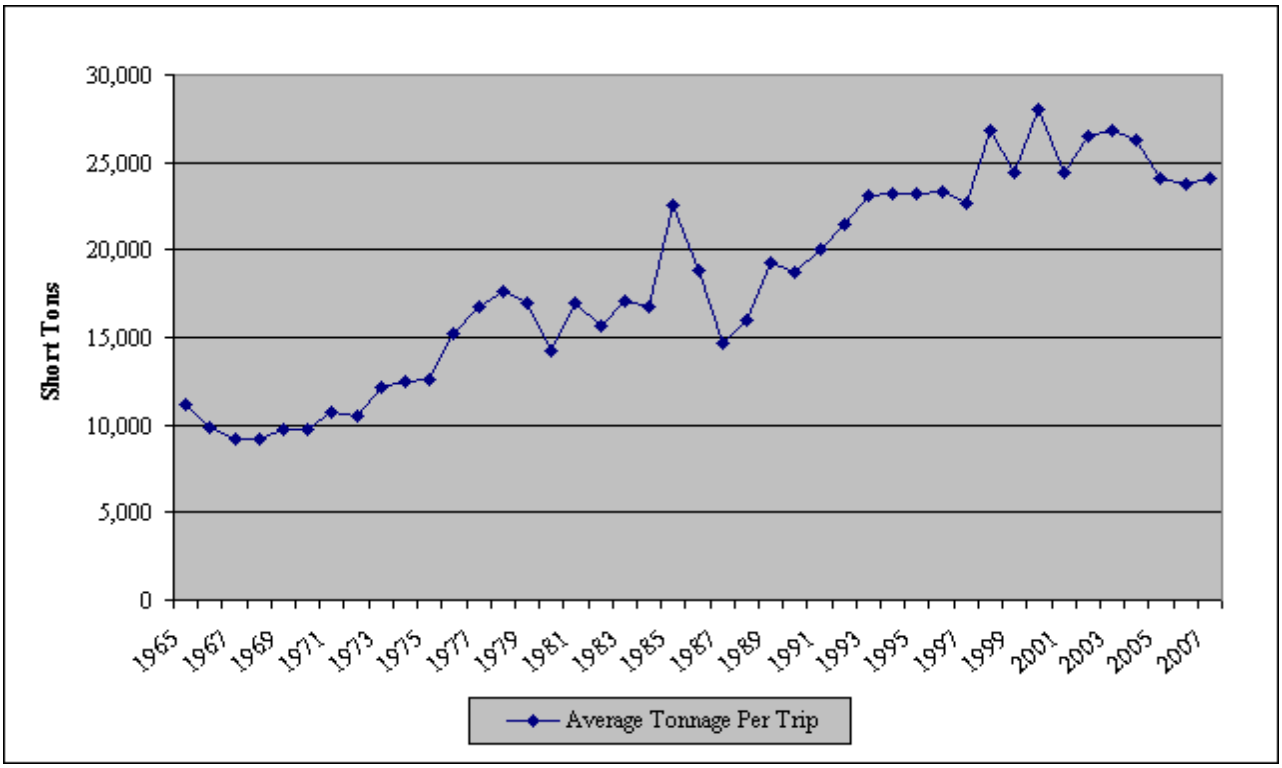
SNWW's vessel utilization patterns were also reviewed in terms of the average tonnage per trip for 1965–2007. Figure V-5 shows average tonnage per trip for oceangoing traffic. The graph shows trips increasing at a slightly decreasing rate and suggests an overall increase in average tonnage per trip. While the increases in the volume of tonnage per trip are primarily associated with crude petroleum and petrochemical products, larger vessels are being used for manufactured goods and crude materials. Since 1993, the volume of tonnage per vessel has increase as the variety of commodities using the waterway has diversified.

Table V-55
SNWW Crude Petroleum Imports,
Percentage of Imports by Vessel DWT,
and Design Draft and Year Built

DWT 1,000s	1993	1998	2002	2003	2004	2005	2006	2007
<50	0.6	0.1	0.1	0.4	0.8	1.6	0.9	0.8
50–74.5	3.8	1.2	8.5	3.1	1.7	1.8	3.4	3.7
75–84.9	18.4	8.1	8.6	18.1	20.4	18.0	25.0	23.0
85–89.9	17.3	10.6	9.9	4.6	0.5	0.0	0.3	0.0
90–119.9	56.0	72.1	65.6	65.8	67.8	71.8	63.8	66.3
120–149.9	1.9	2.7	2.8	2.7	3.3	3.0	2.0	1.7
150–175	2.0	5.2	4.5	5.3	5.5	3.8	4.6	4.5
Total	100.0	100	100.0	100.0	100.0	100.0	100.0	100.0

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

Figure V-5
Sabine-Neches Waterway
1965–2007
Average Tonnage per Trip for Ocean-Going Vessels



Source: USACE (2007a).

Table V-56
SNWW Trips by Loaded Draft (Includes Loaded and Light Vessels)

SNWW Total Inbound and Outbound Trips by Loaded Draft (feet)										
Year/feet	≥43	42	41	40	39	38	37	36	≤35	Total
1990	–	–	39	42	123	82	80	52	1,511	1,929
1993	2	–	–	115	77	214	209	155	1,261	2,033
1996	1	–	–	160	192	277	279	168	1,274	2,351
1999	–	1	–	117	139	276	142	172	1,987	2,834
2000	–	–	–	107	139	325	156	155	2,096	2,978
2001	1	–	–	124	168	324	175	173	2,090	3,055
2002	–	2	–	167	112	441	167	146	2,258	3,293
2003	1	–	1	289	114	347	158	175	2,364	3,449
2004	2	–	–	248	232	300	167	147	2,508	3,604
2005	–	–	–	206	154	312	189	178	2,410	3,449
2006	1	–	1	185	148	545	231	78	2,136	3,425
2007	–	–	2	178	271	263	136	143	2,380	3,373
Inbound Trips by Loaded Draft (feet)										
Year/feet	≥43	42	41	40	39	38	37	36	≤35	Total
1990	–	–	14	38	102	69	55	33	610	921
1993	1	–	–	56	37	108	104	78	642	1026
1996	1	–	–	80	95	140	139	83	627	1,165
1999	–	–	–	101	121	250	126	135	657	1,390
2000	–	–	–	86	110	289	127	113	689	1,414
2001	–	–	–	101	147	301	147	114	646	1,456
2002	–	–	–	141	97	382	145	108	714	1,587
2003	–	–	–	254	102	289	130	121	746	1,642
2004	1	–	–	230	207	260	141	96	993	1,721
2005	–	–	–	181	141	280	164	104	762	1,632
2006	–	–	1	164	133	514	192	94	567	1,666
2007	–	–	2	148	252	209	107	73	869	1,660
Outbound Trips by Loaded Draft (feet)										
Year/feet	≥43	42	41	40	39	38	37	36	≤35	Total
1990	–	–	25	4	21	13	25	19	901	1,008
1993	1	–	–	59	40	106	105	77	619	1,007
1996	–	–	–	80	97	137	140	85	647	1,186
1999	–	1	–	16	18	26	16	37	1,330	1,444
2000	–	0	–	21	29	36	29	42	1,407	1,564
2001	1	0	–	23	21	23	28	59	1,444	1,499
2002	–	2	–	26	15	59	22	38	1,544	1,706
2003	1	–	1	35	12	58	28	54	1,618	1,807
2004	1	–	–	18	25	40	26	51	1,515	1,883
2005	–	–	–	25	13	32	25	74	1,648	1,817
2006	–	–	–	21	15	31	39	84	1,569	1,759
2007	–	–	–	30	19	54	29	70	1,511	1,713

Source: USACE (2007a).

Examination of world trends showed that vessels are not only requiring deeper drafts but that there is an increased concentration of wider beams. Table V-57 displays SNWW 2000, 2001, and 2004 distributions of deep-draft vessels by vessel beam. The table helps illustrate the concentration of wide-beamed vessels. Vessel widths over 110 feet are generally associated with crude oil tankers. An effect of the growing concentration in wider-beam vessels using SNWW is more-difficult and subsequently more-dangerous vessel-meeting situations. The existing 500-foot channel is not wide enough for vessels with beams of 125 feet or more to meet comparable or larger-sized vessels. Project alternatives include channel widening and the construction of vessel holding areas. Widening to 700 feet would enable meetings between Panamax vessels, which have beams of 106 feet, and non-LNG tankers with beams of 144 feet or greater. The availability of several holding area improvements along the Neches River would allow loaded vessels to await berths and would save time that they originally would have spent in an inbound transit mode when the berth became clear. With the holding areas, vessels would only have to shift from the anchorage instead of waiting to sail from offshore.

Table V-57
SNWW Total Vessel Trips for Piloted Vessels

Vessel	2000		2001		2004	
Beam (feet)	Vessels	Percent	Vessels	Percent	Vessels	Percent
<95	619	34	659	37	528	23
100	91	5	128	7	230	10
106	273	15	292	16	367	16
115–134	219	12	238	13	253	11
135–144	565	31	475	26	804	35
145–154	36	2	18	1	46	2
>155	18	1	0	0	69	3
Total	1,821	100	1,810	100	2,297	100

Source: SPA (2005).

As input to the HarborSym model vessel trip estimate were prepared for the 2000–2004 period base and for 2030–2040 average trips. The vessel classes were established based on the HarborSym vessel structure. The coding sheet corresponding to the vessel class groupings is presented in Table V-58. The 2000–2004 period tonnage and the 2000–2004 fleet data used to define existing traffic patterns are presented in tables V-59 and V-60.

Tables V-61 through V-63 present the 2030–2040 period tonnage and trip data. Table V-61 presents the 2030–2040 period tonnage. Table V-62 presents 2030–2040 vessel trips based on no deepening. Table V-63 presents 2030–2040 vessel trips based on deepening. Comparison of the 2030–2040 tonnage and vessel transit data presented in tables V-62 and V-63 shows that the number of vessels for the "without-deepening scenario" is 12 percent higher than the number for the "with-deepening scenario." The effect of modifications to the Sabine Pass Channel and Port Arthur Canal reaches would be a change in the vessel pilot rules. The pilot expectations are that the effect of deepening and widening would be likely to result in vessels with loaded drafts of less than 40 feet being able to meet; however, vessels with loaded drafts

Table V-58
HarborSym Vessel Classes

		Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Total Calls
Bulk	Min Beam	0	76.1	105				
	Max Beam	76	104.9	107				
	# calls	46	143	59				248
	Min Capacity	0	25,001	34,000				
	Max Capacity	25,000	53000	78,000				
Chemical Tanker	Min Beam	0	76.1	105	130			
	Max Beam	76	104.9	107	138			
	# calls	102	76	131	1			310
	Min Capacity	0	25001	33000	85,000			
	Max Capacity	25,000	44000	49000	105,000			
General Cargo	Min Beam	0	76.1	104	120			
	Max Beam	76	103.9	107	142			
	# calls	125	58	16	3			202
	Min Capacity	0	25,001	42,000	75,000			
	Max Capacity	25,000	50,000	69,000	95,000			
LPG	Min Beam	0	76.1	115	140			
	Max Beam	76	107	120	150			
	# calls	15	16	1	1			33
	Min Capacity	0	25,001	60,000	157,000			
	Max Capacity	25,000	56,000	70,000	167,000			
MISC.	Min Beam	0	106					
	Max Beam	76	131					
	# calls	3	2					5
	Min Capacity	0	50,000					
	Max Capacity	25,000	70,000					
Oil Tanker	Min Beam	60	104.1	115	127.1	142		
	Max Beam	104	107	127	150	160		
	# calls	153	96	49	657	15		970
	Min Capacity	8,000	45,000	67,000	80,000	133,000		
	Max Capacity	56,000	73,000	97,000	113000	170,000		
Tank Barge	Min Beam	0	76.1					
	Max Beam	76	107					
	# calls	92	11					103
	Min Capacity	0	25,001					
	Max Capacity	25,000	50,000					
Tug	Min Beam	0	76.1					
	Max Beam	76	100					
	# calls	55	12					67
	Min Capacity	0	25,001					
	Max Capacity	25,000	50,000					
Total Calls	# calls	591	414	256	662	15		1,938
		30.5%	21.4%	13.2%	34.2%	0.8%		100.0%

Table V-59
SNWW 2000–2004 Base Tonnage (1,000s of Short Tons)*

	1,000s Tonnage by Vessel Class, 2000/2004 Base					
Type/Class Code	1	2	3	4	5	Total
Bulk	544.6	3,964.1	2,596.2	0.0	0.0	7,105.0
Chemical	733.9	1,583.9	2,950.9	96.7		5,365.5
General Cargo	705.3	418.6	190.6	24.1		1,338.7
LPG	147.3	235.0	1.7	2.9		386.9
Misc.	0.0	0.3				0.4
Oil Tanker	9,595.6	4,344.8	2,915.0	52,542.6	1,170.0	70,568.1
Tank Barge	1,306.3	138.6				1,444.9
Tug	17.6	153.1				170.7
LNG					5,777.0	5,770.0
Total	6,370.0	10,838.6	15,335.4	52,666.3	6,947.0	95,150.1

*LNG tonnage and vessels were included in the 2000–2004 HarborSym traffic analysis.

Table V-60
SNWW 2030–2040 Tonnage (1,000s of Short Tons)

	1,000s Tonnage by Vessel Class						
Type/Class Code	1	2	3	4	5	6	Total
Bulk	835	6,079	3,982	–	–	–	10,896
Chemical	1,231	2,656	4,949	162	–	–	8,998
General Cargo	1,155	685	312	40	–	–	2,191
LPG	235	376	3	5	–	–	618
Misc.	–	–	–	–	–	–	–
Oil Tanker	4,497	6,703	14,804	81,064	1,805	–	108,875
Tank Barge	2,284	270	–	–	–	–	2,553
Tug	–	1	–	–	–	–	1
LNG	–	–	–	–	5,777	–	5,777
Total	10,237	16,770	24,049	81,271	7,582	–	139,909

Table V-61
SNWW 2030–2040 Tonnage (1,000s of Short Tons)

	1,000s Tonnage by Vessel Class						
Type/Class Code	1	2	3	4	5	6	Total
Bulk	835.2	6,079.4	3,981.6	0.0	0.0	0	10,896.2
Chemical	1,230.8	2,656.2	4,948.5	162.2	0.0	0	8,997.7
General Cargo	1,154.5	685.3	312.1	39.5	0.0	0	2,191.4
LPG	235.4	375.6	2.8	4.6	0.0	0	618.4
Misc.	0.0	0.0	0.0	0.0	0.0	0	0.0
Oil Tanker	14,804.4	6,703.3	4,497.4	81,064.4	1,805.2	0	108,874.7
Tank Barge	2,283.5	269.8	0.0	0.0	0.0	0	2,553.3
Tug	0.3	0.3				0	0.6
LNG	0.0	0.0	0.0	0.0	12,073.3	0	12,073.3
Total	20,544.2	16,769.9	13,742.4	81,270.7	13,878.5	0	146,205.6

Table V-62
SNWW 2030–2040 Vessel Trips Without Deepening

	Vessel Trips by Vessel Class						
Type/Class	1	2	3	4	5	6	Total
Bulk	71	219	90	0	0	0	380
Chemical	171	127	220	2	0	0	520
General Cargo	205	95	26	5	0	0	331
LPG	24	26	2	2	0	0	53
Misc.	1	1	0	0	0	0	2
Oil Tanker	76	148	236	1,014	23	0	1,497
Tank Barge	145	17	0	0	0	0	163
Tug	87	19	0	0	0	0	105
LNG	0	0	0	0	119	0	119
Total	780	652	574	1,023	142	0	3,170

Table V-63
SNWW 2030–2040 Number of Vessel Trips With Deepening

	Vessel Trips by Vessel Class						
Type/Class	1	2	3	4	5	6	Total
Bulk	71	138	112	0	0	0	321
Chemical	171	80	210	6	0	0	467
General Cargo	205	60	41	7	0	0	312
LPG	24	14	7	3	0	0	48
Misc.	1	1	0	0	0	0	2
Oil Tanker	236	86	61	579	315	0	1,277
Tank Barge	145	17	0	0	0	0	162
Tug	87	19	0	0	0	0	105
LNG	0	0	0	0	119	0	119
Total	940	415	431	595	434	0	2,815

over 40 feet would be much more restricted. While the vessel pilots indicated that the effect of deepening would mean a loss of some of the gains in terms of relaxing rules 3–4 (see Table V-54), the combined effect of deepening and widening would result in a reduction in the number of trips necessary to transport a given volume of tonnage and provide added savings to remaining traffic.

Entrance Channel Widening Benefits

The HarborSym model was run for existing conditions and each of the project alternatives. The widening alternatives included widening of the Sabine Pass Channel and Port Arthur Canal from 500 to 700 feet. Evaluation of widths less than 700 feet was also conducted. Widening of the Sabine Pass Channel and Port Arthur Canal reaches were evaluated with and without the Neches River TB and anchorage alternatives and the turning basin anchorage features were evaluated on an incremental basis. The transportation cost savings associated with widening of the Sabine Pass Channel and Port Arthur Canal reaches and Neches River TB and anchorage features were evaluated based on a 40-foot channel depth.

Examination of the output data shows that for the existing condition and pre–base year condition, which reflects the inclusion of LNG carriers, vessels are in the system for 78.2 hours. The output also shows that expansion of the Entrance Channel would reduce the time in system to 76.7 hours. In reviewing the changes in delay times, it was found that there are large variances in throughput times. The minimum time for the without-project condition was on average 11.9 hours and the minimum time for the with-project condition also averaged 11.9 hours. The larger crude oil tankers showed throughput savings for the with-project condition. For instance, Suezmax vessels took an average of 86.7 hours under the without-project condition and an average of 83.1 hours with the widened Entrance Channel. The addition of the LNG vessels would result in longer waiting times for several vessel classes. Without the LNG vessels, the average number of hours in the system was 66.4. The effect of introducing the LNG vessels increases total delay times but reduces average times because the LNG vessels represent a large increase in vessels that travel shorter distances than the existing tanker fleet going to the Neches River and, therefore would not be subject to delays.

Evaluation of widening of the Entrance Channel to 700 feet through the Sabine Pass Channel and Port Arthur Canal showed that, using 2000–2004 traffic levels, vessels would save an average of 1.5 hours per round-trip voyage, with an annual savings of $3,487,322. Evaluation of Port Arthur by itself resulted in annual savings of approximately $2,579,760.

The model was run using 2004-period traffic and 2035 projected traffic. The effect on the reduction in total vessel movements resulting from channel deepening is evaluated in the sensitivity section of the Economic Appendix. Table V-64 summarizes the average annual benefits for 2019–2069 for widening of the Sabine Pass Channel and the Port Arthur Canal. While the results show that widening the contingent reaches produces higher benefits than widening one reach without the other, widening the contingent reaches as a combined feature increases total benefits by less than the sum total. These results indicate that the added benefits decline when the second reach is added. Table V-65 displays the economic

summary data associated with the widening of Sabine Pass and the Port Arthur Canal. The results of the benefit-cost analysis indicated that widening was not an incremental justified feature.

Table V-64
Sabine Pass Channel and Port Arthur Canal
Average Annual Benefits (2008 Dollars at 4.375%)

Year	Sabine Pass Channel	Port Arthur Canal	Sabine Pass Channel and Port Arthur Canal
2004	2,269,264	2,579,760	3,487,322
2019	2,922,548	3,431,103	4,335,553
2029	3,738,979	4,431,691	5,486,406
2039	4,691,482	5,599,044	6,829,067
2049	5,262,983	6,299,456	7,634,664
2059	6,215,486	7,466,809	8,977,326
2069	7,548,990	9,101,103	10,857,052
		Average Annual Benefits (4.375%)	6,379,579

Table V-65
Sabine Pass Channel and Port Arthur Canal
Widening Only
Economic Summary Data (2008 Dollars at 4.375%)

Item	Sabine Pass Channel and Port Arthur Canal
First Cost	78,448,000
Mitigation Cost	48,484,500
Interest During Construction	36,282,311
Total First Cost	163,241,841
Average Annual Construction Cost	8,091,727
Incremental Average Annual O&M Cost	9,587,005
Total Average Annual Cost	17,678,732
Average Annual Benefits	6,379,579
BCR	0.4

Neches River Holding Areas

Evaluation of the Neches River AB was conducted using the HarborSym Model. These proposed features would be used to facilitate vessel passing. The locations of the TBs are contained in Table V-66. As the titles indicate, some of the individual features would include a TB and an anchorage (No. 1, 2, and 4) and some just a TB (No. 3, 5, and 6) or an anchorage (No. 7 and 8). The Sabine Pilots noted that the Turning Basin Anchorages (TBA), such as 1, 2, 4, 7, and 8 would be designed to enable a 48-foot loaded Suezmax tanker to use the inner portion of the feature as an anchorage and also allow a 48-foot loaded Suezmax tanker to turn in the TB section. While some of the features described in Table V-66 would be developed from existing basins (1, 4, and 6) or are new basins (2, 3, 5, 7, and 8), the anchorage components of the

Table V-66
Neches River Turning Basin and Anchorage Features

					CURRENT USE Maximum Vessel Size and Federal Authority (Y/N)				PROPOSED USE Maximum Vessel Size and Federal Authority (Y/N)			
					TURNING Maximum Vessel Size		ANCHORAGE Maximum Vessel Size		TURNING Maximum Vessel Size		ANCHORAGE Maximum Vessel Size	
Title	Location	Description	Station Number	Estimated Miles from Sea Buoy	FEDERAL (Y/N)				FEDERAL (Y/N)			
TBA 1	Lower Fina	Turning Basin Anchorage 1	210+00	43.4	Suezmax	Y	None*	N	Suezmax	Y	Suezmax	Y
TBA 2	Upper Fina	Turning Basin Anchorage 2	275+00	44.6	Suezmax*	N	None*	N	Suezmax	Y	Suezmax	Y
TB 3	Pt Neches	Turning Basin 3	370+00	46.4	None	N	None	N	Suezmax	Y	None	N
TBA 4	Lower Sun	Turning Basin Anchorage 4	510+00	49.1	Suezmax	Y	None*	N	Suezmax	Y	Suezmax	Y
TB 5	Upper Sun	Turning Basin 5	570+00	50.2	Shallow-Draft Barges**	N	Shallow-Draft Barges**	N	Suezmax	Y	None	N
TB 6	Oil Tanking	Turning Basin 6	700+00	52.7	Suezmax	Y	None	N	Suezmax	Y	None	N
AB 7	PA 25	Anchorage Basin 7	750+00	53.6	None	N	None	N	None	N	Suezmax***	Y
AB 8	Below Exxon	Anchorage Basin 8	850+00	56.5	None	N	None	N	None	N	Suezmax***	Y
None	Beaumont	Beaumont Maneuvering Area	975+00	58.8	Suezmax	Y	None	N	Suezmax	Y	None	N

*Light vessels under emergency conditions.

**Under existing conditions, TB 5 is private and used by shallow-draft barges. A new turning basin is proposed immediately north of existing TB 5. This basin would be designed for loaded Suezmax tankers.

***For the "with-project future," anchorage basins 7 and 8 are designed for anchorage; however, the pilots intend to use anchorage basins 7 and 8 for both the anchorage and turning of Suezmax vessels.

features are essentially new, and the proposed dimensions represent new dredging. All but TB 6 are proposed to be dredged over the existing 40-foot project depth. HarborSym was not used to evaluate deepening of the existing TBs. Benefits would be based on related delays in waiting and traveling to another TB.

As an example of how the TBs would be used, an inbound convoy would arrive on the Neches River Channel with the vessels going to docks on the upper end of the Neches leading the convoy. Each vessel would proceed to their respective dock and head into the berth (for the SNWW vessels turn after finishing at the dock). The availability of several holding area improvements was emphasized as it allow loaded vessels to await berths and would save time that they originally would have spent in an inbound transit mode when the berth became clear. With the holding areas, vessels would only have to shift from the anchorage instead of awaiting the ship to sail and to start in according to the traffic rules. The pilots noted that the number of hours saved depends on the dock facility and that the benefits would be primarily for the crude oil tankers and some product carriers; however, all traffic would realize some savings. The availability of anchorages is expected to allow the inclusion of additional ships as part of inbound convoys. Under present conditions, the size of an inbound convoy is limited to berth space. When the berths are available, the vessels would switch from the holding area to a berth. It was noted that it is quicker to put a vessel in an anchorage (approximately 20 minutes) than to dock (approximately 1 hour). Similarly, it is quicker to depart from anchorage than to undock and turn. The net result is that the convoys would move faster and include additional vessels.

The with-project condition would provide for concurrent use of TBA1, TBA2, and TBA4 for both turning and anchorage of individual vessels. An additional item revealed at the meetings was that the maximum vessel size using the TBs was the same for the without- and with-project conditions. Additionally the model assumptions were based on “no change in Neches River transit rules” for the with-project condition. At the meeting, the pilots said that they would, in fact, trade vessels out between the Neches River “holding areas” and “docks” despite night rules and beam and depth restrictions. The vessel arrivals and departures from the Neches River Channel are planned and/or orchestrated rather than random. Under present conditions, a new Neches River inbound fleet cannot come in until the outbound Neches River fleet has traveled down the Neches River Channel and has cleared the Jetty Channel and is in the Outer Bar Channel. Under the without-project condition, the vessels wait offshore. Under the with-project condition, they would also wait offshore; however, the sidings would allow a vessel to move to the dock and start unloading when, under the without-project condition, it would be waiting for an outbound convoy to clear the Jetty Channel. The convoy behavior would not change between the without- and with-project conditions. It is recognized that it would take extra time to maneuver in and out of the sidings, and the effect of this behavior is accounted for in the benefit estimates.

Initial input concerning the number of TBs, TBA combinations, and ABs was made based on pilot interviews. The TBs and TBA combinations are used for both turning and for vessels to wait while others pass. In regard to incremental justification of review concerns, the pilots expressed considerable reluctance to agree to anything less than the six TBs; however, they conceded that if priorities had to be

placed on TBA construction, the priorities would be 1, 4, and 7. Next noted grouping was 1, 4, 5, and 7. It was emphasized that the priority was for all TB improvements.

The benefits of the TB features were evaluated based on pilot input and examination of the HarborSym output data associated with waiting times and other related variables. The initial focus of the discussions with the pilots was to understand present use of the TBs and obtain clarification on the DWT, loaded drafts, beam, length, and number of vessels associated with each of the TBs. Presently, the TBs are used for vessel turning and holding of light vessels (i.e., loaded drafts less than 29 feet). Some TBs are also used for holding light Aframax tankers, again with drafts loaded to less than 29 feet. It was noted that Aframax tankers can be pushed into a TB; however, lack of maintenance dredging makes this practice less frequent and more difficult but it would occur if a vessel, communication, or other breakdown situation requires. The vessel arrivals and departures from the Neches River Channel are planned and/or orchestrated rather than random. Under present conditions, a new Neches River inbound fleet cannot come in until the outbound Neches River fleet has traveled down the Neches, has cleared the Jetty Channel, and is in the Outer Bar Channel. Under the without-project condition, the vessels wait offshore. Under the with-project condition, they would also wait offshore; however, the sidings would allow a vessel to move to the dock and start unloading when, under the without-project condition, it would be waiting for an outbound convoy to clear the Jetty Channel. By building the Neches River sidings, an inbound convoy can save a significant portion of the inbound transit time by being in the sidings and ready to move to the docks as the outbound convoy leaves. The convoy behavior would not change between the without- and with-project conditions. Table V-67 presents the HarborSym output associated with the Neches River anchorages. Discussion with the pilots indicated uncertainty concerning shifting charges; therefore, the effect of their inclusion was evaluated. The benefits were calculated based on shifting costs being levied 50 percent of the time. Tables V-68 and V-69 summarize the average annual savings in comparison to the average construction cost. Table V-68 is similar to Table V-69 and presents the same combinations but differs in that the annual benefits reflect inclusion of “pilot shifting costs” for 100 percent of the time. The annual benefits presented in tables V-67 and V-68 do not reflect future growth and are based on 2004-period traffic levels. Analysis of the data presented in the tables shows that the combination of basins that include alternatives 1, 4, and 8 produce the highest net excess benefits among the alternatives evaluated.

Table V-70 summarizes the project cost and benefits associated with the combination of 1, 4, and 8. The annual benefits presented in Table V-70 are average annual numbers and reflect future growth based on 2019–2069 traffic levels.

Table V-67
Neches River Anchorage Basins (2004-Period Savings)
(All costs in dollars)

Feature	No Shifting Cost	With Shifting Cost	Shifting Cost 50% of the Time
Alt 1	1,011,421	212,798	612,110
Alt 2	1,085,993	287,370	686,682
Alt 3	5,045	1,335	3,190
Alt 4	711,087	0	355,544
Alt 5	3,304	0	1,652
Alt 7	367,215	0	183,608
Alt 8	278,304	0	139,152
Alt 1, 2	1,590,026	791,403	1,190,715
Alt 1, 3	1,012,551	213,928	613,240
Alt 1, 4	1,598,751	800,128	1,199,440
Alt 1, 5	1,012,551	213,928	613,240
Alt 1, 7	1,328,837	530,215	929,526
Alt 1, 8	1,263,380	464,758	864,069
Alt 2, 4	1,598,187	799,565	1,198,876
Alt 2, 7	1,413,856	615,233	1,014,545
Alt 2, 8	1,344,211	0	672,106
Alt 4, 7	1,178,793	380,170	779,482
Alt 4, 8	1,103,461	304,838	704,150
Alt 1, 2, 3	1,592,519	793,896	1,193,208
Alt 1, 2, 4	1,897,906	1,099,283	1,498,595
Alt 1, 2, 5	1,208,613	297,153	752,883
Alt 1, 2, 7	1,824,395	1,025,773	1,425,084
Alt 1, 2, 8	1,750,352	951,730	1,351,041
Alt 1, 3, 4	1,601,048	802,425	1,201,737
Alt 1, 3, 5	1,012,551	213,928	613,240
Alt 1, 3, 7	1,334,789	536,166	935,478
Alt 1, 3, 8	1,334,789	536,166	935,478
Alt 1, 4, 5	1,601,048	802,425	1,201,737
Alt 1, 4, 7	1,697,713	898,950	1,298,332
Alt 1, 4, 8	1,761,501	962,878	1,362,190
Alt 2, 4, 7	1,796,902	0	898,451
Alt 2, 4, 8	1,750,548	0	875,274
Alt 2, 7, 8	1,370,980	998,280	1,184,630
Alt 4, 7, 8	1,259,138	460,516	859,827
Alt 1, 2, 3, 4	1,902,467	1,103,845	1,503,156
Alt 1, 2, 4, 7	2,100,114	1,301,491	1,700,803
Alt 1, 2, 4, 8	2,062,240	1,263,618	1,662,929
Alt 1, 2, 7, 8	1,879,960	1,081,337	1,480,649
Alt 1, 4, 7, 8	1,850,392	1,051,629	1,451,011
Alt 2, 3, 4, 5	1,797,233	998,610	1,397,922
Alt 2, 4, 7, 8	1,707,628	909,005	1,308,317
Alt 1, 2, 4, 7, 8	1,982,703	1,184,081	1,583,392
Alt 2, 3, 4, 5, 7	1,797,233	998,610	1,397,922
Alt 2, 4, 5, 7, 8	1,838,302	1,039,679	1,438,991
Alt 3, 4, 5, 7, 8	1,261,556	462,934	862,245

Table V-68
Average Annual Cost, Transportation Savings Benefits, Net Excess Benefits (4.375%) and BCRs (No Shifting Charges)

Feature	Average Annual Cost	Benefits Based on 2004-Period Traffic	Net Excess Benefits	BCR
		(All costs in dollars)		
Alt 1	317,880	1,011,421	693,541	3.2
Alt 2	393,568	1,085,993	692,424	2.8
Alt 3	120,157	5,045	–115,112	0.0
Alt 4	192,390	711,087	518,697	3.7
Alt 5	351,101	3,304	–347,797	0.0
Alt 7	144,821	367,215	222,393	2.5
Alt 8	132,768	278,304	145,536	2.1
Alt 1, 2	711,448	1,590,026	878,578	2.2
Alt 1, 3	438,037	1,012,551	574,514	2.3
Alt 1, 4	510,270	1,598,751	1,088,481	3.1
Alt 1, 5	462,701	1,012,551	549,849	2.2
Alt 1, 7	450,648	1,328,837	878,189	2.9
Alt 1, 8	317,880	1,263,380	945,501	4.0
Alt 2, 4	585,958	1,598,187	1,012,229	2.7
Alt 2, 7	538,390	1,413,856	875,466	2.6
Alt 2, 8	526,337	1,344,211	817,874	2.6
Alt 4, 7	337,211	1,178,793	841,582	3.5
Alt 4, 8	325,158	1,103,461	778,303	3.4
Alt 1, 2, 3	831,605	1,592,519	760,914	1.9
Alt 1, 2, 4	903,838	1,897,906	994,068	2.1
Alt 1, 2, 5	1,062,549	1,208,613	146,064	1.1
Alt 1, 2, 7	856,269	1,824,395	968,126	2.1
Alt 1, 2, 8	844,216	1,750,352	906,136	2.1
Alt 1, 3, 4	630,427	1,601,048	970,621	2.5
Alt 1, 3, 5	789,138	1,012,551	223,413	1.3
Alt 1, 3, 7	582,858	1,334,789	751,930	2.3
Alt 1, 3, 8	570,805	1,334,789	763,983	2.3
Alt 1, 4, 5	861,371	1,601,048	739,677	1.9
Alt 1, 4, 7	655,091	1,697,713	1,042,622	2.6
Alt 1, 4, 8	643,038	1,761,501	1,118,463	2.7
Alt 2, 4, 7	730,780	1,796,902	1,066,123	2.5
Alt 2, 4, 8	889,491	1,750,548	861,057	2.0
Alt 2, 7, 8	683,211	1,370,980	687,769	2.0
Alt 4, 7, 8	469,980	1,259,138	789,159	2.7
Alt 1, 2, 3, 4	1,023,995	1,902,467	878,472	1.9
Alt 1, 2, 4, 7	1,048,659	2,100,114	1,051,455	2.0
Alt 1, 2, 4, 8	1,036,606	2,062,240	1,025,634	2.0
Alt 1, 2, 7, 8	989,038	1,879,960	890,922	1.9
Alt 1, 4, 7, 8	787,859	1,850,392	1,062,533	2.3
Alt 2, 3, 4, 5	1,057,216	1,797,233	740,017	1.7
Alt 2, 4, 7, 8	863,548	1,707,628	844,080	2.0
Alt 1, 2, 4, 7, 8	1,181,428	1,982,703	801,276	1.7
Alt 2, 3, 4, 5, 7	1,202,038	1,797,233	595,195	1.5
Alt 2, 4, 5, 7, 8	1,189,985	1,838,302	648,317	1.5
Alt 3, 4, 5, 7, 8	941,238	1,261,556	320,318	1.3

Table V-69
Average Annual Cost, Transportation Savings Benefits, Net Excess Benefits (4.375%) and BCRs (Shifting Charges 100% of the Time)

Feature	Average Annual Cost	Benefits Based on 2004-Period Traffic	Net Excess Benefits	BCR
		(All costs in dollars)		
Alt 1	317,880	212,798	–105,082	0.7
Alt 2	393,568	287,370	–106,198	0.7
Alt 4	192,390	0	–192,390	0.0
Alt 7	144,821	0	–144,821	0.0
Alt 8	132,768	0	–132,768	0.0
Alt 1, 2	711,448	791,403	79,955	1.1
Alt 1, 3	438,037	213,928	–224,109	0.5
Alt 1, 4	510,270	800,128	289,859	1.6
Alt 1, 5	462,701	213,928	–248,773	0.5
Alt 1, 7	450,648	530,215	79,567	1.2
Alt 1, 8	317,880	464,758	146,878	1.5
Alt 2, 4	585,958	799,565	213,607	1.4
Alt 2, 7	538,390	615,233	76,843	1.1
Alt 2, 8	526,337	0	–526,337	0.0
Alt 4, 7	337,211	380,170	42,959	1.1
Alt 4, 8	325,158	304,838	–20,320	0.9
Alt 1, 2, 3	831,605	793,896	–37,709	1.0
Alt 1, 2, 4	903,838	1,099,283	195,446	1.2
Alt 1, 2, 5	1,062,549	297,153	–765,396	0.3
Alt 1, 2, 7	856,269	1,025,773	169,503	1.2
Alt 1, 2, 8	844,216	951,730	107,513	1.1
Alt 1, 3, 4	630,427	802,425	171,998	1.3
Alt 1, 3, 5	789,138	213,928	–575,210	0.3
Alt 1, 3, 7	582,858	536,166	–46,692	0.9
Alt 1, 3, 8	570,805	536,166	–34,639	0.9
Alt 1, 4, 5	861,371	802,425	–58,946	0.9
Alt 1, 4, 7	655,091	898,950	243,859	1.4
Alt 1, 4, 8	643,038	962,878	319,840	1.5
Alt 2, 4, 7	730,780	0	–730,780	0.0
Alt 2, 4, 8	889,491	0	–889,491	0.0
Alt 2, 7, 8	683,211	998,280	315,068	1.5
Alt 4, 7, 8	469,980	460,516	–9,464	1.0
Alt 1, 2, 3, 4	1,023,995	1,103,845	79,850	1.1
Alt 1, 2, 4, 7	1,048,659	1,301,491	252,832	1.2
Alt 1, 2, 4, 8	1,036,606	1,263,618	227,012	1.2
Alt 1, 2, 7, 8	989,038	1,081,337	92,299	1.1
Alt 1, 4, 7, 8	787,859	1,051,629	263,770	1.3
Alt 2, 3, 4, 5	1,057,216	998,610	–58,606	0.9
Alt 2, 4, 7, 8	863,548	909,005	45,457	1.1
Alt 1, 2, 4, 7, 8	1,181,428	1,184,081	2,653	1.0
Alt 2, 3, 4, 5, 7	1,202,038	998,610	–203,427	0.8
Alt 2, 4, 5, 7, 8	1,189,985	1,039,679	–150,306	0.9
Alt 3, 4, 5, 7, 8	941,238	462,934	–478,304	0.5

Table V-70
SNWW Neches River Anchorage Analysis
Basins 1, 4, and 8
Economic Summary Data
October 2008 Dollars
(All costs in dollars)

First Cost of Construction	9,452,214
Interest During Construction	190,786
Total Investment	9,643,000
Average Annual Construction Cost	478,073
Average Annual O&M	190,106
Total Annual Cost	668,179

Average Annual Benefits at 4.375%
Incorporates Traffic Growth (2019–2069)
Based on Pilot Shifting Cost Scenarios

Benefit Component	Based on No Pilot Shifting Cost	Based on Pilot Shifting Cost 100% of the Time	Based on Pilot Shifting Cost 50% of the Time
Average Annual Benefits	2,784,668	1,522,166	2,153,417
Net Excess Benefits	2,116,489	853,987	1,485,238
BCRs	4.2	2.3	3.2

Summary of Widening Benefits

Table V-71 displays a summary of the widening benefits. The benefits are for widening the Sabine Pass Channel and Port Arthur Canal to 700 feet and constructing the Neches River anchorage features. Table V-72 presents the economic summary data associated with the channel widening alternatives. The results of the widening analysis show that widening of the Sabine Pass Channel and Port Arthur Canal is not an incrementally justified feature. Widening was not carried forward as a project feature. The ABs are incrementally justified and were included as part of the recommended plan.

The benefit calculations shown in tables V-71 and V-72 are based on 2004-period historical and 2030–2040 projected traffic. The 2030–2040 traffic levels do not account for the effect of trip reductions due to channel deepening. The effect on the reduction in total vessel movements resulting from channel deepening is evaluated in the sensitivity section of the Economic Appendix. For the sensitivity, HarborSym widening model was run based on the reduction in vessel trips as a result of channel deepening. The purpose of the sensitivity was to determine changes in the annual delays in relationship to the widening alternative in combination with channel deepening. The change in vessel trips due to channel deepening was estimated based on the decrease in the number of trips necessary to transport future tonnage. The model results suggest that the reduction in the number of vessel trips, resulting from channel deepening, has a significant effect on the net difference in the duration of vessel delays between the without- and with-project conditions. Further analyses based on various ranges of fleet forecasts

indicate that the increase in benefits from scenarios that included either "deepening and widening" or "deepening and the TB" are primarily attributable to the reduction in trips due to channel deepening. These savings result from the reduction in trips based on vessels carrying additional cargo from the redistribution of vessel sizes based on the availability of a deeper channel and do not vary significantly from the "widening only" benefits shown in Table V-71. The effect of adding these savings to the project benefits is outlined in the sensitivity section of the Economic Appendix.

Table V-71
Sabine Pass Channel and Port Arthur Canal
Average Annual Benefits (2008 Dollars at 4.375%)

Year	Sabine Pass Channel	Port Arthur Canal	Sabine Pass Channel and Port Arthur Canal	Neches River Anchorage Basins
2004	2,269,264	2,579,760	3,487,322	
2019	2,922,548	3,431,103	4,335,553	1,712,658
2029	3,738,979	4,431,691	5,486,406	1,946,282
2039	4,691,482	5,599,044	6,829,067	2,179,907
2049	5,262,983	6,299,456	7,634,664	2,441,575
2059	6,215,486	7,466,809	8,977,326	2,734,652
2069	7,548,990	9,101,103	10,857,052	3,062,910
Average Annual Benefits (4.375%)			6,379,579	2,153,417

Table V-72
Widening Only
Sabine Pass Channel and Port Arthur Canal
Economic Summary Data (2008 Dollars at 4.375%)
(All costs in dollars)

Item	Sabine Pass Channel and Port Arthur Canal	Neches River Anchorage Basins
First Cost	78,448,000	9,452,214
Mitigation Cost	48,484,500	–
Interest During Construction	36,282,311	190,786
Total First Cost	163,241,841	9,643,000
Average Annual Construction Cost	8,091,727	478,073
Incremental Average Annual O&M Cost	9,587,005	190,106
Total Average Annual Cost	17,678,732	668,179
Average Annual Benefits	6,379,579	2,153,417
Net Excess Benefits	–11,299,154	1,485,238
BCRs	0.4	3.2

V.F NED BENEFIT SUMMARY

Table V-73 presents the transportation cost savings by major commodity group and channel reach. The majority of benefits are associated with imports of crude petroleum, LNG and petroleum products, and exports of petroleum products. Crude petroleum and petroleum products represent 84 percent of the benefits at the 45-foot depth and 89 percent at the 50-foot depth. LNG comprises 7 percent of benefits at the 45-foot depth and 4 percent at 50 feet. The LNG benefits are for facilities in the Sabine Pass Channel and Port Arthur Canal reaches.

Table V-74 summarizes the benefit cost analysis, including the first cost of construction, net excess benefits, and the BCR for the project alternatives. The results of the analysis indicate that the 49-foot channel depth represents the plan that most reasonably maximizes net excess benefits.

Incremental Analysis

The project benefits start in the Sabine Pass Channel reach where the Sabine Pass LNG terminal is located (see Figure II-3). The Port Arthur Canal reach follows the Sabine Pass Channel reach. The Golden Pass LNG terminal, which is nearing completion, is located in the Sabine Pass Channel reach. An additional LNG terminal, Port Arthur, is permitted for construction in the Port Arthur Canal reach; however, due to uncertainty, the LNG transportation savings benefits (see Table V-52) do not include the Port Arthur terminal. The Port Arthur Canal reach also provides access to the Taylor Bayou side channel and basin. The Port of Port Arthur facilities are located along the main portion of the Sabine-Neches Canal. The incremental analyses for channel improvements through Port Arthur excluding the Taylor Bayou side channel are shown in Table V-75.

Separable analysis of the Taylor Bayou is shown in Table V-76. The analysis presented in Table V-76 shows that the BCRs for the Taylor Bayou increment are well above unity. Table V-77 presents the Sabine-Neches and Taylor Bayou increments as a separable unit. Table V-77 indicates that the BCRs for the segment through the Sabine-Neches Canal and including Taylor Bayou are below unity due to the inclusion of the entrance channel costs and exclusion of the Neches River benefits. Incremental analysis of the Neches River reach in Table V-78 shows that the BCRs are well above unity. Table V-79 displays the Neches River analysis excluding Taylor Bayou. Table V-80 reflects exclusion of benefits from Taylor Bayou, LNG, and breakbulk. Table V-81 presents calculation of the benefits and costs without inclusion of LNG.

The results of the analyses presented in Tables V-75 through V-81 show that the downstream benefits are not needed to justify the upstream costs. The analysis shows that each of the major reaches provides significant incremental benefits.

Table V-73
Total Average Annual Benefits ($1,000s)
by Channel Reach and Alternative
(50-Year Period of Analysis at 4.375%) (December 2008 Vessel Costs)
(All costs in dollars)

Reach and Commodity	45	46	47	48	49	50
Sabine Pass LNG	3,676	3,676	3,676	3,676	3,676	3,676
Port Arthur LNG	7,464	7,464	7,464	7,464	7,464	7,464
Taylor Bayou						
Crude Petroleum Imports	5,790	6,892	7,510	7,964	8,305	8,928
Petroleum & Chemical Product Imports	2,369	2,758	3,124	3,436	3,709	3,939
Petroleum & Chemical Product Exports	7,348	8,556	9,692	10,653	11,485	12,170
Coastwise Petroleum Products	563	563	563	563	563	563
Taylor Bayou Total	16,070	18,769	20,889	22,616	24,062	25,600
Sabine-Neches Canal						
Breakbulk and Aggregate	2,065	2,387	2,387	2,387	2,387	2,387
Neches River Channel to Beaumont						
Crude Petroleum Imports	35,340	41,759	45,901	53,117	57,868	59,832
Petroleum & Chemical Product Imports	3,554	4,138	4,686	5,155	5,564	5,909
Petroleum & Chemical Product Exports	7,961	9,269	10,499	11,541	12,442	13,184
Coastwise Petroleum Products	918	918	918	918	918	918
Grain Exports	2,172	2,463	2,870	3,187	3,482	3,714
Breakbulk and Aggregate	2,471	2,860	2,860	2,860	2,860	2,860
Neches River Turning Basins	2,153	2,153	2,153	2,153	2,153	2,153
Neches River Total	54,569	63,560	69,887	78,931	85,287	88,570
Grand Total*	83,844	95,856	104,303	115,074	122,875	127,696

*Some totals may not add due to rounding.

Table V-74
SNWW Economic Summary Data
Cost and Benefits ($1,000s) by Channel Alternative
(50-Year Period of Analysis at 4.375%)
(December 2008 Vessel Costs)
(All costs in dollars)

	45	46	47	48	49	50
First Cost of Construction	798,920	889,906	980,891	1,071,877	1,152,079	1,232,280
Interest During Construction	88,981	99,115	109,248	119,382	128,315	137,247
Total Investment	887,901	989,021	1,090,139	1,191,259	1,280,394	1,369,527
Average Annual Cost	44,020	49,033	54,046	59,059	63,478	67,897
Deferred Construction (F&W*)	174	188	201	215	221	227
Average Annual O&M	26,023	28,037	30,052	32,067	32,927	33,787
Total Annual Cost	70,217	77,258	84,299	91,341	96,626	101,911
Average Annual Benefits	83,844	95,856	104,303	115,074	122,875	127,696
Net Excess Benefits	13,627	18,598	20,004	23,733	26,249	25,785
BCRs	1.2	1.2	1.2	1.3	1.3	1.3

F&W = Fish and Wildlife

Table V-75
Sabine Pass, Port Arthur Canal, and Sabine-Neches Canal Incremental Analysis
Cost and Benefits ($1,000s) by Channel Alternative
(50-Year Period of Analysis at 4.375%)
(December 2008 Vessel Costs)
(All costs in dollars)

	45	46	47	48	49	50
First Cost of Construction	510,640	564,696	618,751	672,807	725,314	777,822
Interest During Construction	48,541	54,539	60,538	66,536	71,713	76,889
Total Investment	559,181	619,235	679,289	739,343	797,027	854,711
Average Annual Cost	27,723	30,700	33,677	36,655	39,514	42,374
Deferred Construction (F&W)	174	188	201	215	221	227
Average Annual O&M	21,870	23,477	25,089	26,705	27,332	27,965
Total Annual Cost	49,767	54,365	58,967	63,575	67,067	70,566
Average Annual Benefits	13,205	13,527	13,527	13,527	13,527	13,527
Net Excess Benefits	–36,562	–40,838	–45,440	–50,048	–53,540	–57,039
BCRs	0.3	0.2	0.2	0.2	0.2	0.2

Table V-76
Taylor Bayou Incremental Analysis
Cost and Benefits ($1,000s) by Channel Alternative
(50-Year Period of Analysis at 4.375%)
(December 2008 Vessel Costs)
(All costs in dollars)

	45	46	47	48	49	50
First Cost of Construction	43,755	51,811	59,865	67,919	76,527	85,136
Interest During Construction	2,106	2,494	2,882	3,270	3,683	4,099
Total Investment	45,861	54,305	62,747	71,189	80,210	89,235
Average Annual Cost	2,274	2,692	3,111	3,529	3,977	4,424
Average Annual O&M	1,267	1,451	1,631	1,807	1,945	2,075
Total Annual Cost	3,541	4,143	4,742	5,336	5,922	6,499
Average Annual Benefits	16,070	18,769	20,889	22,617	24,062	25,599
Net Excess Benefits	12,529	14,626	16,147	17,281	18,140	19,100
BCRs	4.5	4.5	4.4	4.2	4.1	3.9

Table V-77
Project Improvements through Port Arthur (including Taylor Bayou)
Cost and Benefits ($1,000s) by Channel Alternative
(50-Year Period of Analysis at 4.375%)
(December 2008 Vessel Costs)
(All costs in dollars)

	45	46	47	48	49	50
First Cost of Construction	554,395	616,507	678,616	740,725	801,842	862,958
Interest During Construction	50,647	57,033	63,420	69,806	75,396	80,988
Total Investment	605,042	673,540	742,036	810,531	877,238	943,946
Average Annual Cost	30,171	33,580	36,989	40,399	43,712	47,025
Deferred Construction (F&W)	174	188	201	215	221	227
Average Annual O&M	23,137	24,929	26,720	28,512	29,276	30,041
Total Annual Cost	53,482	58,697	63,910	69,126	73,209	77,293
Average Annual Benefits	29,275	32,296	34,416	36,144	37,589	39,126
Net Excess Benefits	–24,207	–26,401	–29,494	–32,982	–35,620	–38,167
BCRs	0.5	0.6	0.5	0.5	0.5	0.5

Table V-78
Neches River Incremental Economic Analysis
Cost and Benefits ($1,000s) by Channel Alternative
(50-Year Period of Analysis at 4.375%)
(December 2008 Vessel Costs)
(All costs in dollars)

	45	46	47	48	49	50
First Cost of Construction	244,525	273,399	302,275	331,152	350,237	369,322
Interest During Construction	38,334	42,081	45,829	49,576	52,918	56,259
Total Investment	282,859	315,480	348,104	380,728	403,156	425,581
Average Annual Cost	14,023	15,641	17,258	18,875	19,987	21,099
Average Annual O&M	2,885	3,109	3,332	3,555	3,651	3,746
Total Annual Cost	16,908	18,750	20,590	22,430	23,638	24,845
Average Annual Benefits	54,570	63,560	69,888	78,931	85,287	88,570
Net Excess Benefits	37,661	44,811	49,298	56,500	61,649	63,725
BCRs	3.2	3.4	3.4	3.5	3.6	3.6

Table V-79
SNWW Improvements (excludes Taylor Bayou)
Cost and Benefits ($1,000s) by Channel Alternative
(50-Year Period of Analysis at 4.375%)
(December 2008 Vessel Costs)
(All costs in dollars)

	45	46	47	48	49	50
First Cost of Construction	755,165	838,095	921,027	1,003,958	1,075,551	1,147,144
Interest During Construction	86,875	96,621	106,366	116,112	124,631	133,148
Total Investment	842,040	934,716	1,027,392	1,120,070	1,200,183	1,280,292
Average Annual Cost	41,746	46,341	50,935	55,530	59,502	63,473
Deferred Construction (F&W)	174	188	201	215	221	227
Average Annual O&M	24,755	26,586	28,422	30,260	30,982	31,712
Total Annual Cost	66,676	73,115	79,558	86,005	90,705	95,411
Average Annual Benefits	54,540	63,418	69,746	78,789	85,145	88,428
Net Excess Benefits	–12,135	–9,696	–9,812	–7,217	–5,559	–6,983
BCRs	0.8	0.9	0.9	0.9	0.9	0.9

Table V-80
Neches River Project Improvements (excludes Transportation Benefits for All Other Reaches)
Cost and Benefits ($1,000s) by Channel Alternative
(50-Year Period of Analysis at 4.375%)
(December 2008 Vessel Costs)
(All costs in dollars)

	45	46	47	48	49	50
First Cost of Construction	755,165	838,095	921,027	1,003,958	1,075,551	1,147,144
Interest During Construction	86,875	96,621	106,366	116,112	124,631	133,148
Total Investment	842,040	934,716	1,027,392	1,120,070	1,200,183	1,280,292
Average Annual Cost	41,746	46,341	50,935	55,530	59,502	63,473
Deferred Construction (F&W)	174	188	201	215	221	227
Average Annual O&M	24,755	26,586	28,422	30,260	30,982	31,712
Total Annual Cost	66,676	73,115	79,558	86,005	90,705	95,411
Average Annual Benefits	38,470	44,649	48,857	56,172	61,084	62,829
Net Excess Benefits	–28,206	–28,465	–30,701	–29,834	–29,621	–32,582
BCRs	0.6	0.6	0.6	0.7	0.7	0.7

Table V-81
SNWW Improvements (excludes LNG)
Cost and Benefits ($1,000s) by Channel Alternative
(50-Year Period of Analysis at 4.375%)
(December 2008 Vessel Costs)
(All costs in dollars)

	45	46	47	48	49	50
First Cost of Construction	755,165	838,095	921,027	1,003,958	1,075,551	1,147,144
Interest During Construction	86,875	96,621	106,366	116,112	124,631	133,148
Total Investment	842,040	934,716	1,027,392	1,120,070	1,200,183	1,280,292
Average Annual Cost	41,746	46,341	50,935	55,530	59,502	63,473
Deferred Construction (F&W)	174	188	201	215	221	227
Average Annual O&M	24,755	26,586	28,422	30,260	30,982	31,712
Total Annual Cost	66,676	73,115	79,558	86,005	90,705	95,411
Average Annual Benefits	72,702	84,716	93,164	103,935	111,736	116,556
Net Excess Benefits	6,026	11,601	13,606	17,930	21,031	21,144
BCRs	1.1	1.2	1.2	1.2	1.2	1.2

Benefit-Cost Ratio at 7 Percent

Calculation of benefits and costs at 7 percent interest is required by EC 11-2-194, commonly referred to as the budget Engineering Circular (paragraph 11). The 7 percent calculations are used for budget ranking purposes. Table V-82 outlines the economic calculations at 7 percent.

Table V-82
SNWW Economic Summary Data at 7 Percent
Cost and Benefits ($1,000s) by Channel Alternative
(50-Year Period of Analysis
(December 2008 Vessel Costs)
(All costs in dollars)

	45	46	47	48	49	50
First Cost of Construction	798,920	889,906	980,891	1,071,877	1,152,079	1,232,280
Interest During Construction	150,031	167,118	184,204	201,291	216,352	231,413
Total Investment	948,951	1,057,024	1,165,095	1,273,168	1,368,431	1,463,693
Average Annual Cost	68,761	76,592	84,423	92,254	99,156	106,059
Deferred Construction (F&W)	178	192	206	220	226	232
Average Annual O&M	25,942	27,971	29,999	32,027	32,885	33,742
Total Annual Cost	94,881	104,755	114,628	124,501	132,267	140,033
Average Annual Benefits	81,644	93,305	101,498	112,028	119,631	124,300
Net Excess Benefits	–13,237	–11,450	–13,130	–12,473	–12,636	–15,733
BCRs	0.9	0.9	0.9	0.9	0.9	0.9

Sensitivity Analysis for Additional Advanced Maintenance

During the development of the alternatives, several reaches of the channel were identified as requiring additional advanced maintenance beyond the standard practices of the Galveston District. These reaches included the Sabine Pass Outer Bar Channel, one section of the Sabine Pass Channel, the Port Arthur Junction, and portions of the Neches River Channel.

In these fast-shoaling areas, it was assumed that additional advance maintenance would be required to avoid frequent redredging and to ensure the reliability and least overall cost for operating and maintaining the project's authorized dimensions. This increase in advance maintenance (ranging from 1 to 5 feet) was proposed for some portions of some channel reaches to allow the proposed dredging frequency to remain the same as the existing O&M dredging frequency.

A sensitivity analysis was performed on the O&M costs to determine the impact to the BCR if the additional advance maintenance was not performed on these specific channel reaches. Table V-83 presents the summary of the economic data without this additional advanced maintenance in those limited channel reaches. In a comparison to Table V-74 which summarizes the costs and benefits for the study, the average annual O&M costs increases over the 50-year period of analysis without the additional

advance maintenance because, although less material would be dredged per dredging cycle, the frequency of O&M dredging would increase to maintain the project's authorized depth. This increase in average annual O&M costs results in a decrease in the net excess benefits and a decrease in the BCRs for each of the channel depths. The NED plan of 49-foot depth has a decrease in the BCR from 1.3 to 1.2.

Table V-83
SNWW Economic Summary Data Without Additional Advanced O&M Cost and Benefits ($1,000s) by Channel Alternative (50-Year Period of Analysis at 4.375%) (December 2008 Vessel Costs)
(All costs in dollars)

	45	46	47	48	49	50
First Cost of Construction	798,920	889,906	980,891	1,071,877	1,152,079	1,232,280
Interest During Construction	88,981	99,115	109,248	119,382	128,315	137,247
Total Investment	887,901	989,021	1,090,139	1,191,259	1,280,394	1,369,527
Average Annual Cost	44,020	49,033	54,046	59,059	63,478	67,897
Deferred Construction (F&W)	174	188	201	215	221	227
Average Annual O&M	28,901	31,139	33,377	35,615	36,570	37,525
Total Annual Cost	73,095	80,360	87,624	94,889	100,269	105,649
Average Annual Benefits	83,841	95,856	104,303	115,074	122,875	127,696
Net Excess Benefits	10,746	15,496	16,679	20,185	22,606	22,047
BCRs	1.1	1.2	1.2	1.2	1.2	1.2

V.G REGIONAL BENEFITS

The SNWW is America's largest military port and the second largest importer of crude oil based on tonnage. An estimated 20 to 30 percent of all military jet fuel is produced on the SNWW and an estimated 118 million tons of cargo are moved through the marine terminals. The waterway delivers 12 to 16 percent of the crude oil and refined products supplied east of the Rocky Mountains.

SNWW port activity contributes significantly to the local and regional economy by generating business revenue to local and national firms providing vessel and cargo-handling services at the marine terminals. These firms, in turn, provide employment and income to individuals. The SNWW marine terminals and refinery complexes generate revenue throughout the local, state, and national economies.

Terminals along the SNWW include the public marine terminals owned by the Port of Beaumont and Port of Port Arthur, as well as the petroleum refineries, chemical plants, and bulk/breakbulk terminals. These terminals use vessel and barge transportation to move crude oil, petroleum products, liquid and dry chemicals, steel, and dry bulk cargo.

Revenue generated by the waterway is generated by firms providing services to the commodity and vessel activity at the terminals, revenue from trucking firms, railroads, pipeline operations, terminal operators and associated refineries and chemical plants (from loading and discharging vessels), chandlers, agents, pilots, towing companies, shipyards, and maritime support firms. This revenue is used to purchase

employment (direct jobs) to provide the services, to pay stockholders and for retained earnings, and to purchase goods and services from local firms, as well as national and international firms (creating indirect jobs with these firms). Businesses also pay taxes from the business revenue.

For the communities within the study area, the SNWW is responsible for benefits to the local and regional economy. The Sponsor recently contracted for a study on the *Economic Impact of the Sabine-Neches Waterway* (Martin Associates, 2006). Regional benefits of the SNWW to the communities within the study area include (based on 2004 statistics):

- 83,692 jobs in Texas and Louisiana (private and public marine terminals along SNWW);
- 14,987 jobs directly related to activities along the waterway;
- 13,628 induced jobs from local purchases from SNWW workers;
- 55,077 indirect jobs;
- $877.7 million of direct wages and salaries;
- $2.2 billion in business revenue (excluding the cargo);
- $426.5 million of State and local taxes (generated by activity at the marine terminals); and
- $853 million of Federal taxes (generated by activity at the marine terminals).

The number of jobs that the waterway supports is impressive especially since the Southeast Texas labor force totaled 176,500 people in June 2006, with personal income and consumption attributable to the waterway at $4.7 billion (*Beaumont Enterprise*, 2006).

With the value of the current 40-foot-deep SNWW channel to the region, it is expected that the proposed deepening and widening of the channel for navigational efficiency and safety would increase the benefits to the region or at a minimum maintain the existing benefits.

This page intentionally left blank.

VI. DESCRIPTION OF RECOMMENDED PLAN

VI.A OVERVIEW

In the previous chapter, the economic analysis identified the process and rationale used to identify the NED Plan, which is the 49-foot plan. However, the Recommended Plan identified in Chapter IV is the 48-foot deepening, which is also considered the LPP by the Sponsor. The Sponsor agrees that this plan best addresses the navigational efficiency and safety issues along the existing SNWW channel. This chapter describes the Recommended Plan in more detail. The Engineering Appendix, which includes design information, is available upon request.

VI.B DESCRIPTION OF RECOMMENDED PLAN

The Recommended Plan involves the following modifications to the existing channel:

- Deepening the SNWW to Beaumont to 48 feet, extending the Entrance Channel 13.2 miles,
- Deepening and selective widening of Taylor Bayou channels and TB,
- Decreasing the width of the Sabine Bank Channel to 700 feet with tapering from 800 feet (Station 23+300) to 700 feet wide (Station 25+800 through the end of Sabine Bank Channel),
- Adding or enlarging turning and AB along the Neches River Channel, and
- Bending easing on the Sabine-Neches Canal and Neches River Channel.

With the Recommended Plan, the existing channel depth would be increased by 8 feet, increasing the inland portion from 40 feet to 48 feet and increasing the existing offshore portions from 42 to 50 feet (plus overdepth or advance maintenance as needed). The channel deepening would result in the Entrance Channel being extended 13.2 miles farther south into the Gulf of Mexico. The Sabine Pass Jetty Channel, Sabine Pass Channel, Port Arthur and Sabine-Neches canals, and the Neches River Channel would be deepened from 40 to 48 feet. The existing offshore entrance channels (Sabine Pass Outer Bar Channel and Sabine Bank Channel) would be deepened from 42 to 50 feet, and the Sabine Bank Extension Channel would be dredged to 50 feet. This would increase the SNWW from 64 miles to approximately 77 miles in length. No modifications to the existing Sabine Pass jetties would be required as part of the CIP.

The Taylor Bayou TB and channels would also be widened at its entrance and the upstream bottleneck curve and deepened to 48 feet. Neither the Sabine-Neches Canal nor the Neches River Channel would be widened, but navigation efficiency would be improved with bend easings in both reaches, and the addition or enlargement of turning and ABs on the Neches River Channel.

The Recommended Plan would result in an estimated 98 mcy of new work and 650 mcy of maintenance material over the 50-period of analysis (Table VI-1). The annual maintenance dredging quantities in the SNWW would increase from an average of 8.1 mcy for the current 40-foot project to 13.0 mcy for the proposed 48-foot project. Dredged depths would actually be deeper than the authorized depth when allowances for overdepth and advance maintenance are included. Overdepth dredging and advance

maintenance would be 2 feet each; however, in critical and fast-shoaling areas, additional advance maintenance is required to avoid frequent redredging and to ensure the reliability and least overall cost for operating and maintaining the project's authorized dimensions. An increase in advance maintenance (ranging from 1 to 5 feet) was proposed for some portions of some channel reaches to allow the proposed dredging frequency to remain the same as the existing O&M dredging frequency. These channel depths were included in the mesh for the HS modeling.

Table VI-1
New Work and 50-Year Maintenance Quantities for the Recommended Plan

	Channel Reach	New Work Quantities	50-Year Maintenance Quantities
Offshore	Sabine Bank Extension	18,737,000	36,216,000
	Sabine Bank Channel	15,358,000	96,371,000
	Sabine Pass Outer Bar Channel	5,923,000	223,650,000
	Sabine Pass Jetty Channel	2,978,000	13,527,000
Inshore	Sabine Pass Channel	6,723,200	34,780,800
	Port Arthur Canal	11,697,200	82,857,600
	Sabine-Neches Canal	11,944,000	73,245,000
	Neches River Channel	25,014,000	89,724,800
	Total Quantities	98 mcy	650 mcy

The SNWW Recommended Plan is made up of eight channel reaches: three offshore and five inland. Each channel reach is divided into different sections for dredging contracts. These sections are shown on the Engineering Plates in Appendix 1 of this FFR. The specifics for each channel reach are discussed later in this section. Whenever economically and environmentally feasible, new work and maintenance material are used beneficially either for marsh restoration or shoreline nourishment. Sixteen existing and two new PAs would be used for upland placement.

General Navigation Features of the Recommended Plan

Proposed structural channel improvements are described individually for each reach below (figures VI-1 through VI-7). General navigation features (GNF) of the Recommended Plan consist of:

1) Deepening of navigation channels and basins;
2) 50-year DMMP for both new work and O&M (ODMDSs, upland PAs, and the Neches River and Gulf Shore BU features);
3) Marsh mitigation in Louisiana; and
4) Bridge reinforcements.

Non-General Navigation Features project elements (aids to navigation, Land, Easements, and Rights of Way [LER], and relocations [including utility relocations]) are described at the end of this chapter. The Sabine Bank Extension is discussed separately below, but it is actually part of the Sabine Bank Channel reach.

Sabine Bank Extension Channel

This channel lengthens the existing offshore Entrance Channel approximately 13.2 miles at a bottom width of 700 feet (Figure VI-1). The additional length is required to reach a water depth in the Gulf of Mexico equal to the proposed channel depth. The proposed offshore depth is 50 feet, but advance maintenance and allowable overdepth would add a total of 4 more feet, bringing the total dredged depth of the Extension Channel to 54 feet. It would be constructed by hopper dredge beginning at the end of the Sabine Bank Channel, and it would extend into the Gulf of Mexico at the same bearing as the Sabine Bank Channel. An overview of the project details for the Sabine Bank Extension is listed in Table VI-2.

Table VI-2
Project Details of Sabine Bank Extension

Length of Reach	13.2 miles (new)
Project Depth	50 feet
Bottom Width	700 feet
Advance Maintenance	2 feet
Allowable Overdepth	2 feet
New Work Material	18,737,000 cubic yards
Placement Areas	ODMDSs A, B, C, and D
Beneficial Use of Dredged Material	None
Maintenance Material (50-year quantity)	36,216,000 cubic yards
Increase in Maintenance Material	36,216,000 cubic yards
Placement Areas	ODMDSs A, B, C, and D
Beneficial Use of Dredged Material	None

Sabine Bank Channel

This 14.7-mile-long channel would be deepened from 42 to 50 feet using a hopper dredge (Figure VI-2). When advance maintenance and allowable overdepth are added to the proposed 50-foot depth, the Sabine Bank Channel would be dredged to 54 feet. The bottom width of the Sabine Bank Channel is currently 800 feet; it would remain 800 feet wide for the first mile past the end of the Outer Bar Channel, and then it would taper from 800 to 700 feet over the next one-half mile. The Sabine Bank Channel would continue the 700-foot bottom width for approximately 13.2 miles to its connection with the Extension Channel. Since the existing channel is 800 feet wide, new channel markers would be required to mark the tapered transition and the remainder of the narrowed Sabine Bank Channel. An overview of the project details for the Sabine Bank Channel reach is listed in Table VI-3.

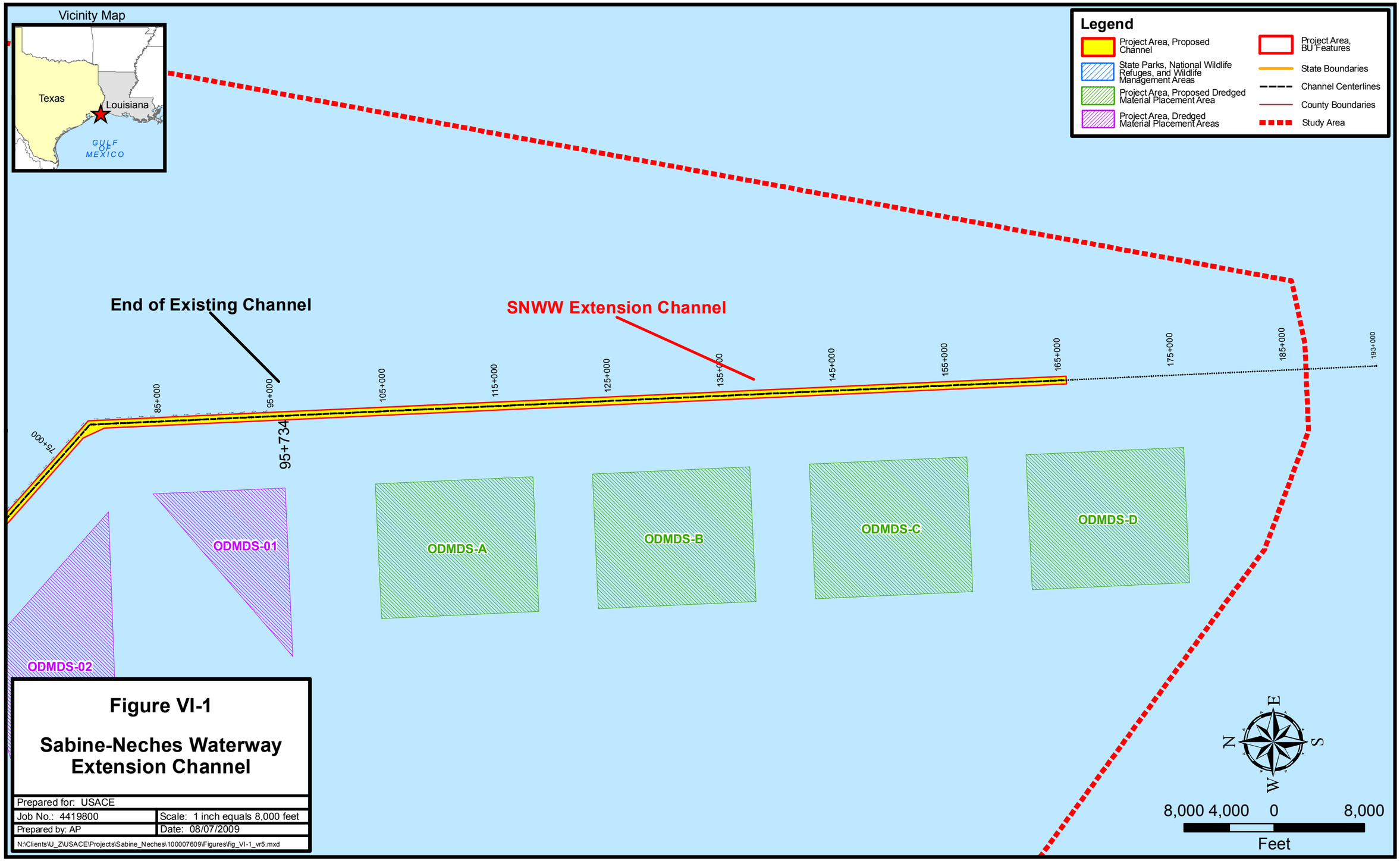


Figure VI-1

Sabine-Neches Waterway Extension Channel

Prepared for: USACE	
Job No.: 4419800	Scale: 1 inch equals 8,000 feet
Prepared by: AP	Date: 08/07/2009
N:\Clients\U_Z\USACE\Projects\Sabine_Neches\100007609\Figures\fig_VI-1_vr5.mxd	

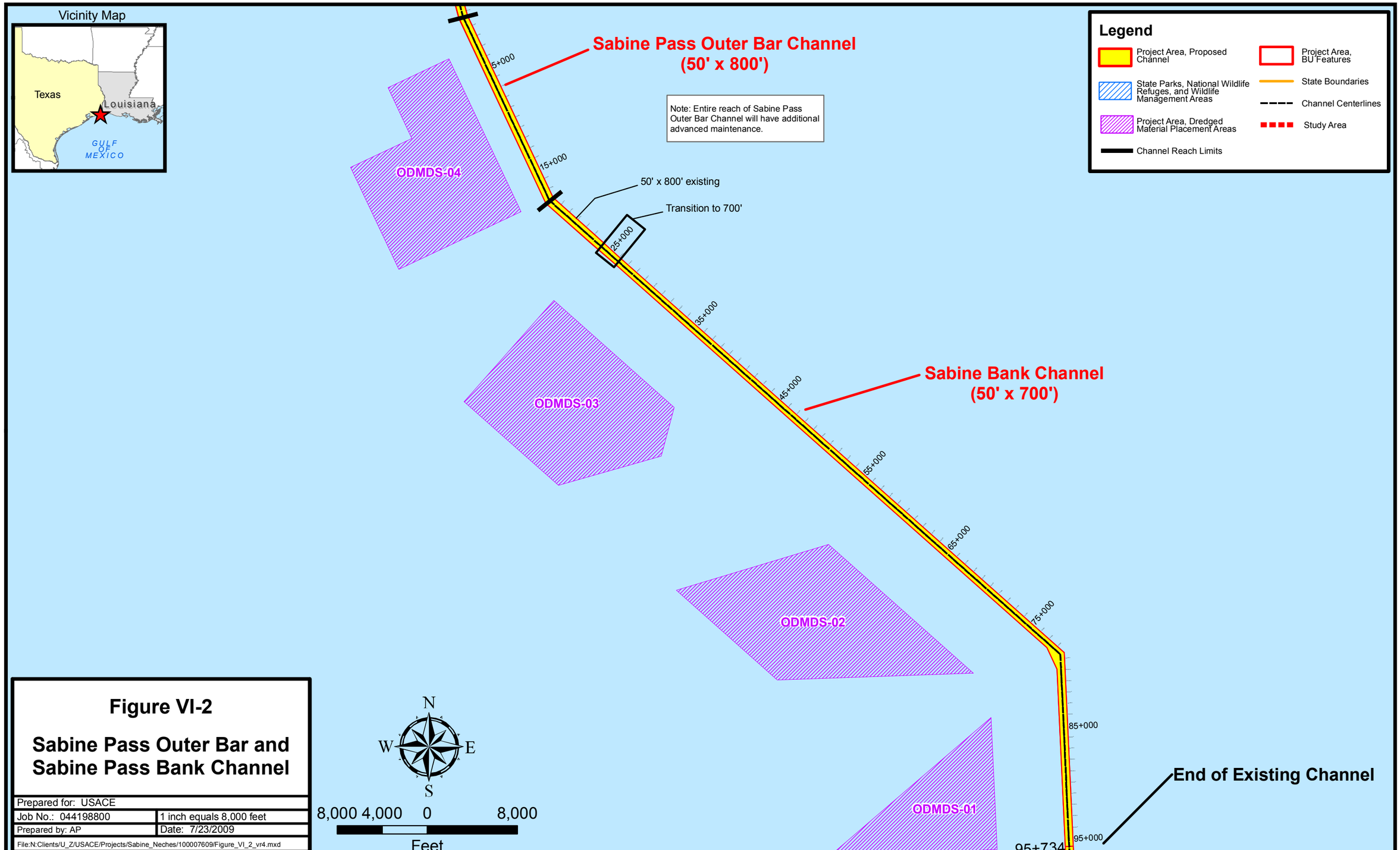
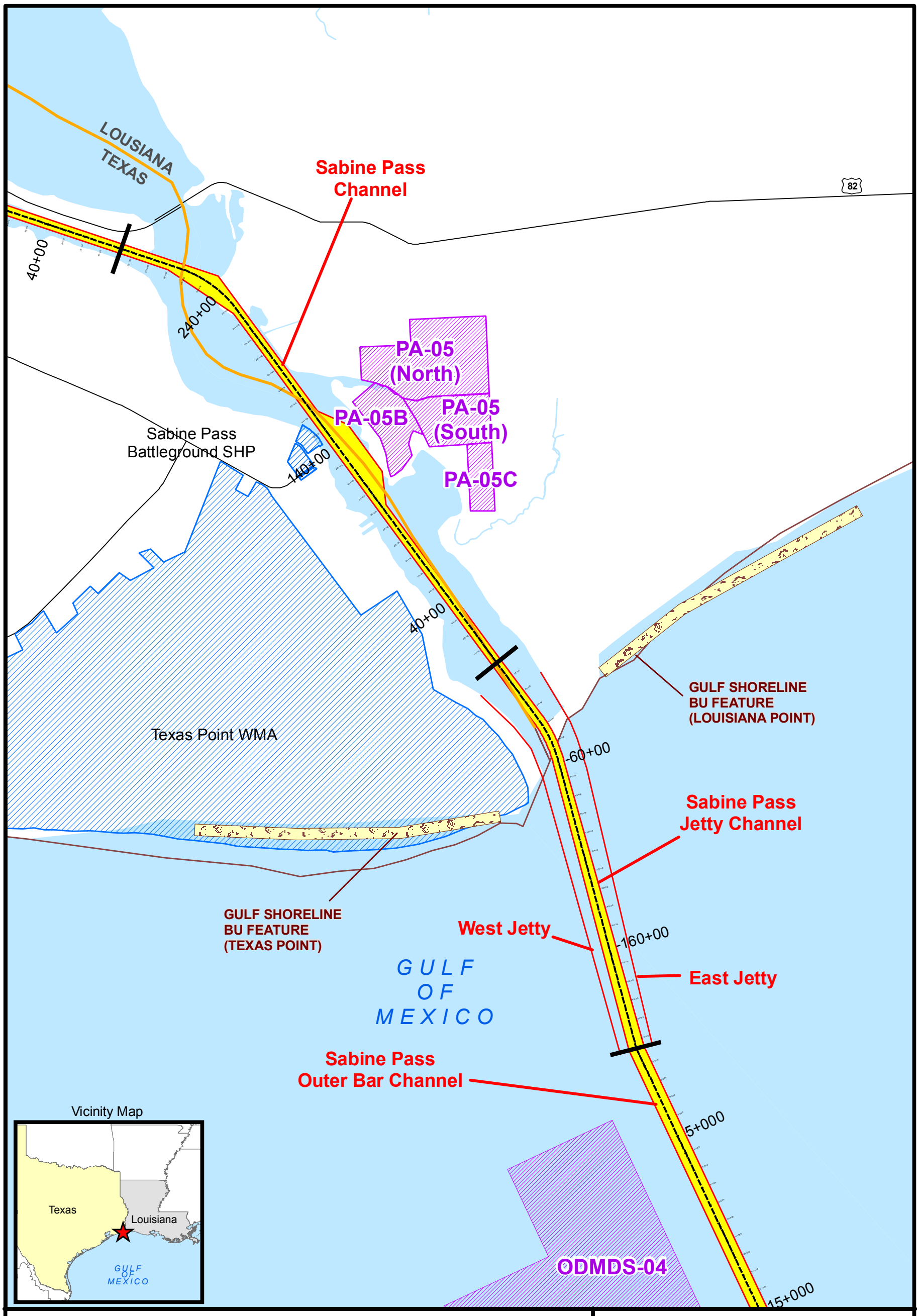


Figure VI-2

Sabine Pass Outer Bar and Sabine Pass Bank Channel

Prepared for: USACE	
Job No.: 044198800	1 inch equals 8,000 feet
Prepared by: AP	Date: 7/23/2009
File:N:Clients/U_Z/USACE/Projects/Sabine_Neches/100007609/Figure_VI_2_vr4.mxd	



Legend

- Project Area, Proposed Channel
- State Parks, National Wildlife Refuges, and Wildlife Management Areas
- Project Area, Dredged Material Placement Areas
- Channel Reach Limits
- Project Area, BU Features
- Shore Nourishment
- State Boundaries
- Channel Centerlines
- County Boundaries
- Study Area

N W E S

0 5,000 10,000

Feet

Figure VI-3

Sabine Pass Jetty Channel

Prepared for: USACE	
Job No.: 044198800	Scale: 1' = 5000'
Prepared by: AP	Date: 7/23/2009

File: N:/Clients/U_Z/USACE/Projects/Sabine_Neches/100007609/figures/Figure_VI_3.mxd

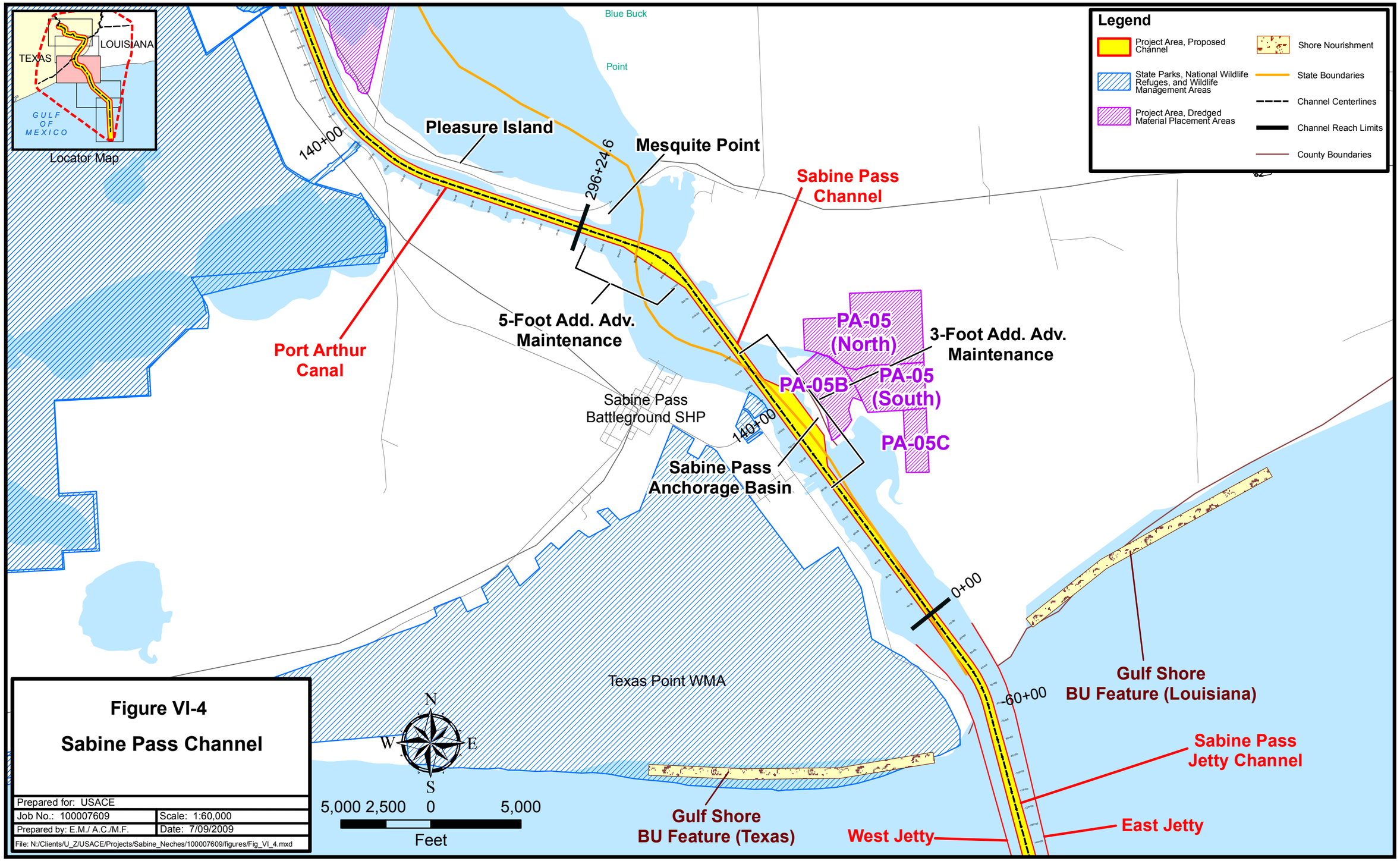
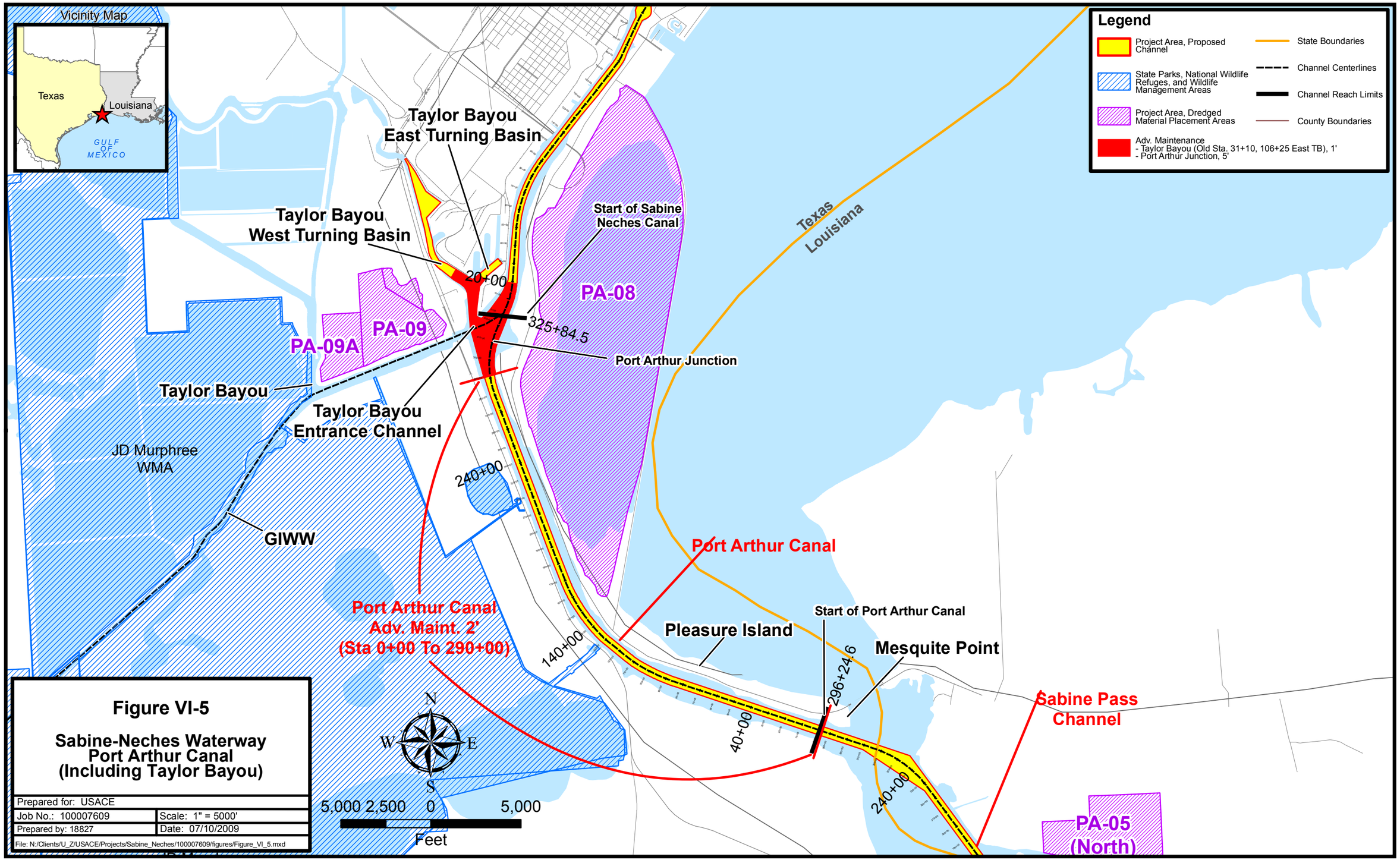


Figure VI-4

Sabine Pass Channel

Prepared for: USACE	
Job No.: 100007609	Scale: 1:60,000
Prepared by: E.M./ A.C./M.F.	Date: 7/09/2009
File: N:/Clients/U_Z/USACE/Projects/Sabine_Neches/100007609/figures/Fig_VI_4.mxd	


Vicinity Map
Texas
Louisiana
GULF OF MEXICO
Legend
Project Area, Proposed Channel
State Parks, National Wildlife Refuges, and Wildlife Management Areas
Project Area, Dredged Material Placement Areas
Adv. Maintenance
- Taylor Bayou (Old Sta. 31+10, 106+25 East TB), 1'
- Port Arthur Junction, 5'
State Boundaries
Channel Centerlines
Channel Reach Limits
County Boundaries
Taylor Bayou East Turning Basin
Taylor Bayou West Turning Basin
Start of Sabine Neches Canal
Texas
Louisiana
20+00
PA-08
PA-09
PA-09A
325+84.5
Port Arthur Junction
Taylor Bayou
Taylor Bayou Entrance Channel
JD Murphree WMA
240+00
GIWW
Port Arthur Canal
Port Arthur Canal Adv. Maint. 2' (Sta 0+00 To 290+00)
Start of Port Arthur Canal
Pleasure Island
Mesquite Point
140+00
296+24.6
Sabine Pass Channel
40+00
240+00
PA-05 (North)
N
W
E
S
5,000 2,500 0 5,000
Feet
Figure VI-5
Sabine-Neches Waterway
Port Arthur Canal
(Including Taylor Bayou)
Prepared for: USACE
Job No.: 100007609
Scale: 1" = 5000'
Prepared by: 18827
Date: 07/10/2009
File: N:/Clients/U_Z/USACE/Projects/Sabine_Neches/100007609/figures/Figure_VI_5.mxd

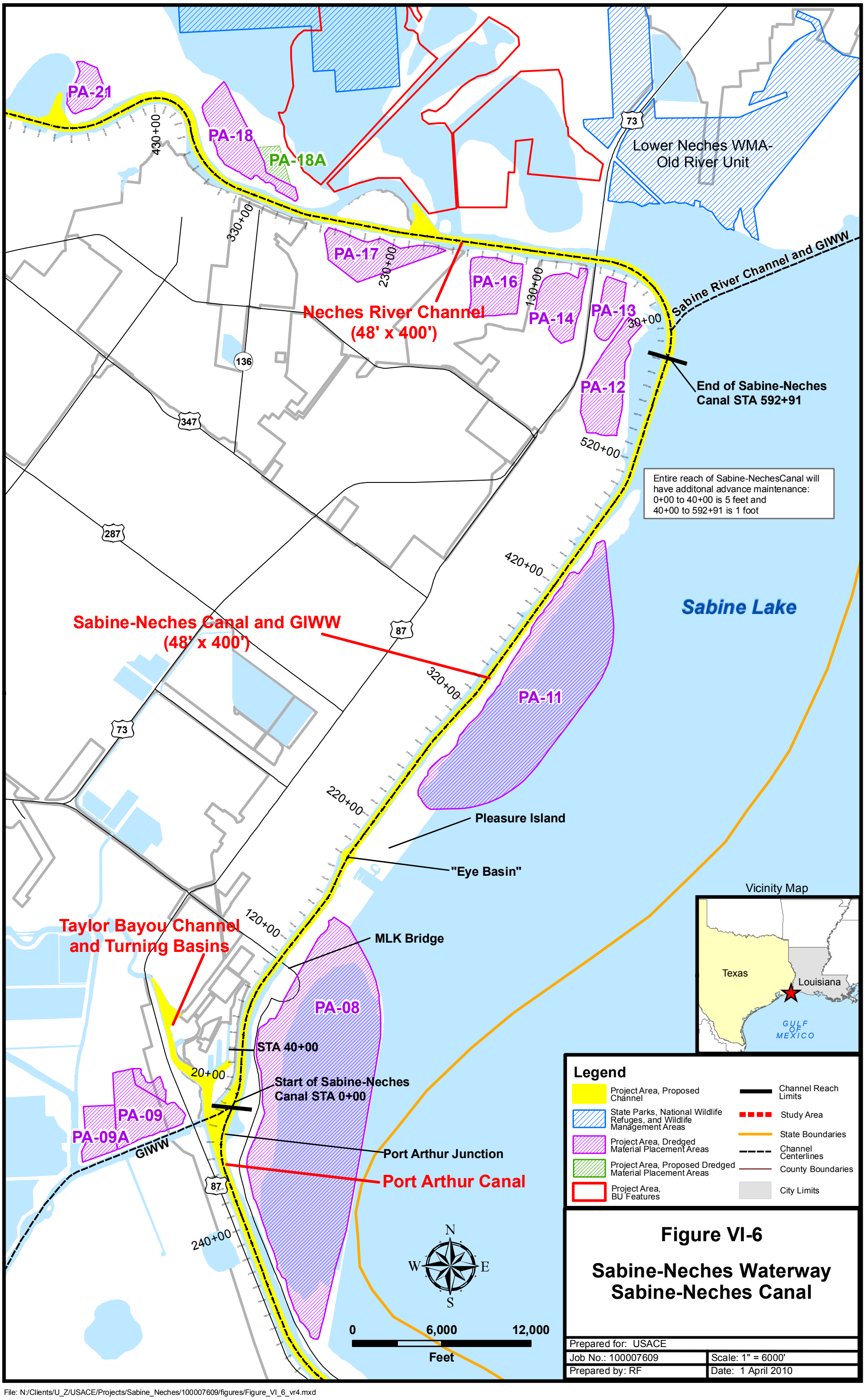


Figure VI-6

Sabine-Neches Waterway
Sabine-Neches Canal

Prepared for: USACE	
Job No.: 100007609	Scale: 1" = 6000'
Prepared by: RF	Date: 1 April 2010

File: N:/Clients/U_Z/USACE/Projects/Sabine_Neches/100007609/figures/Figure_VI_6_vr4.mxd

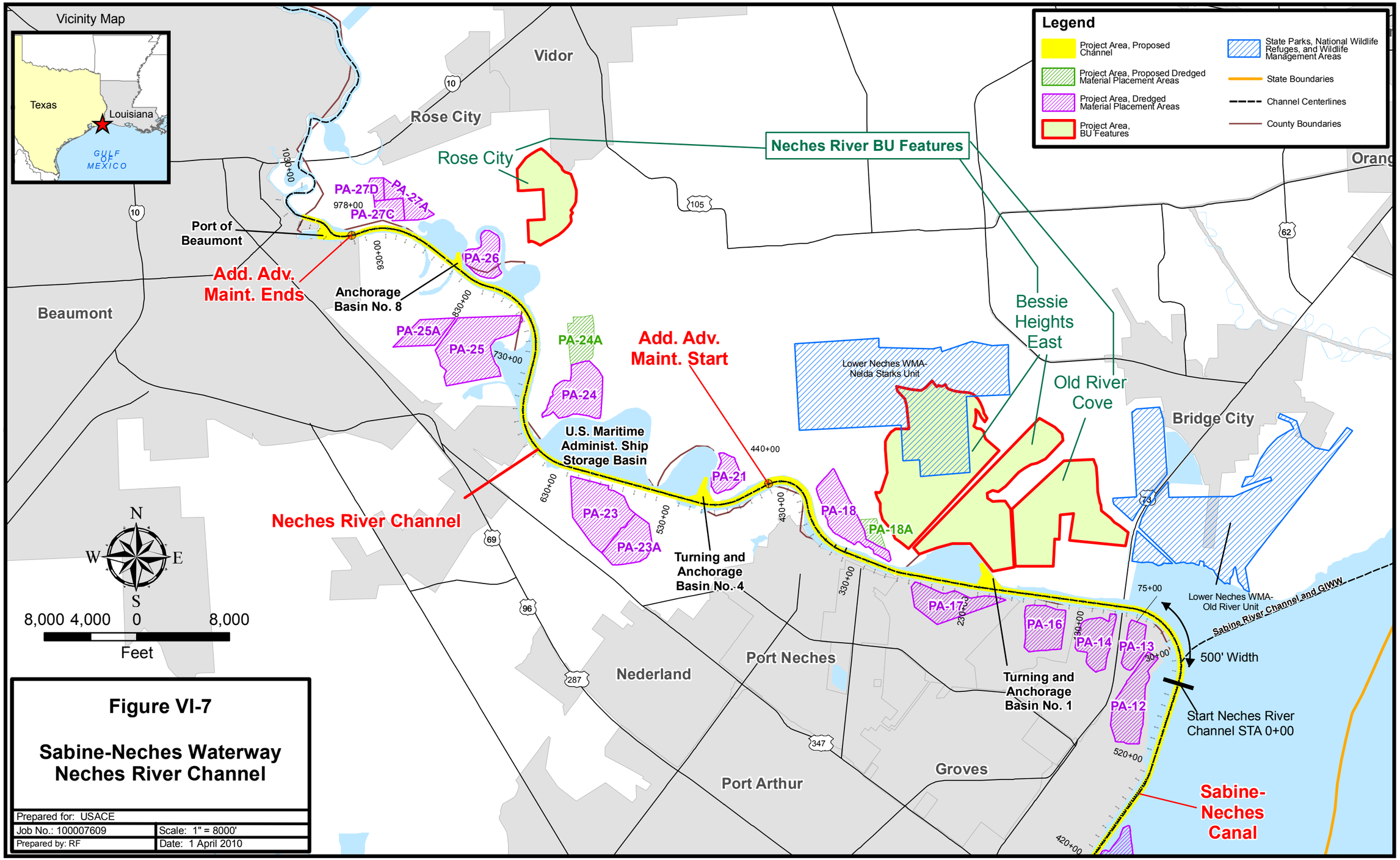


Figure VI-7

Sabine-Neches Waterway Neches River Channel

Prepared for: USACE	
Job No.: 100007609	Scale: 1" = 8000'
Prepared by: RF	Date: 1 April 2010

File: N:/Clients/U_Z/USACE/Projects/Sabine_Neches/100007609/Figure_VI_7_vr4.mxd

Table VI-3
Project Details for Sabine Bank Channel Reach

Length of Reach (Sections 1, 2)	14.7 miles (no change)
Project Depth	50 feet
Bottom Width	800 feet then narrow to 700 feet
Advance Maintenance	2 feet
Allowable Overdepth	2 feet
New Work Material	15,358,000 cubic yards
Placement Areas	ODMDS 1 and 2
Beneficial Use of Dredged Material	None
Maintenance Material (50-year quantity)	96,371,000 cubic yards
Increase in Maintenance Material	45,549,000 cubic yards
Placement Areas	ODMDS 1 and 2
Beneficial Use of Dredged Material	None

Sabine Pass Outer Bar Channel

This 3.4-mile-long channel would be deepened from 42 to 50 feet using a hopper dredge (Figure VI-2). This portion of the channel has higher velocity eddies moving around the end of the east jetty, which causes sediment to settle out as the currents cross the navigation channel, creating a higher shoaling rate. Due to the high shoaling rate, advance maintenance amounts are increased to maintain current maintenance dredging cycles. When advance maintenance and allowable overdepth are added, the Outer Bar Channel could be dredged to 58 feet. The Outer Bar Channel would remain at its current 800-foot bottom width due to strong crosscurrents just beyond the end of the jetties. An overview of the project details for the Sabine Pass Outer Bar Channel reach is listed in Table VI-4.

Table VI-4
Project Details for Sabine Pass Outer Bar Channel Reach

Length of Reach (Section 3)	3.4 miles (no change)
Project Depth	50 feet
Bottom Width	800 feet
Advance Maintenance	2 feet
Allowable Overdepth	2 feet
Additional Advance Maintenance	4 feet
New Work Material	5,923,000 cubic yards
Placement Areas	ODMDS 3
Beneficial Use of Dredged Material	None
Maintenance Material (50-year quantity)	223,650,000 cubic yards
Increase in Maintenance Material	123,965,000 cubic yards
Placement Areas	ODMDS 3
Beneficial Use of Dredged Material	None

Sabine Pass Jetty Channel

This 4.1-mile-long channel would be deepened to 48 feet using a hopper dredge (Figure VI-3). When advance maintenance and allowable overdepth are added, the Sabine Pass Jetty Channel could be dredged to 52 feet. The width of the channel would remain the same with the channel gradually tapering from the existing 800-foot width at the jetties mouth to 500 feet wide at the jetties head (Station 0+00). No impacts to the jetties have been identified that are associated with the proposed improvements. An overview of the project details for the Sabine Pass Jetty Channel reach is listed in Table VI-5.

Table VI-5
Project Details for Sabine Pass Jetty Channel Reach

Length of Reach (Section 4)	4.1 miles (no change)
Project Depth	48 feet
Bottom Width	800 to 500 feet
Advance Maintenance	2 feet
Allowable Overdepth	2 feet
New Work Material	2,978,000 cubic yards
Placement Areas	ODMDS 4
Beneficial Use of Dredged Material	None
Maintenance Material (50-year quantity)	13,527,000 cubic yards
Increase in Maintenance Material	2,142,000 cubic yards
Placement Areas	ODMDS 4
Beneficial Use of Dredged Material	None

Sabine Pass Channel

This 5.6-mile-long channel begins just north of the jetties and extends upstream to Mesquite Point on Pleasure Island (Figure VI-4). It would be deepened to 48 feet and constructed with a hydraulic pipeline dredge. Advance maintenance varies in different sections of the Sabine Pass Channel to account for differences in shoaling rates. The maximum dredging depth for two reaches of this channel (Station 0+00 to Station 100+00, and Station 180+00 to Station 230+00) would be 52 feet. Due to additional advance maintenance required to maintain existing O&M dredging cycles, the reaches from Station 100+00 to Station 180+00 and Station 230+00 to the end of the Sabine Pass Channel at 295+61 would be dredged to a depth of 55 feet. The bottom width of the Sabine Pass Channel would remain at 500 feet with a new centerline closely following the existing centerline. The Sabine Pass Anchorage is located in this reach and its footprint would be reduced in size because it has never been fully utilized. The width would be decreased from 1,500 to 855 feet, but the length would remain at 8,200 feet. The angle of approach would remain the same. An overview of the project details for the Sabine Pass Channel reach is listed in Table VI-6.

Table VI-6
Project Details for Sabine Pass Channel Reach

Length of Reach (Sections 5, 6)	5.6 miles (no change)
Project Depth	48 feet
Bottom Width	500 feet
Advance Maintenance	2 feet
Allowable Overdepth	2 feet
Additional Advance Maintenance	Station 100+00 to Station 180+00 is 3 feet Station 230+00 to Station 295+61 is 3 feet
New Work Material	6,723,000 cubic yards
Placement Areas	PA 5
Beneficial Use of Dredged Material	None
Maintenance Material (50-year quantity)	34,781,000 cubic yards
Increase in Maintenance Material	4,191,000 cubic yards
Placement Areas	PA 5
Beneficial Use of Dredged Material	Gulf Shore Beneficial Use Feature

Port Arthur Canal (including Taylor Bayou Channels and Turning Basins)

This 6.2-mile-long canal begins near Mesquite Point and ends at the Port Arthur Junction Area with the Taylor Bayou channels (Figure VI-5). The Junction Area serves as a TB and has an irregular shape where the Taylor Bayou channels and the GIWW merge with it. The Port Arthur Canal would be deepened to the proposed depth of 48 feet with a hydraulic pipeline dredge. Advance maintenance would vary in different sections of the Port Arthur Canal to account for differences in shoaling rates. The reach from Station 00+00 to Station 290+00 would be dredged to a maximum depth of 53 feet. The remaining part (Port Arthur Junction) between Stations 290+00 and 326+37 would be dredged to a maximum depth of 57 feet. The bottom width of the Port Arthur Canal would remain 500 feet. An overview of the project details for the Port Arthur Canal reach (including Taylor Bayou) is listed in Table VI-7.

Located at the confluence of the Port Arthur Junction Area, the GIWW, and the mouth of the original Taylor Bayou, the Taylor Bayou Channels and TB consist of several subreaches: Entrance Channel, East TB, West TB, Connecting Channel, and the Taylor Bayou TB. Several significant changes are proposed for this area. When advance maintenance and allowable overdepth are added to the proposed 48-foot depth, all of the Taylor Bayou channels and TB could be dredged to 53 feet. The Taylor Bayou portion of the Junction Area, between Taylor Bayou stations 0+00 and 31+10, would be dredged to 57 feet. The Taylor Bayou Entrance Channel and the West TB bottleneck curve would be widened, and a structural wall would protect local railroad tracks. Changes for each subreach are detailed below.

- Taylor Bayou Entrance Channel. The new bottom width widens on the west side of the channel. The channel would be widened to 444 feet at new Station 10+00. The new bottom width would taper back to the existing width by the end of the first curve at Station 28+38.

Table VI-7
Project Details for Port Arthur Canal Reach (including Taylor Bayou)

Length of Reach (Sections 7, 8)	6.2 miles (no change)
Project Depth	48 feet
Bottom Width	Varies (widest is 500 feet)
Advance Maintenance	2 feet
Allowable Overdepth	2 feet
Additional Advance Maintenance	(PA Canal) Station 0+00 to 290+00 is 1 foot (PA Canal) Station 290+00 to 326+37 is 5 feet (Taylor Bayou) Station 0+00 to 31+10 is 5 feet (Taylor Bayou) Station 31+10 to 106+25 is 1 foot
New Work Material	11,697,000 cubic yards
Placement Areas	PAs 8 and 9
Beneficial Use of Dredged Material	None
Maintenance Material (50-year quantity)	82,858,000 cubic yards
Decrease in Maintenance Material	5,391,000 cubic yards
Placement Areas	PA 8 and 9
Beneficial Use of Dredged Material	None

- East TB. The right side width would decrease 16 feet as the new depth extends down the existing side slope.
- West TB. The width of the existing bottleneck has been increased up to 120 feet on the west side, between new stations 33+00 and 55+00. The west bank of the basin would be protected by a structural wall, preventing impacts to the local railroad tracks present in this area.
- Connecting Channel. The West TB widening tapers back to the existing width in the Connecting Channel, between stations 55+00 and 67+00.
- Taylor Bayou TB. No changes would be made to the existing dimensions, but the basin would be deepened to the proposed 48-foot depth. Existing shore protection belonging to a local facility near Station 90+00 would be affected by penetration by the top-of-cut for the new depth.

Sabine-Neches Canal

The 11.2-mile-long canal begins at the Port Arthur Junction Area and ends just south of the mouth of the Neches River (Figure VI-6). The GIWW shares this canal with the deep-draft channel. It would be deepened to the proposed depth of 48 feet with a hydraulic pipeline dredge. When advance maintenance and allowable overdepth are added for the shoaling rate in the canal, stations 0+00 to 40+00 could be dredged to 57 feet, and remainder of the canal through Station 592+91 could be dredged to 53 feet.

The bottom width of this canal would be selectively widened in three separate sections. The bottom width of the most-downstream curve (stations 0+00 to 20+00) would be widened to 500 feet on the east side of the channel, and then promptly tapered to the existing 400-foot width prior to the MLK Bridge (SH 82). The canal would be widened to 450 feet adjacent to the Port of Port Arthur, with gradual tapering

upstream and downstream between stations 120+00 and 170+00. The third widening section begins to taper at Station 565+00, gradually widening to 500 feet and remaining that width to the end at Station 592+91.

Bend easing is planned for three areas in the Sabine-Neches Canal to improve ship maneuverability: stations 265+00 to 305+00, stations 350+00 to 395+00, and stations 500+00 to 520+00. The bend easing between Stations 350+00 to 395+00 eliminates a wiggle in the alignment, and shifts the footprint of the canal 10 feet east of the existing alignment up to Station 520+00.

Changes are also recommended for the canal bottom adjacent to the Port Arthur Dock and the "Eye Basin." The canal toes adjacent to the Port of Port Arthur would be moved approximately 10 feet to the east while keeping the same bottom width of 450 feet. The diameter of the turning point ("Eye Basin") at Station 190+00 would be decreased by 16 feet. An overview of the project details for the Sabine-Neches Canal reach is listed in Table VI-8.

Table VI-8
Project Details for Sabine-Neches Canal Reach

Length of Reach (Sections 9, 10)	11.2 miles (no change)
Project Depth	48 feet
Bottom Width	varies 400 to 500 feet
Advance Maintenance	2 feet
Allowable Overdepth	2 feet
Additional Advance Maintenance	Station 0+00 to 40+00 is 5 feet Station 40+00 to 592+91 is 1 foot
New Work Material	11,944,000 cubic yards
Placement Areas	PAs 8 and 11
Beneficial Use of Dredged Material	None
Maintenance Material (50-year quantity)	73,245,000 cubic yards
Increase in Maintenance Material	13,122,000 cubic yards
Placement Areas	PAs 8 and 11
Beneficial Use of Dredged Material	None

Neches River Channel

This 18.5-mile-long channel begins just south of the mouth of the Neches River (Figure VI-7). It would be deepened to the proposed depth of 48 feet to Station 980+00 with a hydraulic pipeline dredge. Advance maintenance would vary in different sections of the Neches River Channel to account for differences in shoaling rates. Between stations 0+00 and 440+00, the maximum dredged depth would be 52 feet; between stations 440+00 and 978+00, it would be 54 feet. While the overall bottom width of 400 feet does not change for the majority of the channel length, the first curve at the mouth of the Neches River (between stations 0+00 and 75+00) would be widened to 500 feet, and then tapered back to 400 feet prior to the SH 87 twin bridges. An overview of the project details for the Neches River Channel reach is listed in Table VI-9.

Table VI-9
Project Details for the Neches River Channel Reach

Length of Reach (Sections 11–18)	18.5 miles (no change)
Project Depth	48 feet
Bottom Width	400 feet (majority of channel)
	500 feet Station 0+00 to 75+00
Advance Maintenance	2 feet
Allowable Overdepth	2 feet
Additional Advance Maintenance	Station 440+00 to 978+00 is 2 feet
New Work Material	25,014,000 cubic yards
Placement Areas	PAs 12, 13, 14, 16, 18, 21, 23, 24, 25, 26, 27
Beneficial Use of Dredged Material	Neches River BU Feature
Maintenance Material (50-year quantity)	89,725,000 cubic yards
Increase in Maintenance Material	23,277,000 cubic yards
Placement Areas	PAs 12, 13, 14, 16, 17, 18, 21, 23, 24, 25, 26, 27
Beneficial Use of Dredged Material	Neches River BU Feature (Bessie Heights East, Rose City East)
Turning Basins/Anchorage Areas	1 new; 2 enlarged; 5 no change

Three basins would be added or enlarged on the Neches River Channel. All three would be dredged to the proposed depth of 48 feet, plus the advance maintenance and allowable overdepth associated with the specific channel reach in which they are located. One TB, Turning Basin No. 6, is an existing basin and would continue to be maintained at the existing 40-foot depth and existing advance maintenance and allowable overdepth.

- Turning and AB No. 1 is located in an old river oxbow at the east end of Texaco Island near Station 210+00. The TB enlarges the existing basin from 1,000 to 1,350 feet in diameter. A new AB, 250 by 1,100 feet in size, would be added.

- Turning and AB No. 4 enlarges an existing turning point at Station 510+00 from 1,000 to 1,350 feet in diameter. A new AB in the old river oxbow at Station 500+00 would be 250 by 1,100 feet in size.

- AB No. 8 is new and would be located at Station 850+00. The 250- by 1,100-foot basin is located in an old river oxbow.

Management of Dredged Material

Federal dredged material from construction and maintenance of the Recommended Plan would be managed in accordance with the DMMP as described in Section VIII of this document and Appendix D of the FEIS. The DMMP GNF includes an extensive BU plan that uses new work and maintenance material from the proposed 48-foot project to restore large marsh complexes on the Neches River, and nourish the Gulf shoreline in Texas and Louisiana.

Construction of the Recommended Plan would generate 98 mcy of new work material and 650 mcy of maintenance material for the 50-year period of analysis. Forty-four percent of the new work material would be placed in offshore disposal sites. Forty-seven percent of the new work material would be used to construct and rehabilitate PA containment levees; 8 percent would be used in DMMP marsh restoration; and 1 percent would be surplus and pumped to upland PAs. The material type expected to be dredged with construction of the Recommended Plan is predominantly clay (USACE, 1982), and is suitable material for the construction and rehabilitation of PA containment levees. However, one short stretch of the Neches River Channel near the upstream end of the project contains sandier sediments (clayey sands, sandy clays, silty sands, and poorly graded sands). Since specific dredging practices may influence the degree to which the material would stack, regular monitoring of the dredging activities would be necessary.

Shoaling is projected to increase with the Recommended Plan for several reasons (Parchure et al., 2005). The Entrance Channel is being extended an additional 13.2 miles into the Gulf of Mexico, and this would result in higher offshore maintenance dredging quantities. The larger channel cross section would lower velocities near the bottom of the navigation channel creating conditions favorable for sediment deposition; the deeper channel would have a greater surface area, making it function as a larger sediment trap; and higher salinities would increase flocculation and increase the deposition of suspended sediment.

Maintenance dredging material quantities for the proposed 48-foot project would therefore increase from 407 mcy to 650 mcy. Expressed as average annual equivalents, estimated dredging quantities increase from 8.1 mcy to 13.0 mcy per year over the 50-year period of analysis (Table VI-10). Fifty-seven percent of the maintenance quantities would originate from the offshore channels, and 43 percent from the inshore channels.

Table VI-10
Existing and Proposed Maintenance Dredging Quantities

Channel Reach	Existing 50-Year Maintenance Quantities	Proposed 50-Year Maintenance Quantities
Neches River Channel	66,447,680	89,724,800
Sabine-Neches Canal	60,122,600	73,245,000
Port Arthur Canal	88,248,750	82,857,600
Sabine Pass Channel	30,590,400	34,780,800
Sabine Pass Jetty Channel	11,385,000	13,527,000
Sabine Pass Outer Bar Channel	99,685,000	223,650,000
Sabine Bank Channel	50,822,400	96,371,000
Sabine Bank Extension		36,216,000
Total Quantities	407 mcy	650 mcy

Beneficial Use Features of the DMMP

Dredged material will be used beneficially to restore large degraded marsh areas on the Neches River (Rose City East, Bessie Heights East, and Old River Cove), and nourish the Gulf shoreline at Texas and

Louisiana Points. Shoreline nourishment at Texas Point is located within the boundaries of the Texas Point NWR. Detailed descriptions of these efforts can be found in Section VIII of this report and in Appendix C of the FEIS.

The DMMP BU features (Neches River and Gulf Shore BU features) are least-cost, environmentally acceptable placement alternatives and, as such, are considered GNF of the Recommended Plan. They will contribute significantly to a sustainable environment while providing placement capacity for the proposed project. The Neches River BU Feature would take advantage of new work material provided by the channel-deepening project to build hydraulic containment levees within degraded, former marsh areas at Rose City East, Bessie Heights East, and Old River Cove. Each of these areas is referred to as a component of the overall Neches River BU Feature. Marsh would be created in each component using only new work, or a combination of new work and maintenance material. At the Rose City East component, new work material would be used to construct containment levees and ridges, then the marsh would be completed with the placement of maintenance material during the first maintenance cycle following construction. In the Bessie Heights East component, maintenance material would be placed incrementally in seven maintenance cycles over 28 years. The Old River Cove component would be filled during initial construction with new work material, alone. The Gulf Shore BU Feature nourishes shorelines at Texas and Louisiana Points with the placement of maintenance material every 3 years over the 50-year period of analysis, with placement episodes alternating between each side of Sabine Pass.

BU features of the DMMP (Neches River and Gulf Shore features) will offset all project impacts in Texas by restoring 2,853 acres of emergent marsh, improving 871 acres of shallow-water habitat, and nourishing 1,234 acres of existing marsh. Benefits of the Neches River BU Feature also more than offset the direct impact of conversion of 86 acres of fresh marsh to a confined PA (PA 24A) and the indirect impact of the increase in salinity over 39,000 wetland acres in Texas. The Gulf Shore BU Feature offsets minor erosion impacts by periodically nourishing 6 miles of Texas and Louisiana Gulf shorelines. Benefits of the DMMP offset all impacts of the Recommend Plan in Texas and, therefore, no compensatory mitigation is proposed for Recommend Plan effects in Texas.

The Keith Lake Section 1135 CAP study was begun in 2003, well before impacts of the SNWW CIP had been determined or potential mitigation measures defined. Since at that time it seemed likely that the CAP study and project construction would be completed before the SNWW CIP could be authorized and constructed, the Keith Lake Section 1135 study was considered separable from the SNWW CIP. It was assumed that a water control structure at the Fish Pass would be part of the FWOP condition for the SNWW CIP.

Incremental impacts of the SNWW CIP will be calculated for the Salt Bayou unit of the SNWW study area when WVA modeling is completed for the Keith Lake Section 1135 study. It is possible that the excess DMMP benefits (316 AAHUs) of the SNWW CIP will cover all incremental project impacts. However, if it is determined that additional mitigation is needed, then the USACE and the non-Federal sponsor of the SNWW CIP will initiate consultation with resource agencies, identify and incrementally justify additional compensatory mitigation for the Salt Bayou unit, and prepare a supplement EIS.

Upland Placement Areas

Sixteen existing PAs and two expansion cells are proposed for use with the Recommend Plan. A list and description of proposed upland PAs can be found in Chapter VII of this report. For the inland channel reaches, existing upland PAs will be used to the greatest extent possible; however, expansion of some existing PAs will also be required. Forty-seven percent of the new work material will be used to construct and rehabilitate PA containment levees; 8 percent will be used in DMMP marsh restoration; and the remainder would be pumped to upland PAs. Upland PAs on the Port Arthur and Sabine-Neches canals and the Neches River Channel would also provide capacity for non-Federal dredging of private facilities. A capped landfill has been found in PA 17 that is unrelated to dredged material or dredging activities. Issues related to possibly hazardous materials in the landfill must be resolved by the Sponsor before the PA could be used. Alternate PAs are available should this issue not be resolved in time for use.

Ocean Dredged Material Disposal Sites

For the offshore channel reaches, the Recommended Plan provides for the use of four existing ODMDSs (1–4) and four proposed ODMDSs (A–D). These sites are in the Sabine Bank Channel and the Sabine Bank Extension (see figures VI-1 and VI-2). Site selection criteria for the four proposed Extension Channel ODMDSs are discussed in the FEIS for ODMDS designation (FEIS Appendix B) and in Chapter VII of this report. This document provides required NEPA review and public coordination to support Environmental Protection Agency (EPA) designation, per 40 CFR 228, of new ODMDSs that provide environmentally acceptable, and economically and physically feasible, areas for the placement of the construction material and future maintenance material from the Extension Channel. All of the new sites, as well as the existing sites, are located west of the navigation channel to minimize channel-shoaling effects of the prevailing east to west littoral drift in this portion of the Gulf of Mexico.

Maintenance dredging volumes for the offshore channel would increase more than the inshore reaches (increase of 128 percent and 14 percent, respectively). Additional capacity for the offshore reaches would be obtained by designating new ODMDSs. Material from four of the offshore channel reaches (Extension Channel, Sabine Bank Channel, Sabine Pass Outer Bar Channel, and Sabine Pass Jetty Channel) would be placed in the ODMDSs as described in Appendix B of the FEIS. The types of material expected to be dredged with construction of the Recommended Plan were established with soil borings through the maximum dredging depth along the centerline of the existing channel and proposed channel extension (USACE, 1982). The cores are composed overwhelmingly of inorganic clays, with the exception of the channel segment adjacent to proposed ODMDS C where sediments are approximately 70 percent silty or clayey sands and 30 percent clay.

Compensatory Mitigation

The USACE has developed a compensatory mitigation plan for project impacts that would remain after application of DMMP BU Feature benefits. Project impacts are fully described in the FEIS; DMMP BU benefits and compensatory mitigation are summarized in chapters VII and VIII of this document. No

mitigation would be necessary in Texas because benefits of the DMMP offset all impacts in Texas; therefore, all mitigation areas would be located in Louisiana.

The recommended Mitigation Plan would consist of restoring five degraded marsh areas east of Sabine Lake in Louisiana. Each of the mitigation measures is described in detail in Section 5.0 of the FEIS. The Mitigation Plan would compensate for the Recommended Plan's salinity increase and associated losses in biological function and productivity by marsh creation activities in the Willow and Black Bayou watersheds. A hydraulic pipeline dredge would pump a sediment slurry into a total influence area of 8,095 acres. The sediment would restore 2,783 acres of emergent marsh in existing open-water areas within the influence area; improve 957 acres of shallow-water habitat by creating shallower, smaller ponds and channels within the restored marsh; and stabilize and nourish 4,355 acres of existing marsh located in the influence area. The amount of recommended mitigation was determined by the WVA Model and is the amount of marsh that would need to be restored to compensate for the mitigation target of the 1,159 AAHUs. In total, these measures produce 1,181 AAHUs and provide full compensation for all impacts of the CIP. This plan is described more fully in Chapter VIII.

Aids to Navigation – USCG Channel Markers

Most of the existing USCG channel markers along the waterway would require removal and replacement. However, markers along the Neches River Channel upstream from the Beaumont Maneuvering Basin and in the vicinity of SH 87 would not require changes in the navigation aids. The Port Arthur Junction area would require relocation of the aids to navigation, and new aids would be required along the Extension Channel. The USCG would be responsible for replacing the structures when the channel modifications are constructed.

Bridge Reinforcements and Fenders

Deepening improvements to the SNWW navigation channels would affect existing fender systems of the Rainbow Bridge and Veteran's Memorial Bridge over the Neches River Channel on SH 87 and the MLK Bridge over the Sabine-Neches Canal on SH 82. Bridge fender systems on both sides of the channel would require removal and replacement. Additional stabilization of the bridge foundation would be needed at the MLK Bridge. None of the bridges would cause an unreasonable obstruction to navigation, and thus would not require modification or replacement pursuant to the Truman-Hobbs Act. Bridge piers with a hardened structure would be necessary to maintain the proposed 400-foot channel width.

Lands, Easements and Rights-of-Way

The project Sponsor is required to furnish the LER for the proposed cost-shared project. The real estate requirements must support construction as well as operation and maintenance of the project after completion. A summary of the real estate requirements for each channel reach is provided in Table VI-11. Specific details of the real estate requirements can be found in the Real Estate Plan, Appendix 4 of this document.

Table VI-11
Real Estate Requirements for Placement Areas

	Real Estate Requirement
Channel Reach	
Sabine Bank Extension	Navigational servitude
Sabine Bank Channel	Navigational servitude
Sabine Pass Outer Bar Channel	Navigational servitude
Sabine Pass Jetty Channel	Navigational servitude
Sabine Pass Channel	Acquire in Fee (PA 5)
Port Arthur Canal	Navigational servitude (PA 8) Acquire in Fee (PA 9)
Sabine-Neches Canal	Navigational servitude (PAs 8, 11)
Neches River Channel	Owned by Sponsor (no action) (PAs 12, 13, 14, 16, 18, 18A, 21, 23, 23A, 24, 24A, 25, 25A) Acquire in Fee (PAs 17, 26, 27A, 27C, 27D) Turning Basins – two would require the acquisition of land in perpetual channel improvement easement.
Louisiana Mitigation Areas	
Willow/Black Bayou Areas	Navigational Servitude

Relocations

The following assumptions were made to identify pipelines that could be affected by the Recommended Plan and to develop associated costs. The individual circumstances of each pipeline will be evaluated by USACE in consultation with the pipeline owner during the PED and Construction phases, and decisions regarding necessary actions will be made individually for each pipeline at that time. Feasibility engineering guidelines indicate that pipelines with a minimum of 8 feet of cover for trenched lines or 5 feet of cover for directionally drilled lines would not be adjusted. Pipelines that do not meet the minimum cover requirement would be required to be adjusted. The adjusted pipelines must be located 20 feet below the authorized 48-foot depth. The 20 feet includes any advance maintenance and allowable overdepth. The relocation of active pipelines is assumed to be installed with directional drilling, and bundled where possible.

A total of 104 pipelines have been identified crossing the SNWW navigation channels. Of the 104 pipelines, 46 require adjustment to meet the minimum required vertical and horizontal clearances for the CIP.

Pursuant to Section 101(a) of the Water Resources Development Act (WRDA) of 1986, as amended, the Sponsor is responsible for performing, or assuring performance, of all relocations, including utility relocations, which are necessary for the CIP. All relocations, including utility relocations, are to be accomplished at no cost to the Federal Government.

The Galveston District has concluded preliminarily that 41 of the 46 lines located within the channel must be relocated and are classified as utility relocations for which the Sponsor must perform or assure performance. In accordance with Section 101(a)(4) of WRDA 86, one-half of the cost of each such relocation will be borne by the owner of the facility being relocated and one-half of the cost of each such

relocation will be borne by the Sponsor. Such relocation costs will not include any cost for upgrading or improving such facilities, which is to be borne by the facility owner.

For more specific information regarding the utility relocations, and preliminary conclusions regarding the remaining five lines that must be removed but not replaced, see the Real Estate Plan, Appendix 4, of this document.

DMMP marsh restoration at Bessie Heights and mitigation marsh restoration measures east of Sabine Lake were assumed to require no relocations. However, since oil production is active in some of these areas, additional pipeline searches and coordination with pipeline owners would be required prior to construction to avoid impacts.

No relocations would be required for overhead power utilities, highway bridges, the Port Arthur HFP Levee, or its associated pump stations and closure structures.

Impact Analysis and Mitigation Needs Summary for the Recommended Plan

A summary of impacts before DMMP benefits and compensatory mitigation is provided in tables VI-12 and VI-13 for Louisiana and Texas, respectively. A full summary of the impact analysis and compensatory mitigation needs for the Recommended Plan is presented in Table VI-14 for each state. The calculation of impacts and benefits of the DMMP BU features and mitigation measures are described in Section 2.5 and throughout Section 4.0 of the FEIS.

Critical Assumptions

Critical planning and environmental assumptions were made in the evaluation of the benefits and impacts of the Recommended Plan. Table VI-15 provides a brief summary of the major assumptions, the scientific basis or rationale behind each assumption, and an indication of the consequences if the assumptions turns out not to be valid.

VI.C RECOMMENDED PLAN AND RECENT USACE INITIATIVES

As stated in Chapter III of this report, the USACE has implemented the EOP and the Actions for Change over the past few years. These initiatives were developed to ensure the 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 the SNWW CIP is described below:

USACE Environmental Operating Principles

- **Strive for environmental sustainability** – Construction of BU, restoration, and mitigation sites were developed for a 50-year period of analysis. Development and design of these areas were made to address potential changes over time (e.g., sea-level rise, shoreline erosion, etc.).

Table VI-12
SNWW WVA Impacts Summary-Before DMMP Benefits and Mitigation
Louisiana Impacts (Sorted by AAHUs)

HU #	Hydrologic Unit	Habitat Type	FWOP Net Change Acres	FWP Net Change Total Acres	FWP Net Change % Acres	FWOP Net Change AAHUs	FWP Net Change AAHUs	FWOP Salinity (ppt)	FWP Salinity (ppt)	FWP Net Salinity Change (ppt)
LA 3	Black Bayou	Intermediate Marsh	–1,713	–130	–0.3	14,734	–509	4.00	5.10	1.1
LA 2	Willow Bayou	Intermediate (Brackish lumped)	–2,116	–102	0.3	11,249	–328	6.30	7.20	0.9
LA 4	West Johnson's Bayou	Intermediate Marsh	–1,703	–142	–0.8	5,729	–269	6.30	7.50	1.2
LA 5	Sabine Lake Ridges	Intermediate Marsh	–1,103	–93	–0.7	4,868	–218	6.30	7.50	1.2
LA 9	East Johnson's Bayou	Intermediate Marsh	–895	–46	–0.2	13,820	–190	4.20	5.20	1.0
LA 1	Perry Ridge	Fresh Marsh	–921	–50	–0.2	8,947	–65	0.90	1.24	0.3
LA 1	Perry Ridge	Intermediate Marsh	–191	–12	–0.1	1,873	–53	0.90	1.24	0.3
LA 5	Sabine Lake Ridges	Saline Marsh	–398	–10	–0.5	2,184	–35	17.00	18.40	1.4
LA 8	Southwest Gum Cove	Fresh Marsh	–152	–8	–0.3	2,170	–2	1.20	2.10	0.9
LA 5	Sabine Lake Ridges	Brackish Marsh	–2,567	–43	–0.1	9,113	–14	8.00	8.60	0.6
LA 7	Southeast Sabine	Fresh Marsh	–40	0	0.0	1,231	–11	1.80	2.30	0.5
LA 6	Johnson's Bayou Ridge	Brackish Marsh	–707	–22	–0.3	1,285	–6	6.00	6.70	0.7
LA 8	Southwest Gum Cove	Intermediate (Brackish lumped)	–233	–15	–0.2	3,253	–4	2.40	3.30	0.9
LA 6	Johnson's Bayou Ridge	Saline Marsh	–93	–5	–1.0	195	–2	12.00	13.80	1.8
LA 3	Black Bayou	Brackish Marsh	–803	–4	0.0	1,643	–1	3.00	3.80	0.8
LA 4	West Johnson's Bayou	Brackish Marsh	–1,189	–6	–0.2	768	–1	6.00	6.70	0.7
LA 2	Willow Bayou	Brackish Marsh	–695	–2		498	–1			1.4
LA/TX 1	Sabine Island	Cypress/Tupelo Swamp	0	0	0.0	4,499	0	0.69	1.10	0.4
LA/TX 2	Blue Elbow	Cypress/Tupelo Swamp (BH lumped)	0	0	0.0	300	0	1.00	1.60	0.6
LA 7	Southeast Sabine	Intermediate (Brackish lumped)	–96	–1	0.0	3,204	0	1.80	2.00	0.2
LA 1	Perry Ridge	Bottomland Hardwood	0	0	0.0	2,080	0	0.90	1.24	0.3
LA/TX 1	Sabine Island	Bottomland Hardwood	0	0	0.0	999	0	0.69	1.10	0.4
Total			–15,615	–691		94,642	–1,709			

Table VI-13
SNWW WVA Impacts Summary-Before DMMP Benefits and Mitigation
Texas Impacts (Sorted by AAHUs)

HU #	Hydrologic Unit	Habitat Type	FWOP Net Change Acres	FWP Net Change Total Acres	FWP Net Change % Acres	FWOP Net Change AAHUs	FWP Net Change AAHUs	FWOP Salinity (ppt)	FWP Salinity (ppt)	FWP Net Salinity Change (ppt)
TX 7	GIWW North	Fresh (Intermediate lumped)	–539	–63	–0.4	2,602	–140	0.70	1.20	1.6
TX 6	Old River Cove	Brackish Marsh	–1,518	–46	–0.3	3,061	–116	10.00	11.00	1.8
TX 3	Rose City PA24A	Fresh Marsh	–3	–86	–63.3	53	–32			0.3
TX 8	Texas Point	Intermediate (Fresh lumped)	–245	–6	–1.3	940	–19	5.50	8.00	0.8
TX 12	Blue Elbow South	Cypress/Tupelo Swamp	0	0	0.0	418	–18	1.67	2.60	0.6
TX 10	Cow Bayou	Fresh Marsh	–75	–6	–0.1	824	–18	2.00	2.20	1.0
TX 11	Adams Bayou	Fresh Marsh	–28	–3	–0.7	305	–15	2.10	4.10	1.5
TX 5	Bessie Heights	Intermediate (Brackish lumped)	31	–1	0.0	1,273	–14	4.20	4.70	0.3
TX 10	Cow Bayou	Intermediate Marsh	–59	–3	0.0	741	–12	2.00	2.20	1.0
TX 7	GIWW North	Brackish Marsh	–62	–2	–0.1	380	–8	9.00	9.60	1.6
TX 8	Texas Point	Brackish Marsh	–252	–5	–0.4	1,464	–7	8.50	11.00	0.8
TX 8	Texas Point	Saline Marsh	–2,446	–17	–0.9	2,480	–5	12.50	15.00	0.8
TX 11	Adams Bayou	Cypress/Tupelo Swamp	0	0	0.0	44	–4	2.10	4.10	0.8
TX 13	Groves	Intermediate Marsh	–68	–3	–0.7	220	–3			1.0
TX 3	Rose City	Fresh Marsh	–93	–3	–0.1	1,365	–1	0.25	0.55	0.3
TX 2	Neches-Lake Bayou	Cypress/Tupelo Swamp	0	0	0.0	1,977	0	2.00	2.90	0.0
TX 1	North Neches River	Cypress/Tupelo Swamp	0	0	0.0	2,399	0	0.90	1.70	0.0
LA/TX 2	Blue Elbow	Cypress/Tupelo Swamp (BH lumped)	0	0	0.0	1,261	0			0.3
TX 2	Neches-Lake Bayou	Fresh Marsh	–24	0	–0.1	808	0	2.00	2.90	0.1
LA/TX 1	Sabine Island	Cypress/Tupelo Swamp	0	0	0.0	896	0			0.0
TX 5	Bessie Heights	Fresh Marsh	–40	–2	–0.1	1,313	0	1.00	1.50	0.5
TX 1	North Neches River	Fresh Marsh	–8	0	0.0	249	0	0.90	1.70	0.0
TX 10	Cow Bayou	Cypress/Tupelo Swamp	0	0	0.0	55	0	2.00	2.20	1.0
TX 4	West of Rose City	Fresh Marsh	–24	–1	–0.1	238	0	0.10	0.40	0.4
TX 5	Bessie Heights	Bottomland Hardwood	0	0	0.0	225	0	1.00	1.50	0.5
TX 3	Rose City	Cypress/Tupelo Swamp	0	0	0.0	217	0	0.25	0.55	0.3

Table VI-13 (Cont'd)

HU #	Hydrologic Unit	Habitat Type	FWOP Net Change Acres	FWP Net Change Total Acres	FWP Net Change % Acres	FWOP Net Change AAHUs	FWP Net Change AAHUs	FWOP Salinity (ppt)	FWP Salinity (ppt)	FWP Net Salinity Change (ppt)
TX 1	North Neches River	Bottomland Hardwood	0	0	0.0	277	0	0.90	1.70	0.0
LA/TX 1	Sabine Island	Bottomland Hardwood	0	0	0.0	503	0			0.0
TX 3	Rose City	Bottomland Hardwood	0	0	0.0	698	0	0.25	0.55	0.3
TX 6	Old River Cove	Bottomland Hardwood	0	0	0.0	149	0	1.00	1.50	0.5
TX 10	Cow Bayou	Bottomland Hardwood	0	0	0.0	286	0	2.00	2.20	1.0
TX 11	Adams Bayou	Bottomland Hardwood	0	0	0.0	402	0	2.10	4.10	0.8
TX 2	Neches-Lake Bayou	Bottomland Hardwood	0	0	0.0	1,164	0	2.00	2.90	0.0
	Totals		–5,453	–247		28,124	–412			

Table VI-14
Impact Analysis and Mitigation Need

	Texas	Louisiana	Project as Whole
Impact analysis (AAHUs)			
Negative Impacts (–) before DMMP BU	–412	–1,709	–2,121
Positive Impacts Resulting from DMMP BU	1,068	210	1,278
Net Gain or Loss (–) after DMMP BU	656	–1,499	–843
Offset of Impacts to Louisiana Federal Lands from Excess Texas BU Benefits	–340	340	NA
Net Gain or Loss (–) after BU Benefits	316	–1,159	–843
Compensatory Mitigation (AAHUs)			
Total Compensation	0	1,181	1,181
Net Gain after BU Benefits and Mitigation	**316**	**22**	**338**
Impact Analysis (acres)			
Size of Potential Impact	58,649	197,530	256,179
Area with No Impacts	19,421	15,247	34,668
Area of Direct Impacts	86	0	86
Area of Indirect Impacts	39,228	182,283	221,511
Net Acres of Land Loss (–) before DMMP BU	–243	–691	–934
Total Miles of Shoreline Influenced by DMMP BU	3	3	6
Total Acres Affected by DMMP BU	4,958	0	4,958
Created Emergent Marsh	2,853	0	2,853
Improved Shallow Water	871	0	871
Nourished Existing Marsh	1,234	0	1,234
Compensatory Mitigation (acres)			
Total Acres Affected by Mitigation	0	8,095	8,095
Created Emergent Marsh	0	2,783	2,783
Improved Shallow Water	0	957	957
Nourished Existing Marsh	0	4,355	4,355
Total Acres Affected by DMMP BU and Mitigation	**4,958**	**8,095**	**13,053**
Created Emergent Marsh	2,853	2,783	5,636
Improved Shallow Water	871	957	1,828
Nourished Existing Marsh	1,234	4,355	5,589

Table VI-15
Critical Assumptions

Assumption	Rationale for the Assumption	Consequences if Assumption Becomes Invalid
Future without-project (FWOP) Condition		
Louisiana Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) Projects in operation at Willow Bayou, Black Bayou, and Perry Ridge for remainder of project life.	Ecological effects of CWPPRA projects (reductions in land loss rates and/or salinity) based upon changes projected in environmental assessments.	If ecological benefit of CWPPRA project is less than expected, then FWOP salinity and land loss impacts would be slightly higher than expected; conversely, if ecological benefits are higher, FWOP impacts would be slightly lower than expected.
Most likely rate of RSLR estimated to be 1.1 feet in the study area by year 2069. Full potential range of RSLR estimated to be from 0.3 to 2.8 feet over period of analysis.	Eustatic sea-level rise based upon mid- to high mid-range projected by NRC and IPCC, respectively. Local subsidence component based upon long-term trends obtained from basal peat analysis. Full potential range calculated as required by Circular No. 1165-2-211.	Little consequence if RSLR is lower than expected. High rate of RSLR could result in small increase in maintenance dredging and PA levee heights for existing project; increase in hurricane tidal surge elevation; an increase in land loss due to submergence of intertidal marshes and salinity increase. Functioning of navigation channel would not be affected; improvements at some dock facilities might be needed.
Future freshwater inflows assumed for HS modeling are slightly higher on Neches River than existing inflows; about the same as existing inflows on the Sabine River.	Future freshwater inflows were based upon demand projections and supply strategies approved by the 2007 Texas State Water Plan.	Little consequence if inflows are higher than projected. If inflows are lower than expected, FWOP ecological impacts would be higher than expected and more areas would be experiencing suboptimal salinities.
Changes in land loss rates are driven by the interaction of salinity and submergence, resulting in a reduction in plant productivity, leading to a decrease in plant growth, plant death, followed by peat collapse and wetland loss. Assumed linear relationship between change in salinity due to RSLR and change in FWOP land loss rate.	The salinity-vegetation productivity relationship is based upon algorithms developed for dominant wetland vegetation species in the study area. The algorithms were developed for the Louisiana Coastal Areas Ecosystem Restoration Study, using data from a large number of professional studies.	If the relationship between salinity and land loss is different from that projected, FWOP land loss would be higher or lower than current estimates.

Table VI-15 (Cont'd)

Assumption	Rationale for the Assumption	Consequences if Assumption Becomes Invalid
Future with-project (FWP) Condition (Recommended Plan)		
RSLR – same as FWOP because deepening project causes only negligible increase in water surface elevation.	FWP water surface elevation change determined by the ERDC HS modeling.	Little consequence if RSLR is lower than expected. No FWP effect on maintenance dredging, PA levee heights, or tidal surge penetration. At high rate, all areas suitable for marsh mitigation could be susceptible to submergence. DMMP BUs protected by containment structures.
Additional land loss would result primarily from the interaction of higher FWP salinities with FWOP RSLR. Assume direct linear relationship between salinity and land loss changes.	Associating land loss with salinity increases is based upon well-documented biological responses of inundated vegetation to salinity change. No data are currently available that relate specific salinity changes to specific land loss rate changes.	If the relationship between salinity and land loss is different from that projected, FWP impacts would be higher or lower than current estimates.
Cost Estimates		
Cost estimate of the Recommended Plan utilized appropriate probabilities of risk.	Cost risk analysis was performed using required forecasting and analysis tools. Cost contingencies developed by this analysis have been included in the total project cost estimate.	An increase in total project cost, exclusive of price level changes, of more than 20 percent of the total project cost stated in the authorizing legislation would require Congressional authorization.
It was assumed that up to 5 pipeline dredges would be available for use at one time for inshore channel dredging, and mitigation and BU marsh creation. Offshore dredging assumes use of only one hopper dredge at a time.	Assume offshore hopper dredge production averaging 7.9 mcy/yr; inshore pipeline dredge production of 7.2 mcy/yr; and no more than 550 acres/year of mitigation or BU marsh creation by any one dredge.	If the assumed production rate is too high, or if the assumed number of dredges is not available, then construction would take longer and the total cost of construction would increase.
Funding		
Sufficient funding streams would be available to construct the Recommended Plan over the assumed construction periods and to provide long-term operation and maintenance.	USACE planning policy states that plans should be developed without funding constraints. Federal funding priorities are difficult to predict.	Total project cost could be higher because of longer construction schedule. Inadequate O&M funding could cause an increase in navigation costs or adversely affect monitoring of mitigation and BU features.

mcy/yr = million cubic yards per year.

- **Consider environmental consequences** – 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.
- **Seek balance and synergy** – Opportunities to beneficially use the large quantities of dredged material that would be generated by this project were thoroughly explored. The needs of the project to find environmentally acceptable placement areas were satisfied with the development of BU features that would contribute to the long-term sustainability of interior wetlands and the coastal zone.
- **Accept responsibility** – All environmental impacts of the proposed project have been addressed and either offset by beneficially using dredged material or mitigating for impacts.
- **Mitigate impacts** – Project impacts were identified and the type and location of the compensation to be performed. No mitigation is required in Texas since the long-term management plan more than offsets the impacts to occur in that state. Mitigation has been identified to offset project impacts in Louisiana. The recommended mitigation plan results in an excess of overall environmental benefits vs. impacts.
- **Understand the environment** – Some of the most knowledgeable and experienced environmental professionals in Texas and Louisiana participated on an ICT. Their expertise ensured that the broad spectrum of environmental habitats of the study area were adequately understood, impacts accurately identified, and the appropriate amount and type of mitigation was developed.
- **Respect other views** – Collaboration among the USACE, Sponsor, and ICT members occurred throughout the study process. The interactions were professional and respectful, and always entertaining the opinions and expertise of others.

USACE Actions for Change as Reflected in the Campaign Plan

Engineering Sustainable Water Resource (integrated solutions, collaborative approaches, streamlined processes)

- SNWW study analyzed potential effects over a 2,000-square-mile area, incorporating the entire Sabine-Neches watershed.
- Dredged material placement plans were developed to beneficially use the material to the benefit of the entire system (inshore and offshore) to the greatest extent possible.
- Close collaboration with local sponsor throughout study.

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 Chapter IX.
- 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 and Louisiana were integrally involved in the evaluation and development of plans to offset environmental impacts of the project.

VII. DREDGED MATERIAL MANAGEMENT PLAN (DMMP)

VII.A OVERVIEW

This chapter presents the process and analyses used to evaluate dredged material placement issues and opportunities for the proposed 48-foot project (the Recommended Plan). It begins with an introduction to Regional Sediment Management (RSM), an approach that uses understanding of the SNWW sediment system to provide a context for managing the dredged material that would result from construction and management of the project. The following section describes the sediment system, summarizes a sediment budget for the Sabine Pass littoral zone, and characterizes material types and shoaling for the existing project. The next section describes problems and opportunities related to sediment management that were identified for the SNWW study area, and presents the results of a preliminary screening that was designed to identify BU features to be carried forward into the detailed phase of analysis. These BU features are then combined with upland placement features to form two alternative DMMPs, and the costs of these plans are then compared to identify the DMMP for the Recommended Plan. The BU Alternative was identified as the most-cost-effective, environmentally acceptable placement plan for both the new work and maintenance material, and it becomes the 50-year DMMP for the Recommended Plan. The DMMP is then summarized, followed by a description of the ecological benefits of the DMMP. The Base Plan for without-project disposal practices for the existing SNWW 40-foot project is then compared to proposed O&M placement activities for the Recommended Plan in order to determine the incremental O&M cost of the Recommended Plan.

VII.B REGIONAL SEDIMENT MANAGEMENT OBJECTIVES AND SCOPE

The principles of RSM were applied in evaluating alternatives and developing the DMMP for the placement of dredged material from the proposed SNWW CIP. The RSM is an approach for managing projects involving sand and other sediments derived from dredging and other activities in riverine, estuarine, and coastal systems (USACE, 2006a). Its major objective is the retention of these sediments within natural aquatic systems, thereby supporting a more sustainable process and potentially reducing project costs (Martin, 2002). The RSM incorporates many of the principles of watershed planning, but applies them in the context of dredging and other activities that influence sediment resources. It broadens the problem-solving perspective from a project-specific scale to a larger spatial and longer-term perspective. This requires the integration of a broad range of disciplines and collaborative partnerships among stakeholders. The USACE authorities and policies that support implementation of the RSM are discussed in Technical Note No. 8 for the RSM Demonstration Program (USACE, 2003).

The geographic focus of an RSM analysis is a sediment system on a scale that is relevant to issues (e.g., dredged material management or processes like erosion or shoaling) that have been identified by stakeholders in the region. The RSM study area essentially coincides with the SNWW study area and contains riverine, estuarine, and coastal environments. It is large enough to facilitate understanding of sediment processes and behavior, and the inherent interconnectedness of all parts of a sediment system.

The RSM study area includes the existing 65-mile-long SNWW navigation channel that extends from 22 miles offshore in the Gulf of Mexico, through a jettied entrance at Sabine Pass, up artificial canals on the west side of Sabine Lake, and finally up the Neches River Channel to the City of Beaumont. The SNWW area of analysis incorporates all of the existing and proposed navigation and placement features, and significant inflows and structures that affect the system. The littoral portion of the study area extends from Holly Beach, Louisiana, to Sea Rim State Park in Texas, roughly a distance of 40 miles. It extends into the Gulf of Mexico along the existing Entrance Channel, proposed channel extension, and ODMDSs for a distance of roughly 40 miles; and it extends inland from the coastline approximately 40 miles to incorporate the tidally influenced reaches of the Sabine and Neches rivers watersheds and Sabine Lake.

The Texas Coastwide Erosion Response Plan has identified several parts of the study area as "critical erosion areas" because of impacts to habitats and traffic safety from ongoing erosion, and has called for an increase in the BU of dredged material from the SNWW project to help address these issues. The plan was developed as part of the CEPRA (GLO, 2004, 2005). The program has identified the Gulf shoreline between Texas Point and Sea Rim State Park as a critical erosion area. It attributes the erosion, in part, to a lack of sediment coming down the Sabine and Neches rivers, and the interruption of longshore sediment transport by the SNWW jetties.

The CEPRA Plan recommends that long-term RSM be utilized, along with highway realignment and beach dune restoration, to protect the important coastal evacuation route of SH 87 in Jefferson County. As described below, the Gulf Shore BU Feature would provide a long-term, RSM approach to restoring some sediment to the littoral zone in this area of high erosion. In Orange County, the CEPRA Plan calls for restoration of 9,400 acres of marsh in the Lower Neches River using dredged material to raise soil elevations in the former marsh areas that have become open water. These are the same marsh areas (i.e., Rose City, Bessie Heights, and Old River Cove) that have been combined into the Neches River BU Feature. The evaluation of these BU features is described more fully later in this chapter.

VII.C EXISTING SHOALING AND SEDIMENT TRANSPORT CONDITIONS

A detailed description of the existing SNWW sediment system is provided in Section 2.5 of the FEIS. The reader is referred to that document for descriptions of geomorphology, winds, tides, circulation, and longshore sediment transport patterns.

Shoreline Descriptions

Jefferson County and Cameron Parish coastlines in the study area are mainland beaches fronting the Chenier Plain (King, 2007; USACE, 2000a). The upland area adjacent to the coast is a relatively flat, gently sloping terrain with marsh elevations of 1 to 2 feet msl and ridge elevations of 5 to 6 feet msl. Saline marsh vegetation covers the upland area behind the eroding shoreface. In the Texas Point NWR, a fillet of muddy substrate that was created by rapid deposition over approximately the last 100 years lies seaward of the chenier ridges. For the period between 1883 and 1970, the net accretion was documented

at 2,225 feet (Morton, 1975). The fillet of recent deposits recedes rapidly and disappears approximately ½ mile from the west jetty, where the Chenier Plain again fronts the Gulf until it ends about 18 miles from Sabine Pass (Pacific International Engineering [PIE], 2003).

The shoreline in the Texas Point NWR (between Sabine Pass and Sea Rim State Park) is a muddy shoreface composed of consolidated mud (King, 2007; PIE, 2003). A thin veneer of sand thrown up onto the marsh edge by storms covers some areas of the mud substrate. Farther west, the Sea Rim State Park area is a sediment transport convergence zone, and the beach typically has a substantial veneer of sand. In Louisiana, the coastline for approximately 10 miles east of the jetty contains tidal sand/mudflats, sand bars, and sandy beaches with tidal flats (PBS&J, 2006). A narrow tidal sand/mudflat, ranging from 30 to 450 feet in width, extends for about 1.5 miles east of the jetty, and then transitions to a sandy beach. These beaches vary in width from 50 to 300 feet and end at an eroded, low mud bank shoreline.

Historical Shoreline Change in the Study Area

The northwest Gulf coast system is sand starved, and essentially no modern-day sand is being delivered to these beaches (Lee, 2003; Morton, 1977; Morang, 2006). The only coarse-grained sand reaching the Texas shores appears to originate from the erosion of underlying Pleistocene barrier-strand plain deposits, which contain lenses of fine-grained and poorly sorted sands in massive clay and silt deposits (Isphording et al., 1989). The lack of delivery of coarse-grained sand contributes significantly to shoreline erosion in the area. The very limited coarse-grained load of the Sabine and Neches rivers is deposited in bay-head deltas in Sabine Lake rather than on the coast (Mason, 1981; Morang, 2006; USACE, 1971b).

Chronic shoreline erosion is believed to be associated with the diversion of sand and other sediment resulting from channelization and regulation of the Mississippi and Atchafalaya rivers to the east, and the Sabine and Neches rivers in Texas. The Calcasieu and Mermentau also do not supply coarse-grained sediments, and the Cameron jetties deflect the little material that does exist away from the Holly Beach area, so that it accumulates to the west at Long Beach, Louisiana's westernmost sandy beach (Louisiana Department of Natural Resources [LDNR], 1997; USACE, 2000a). The Sabine Pass jetties also intercept sediment moving westward in the littoral drift, creating a wide, muddy, tidal flat next to the east jetty (PBS&J, 2006; USACE, 2000a). On the Texas side, a ½-mile-wide fillet of silt and mud immediately adjacent to the west jetty intercepts sediments moving from the west during periodic reversals near Sea Rim State Park in the dominant longshore movement (PIE, 2003).

Shoreline change has been extensive in this region. In the area between Ocean View Beach and the Sabine jetties, the shoreline prograded seaward at an average rate of +12.9 feet/year between 1883 and 1994. Recently, however, accretion has slowed to +1.2 feet/year, and the behavior of this shoreline has become erratic, with change rates varying between –13.2 and +14.7 feet/year (USACE, 2000a). On the Texas side of Sabine Pass, a ½-mile stretch of shoreline adjacent to the west jetty is aggrading at a rapid rate, but beyond this narrow zone, to the west, is an active erosion zone extending approximately 15 miles to the vicinity of Sea Rim State Park (Morang, 2006). This eroding stretch of the Jefferson County coastline is experiencing the largest erosion rate on the upper Texas coast, up to 40 to 50 feet/year (King,

2007). It has been identified as a "critical erosion area" by the Texas Coastwide Erosion Response Plan because of threats to traffic safety and wildlife habitat. Shoreline erosion has destroyed a portion of SH 87, an important hurricane evacuation route, and is eroding coastal wetland habitat at Texas Point and McFaddin NWRs (GLO, 2004, 2005).

Sabine Pass Sediment Budget

New littoral transport rates have recently been calculated for the Sabine Pass littoral zone. The Sabine Pass sediment budget (Morang, 2006) applied shoreline change statistics that were computed from changes in sediment volume for littoral cells, using cross-shore profiles that were projected with an ERDC modeling study (King, 2007). The sediment budget focused on characterizing sediment movement in the coastal segments of the navigation channel and nearby Texas shoreline. Accurate estimates of the percentage of total transport that is suspended sediment load from the inshore area were not available. Six of the 23 cells defined for this study are relevant to this discussion – 3 cells (the Sabine Pass Channel, the Sabine Jetty Channel, and the Sabine Outer Bar Channel) were used to analyze sediment movement in the navigation channels through Sabine Pass and past the jetties; 3 other cells (the Sabine Fillet, Texas Point NWR, and Sea Rim State Beach) were used to calculate sediment movement along the littoral zone westward of the Sabine Pass. A summary of the sediment budget results is presented in Table VII-1

Existing Project Shoaling and Sediment Transport Conditions

The following summary of shoaling and transport conditions for the existing SNWW includes all segments of the existing SNWW navigation system. The analysis of channel sections covered by the Sediment Budget (Table VII-1) is derived primarily from Morang (2006); dredging cycle lengths, velocity data, average percentages of sediment sizes, and dredging quantities (for channel reaches not covered by the Sediment Budget) were obtained from the SNWW Sediment Study (Parchure et al., 2005); other supporting analyses are identified as the data are presented. The discussion begins with the upstream end of the SNWW (the Neches River Channel), and moves downstream through the confined Sabine-Neches and Port Arthur canals, the Sabine Pass Channel, and then offshore into the Sabine Pass Jetty Channel, the Sabine Pass Outer Bar Channel, and the Sabine Bank Channel. Finally, the interaction of the channel and adjacent shoreline sections is described.

Neches River Channel

Dredging cycles on the Neches River Channel vary from 3 to 4 years along the eastern half of the channel near Sabine Lake to 6 years along the western segment near Beaumont. Approximately 3.1 mcy/cycle are dredged from eastern channel sections 11, 12, 13, 14, and 15 and placed into PAs 12, 13, 14, 16, 18, 21, 23, and 23A. Approximately 3.3 mcy/cycle are dredged from western channel sections 16, 17, and 18 and placed in PAs 24, 25, 25A, 26, 27A, 27C, and 27D near Beaumont. Peak ebb and flood velocities are low (0.8 foot/second and 0.3 foot/second, respectively). Bed sediments average 62 percent silt and clay and 38 percent sand.

Sabine-Neches and Port Arthur Canals

These canals traverse the confined channel segment between the City of Port Arthur and Pleasure Island. Sabine-Neches Canal sections 9 and 10 are dredged every 4 years. Approximately 3.7 mcy/cycle are placed in PAs 8 and 11. Bed sediments average 78 percent silt and clay and 22 percent sand. Port Arthur Canal Section 7 is dredged every 3 years and approximately 1.8 mcy/cycle are placed in PA 8. Section 8 and the Taylor Bayou Channels and Basins are dredged every 2 years; approximately 2.3 mcy/cycle are placed in PAs 8, 9, and 9A. Peak ebb and flood velocities are 2.6 and 2.2 feet/second, respectively. Bed sediments average 84 percent silt and clay and 16 percent sand. The junction of the Port Arthur Canal, Taylor Bayou Channel, and the Sabine Pass Channel is an existing dredging hot spot, often requiring dredging more frequently than the 2-year cycle. This is due, at least in part, to a rapid decrease in velocity as the flows move into the much wider junction. In addition, existing erosion along the channel side of Pleasure Island may be returning sediment to the system (Parchure et al., 2005).

Table VII-1
Annual Sediment Budget for Sabine Pass (adapted from Morang, 2006)

Cell	Sources and Quantity (1,000 cubic yards per year)	Sinks and Quantity (1,000 cubic yards per year)	PA/ODMDS and Quantity (1,000 cubic yards per year)
Sabine Pass Channel	866.7 (approximately 20% sand) from Port Arthur Canal and Sabine Lake	274.2 mud and sand into Jetty Channel	592.5 into PA 5
Sabine Pass Jetty Channel	274.2 (mud and minor sand) from Sabine Pass Channel	Unknown quantity of fine-grained material carried in suspension offshore	289.1 to ODMDS 4 (dispersed by shelf circulation, storm and tidal currents)
	14.9 (mud) offshore		
Sabine Outer Bar Channel	Unknown amount from Sabine Jetty Channel (possible mud input)		1,722.6 to ODMDS 3 (dispersed by shelf circulation, storm and tidal currents)
	1,722.6 from undetermined source (littoral sediments and/or ODMDS)		
Sabine Fillet	25.1 longshore transport from Texas Point NWR (west)	14.9 longshore transport (mud and minor sand) to Jetty Channel	
		10.2 shoreline growth at Sabine mud fillet	
Texas Point NWR	434.2 from beach erosion (90+ % mud)	152.0 overwash losses	
		173.7 mud lost offshore	
		25.1 longshore transport of mud to east	
		83.5 longshore transport to west (sand and shell)	
Sea Rim State Beach	83.5 longshore transport from Texas Point NWR (east)	117.7 beach growth at Sea Rim State Beach	
	34.3 longshore transport from McFadden NWR (west)		

*Sediment Budget quantities are based on 25 years of data from Galveston District's Dredging Database. SNWW CIP without-project shoaling quantities are based on data from 1967 to 2001. A cross check and conversion verified that the quantities are similar.

Sabine Pass Channel

Channel sections 5 and 6 are dredged every 3 years and approximately 1.9 mcy/cycle are placed in PA 5. Bed sediments average 70 percent silt and clay and 30 percent sand. There are no obvious sand sources because the banks of the channel are low mudflats. Little sand reaches the open coast from the Sabine and Neches rivers because Sabine Lake is an efficient sediment trap and most of its coarse material is deposited in the lake or trapped in the lower alluvial reaches of the rivers. Since the dredged material is removed from the system, some mechanism must be replenishing the sand. It may be delivered to this channel by unusually high runoff from Sabine Lake or the Port Arthur Canal. Although ebb and flood velocities are roughly equal through this section, lower velocities are present where Sabine Lake discharges into the channel; shoaling rates are higher than average around this discharge point. Peak ebb and flood velocities in the remainder of the channel are 4.0 and 3.2 feet/second, respectively. Negligible amounts of material come from the littoral system, entering the channel and moving upstream. Conversely, plumes of fine-grained material can be seen moving through the pass into the Gulf in satellite images. This material disperses over the continental shelf and does not contribute to the littoral budget.

Sabine Pass Jetty Channel

Section 4 is self-scouring and needs far-less-frequent maintenance dredging than the other coastal reaches. Ebb velocities are high, peaking at about 3.5 feet/second, and flood velocity reaches 3.0 feet/second. Despite this jetting action, on the average about 1.1 mcy/cycle of dredged material are placed in ODMDS 4 in a 5-year dredging cycle. Sediment delivered by the Sabine Pass Channel is predominantly silt and some sand, and about 5 percent of the total transport comes from the littoral system. A small boat cut in the east jetty may allow material carried by the longshore current moving west from Louisiana to enter the channel (PBS&J, 2004a). Bed samples average 89 percent clay and silt and 11 percent sand. Before- and after-dredging bathymetry surveys have demonstrated that the material placed offshore in the ODMDSs does not accumulate; it disperses quickly after placement in the offshore environment.

Sabine Pass Outer Bar Channel

Section 3 is the first 3.4 miles of navigation channel outside of the jetties. Ebb velocities fall rapidly as the channel discharges over the Outer Bar. Peak ebb velocities fall from about 3.5 feet/second within the jetties to 2.7 feet/second just beyond the jetties, to 1.3 feet/second near the intersection with the Sabine Bank Channel. Peak flood velocities of 3.0 feet/second within the jetties fall to 2.4 feet/second just beyond the jetties, and to 0.4 foot/second at the end of the channel reach. It appears that little material moves from the Sabine Pass Jetty Channel into the Sabine Outer Bar channel, based upon the balance of material entering versus what is removed by dredging. Yet, the shoaling rate in this section is very high. Approximately 1.9 mcy/cycle are removed yearly and placed in ODMDS 4. Bed samples average 96 percent silt and clay and 4 percent sand. The source of the sediment is undetermined. Existing and proposed ODMDSs are located west of the channel because the mean current flow in this area is westward most of the year. However, this flow reverses and moves eastward for a month or longer during the late spring (Rouse et al., 2004). During periods of reversal, sediment may drift back into the channel

from ODMDS 4. However, typical flow patterns move ebb flows to the south/south-southwest just beyond the jetties, and flood flows generally come from the east (Parchure et al., 2005). Furthermore, anecdotal accounts from Sabine Pilots report a strong east to west current crossing just outside the jetties in the vicinity of ODMDS 4 (Webb, 2003).

Sabine Bank Channel

Sections 1 and 2 (totaling 6.6 miles long) extend the navigation channel into the open Gulf. They are dredged every 4 years and approximately 4.2 mcy/cycle is placed in ODMDSs 1 and 2. Bed sediments average 76 percent silt and clay and 24 percent sand. Ebb and flood velocities are nearly equal (ranging between 0.25 and 0.70 foot/second), but the velocity pattern is erratic. Rapid shoaling is not a problem in this reach, and no other management concerns are known.

Adjacent Gulf Shorelines

At Louisiana Point, the littoral current has supplied sufficient sediment in the recent past to cause shoreline progradation between Ocean View Beach and the Sabine jetties (USACE, 2004), and create a wide tidal mudflat against the jetty (PBS&J, 2006). Some fine-grained sediment from this westward littoral current may be entering the Sabine Pass Jetty Channel through a small boat cut in the east jetty (PBS&J, 2004a).

All but the easternmost wedge of Texas Point (the Sabine Fillet) is undergoing severe beach erosion, with shoreline retreat of up to 1,150 feet between 1974 and 2000. Shoreface sediment losses are approximately 434,200 cubic yards/year. Longshore transport to the west carries 20 percent to Sea Rim State Beach (PIE, 2003), 35 percent is lost to overwash, and 40 percent is carried offshore. Approximately 6 percent moves eastward, carried by periodic reversals in the dominant longshore current (King, 2007; PIE, 2003). The west jetty intercepts about 40 percent of the total eastward transport, creating a ½-mile-wide fillet of silt and mud against the jetty; the remainder is carried into the Sabine Pass Jetty Channel.

In contrast to Texas Point, Sea Rim State Beach is located in a convergence zone and receives 117,700 cubic yards/year of littoral material from both the east and west. About 70 percent is carried by longshore transport from the east at Texas Point, and 30 percent comes from McFaddin NWR to the west. The accreting beach is comprised of sand (0.10 to 0.14 mm in size) and shell fragments, underlain by mud.

VII.D ANALYSIS OF SEDIMENT-RELATED PROBLEMS AND OPPORTUNITIES

The next section describes the RSM problems and opportunities that were identified by the SNWW study area, and presents the results of a preliminary screening that was designed to identify potential cost-effective BU for the dredged material that would be generated with the Recommended Plan.

The principles of the RSM were applied to ensure that the dredged material arising from the SNWW CIP would be viewed as a valuable resource, integral to economic viability and environmental sustainability

of the region. In developing the DMMP for the project, this study searched for opportunities to achieve savings by defining sediment-related problems, coordinating projects, and identifying opportunities for BU (Martin, 2002). The large quantities of dredged material that would be generated by the Recommended Plan created an ideal opportunity for the exploration of the BU of dredged material. A series of public workshops and extensive ICT consultation evaluated a wide array of opportunities to use dredged material beneficially (Gulf Engineers and Consultants, Inc. [GEC], 2002; Turner Collie & Braden, 2003).

A variety of private stakeholders, State and Federal resource agencies, and the USACE engineering and scientific experts identified the following existing and FWOP sediment-related problems in the region:

- Lack of sand in the littoral system
- Interruption to the littoral system caused by SNWW jetties
- Extensive shoreline erosion at Texas Point
- Erratic accretion and erosion at Louisiana Point
- Rapid shoaling in the Sabine Pass Outer Bar Channel
- Rapid shoaling in the Port Arthur Junction
- Erosion of west side of Pleasure Island
- Erosion of Sabine Lake eastern shore
- Lack of sediment recharge to, and continuing loss of, sediment from emergent marshes

The following future with-project (FWP) impacts that could potentially be addressed with the BU of dredged material or other project elements were also identified:

- Project impacts associated with the creation of new ODMDSs for the Extension Channel
- Project impacts associated with the creation of new upland PAs to accommodate new work material, and increased quantities of maintenance material over the period of analysis
- Project impacts associated with a small increase in Gulf coast shore erosion within 3.5 miles of each jetty
- Project impacts to cypress-tupelo swamps and intertidal marshes from reductions in biological productivity due to project-induced salinity increases and marsh loss
- Additional advance maintenance due to a higher than average increase in shoaling in the Sabine Pass Outer Bar Channel, one section of the Sabine Pass Channel, the Port Arthur Junction, and portions of the Neches River Channel

Preliminary Screening – Features Eliminated from Consideration

Opportunities to use dredged material beneficially to address these sediment-related concerns were suggested by public workshop participants and the ICT, and/or developed by the USACE technical studies. These suggestions resulted in the evaluation of a wide array of BU features, which could reduce

or avoid salinity impacts, restore or replace degraded wetlands, create new terrestrial or marine habitat, and return sediment to the littoral zone. Table VII-2 lists all features that were considered and eliminated during preliminary screening, and the reason for dropping them from further consideration. The incremental cost estimates presented in the table were developed during preliminary screening; they are based upon 2005 cost levels and use $2.05/gallon for marine diesel. Incremental costs are the additional costs that would be needed to use the material beneficially, over and above the normal costs of dredging and placement in designated PAs or ODMDSs. It is likely that the actual costs would be much higher than estimated here.

The feasibility of using new work and/or maintenance material was considered for all features. In the analysis for the inshore reaches, PA containment levee construction was the first priority for the use of new work material, followed by BU opportunities. In the offshore reaches, opportunities for BU of new work material were evaluated and eliminated before material was committed to existing and proposed ODMDSs. For maintenance material in both inshore and offshore reaches, priority was given to BU if it could be demonstrated to be the least-cost alternative.

Given the large amount of dredged material that would be generated with the proposed project, considerable effort was expended to identify areas that could benefit from its BU. All degraded marsh areas near the SNWW were investigated to determine whether least-cost BU features could be developed. No interior marsh areas in need of nourishment or restoration were identified adjacent to Sabine Pass in Louisiana. Areas in Louisiana that could benefit from BU of dredged material are all located in the marshes east of Sabine Lake. However, these were found to be too distant from the navigation channel to permit cost-effective use of dredged material from the SNWW navigation channels. Numerous degraded marshes in Texas with potential for BU were identified adjacent to the navigation channel. They are located in the Texas Point NWR adjacent to the Sabine Pass Channel, in the J.D. Murphree WMA adjacent to the Sabine-Neches Canal, and in areas of the Neches River WMA and private lands adjacent to the Neches River Channel. The Gulf shoreline at Texas and Louisiana Points is close enough to the navigation channel to allow cost-effective BU of dredged material. The shoreline on the Texas side of Sabine Pass was also identified as a high priority area for BU because of high ongoing erosion in this area.

Several hydrologic restoration features that were intended to prevent higher FWP salinities in portions of the study area were eliminated early in the screening process. They were modeled using the HS model and found to be either ineffective at reducing salinities or to have significant unintended impacts. For example, marsh islands constructed with new work material were proposed as a means of isolating the salinity wedge in the Sabine-Neches Canal from Sabine Lake. Modeling determined that the islands did block the flow into the lake, but forced a salinity wedge to travel up the Sabine River Channel, potentially affecting cypress-tupelo swamps in that watershed. Other proposed BU features that were unsuccessful in reducing salinities are described in Table VII-2.

Table VII-2
Preliminary Screening: Dredged Material Beneficial Use Features Eliminated from Consideration

Feature Description	Reason for Elimination
Hydrologic Restoration	
Marsh islands isolating Sabine-Neches Canal from Sabine Lake	Increased salinities in Black Bayou and up the Sabine River
Marshes constricting flow at mouth of Sabine Lake (north and south of SH 82 swing bridge)	Ineffective at reducing salinities Increases velocities through mouth of Sabine Lake
Marshes constricting flow along the side of the Port Arthur Canal	Ineffective at reducing salinities High cost relative to amount of marsh acres created
Construction of channel islands blocking flow from bayous emptying Neches River marshes at Rose City and Bessie Heights	Potential to cause backwater flooding Obstructed channel access for private landowners Navigation safety concerns
Filling canal at Texas Bayou using new work material from Sabine Pass Channel	Ineffective at reducing salinities because access still provided by Texas Bayou
Emergent Marsh Restoration	
Marsh restoration using new work material from Neches River Channel to restore marsh in Rose City West	Area is being developed as a mitigation bank; no longer available for restoration
Marsh restoration using new work material from Neches River Channel to restore marsh in Bessie Heights West	Would be feasible but cost exceeds Traditional Placement Plan. Preliminary estimate of incremental cost – $581K. Sponsor has not been identified.
Marsh restoration using new work material along the east shore of PAs 8 and 11 at Pleasure Island	Unacceptable location – interferes with levee maintenance
Marsh restoration at Old River Cove, east of power plant inflow channel, using new work material from the Neches River Channel	Would be feasible but cost exceeds Traditional Placement Plan. Preliminary estimate of incremental cost – $472K. Sponsor has not been identified.
Marsh restoration north of Keith Lake using maintenance material from Port Arthur Canal	Would be feasible but cost exceeds Base Plan. Preliminary estimate of incremental cost – $300K. Sponsor has not been identified.
Marsh restoration in Texas Point NWR using new work material from Sabine Pass Channel to restore marsh behind subsided jetty section.	Would be feasible but cost exceeds Traditional Placement Plan. Preliminary estimate of incremental cost – $445K. Sponsor has not been identified.
Wildlife Habitat Creation	
Bird island constructed in Sabine Lake using new work material from Sabine-Neches Canal	Would be feasible but cost exceeds Traditional Placement Plan. Preliminary estimate of incremental cost – $1.9 million. Sponsor has not been identified.
Returning Sediment to Littoral Zone	
Texas or Louisiana Point shore nourishment using new work material from Section 5 of the Sabine Pass Channel	Would be feasible but cost exceeds Traditional Placement Plan. Preliminary estimate of incremental cost – $6.6 million. Sponsor has not been identified.
Texas or Louisiana Point shore nourishment using new work material from sections 5 and 6 of the Sabine Pass Channel	Would be feasible but cost exceeds Traditional Placement Plan. Preliminary estimate of incremental cost – $19.5 million. Sponsor has not been identified.
Stockpiling new work material from Extension channel for future beneficial use	Not feasible because material would disperse rapidly and not be available for use at a later date.
Transporting sediment from new work dredging of the Extension Channel to the Texas or Louisiana littoral zone	Would be feasible but cost exceeds Traditional Placement Plan. Preliminary estimate of incremental cost – $86.3 million. Sponsor has not been identified.
Marine Habitat Restoration	
Construction of topographic high in littoral zone with new work material	Topographic elevation would be temporary. Incremental costs ($268 million) make it economically infeasible.

A large number of conceptual designs for emergent marsh restoration throughout the study area were initially identified as possible compensatory mitigation measures. Because of their proximity to the navigation channel, several marsh restoration features in Texas were also evaluated to determine whether they would be less costly than traditional placement. Only the Neches River and Gulf Shore BU features were determined to be less costly than using upland PAs for new work (Traditional Placement Plan) or maintenance material (Base Plan). These features and the cost analysis are presented in detail later in this chapter. Marsh restoration features considered but eliminated included marsh restoration in Texas Point NWR using new work material from the Port Arthur Canal or the Sabine Pass Channel. Another feature used new work material for marsh restoration in the part of Old River Cove marsh that lies east of the intake canal. All were found to be feasible, but more costly that traditional upland placement. The preliminary incremental costs for these features were relatively low, ranging from $300,000 to $581,000. No sponsor has been identified to share the incremental cost of these features.

The creation of new wildlife habitat using new work material from the Sabine-Neches Canal was also explored. This feature would provide needed nesting habitat for colonial waterbird species such as cormorant, pelican, heron, egret, spoonbill, gull, tern, and skimmer. These birds regularly nest in large numbers along the Texas and Louisiana coasts, frequently on bay islands, both natural and man-made. Despite the presence of excellent waterbird habitat in the Sabine NWR, no colonies have been documented in Louisiana within the study area. The lack of isolated, predator-free islands is believed to be a primary cause for this lack of nesting habitat. It was proposed that an island be constructed in the middle of Sabine Lake with new work material from the Sabine-Neches Canal. This feature was eliminated when the cost was found to be approximately $2 million higher than the use of traditional upland PAs and no sponsor was identified to share the incremental cost.

Several features were evaluated that would return sediment normally placed in upland PAs or ODMDSs to the littoral zone. Conceptual plans were developed for shore nourishment at Texas and Louisiana Points using new work material from Section 5 or sections 5 and 6 of the Sabine Pass Channel. The features were found to be feasible but cost $6.6 and $19.5 million, respectively, more than upland placement in PA 5. Stockpiling dredged material in ODMDS 4 for later use was also investigated. Like all other SNWW ODMDSs, material placed at this site disperses quickly after placement. Although it is closest to shore, the dispersed material in ODMDS 4 is not likely to migrate into the littoral zone because it is located beyond the depth of closure. It is expected that any material stockpiled within ODMDS 4 would be unavailable for use within 3 months of placement. Since stockpiling assumes that the beneficial use needs will not be immediate or short term, it was concluded that this feature is not a viable alternative.

Transporting and discharging coarser-grained sediments from the new work dredging of the Extension Channel (stations 117+000 to 146+000) into the littoral zone offshore of Texas or Louisiana Point was also evaluated. A hopper dredge with pump-out capability could be used to dredge the channel, move as close as possible to shore, and pump the material via a connecting pipeline to a discharge point within the 14-foot depth contour. Discharging the material at or inshore of the depth of closure should guarantee the reintroduction of sediments within the littoral zone, where natural processes will beneficially distribute

the sediments. It is estimated that the incremental cost of this action would be about $86.3 million. While feasible, this BU feature is much more costly than placement in the proposed ODMDSs B and C. No sponsor has been identified to share the incremental cost of the feasible BU features discussed above.

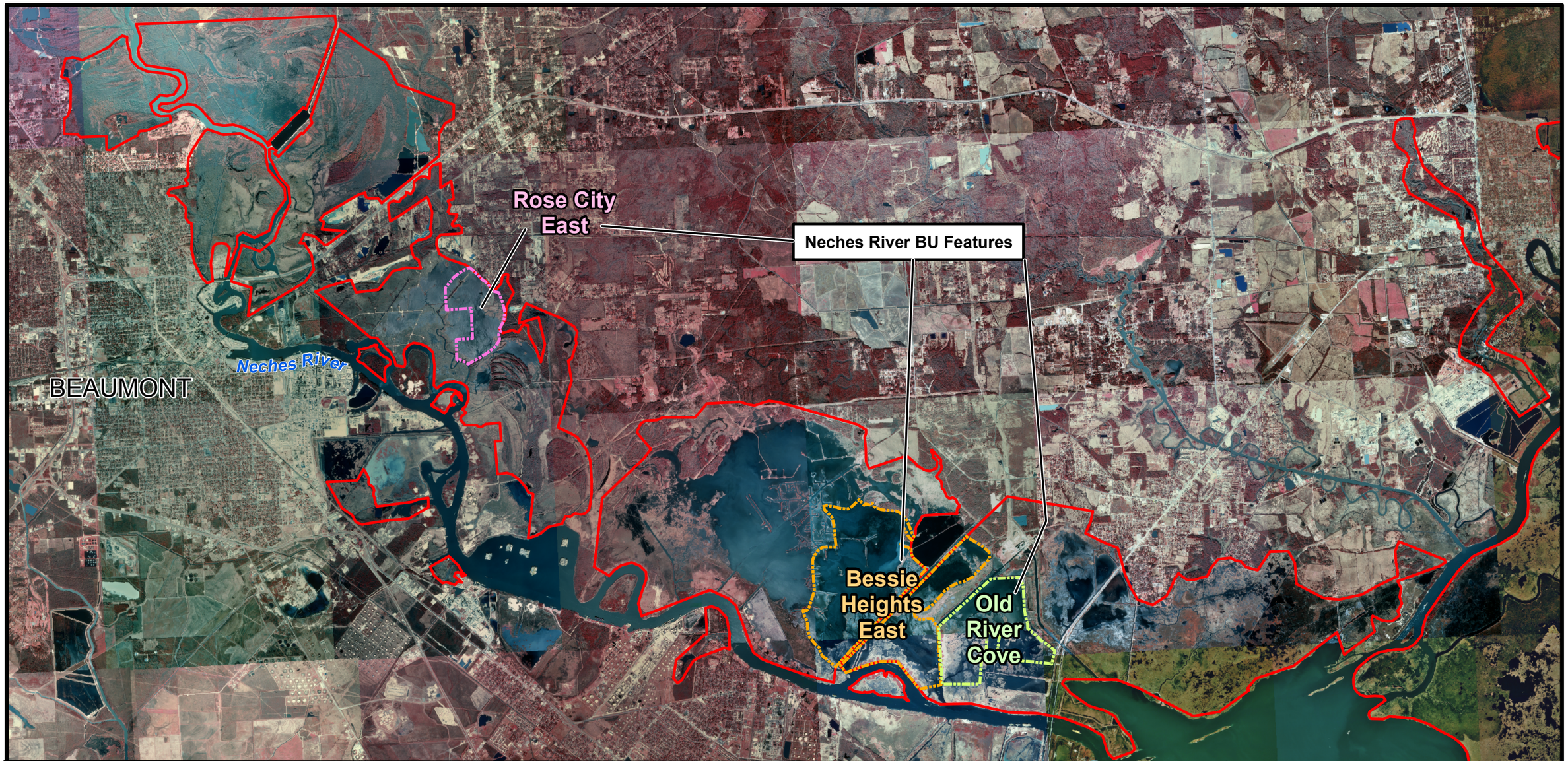
The creation of new marine habitat in the form of a "topographic high" offshore of Louisiana Point was also investigated. This feature would involve the BU of new work material from the deepened Sabine Bank and Extension channels to create a new refuge or feeding locale for fish and shrimp. The material would be dredged as usual with a hopper dredge and then transported far enough upcurrent to prevent redeposition in the navigation channel. The material would be dropped in mounds forming a series of rows over a large area, roughly 2.0 x 2.5 miles. The actual ecological benefits of such a feature off the Texas coast have not been demonstrated. A similar feature was constructed outside of Galveston Bay, but no monitoring was conducted to determine whether any benefits accrued. In addition, the feature would be temporary because the dispersive processes acting on the ODMDSs would also be present here. It was eliminated from further consideration when it was estimated that the incremental cost of the temporary habitat would be approximately $268 million.

Detailed Evaluation of Disposal Features

After the preliminary screening, BU features that appeared to be least-cost alternatives for the BU of dredged material in reducing with-project salinities, restoring marsh, or providing shoreline nourishment were advanced for detailed evaluation. Water and sediment sampling and bioaccumulation studies have established that dredged material from all SNWW navigation channels is suitable for BU (PBS&J, 1999, 2002, 2004b). The ecological benefits of the following BU features were evaluated and quantified using the WVA Model, and these benefits were used to offset project impacts as described below. A description of the WVA Model is provided in Section IX. In addition, numerous existing upland PAs were evaluated for use with the Recommended Plan. All BU alternatives to ODMDSs were eliminated during the preliminary screening. Existing and proposed ODMDS sites were therefore evaluated for the placement of all material from the offshore channel reaches.

Neches River Beneficial Use Feature

Four former marsh areas on the Neches River were combined into one large management feature, called the Neches River BU Feature, to provide flexibility in the use of new work and maintenance material from the several construction reaches of the Neches River Channel. The primary objective of this combination feature would be to beneficially utilize dredged material to restore emergent marsh in an area that has suffered dramatic, widespread loss of marsh. The BU feature would utilize new work and maintenance material that would otherwise be removed from the sediment system and stored in upland, confined PAs. Figure VII-1 shows the components of the Neches River BU Feature.



Rose City East

Bessie Heights East

Old River Cove

Hydrologic Unit

0 8,750 17,500

Feet

N
W E
S

Figure VII-1

Neches River

BU Feature

Prepared for: USACE	
Job No.: 100007609	Scale: 1 inch equals 8,750 feet
Prepared by: 18827	Date: 08/05/2009

N:/Clients/U_Z/USACE/Projects/Sabine_Neches/100007609/Figures/Fig_VII_2_vr2.mxd

This page intentionally left blank.

The Neches River BU Feature would offset all indirect salinity impacts to Texas wetland habitats on the Neches and Sabine rivers (hydro-units TX 3 through TX 8, and TX 10 through TX 13) by restoring 2,853 acres of emergent marsh; improving 871 acres of shallow water by creating shallower ponds and interconnecting channels; and nourishing 1,234 acres of existing fringing marsh by winnowing fine-grained material from unconfined flows of dredged material effluent (Table VII-3). The BU feature thus provides benefits to a total of 4,958 acres of degraded marsh on the lower Neches River, or 53 percent of the restoration target set by the CEPRA 2004 plan update for the lower Neches River (GLO, 2004). The BU feature also offsets the direct impact of converting 86 acres of freshwater wetland to a confined placement area (PA 24A).

Table VII-3
Acreage Restored by Neches River BU Feature

Components of the Neches River BU Feature	Restored Emergent Marsh	Improved Shallow-water Habitat	Nourished Existing Marsh	Total Influence Area
Rose City East	345	72	151	568
Bessie Heights East	1,869	660	651	3,180
Old River Cove West	639	139	432	1,210
Total	2,853	871	1,234	4,958

Gulf Shore Beneficial Use Feature

The use of dredged material was also evaluated for Gulf shoreline nourishment at Texas and Louisiana Points (Figure VII-2). Over the 50-year period of analysis, approximately 24 mcy of maintenance material would be hydraulically pumped from Section 5 of the adjacent Sabine Pass Channel onto a total of 6 miles of shoreline on both sides of Sabine Pass. Some material is expected to flow over existing marsh while the remainder will flow into nearshore waters. Material placement during each 3-year Sabine Pass Channel dredging cycle would alternate between Texas and Louisiana, so that material would be placed on each state's shoreline every 6 years. This recurring action would nourish eroding marsh, restore sediment to the littoral zone, minimize projected FWP shoreline impacts, and, potentially, create new marsh with the recurring placement of approximately 1.5 mcy every 3 years.

Texas Point is undergoing severe beach erosion, with shoreline retreat of up to 1,150 feet between 1974 and 2000 (King, 2007; Morang, 2006). This is the highest rate of shoreline loss on the upper Texas coast and a CEPRA "critical erosion area" (GLO, 2005). In Louisiana, persistent erosion along the shoreline between Ocean View and Holly Beach, on the order of –4.3 feet/year between 1985 and 1998, was recorded here prior to Hurricane Rita (USACE, 1971a, 2004). Nearer to Louisiana Point, significant accretion over the last 100 years has slowed to +1.2 feet/year, and the behavior of this shoreline has become erratic, with some areas eroding and some aggrading (USACE, 2004).

Historic dredging records indicate that the maintenance material from Sabine Pass will average 51 percent silt, 31 percent clay, and 18 percent fine sand (USACE dredging database). This mix of materials does not contain typical beach-quality sand, but the material types and composition are similar to what is present

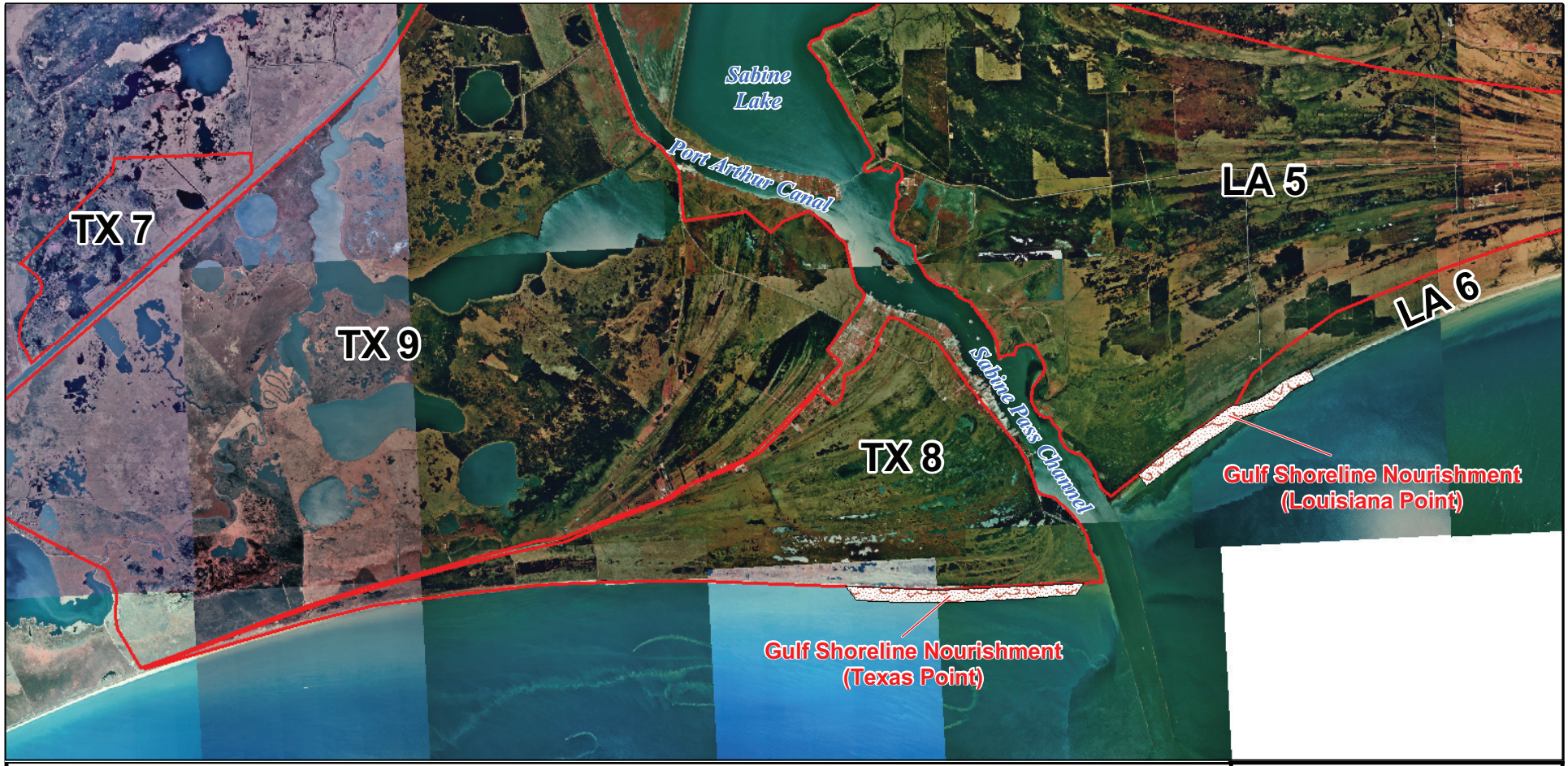
on the shorelines today. Narrow beachfronts of silt or clay lie seaward of eroding overwash marsh terraces (PBS&J, 2006). Given the unusual characteristics of this sand-starved system, returning the material to the littoral system is likely to have a net beneficial effect, regardless of material type. The longshore transport in this system contains primarily fine-grained sediments, but these sediments have been shown to accumulate in the near shore zone and result in shoreline accretion by as yet poorly understood processes (King, 2007; Morang, 2006).

The Gulf Shore BU Feature will provide a regular source of predominantly fine-grained sediment that should contribute to mudflat accretion and periodically move onshore to become shore-attached through a process described by PIE (2003). On the western Louisiana and east Texas coasts, sediments accumulate as mudflats and underwater mudshoals (or "fluid mud") in the nearshore region. Nearshore, fluid mud can be trapped against the shoreline by prevailing south and southwesterly winds, and storms carry the trapped muddy ooze onto the chenier shoreline. The northwest Gulf is a microtidal, storm-dominated environment. In a typical year there are about 20 to 30 frontal passages generating waves, surges, and wind-driven currents, with most-frequent waves from the southeast about 3 to 4.5 feet in height (PIE, 2003).

Mudflat accretion on the western Louisiana coast appears to correlate with periods of high sediment influx from the Atchafalaya River and the passage of large storm systems. Up to 1,000 feet of shoreline accretion along 4.5 miles of shoreline in western Louisiana occurred over a few days during the passage of Hurricane Audrey (Morgan et al., 1958). Another study reports that accretion in western Louisiana occurs most frequently during storms and that it can be very rapid (Wells and Kemp, 1986). Huh et al. (1991) reports that surge deposits of gel-like mud become stranded on the upper shoreface during storms. These deposits can dry and crack, forming mud cobbles that help to armor the shoreline. Fluid mud and mudflat accretion at the shoreline has also been observed on the Jefferson County shoreline. At Sea Rim State Beach in June 2002 (PIE, 2003), shoreline features were observed that resembled the storm surge deposits of fluid mud and mud cobbles reported above.

The presence of additional fine-grained sediments in the littoral system that will be provided by the BU feature should reduce the current erosion rate and minimize the small increase in shore erosion predicted with the project (Gravens and King, 2003). In systems that have an abundant supply of fine-grained sediments, the nearshore seabed can be blanketed with fluid mud. The presence of additional muddy sediment in the nearshore environment may attenuate waves and lessen wave-induced erosion (Hsiao and Shemdin, 1980; Tubman and Suhayda, 1976; Wells and Kemp, 1986). There are also anecdotal reports of Gulf areas off Louisiana and Texas Points being safe havens for vessels during storms due to the near-total attenuation of waves (Block, 1984; King, 2007; Wells and Kemp, 1986).

The BU dredged material is expected to be composed largely of unconsolidated muds. The fine-grained sediments are expected to initially be highly mobile and some portion of the material will be rapidly lost from the vicinity of the shoreline. As demonstrated by another BU project at Texas Point (USACE, 2000a), a significant percentage will also flow onshore and nourish existing marsh along the eroding



Shoreline Nourishment

Hydrologic Unit

2 1 0 2
Miles

N
W E
S

Figure VII-2

Gulf Shore BU Feature

Prepared for: USACE	
Job No.: 044198800	Scale: 1:93,500
Prepared by: A. Christiansen	Date: 04/28/2008

File: N:/Clients/U_Z/USACE/Projects/Sabine_Neches/044198000/figures/Fig_VII_3_vr2.mxd

beachfront. Because of the prevailing wave climate, the mobile material within the surf zone should generally migrate to the west at both Texas and Louisiana Points (Wamsley, 2008). Transport processes identified by the Sabine Pass Sediment Budget (Morang, 2006) indicate that the material would move toward the eroding shoreline at Texas Point. There, the additional fine-grained sediments could lower erosion rates through the mudflat accretion and wave attenuation processes described above. A small quantity of material may migrate to the east and contribute to the Sabine fillet at the west jetty (King, 2007; Morang, 2006).

In Louisiana, the sand bar formed by BU sediments from the Sabine Pass LNG project may shelter the shoreline from wave energy sufficiently to allow fine-grained sediments to form a mudflat behind the sandbar (Nairn and Willis, 2002). While a significant percentage of the sediment will be rapidly carried offshore, some is likely to move downcoast with the littoral current, enlarging the sand and mudflat already present at the east jetty. Potential impacts of elevated levels of total suspended solids are expected to be similar to those that resulted from the Sabine Pass LNG BU project (PBS&J, 2004a). A temporary increase in suspended silt/clay was expected during the first 8–9 months following placement. After the termination of placement activities, total suspended solids were expected to decrease for about 18 months when concentrations reached background levels. Modeling conducted for the Sabine Pass project indicated that it will take 9 years before the silt and clay component of Sabine Pass LNG BU material become totally suspended and are removed from the littoral zone. Since the Gulf Shore BU Feature proposes a placement episode every 6 years, all the fine-grained sediments would not have been removed before new material is added.

This should result in the retention of some portion of the fine-grained sediment, and thus facilitate mudflat accretion through the processes described above. During and after each placement episode, most of the resuspended silt and clay are expected to enter the Sabine Pass Jetty Channel through the shallow boat cut, but deposition in the channel is not expected. It should remain in suspension and be transported back into the Gulf.

Although the BU sediments will be largely fine grained, approximately 18 percent of maintenance material is expected to be sand. Sands that are deposited onshore will nourish and stabilize eroding marshes; sand deposited in the nearshore zone should stay in the nearshore environment, moving back and forth across the shoreface (Wamsley, 2008). Sand placed at Louisiana Point should remain on the shoreface where it was deposited; no significant amounts of sand are expected to enter the Jetty Channel. On erosive mud shorelines like those in the BU area, the sand percentage should increase, and it will form sandy lenses or a veneer over the mud shoreline substrate. As the sand lenses thicken, the sands help protect the underlying mud from further erosion (Nairn, 1992). However, in smaller quantities, sand can also accelerate erosion of a mud beach. If the consolidated mud is not covered by a sand veneer, any sand that is mobilized by wave action will act as a scouring agent (King, 2007).

It is acknowledged that the behavior of the BU sediments within this complex littoral system cannot be predicted with certainty over the period of analysis, especially given the potential for strong storms to affect the coastal environment. However, there is sufficient knowledge of general processes and baseline

conditions to support evaluation of potential impacts and benefits. Furthermore, the engineering feasibility and potential environmental benefits have been demonstrated by successful recent BU projects at Texas and Louisiana Points (PBS&J, 2004a; USACE, 2000a). All of this information was used to establish explicit assumptions about the expected behavior of the BU material in the quantification of project impacts and benefits using the WVA model, as described in Appendix C of the FEIS. The WVA analysis assumed that 60 percent of the pumped quantity will remain in the existing marsh and on the shallow nearshore slope in front of the existing shorefront immediately after material placement. Since the material is unconsolidated and prone to erosion, only 50 percent of that material was assumed to remain by the end of each 6-year cycle. It was further assumed that the regular addition of material every 6 years would slow the resuspension of fine sediments, and result in the accumulation of some new marsh by the end of the period of analysis. No attempt was made to account for the effect of large storm systems.

No long-term impacts to vegetation or benthic sediments should result from nourishment episodes. The NWR personnel reported that the marsh vegetation at Texas Point rebounded quickly and with renewed vigor after being covered with up to 1 foot of material by a previous Texas Point BU project (Walther, 2005). Potential impacts to Critical Habitat for the wintering piping plover are expected to be beneficial in the long term, with short-term displacement of some birds during disposal activities. Benthic invertebrate fauna residing in the intertidal and tidal impact zones will be smothered, but studies have shown the impact to be similar to that resulting from natural events such as storms and hurricanes (Saloman and Naughton, 1977; Simon and Dauer, 1977). Following the burial, the resident species should recover quickly because of their short life cycle, high reproductive potential, and the rapid recruitment of larvae and motile macrofauna from nearby unaffected areas (Nelson and Pullen, 1988).

Upland Placement Features

Existing Active PAs

Existing PAs were evaluated to determine whether they possessed sufficient capacity for new work and maintenance material over the 50-year period of analysis. All of the upland PAs were reviewed by the ICT, and no further environmental review was recommended for existing PAs that were in active use. Existing and proposed upland PAs are shown on figures VI-3 through VI-7.

Existing Inactive PAs

Field visits were made to existing PAs that had been inactive in recent years (PAs 23A, 25A, 26, 27C, and 27D). Inactive PAs were visited to determine whether habitat and connectivity had developed since their last use such that they were contributing to the function of adjacent wetlands. No field visits or further review of inactive PA 25A were needed; no impacts are expected because it is known to contain low-quality, upland habitat. PA 25A is included in the DMMP.

The remaining inactive PAs were evaluated for potential impacts. All of these areas have been modified extensively by past placement activities and associated levee systems, which have artificially altered the

hydrology. Surrounding containment levees hold water and isolate the areas from adjacent water bodies, preventing them from contributing to the function of the adjacent wetlands and riparian corridor. All contain degraded habitat with low habitat values, primarily roosting habitat for birds and some wildlife cover. Renewed use of PAs 23A, 26, 27C, and 27D would not constitute a significant adverse change to the existing environmental condition, and all are included in the DMMP.

Areas Considered for PA Expansion

The quantities of dredged material projected for the Recommended Plan necessitated additional PA capacity. Finding areas suitable for the development of new upland PAs along the inshore reaches was difficult. The majority of land adjacent to the SNWW is either covered by residential and industrial development, existing PAs, forested uplands, or wetlands. Areas adjacent to existing PAs 14, 16, 18, and 24 were evaluated to determine their suitability as PAs. Potential expansion areas were designated as PA 14A, PA 16A, PA 18A, and PA 24A.

PA 14A (82 acres) is located south of existing PA 14, on the south side of the Neches River near its mouth. It is a relatively undisturbed intermediate marsh containing numerous small ponds that are seasonally connected to the riparian corridor. It provides habitat for numerous native wildlife species. It was determined that use of this area would be a significant adverse change to existing conditions because of its value to native wildlife species and preserving water quality. Placement needs for the Neches River Channel were reevaluated and the area was dropped from further consideration for use as a PA.

PA 16A (202 acres) is located west of existing PA 16 on the south side of the Neches River near its mouth. It is covered by intermediate marsh, has excellent hydrologic connectivity to adjacent wetlands, and provides important habitat for native fish and wildlife. The EPA includes the 16A area in a preliminary area of concern for the Star Lake Canal Superfund Site (EPA, 2006); an EPA feasibility study to determine the nature and extent of contamination is underway. Due to contaminant concerns and the biological and water quality value of its wetlands, the area has been dropped from further consideration for use as a PA.

PA 18A (71 acres) is located north of existing PA 18. It is a disturbed upland area containing low-quality scrub habitat. The Habitat Workgroup reviewed an aerial photograph of the proposed expansion area and determined that no field visit would be required. PA 18A is included in the DMMP.

PA 24A (187 acres) is located north of the Maritime Administration's Reserve Fleet area. The area contains a central upland ridge with surrounding wetland components. Initially, a 331-acre tract was evaluated for use. To minimize impacts to wetlands, 144 acres of marsh-hay cordgrass in the northern section were excluded, reducing the proposed PA to 187 acres. The 187-acre area contains 85 acres of lower quality wetlands comprised primarily of California bulrush and common reed. Impacts associated with conversion to a confined PA were evaluated with the WVA model, and it was determined that the impact of –44 AAHUs is fully offset by benefits of the DMMP Neches River BU Feature. PA 24A is included in the DMMP.

ODMDS Features

Four ODMDSs (Nos. 1–4) are currently in use for the existing SNWW project. Features for the placement of new work and maintenance material resulting from the construction of a deeper and longer offshore channel have been evaluated in an ODMDS Site Designation FEIS, which is included as Appendix B of the FEIS. Appendix B evaluates alternatives for the selection of new ODMDSs, including the use of the existing ODMDSs for the proposed CIP and BU sites. Existing and proposed ODMDSs are shown on Figure VII-3.

The existing ODMDSs were evaluated to determine whether they could accommodate all new work and maintenance material from the Recommended Plan. Although it was determined that they were large enough to hold all the material, the 13.2-mile length of the channel extension would make the cost of hauling all new work and maintenance material to existing ODMDSs prohibitively expensive. Designation of four new ODMDSs will be necessary. The best locations for the new sites were determined using the "zone of siting feasibility" screening technique, which delineates economically feasible sites that are sufficiently removed from ecologically sensitive or incompatible use areas to eliminate or minimize adverse impacts.

The ODMDS FEIS found no significant environmental impacts related to the use of existing and proposed ODMDS sites for the SNWW Recommended Plan. Analysis of northwestern Gulf of Mexico circulation patterns confirmed that the existing and proposed ODMDSs were properly located on the west side of the navigation channel. Before- and after-dredging bathymetry surveys have demonstrated that material placed offshore in the ODMDSs does not accumulate; it disperses quickly after placement in the offshore environment.

VII.E IDENTIFYING THE LEAST-COST PLACEMENT ALTERNATIVE

Description of Placement Alternatives

Placement features that survived the detailed evaluation were grouped into two comprehensive placement alternatives for further analysis. The Traditional Placement Alternative and the BU Alternative were compared to determine the least-cost, environmentally acceptable DMMP for both new work and maintenance material arising from the proposed 48-foot project.

In the Traditional Placement Alternative, it was assumed that management practices for the existing project would continue, adapting and expanding as needed to provide increased capacity for the proposed 48-foot project. Dredged material would be placed in the 4 existing and 4 proposed ODMDS features, the 16 existing upland PA features, and expansion cells in PAs 18A and 24A. Capacities of the existing upland PA features would be increased over the 50-year period of analysis by regular raising of containment levee heights. Without the additional capacity provided by the BU features described below, a final levee elevation of 36 feet would be required at PA 5 in Sabine Pass. On the Neches River Channel, final levee elevations at PAs 13–14, 16–18A, 21, and 23–27D would range from 17 to 47 feet. On the

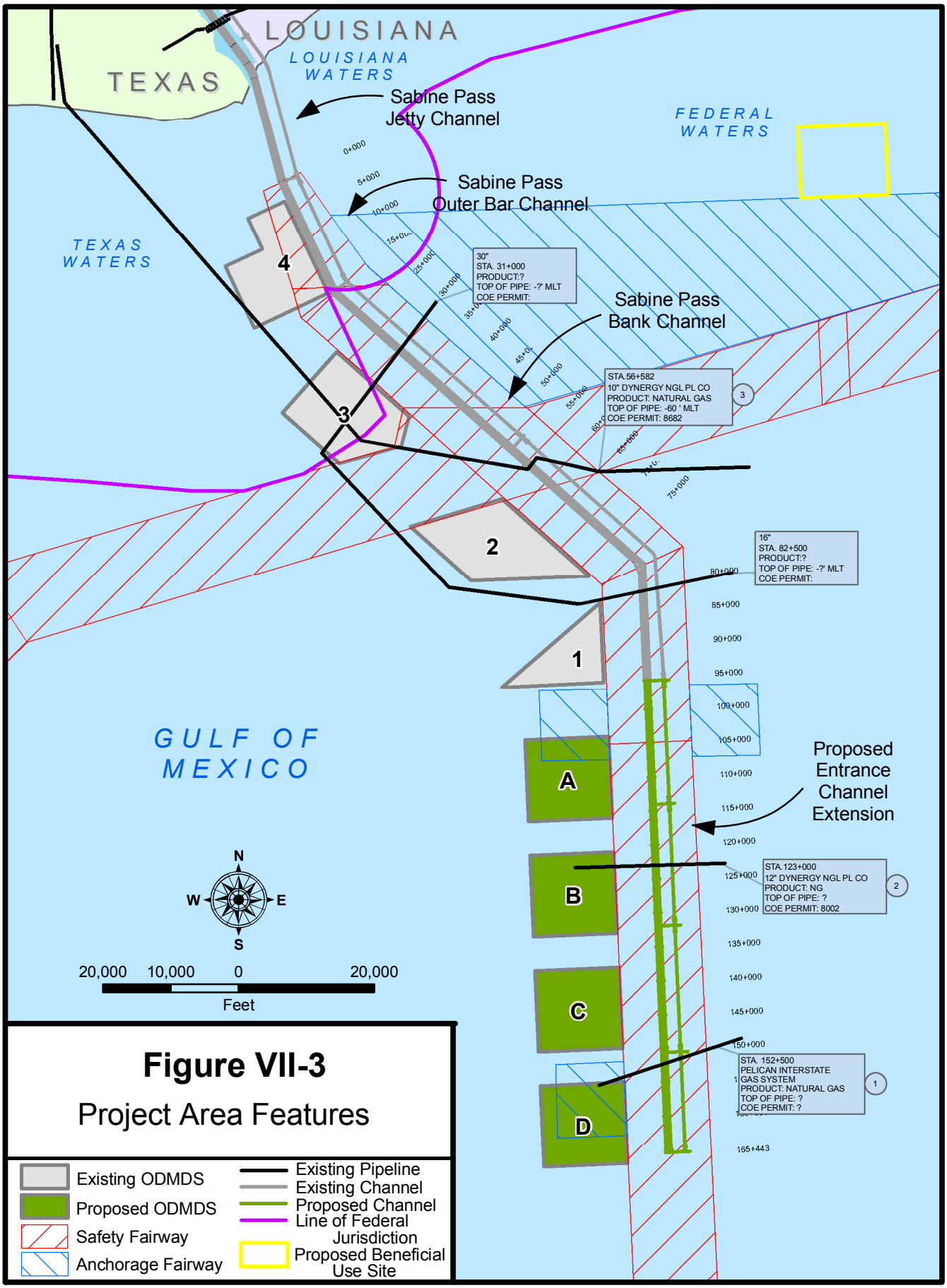


Figure VII-3

Project Area Features

N:441206/post_HU_projects/Projects/Original_Revised_Figure_Numbers/Figure_2_2_Vr2.mxd (A.P. 3/08/07)

Port Arthur and Sabine-Neches Canals (PAs 8, 9, 11, and 12), final elevations would be the same as the Recommended Plan. It is assumed that regular dewatering management practices (DAMP) would be required on the Neches River Channel PAs to provide the required 50-year capacity. PAs requiring DAMP include PAs 12, 13, 14, 16, 25A, 27A, and 27C. The Traditional Placement Alternative includes hopper and hydraulic dredging costs to place material at ODMDSs and upland PAs, to construct and maintain higher containment levees over the 50-year period of analysis, and real estate costs to acquire property needed for proposed PAs 18A and 24A.

The BU Alternative assumed the use of the Neches River and Gulf Shore BU features, in addition to all of the upland PA and ODMDS features that are also included in the Traditional Placement Alternative. The final levee elevation at PA 5 at Sabine Pass would be 34 feet; on the Port Arthur and Sabine-Neches canals (PAs 8, 9, 11, and 12), final levee elevations would range from 23 to 42 feet; and on the Neches River Channel, final levee elevations at PAs 13–14, 16–18A, 21, and 23–27D would range from 14 to 39 feet. This alternative takes advantage of new work material provided by the channel-deepening project to build hydraulic containment levees within degraded, former areas at Rose City East and West, Bessie Heights East, and Old River Cove. Each of these areas is referred to as a component of the overall Neches River BU Feature. Marsh would be created in each component using only new work, or a combination of new work and maintenance material. Marsh would be created in Old River Cove using only new work material. The first phase of Rose City East would be constructed with new work material, and it would be completed with the first cycle of maintenance material. Bessie Heights East would be completed with maintenance material over seven cycles. In addition to costs associated with providing upland PA capacity, costs for this plan include additional pumping distances and pipe movements for the BU features and their containment structures, training levees and circulation channels; maintenance of containment structures over the multiyear marsh construction period; marsh plantings; and monitoring costs.

Cost Comparison of Placement Alternatives

The average annual cost of new work and 50-year O&M plans for both alternatives are compared in Table VII-4. These costs were developed during the detailed design phase, using a different cost ($1.12/gallon fuel cost) and price level (October 2005). Costs have not been updated for this comparison because it is a screening phase cost comparison. Costs for both alternatives would change proportionately if they were updated with October 2009 price levels, and the difference in cost between the two plans would not be materially different. New work material is used beneficially only along the Neches River Channel. There are no differences between the new work costs for the first four channel reaches (Offshore Channels, Sabine Pass Channel, Port Arthur Canal, and Sabine-Neches Canal) because none of the new work material from these reaches would be used beneficially. New work material provided by the channel deepening is used at Rose City East, Bessie Heights East, and Old River Cove. Bessie Heights East and Rose City East would also use maintenance material from the Neches River to complete marsh restoration. These reaches exhibit differences in the O&M section of Table VII-4 because they are the only channel sections from which O&M material is proposed to be used beneficially. All of the costs have been annualized so that the time value of money is considered. Both the new work and O&M costs are

expressed as 50-year annualized costs to make them comparable. The annualizations were calculated on mid-year costs, using October 2005 price levels, and an interest rate of 4.875 percent.

Table VII-4
Average Annual Cost Comparison of Placement Plan Alternatives
for the Proposed 48-foot Project
(October 2005 Price Levels; $1.12 fuel cost; 4.875%)
(All costs in dollars)

Channels	**Offshore Channels (Hopper Dredging)**	**Sabine Pass Channel**	**Port Arthur Canal**	**Sabine-Neches Canal**	**Neches River Channel**			**Totals**
New Work Associated Beneficial Use Sites								
Associated Channel Sections	Sections D-A, 1–4	Sections 5 & 6	Sections 7 & 8	Sections 7 & 8	Sections 11, 12, 13	Sections 14, 15, 16	Sections 17 & 18	Total
					Neches River Combination Feature			
Placement Plan Alternatives					Old River Cove	Bessie Heights East	Rose City East	
Beneficial Use Alternative	10,048,000	3,469,000	7,696,000	5,655,000	3,961,000	7,631,000	12,094,000	50,554,000
Traditional Placement Alternative	10,048,000	3,469,000	7,696,000	5,655,000	4,522,000	7,837,000	12,447,000	51,674,000
Difference	–	–	–	–	(561,000)	(206,000)	(353,000)	(1,120,000)

O&M Associated Beneficial Use Sites								
Associated Channel Sections	Sections D-A, 1–4	Sections 5 & 6	Sections 7 & 8	Sections 7 & 8	Sections 11, 12, 13	Sections 14, 15, 16	Sections 17 & 18	Total
					Neches River Combination Feature			
Placement Plan Alternatives		Gulf Shore Feature			Bessie Heights East	Bessie Heights East	Rose City East	
Beneficial Use Alternative	29,470,000	3,225,000	8,928,000	4,177,000	3,055,000	2,932,000	1,523,000	53,310,000
Traditional Placement Alternative	29,470,000	3,225,000	8,928,000	4,177,000	3,551,000	3,050,000	1,571,000	53,972,000
Difference	–	–	–	–	(496,000)	(118,000)	(48,000)	(662,000)

The Gulf Shore BU Feature uses maintenance material to regularly renourish shorelines and Texas and Louisiana Points every 6 years over the period of analysis. This disposal method was found to be the least-cost method of disposal for all maintenance material from Section 5 of the Sabine Pass Channel, and is included in the base disposal plan. Therefore, displayed costs for this feature are equal for both the Revised BU Alternative and the Traditional Placement Alternative. All of the costs have been annualized so that the time value of money is considered. Both the new work and O&M costs are expressed as 50-year annualized costs to make them comparable. The annualizations were calculated on mid-year costs, using October 2005 price levels, and an interest rate of 4.875 percent.

Selection of the DMMP

The BU Alternative is recommended for adoption in the DMMP for the Recommended Plan because it is the least-cost, environmentally acceptable placement alternative. In addition to being a least-cost plan, it provides substantial ecological benefits that offset all project impacts in Texas, and some impacts in Louisiana.

VII.F DESCRIPTION OF THE DMMP FOR THE RECOMMENDED PLAN

The DMMP for the Recommended Plan provides for the placement of both new work and maintenance material for the 50-year period of analysis. The locations of channel reaches, waterway sections, PA and ODMDS features, and BU features are shown on Engineering Drawings C-01 through C-12 (Appendix 1). A comprehensive DMMP is needed because new work material would be used to construct containment levees for BU features that would be completed with maintenance material after channel construction is completed. The DMMP, therefore, differs from the discussion of the incremental O&M cost of the Recommended Plan in later sections of this chapter, as they focus solely on O&M costs and the placement plan for maintenance material only.

DMMP BU Features

All BU features proposed as part of the DMMP are described in Table VII-5. Details of plan implementation for each of the BU features were described above and are discussed further in the FEIS. The DMMP BU features are not being pursued as separable elements of an ecosystem restoration plan under Section 204 or 207 authorities. They are not ecosystem restoration measures, and as such, do not target a specific historical condition for the level of restoration. They are least-cost, environmentally acceptable placement features and are included as GNF of the DMMP.

Upland PA Features

Sixteen existing PA features, and two new cells (PAs 18A and 24A) that enlarge existing PAs, are proposed for use in the Recommended Plan (Table VII-6). Existing PAs will be used to the greatest extent possible; five currently inactive PAs or PA cells (PA 23A, 25A, 26, 27C, and 27D) will be rehabilitated

and restored to active use. Non-Federal dredging is projected to contribute 4.6 percent of material placed in upland PA features. Non-Federal facilities using these PAs are located along the Port Arthur and Sabine-Neches canals and the Neches River Channel; this material will be placed in the same PAs used for material from the adjacent navigation channels.

Table VII-5
DMMP BU Features

Beneficial Use Features	No.	Description	Size of Influence Area
Rose City East (component of Neches River BU Measure)	TX 3-1 East	Restoring 345 acres of fresh marsh, improving 72 acres of shallow-water habitat, and nourishing 151 acres of existing marsh in two construction events. New work material from Neches River Channel will be used to restore 225-acre marsh, and construct hydraulic containment levees and higher elevation features. Maintenance material from the first maintenance cycle will be used to restore an additional 120 acres of marsh.	Influence area – 568 acres
Bessie Heights East (component of Neches River BU Measure)	TX 5-2	Restores 679 acres of brackish and 1,190 acres of intermediate marsh, improves 660 acres of shallow-water habitat, and nourishes 651 acres of existing marsh. Marsh will be constructed with maintenance material from Neches River Channel for 28 years. New work material is used to build hydraulic containment levee.	Influence area – 3,180 acres
Old River Cove (component of Neches River BU Measure)	TX 6-1	Restores 639 acres of brackish marsh, improves 139 acres of shallow-water habitat, and nourishes 432 acres of existing marsh with new work material from Neches River Channel. New work material used to construct hydraulic containment levee.	Influence area – 1,210 acres
Gulf Shore BU Feature (Texas and Louisiana Points)	TX 8-11 LA 5-2/6-2	Nourish 3 miles of Gulf shoreline on both sides of Sabine Pass, from 0.5 to 3.5 miles from east and west jetties, using maintenance material from Sabine Pass Channel. Unconfined placement of maintenance material along shoreline every 3 years for 50-year period of analysis (8 placement episodes). Assume 50:50 split of material between Texas and Louisiana accomplished by alternating placement in Texas and Louisiana.	Affected shoreline 6.0 miles total

Table VII-6
Dredged Material Management Plan Upland Placement Areas

Placement Area	Additional Cell(s)	Size (acres)	Associated Waterway Section**
5	N&S, B and C	957	Sabine Pass Channel (Sec. 5 and 6)
8		3,570	Port Arthur Canal (Sec. 7 and 8) Sabine-Neches Canal (Sec. 9)
9A	B	481	Port Arthur Canal (Sec. 8)
11		2,170	Sabine-Neches Canal (Sec. 10)
12		355	Neches River Channel (Sec. 11)
13		140	Neches River Channel (Sec. 11)
14		255	Neches River Channel (Sec. 12)
16		288	Neches River Channel (Sec. 13)
17		316	Neches River Channel (Sec. 13)
18	A*	432	Neches River Channel (Sec. 14)
21		135	Neches River Channel (Sec. 14)
23	A	773	Neches River Channel (Sec. 15)
24	A*	575	Neches River Channel (Sec. 16)
25	A	820	Neches River Channel (Sec. 17)
26		192	Neches River Channel (Sec. 18)
27	A, C, and D	270	Neches River Channel (Sec. 18)

* New cells (PAs 18A and 24A), which enlarge existing PAs.
** Waterway sections are shown on FFR Engineering Plates C-01 through C-12 (Appendix 1).

Offshore Placement Features

The ODMDSs for the Recommended Plan are four existing (sites 1–4) and four proposed ODMDSs (sites A–D). All of the new ODMDSs are located on the west side of the channel since the littoral drift (movement of offshore sediment) is most commonly from east to west. Sizes and associated channel reach, beginning with the farthest offshore reach, are provided in Table VII-7.

Table VII-7
Existing and New ODMDSs

Placement Area	Size (acres)	Status	Associated Waterway Section
D	3,392	New	Extension Channel
C	3,392	New	Extension Channel
B	3,392	New	Extension Channel
A	3,392	New	Extension Channel
1	2,048	Active	Section 1
2	4,736	Active	Section 2
3	3,968	Active	Section 3
4	3,456	Active	Section 4

The USACE and EPA have cooperated in the preparation of an FEIS for the proposed ODMDSs; this document is Appendix B of the FEIS. Public comment on the proposed ODMDSs will be requested

concurrently with comments on the FEIS for the SNWW CIP. If the FFR and FEIS are approved by the USACE and the Recommended Plan is authorized by the U.S. Congress, the EPA will publish a rule-making in the *Federal Register* that establishes SNWW ODMDSs A, B, C, and D for use in conjunction with construction and operation of the 48-foot project.

VII.G INCREMENTAL ENVIRONMENTAL IMPACTS AND BENEFITS OF THE DMMP

Incremental Environmental Impacts of the DMMP

Incremental DMMP impacts of the proposed 48-foot project are discussed in detail in the FEIS, but are summarized here. The incremental impact would consist of marsh lost with construction of one new upland placement cell, and four new ODMDSs. No impacts are anticipated with improvements to existing upland PAs that are needed to provide additional capacity for the 50-year period of analysis, since improvements are limited to increasing containment levee heights. The DMMP BU features have net ecological benefits that are described below.

Incremental Ecological Benefits of the DMMP

Methods and Objectives

The DMMP BU features described above provide ecological benefits that would offset project impacts. The benefits were used to offset project impacts before remaining, unavoidable impacts were quantified and compensatory mitigation was developed. The WVA Model was used to quantify impacts to all affected habitat types in the study area and establish the appropriate amount of offsetting DMMP benefits by habitat type. An HS model was used to evaluate and quantify salinity impacts and benefits of the BU plan. The WVA model is summarized in Chapter VIII and described in detail in Appendix C of the FEIS. The HS model is also summarized in Chapter VIII, but it is described in detail in Brown and Stokes (2009). Evaluation of BU alternatives was conducted within the ICT and technical workgroups in meetings conducted from 2001 to 2006. The BU plan was revised by the USACE in 2009 to reflect changes necessitated by project reformulation and revised HS modeling.

The DMMP benefits contribute to multiagency regional plans (the TPWD regional management plan for J.D. Murphree WMA, Sea Rim State Park, Texas Point NWR, and McFaddin NWR [see Keith Lake: the Texas Coastwide Erosion Response Plan [GLO 2004, 2005]; the Louisiana Comprehensive Management Plan [Louisiana Coastal Protection and Restoration Authority [LACPRA], 2007; USACE, 2008b]; the LA Coast 2050 Plan [LCWCR/WCRA, 1998], and the North American Waterfowl Plan (NAWMP Committee, 2004]), by restoring and preserving scarce and vulnerable wetlands and wildlife habitat, nourishing eroding Gulf shorelines, restoring sediment to the littoral zone, and using dredged material beneficially to the greatest extent possible. The DMMP also complies with Coastal Zone Management Plans (CZMP) for each state by sharing dredged material from the Sabine Pass Channel to accomplish regular shoreline nourishment. The Gulf Shore BU Feature shares this resource equally between the states because it is dredged from a channel that straddles the state boundary.

Offsetting Ecological Impacts

BU features included in the DMMP provide benefits that offset all indirect and direct Texas impacts (–412 AAHUs) of the Recommended Plan (Table VII-8) and partially offset impacts in Louisiana (Table VII-9). In Texas, construction of the Neches River BU Feature and the Texas portion of the Gulf Shore BU Feature will produce benefits totaling 1,068 AAHUs. Therefore, there will be a net gain of 656 AAHUs, which more than offsets all negative impacts that occur in Texas. Impacts that are offset include the direct loss of 32 AAHUs for the conversion of fresh marsh to upland PA 24A. The majority of the offset Texas impacts are in the Neches River watershed, but approximately 16 percent are losses to cypress-tupelo swamp (–22 AAHUs) and fresh and intermediate marsh (–45 AAHUs) in the Sabine River watershed. In Louisiana, the Gulf Shore BU Feature provides benefits totaling 210 AAHUs. Given total Louisiana impacts of 1,709 AAHUs, there is a net loss of 1,499 AAHUs remaining in Louisiana after offsetting benefits of the Louisiana portion of the Gulf Shore BU Feature are applied.

It is important to note that the impacts presented here do not include all impacts of the Recommended Plan in Texas as FWP impacts in Texas's Salt Bayou (TX 9) hydro-unit are not included. This is the result of an ICT decision made in response to a USACE policy determination on a related project. During an in-progress review of the Keith Lake Fish Pass Section 1135 study, it was determined that SNWW CIP impacts to this area were being evaluated concurrently for the same area. The USACE Headquarters concluded that impacts could not be evaluated under the CIP study if they were being addressed under the Section 1135 Keith Lake Fish Pass project. The non-Federal sponsor of the Section 1135 study elected to continue that study with the understanding that the ICT review of the Recommended Plan impacts to the Salt Bayou hydro-unit would be necessary if a Section 1135 project is not approved prior to authorization of the SNWW CIP. Excess in-kind benefits associated with Texas's DMMP features (316 AAHUs) could be used to partially offset the predicted Salt Bayou AAHU loss of 658 AAHUs.

With adoption of the DMMP, all FWP impacts in Texas would be offset and no compensatory mitigation is proposed in conjunction with construction of the Recommended Plan. Impacts in Louisiana are minimized to the greatest extent possible by the DMMP, but unavoidable impacts of 1,499 AAHUs remain. When the impacts and DMMP benefits are not subdivided by state but are applied to the project as a whole, a loss of 843 AAHUs remains (Table VII-10). A mitigation plan, described in Chapter VIII, has been developed to compensate for unavoidable impacts of the Recommended Plan.

VII.H BASE PLAN FOR THE EXISTING 40-FOOT PROJECT

A Base Plan was developed that describes the without-project practices that would accomplish the disposal of dredged material from the existing 40-foot project in the least costly, environmentally acceptable manner. A summary description of existing and proposed PAs and BU features of the Base Plan are provided below. In the next section, the cost of the Base Plan is compared to the O&M cost of the Recommended Plan to determine the incremental O&M cost of the Recommended Plan (see Table VII-12).

Table VII-8
Texas – FWP Impacts and Benefits by Habitat Type

HU #	Hydrologic Unit (HU) Name	Offset Impacts by Acres and Habitat Type (acres)			Total Impacts / Benefits by Habitat Type (AAHUs)		
		No Effect	Impacts Offset by BU Plan	Acres Impacted	Total Loss	Offsetting Benefits of BU Plan	Net FWP Benefit
Bottomland Hardwood							
Neches River Watershed							
TX 1	North Neches River	412			0		0
TX 2	Neches-Lake Bayou	1,040			0		0
TX 3	Rose City	1,775			0		0
TX 5	Bessie Heights	293			0		0
TX 6	Old River Cove	197			0		0
Subtotal - Neches River		**3,717**	**0**	**0**	**0**	**0**	**0**
Sabine River Watershed							
TX 10	Cow Bayou	388			0		0
TX 11	Adams Bayou	640			0		0
LA/TX 1	Sabine Island	524			0		0
Subtotal - Sabine River		**1,552**	**0**	**0**	**0**	**0**	**0**
Total Bottomland Hardwood		**5,269**	**0**	**0**	**0**	**0**	**0**
Cypress/Tupelo Swamp							
Neches River Watershed							
TX 1	North Neches River	2,760			0		0
TX 2	Neches-Lake Bayou	2,277			0		0
TX 3	Rose City	464			0		0
Subtotal - Neches River		**5,501**	**0**	**0**	**0**	**0**	**0**
Sabine River Watershed							
TX 10	Cow Bayou	110			0		0
TX 11	Adams Bayou			115	-4		-4
TX 12	Blue Elbow South			689	-18		-18
LA/TX 1	Sabine Island	1,194			0		0
LA/TX 2	Blue Elbow	2,737			0		0
Subtotal - Sabine River		**4,041**	**0**	**804**	**-22**	**0**	**-22**
Total Cypress/Tupelo Swamp		**9,542**	**0**	**804**	**-22**	**0**	**-22**
Fresh Marsh							
Neches River Watershed							
TX 1	North Neches River	436			0		0
TX 2	Neches-Lake Bayou	1,535			0		0
TX 3	*Rose City PA24A**			86	-32		-32
TX 3	Rose City			3,241	-1	178	177
TX 4	West of Rose City	492			0		0
TX 5	Bessie Heights	2,147			0		0
TX 7	GIWW North			4,806	-140		-140
Subtotal - Neches River		**4,610**	**0**	**8,133**	**-173**	**178**	**5**
Sabine River Watershed							
TX 10	Cow Bayou			1,775	-18		-18
TX 11	Adams Bayou			599	-15		-15
Subtotal - Sabine River		**0**	**0**	**2,374**	**-33**	**0**	**-33**
Total Fresh Marsh		**4,610**	**0**	**10,507**	**-206**	**178**	**-28**
Intermediate Marsh							
Neches River Watershed							
TX 5	Bessie Heights			6,933	-14	433	419
TX 8	Texas Point			1,742	-19		-19
TX 13	Groves			437	-3		-3
Subtotal - Neches River		**0**	**0**	**9,112**	**-36**	**433**	**397**
Sabine River Watershed							
TX 10	Cow Bayou			1,144	-12		-12
Subtotal - Sabine River		**0**	**0**	**1,144**	**-12**	**0**	**-12**
Total Intermediate Marsh		**0**	**0**	**10,256**	**-48**	**433**	**385**
Brackish Marsh							
Neches River Watershed							
TX 6	Old River Cove			8,760	-116	235	119
TX 8	Texas Point			2,546	-7		-7
TX 7	GIWW North			647	-8		-8
Subtotal - Neches River		**0**	**0**	**11,953**	**-131**	**235**	**104**
Total Brackish Marsh		**0**	**0**	**11,953**	**-131**	**235**	**104**
Saline Marsh							
Neches River Watershed							
TX 8	Texas Point		5,708		-5	222	217
Subtotal - Neches River		0	5,708	0	-5	222	217
Total Saline Marsh		**0**	**5,708**	**0**	**-5**	**222**	**217**
Total Neches River Impacts		13,828	5,708	29,198	-345	1,068	723
Total Sabine River Impacts		5,593	0	4,322	-67	0	-67
Total - All Habitats		**19,421**	**5,708**	**33,520**	**-412**	**1,068**	**656**

* Direct impact associated with conversion of wetland to upland PA24A.

Table VII-9
Louisiana – FWP Impacts and Benefits by Habitat Type

HU #	Hydrologic Unit (HU) Name	Offset Impacts by Acres and Habitat Type (acres)			Total Impacts / Benefits by Habitat Type (AAHUs)		
		No Impact	Impacts Offset by BU Plan	Acres Impacted	Total Loss	Offsetting Benefits of BU Plan	Net FWP Impact
All HUs in Sabine River Watershed							
Bottomland Hardwood							
LA 1	Perry Ridge	2,158	0	0	0	0	0
LA/TX 1	Sabine Island	1,041	0	0	0	0	0
	Subtotal	3,199	0	0	0	0	0
Cypress/Tupelo Swamp							
LA/TX 1	Sabine Island	5,998	0	0	0	0	0
LA/TX 2	Blue Elbow	650	0	0	0	0	0
	Subtotal	6,648	0	0	0	0	0
Fresh Marsh							
LA 1	Perry Ridge	0	0	18,859	-65	0	-65
LA 7	Southeast Sabine	0	0	2,634	-11	0	-11
LA 8	Southwest Gum Cove	0	0	3,615	-2	0	-2
	Subtotal	0	0	25,108	-78	0	-78
Intermediate Marsh							
LA 1	Perry Ridge	0	0	4,704	-53	0	-53
LA 2	Willow Bayou	0	0	35,109	-328	0	-328
LA 3	Black Bayou	0	0	34,941	-509	0	-509
LA 4	West Johnsons Bayou	0	0	11,110	-269	0	-269
LA 5	Sabine Lake Ridges	0	0	9,270	-218	0	-218
LA 7	Southeast Sabine	5,400	0		0	0	0
LA 8	Southwest Gum Cove	0	0	6,605	-4	0	-4
LA 9	East Johnsons Bayou	0	0	26,138	-190	0	-190
	Subtotal	5,400	0	127,877	-1,571	0	-1,571
Brackish Marsh							
LA 2	Willow Bayou	0	0	1,182	-1	0	-1
LA 3	Black Bayou	0	0	3,195	-1	0	-1
LA 4	West Johnsons Bayou	0	0	2,078	-1	0	-1
LA 5	Sabine Lake Ridges	0	0	15,962	-14	0	-14
LA 6	Johnsons Bayou Ridge	0	0	2,744	-6	0	-6
	Subtotal	0	0	25,161	-23	0	-23
Saline Marsh							
LA 5	Sabine Lake Ridges	0	3,767	0	-35	210	173
LA 6	Johnsons Bayou Ridge	0	370	0	-2		
	Subtotal		4,137	0	-37	210	173
Louisiana Impacts Total		15,247	4,137	178,146	-1,709	210	-1,499

Table VII-10
Net FWP Impacts for Project as a Whole (AAHUs)

	Bottom-land Hardwood	Cypress-Tupelo Swamp	Fresh Marsh	Intrmd Marsh	Brackish Marsh	Saline Marsh	Total
Impacts							
Texas							
Neches River watershed	0	0	-173	-36	-131	-5	-345
Sabine River watershed	0	-22	-33	-12	0	0	-67
Subtotal	0	-22	-206	-48	-131	-5	-412
Louisiana							
Sabine River watershed	0	0	-78	-1,571	-23	-37	-1,709
Total Impacts	0	-22	-284	-1619	-154	-42	-2121
DMMP Benefits							
Texas							
Neches River watershed							
Neches River BU Feature	0	0	178	305	363	0	846
Gulf Shore BU Feature (TX Point)	0	0	0	0	0	222	222
Subtotal	0	0	178	305	363	222	1068
Louisiana							
Sabine River watershed							
Gulf Shore BU Feature (LA Point)	0	0	0	0	0	210	210
Total DMMP Benefits	0	0	178	305	363	432	1278
Net SNWW CIP FWP Impacts							
Texas							
Neches River watershed	0	0	5	269	232	217	723
Sabine River watershed	0	-22	-33	-12	0	0	-67
Net Texas Benefits (positive)							656
Net Louisiana Impacts (negative)	0	0	-78	-1571	-23	173	-1499
Net FWP Impacts	0	-22	-106	-1314	209	390	-843

The offshore channels (Sabine Bank Channel, Sabine Pass Outer Bar Channel, and Sabine Pass Jetty Channel) would be maintained with a hopper dredge, and approximately 162 mcy of material would be placed in four existing ODMDSs. Bed sediments in the offshore channels vary from 4.3 percent sand and 95.7 percent silt plus clay in the Sabine Pass Outer Bar Channel to 24.3 percent sand and 75.7 percent silt plus clay in the Sabine Bank Channel (Parchure et al., 2005). These sites have sufficient capacity for the 50-year period of analysis as they are located in a dispersive environment where dredged material does not accumulate.

For the inshore Sabine Pass Channel, the analysis of placement alternatives conducted for this study resulted in a change from traditional upland placement at PA 5. The Gulf Shore Feature was evaluated as a BU alternative for 13.8 mcy of maintenance material from Section 5 (total of 16 cycles, 3 years each), the channel section closest to the coast (see Engineering Plates C-09 and C-10, Appendix 1). Material from channel Section 6 would continue to be placed into PA 5 (16.8 mcy total; 16 cycles of 3 years each), because the longer pumping distance to the coast makes shore nourishment cost prohibitive. The 50-year stream of costs for BU and traditional upland placement alternatives was compared for both the Base and Recommended Plans, as shown in Table VII-11. These costs were developed during the detailed design phase, using a different cost ($1.12/gallon fuel cost) and price level (October 2005). Costs have not been

updated because it is a screening phase cost comparison. No changes have been made to these alternatives since they were initially compared. Costs for both alternatives would change proportionately if they were updated with October 2009 price levels, and the difference in cost between the two plans would not be materially different. During the detailed evaluation of screened alternatives, the Gulf Shore Feature was compared to the Base Plan option. The Base Plan option entails placing all Section 5 material in upland confined PA 5, with regular raisings of the containment levee as required to contain the material. The cost analysis determined that the Gulf Shore Feature is the least-cost, environmentally acceptable alternative for the 40-foot Base Plan. It is, therefore, included in the Base Plan for the existing project. Since it is also the least-cost O&M alternative for the proposed 48-foot project, it is the preferred placement option for Sabine Pass Channel Section 5 in the Recommended Plan.

Table VII-11
Cost Comparison of Gulf Shore Beneficial Use Feature to Base Plan PA 5
(All costs in dollars)

Placement Alternatives for Section 5 Maintenance Material	Base Plan	Selected Plan
Gulf Shore BU Feature	2,006,000	3,225,000
Upland PA 5	2,200,000	4,366,000
Difference	(194,000)	(1,141,000)

Presented as average annual costs; October 2005 price levels, $1.12 per gallon fuel cost; 4.875 percent interest rate

To contain 229.4 mcy of material from the inshore channels over the 50-year period of analysis for the project as a whole, the heights of existing PAs would be raised on a regular, recurring schedule in accordance with existing SNWW management practices. One new PA in the middle reach of the Neches River Channel (an expansion cell at PA 24A) would be needed to provide sufficient capacity for the 50-year period. On average, bed sediments vary in the inland channels from 38.3 percent sand and 61.7 percent silt plus clay in the Neches River Channel, to 16.2 percent sand and 83.8 percent silt plus clay in the Port Arthur Canal (Parchure et al., 2005). BU features are not included in the Base Plan for the inland channels because the lack of suitable material makes construction and maintenance of containment levees more expensive than placing the material in existing PAs. However, Section 204 projects will be considered on a project-by-project basis if non-Federal sponsors express an interest in paying the incremental cost for such projects.

Material from non-Federal dredging of private mooring and dock facilities would also continue to be placed in upland PAs along with the material from the Federal project. Non-Federal dredging quantities vary throughout the length of the waterway. The non-Federal dredging quantity is defined as a percentage of the channel shoaling by section and can be found within the Shoaling Parameters Table in the DMMP (FEIS, Appendix D). The quantity is based on the presence of local facilities, the square footage of the facility, and the shoaling rate of the adjacent channel. The non-Federal material is placed within the same PAs as the material from the adjacent waterway section.

The average annual cost of the 50-year Base Plan for the 40-foot project is $40,938,000. Base Plan costs are presented as average annual equivalents of the stream of maintenance costs over the 50-year period of analysis. Prices used for the comparison were developed in October 2007, with an interest rate of 4.875 percent. Costs include cyclical maintenance dredging using a hopper dredge offshore and a hydraulic pipeline dredge for the inshore reaches, regular levee raisings to provide additional capacity at inland PAs, and the purchase and development of a new upland site at PA 24A. The cost to provide additional capacity for non-Federal dredging is included in the total cost per reach.

VII.I INCREMENTAL O&M COST OF THE PROPOSED 48-FOOT PROJECT

Description of O&M Activities for the Recommended Plan

The 50-year O&M plan for the placement of dredged material from the Recommended Plan is also summarized in Table VII-12. The O&M placement plan for the Recommended Plan must provide significantly more PA capacity than the SNWW 40-foot Base Plan. The Recommended Plan would generate 650 mcy of maintenance material over the 50-year period of analysis, which is 60 percent higher than the base plan quantities. Forty-three percent of the maintenance quantities projected for the Recommended Plan would originate from inshore channels, and 57 percent from offshore channels. It is projected that approximately 5.2 percent of the dredged material from inshore channels will be associated with non-Federal dredging. The quantity is based on the presence of local facilities, the square footage of the facility, and the shoaling rate of the adjacent channel. The non-Federal material is placed within the same PAs as the material from the adjacent waterway section.

O&M for the Recommended Plan consists of the continued use of 4 existing ODMDSs; the creation of 4 new ODMDSs; 16 existing upland PAs; the addition of 2 new cells at existing upland sites (PAs 18A and 24A), and BU components of the Neches River Feature (Bessie Heights East and Rose City East) and Gulf Shore Feature. The existing management practice of regular, recurring containment levee lifts would continue at all upland PAs, but no DAMP would be used.

The hydraulic construction of containment levees with new work material provides a cost-effective construction method that reduces the cost of providing capacity for the new work and maintenance material on the Neches River Channel by reducing final levee elevations at upland PAs.

Incremental O&M Cost of the Recommended Plan

The average annual cost of the 50-year O&M plan for the Recommended Plan is $68,632,000. The total O&M incremental cost for the Recommended Plan is $32,067,000. Of this total, $61,000 is the cost of providing non-Federal disposal facility capacity. The O&M costs for the Recommended Plan presented in Table VII-12 do not include new work construction costs. The non-Federal disposal facility costs are summarized per channel for the Recommended Plan in Table VII-12 to facilitate proper distribution of Federal and non-Federal project costs. Costs are presented as average annual equivalents of the stream of

Table VII-12
Incremental O&M Cost for the Recommended Plan

Average Annual Costs, October 2009 Price Levels, 4.375% Interest Rate									
	40-foot Base Plan			48-foot Selected Plan					
Channel	Placement Sites	50-year Quantity (mcy)	Average Annual Cost ($)	Placement Sites	50-year Quantity (mcy)	Average Annual Cost ($)	non-Federal Disposal Facility Average Annual Cost ($)	Federal Project O&M Average Annual Costs ($)	Total Incremental O&M Average Annual Cost ($)
Sabine Bank Extension	ODMDSs A, B, C, D	n/a	n/a	ODMDSs A, B, C, D	36.2	3,913,000		3,913,000	3,913,000
Sabine Bank Channel	ODMDSs 1 and 2	50.8	2,291,000	ODMDSs 1 and 2	96.4	8,089,000		8,089,000	5,798,000
Sabine Pass Outer Bar Channel	ODMDS 3	99.7	10,761,000	ODMDS 3	223.7	21,733,000		21,733,000	10,972,000
Sabine Pass Jetty Channel	ODMDS 4	11.4	1,472,000	ODMDS 4	13.5	1,973,000		1,973,000	501,000
Sabine Pass Channel	PAs 5 (N&S), 5B, 5C, TX8-11, LA5-6	30.6	2,508,000	PAs 5 (N&S), 5B, 5C, TX8-11, LA5-6	34.8	4,464,000		4,464,000	1,956,000
Port Arthur Canal & Taylor Bayou Basins & Channels	PAs 8, 9, 9A	88.2	7,851,000	PAs 8, 9A, 9B	82.9	12,482,000	6,000	12,482,000	4,631,000
Sabine-Neches Canal	PAs 8, 11	60.1	3,629,000	PAs 8, 11	73.2	6,067,000	9,000	6,067,000	2,438,000
Neches River Channel	PAs 12, 13, 14, 16, 17, 18, 21, 23, 23A, 24, 24A, 25, 25A, 26, 27A, 27C, 27D	66.5	8,134,000	PAs 12, 13, 14, 16, 17, 18, 18A, 21, 23, 23A, 24, 24A, 25, 25A, 26, 27A, 27C, 27D, TX5-2, TX3-1E	89.7	9,992,000	46,000	9,992,000	1,858,000
Totals		407.3	36,646,000		650.4	68,713,000	61,000	68,713,000	32,067,000

Average Annual Costs, October 2009 Price Levels, 4.375% interest

maintenance costs over the 50-year period of analysis. Prices used for the comparison were developed in October 2009, with an interest rate of 4.375 percent. O&M costs for the Recommended Plan include cyclical maintenance dredging using a hopper dredge in the offshore channels and a pipeline dredge for the inshore channels; offshore placement at four existing and four new ODMDS; real estate costs to obtain and construct two new upland sites at PA 18A and PA 24A; regular levee lifts and spillway rehabilitation for upland PAs; the placement of maintenance material at Bessie Heights East (7 cycles) and Rose City East (1 cycle) components of the Neches River BU Feature and the Gulf Shore Feature (15 cycles); maintenance of containment levees at the BU sites; and monitoring of the BU sites.

VIII. DEVELOPMENT OF THE MITIGATION PLAN

VIII.A OVERVIEW

This chapter discusses the evaluation of mitigation measures considered during formulation of the Recommended Plan, and presents the Ecological Mitigation Plan. The Ecological Mitigation Plan compensates for unavoidable impacts to nationally significant intertidal marsh habitat. Evaluation of measures was conducted within the ICT and technical workgroups. ICT and workgroup meetings were conducted from 2001 to 2006. In 2009, changes in the proposed project and HS modeling necessitated that the WVA modeling be revised. Due to schedule constraints, the USACE performed the modeling without the ICT involvement, basing it as closely as possible on methods and assumptions used by the ICT in the original modeling. The results of this remodeling were coordinated with the ICT. A quality check was also performed for the revised worksheets. The potential for cultural resource mitigation is described at the end of this section.

VIII.B ECOSYSTEM IMPACTS SUMMARY

The impacts of the Recommended Plan are related primarily to a decrease in the overall biological productivity of approximately 182,000 acres of marshes and forested wetlands over the 50-year period of analysis. Biological productivity of the wetlands in the affected area would decline as increases in salinity affect the productivity of marsh and cypress-tupelo swamp, and the fish and wildlife that depend upon this habitat. Indirect adverse effects could lead to the loss of marsh acreage as stressed emergent marsh converts to open water. The WVA Emergent Marsh Community Model (EMCM) predicts a loss of 691 acres of marsh in Louisiana over the period of analysis. Higher salinity would have a negligible effect on the productivity of cypress-tupelo swamp on the Sabine River near the GIWW by marginally slowing the rates of tree growth and reducing some herbaceous understory; no loss of cypress-tupelo swamp acreage would be expected. No impacts from the Recommended Plan were identified for bottomland hardwoods.

Direct effects of the Recommended Plan would be minor and temporary. These temporary, short-term impacts are associated with navigation channel improvements and the placement of dredged material. They include (1) impacts to water quality and benthic organisms and their Gulf, estuarine, and riverine water-bottom habitats resulting from dredging to construct the navigation improvements, the creation of new offshore ODMDSs, the borrow area trench for Willow Bayou mitigation areas, and marsh restoration in shallow, open-water areas; (2) potential dredging impacts to bottom-feeding and pelagic organisms such as sea turtles; and (3) impacts to shoreline birds and their habitat from the placement of maintenance material on the Gulf shoreline.

Potential adverse affects to threatened and endangered sea turtles during hopper dredging to construct the Entrance Channel would be addressed by the adoption of reasonable and prudent measures to avoid impacts that are established in the Biological Opinion for the CIP. No other adverse effects to threatened and endangered species have been identified.

The Recommended Plan's effects on the SNWW's marsh and swamp systems were quantified using the WVA Model. In the table below, net changes in acres and AAHUs are presented for the Recommended Plan, including benefits of the DMMP BU features (Table VIII-1). The lost ecological value of all potential project impacts (prior to reduction by benefits of the BU features) is represented by –2,121 AAHUs. These impacts would be offset by adoption of the DMMP BU features that provide benefits of 1,278 AAHUs. When the impacts and DMMP benefits are applied to the project as a whole, unavoidable impacts of –843 AAHUs would remain.

Table VIII-1
Net Project Impacts and Benefits by Average Annual Habitat Units

	Bottomland Hardwood	Swamp	Fresh Marsh	Intrmd Marsh	Brackish Marsh	Saline Marsh	Totals
Recommended Plan Impacts (negative AAHUs)							
Texas	0	–22	–206	–48	–131	–5	–412
Louisiana	0	0	–78	–1,571	–23	–37	–1,709
Total Project Impacts	0	–22	–284	–1,619	–154	–42	–2,121
Recommended Plan Benefits (positive AAHUs)							
Texas	0	0	178	433	235	222	1,068
Louisiana	0	0	0	0	0	210	210
Total Project Benefits	0	0	178	433	235	432	1,278
Net Project Benefits or Impacts (AAHUs)	0	–22	–106	–1,186	81	390	–843

VIII.C PROCEDURES FOR THE FORMULATION AND ASSESSMENT OF MITIGATION MEASURES

Compliance with Federal Requirements

Implementation guidance for Section 2036(a) of Water Resources Development Act (WRDA) 07 (Mitigation for Fish and Wildlife and Wetlands Losses), issued August 31, 2009, requires that the Recommended Plan contain a specific plan to mitigate fish and wildlife losses since it has been determined that the Recommended Plan would have unavoidable impacts after benefits of the DMMP BU features are applied. Adverse impacts to ecological resources that are caused by a proposed project must be avoided or minimized to the extent practicable, and remaining unavoidable impacts compensated to the extent justified. A Mitigation Plan has been developed for the CIP Recommended Plan, which minimizes impacts as described briefly below, and provides sufficient compensatory mitigation for significant resources such that only negligible adverse impacts remain.

Central to mitigation planning is the determination of significance, as mitigation is required only for impacts to significant resources. Significance must be based upon the contribution of the resource to the Nation's economy, and technical, institutional, and/or public recognition of the value the resource. Criteria for determining significance include, but are not limited to, scarcity or uniqueness of the resource

from a national, regional, state, or local perspective. The USFWS Habitat Stewardship Program has identified three nationally recognized "scarce and vulnerable" wetland habitats in the study area: estuarine intertidal emergent, palustrine emergent, and palustrine forested wetlands. These are the same sensitive wetland habitats (saline, brackish, intermediate and fresh marsh, cypress-tupelo swamps, and bottomland hardwoods) addressed by the CIP Mitigation Plan.

These same habitats are also considered significant and vulnerable by the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), Public Law 101-646 (Title III) and the NAWMP (2004). The Texas Land and Water Resources Conservation Plan (TPWD, 2005) recognizes the Gulf coastal marshes in Tier One of high priority eco-regions, and considers these habitats to be the most threatened of the state's two high diversity eco-regions. Significant marsh habitat on the Lower Neches River and along the Texas Point shoreline has been declared "critical erosion areas" by the Texas Coastwide Erosion Response Plan. Furthermore, coastal marshes in the Louisiana portion of the study area are recognized as threatened and vulnerable by the Louisiana Coast 2050 Plan (LCWCR/WCRA, 1998), the Louisiana Coastal Areas Ecosystem Restoration Study (USACE, 2004) and the Louisiana Comprehensive Management Plan (LACPRA, 2007; USACE 2008). High population growth and associated development along the coast have fragmented wildlife habitat, changed river flows, decreased water quality, and increased sediment loads and pollutants.

The most significant trend adversely affecting the study area is the high rate of wetland loss that has occurred in recent decades (Berman, 2005; Morton, 2003; Morton et al., 2005; Shinkle and Dokka, 2004; Titus and Narayanan, 1995). In Louisiana, a net land loss of 21 percent between 1978 and 2000 has been reported in the Chenier Plain subregion of coastal Louisiana, which includes the Sabine estuary (USACE, 2004). In Texas, the most extensive losses of interior coastal wetlands in the state (12,632 acres between 1930 and 1978) have occurred in the Neches River delta. In total, over 90 percent of the emergent marshes in the Lower Neches River delta have been converted to open water (Morton and Paine, 1990; White et al., 1987), which is more than half of the total wetland loss in the State of Texas (Sutherlin, 1996).

Mitigation may include avoiding and minimizing project impacts to ecological resources, rectifying impacts by restoring the affected environment, and reducing or eliminating impacts by preservation or maintenance operations during the period of analysis. The Recommended Plan includes large DMMP BU features on the Neches River and Gulf shoreline, which replace marsh and minimize shoreline erosion that would occur as a result of the Recommended Plan. These DMMP features are described and quantified in Chapter VII. In the Mitigation Plan, replacements of ecological resources are made "in-kind" to the greatest extent possible. The WVA Model quantifies impacts to all affected habitat types in the study area and provides a means to establish the appropriate amount of compensatory mitigation by habitat type. The WVA Model and its results are described in detail in Appendix C of the FEIS.

Recommended mitigation measures are justified by an incremental analysis that is presented in detail in the FEIS; results are summarized later in this chapter. This analysis identified the best-buy mitigation plan, e.g., that plan in which the value of the last increment of losses prevented, reduced, or replaced is at

least equal to the costs of the last added increment. The incremental analysis of mitigation measures was performed with the certified version of IWR-PLAN software.

The USACE regulations (USACE, 2000b) recognize wetland resources and bottomland hardwoods for special consideration in mitigation planning; these are the primary types of ecological resources affected by the Recommended Plan. Impacts to wetlands must be fully mitigated and projects must meet the goal of "no net loss" of wetlands. Mitigation for bottomland hardwoods should be made in-kind to the extent possible. Bottomland hardwood forests should be treated as an ecological system when devising mitigation, rather than mitigating specific species that use this habitat.

The Mitigation Plan described below fulfills the special requirements for wetlands and bottomland hardwoods. These plans also contribute to several multiagency regional plans, such as the Louisiana Comprehensive Management Plan (LACPRA, 2007; USACE, 2008b), Louisiana Coast 2050 (LCWCR/WCRA, 1998), the Texas Land and Water Resources Conservation Plan (TPWD, 2005), and the NAWMP (NAWMP Plan Committee, 2004), by restoring and preserving scarce and vulnerable wetlands and wildlife habitat.

Mitigation Planning Objectives

The following objectives were established to evaluate mitigation measures considered for the SNWW CIP. The objectives were developed by the USACE in consultation with the ICT.

- Minimize salinity impacts to the SNWW affected area;
- Maximize the use of dredged material in mitigation measures;
- Meet the national goal of "no net loss" of wetlands;
- Replace lost habitat quality on a one-to-one basis as measured by AAHUs;
- Replace habitats in-kind to the extent practicable; and
- Mitigate losses in the state where they occur

These objectives reflected the most significant expected impacts of the CIP, widespread interest in potential BU of dredged material, the national policy objective to prevent wetland loss, and the USACE requirements to fully compensate for unavoidable project adverse effects. While the FEIS evaluates impacts on the SNWW coastal and estuarine system without regard to state boundaries, the mitigation plan should comply, to the greatest extent practicable, with the CZMP for each state. Under the Coastal Zone Management Act (CZMA), states with approved coastal management programs have jurisdiction within their coastal boundaries to ensure compliance with their programs. The CZMA and its implementing regulations require that Federal activities comply to the maximum extent practicable with these programs. In Louisiana, the Louisiana State and Local Coastal Resources Management Act functions as the state coastal management program for CZMA purposes. Compensatory mitigation is used to offset any net loss of wetland ecological value after efforts have been made to avoid or minimize impacts. Furthermore, the CWPPRA requires that Federal agencies ensure that maintenance or

modification of navigation projects be consistent with the purposes of the restoration plan submitted under CWPPRA. Louisiana has adopted a Coastal Wetlands Conservation Plan under this authority with a goal of no net loss of wetlands in coastal areas of Louisiana as a result of development activities. In essence, this means that the SNWW mitigation plan for unavoidable project impacts in Louisiana would propose one-to-one compensation for all AAHU losses. There is, however, a significant exception to this requirement. Federal lands are excluded from coverage under the CZMA, and this means that compensatory mitigation for impacts to Federal lands may be developed without regard to state boundaries.

Since the CZMA does not apply to Federal lands, excess Texas BU benefits could be used to compensate for impacts to Federal lands in Louisiana. The only lands affected by this exclusion are located in the Sabine NWR. While the Texas Point and McFaddin NWRs in Texas would also be affected by salinity increases associated with the project, two DMMP BU features (the Neches River and the Gulf Shore BU features) provide benefits that offset all project impacts in Texas (including impacts to both NWRs) and provide excess benefits of 656 AAHUs. The DMMP BU features fulfill Texas's CZMP requirements to avoid and minimize impacts to the coastal zone, such that no compensatory mitigation for Texas state resources is needed.

Total SNWW project impacts to the Sabine NWR are –340 AAHUs. When these are removed from the total project impacts in Louisiana (–1,499 AAHUs), the mitigation target proposed for compliance with Louisiana's CZMP is –1,159 AAHUs. Table VIII-2 illustrates this calculation. Since all mitigation measures for the SNWW would be located in Louisiana, the new mitigation target would compensate for total project losses of –843 AAHUs by providing 1,159 AAHUs of compensatory mitigation.

Table VIII-2
FWP Compensatory Mitigation Target for Louisiana

Units (AAHUs)	Texas	Louisiana	Project
Net FWP Benefits/Impacts			
Total Impacts (negative)	–412	–1,709	–2,121
Total BU Benefits (positive)	1,068	210	1,278
Net FWP Benefits (positive) or Impacts (negative)	656	–1,499	–843
Excess Texas Benefits Applied to Federal Lands			
Excess Texas Benefits	656		
Sabine National Wildlife Refuge Impacts	–340		
Net Excess Texas Benefits	316		
Compensatory Mitigation Target			
Net Impacts by State and Project		–1,499	–843
Federal Impacts Compensated with Texas Excess Benefits		340	
FWP Compensatory Mitigation Target		–1,159	–843

Models Used to Evaluate Environmental Effects and Mitigation Measures

Since the primary environmental concerns are the interrelated issues of saltwater intrusion, marsh loss, and destruction of wildlife habitat and fishery nursery areas, an engineering model was used to evaluate salinity changes and an ecological model was used to evaluate the ecological effects of the CIP. Both models played an integral role in the development of FWOP and FWP conditions and were used to compare the effectiveness of mitigation measures. The HS model used for this study is an established, three-dimensional (3-D) estuarine model adapted by the ERDC and applied to numerous deep-draft CIPs around the country over the last decade (Brown and Stokes, 2009). The WVA Model is a suite of ecological, habitat-based, community models known primarily from its use by a multiagency team of Federal and State agencies in Louisiana to evaluate proposals for coastal restoration projects (LDNR, 1993; USFWS, 2002b, 2002c, 2002d, 2002e). It has also been used for other USACE projects in Louisiana and on the upper Texas coast.

HS Modeling

Concerns that a deeper navigation channel would increase salinity in the Sabine Lake estuarine system were addressed with a 3-D HS model that predicts changes in salinity, circulation, and water elevation due to proposed channel improvements. The ERDC's CHL worked closely with the MW to calibrate and verify the base model for use in this system. Most of the agencies on the ICT were represented in the MW and several (TPWD, TWDB, and ERDC-CHL) provided individuals with experience and expertise in HS modeling. The MW reviewed the ERDC's model calibration and verification process, provided data and information on hydrologic connectivity, marsh elevation, and bathymetry, and reviewed modeling results as part of the impacts evaluation. Baseline conditions of the channel geometry included actual depths, not authorized depths, to ensure that environmental impacts associated with changes in salinity from the existing condition versus the proposed 48-foot deep channel were captured.

The ERDC-CHL applied an established 3-D estuarine model (the ERDC-modified TABS Multi-Dimensional Numerical Modeling System) to compute hydrodynamics and salinity transport for the proposed CIP. The model includes forcing due to tides, freshwater inflows, wind, Coriolis, and density gradients due to salinity variation, and accounts for precipitation and evaporation. The code uses a finite–element formulation, which gives it great flexibility in matching complex geometry. Over the last decade, the code has been extensively used for a variety of the USACE field projects, including the Houston-Galveston Navigation Channels project; New York Harbor; St. Johns River, Florida; and Atchafalaya Bay in Louisiana. Two of the special features of the code, wetting/drying and "marsh porosity," enable successful modeling of wetlands. A description of the model and its output is provided in a draft report by the ERDC-CHL (Brown and Stokes, 2009). A detailed description of assumptions and methods underlying use of HS model output in the ecological model is provided in Appendix C of the FEIS.

The estuarine model covers the entire study area from the Salt Bayou watershed on the west to near Gum Cove Ridge in Louisiana on the east, and inland to north of IH 10. Effects were predicted by comparing the model's simulation of existing conditions and FWOP with RSLR conditions to those resulting from a

48-foot channel. The design flows were based on inflows provided by the TWDB, utilizing future demand and supply strategies from the 2007 Texas State Water Plan (TWDB, 2006). Modeling indicated that RSLR would likely increase FWOP salinities up to 2.0 ppt in portions of the project area. FWP salinities would not increase on the upper Neches and Sabine rivers but an increase of about 1.8 ppt on the Neches River near Bessie Heights, 1.4 ppt near Keith Lake Fish Pass, and about 1.4 to 1.6 ppt on the eastern shore of Sabine Lake would be likely.

Ecological Modeling

Habitat-based ecological models were used to determine the impacts and benefits of proposed navigation channel improvements, BU features, and mitigation measures. The WVA Model employs a community approach that assumes that optimal conditions for all fish and wildlife within a specific type of coastal wetland habitat can be characterized by a group of significant variables, and that existing or future conditions can be compared to that optimum, providing an index of habitat quality similar to those developed under the well-established Habitat Evaluation Procedure (HEP). Variables utilized in the WVA Model were selected from existing, widely accepted HEP models of resident fish and wildlife species (USFWS, 1980). Appendix C of the FEIS maps and characterizes all significant habitats in the study area, explains how the WVA Model evaluates project impacts and benefits, describes the methods and assumptions used in the modeling process, assesses impacts of the Recommended Plan, and evaluates the effectiveness of DMMP BU and mitigation measures in AAHUs.

The WVA Model was chosen as the most appropriate ecological model for the SNWW project based on a number of factors. It is a quantitative, habitat-based assessment methodology developed to prioritize Louisiana coastal restoration projects submitted for funding under the CWPPRA. The WVA model applies specifically to habitat types present along the Louisiana coast, and these same types of coastal habitat (Chenier Plain, emergent coastal marsh, bottomland hardwoods, and cypress-tupelo swamp) are present throughout the Sabine-Neches coastal watershed in both Texas and Louisiana, and in fact are a continuation of the same system (Daigle et al., 2006; Griffith et al., 2004). In addition, the areas contain the same fish and wildlife communities and similar soils and topography, and the Sabine-Calcasieu basins share an interconnected hydrology. Furthermore, the types of variables measured by the WVA Model are sensitive to the types of changes that have been identified as the highest concerns by resource agencies and the general public for the SNWW project. Specifically, these are potential changes in salinity, stress and death of marsh vegetation, and further loss or degradation of already stressed coastal marshes. The variables measured by the WVA Model are recognized scientifically and technically as important in characterizing overall habitat quality. The WVA Model has community-specific models (e.g., saline marsh or cypress-tupelo swamp) each with a unique set of variables. It combines the effects of changes in habitat productivity (quality) and changes in wetland acreage (quantity) into one AAHU value. Habitat productivity is measured by changes to both terrestrial and shallow-water habitat that affect its usefulness to fish and wildlife. Variables included in the models were selected based on their importance as fish and wildlife habitat and for their sensitivity to the types of changes that have been identified as the highest concerns for this study (e.g., salinity, stress, and death of marsh vegetation, further loss or degradation of already stressed coastal marshes).

The WVA Model has been assessed for use in conjunction with the SNWW project, as required by EC 1105-2-407. The WVA Model is not a USACE corporate model, and therefore certification is not required, but the model must be approved for use. This approval was provided by the Deep-Draft Center for Expertise based upon the results of a model assessment (Louis Berger Group and Toxicological and Environmental Associates [LBG/TEA], 2008). The assessment evaluated the application of all of the model components used to quantify impacts and benefits of SNWW CIP alternatives, including BU features and compensatory mitigation. The assessment determined that the model was theoretically appropriate and correctly applied, and it has been approved for use for the SNWW study by the Deep-Draft Navigation Center of Expertise (see FEIS Appendix C, Attachment 1).

Consideration of Environmental Mitigation Costs During Plan Formulation

During the preliminary plan formulation screening for the CIP project as a whole, ecological benefits and mitigation costs were not calculated for the nonstructural and 120-plus variations of structural plans for channel improvements. However, all plans, including the No-Action Alternative, were informally reviewed for potential effects to the environment in a nonquantitative manner, and this information was evaluated along with cost data in determining which plans would advance into detailed evaluation.

During detailed evaluation of screened CIP alternatives, the identification of the Recommended Plan was based upon technical, economic, and environmental factors. Costs were estimated for all of the alternatives and used to determine the benefit to cost ratio in the economic analysis. Included in the costs were dredging, levee construction, relocations (including utility relocations), and O&M costs for the 50-year period of analysis. Ecological mitigation costs for the six depth alternatives were estimated using HS model salinity projections for the 40-, 45- and 48-foot channel depths. Salinity was chosen as the best factor on which to base interpolations of mitigation costs because it is the primary driver in the ecological modeling that was used to determine the compensatory mitigation plan. The cost interpolation assumed that there would be a linear relationship between predicted salinities for each channel depth at the end of the period of analysis and the cost of mitigation.

VIII.D SELECTION OF THE BEST BUY MITIGATION PLAN

A detailed description of the preliminary and final screening of potential mitigation measures is provided in the FEIS. A large number of potential mitigation measures was evaluated; measures were generally of two types: measures to reduce or avoid salinity intrusion and measures to restore or protect habitat. The purchase of credits from mitigation banks established by others was considered as an option in providing compensatory mitigation for the Recommended Plan. Only two existing mitigation banks were identified in the lower Sabine and Neches watersheds. Neither was available for use as the credits from one were sold out and the other was developed for the exclusive use of a State agency.

The recommended mitigation plan was selected using the tools of cost-effectiveness analysis and incremental cost analysis (CE/ICA) and the certified version of IWR-PLAN. The result of the incremental analysis is shown on Figure VIII-1 and Table VIII-3. Ten best buy plans were identified, with incremental

costs ranging from $2,716 to $19,935 per AAHU. A detailed explanation of this table is provided in the FEIS, Chapter 5.

Figure VIII-1. Results of the CE/ICA Analysis

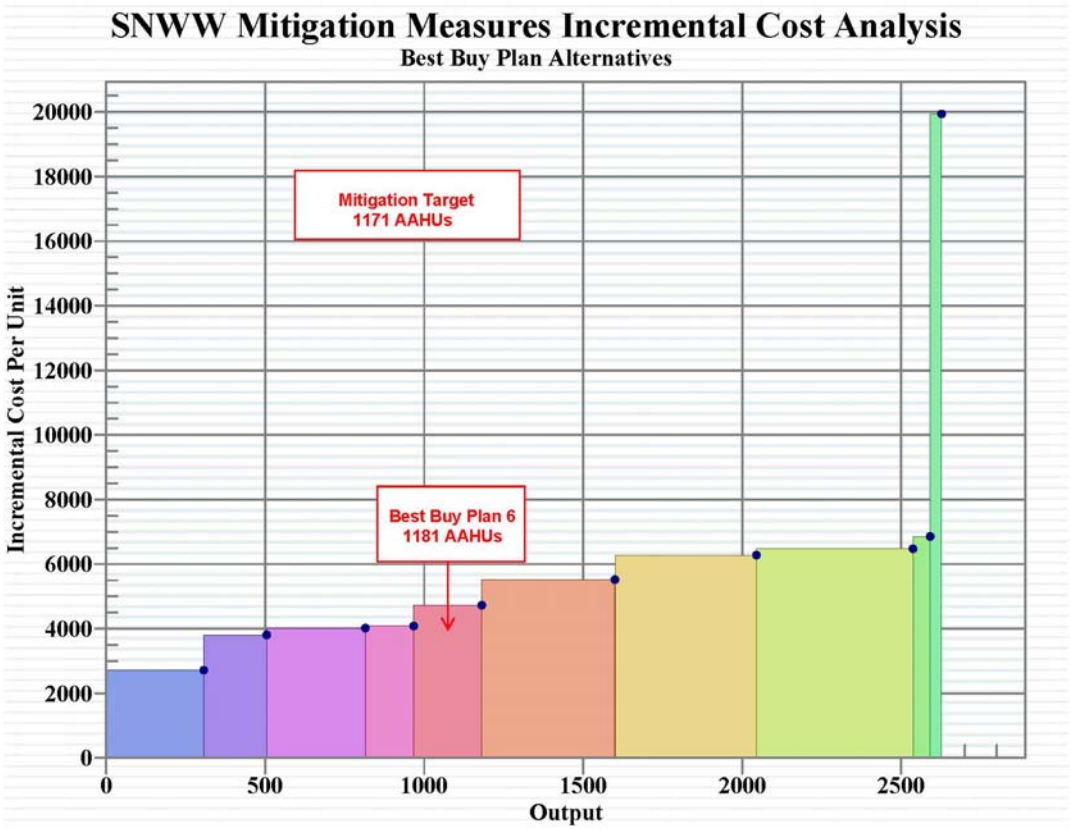


Table VIII-3
Best Buy Plans Identified by Incremental Cost Analysis (October 2005 Price Levels)

Counter	Plan Alternative	Output (AAHU)	Cost ($1.00)	Average Cost	Incremental Cost	Inc. Output ($1.00)	Inc. Cost Per AAHU
				($1.00 / AAHU)			
1	No Action Plan	0.00	0.00				
2	A0B0C0D0E0F0G0H0I0J0K1L0M0	307.00	833,787.00	2,715.9186	833,787.0000	307.0000	2,715.9186
3	A0B0C0D0E0F0G0H1I0J0K1L0M0	505.00	1,587,504.00	3,143.5723	753,717.0000	198.0000	3,806.6515
4	A0B0C0D0E0F0G0H1I0J0K2L0M0	815.00	2,833,144.00	3,476.2503	1,245,640.0000	310.0000	4,018.1935
5	A0B0C0D1E0F0G0H1I0J0K2L0M0	967.00	3,454,021.00	3,571.8935	620,877.0000	152.0000	4,084.7171
6	**A0B0C0D2E0F0G0H1I0J0K2L0M0**	**1,181.00**	**4,465,620.00**	**3,781.2193**	**1,011,599.0000**	**214.0000**	**4,727.0981**
7	A0B0C0D3E0F0G0H1I0J0K2L0M0	1,600.00	6,778,538.00	4,236.5863	2,312,918.0000	419.0000	5,520.0907
8	A0B0C1D3E0F0G0H1I0J0K2L0M0	2,045.00	9,573,089.00	4,681.2171	2,794,551.0000	445.0000	6,279.8899
9	A0B0C2D3E0F0G0H1I0J0K2L0M0	2,537.00	12,759,111.00	5,029.2121	3,186,022.0000	492.0000	6,475.6545
10	A0B0C2D3E0F0G0H1I0J0K2L0M2	2,591.00	13,129,173.00	5,067.2223	370,062.0000	54.0000	6,853.0000
11	A0B0C2D3E0F0G0H1I0J0K2L0M3	2,627.00	13,846,826.00	5,270.9654	717,653.0000	36.0000	19,934.8056

Best Buy Plan 6 (Solutions D_2, H_1, and K_2 – shown in bold in Table VIII-4) appears to be an efficient mitigation plan since it reaches the mitigation target of 1,159 AAHUs by providing a total of 1,181 AAHUs. Best Buy Plan 6 consists of emergent marsh restoration in two Willow Bayou areas (totaling 687 acres) and three areas in the Black Bayou area (totaling 2,096 acres). Best Buy Plan 7 was also evaluated to determine whether its considerable additional benefits were worth the comparatively small incremental cost. Best Buy Plan 7 provides 420 additional AAHUs (719 more acres restored in Willow Bayou) by adding Solution D_3 for an additional average annual cost per unit of output of $4,237 (total average annual cost of $2,312,918). Since the estimated total first cost of this increment is $39,275,000 (screening-level cost) and Best Buy Plan 6 meets the mitigation target, Best Buy Plan 7 was deemed not worth the additional investment.

Table VIII-4
Recommended Mitigation Plan

Recommended Mitigation Plan	Mitigation AAHUs
Willow Bayou	
LA 2-18 B Marsh Restoration (Sabine Lake dredging)	152
LA 2ADD B Marsh Restoration (Sabine Lake dredging)	214
Black Bayou West	
LA 3-10R Marsh Restoration (Sabine River Channel maintenance material)	198
Black Bayou East	
LA 3-15 B Marsh Restoration (GIWW dredging)	307
LA 3-18 B Marsh Restoration (GIWW dredging)	310
Total Compensation	1,181
FWP Mitigation Target	–1,159
Net Benefits After Compensation	**22**

VIII.E RECOMMENDED ECOLOGICAL MITIGATION PLAN

The CE/ICA selected Best Buy Plan 6 as the most efficient combination of mitigation measures to compensate for the indirect impacts of the Recommended Plan. It provides 1,181 AAHUs, which is 22 AAHUs more than the mitigation target. It is important to remember that additional compensatory mitigation would be provided in Louisiana beyond the total 843 AAHUs impacts of the Recommended Plan. The mitigation plan would result in a net gain of 338 AAHUs for the project as a whole.

Unavoidable impacts of the SNWW CIP remain only in Louisiana; all CIP impacts in Texas are minimized and offset by the DMMP BU and no mitigation is required. Therefore, all of the mitigation measures in Best Buy Plan 6 would be located in Louisiana. The mitigation plan consists of restoring five degraded marsh areas east of Sabine Lake near Willow and Black bayous, Louisiana (Figure VIII-2, Table VIII-5). The reader is referred to the FEIS for a detailed description of each mitigation measure.

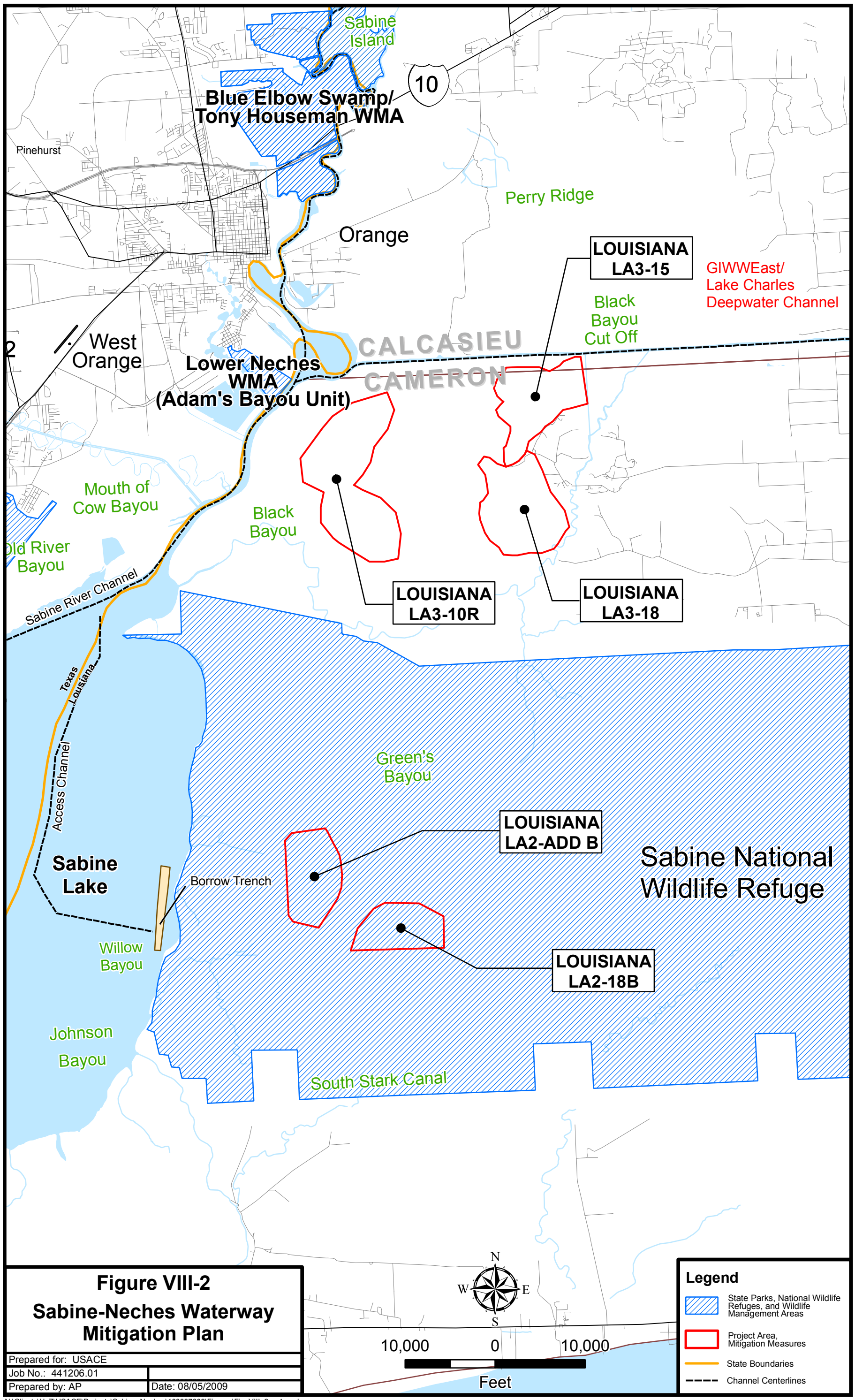


Figure VIII-2

Sabine-Neches Waterway Mitigation Plan

Prepared for: USACE	
Job No.: 441206.01	
Prepared by: AP	Date: 08/05/2009

N:\Clients\U_Z\USACE\Projects\Sabine_Neches\100007609\Figures\Fig_VIII_2_vr4.mxd

This page intentionally left blank.

Table VIII-5
Recommended Mitigation Plan – Acreage Analysis

Mitigation Measure	AAHUs	Total Influence Area (acres)	Nourished Existing Marsh (acres)	Restored Open Water (acres)	Restored Emergent Marsh (acres)
Willow Bayou					
LA 2-18B	152	681	367	63	251
LA 2-ADD B	21	1,285	745	104	436
Subtotal	173	1,966	1,112	167	687
Black Bayou West					
LA 3-10R	198	2,465	1,317	356	792
Black Bayou East					
LA 3-15B	307	1,788	878	227	683
LA 3-18B	310	1,876	1,048	207	621
Subtotal	617	3,664	1,926	434	1,304
Total Mitigation	1,181	8,095	4,355	957	2,783

The recommended Mitigation Plan compensates for the Recommended Plan's salinity increase and associated losses in marsh and productivity by marsh creation activities that would influence a total of 8,095 acres of Louisiana marshes in the Willow and Black Bayou watersheds. The plan would restore 2,783 acres of emergent marsh in existing open-water areas within the marsh, improve 957 acres of shallow-water habitat by creating shallower, smaller ponds and channels within the restored marsh, and stabilize and nourish 4,355 acres of existing marsh located in and around the marsh restoration zone.

Upon authorization of the CIP, the USACE would use its Navigation Servitude to access the mitigation areas for the purposes of planning, construction, and postconstruction monitoring. Landowners would be advised for access to their property. All restored areas would remain jurisdictional wetlands and continue to be subject to the navigational servitude; therefore, conservation easements would not be required.

Monitoring and Contingency Plans

Monitoring and contingency plans for the mitigation measures and DMMP BU features are presented in Appendix J of the FEIS. The monitoring and contingency plans for mitigation measures and BU features have been developed in accordance with recent implementing guidance for Sections 2036 (a) and 2039, respectively, of WRDA 07. The monitoring plans identify specific ecological success criteria to be used in determining if the mitigation and DMMP BU features have been successful. Appendix J presents a description of the key monitoring parameters, periodicity, costs, and responsible parties.

Periodic monitoring to determine the success of marsh mitigation measures and DMMP BU features would continue until the Division Commander determines that the ecological success criteria of the mitigation and DMMP BU features have been met. This determination would be based upon monitoring results and the ICT consultation reports provided by the District Engineer. The ICT would be consulted annually to determine progress in the planning, construction, and postconstruction evaluation of the ecological success of these features.

VIII.F FULFILLMENT OF MITIGATION PLANNING OBJECTIVES

Adoption of the ecological mitigation plan will fulfill the second planning objective to maintain the ecological values of estuarine resources within the project area. The mitigation plan (+1,181 AAHUs) fully compensates for AAHU losses to state resources in Louisiana, and results in a net gain of 338 AAHUs for the project as a whole. Impacts to East Sabine Lake marshes are replaced in-kind by the marsh mitigation plans in Willow and Black bayous. Minor productivity impacts to cypress-tupelo swamp on the Sabine River near the GIWW are not matched in-kind. The ICT considered this to be acceptable since the loss in function is negligible. Projected FWP salinity levels are within the tolerance levels of these swamps, and the CIP causes no loss of swamp acreage.

Sediment placed in former open-water areas of the marsh would increase marsh elevations and create a higher, more-stable landform for marsh growth and long-term survival. Restored marshes would filter runoff from surrounding uplands, and improved shallow-water habitat would encourage the growth of additional submerged aquatic vegetation. The restored marshes would increase available habitat for bird and wildlife species, and the improved shallow-water habitat would provide additional nursery areas and nutrients for aquatic organisms. The Coordination Action Report (CAR) for the SNWW CIP has been prepared by the USFWS and is included in FEIS Appendix A3. The CAR affirms the USACE impact assessment and approves the proposed BU and mitigation.

VIII.G CULTURAL RESOURCES MITIGATION

No specific cultural resource impacts requiring mitigation have been identified at this time. However, the Recommended Plan has the potential to affect significant cultural resources (e.g., historic properties) since numerous prehistoric and historic sites, structures, and shipwrecks are located adjacent to the project area. Investigations to identify historic properties that may be affected by the Recommended Plan were begun during the feasibility study, but will be completed during the PED phase in compliance with a Programmatic Agreement with the Texas and Louisiana State Historic Preservation Officers. Additional terrestrial archeological surveys and testing are anticipated for DMMP BU sites and marsh mitigation areas. Nautical archeological survey and dive assessments also must be completed for some project components. Funds for potential historic properties data recovery have also been included in the estimate and allocated in compliance with Section 7 of PL 93-291. Based upon historic properties identified to date, it is assumed that the highest potential for historic property data recovery is in the Sabine Pass Channel, the site of a significant Civil War naval battle.

IX. RISK AND UNCERTAINTY ANALYSIS

IX.A OVERVIEW

This chapter outlines the approach being taken for the SNWW CIP for evaluating risks, uncertainties, and consequences inherent in evaluation of alternatives and identification of the Recommended Plan. This approach involves a two-step process: (1) application of the USACE Risk and Uncertainty Analysis procedures assessing and incorporating uncertainty in the technical evaluation process; and (2) the evaluation and selection of a Recommended Plan that takes into account a wide array of economic, environmental, technical, and societal risk factors.

IX.B GUIDANCE AND CONCEPTS

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 (Pub. L. 89-80), as amended (42 USC 1962 a-2 and d-1), require that areas of risk and uncertainty be identified and clearly described so that public investment decisions can be informed 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.

Risk-informed decision making and asset management has been emphasized as part of Goal 3 of the USACE Campaign Plan (USACE, 2009b). This policy, developed from analyses done by the Interagency Performance Evaluation Task Force in the aftermath of Hurricane Katrina (Interagency Performance Evaluation Task Force, 2007), pointed to the need for organizational changes to transform the USACE priorities, processes, and planning in an effort to improve public safety and the USACE water resources infrastructure. The 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, hydrologic, and meteorological events 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 database, the probability distribution of random future events can be described subjectively, based upon the 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 (IPCC, 2007).

The degrees of risk and uncertainty also will differ among various aspects of a project, and will vary by time. Obviously, high levels of risk associated with project elements that could adversely affect human health and safety are not acceptable; while it might be acceptable to trade lower economic costs for higher levels of risk for project elements that do not affect human health or safety. In relation to time, components that may be relatively certain at the beginning of a project may be relatively uncertain at the end of the period of analysis.

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 distributions" (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 damage reduction projects, i.e., it is known that a river will flood to a specific elevation on the average of once in 20 years. When applied to ecological modeling and impact analysis, risk should be viewed as an inevitable consequence of the uncertainties inherent in the current state of knowledge of ecological systems.
- "Uncertainty" is a measure of imprecision of knowledge of parameters and functions used to describe the hydraulic, hydrologic, 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" This concept is best understood in relation to flood damage reduction studies, i.e., residual risk is the flood risk that remains after a proposed project is implemented; or, in other words, the residual damages and potential loss of life due to exceedence of design capacity. For navigation studies, one type of residual risk might be risk that benefits are foregone in those situations where LPPs are selected over the NED Plan.

IX.C UNCERTAINTY IN TECHNICAL EVALUATIONS

Forecasting Tools and Analyses

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 behaviors. 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 SNWW CIP, the "most likely future" method was chosen due to the size, scope, and complexity of the overall analysis.

After the identification of the most likely FWOP scenario for the SNWW CIP, the next step was the evaluation of alternative depths (i.e., the 45-, 48-, and 50-foot channel depths and various widening scenarios advanced for detailed screening) using hydrodynamic, economic, and ecological models. Other variations of these alternatives (associated with placement features and mitigation measures) were also evaluated with selected models.

A suite of engineering models was employed to evaluate future without- and with-project conditions regarding the effect of proposed channel modifications on deep-draft ship maneuverability and safety (ship simulation model); estuarine hydrology, circulation, and salinity (HS model); shoaling rates (sediment model); channel bank erosion (vessel effects model); and coastal shoreline erosion (shoreline impacts model). All of the engineering models were developed by the USACE-ERDC and applied with the support of a team of the USACE and Federal and State resource agency representatives.

Planning models that were applied in this study include economic and ecological models. Economic models consist of desktop spreadsheet models and the HarborSym model. Ecological modeling was performed using the WVA model. Developed by an interagency working grouping of resource agencies in Louisiana, the WVA model was applied with the support of the ICT, comprised of representatives from the USACE, other Federal, and Texas and Louisiana state agency representatives.

While this section paints a broad picture of the application of techniques used to address risk and uncertainty, the FFR, Economic Appendix, and the FEIS and Appendix C go into greater detail on how each discipline addressed these issues.

Engineering Data and Models

Data

Hydrologic Data

Hydrologic data needed to calibrate and verify the HS model was collected by the ERDC-CHL in a 9-month field study (Fagerburg, 2003). Long-term and short-term data-collection sites were established to provide good coverage for determination of tidal velocity magnitudes and directions, ranges of water level elevations, and changes in salinity values. In coordination with USCG, existing Aids-to-Navigation structures were used whenever possible as more-permanent platforms for the deployment of the instruments. The pressure-sensing water level recorder was fully programmable with accuracy of the sensor of ±0.01 foot. The fully programmable salinity recorders were calibrated properly at the start of monitoring. In order to assure quality data collection, the recorders were serviced regularly in 3-week intervals to download data and clean and recalibrate the instruments. Acoustic Doppler Velocity (ADV) meters had pressure sensors with an accuracy of ±0.003 foot. Two of the water level recorders were destroyed and were not replaced due to the project economic constraints and lack of vital necessity of those data. Also, any of the field data that were obviously corrupted by bio-fouling of the salinity sensors were omitted in the hydrodynamic and other analyses.

It is believed that the selected gage sites provided an adequate coverage of the study area, and the programmable data recorders had a high degree of accuracy and minimal degree of human error involved. Further, more-conservative analyses were employed in the HS model and other models to provide more-reliable results. Thus, the degree of uncertainty in the collection and use of data is diminished appreciably. As such, considering project economics, it was deemed impractical to gather additional data for a logical, risk-based analysis since it would not essentially enhance the accuracy of the results.

New Work and Maintenance Material Data

New work material quantities were calculated using a digital terrain model generated by the InRoads software program. Each channel or canal had its own existing template and proposed template. A model was developed and volumes were calculated. The existing template included the current allowable overdepth and advance maintenance values. The proposed new template also included a standard advance maintenance depth of 2 feet and constant 2 feet of allowable overdepth per reach. Any potential uncertainties in these calculations are addressed by incorporation of the maximum amount of allowable overdepth and advance maintenance, and by the contingencies identified in the cost risk analysis discussed later in this section.

Maintenance material estimates for the proposed project were predicted by a desktop sediment model that incorporates information from historical dredging rates, the HS model (Brown and Stokes, 2009), and a subjective evaluation of contributive shoaling factors (Parchure et al., 2005; Brown and Stokes, 2009). An extensive amount of field data for the bed and suspended sediment, salinity, and velocities was collected and analyzed by the ERDC laboratory. An increase in shoaling quantities resulting from channel

deepening and widening is attributed to many different factors including increased bottom width, decreased flow velocity due to enlarged section, modified salinity regime from greater salt penetration, and other general factors such as increased erosion from higher vessel traffic, channel bank failure, and sediment brought down by rivers. The effect of RSLR was investigated by the ERDC, and it was found to have no significant effect on projected maintenance dredging quantities.

Because of the uncertainty involved in the assumptions and calculations of water levels, velocity data, and salinity data by the HS model, the calculated shoaling quantities for the project condition is subject to a certain degree of uncertainty. It is believed that the dredging data record is good reliable data and would not be essentially improved by more data. Moreover, the prediction of shoaling rates is influenced by assumed values of shoaling factors, which are subjectively selected as stated above. Hence, the future shoaling rates as calculated are not amenable to risk-based analysis. Further, a more-accurate shoaling analysis would require detailed numerical sediment modeling, which would entail a significant amount of additional data and analysis. Because of inherent assumptions involved in an analytical full-fledged sediment modeling procedure, albeit a significant amount of extra data, increased accuracy of results would still be questionable. Thus, no further additional work is recommended.

Models

For lack of extensive measurable data and reliable analytical methodologies, the 'Plans' and 'Conclusions' as developed by various modeling studies by the ERDC are subject to uncertainties. Moreover, some future economic, hydrologic, and meteorological factors are essentially unpredictable. Thus, no logical probability-based analysis can be developed. However, sensitivity or a subjective analysis can be performed describing the limiting values of various factors considered.

In general, the study analyzed the 50-foot depth alternative in addition to the recommended depth of 48 feet for the enlarged future channel, and there were minimal adverse effects for the with-project condition in terms of salinity, tidal current velocities, shoreline wave heights, sediment transport, potential bank-recession/erosion, and navigational safety. Thus, the uncertainty in assumed values or the reliability of analytical procedures is essentially covered by the conservative assumptions in the study.

Ship Simulation Model

Ship simulation modeling reproduced real-time vessel responses to various interacting forces including water currents, wind force, bank forces, tug and bow thruster forces, and ship-to-ship interaction (Webb, 2003). The visual database provided a feeling of realism for the site and its development included the ship being simulated and other vessels, shoreline, and other landmarks. The environmental database involved channel and bathymetric surveys, currents for the existing and proposed conditions, waves, and wind velocities. For the simulation validation, experienced pilots were used in real-time runs, and then various plans for existing and proposed conditions were tested. Final results for the optimized channel were based on comparison of simulation runs for existing and proposed conditions and analyses of vessel tracks, navigation parameter plots, and pilot evaluations.

Although there is a degree of uncertainty involved in the accuracy of visual and environmental data, the real-time simulation by ship pilots essentially validated the optimal channel widths required for safe navigation. So, the real-time runs are guided by the personal experience and knowledge of the pilots, and their testing is quite subjective. As such, the risk-based analysis is somewhat inappropriate for ship simulation.

HS Model

A 3-D numerical modeling study of circulation and salinity impacts resulting from proposed channel deepening was conducted (Brown and Stokes, 2009). The model was also validated for hydrodynamics and salinity using field data, evaluation of proposed plan conditions, and comparison and analysis of results.

The potential for the channel deepening to increase the effects of hurricane storm surges on water elevations and flooding was simulated using the HS model. The tidal signal was generated using tide gage records from Sabine Pass during Tropical Storm Frances (September 11, 1998). This storm was selected for the simulation because it produced very high tides for an extended period of time, and caused very significant damage to the upper Texas coast in the form of beach erosion and inland flooding. The tides rose above 4 feet above mean low lower water and reached maximum levels between about 5.5 and 7 feet for 36 to 48 consecutive hours. Maximum storm surge differences occurred at or near the peak storm surge, and varied between 0 and +0.4 foot. The modeling indicated that the largest effects would occur in the upper reaches of the Neches River near Beaumont. This result must be interpreted as exceedingly conservative. The predicted increase is calculated as if no flows were allowed to leave the channel and is therefore much higher than would occur under natural conditions when storm surge flows spread over the wide, flat coastal plain.

This model was previously run for the 50-foot channel depth, which marked the worst-case scenario for possible adverse impacts. Comparing the results of 48-foot (recommended) plan and the 50-foot plan, the difference in salinity impacts at various places remained within the range of standard deviation. Thus, the analysis essentially provided conservative results for the recommended 48-foot depth plan.

Storm Surge Model

A sensitivity analysis using the ADCIRC model was also performed to determine what effect the proposed SNWW CIP might have on surge levels in the study area (Wamsley et al., 2010). The ADCIRC model was run to estimate water levels for two worst-case hypothetical storms, both with and without proposed SNWW CIP project features in place. Project features evaluated by the modeling are the deeper navigation channel, proposed PAs with maximum levee heights, and 2 expanded PAs. The two simulated storms exhibited minimum central pressures of 900 millibars, offshore pressure radii between 14.9 and 18.4 nautical miles, and forward speeds of 11 knots. Each produced water levels near or higher than the estimated 500-year level, and both would be considered extreme events. One storm tracked in the northwesterly direction, producing maximum surges of 18 feet near the coast at Sabine Pass and surges of 13–14 feet in Sabine Lake near Port Arthur, Texas. The second storm tracked in a north-northeasterly

direction, producing maximum surges of over 20 feet near Sabine Pass and surges of 15 to 17 feet in Sabine Lake near Port Arthur.

The sensitivity analysis concluded that the greatest changes would occur north of Port Arthur along the Neches River. These changes are primarily due to the proposed increase in depth of the navigation channel. All changes are local, and there are no project-induced increases in surges away from the immediate vicinity of the navigation channel. Water levels in the marshes and open-water areas immediately north of the river would increase on the order of 4 to 8 inches or less. The modeling indicates some interior flooding would occur within the City of Port Arthur with both storms, both with and without the project. Changes in peak surge within the city for these two events, with the project in place, are caused by a slight increase in surge elevation and/or duration causing additional overtopping of the surrounding levee or internal topographic features. Peak surges for 100-year events are estimated to be approximately 9 feet in the Port Arthur area. Although simulations of less-intense events were not made as part of this study, in light of the 14- to 24-foot levees surrounding Port Arthur, significant interior flooding is not expected for the Base condition. Any changes in peak surge on the order of inches should not cause any significant change in interior flooding for the with-project condition.

The Recommended Plan for the SNWW CIP also includes ODMDSs and marsh restoration measures. All of the existing and proposed ODMDSs are located several miles from the Gulf shoreline in water too deep to affect wave setup on the shoreline. The influences of marsh restoration on hurricane surge have been documented by Wamsley et al. (2009a, 2009b). Surges tend to slightly increase over and just seaward of the marsh as the surge propagation is slowed, which may result in reductions in peak water levels landward of marsh features. The impact of the proposed SNWW CIP marsh restoration features are relatively small and expected to modify peak surge levels locally by a minimal amount (Wamsley et al., 2010). No significant reductions or increases in surge level would be expected from either the marsh restoration or the ODMDSs.

Sediment Model

The needed data for computed water levels, tidal velocities, and salinity values at various nodes was provided by the HS model for the Base and Plan conditions (Parchure et al., 2005). This report deals with two problems—the first is the effect of channel modifications on the future shoaling quantities, and the second is the impact of the channel modifications on the Pleasure Island shoreline erosion. As a first step, sediment modeling requires results from a satisfactorily validated hydrodynamic model. Since fine sediment dynamics is significantly influenced by salinity, a 3-D model including salinity simulation was used to provide results for this model. For some studies, a full-fledged numerical sediment model can be used to provide increased accuracy for sediment analysis. However, huge amount of additional data needed for a project extending over several miles would become very expensive and time consuming. Hence, a desktop modeling study was used as a good alternative to detailed sediment modeling. Because estimation of future shoaling involves an unavoidable subjective element and further, the detailed sediment modeling procedure has some inherent assumptions and limitations, the desktop study was considered adequate. Moreover, the computed changes in flow velocities, salinities, and erosion rates

between base and plan conditions are quite low in relation to their effects on shoaling and erosion. As such, no additional effort is needed, and no logical risk-based analysis is warranted.

Vessel Effects Study Model

This study was used to estimate erosion potential resulting from increased ship waves for the plan condition for the enlarged channel (Maynord, 2005). The analysis employed a numerical model (HIVEL2D) to simulate the ship-induced velocity at the bank, using information on vessels in the existing and future fleets and on vessel speeds under both the FWOP and FWP conditions. Overall, the effect of the Recommended Plan would be to reduce the rate of erosion on inland channels relative to the FWOP condition because of the larger channel and the fewer vessel trips that are predicted with the Recommended Plan. There is some uncertainty involved in the forecasting estimate of the future vessel fleet and the accuracy of predicted erosion rates. However, the modeling used the largest vessel that can efficiently use the waterway, and assumed that all erosion effects were due to vessel wakes. Therefore, the model provides a conservatively high estimate of ship effects on erosion, and further risk analysis would not add practical value.

Shoreline Impacts Model

Potential wave-induced impacts of the proposed deepening of the SNWW on the open coastal shorelines adjacent to the project area were modeled by the ERDC using the STWAVE and GENESIS models (Gravens and King, 2003). These models evaluate potential impacts due to changes in wave refraction patterns, and are well-known, widely used models that represent state of the practice in forecast modeling.

The STWAVE and GENESIS are deterministic models. As presently applied, results were not placed in a risk-based context and to do so would require a significant effort. However, such additional work is not warranted, would not add practical value, and would not be expected to change the specific STWAVE/GENESIS study conclusions. The models calculated insignificant changes in the waves and longshore sediment transport rates within the study area. It is important to note that the STWAVE/ GENESIS analysis was extremely conservative in nature, and as performed the analysis overestimates any wave-induced impacts to the shoreline as a result of the channel deepening. The results are conservative since the wave dissipation due to the presence of mud and the sheltering effect of the jetties was purposely not included. Thus, the analysis as performed, without inclusion of jetties, maximized wave refraction and shoaling influence of the proposed channel deepening. Applying a risk-based type of analysis would only yield order of magnitude variability within these extremely conservative minor results, which would add no additional practical value and could not be expected to change the specific STWAVE/GENESIS study conclusions.

Other Analyses

Relative Sea Level Rise

In fulfillment of requirements of Circular No. 1165-2-211, Water Resources Policies and Authorities Incorporating Sea-level Change Considerations in Civil Works Programs (USACE, 2009a), the sensitivity of project alternatives to the full range of potential FWOP changes in sea level has been evaluated. There are a wide range of potential effects related to the full range of RSLR, but the sensitivity of project alternatives would be more limited. In particular, alternatives were evaluated to determine if the purpose and function of navigation features could be undermined, if environmental impacts might be exacerbated, and how economic benefits and costs might be affected by sea level change. Nonstructural alternatives were evaluated but eliminated in the second screening; they are therefore not addressed in this analysis.

RSLR rates that may be appropriate for the project area are discussed in detail in Section 3.3 of FEIS, Appendix C to the FEIS. 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 average rate of RSLR measured at the Sabine Pass tide gage was 0.2 inch/year for the 48-year period between 1958 and 2006 (U.S. Department of Commerce and National Oceanic and Atmospheric Administration, 2006, 2009). However, there is significant scientific debate concerning the validity of tidal records with respect to the projection of future subsidence rates in the northwest Gulf coastal plain. 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 in these activities may result in rapid deceleration of subsidence rates, returning them to long-term average rates best represented by the basal peat data. Deriving RSLR estimates using both basal peat and tide gage data, possible RSLR rates were estimated for the period from 2019 to 2069 to range from 0.3 to 2.8 feet. Possible low, intermediate, and high rates are as follows:

- 0.3 foot, Low (1.83 mm/year), based on basal peat subsidence rates
- 0.7 foot, Intermediate (4.27 mm/year), based on basal peat subsidence rates
- 1.1 feet, Intermediate (6.71 mm/year), based on tide gage subsidence rates. (This value was used in the HS modeling of the estuary for this project.)
- 1.5 feet, Intermediate (9.14 mm/year), based on tide gage subsidence rates
- 2.2 feet, High (13.44 mm/year), based on basal peat subsidence rates
- 2.8 feet, High (17.07 mm/year), based on tide gage subsidence rates

An intermediate rate of RSLR (1.1 feet by year 2069) was used as the “most likely” estimate of RSLR in the alternative analysis for this project, in accordance with the USACE planning guidance. The following discussion describes possible ways that high and low RSLR might affect the project alternatives and the recommended action. There are relatively little data and analyses currently available that would permit a detailed, quantitative, analysis of the impacts of each of the possible RSLR scenarios on the project

alternatives. Ways in which different RSLR rates might affect project design and impacts are presented in Table IX-1.

In general, the functioning of the navigation features associated with all alternatives (channel depths of 45 through 50 feet, TB/AB, PAs/ODMDSs, and the BU features) would not be significantly affected by the full range of potential sea level change. Construction dredging would occur within 10 years and would not be affected by future rates of RSLR. While shoaling rates toward the end of the period of analysis could increase due to an enlarged cross section and greater saltwater penetration, this small effect would probably be offset by increased overall water depths. PAs and BU features have been designed to accommodate sea level changes through the high RSLR range. PAs are located at sufficiently high elevations to withstand the potential rise, and appropriate erosion control measures are included. BU features are located well inland on the Neches River, and they have been designed with erosion control features that would survive the full range of RSLR. The addition of mineral soils and higher marsh elevations would provide stable landforms. Biomass accumulation and sediment from adjacent terrace margins should enable restored marsh vegetation to maintain itself even with the high RSLR rate.

The protection of human health and improvements in safety are not project objectives and therefore potential effects on calculated risk are not applicable. RSLR does not affect the functioning of the various depth alternatives or vessel safety. At the intermediate and high rates of RSLR, a significant increase in tidal surge penetration would be expected, but this would not affect project alternatives because tidal surge protection is not a project objective. Furthermore, HS modeling has determined that little or no increase in water surface elevation would be expected due to the deeper navigation channel.

The primary impact of RSLR on this project may be its potential impact on mitigation measures proposed for the Louisiana marshes along the east side of Sabine Lake. These mitigation measures are planned for marshes that could experience submergence and erosion at the high RSLR rate. In recent decades, marshes in the study area have been able to keep up with rates of 5.6 to 6.5 mm/year, suggesting that these marshes may be able to sustain themselves through rises in the intermediate range of RSLR (4.3 to 9.1 mm/year). The high rate of RSLR (17.1 mm/year) could threaten long-term survivability. Sustainability thresholds are determined by local physical, chemical, climatologic, and hydrologic conditions and cannot be extrapolated to other regions. However, as an example, studies in the mid-Atlantic region indicate that the tipping point for coastal ecosystems could range from a RSLR of as low as 2.0 mm/year to as high as 10 mm/year (U.S. Climate Change Science Program, 2009). There are relatively little data and analyses currently available that would permit a detailed, quantitative analysis of the impacts of the full range of potential RSLR on the SNWW ecosystem and project alternatives.

A monitoring and contingency/adaptive management plan has been developed to identify corrective actions (FEIS Appendix J). Corrective actions proposed in the contingency plan assume that the low to intermediate rates of RSLR will occur; the high rate is assumed to be unlikely. If monitoring determines that the extent of vegetation coverage does not meet ecological success criteria specified in the monitoring plan, manual planting would be employed to restore the requisite acres of emergent marsh. The ICT would determine if marsh planting is needed and if so, to what extent and in which areas.

Table IX-1
RSLR Sensitivity of Project Alternatives

Sensitivity of Design				Sensitivity of Impacts		
Navigation Channel Alternatives A–G	DMMP (PAs/ODMDSs)	DMMP (BU Features)	Mitigation Measures	Human Health/Safety	Environmental Impacts	Economic Costs/Benefits
Low Rate (0.3 foot over 50 years)						
No significant effect for any depth alternative. Low range of future RSLR is lower than recent historical rate.	No change to existing shoaling rate and maintenance dredging expected. All PAs designed for intermediate RSLR rate.	All BU features were designed to accommodate intermediate RSLR; low rate would have no effect.	All mitigation measures were designed to accommodate intermediate RSLR; low rate would have no effect.	RSLR does not affect the functioning of the various depth alternatives or vessel safety. Small increase in tidal surge penetration due to low RSLR rate would be expected; tidal surge protection is not a project objective. No increase in tidal surge impacts due to project.	Primary project impact is result of greater salinity intrusion. Salinity difference for low RSLR is within one standard deviation of the salinity difference between FWOP and FWP.	Benefits and costs of the deepened navigation channel would be the same as FWP forecast.
Intermediate Rate (0.7 to 1.5 feet over 50 years)						
No significant effect for any depth alternative. Rising water depth offset by increased shoaling. Potential impacts to Sabine Pass jetties addressed by separate O&M major rehabilitation project.	No significant increase in maintenance dredging for depths greater than 48 feet. Possible rise of water surface elevation is within range used for engineering design of all PAs. No effect to ODMDSs.	Possible RSLR rise is within range used for engineering design of all BU features.	Possible RSLR rise is within range used for engineering design of all mitigation measures.	RSLR does not affect the functioning of the various depth alternatives or vessel safety. Intermediate increase in tidal surge penetration due to RSLR rate; tidal surge protection is not a project objective. No increase in tidal surge impacts due to project.	Salinity impacts were based upon RSLR of 1.1 feet. Salinity difference for range of intermediate RSLR rates is within one standard deviation of the salinity difference between FWOP and FWP.	Benefits and costs of the deepened navigation channel for the full intermediate range would be the same as FWP forecast.

Table IX-1 (Cont'd)

Sensitivity of Design				Sensitivity of Impacts		
Navigation Channel Alternatives A–G	DMMP (PAs/ODMDSs)	DMMP (BU Features)	Mitigation Measures	Human Health/Safety	Environmental Impacts	Economic Costs/Benefits
High Rate (2.8 feet over 50 years)						
No significant effect for any depth alternative. Possible small increase in maintenance dredging for all depth alternatives resulting from enlarged cross section and greater saltwater penetration. Potential impacts to Sabine Pass jetties addressed by separate O&M major rehabilitation project.	Small increase in levee heights and/or armoring may be needed for some PAs. No significant effect to ODMDSs.	Addition of mineral soils and higher marsh elevations provides more-stable landforms. Biomass accumulation may enable restored marsh vegetation to remain stable relative to high RSLR rate. Erosion control features would survive the full range of RSLR.	Addition of mineral soils and higher marsh elevations provides more-stable landforms. High rate of RSLR could result in submergence and erosion of restored marsh. Monitoring and adaptive management plan recommended to guide decisions on changes that might be needed toward the end of the period of analysis.	RSLR does not affect the functioning of the various depth alternatives or vessel safety. High rate of RSLR would increase tidal surge penetration; tidal surge protection is not a project objective. No increase in tidal surge impacts due to project.	Potential salinity increase with high range of RSLR is still within one standard deviation of the salinity difference between FWOP and FWP. No significant increase in salinity impacts would be expected.	Benefits of the deepened navigation channel would be the same as FWP forecast. No facilities used by shipping industry would be rendered ineffective by the high range of RSLR. O&M costs could increase slightly toward the end of the period of analysis, but not enough to reduce BCR below parity.

Relocation of the mitigation areas to areas that would be protected from the potential effects of the full range of RSLR is not feasible. All intertidal marshes in the study area would be similarly affected by the sea level change because of the extremely low slope of the coastal plain. The option of purchasing credits in a mitigation bank was investigated; however, no mitigation banks exist for this area and resource type.

For the Coastal Shoreline Impacts Study (Gravens and King, 2003), the primary conclusion was that the proposed deepening project would have minimal impacts on adjacent shorelines. Actually, the project would result in a small beneficial reduction in erosion near the jetties. The changes resulting from the 2-foot increase in depth for the wave heights and wave angles would be minimal.

For the Sediment Study (Parchure et al., 2005), comparing the results of 2 feet increased depth, the overall changes in bottom velocities and bottom salinities would be insignificant. The estimated annual shoaling quantities would increase about 6 percent, but that is considered to be within uncertainty of assumptions of this estimate.

For the Vessel Effects study for Bank Recession (Maynord, 2005), based on the historical vessel traffic, vessel fleet (ship sizes and frequency of passage) was developed for the future years 2030 and 2060 for the existing and proposed waterway. The conclusion of this study was that for both sites in the Sabine-Neches Canal and Port Arthur Canal, bank recession for the FWP condition would be less than the FWOP condition because of fewer vessel trips. Impact on bank recession resulting from increased depth as a result of sea level rise is estimated to be minimal.

For the Ship Simulation Study (Webb, 2003), simulation by ship pilots essentially validates the optimal channel widths required for various reaches for safe navigation of vessels for the existing and proposed channels. So, navigable vessels are predicted to experience insignificant impacts of higher water elevation resulting from about 1.56-foot rise in sea level.

Stability Analyses (Bridges and Port Arthur Hurricane Protection Levee)

Limited stability evaluations were undertaken to identify potential impacts of the new channel to the HFP system, MLK Bridge, Rainbow Bridge, and Veterans Memorial Bridge and recommendations were made to accommodate a deeper channel while preserving the integrity of the above structures.

The evaluation of the HFP system, involved (1) reviewing original design documents and inspection reports of the adjacent levee system; (2) performing site reconnaissance; (3) reviewing subsurface data and soil strength parameters; (4) reviewing prior slope stability analyses methods and results; (5) evaluating cross section surveys at suspect areas; (6) performing additional slope stability analyses (using the Simplified Bishop and Simplified Janbu methods with the STABL6H computer program) of the slope configuration for new project; and (7) providing recommendations. This review indicated that the HFP levee between SNWW stations 165+00 and 240+00 would likely be impacted by the preliminary design layout of the deepened channel. Therefore, the channel was realigned and shifted away from the HFP levee. The design 2:1 slope angles for the deepened channel can be maintained if the channel is shifted far enough away from the HFP system to minimize adverse stability impacts. Acceptable factors of safety

were established for the recommendations from the slope stability analysis, and a suitable offset distance was determined and incorporated into the proposed alignment.

The evaluation of the MLK Bridge, consisted of (1) reviewing available soils data from Design Memorandum No. 2 (Sabine-Neches Waterway, Texas, 40-foot Project and Channel to Echo, Bridge Replacement at Port Arthur, dated May 1964), prepared by Modjeski and Masters, Inc.; (2) reviewing survey cross-section information taken in May 2005; (3) performing slope stability analysis using soil strength data from nearby HFP levee and empirical correlations (due to limited data provided in the DM No. 2.); and (4) providing recommendations. The analysis determined that the 48-foot channel slope would likely impact the embedment of the pile cap and the upper portions of the piles of the bridge's tower pier foundations. The degree to which this impact affects the bearing capacity of the piles or the integrity of the pile cap was beyond the scope of this study. Regardless, for this study, this anticipated impact is considered significant because the failure arc passes through the bridge foundation. Since it is necessary to maintain the 400-foot channel width beneath the bridge, the bridge piers must be protected with a hardened structure to minimize impact to the foundations. Designs and costs for construction of a bulkhead to protect the bridge foundations were developed by the Texas Department of Transportation, and the cost of this protection has been included in the project cost estimate.

The evaluation of the Rainbow Bridge involved reviewing a "Channel Stability Cut Analyses" report prepared by URS Group Inc. in the form of a memorandum with design drawings by the Texas Department of Transportation. Based on conclusions of the memorandum, no impact to the bridge foundations as a result of potential slope instability due to channel deepening is anticipated. However, URS recommended that the dolphins may need to be relocated. These design issues will be further addressed during the preconstruction engineering and design (PED) phase.

Cost Risk Analysis

In accordance with a July 2007 USACE memorandum (Application of Cost Risk Analysis Methods to Develop Contingencies for Civil Works Total Project Costs), a formal cost-risk analysis was performed for the SNWW CIP (FFR, Appendix 3). The cost risk analysis utilizes the MII cost estimate, along with specific project information, to develop contingencies to be used in the formulating the Total Project Cost for the project plan being recommended to Congress. The objective of using the cost risk analysis is to identify areas of high cost uncertainty and the probability that the estimated project cost will or will not be exceeded (USACE, 2007b).

Crystal Ball™, an accepted commercially available computer-based forecasting and analysis program, was used to run Monte Carlo simulations for developing the baseline contingency. The contingency simulation included estimates for all individual activities and risk variables. Since the 48-foot deepening alternative (including selective widening and TB and AB) has been identified as the Recommended Plan (and also the LPP), the Crystal Ball analysis was performed on the cost estimate for this alternative. The results of the cost risk analysis identified the contingency percentages (levels of uncertainty) in the cost estimates for specific project components (e.g., relocations, navigation ports and harbors, cultural

resources, etc.). The average contingencies determined from the cost risk analysis were 30–31 percent, which is higher than the original contingencies identified in the original project cost estimate.

The contingencies were used along with the updated estimate to revise the Total Project Cost Summary (TPCS). ATR of the TPCS for the Recommended Plan has been conducted by the USACE Center of Expertise for Cost Engineering for Civil Works. The ATR has verified that the Total Project Cost baseline, the project scope, report, cost estimate, schedule, escalation, and contingencies were developed in accordance with current cost engineering guidance.

Economic Data and Models

Data

The base data used to establish existing conditions and in preparation of the traffic forecasts were compiled from the sources listed in Table IX-2.

Table IX-2
Primary Data Used for SNWW Economic Analysis

Component	Data Origin
Historical Vessel Traffic	USACE, Waterborne Commerce of the U.S., Part 2, 1965–2007
	USACE, Waterborne Commerce of the U.S., Part 5, 1985–2007
	USDA
	USACE, Navigation Data Center, unpublished databases
	U.S. Department of Energy, website access
	Lloyd's Register-Fairplay, 2005–2009
	U.S. Department of Energy, Energy Information Administration, website access data
	U.S. Department of Commerce, Bureau of Economic Analysis, website access data
	U.S. Coast Guard's Port Arthur Marine Safety Office
Forecast Data by Commodity	
Petroleum and LNG	U.S. Department of Energy, 2009 Annual Energy Review, March 2009
Petroleum and Other Commodities	Global Insight, The U.S. Economy, The 30-Year Focus, First Quarter 2009
Grain Exports	USDA, February 2009
Breakbulk and Other Cargo	Historical Trendlines; Global Insight, and Institutional Knowledge
Other general references	*Journal of Commerce* and other trade magazines
	Government Accountability Office (GAO), Report Number GAO-18–14, January 2008

Risk and Uncertainty

The IWR is currently developing risk-based analysis procedures for the economic evaluation of deep-draft navigation studies. Unlike the current risk-based flood damage model, the navigation model will

integrate both benefit (related to fleet and commodity forecasts) and cost uncertainties (related to dredging and disposal costs). Districts are expected to use sensitivity analyses to evaluate risk and uncertainty until risk-based models for navigation studies are released to the field (ER 1105-2-100.E-10.a). The effects of uncertainty are addressed in terms of sensitivity analyses. An expanded sensitivity section is included in Section 8 of the Economic Appendix.

Models

Deepening Analysis. The USACE-SWG spreadsheet models were used for calculation of transportation costs and evaluation of deepening benefits associated with the without- and with-project futures.

Widening Analysis. The HarborSym model was used in evaluation of the entrance channel widening and the Neches River TB and anchorage features. The outputs from HarborSym were aggregated into Excel spreadsheets and are summarized in this section of the report. HarborSym is a planning-level model developed by the IWR to assist in economic analyses of channel widening improvements. HarborSym is an event-driven simulation model and includes data from user-specified transit rules that the model processes with each vessel call in order to calculate delays within the system. The model is presently in the model certification process. While not yet certified, the model is scheduled for review under the USACE's certification system. The model is presently being used by several USACE district offices for channel widening studies, and the outputs of these have undergone ATR and USACE headquarters review.

Environmental Data and Models

Uncertainty in environmental analyses is associated with the quality of data used to evaluate impacts. The quality of data used for assessments of environmental impacts in this study was assessed based on its origin as presented in Table IX-3.

WVA Model

An analysis of risk and uncertainty associated with the WVA model application to the SNWW CIP was performed. A summary of the sensitivity analysis is presented in FEIS Section 4.2, and the complete analysis is presented in FEIS Appendix C. Uncertainty is inherent in ecosystems, and therefore unavoidable when evaluating ecological processes and impacts. There is often a lack of extensive data sets for all parameters under study, and many of the physical and biological processes are not completely understood. Ecological analyses for the study utilized input from several engineering models referenced in the table above.

Risks to human health and safety associated with ecological impacts evaluated by the model are small. The predicted loss of marsh acreage is 691 acres (less than one-half of 1 percent of the affected marsh acreage) in the interior of the large estuarine marshes east of Sabine Lake. The loss of marsh elevation would make affected areas of these wetlands more vulnerable to the salinity pulses from large tropical storms and hurricanes, but it would not affect the overall effectiveness of these coastal wetlands in

buffering inland areas from storm surge effects. The proposed compensatory mitigation plan would contribute to the long-term sustainability of these areas by adding stabilizing mineral sediments in an amount well above the predicted loss, increasing marsh elevations, and decreasing the size of open-water areas within the interior marshes.

Table IX-3
Quality of Data Used in Ecological Analyses

Environmental Parameter	Data Origin	Data Quality
Hydrodynamic data on circulation, velocity, flows	Field sampling (ERDC-CHL; Brown and Stokes, 2009)	High
Water quality	Historical data and field sampling (ERDC-CHL; Fagerburg, 2003; PBS&J, 2004a, 2004b)	High
Salinity (for HS model verification)	Field sampling studies (ERDC-CHL; Fagerburg, 2003)	High
Salinity – FWP projections	HS Model (ERDC-CHL; Brown and Stokes, 2009)	Moderate
Sediment quality	Historical data, field sampling studies, and biological testing (PBS&J, 1999, 2004a, 2004b)	High
Gulf shoreline erosion	ERDC-CHL modeling (Gravens and King, 2003)	High
Inland channel erosion	ERDC-CHL modeling (Maynord, 2005; Parchure et al., 2005)	High
Vegetation/habitat type mapping	(TPWD, 1992, 2002, 2004; USFWS 2001a, 2001b, 2004, 2008; USFWS and GLO, 1992) and limited survey and field verification for this study	Moderate
Submerged aquatic vegetation	Limited field survey; best professional judgment	Low
Historic land loss rates	U.S. Geological Survey (USGS), TPWD and Bureau of Economic Geology GIS analyses (Britsch and Dunbar, 1992; Dunbar et al., 1992; Greco and Clark, 2005; TPWD, 2003; USGS-LDNR, 1993; White et al., 1996)	Moderate
Bottomland hardwoods growth rates	Professional literature (Brown and Montz, 1986; USDA, 1983, 1990)	Moderate
Endangered species habitat mapping	Field survey (PBS&J, 2006)	High
Fish and wildlife species	Professional literature (too lengthy to list; see FEIS)	Moderate
Oyster reef	Survey and field verification for possible channel widening (PBS&J, 2005)	High
Hazardous and toxic waste	Field sampling and biological testing (PBS&J) of specific areas near Superfund sites; literature and database review for entire area (PBS&J, 2002)	Moderate
Cultural resources-nautical	Marine remote sensing surveys (Hoyt et al., 1994; Hoyt and Schmidt, 1997; PBS&J, 2005)	Moderate
Cultural resources-terrestrial	Professional literature and state records searches (too lengthy to list; see FEIS)	Moderate
Marsh elevations in BU and mitigation areas	Field investigations in BU areas (TCB); best professional judgment in mitigation areas	Low

There are two types of uncertainty that have been identified for the predictive ecological modeling conducted in this study—uncertainty associated with model quality and performance, and uncertainty associated with model predictions. The first type of uncertainty was evaluated by an extensive technical review of the WVA model. Application of the WVA model for the SNWW study was evaluated by an independent technical review at the Deep Draft Center of Expertise, an External Peer Review (Battelle, 2010), and a formal model assessment in conformance with EC 1105-2-407. The WVA Model Assessment (LBG/TEA, 2008) determined that the theoretical approaches behind the WVA model's application to the SNWW project are valid, and approved its use for this study. The Planning Center of Expertise for Deep-Draft Navigation approved the model for use in conjunction with this project by memo dated June 30, 2009 (see FEIS Appendix C, Attachment 1).

For evaluating the second type of uncertainty, the WVA models do not include a direct way to calculate a probability distribution that provides a statistically significant confidence level for the model projections (LBG/TEA, 2008). However, a sensitivity analysis of the model results was conducted by substituting different values in the most important variables. This sensitivity analysis measures the degree of certainty associated with model predictions, and how different predictable outcomes could affect environmental impacts, benefits, and costs. In this case, a range of possible outcomes associated with variable V_1 (percent of emergent marsh) in the EMCM, and variables V_4 and V_5 (salinity) in the Swamp Community Model (SCM) and EMCM, respectively, were evaluated to determine how uncertainties related to variable assumptions and values could affect impact predictions and compensatory mitigation decisions.

Salinity Sensitivity Analysis

The salinity sensitivity analysis of the WVA model (variables V_4 and V_5 in the SCM and EMCM) demonstrated that there is a wide range of potential outcomes in AAHU losses attributable to uncertainties in salinity predictions. These outcomes range from a loss of –340 AAHUs to a loss of –3,146 AAHUs within the 95 percent confidence range of salinities used in the analysis. The total predicted FWP loss of –1,499 AAHUs for Louisiana hydro-units is based upon forecasts of the most likely salinity levels, and takes into account the potential effects of RSLR and future freshwater inflows. The recommended compensatory mitigation plan contains sufficient mitigation to ensure that the Recommended Plan will not have more than negligible impacts on the ecological resources of the study area. It is based upon scientifically based projections of changes in habitat resulting from the predicted salinity change, and the professional judgment and knowledge of the area by the large team of natural resource and engineering professionals who applied the HS and WVA models to the SNWW CIP.

Percent Emergent Marsh Sensitivity Analysis

The sensitivity analysis of the variable V_1 (percent of emergent marsh) in the EMCM explores the effects of an assumption that underlies the valuation of emergent marsh for this variable. In this application of the WVA model, optimal vegetative coverage is assumed to be 100 percent (Suitability Index [SI] = 1.0) for all marsh types. This assumption diverges from the general biological understanding that optimal cover falls in the 60–80 percent range, but it was adopted to reflect the significance of emergent marsh in the

study area. Existing and potentially accelerated marsh loss associated with channel deepening has been identified as one of the highest concerns by resource agencies and the general public. To evaluate the effect of this assumption on the SNWW application, the EMCM was rerun using a revised formula for the variable in which optimal vegetative coverage (SI = 1.0) is assumed for a marsh coverage of 60 to 80 percent (V_1-Revised).

Overall, impacts using V_1-Revised dropped 3 percent as expressed in AAHUs. However, this reduction would be more than offset by the increase in mitigation that would result from the use of V_1-Revised to compute compensatory mitigation, because the amount of credit (in AAHUs) would decrease by about 30 percent. Using V_1-Revised to compute required compensatory mitigation for the mitigation measures, as currently designed, would increase mitigation costs by 42 percent. If the same mitigation measures were redesigned so that marsh fill was a maximum of 80 percent, compensation measured with the V_1-Revised formula would increase by about 10 percent. However, total cost of this revised mitigation plan would be about 3 percent greater than the recommended mitigation plan. More significantly, the modified plan would restore about 18 percent fewer acres and do less to ensure the long-term sustainability of the marsh.

The WVA Model Assessment (LBG/TEA, 2008) confirmed that the original model assumption applied for variable V_1-Original (e.g., optimal vegetative coverage is assumed to be 100 percent) is appropriate for the SNWW application in computing both impacts and mitigation, as it reflects the importance of emergent vegetation as habitat for this study area. Given serious existing rates of marsh loss, the predicted increase in marsh loss in the FWP condition, and uncertainties related to salinity and land loss impacts due to the project, it is reasonable and appropriate to utilize the assumption that maximizes the value of emergent marsh to the sustainability of the marsh system. Without the structure provided by the emergent marsh, the majority of the ecological benefits provided by this system disappear.

Cultural Resources

There is uncertainty related to the potential cost of cultural resource mitigation because all areas that would be impacted by the CIP have not been assessed for their potential to contain properties eligible for NRHP listing. While no specific historic property impacts have been identified at this time, there is moderate potential to affect a significant historic shipwreck. The highest potential for historic property mitigation is associated with channel deepening through Sabine Pass, the site of a significant Civil War naval battle. To account for this uncertainty, the estimated cost for historic property data recovery has been included in the project cost estimate. More details can be found in Section 4.14 of the FEIS.

Real Estate Data

There are 16 PAs, of which 13 are already owned by the local Sponsor and 3 are to be acquired by the non-Federal sponsor. Contaminant materials have been found in PA 17 that are unrelated to dredged material or dredging activities. Issues related to these contaminated materials must be resolved by the non-Federal sponsor before PA 17 can be used. Alternate PAs are available. The other two PAs are

available and would be acquired by the non-Federal sponsor. There are three proposed TBs on the Neches River. Of those, two would require acquisition of 12.10 available acres. All of the remaining lands are subject to Navigation Servitude. The risks to increase project costs and lengthen the project schedule are low.

IX.D COMMUNICATION OF RISK

Extensive scoping effort allowed effective communication of public and agency perception of risks associated with potential channel deepening. The USACE and the SNND developed a public involvement plan to ensure that the USACE and SNND were responsive to the needs and concerns of all stakeholders and to ensure public involvement through an open, interactive process. The plan helped the USACE and SNND provide information to, and obtain information from, the stakeholders. A proactive outreach program ensured that the public, resource agencies, industry, local government, and other interested parties were informed about the project and that any concerns were identified and addressed. More discussion of the outreach program can be found in Chapter XII of this report and also in Appendix A of the FEIS.

Uncertainties associated with precision of data and model robustness were communicated to State and Federal resource agencies as they participated in the ICT review of data collection, model application, and model results. The risks of the various project alternatives and the Recommended Plan will be communicated to general public at public meetings held during public review of the FEIS. Public comments regarding perceptions of risk, uncertainties, and consequences will be included as part of the final feasibility report and FEIS. Potential risk and uncertainties with the CIP, and those expressed by the public will be provided to decision makers and during the Civil Works Review Board briefings.

X. RECOMMENDED PLAN

X.A OVERVIEW

Previous chapters described the analyses conducted during the planning study process to identify the NED Plan, the Recommended Plan, the DMMP, and Mitigation Plan with the ultimate goal of identifying the Recommended Plan. The purpose of this chapter is to describe the plan that will be recommended for implementation to the U.S. Congress.

The Recommended Plan described below addresses the problems and opportunities, identified at the beginning of the study, and satisfies the planning objectives of increasing navigational efficiency along the SNWW while maintaining the coastal and estuarine resources within the project area. The Recommended Plan is the LPP Plan, preferred by the Sponsor. Engineering Plates referenced in this section are in Appendix 1 of this document.

X.B GENERAL NAVIGATION FEATURES OF RECOMMENDED PLAN

The Recommended Plan calls for a 48-foot-deep channel from Sabine Pass Channel to the Port of Beaumont on the Neches River Channel with no additional widening, widening and deepening of Taylor Bayou TBs and channels to 48 feet, and several TBs and ABs on the Neches River Channel (Figure X-1). The Recommended Plan would increase the existing channel depth by 8 feet, increasing the inland portion from 40 to 48 feet and increasing the existing offshore portions from 42 to 50 feet (plus overdepth and advance maintenance as needed). Two feet of overdepth and 2 feet of advance maintenance are included for the entire channel length. In high shoaling areas, additional advance maintenance is required in order to maintain current maintenance dredging cycles along the waterway. The total length of the SNWW with the proposed channel modifications would be approximately 77 miles. No modifications to the existing Sabine Pass jetties are required by the proposed project.

The following description of the recommended channel improvements to the SNWW begins at the Gulf of Mexico (offshore) channel reach and moves inland to the Beaumont TB on the Neches River. A plan view of the Recommended Plan is provided on Engineering Plate G-02, and the project dimensions are identified in Table X-1.

Sabine Bank Extension Channel

This channel lengthens the existing offshore entrance channel approximately 13.2 miles at a bottom width of 700 feet (Engineering Plate No. C-12). The additional length is required to reach a water depth in the Gulf of Mexico equal to the proposed channel depth. The proposed offshore depth is 50 feet, but advance maintenance and allowable overdepth would add a total of 4 more feet, bringing the total dredged depth of the Extension Channel to 54 feet. It would be constructed by hopper dredge beginning at the end of the

Table X-1
Project Dimensions for Recommended Plan

Reach	Station	to	Station	Bottom Width (feet)	Project Depth (feet)	Side Slope
Extension Channel	165+443		95+734	700	50	1V/2H
Sabine Bank Channel	95+734		18+000	700–800	50	1V/2H
Sabine Pass Outer Bar Channel	18+000		0+000	800	50	1V/10H
Sabine Pass Jetty Channel	–214+88		0+00	800–500	48	1V/2H
Sabine Pass Channel	0+00		296+25	500	48	1V/2H
Port Arthur Canal	0+00		325+84	500	48	1V/2H
Sabine-Neches Canal	0+00		592+94	400	48	1V/2H
Neches River Channel	0+00		980+00	400	48	1V/2H
Taylor Bayou						
Entrance Channel	0+00		25+27	406–764	48	1V/2H
East Turning Basin	0+00		17+65	532–354	48	1V/2H
West Turning Basin	25+27		41+30	776	48	1V/2H
Connecting Channel	41+30		71+50	470–250	48	1V/2H
Taylor Bayou Turning Basin	71+50		106+25	1000	48	1V/2H

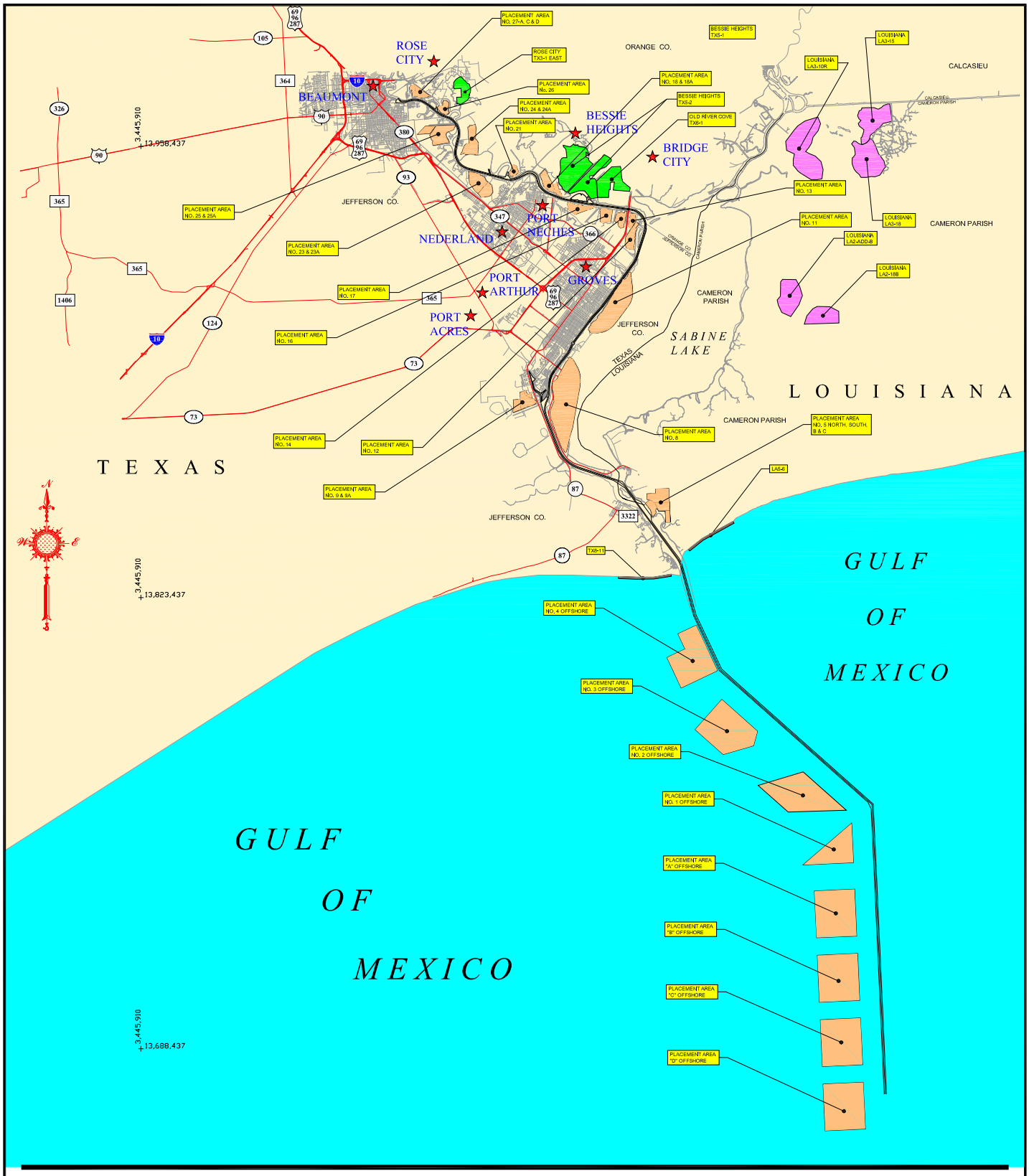
Sabine Bank Channel and it would extend into the Gulf of Mexico at the same bearing as the Sabine Bank Channel.

Sabine Bank Channel

This 14.7-mile-long channel would be deepened from 42 to 50 feet using a hopper dredge (Engineering Plate No. C-11). When advance maintenance and allowable overdepth are added to the proposed 50-foot depth, the Sabine Bank Channel would be dredged to 54 feet. The bottom width of the Sabine Bank Channel is currently 800 feet; it would remain 800 feet wide for the first mile past the end of the Outer Bar Channel, and then it would taper from 800 to 700 feet over the next ½ mile. The Sabine Bank Channel would continue the 700-foot bottom width for approximately 13.2 miles to its connection with the Extension Channel. Since the existing channel is 800 feet wide, new channel markers would be required to mark the tapered transition and the remainder of the narrowed Sabine Bank Channel.

Sabine Pass Outer Bar Channel

This 3.4-mile-long channel would be deepened from 42 to 50 feet using a hopper dredge. Due to high shoaling rates in this portion of the channel, advance maintenance depths would be increased to maintain current maintenance dredging cycles. Including allowable overdepth, advance maintenance, and additional advance maintenance, the Outer Bar Channel would be dredged to 58 feet. The Outer Bar Channel would remain at its current 800 feet bottom width due to strong crosscurrents just beyond the end of the SNWW jetties (Engineering Plate No. C-11).



SABINE-NECHES WATERWAY TEXAS & LOUISIANA CHANNEL IMPROVEMENT PROJECT 2009

LEGEND

- MAJOR ROADS
- USACE PLACEMENT AREAS
- TOPOGRAPHIC FEATURES
- MITIGATION
- DMMP ENVIRONMENTAL FEATURES
- NECHES RIVER BU FEATURE
- GULF SHORE BU FEATURE

NOTE: The data is only a representation of features on the earth compiled by computer program 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 covered 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.

PREPARED BY:
REAL ESTATE DIVISION
AUG. 2009

DATUM: NORTH AMERICAN 1983 FEET
PROJECTION: STATE PLANE
ZONE: SOUTH CENTRAL TEXAS

1" = 10,000' — 10,000 5,000 0 10,000 20,000 30,000 40,000 — SCALE IN FEET

US Army Corps of Engineers
Galveston District

Sabine Pass Jetty Channel

This 4.1-mile-long channel would be deepened to 48 feet using a hopper dredge. When advance maintenance and allowable overdepth are added, the Sabine Pass Jetty Channel would be dredged to 52 feet. The width of the channel would remain the same, the channel would gradually taper from the existing 800-foot width at the mouth of the jetties to 500 feet wide at the head of the jetties (Station 0+00). No impacts to the jetties have been identified that are associated with the proposed improvements.

Sabine Pass Channel

This 5.6-mile-long channel begins just north of the jetties and extends upstream to Mesquite Point on Pleasure Island (Engineering Plate Nos. C-10, C-11, and C-12). It would be deepened to 48 feet and constructed with a hydraulic pipeline dredge. Shoaling rates vary in different sections of the Sabine Pass Channel, and advance maintenance and allowable overdepth vary to meet these conditions. The total dredging depth for two reaches (Station 0+00 to Station 100+00, and Station 180+00 to Station 230+00) would be 52 feet. Due to higher shoaling rates, the reach from Station 100+00 to Station 180+00 would require additional advance maintenance and be dredged to a depth of 55 feet, while the reach from Station 230+00 to the end of the Sabine Pass Channel at Station 295+61 would be dredged to a depth of 57 feet. The bottom width of the Sabine Pass Channel would remain at 500 feet with a new centerline closely following the existing centerline. The Sabine Pass Anchorage is located in this reach, and its footprint would be reduced in size because it has never been fully utilized. The width would be decreased from 1,500 to 855 feet, and the length would remain at 8,200 feet. The angle of approach would remain the same.

Port Arthur Canal

This 6.2-mile-long canal begins near Mesquite Point and ends at the Port Arthur Junction Area with the Taylor Bayou channels (Engineering Plate Nos. C-08 and C-09). The Port Arthur Canal would be deepened to the proposed depth of 48 feet with a hydraulic pipeline dredge. The Port Arthur Junction Area serves as a TB and has a high shoaling rate due to the confluence of the GIWW and the Taylor Bayou TB with the SNWW. This confluence of water bodies decreases channel velocities resulting in increased shoaling. For these reasons, the reach from Station 0+00 to Station 290+00 would be dredged to a depth of 54 feet. The remaining part (Port Arthur Junction) between stations 290+00 and 326+37 would be dredged to a depth of 57 feet. Additional advance maintenance is required in these reaches to address high shoaling areas while keeping the current dredging frequency. The bottom width of the Port Arthur Canal would remain 500 feet.

Taylor Bayou Channels and Turning Basins

Located at the confluence of the Port Arthur Junction Area, the GIWW, and the mouth of the original Taylor Bayou, the Taylor Bayou Channels and TB consist of several subreaches: Entrance Channel, East TB, West TB, Connecting Channel, and the Taylor Bayou TB. Several significant changes are proposed for this area. When advance maintenance and allowable overdepth are added to the proposed 48-foot

depth, the Taylor Bayou channels and TB would be dredged to 54 feet. The Taylor Bayou portion of the Junction Area, between stations 0+00 and 31+10, would be dredged to 57 feet (see additional advance maintenance explanation provided for Port Arthur Canal). The Entrance Channel and the West TB bottleneck curve would be widened, and a structural wall would protect local railroad tracks. Changes for each subreach are detailed below.

- **Entrance Channel**. The new bottom width widens on the west side of the channel. The channel would be widened to 444 feet at new Station 10+00. The new bottom width would taper back to the existing width by the end of the first curve at Station 28+38.
- **East Turning Basin**. The right side width would decrease 16 feet as the new depth extends down the existing side slope.
- **West Turning Basin**. The width of the existing bottleneck has been increased up to 120 feet on the west side, between new stations 33+00 and 55+00. The west bank of the basin would be protected by a structural wall, preventing impacts to the local railroad tracks present in this area.
- **Connecting Channel**. The West TB widening tapers back to the existing width in the Connecting Channel, between stations 55+00 and 67+00.
- **Taylor Bayou Turning Basin**. No changes would be made to the existing dimensions, but the basin would be deepened to the proposed 48-foot depth. Existing shore protection belonging to a local facility near Station 90+00 would be affected by the top-of-cut for the new depth.

Sabine-Neches Canal

The 11.2-mile-long canal begins at the Port Arthur Junction Area and ends just south of the mouth of the Neches River (Engineering Plate Nos. C-04, C-05, C-06, and C-07). The GIWW shares this canal with the deep-draft channel. It would be deepened to the proposed depth of 48 feet with a hydraulic pipeline dredge. Additional advance maintenance (near the junction of the Port Arthur Canal and the Sabine-Neches Canal) is required since the area is a high-shoaling area, and additional advance maintenance dredging would allow current O&M dredging frequencies to be maintained. When allowable overdepth, advance maintenance, and additional advance maintenance are added, stations 0+00 to 40+00 would be dredged to 57 feet, and remainder of the canal through Station 592+91 would be dredged to 53 feet.

The bottom width of the canal would be selectively widened in three separate sections. The bottom width of the most-downstream curve (stations 0+00 to 20+00) would be widened to 500 feet on the east side of the channel, and then promptly tapered to the existing 400-foot width prior to the MLK Bridge (SH 82). The canal would be widened to 450 feet adjacent to the Port of Port Arthur, with gradual tapering upstream and downstream between stations 120+00 and 170+00. The third widening section begins to taper at Station 565+00, gradually widening to 500 feet and remaining that width to the end at Station 592+91.

Bend easing is planned for three areas in the Sabine-Neches Canal to improve ship maneuverability: stations 265+00 to 305+00, stations 350+00 to 395+00, and stations 500+00 to 520+00. The bend easing

between stations 350+00 and 395+00 eliminates a wiggle in the alignment, and shifts the footprint of the canal 10 feet east of the existing alignment up to Station 520+00.

Changes are also recommended for the canal bottom adjacent to the Port Arthur Dock and the "Eye Basin." The canal toes adjacent to the Port of Port Arthur would be moved approximately 10 feet to the right while keeping the same bottom width of 450 feet. The diameter of the existing turning point ("Eye Basin") at Station 190+00 would be decreased by 16 feet.

Neches River Channel

This 18.5-mile-long channel begins just south of the mouth of the Neches River (Engineering Plate Nos. C-01, C-02, C-03, and C-04). It would be deepened to the proposed depth of 48 feet to Station 980+00 with a hydraulic pipeline dredge. Shoaling rates vary in different sections of the Neches River Channel, and advance maintenance and allowable overdepth would vary to meet these conditions. Between stations 0+00 and 440+00, the total dredged depth would be 52 feet; between stations 440+00 and 978+00, it would be 54 feet (due to 2 feet of additional advance maintenance). While the overall bottom width of 400 feet does not change for the majority of the channel length, the first curve at the mouth of Neches River (between stations 0+00 and 75+00) would be widened to 500 feet, and then tapered back to 400 feet prior to the SH 87 twin bridges.

Three basins would be added or enlarged on the Neches River Channel. All three would be dredged to the proposed depth of 48 feet, plus the advance maintenance and allowable overdepth associated with the specific channel reach in which they are located. One TB, Turning Basin No. 6, is an existing basin and would continue to be maintained at the existing 40-foot depth and existing advance maintenance and allowable overdepth.

- **TB and AB No. 1** is located in an old river oxbow at the east end of Texaco Island near Station 210+00. The TB enlarges the existing basin from 1,000 to 1,350 feet in diameter. A new AB, 250 by 1,100 feet in size, would be added.
- **TB and AB No. 4** enlarges an existing turning point at Station 510+00 from 1,000 to 1,350 feet in diameter. A new AB in the old river oxbow at Station 500+00 would be 250 by 1,100 feet in size.
- **AB No. 8** is new and would be located at Station 850+00. The 250 by 1,000-foot basin is located in an old river oxbow.

DMMP

PAs would be able to accommodate material from both construction and maintenance dredging of the Federal channel over the 50-year period of analysis. They are also designed to accommodate non-Federal dredging (estimated at 5.2 percent of material to be placed in upland PAs) of private facilities on the Port Arthur and Sabine-Neches canals, and the Neches River Channel. PAs proposed as part of the Recommended Plan consist of upland PAs, ODMDS and GNF BU features (Neches River and Gulf Shore BU features) (tables X-2, X-3, and X-4). Sixteen existing and two expanded upland PAs are proposed for

use with the Recommended Plan. Offshore placement consists of four existing ODMDSs (1–4) and four new ODMDSs (A–D). More-detailed descriptions of the 50-year DMMP for the Recommended Plan can be found in Section VIII of this document and in Appendix D of the FEIS.

Table X-2
Upland Placement Areas for the Recommended Plan

Placement Area	Additional Cell(s)	Size (acres)	Associated Waterway Section
5	N&S, B, C	957	Sabine Pass Channel (sections 5 and 6)
8		3,570	Port Arthur Canal (sections 7 and 8) Sabine-Neches Canal (Section 9)
9A	B	481	Port Arthur Canal (Section 8)
11		2,170	Sabine-Neches Canal (Section 10)
12		355	Neches River Channel (Section 11)
13		140	Neches River Channel (Section 11)
14		255	Neches River Channel (Section 12)
16		288	Neches River Channel (Section 13)
17		316	Neches River Channel (Section 13)
18	A	432	Neches River Channel (Section 14)
21		135	Neches River Channel (Section 14)
23	A	773	Neches River Channel (Section 15)
24	A	575	Neches River Channel (Section 16)
25	A	820	Neches River Channel (Section 17)
26		192	Neches River Channel (Section 18)
27	A, C, D	270	Neches River Channel (Section 18)

Table X-3
Ocean Dredged Material Disposal Sites for Recommended Plan

Placement Area	Size (acres)	Status	Associated Waterway Section
A	3,405	New	Extension Channel
B	3,405	New	Extension Channel
C	3,405	New	Extension Channel
D	3,405	New	Extension Channel
1	2,020	Active	Section 1
2	4,738	Active	Section 2
3	3,939	Active	Section 3
4	3,444	Active	Section 4

Table X-4
GNF Beneficial Use Features in the Recommended Plan

Neches River BU Feature

- **Rose City East Marsh Restoration** (Engineering Plate No. C-01)

  (TX 3-1 East) – Restoration of 345 acres of fresh marsh; improvement of 72 acres of shallow-water habitat; nourishment of 151 acres of existing marsh

- **Bessie Heights East Marsh Restoration** (Engineering Plate No. C-24)

  (TX 5-2) – Restoration of 679 acres of brackish marsh and 1,190 acres of intermediate marsh; improvement of 660 acres of shallow-water habitat; nourishment of 651 acres of existing marsh

- **Old River Cove Marsh Restoration** (Engineering Plate No. C-25)

  (TX 6-1) – Restoration of 639 acres of brackish marsh; improvement of 139 acres of shallow-water habitat; nourishment of 432 acres of existing marsh

Gulf Shore BU Feature

- **Texas Point Shoreline Nourishment** (Engineering Plate No. C-27)

  (TX 8-11) – Nourishment of 3 miles of Texas shoreline with maintenance material every 6 years

- **Louisiana Point Shoreline Nourishment** (Engineering Plate No. C-27)

  (LA 5-6) – Nourishment of 3 miles of Louisiana shoreline with maintenance material every 6 years

Figure X-1 identifies the location of the major features of the Recommended Plan, specifically the DMMP BU features and the mitigation measures, existing and new PAs, and the existing and new ODMDSs.

Ecological Mitigation for the Recommended Plan

Marsh Mitigation

Marsh mitigation for the Recommended Plan consists of restoring five degraded marsh areas east of Sabine Lake near Willow and Black bayous, Louisiana (Table X-5). The mitigation plan compensates for the Recommended Plan's salinity increase and associated losses in biological productivity by restoring 2,783 acres of emergent marsh in existing open-water areas within degraded marsh; improving 957 acres of shallow-water habitat by creating shallower, smaller ponds and channels within the restored marsh; and stabilizing and nourishing 4,355 acres of existing marsh located in and around the mitigation areas. Additional details are provided in the FEIS.

Table X-5
Mitigation for Recommended Plan

Recommended Mitigation Plan	Mitigation AAHUs
Willow Bayou	
LA 2-18 B Marsh Restoration (Sabine Lake dredging)	152
LA 2ADD B Marsh Restoration (Sabine Lake dredging)	214
Black Bayou	
LA 3-10R Marsh Restoration (Channel to Orange maintenance material)	198
LA 3-15 B Marsh Restoration (GIWW dredging)	307
LA 3-18 B Marsh Restoration (GIWW dredging)	310
Total Compensation	1,181
FWP Mitigation Target	–1,159
Net Benefits After Compensation	**22**

X.C LANDS, EASEMENTS, AND RIGHTS-OF-WAY

The project Sponsor is required to furnish the LER for the proposed cost-shared project. The real estate requirements must support construction as well as operation and maintenance of the project after completion. A summary of the real estate requirements for each channel reach is provided in Table VII-6. Specific details of the real estate requirements can be found in the Real Estate Plan, Appendix 4 of this document.

X.D RELOCATIONS

The following assumptions were made to identify pipelines that could be affected by the Recommended Plan and to develop associated costs. The individual circumstances of each pipeline will be evaluated by USACE in consultation with the pipeline owner during the PED and Construction phases, and decisions regarding necessary actions will be made individually for each pipeline at that time. Feasibility engineering guidelines indicate that pipelines with a minimum of 8 feet of cover for trenched lines or 5 feet of cover for directionally drilled lines would not be adjusted. Pipelines that do not meet the minimum cover requirement would be required to be adjusted. The adjusted pipelines must be located 20 feet below the authorized 48-foot depth. The 20 feet includes any advance maintenance and allowable overdepth. The relocation of active pipelines is assumed to be installed with directional drilling, and bundled where possible.

A total of 104 pipelines have been identified crossing the SNWW navigation channels. Of the 104 pipelines, 46 require adjustment to meet the minimum required vertical and horizontal clearances for the CIP.

Pursuant to Section 101(a) of the WRDA 86, as amended, the Sponsor is responsible for performing, or assuring performance, of all relocations, including utility relocations, which are necessary for the CIP. All relocations, including utility relocations, are to be accomplished at no cost to the Federal Government.

The Galveston District has concluded preliminarily that 41 of the 46 lines located within the channel must be relocated and are classified as utility relocations for which the Sponsor must perform or assure performance. In accordance with Section 101(a)(4) of WRDA 86, one-half of the cost of each such relocation will be borne by the owner of the facility being relocated and one-half of the cost of each such relocation will be borne by the Sponsor. Such relocation costs will not include any cost for upgrading or improving such facilities, which is to be borne by the facility owner.

For more-specific information regarding the utility relocations, and preliminary conclusions regarding the remaining five lines that must be removed but not replaced, see the Real Estate Plan, Appendix 4, of this document.

DMMP marsh restoration at Bessie Heights and mitigation marsh restoration measures east of Sabine Lake were assumed to require no relocations. However, since oil production is active in some of these areas, additional pipeline searches and coordination with pipeline owners would be required prior to construction to avoid impacts.

No relocations would be required for overhead power utilities, highway bridges, the Port Arthur HFP Levee, or its associated pump stations and closure structures.

X.E AIDS TO NAVIGATION

Channel Markers

Some of the existing channel markers along the waterway would require removal and replacement. No changes in channel markers are needed upstream of the Beaumont Maneuvering Basin and in the vicinity of SH 87 on the Neches River Channel. However, channel markers along the remainder of the waterway may need to be relocated, and new markers would be required along the Extension Channel.

X.F BRIDGE REINFORCEMENTS AND FENDERS

Channel modifications would require the removal and replacement of bridge fender systems that protect the Rainbow Bridge and the Veterans Memorial Bridge over the Neches River, and the MLK Bridge over the Sabine-Neches Canal. In addition, the existing support piers of the MLK Bridge would be hardened to prevent instability that may develop with construction of the proposed 400-foot channel width.

XI. PLAN IMPLEMENTATION

XI.A OVERVIEW

This chapter identifies project cost sharing responsibilities for the Government and the Sponsor for the construction and O&M of the Recommended Plan.

XI.B DIVISION OF PLAN RESPONSIBILITIES AND COST SHARING REQUIREMENTS

The Recommended Plan would be accomplished at different cost sharing rates. Project cost sharing for the project would be as follows:

- **GNF down to 45-foot depth** – 75 percent Federal and 25 percent non-Federal
- **GNF deeper than 45-foot depth** – 50 percent Federal and 50 percent non-Federal
- **O&M down to 45-foot depth** – 100 percent Federal
- **O&M deeper than 45-foot depth** – 50 percent Federal and 50 percent non-Federal

XI.C DESIGN PHASE COSTS FOR ALTERNATIVES SCREENING

During the detailed design phase, a different cost ($1.12/gallon fuel cost) and price level (October 2005) were used to identify the least-cost placement alternative (Section VII.E, Table VII-4). Costs have not been updated for this comparison because it was used to screen two placement plan alternatives (a Traditional Placement Alternative and the BU Alternative) during the detailed design phase. No changes have been made to the alternatives that were compared. Costs for both alternatives would change proportionately if they were updated with the most recent price levels. The difference in cost between the two plans would not be materially different, and thus the decision to adopt the BU Alternative as a GNF of the DMMP for the Recommended Plan would not be affected. An explanation of the $1.12 fuel cost estimate is included below to explain the reasoning behind its use at that time.

Large fluctuations in fuel costs that occurred during the preparation of this report raised concerns that benefits and costs, based upon different cost assumptions as required by the USACE guidance, would lead to an unanticipated bias in the BCR. The USACE Headquarters provided interim guidance requiring a different method of cost determination, which was followed in the preparation of cost screenings for the SNWW CIP until deep-draft vessel operating costs were updated (EGM #08-04). In the interim guidance, the USACE Headquarters and the IWR developed a price adjustment applicable to existing estimates of inland vessel bunkerage costs, which approximated deep-draft or coastal dredge plant costs. The guidance recommended that an estimated value of $1.12 per standard gallon be used for the economic analysis until the EGM could be updated. Subsequently, the revised EGM was issued in November 2007, and the project costs have been updated. The project cost tables presented in the sections below use the October 2009 price level and updated vessel-operating costs per EGM #08-04.

XI.D PROJECT COSTS

Three costs were developed for evaluation of the Recommended Plan. These costs include the Total First Cost, the Recommended Plan Investment Cost, and the Fully Funded Cost. The Total First Cost is at current levels, does not include interest during construction (IDC) or expected price escalation. The Investment Cost includes all first costs and IDC. The Fully Funded Cost includes all first costs and price escalation, but does not include the IDC. All three costs include associated costs such as LER, relocations (including utility relocations), berthing area and dock modifications, and aids to navigation. All costs in the project cost tables presented in the chapter were developed using October 2009 price levels; annualized costs use an interest rate of 4.375 percent. Deep-draft vessel operating costs for the economic analysis were developed based upon EGM #08-04.

Costs for the Recommended Plan

Total First Cost and Annualized O&M Costs

The Total First Cost is the cost at current levels and does not include IDC, or expected price escalation. The Total First Cost for all project components ($1,071,877,000; Table XI-1) includes implementation costs and associated costs. Implementation costs include postauthorization planning and design costs, construction costs, LER, relocations, mitigation costs, and O&M. Construction costs include costs for dredging, PA construction, aids to navigation (e.g., channel markers) and protection for MLK Bridge supports and bridge fender replacement. The USACE coordinated with the USCG to develop costs for aids to navigation, and with the Texas Department of Transportation to develop costs for bridge support protection and fender systems. Costs for compensatory fish and wildlife mitigation (including deferred construction costs for one mitigation measure) and cultural resource mitigation are also included. Associated Federal and non-Federal costs are the costs of resources directly required for project construction, but for which no project expenditure is made, such as USCG navigation aids, relocations (including utility relocations), and non-Federal berthing/dock modifications. A formal cost risk analysis was performed in accordance with Engineering and Construction Bulletin 2007-17 that developed project contingencies at the 80 percent confidence level. First costs and incremental O&M costs are expressed as total average annual costs in the bottom portion of Table XI-1. Construction funding would fund all project construction components.

Deferred Construction Costs

Deferred construction costs are related to one mitigation measure at West Black Bayou, Louisiana (LA 3-10R). This mitigation measure would be constructed using material from regular maintenance dredging of the Sabine River Channel to Orange over a 30-year period. The cost of the mitigation measure is the incremental cost of pumping the additional distance to Louisiana and marsh restoration activities. The first cycle of placement is included as a first cost of construction in the Recommended Plan cost estimates (Contract 14). Intermittent construction over 30 years (six additional 5-year maintenance cycles) is shown separately as an annualized deferred construction cost in tables XI-1 and XI-2. The Deferred construction would be cost shared with the non-Federal project sponsor for the SNWW CIP.

Table XI-1
Total First Cost and Annualized O&M for the Recommended Plan
(All costs in dollars)
(October 2009 price level; 4.375% interest rate)

First Cost of Construction	873,610,000
Fish and Wildlife Mitigation	77,491,000
Cultural Resources Mitigation	1,248,000
Lands	4,361,000
Relocations	41,627,000
Bridge Modifications	51,794,000
Navigation Aids	1,492,000
Berthing and Dock Modifications	20,254,000
Total Project Cost	1,071,877,000
Average Annual Costs	
First Cost Amortization	59,059,000
Deferred Construction (Fish and Wildlife Mitigation)	215,000
Incremental O&M	
Total Incremental	32,006,000
non-Federal Disposal Facility Costs	61,000
Average Annual Costs	91,341,000

Since the Sabine River Channel is a separate project with a different non-Federal sponsor, each Sabine River Channel maintenance cycle involving deferred construction would utilize three funding sources (Federal O&M funds from the Sabine River Channel, and Federal construction funds and Sponsor construction funds from the SNWW CIP). The Federal government and Sponsor must diligently budget for the deferred construction so that funds are available when needed to avoid any delays in channel maintenance and mitigation site construction.

Federal O&M Costs

The maintenance of project features would be funded through annual appropriations of the O&M program. The actual amounts would 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. O&M costs also vary between channel depths. In accordance with Section 101(b) of WRDA 86 (Policy Guidance Letter [PGL] 47), O&M dredging and placement costs for maintenance of the channel depths between 40 and 45 feet would be allocated as 100 percent Federal; this would be calculated as 62.5 percent of the total O&M cost, determined as described for the GNF features in the Fully Funded Cost section, below. Costs for maintenance of the channel depth below 45 feet (37.5 percent of the total O&M costs) would be allocated as 50 percent non-Federal and 50 percent Federal. Expected cost sharing for all project components is compliant with PGL 47, Dredged Material Disposal Facilities, and Dredged Material Disposal Facility Partnerships.

Table XI-2
Total Investment Cost for the Recommended Plan
(October 2009 price level; 4.375 percent interest rate)

Total First Cost	1,071,877,000
Months to Construct	96
Interest During Construction	119,382,000
NED Investment Costs	1,191,259,000
Average Annual Project Cost	59,059,000
Incremental O&M	32,067,00
Deferred Construction (F&W Mitigation)	215,000
Total Annual Cost	91,341,000
Annual Benefits	115,074,000
Net Excess Benefits	23,733,000
BCR	1.3

Additional PA capacity for the Recommended Plan would be constructed regularly over the 50-year period of analysis in conjunction with maintenance dredging cycles. Since established dredged material management practices for the SNWW 40-foot project include regularly recurring levee raisings and the enlargement or installation of new dewatering structures, the additional investment required to provide the increased PA capacity for the Recommended Plan and PA costs attributable to the 40-foot project Base Plan would be cost shared as O&M costs. Costs for disposal facility maintenance would be allocated as 100 percent Federal for maintenance of channel depths between 40 and 45 feet. Costs for disposal facility maintenance associated with channel deepening below 45 feet would be allocated as 50 percent non-Federal and 50 percent Federal.

Non-Federal O&M Costs

In the SNWW, non-Federal maintenance material has traditionally been placed into the same PAs as Federal material, at the request of the non-Federal sponsor. Additional capacity needed for the non-Federal maintenance material was therefore considered when determining improvements needed to provide capacity for the 50-year period of analysis. It is projected that approximately 5.2 percent of the 48-foot project 50-year maintenance dredging quantity to be placed in upland disposal facilities would originate from non-Federal dredging. Costs of providing the capacity needed to contain the non-Federal dredged material are a local responsibility and are shown separately from the incremental Federal O&M costs that would be cost-shared as described above.

National Economic Development Investment Cost

The Investment Cost is expressed in current dollars with IDC added (see Table XI-2). The Investment Cost includes all of the implementation costs and non-Federal and Federal associated costs included in the First Cost as described above. First costs, incremental O&M, and deferred construction for fish and wildlife mitigation are expressed as total average annual costs in the bottom portion of Table XI-2, and then net excess benefit totals and the BCR are calculated. Total average annual costs are compared to

projected annual benefits to determine net excess benefits and the BCR. The BCR for the Recommended Plan is 1.3.

Fully Funded Cost

Total First Costs and price escalation, calculated by estimating the midpoint of the proposed construction contracts, are combined to create the Fully Funded Cost. In order to allocate the share of construction and O&M costs between the Federal government and the Sponsor, the cost must first be allocated by depth in accordance with Section 101 of Public Law 99-662 (USACE, 2000b). Costs for the transportation and placement of material during construction of the 48-foot project are GNF costs. The GNF costs are assigned to the two depth ranges, in accordance with Section 101(a) of WRDA 86, by applying the proportion of the channel deepening that would occur within each depth range. The cost allocation by depth in first cost is shown in Table XI-3. Table XI-4 shows this cost allocation using the fully funded cost. The amount associated with deepening between 40 and 45 feet (cost shared at 25 percent non-Federal and 75 percent Federal) was calculated by using an estimate for the 45-foot project. This 45-foot cost estimate was developed to a level comparable to an MII cost estimate. The amount associated with deepening below 45 feet (cost shared at 50 percent non-Federal and 50 percent Federal) was calculated by taking the cost difference between the 48-foot alternative and the 45-foot plan. Costs for various categories such as advance maintenance and allowable overdepth dredging were included in both the 45-foot estimates and 48-foot estimates and are included in both depths in the same manner as other GNF costs. None of the existing berthing areas and docks is presently deeper than the 40-foot channel, and therefore these costs would also be allocated between the depths as are all other GNF costs. The Federal costs for lands, fish and wildlife mitigation, cultural resources, and aids to navigation are the same in both the 45-foot and 48-foot plans; therefore, there are no additional costs included in the analysis for deepening from 45 to 48 feet.

XI.E COST SHARING ALLOCATION

The GNF costs for deepening between 40 and 45 feet are cost shared at 25 percent non-Federal and 75 percent Federal; costs for deepening below 45 feet are cost shared at 50 percent non-Federal and 50 percent Federal. The costs are separated into expected Federal and non-Federal shares and detailed in tables XI-5 and XI-6. Table XI-5 used the projects first costs while Table XI-6 is in fully funded escalated costs. Fish and wildlife mitigation is considered a GNF and is cost shared in the same manner as other GNF costs. Costs for cultural resources data recovery 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. Based upon information available at this time, data recovery costs are not expected to exceed the 1 percent limitation.

The Sponsor also must pay an additional 10 percent of the GNF costs in cash over a period not to exceed 30 years. This additional 10 percent cash contribution is offset by credit for LER and relocations (including utility relocations) pursuant to Section 101(a)(2) of WRDA 86, as amended. Owners of berth and dock facilities that would require modification in conjunction with the Recommended Plan would be

responsible for 100 percent of those associated costs. The USCG is responsible for 100 percent of the cost for aids to navigation.

Table XI-3
Recommended Plan First Costs Allocation by Depth
(October 2009 Price Level)
(All costs in dollars)

	Costs Allocated to 45-foot Depth	Costs Allocated to Increment below 45-foot Depth	Total Costs
General Navigation Features			
Construction Dredging and Placement Areas	520,408,000	184,569,000	704,977,000
Bridge Modifications	45,577,000	6,217,000	51,794,000
Engineering and Design	82,895,000	22,817,000	105,712,000
Construction Management	48,425,000	14,496,000	62,921,000
Lands	744,000	0	744,000
Fish and Wildlife Mitigation	55,212,000	22,279,000	77,491,000
Cultural Resources Mitigation	1,248,000	0	1,248,000
Subtotal	754,509,000	250,378,000	1,004,887,000
Lands, Easements, Rights-of-Way, and Relocations			
Land	3,617,000	0	3,617,000
Utility Relocations	0	20,813,500	20,813,500
Subtotal	3,617,000	20,813,500	24,430,500
Other Federal Costs			
Aids to Navigation - USCG Channel Markers	1,492,000	0	1,492,000
Associated non-Federal Costs (owner cost)			
Utility Relocations		20,813,500	20,813,500
Berthing Areas & Dock Modifications	13,187,000	7,067,000	20,254,000
Subtotal	13,187,000	27,880,500	41,067,500
First Costs	772,805,000	299,072,000	1,071,877,000

Table XI-4
Recommended Plan Fully Funded Costs Allocation by Depth
(October 2009 Price Level)
(All costs in dollars)

	Costs Allocated to 45-foot Depth	Costs Allocated to Increment below 45-foot Depth	Total Costs
General Navigation Features			
Construction Dredging and Placement Areas	564,466,000	200,193,000	764,659,000
Bridge Modifications	49,436,000	6,743,000	56,179,000
Engineering and Design	88,861,000	24,459,000	113,320,000
Construction Management	52,555,000	15,732,000	68,287,000
Lands	802,000	0	802,000
Fish and Wildlife Mitigation	59,928,000	24,181,000	84,109,000
Cultural Resources Mitigation	1,389,000	0	1,389,000
Subtotal	817,437,000	271,308,000	1,088,745,000
Lands, Easements, Rights-of-Way, and Relocations			
Land	3,864,000	0	3,864,000
Utility Relocations	0	22,658,500	22,658,500
Subtotal	3,864,000	22,658,500	26,522,500
Other Federal Costs			
Aids to Navigation - USCG Channel Markers	1,618,000	0	1,618,000
Associated non-Federal Costs (owner cost)			
Utility Relocations	0	22,658,500	22,658,500
Berthing Areas & Dock Modifications	14,212,000	7,616,000	21,828,000
Subtotal	14,212,000	30,274,500	44,486,500
First Costs	837,131,000	324,241,000	1,161,372,000

Table XI-5
Recommended Plan – First Costs Allocation
(October 2009 Price Level)
(All costs in dollars)

	Costs Allocated to 45-foot Depth			Costs Allocated to Depth Increment below 45 feet					
General Navigation Features	Federal Share (75% of 45-ft Costs)	non-Federal Share (25% of 45-ft Costs)	Total	Federal Share (50% of Cost - Depth Increment Greater than 45 ft)	non-Federal Share (50% of Cost - Depth Increment Greater than 45 ft)	Total	Total Federal Share	Total non-Federal Share	Total First Cost
Construction Dredging and Placement Areas	390,306,000	130,102,000	520,408,000	92,284,500	92,284,500	184,569,000	482,590,500	222,386,500	704,977,000
Bridge Modifications	34,182,750	11,394,250	45,577,000	3,108,500	3,108,500	6,217,000	37,291,250	14,502,750	51,794,000
Engineering and Design	62,171,250	20,723,750	82,895,000	11,408,500	11,408,500	22,817,000	73,579,750	32,132,250	105,712,000
Construction Management	36,318,750	12,106,250	48,425,000	7,248,000	7,248,000	14,496,000	43,566,750	19,354,250	62,921,000
Lands	558,000	186,000	744,000	–	–	–	558,000	186,000	744,000
Fish and Wildlife Mitigation	41,409,000	13,803,000	55,212,000	11,139,500	11,139,500	22,279,000	52,548,500	24,942,500	77,491,000
Cultural Resource Mitigation		**100% Federal up to 1% Limitation**			**100% Federal up to 1% Limitation**				
	1,248,000	–	1,248,000	–	–	–	1,248,000	–	1,248,000
Subtotal	566,193,750	188,315,250	754,509,000	125,189,000	125,189,000	250,378,000	691,382,750	313,504,250	1,004,887,000
Lands, Easements, ROW, and Relocations (LERRs)		**100% non–Federal**			**100% non–Federal**				
Lands	–	3,617,000	3,617,000	–	–	–	–	3,617,000	3,617,000
Utility Relocations	–	–	–	–	20,813,500	20,813,500	–	20,813,500	20,813,500
Subtotal	–	3,617,000	3,617,000	–	20,813,500	20,813,500	–	24,430,500	24,430,500
Other Federal Costs		**100% Federal**			**100% Federal**				
Aids to Navigation - USCG Channel Markers	1,492,000	–	1,492,000	–	–	–	1,492,000	–	1,492,000
Associated non-Federal Costs (owner cost)		**100% non–Federal**			**100% non–Federal**				
Utility Relocations	–	–	–	–	20,813,500	20,813,500	–	20,813,500	20,813,500
Berthing Areas & Dock Modifications	–	13,187,000	13,187,000	–	7,067,000	7,067,000	–	20,254,000	20,254,000
Subtotal	–	13,187,000	13,187,000	–	27,880,500	27,880,500	–	41,067,500	41,067,500
Total First Costs	567,685,750	205,119,250	772,805,000	125,189,000	173,883,000	299,072,000	692,874,750	379,002,250	1,071,877,000

Table XI-6
Recommended Plan – Fully Funded Costs Allocation
(October 2009 Price Level)
(All costs in dollars)

	Costs Allocated to 45-foot Depth			Costs Allocated to Depth Increment below 45 feet					
General Navigation Features	Federal Share (75% of 45-ft Costs)	non-Federal Share (25% of 45-ft Costs)	Total	Federal Share (50% of Cost - Depth Increment Greater than 45 ft)	non-Federal Share (50% of Cost - Depth Increment Greater than 45 ft)	Total	Total Federal Share	Total non-Federal Share	Total Fully Funded Cost
Construction Dredging and Placement Areas	423,349,500	141,116,500	564,466,000	100,096,500	100,096,500	200,193,000	523,446,000	241,213,000	764,659,000
Bridge Modifications	37,077,000	12,359,000	49,436,000	3,371,500	3,371,500	6,743,000	40,448,500	15,730,500	56,179,000
Engineering and Design	66,645,750	22,215,250	88,861,000	12,229,500	12,229,500	24,459,000	78,875,250	34,444,750	113,320,000
Construction Management	39,416,250	13,138,750	52,555,000	7,866,000	7,866,000	15,732,000	47,282,250	21,004,750	68,287,000
Lands	601,500	200,500	802,000	–	–	–	601,500	200,500	802,000
Fish and Wildlife Mitigation	44,946,000	14,982,000	59,928,000	12,090,500	12,090,500	24,181,000	57,036,500	27,072,500	84,109,000
Cultural Resource Mitigation		**100% Federal up to 1% Limitation**			**100% Federal up to 1% Limitation**				
	1,389,000	–	1,389,000	–	–	–	1,389,000	–	1,389,000
Subtotal	613,425,000	204,012,000	817,437,000	135,654,000	135,654,000	271,308,000	749,079,000	339,666,000	1,088,745,000
Lands, Easements, Rights of Way, and Relocations		**100% non-Federal**			**100% non-Federal**				
Lands	–	3,864,000	3,864,000	–		–	–	3,864,000	3,864,000
Utility Relocations	–	–	–	–	22,658,500	22,658,500	–	22,658,500	22,658,500
Subtotal	–	3,864,000	3,864,000	–	22,658,500	22,658,500	–	26,522,500	26,522,500
Other Federal Costs		**100% Federal**			**100% Federal**				
Aids to Navigation - USCG Channel Markers	1,618,000	–	1,618,000	–	–	–	1,618,000	–	1,618,000
Associated non-Federal Costs (owner cost)		**100% non-Federal**			**100% non-Federal**				
Utility Relocations	–	–	–	–	22,658,500	22,658,500	–	22,658,500	22,658,500
Berthing Areas & Dock Modifications	–	14,212,000	14,212,000	–	7,616,000	7,616,000	–	21,828,000	21,828,000
Subtotal	–	14,212,000	14,212,000	–	30,274,500	30,274,500	–	44,486,500	44,486,500
Fully-Funded (Escalated) Costs	615,043,000	222,088,000	837,131,000	135,654,000	188,587,000	324,241,000	750,697,000	410,675,000	1,161,372,000

XI.F ADDITIONAL NON-FEDERAL SPONSOR CASH CONTRIBUTION

For all navigation channel depths, the Sponsor must provide an additional cash contribution equal to 10 percent of fully funded GNF costs as shown below in Table XI-7 (USACE, 2000b). These costs may be paid over a period not exceeding 30 years. The Sponsor's costs for LER and relocations (including utility relocations) are credited against the additional cash contribution.

Table XI-7
Total General Navigation Features Costs and Credits
(October 2009 Price Level)
(All costs in dollars)

Cost-Shared GNF	1,088,745,000
10% of GNF	108,874,500
Creditable Land Costs	3,864,000
Relocation Costs	22,658,500
Total non-Federal Sponsor Creditable Costs	26,522,500
Creditable Difference	(82,352,000)

XI.G NON-FEDERAL SPONSOR VIEWS

The Sponsor for the existing project, SNND, has actively participated in the entire planning process. Their primary concern has been to provide the community with a channel design, preferably 48 feet deep, to increase navigation efficiency and prepare for future needs. The SNND fully supports the Recommended Plan and has indicated an interest in beginning construction as soon as possible.

XII. SUMMARY OF COORDINATION

XII.A OVERVIEW

This section identifies the coordination process used during the feasibility study to obtain comments and concerns from the general public, State and Federal resource agencies, and any other interested parties. A general summary of the comments is provided below. A more detailed description of the public involvement process and a complete list of all comments can be found in Appendix A of the FEIS.

XII.B COORDINATION

The USACE and SNND developed a public involvement plan to be used during the feasibility phase for the SNWW CIP. The goal of the public involvement plan was to ensure that the USACE and SNND were responsive to the needs and concerns of all stakeholders and to ensure public involvement through an open, interactive process. Stakeholders include all the various publics that could be affected or might be interested in the project. The plan helped the USACE and SNND provide information to, and obtain information from, the stakeholders.

Coordination with resource agencies was conducted primarily through the ICT and technical working group meetings. Resource agencies and the study team met regularly throughout the study process. Over 30 workgroup meetings and 11 ICT meetings were held.

A proactive outreach program was initiated to ensure that the public, resource agencies, industry, local government, and other interested parties were informed about the project and that any concerns were identified and addressed. Each of the activities listed here is described individually in Appendix A of the FEIS. The outreach program included:

- Scoping meetings;
- Public workshops to obtain ideas for BU of dredged material;
- Media trips by boat down the waterway;
- Presentations at the GMFMC's Texas Habitat Protection Advisory Panel;
- Presentations at regular meetings of Southeast Texas Waterway Advisory Council,
- Meetings with SPA;
- Presentation at the 2007 South East Texas Leaders meeting; and
- Meetings with SNWW industries.

XII.C PUBLIC/AGENCY COMMENTS

The following is an overview of the comments and concerns throughout the study process. These comments were received from the general public, State and Federal resource agencies, and other interested parties.

Saltwater Intrusion

The primary environmental concern is the potential for the proposed CIP to increase saltwater intrusion, and for higher salinity levels to further degrade marshes and cypress swamps in both Texas and Louisiana. The combined effects of subsidence and sea level rise are expected to increase marsh submergence and worsen this trend. The public and resource agencies identified severely stressed marsh areas at Texas Point and Salt Bayou in the Sabine Pass area, in the Neches River reach between Sabine Lake and IH 10, and in the extensive marshes east of Sabine Lake.

An associated issue is the deterioration of wildlife habitat and fishery nursery areas and the destruction of fish and wildlife resources that could occur as a result of increased wetland loss. All or portions of the following federally and State-protected lands are located in sensitive habitats, which may be affected by the proposed CIP: the Sabine NWR, the McFaddin NWR, the Texas Point NWR, the J.D. Murphree WMA, the Lower Neches WMA, the Tony Houseman WMA, and the Sabine Island WMA.

It was suggested that environmental impacts as a consequence of the proposed CIP should be avoided if possible. A lock at Sabine Pass, a sill or constriction at the mouth of Sabine Lake, and smaller water control structures in the marshes east of Sabine Lake were suggested as methods to minimize or avoid impacts. Other comments warned of the potential harmful effects of water control structures, which inhibit the movement of marine organisms into and out of intertidal marshes.

Threatened and Endangered Species

Potential impacts to threatened and endangered species are a concern, particularly dredging impacts to endangered sea turtles. The offshore channel deepening and extension would require the use of hopper dredges, which create particular hazards for sea turtles. Critical Habitat for the wintering piping plover is present in the study area.

Contaminated Sediments

The public also expressed concern that dredging for the proposed CIP and the placement of dredged material would spread contaminated sediments or affect water quality. It is feared that new work dredging would release contaminants from past industrial discharges into the water column, or that areas selected for the BU of dredged material could be polluted.

The BU of dredged material to restore degraded marshes was encouraged by the public and resource agencies. The following sites were specifically identified as areas that could benefit: Rose City marsh, Bessie Heights marsh, Keith Lake marsh, marshes in the McFaddin NWR, east Sabine Lake marshes, and the Gulf shoreline at Texas Point and Holly Beach. Construction of a bird island in Sabine Lake was also suggested. The BU of dredged material would reduce the need for new or expanded PAs and reduce potential wetland impacts.

Essential Fish Habitat

The proposed CIP, including the Gulf of Mexico ODMDSs, could impact EFH for red drum; brown, white, and pink shrimp; Spanish mackerel; and estuarine water column and mud/sand bottoms. Potential effects to nursery and foraging habitat for economically important marine fishery species such as spotted sea trout, flounder, Atlantic croaker, black drum, Gulf menhaden, striped mullet, and blue crab also need to be evaluated for adverse effects associated with proposed water control structures.

Storm Surge and Erosion

Concern has been expressed that the proposed CIP could increase tidal amplitude, and increase damage during storm surges by allowing the surge to inundate areas that have not been affected by previous storms. Concerns were also expressed about the potential increased erosion along the shoreline of the channel due to increased or larger vessel traffic.

Cultural Resources

Concern was expressed that the use of the existing PA 5 would adversely affect public access to the Sabine Lighthouse, a National Register-listed property. A road around the perimeter of the PA is currently the only access route to the Lighthouse. Changes or enlargements to this PA could limit or remove access to the historic property. Furthermore, proposed project improvements could affect the Sabine Pass Battleground Park, Fort Griffin, and associated shipwrecks along the waterway. These sites and the shipwrecks are associated with important battles during the U.S. Civil War.

Socioeconomic and Project Costs

Considerable concern was expressed by government agencies in Louisiana that the proposed CIP would have adverse effects on their State's environment while providing no economic benefits for Louisiana. Officials at the West Calcasieu Port, Harbor and Terminal District urged that navigation improvements be evaluated on a regionwide basis, because channel improvements in Texas could put their facilities and the Port of Lake Charles at a competitive disadvantage. Cameron Parish officials expressed support for economic development that would benefit their constituents. Cameron Parish officials were also concerned that lands suitable for commercial development at Sabine Pass were being considered for use as PAs. Developable lands are limited on the Louisiana side of the SNWW, and all are needed to promote economic development.

The high concentration of petrochemical refineries and terminals in the study area means that a large number of pipelines are also present. Local industries are concerned that these pipelines would be affected by the proposed channel deepening and that they would be responsible for the cost of relocating these pipelines below a deeper channel bottom.

Several members of the general public expressed concern that the cost of this project would be large, that benefits would not be sufficient to outweigh costs, and that costs would be passed on to taxpayers in the form of higher taxes.

Public Infrastructure

Jefferson County Drainage District #7 expressed concern that channel widening and deepening could affect the structural integrity of the Port Arthur Hurricane Protection Levee, pump stations, and closure structures. The Texas Department of Transportation expressed concern that increased erosion could adversely affect SH 82 and SH 87. Both are located immediately adjacent to the SNWW and are affected by present channel bank erosion. Additional erosion of SH 87 could destroy the only road access to the City of Sabine Pass.

XIII. RECOMMENDATIONS

Based on the analyses and information in this document and the FEIS, it is recommended that the existing SNWW, Texas, authorized by the RHA of 1962, 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 consider advisable, and subject to cost-sharing and financing arrangements satisfactory to the President of the United States and Congress, to provide deep-draft channel and selective widening improvements and continued maintenance of the SNWW Channel.

A categorical exemption for navigation projects exists to deviate from selection of the NED plan in accordance with ER 1105-2-100, E-3.b(5) that states:

> "Categorical Exemption for Flood Control and Navigation Projects. If the non-Federal sponsor identifies a constraint to maximum physical project size or a financial constraint due to limited resources, and if net benefits are increasing as the constraint is reached, the requirement to formulate larger scale plans in an effort to identify the NED plan is suspended. The constrained plan may be recommended. . . ."

The proposed project meets the requirements for a categorical exemption due to the sponsor's financial constraint and is recommended as the recommended plan. This constrained LPP consists of deepening of the channel to 48 feet as described in Section X of this report.

XIII.A PROJECT COSTS (October 2009 Price Levels)

For the purpose of calculating the Section 902 limit, the total estimated first cost of the project is $1,029,318,000, including an estimated Federal share of $691,383,000 and an estimated non-Federal share of $337,935,000. Total First Cost of all project components in current dollars, without escalation and IDC, totals $1,071,877,000. The Fully Funded Cost for the project, which includes Total First Costs and expected escalation, is $1,161,372,000. The Investment Cost of all components totals $1,191,259,000, and includes $119,382,000 in IDC. Total annual costs for the project are $91,341,000 and total annual benefits are $115,074,000, resulting in a project BCR of 1.3.

XIII.B REQUIREMENTS

These recommendations are made with the provision that, prior to implementation of the recommended improvements, the Sponsor shall enter into binding agreements with the Federal government to comply with the following requirements.

The SNND shall:

a. Provide 10 percent of the total cost of construction of the general navigation features (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 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, easements, and rights-of-way (LER), including those necessary for the borrowing of material and the disposal of dredged or excavated material, and perform or ensure the performance of all relocations, including utility relocations, all as determined by the Federal 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 the GNFs less the amount of credit afforded by the Government for the value of the LER and relocations, including utility relocations, provided by the Sponsor for the GNF. If the amount of credit afforded by the Government for the value of the LER and relocations, including utility relocations, provided by the Sponsor equals or exceeds 10 percent of the total cost of construction of the GNFs, the 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 cost of construction of the GNFs;

d. Provide, operate, maintain, repair, replace, and rehabilitate, at its own expense, 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 Federal Government;

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

f. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the 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 GNFs, 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 Federal Government determines to be necessary for the construction or operation and maintenance of the GNFs. However, for lands that the Government determines to be subject to the navigation servitude, only the Government shall perform such investigations unless the Federal Government provides the Sponsor with prior specific written direction, in which case the Sponsor shall perform such investigations in accordance with such written direction;

j. Assume complete financial responsibility, as between the Federal Government and the Sponsor, for all necessary cleanup and response costs of any hazardous materials regulated under CERCLA that are located in, on, or under LER that the Federal 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 Public Law 91-611, Flood Control Act of 1970, as amended (42 USC 1962d-5b), and Section 101 of the WRDA 86, Public Law 99-662, as amended, which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the 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, Public Law 91-646, as amended (42 USC 4601–4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring LER required for construction or operation and maintenance of the project; 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, Public Law 88-352 (42 USC § 2000d et seq.), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army." The Sponsor is also required to comply with all applicable Federal labor standards requirements including, but not

limited to, 40 USC 3144–3148 and 40 USC 3701–3708 (revising, codifying, and enacting without substantive change the provisions 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; and

p. Not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefor, to meet any of the Sponsor's obligations for the project 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.

Construction of the recommended channel improvements is estimated to take 7 years to complete. During this period, the Government and the Sponsors 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 would be considered to be maintenance material and cost-shared according to the new agreement.

XIII.C MAINTENANCE OF NEW CHANNEL AND EXISTING CHANNEL

The portions of the SNWW channel that are deepened and widened (including any newly created areas) shall be operated and maintained according to the terms and provision of the new agreements. All other portions of the existing SNWW channel shall continue to be operated and maintained according to the existing agreement applicable to that portion of the channel. With the cost of maintenance dredging continuing to rise every year, it is imperative to fully fund the maintenance portion of this project each year. Recent fiscal year funding of $12–$15 million is insufficient and does not allow the channel to be maintained at the current authorized depth of 40 feet. This report forecasts a shoaling rate nearly double the current rate. This increased rate, combined with more fully loaded ships traversing the waterway, stresses the importance of maximum and consistent funding of O&M costs for the new project depth.

XIII.D RECOMMENDATION

The recommendations of the Sabine-Neches CIP to deepen the waterway depth to 48 feet with selective widening, as described in Section X of this document, reflects 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 Sponsor, the State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Christopher W. Sallese
Colonel, U.S. Army Corps of Engineers
District Commander

10 FEB 11
Date

This page intentionally left blank.

XIV. LITERATURE CITED

Armstrong, N.E., M. Brody, and N. Funicelli. 1987. The ecology of open-bay bottoms of Texas: a community profile. U.S. Fish and Wildlife Service Biological Report 85(7.12):104. U.S. Department of the Interior, Washington, D.C.

Battelle. 2010. Addendum to Final Peer Review Report for the Sabine-Neches Waterway (SNWW) Channel Improvement Project (CIP), Feasibility Study, compiled by Battelle, Columbus, Ohio.

Beaumont Enterprise. 2006. Report confirms ship channel's importance here. *Beaumont Enterprise*, Beaumont, Texas. July 24. http://www.zwire.com/site/index.cfm?newsid=16955312&BRD=2287&PAG=461&dept_id=512588&rfi=8.

Berman, A.E. 2005. The debate over subsidence in coastal Louisiana and Texas. Houston Geological Society Publications Bulletin, November 24, 2005.

Blackburn, J., C. Johnson, and M. Berryhill. 2001. The value of the Texas bays and adjacent wetlands. CLE International Wetlands Conference February 2001. Austin, Texas.

Blair, W.F. 1950. The biotic provinces of Texas. Texas Journal of Science 2:93–117.

Block, W.T. 1984. Sabine Pass' Famed "Oil Pond," It Saved Ships, but Snared Whales. Beaumont Enterprise, February. (http://www.wtblock.com/wtblockjr/oilpond.htm) (accessed March 23, 2008).

Britsch, L.D., and J.B. Dunbar. 1993. Land loss rates: Louisiana coastal plain. Journal of Coastal Research 9:324–338.

Brown, C.A., and G.N. Montz. 1986. Baldcypress, the Tree Unique, the Wood Eternal. Claitor's Publishing Division, Baton Rouge, Louisiana.

Brown, G.L., and J. Stokes. 2009. Numerical Model Study of Potential Salinity Impacts Due to Proposed Navigation Improvements to the Sabine-Neches Waterway, Texas (August 2009 draft report). U.S. Army Engineer Research Development Center – Coastal and Hydraulics Laboratory (ERDC-CHL), Vicksburg, Mississippi.

Bureau of Economic Geology. Revised 1982. Geologic Atlas of Texas. Houston Sheet. The University of Texas at Austin.

Coalition to Restore Coastal Louisiana. 2002. Coast Wise Publication. www.crcl.org/pubs/wise/sabine.htm.

Daigle, J.J., G.E. Griffith, J.M. Omernik, P.O. Faulkner, R.P. McCulloh, L.R. Handley, L.M. Smith, and S.S. Chapman. 2006. Ecoregions of Louisiana (color poster with map, descriptive text, summary tables and photographs). U.S. Geological Survey, Reston, Virginia (map scale 1:1,000,000).

Davis, D.W. 1996. The Sabine Lake area: a region in transition. Proceedings, Sabine Lake Conference, September 13–14, Beaumont, Texas (TAMU-SG-97-101):8–12.

Dunbar, J.B., L.D. Britsch, and E.R. Kemp III. 1992. Land-loss rates (Report 3), Louisiana coastal plain. Technical Report GL-90-2, U. S. Army Corps of Engineers, New Orleans District, Louisiana.

Energy Information Administration (EIA). 2007. Annual Energy Outlook 2007 with Projections to 2030. Washington, D.C. http://www.eia.doe.gov/oiaf/aeo/.

———. 2008. Imports by Area of Entry. Washington, D.C. http://www.eia.doe.gov/dnav/pet/pet_move_imp_dc_NUS-Z00_mbbl_a.htm.

Environmental Protection Agency (EPA). 2006. Star Lake Canal Superfund Site, Port Neches, Jefferson County, Texas, EPA ID#TX0001414341, Site ID: 0605043, Updated February 2006 (EPA publication date March 6, 2006). Region 6 Superfund Program, Information Bulletins/Fact Sheets/Site Updates. http://epa.gov/region6/6sf/pdffiles/0605043.pdf.

Fagerburg, T. 2003. Field Data Collection Summary Report for the Sabine-Neches Waterway Study. U.S. Army Engineer Research and Development Center, Waterways Experiment Station (ERDC-WES). Vicksburg, Mississippi.

Gammill, S., K. Balkum, K. Duffy, E. Meselhe, J. Porthouse, E. Ramsey, and R. Walters. 2002. Hydrologic Investigation of the Louisiana Chenier Plain. Report prepared for the Louisiana Coastal Wetlands Conservation and Restoration Task Force by the Louisiana Department of Natural Resources, Baton Rouge.

General Land Office (GLO). 2004. Texas Coastwide Erosion Response Plan, 2004 Update. Texas GLO, Austin. http://www.glo.state.tx.us/coastalerosion/CEPRA-LegReport2005/pdf/.

———. 2005. Coastal Erosion Planning and Response Program (CEPPRA) Report to the 79th Legislature. Texas GLO, Austin. http://www.glo.state.tx.us/coastalerosion/CEPRA-LegReport2005/index.html.

Gosselink, J.G., C.L. Cordes, and J.W. Parsons. 1979. An ecological characterization study of the Chenier Plain coastal ecosystem of Louisiana and Texas. 3 vols. U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-78/9 through 78/11.

Gould, H.R., and E. McFarlan, Jr. 1959. Geologic history of the Chenier Plain, southwestern Louisiana. Gulf Coast Association of Geological Societies Transactions 9:261–270.

Gravens, M., and D. B. King. 2003. Shoreline impacts study for Sabine-Neches Project. U.S. Army Corps of Engineers, Engineer Research and Development Center, Coastal Hydraulics Laboratory (ERDC-CHL), Vicksburg, Mississippi.

Greco, R., and D. Clark. 2005. GIS analysis of East Sabine Lake shoreline retreat, 1978–2004. U.S. Fish and Wildlife Service, Ecological Services Field Office, Lafayette, Louisiana.

Griffith, G.E., S.A. Bryce, J.M. Omernik, J.A. Comstock, A.C. Rogers, B. Harrison, S.L. Hatch, and D. Bezanson. 2004. Ecoregions of Texas (color poster with map, descriptive text, and photographs): U.S. Geological Survey, Reston, Virginia (map scale: 1:2,500,000).

Gulf Engineers and Consultants, Inc (GEC). 2002. Sabine-Neches Waterway Feasibility Study, Environmental Restoration /Beneficial Use Workshops. Prepared for the U.S. Army Corps of Engineers, Galveston District, Baton Rouge, Louisiana.

Gulf Intracoastal Canal Association (GICA). 2008. Gulf Intracoastal Canal Association On-Line. http://www.gicaonline.com/pages/about /mission.html (accessed March 2008).

Gulf of Mexico Fisheries Management Council (GMFMC). 2004. Final Environmental Impact Statement for the Generic Amendment to the following fishery management plans of the Gulf of Mexico: Shrimp Fishery of the Gulf of Mexico, Red Drum Fishery of the Gulf of Mexico, Reef Fish Fishery of the Gulf of Mexico, Stone Crab Fishery of the Gulf of Mexico, Coral and Coral Reef Fishery of the Gulf of Mexico, Spiny Lobster Fishery of the Gulf of Mexico and South Atlantic; Coastal Migratory Pelagic Resources of the Gulf of Mexico and South Atlantic. Gulf of Mexico Fishery Management Council, Tampa, Florida.

Heideman, G. 2002. Texas Department of Health, Seafood Safety Division. Personal communication to Lisa Vitale, PBS&J, Austin, Texas. May 16.

Hoyt, S.D. and J.S. Schmidt. 1997. Diving Assessments for Twenty-six Localities, Sabine Pass Channel, Jefferson County, Texas, Cameron Parish, Louisiana. Document No. 960983. Espey, Huston & Associates, Inc., Austin, Texas.

Hoyt, S.D., J.S. Schmidt, and Robert Gearhart. 1994. Magnetometer survey of Sabine Pass Channel and assessment of the *Clifton*, 41JF65, Jefferson County, Texas, Cameron Parish, Louisiana. Document No. 940510. Espey, Huston &Associates, Inc., Austin, Texas.

Hsiao, S.V., and O.H. Shemdin. 1980. Bottom dissipation in finite-depth water waves. Proceedings of the 16th Coastal Engineering Conference. Hamburg, Germany.

Hubbs, C. 1982. A checklist of Texas freshwater fishes. Technical Series No. 11. Texas Parks and Wildlife Department, Austin.

Huh, O.K., H. Roberts, L.J. Rouse, and D.A. Rickman. 1991. Fine grain sediment transport and deposition in the Atchafalaya and Chenier Plain sedimentary system. Coastal Sediments 1991. American Society of Civil Engineers, New York. Pp. 817–830.

Institute of Water Resources (IWR). 1991. National Economic Development Procedures Manual, Deep Draft Navigation. Report 91-R-13. November 1991, p. 77.

Interagency Performance Evaluation Task Force. 2007. Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System, 9 Volumes. Interim Final. Vicksburg, Mississippi. https://pet.wes.army.mil/.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Core Writing Team R.K. Pachauriand and A. Reisinger [editors]). IPCC, Geneva, Switzerland, 104 p.

Isphording, W.C., F.D. Imsand, and G.C. Flowers. 1989. Physical characteristics and aging of gulf coast estuaries. Transactions – Gulf Coast Association of Geological Societies, Vol 39.

Kane, H.E. 1959. Lake Quaternary geology of Sabine Lake and vicinity, Texas and Louisiana. Gulf Coast Association of Geological Societies Transactions 9:225–235.

King, David B, Jr. 2007. Wave and Beach Processes Modeling for Sabine Pass to Galveston Bay, Texas, Shoreline Erosion Feasibility Study. ERDC/CHL TR-07-6. Coastal and Hydraulics Laboratory, U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Lee, Hoo Il. 2003. Shoreline Assessment of Jefferson County, Texas. Thesis submitted to Texas A&M University, College Station.

Lloyd's Register-Fairplay. 2003. Enhanced Register of Ships on CD. http://www.ships-register.com/help.aspx?Control= license.

Louis Berger Group and Toxicological and Environmental Associates (LBG/TEA). 2008. Wetland Value Assessment Model: Application in the Sabine-Neches Waterway Channel Improvement Project, Model Assessment Report. Prepared for the U.S. Army Corps of Engineers, Mobile District.

Louisiana Coastal Protection and Restoration Authority (LACPRA). 2007. Integrated Ecosystem Restoration and Hurricane Protection: Louisiana's Comprehensive Master Plan for a Sustainable Coast. LCPRA, Baton Rouge, Louisiana.

Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority (LCWCR/WCRA). 1998. Coast 2050: Toward a Sustainable Coastal Louisiana, Louisiana Department of Natural Resources, Baton Rouge. http://www.coast2050.gov/reports/

———. 1999. Coast 2050: Toward a Sustainable Coastal Louisiana, The Appendices. Appendix F-Region 4 Supplemental Information. Louisiana Department of Natural Resources, Baton Rouge.

Louisiana Department of Natural Resources (LDNR). 1993. Bottomland Hardwoods Model, modified from Habitat Assessment Models for Fresh Swamp and Bottomland Hardwoods within the Louisiana Coastal Zone.

———.1997. Holly Beach to Constance Beach Shore Protection Preliminary Feasibility Report. LDNR, Coastal Restoration Division, Open File Report 97-01. Baton Rouge, Louisiana.

Louisiana Department of Wildlife and Fisheries (LDWF). n.d. Lower Sabine River fisheries data. Louisiana Department of Fisheries and Wildlife, Inland Fisheries Division, Baton Rouge.

Lower Neches Valley Authority. 2002. 2002 Basin highlights report. Lower Neches Valley Authority, Beaumont, Texas.

Martin Associates. 2006. Economic Impacts of the Sabine-Neches Waterway and Economic Benefits of Maintenance Dredging of the Waterway. Martin Associates, Lancaster, Pennsylvania.

Martin, L. 2002. Regional Sediment Management: Background and Overview of Initial Implementation. IWR Report 02-PS-2. U.S. Army Corps of Engineers, Institute for Water Resources, Belvoir, Virginia.

Mason, C. 1981. Hydraulics and stability of five Texas inlets. Miscellaneous Paper CERC-81-1. U.S. Army Engineer Coastal Engineering Research Center, Fort Belvoir, Virginia.

Maynord, S. 2005. Ship effects before and after deepening of Sabine-Neches Waterway, Port Arthur, Texas. ERDC/CHL TR-03-15. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Military Surface Deployment and Distribution Command. 2004. "The History Channel captures operations at Beaumont, Texas," TRANSLOG Summer 2004. The Transportation Engineering Agency, the 597th Transportation Group, Alexandria, Virginia.

———. 2006. Port of Beaumont reaches milestone handling military cargo. TRANSLOG, Summer 2006. The Transportation Engineering Agency, the 597th Transportation Group, Alexandria, Virginia.

Morang, Andrew. 2006. North Texas Sediment Budget, Sabine Pass to San Luis Pass. Coastal and Hydraulics Laboratory, U.S. Army Engineer Research and Development Center. ERDC/CHL TR-06-17. Vicksburg, Mississippi.

Morgan, J.P., L.G. Nichols, and M. Wright. 1958. Morphological effect of Hurricane Audrey. Technical Report No. 10, Coastal Studies Institute, Louisiana State University, Baton Rouge.

Morton, R.A. 1975. Shoreline Changes Between Sabine Pass and Bolivar Roads, An Analysis of Historical Changes of the Texas Gulf Shoreline. Bureau of Economic Geology, The University of Texas at Austin.

———. 1977. Historical Shoreline Changes and Their Causes, Texas Gulf Coast. Bureau of Economic Geology, The University of Texas at Austin.

———. 1996. Geological and historical development of Sabine Lake – an overview. Proceedings, Sabine Lake Conference, September 13–14, Beaumont, Texas (TAMU SG 97-101). http://nsgl.gso.uri.edu/tamu/tamuw9600.pdf Publication by Texas A&M University, College Station (TAMU-SG-97-101).

———. 2003. An Overview of Coastal Land Loss: With Emphasis on the Southeastern United States: USGS OFR 03-337.

Morton, R.A., J.C. Bernier, J.A. Barras, and N.F. Ferina. 2005. Rapid Subsidence and Historical Wetland Loss in the Mississippi Delta Plain: Likely Causes and Future Implications: Open-File Report 2005–1216, U.S. Department of the Interior, U.S. Geological Survey.

Morton, R.A., and J.G. Paine. 1990. Coastal land loss in Texas – an overview. Transactions – Gulf Coast Association of Geological Societies: 40:625–634.

Nairn, R.B. 1992. Designing for cohesive shores. Proceedings Coastal Engineering in Canada. J.W. Kamphuis, editor, Department of Civil Engineering, Queen's University, Kingston, Canada.

Nairn, R.B., and D.H. Willis. 2002. Erosion, transport, and deposition of cohesive sediments. Coastal Engineering Manual, Part III, Coastal Sediment Processes, Chapter 5, T. Walton, editor, Engineer Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington, D.C.

National Research Council (NRC). 1987. Responding to changes in sea level: engineering implications. Commission of Engineering and Technical Systems, National Research Council, National Academy Press, Washington, D.C.

Natural Diversity Database, Texas Parks and Wildlife Department (TPWD). 2005. Annotated county lists of rare species, Jefferson County. Texas Parks and Wildlife Department, Wildlife Diversity Branch, Austin. Revised April 6.

Nelson, D.A., and E.J. Pullen. 1988. Environmental considerations using beach nourishment for dredged material placement. In R.L. Lazor and R. Medina (editors). 1990, Beneficial uses of dredged material: proceedings of the Gulf coast regional workshop. USACE, Washington, D.C. Technical Report D-90-3.

North American Waterfowl Management Plan (NAWMP), Plan Committee. 2004. North American Waterfowl Management Plan 2004. Gulf Coast Joint Venture: Initiative Plans. Canadian Wildlife Service, U.S. Fish and Wildlife Service, Secreteria de Medio Ambiente y Recursos Naturales.

Pacific International Engineering (PIE). 2003. Coastal geomorphology of a non-barrier Gulf of Mexico beach: Analysis for protection of Highway 87 and McFaddin NWR in Jefferson County, Texas. Austin, Texas.

Parchure, T.M., S. Maynord, and S. Sarruff. 2005. Desktop Study for Sediment-Related Problems at Sabine-Neches Project. U.S. Army Corps of Engineers, Engineer Research and Development Center, Coastal Hydraulics Laboratory, Vicksburg, Mississippi.

PBS&J. 1999. Sabine-Neches Waterway Entrance Channel, Contaminant Assessment. Document No. 991247. PBS&J, Austin, Texas.

———. 2002. Hazardous, toxic, and radioactive waste survey of the Sabine-Neches Waterway. Document No. 020157. PBS&J, Austin, Texas.

———. 2004a. Sediment Transport Modeling of Dredged Disposal Material. Cheniere Sabine Pass Liquefied Natural Gas Terminal, Cameron Parish, Louisiana. PBS&J, Houston, Texas.

———. 2004b. Sabine-Neches Waterway Entrance Channel, Contaminant Assessment. Document No. 040274. PBS&J, Austin, Texas.

———. 2005. Historic Properties Identification, Oyster Reef Identification, and Pipeline and Obstruction Identification for the Sabine/Neches Waterway Widening and Deepening, Jefferson and Orange Counties, Texas, and Cameron Parish, Louisiana. PBS&J, Austin, Texas.

———. 2006. Biological Assessment for Impacts to Endangered and Threatened Species Relative to the Sabine-Neches Waterway Channel Improvement Project, Texas and Louisiana. PBS&J, Austin, Texas.

Port Arthur News. 2008. "Valero Expansion Expands Community Opportunities," February 29.

Rabinow, Richard A. 2004. The Liquid Pipeline Industry in the United States, "Where It's Been, Where It's Going, a report for the Association of Oil Pipe Lines, April 2004, p. 14.

Rouse, L.J., Jr., W.J. Wiseman, Jr., L.C. Bender, N.L. Guinasso, Jr., F.J. Kelly, D.A. Brooks, Y-T Lo, J. She, and A. Valle-Levinson. 2004. Observational and Predictive Study of Inner Shelf Currents over the Louisiana-Texas Shelf. Coastal Marine Institute, Louisiana State University. Published by U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. OCS Study, MMS 2004-036.

Sabine Pilots Association (SPA). 2005. Unpublished data. Sabine Pilots. Groves, Texas. http://www.sabinepilots.com/index.html.

———. 2007. Guidelines: Ship Traffic Control for the Sabine-Neches Waterway. Groves, Texas. http://www.Sabinepilots.com/guidelines.htm.

Sabine River Authority of Texas (SRA-TX). 2002. Monthly Water Quality Reports. www.sra.dst.tx.us/.

Saloman, C.H., and S.P. Naughton. 1977. Effects of Hurricane Eloise on the benthic fauna of Panama City Beach, Florida. Marine Biology, Vol 42.

Scroggs, S. 2002. Great Texas Birding Classic Tournament Coordinator. Texas Parks and Wildlife Department. Telephone conversation with K. Martel Goldsmith, PBS&J, Austin, Texas. December 5, 2002.

Shinkle, K.D., and R.K. Dokka. 2004. NOAA Technical Report NOS/NGS 50: Rates of vertical displacement at benchmarks in the lower Mississippi valley and the northern Gulf Coast. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service.

Simon, J.L., and D.M. Dauer. 1977. Reestablishment of a benthic community following natural defaunation. In Belle W. Barauch Institute for Marine Biology and Coastal Research. Ecology of Marine Benthos, 1st ed. University of South Carolina Press, Columbia.

Smeins, F.E., D.D. Diamond, and C.W. Hanselka. 1991. Coastal prairie. Pages 269–290 in R.T. Coupland (editor), Ecosystems of the world: Natural grasslands–introduction and western hemisphere. Elsevier, New York.

Sutherlin, J. 1996. Historical development of the marsh system on the west side of Sabine Lake. Sabine Lake Conference: Where Texas and Louisiana Come Together (conference proceedings). Sabine Lake Conference, Beaumont, Texas. http://nsgl.gso.uri.edu/tamu/tamuw96001.pdf. Publication by Texas A&M University, College Station (TAMU-SG-97-101).

Texas Department of Health (TDH). 2002. Classification of shellfish harvesting areas of Sabine Lake. http://www.tdh.texas.gov/bfds/ssd/sab.html.

Texas Parks and Wildlife Department (TPWD). 1992. Coastal wetlands habitat (CWH) – Lower Neches River. TPWD Resource Protection, Aquatic Studies Branch.

———. 2002. Habitat and land use classification of Cow Bayou, Orange County, Texas (January 3, 2002). TPWD GIS Laboratory, Austin, Texas.

———. 2003. Salt Bayou Open Water Trend Analysis, 2003 and 2004 Revision. GIS Department, Austin, Texas.

———. 2004. Wetland Habitat Map of J.D. Murphree WMA. Texas Parks and Wildlife, Port Arthur, Texas.

———.2005. Land and Water Resources Conservation and Recreation Plan. TPWD, Austin, Texas. http://www.tpwd.state.tx.us/publications/pwdpubs/ media/pwd_pl_e0100_0867.pdf.

Texas Water Development Board (TWDB). 2006. The 2007 State Water Plan. http://www.twdb.state.tx.us/publications/reports/State_Water_Plan/2007/2007StateWaterPlan/2007StateWaterPlan.htm, Chapters 1 (Highlights), 2 (Region I Planning Document), and 3 (Fifty Years of Water Planning in Texas). Adopted November 14, 2006 (accessed January 2007). Austin, Texas.

Titus, J.G., and V. Narayanan. 1995. The probability of sea level rise. U.S. Environmental Protection Agency (EPA), EPA-230-R-95-008.

Törnqvist, T.E., S.J. Bick, K. van der Borg, and A.F.M. de Jong. 2006. How stable is the Mississippi Delta?: Geology 34:697–700, doi: 10.1130/G22624.1.

Tubman, M.W., and J.N. Suhayda. 1976. Wave action and bottom movements in fine sediments. Proceedings of the 15th Coastal Engineering Conference, Honolulu. ASCE, New York.

Turner Collie & Braden. 2003. Sabine-Neches Waterway Feasibility Site Concept, Beneficial Use Development, Prepared for the U.S. Army Corps of Engineers by Turner Collie & Braden, Inc. July 14.

U.S. Army Corps of Engineers (USACE). 1971a. Survey of Holly Beach and Vicinity, Louisiana, Series No. 95. USACE, New Orleans District, Louisiana. 19 p.

———. 1971b. Texas coast shores regional inventory report.: U.S. Army Corps of Engineers, Galveston District. Galveston, Texas.

———. 1975 (reprinted 1984). Final Environmental Impact Statement: Maintenance Dredging Gulf Intracoastal Waterway Texas Section, Main Channel and Tributary Channels. Volumes 1, 2, and 3. Galveston, Texas.

———. 1982. Sabine-Neches Waterway, Texas: feasibility report and environmental impact statement for channel improvements for navigation. U.S. Army Engineer District, Galveston, Texas.

———. 1991. Deep-Draft Navigation Manual. Report 91-R-13. November 1991.

———. 1998. Environmental assessment for a change in location of the Neches River and tributaries, saltwater barrier at Beaumont, Texas. U.S. Army Engineer District, Galveston, Texas.

———. 2000a. Environmental Assessment: Alternate Maintenance Dredging Placement Area for Sabine-Neches Waterway, Texas Point National Wildlife Refuge, Jefferson County, Texas. Galveston District, Southwestern Division, Texas.

———. 2000b. Planning-Planning Guidance Notebook. Proponent: CECW-P. http://www.usace.army.mil/publications/eng-regs/er1105-2-100/toc.htm.

———. 2003. Authorities and Policies Supporting Implementation of Regional Sediment Management. Regional Sediment Management (RMS) Demonstration Program Technical Note. Engineer Research and Development Center (ERDC). ERDC/RSM-TN-8, June 2003.

———. 2004. Louisiana Coastal Areas Environmental Impact Statement. New Orleans District, Corps of Engineers. New Orleans, Louisiana.

———. 2005. "Economic Guidance Memorandum (EGM) 05-01, Deep Draft Vessel Operating Costs FY 2005, General Technical Support Document." U.S. Army Corps of Engineers, Planning and Policy Compliance Division, Planner's Library. http://www.usace.army.mil/cw/cecw-cp/library/egms/egm05-01.pdf.

———. 2006a. "12 Points for Change," USACE Headquarters, Washington D.C., released August 24, 2006.

———. 2006b. 10 Frequently Asked Questions about Regional Sediment Management. USACE. http://www.iwr.usace.army.mil/inside/products/proj/docs_proj/ RSMFAQs-3.doc (accessed on March 25, 2008).

———. 2007a. Waterborne Commerce of the U.S., Part 2, 1965–2007. Waterborne Commerce Statistics Center. New Orleans, Louisiana. http://www.iwr.usace.army.mil/ndc/wcsc/wcsc.htm.

———. 2007b. Memorandum from CECW-CE, Subject: Application of Cost Risk Analysis Methods to Develop Contingencies for Civil Works Total Project Costs, dated July 3, 2007, USACE, Washington, D.C.

———. 2008a. Application of USACE, unpublished update of Economic Guidance Memorandum #08-04, Deep-Draft Vessel Operating Cost FY 2008, December 2008.

———. 2008b. Louisiana Coastal Protection and Restoration Draft Technical Report. U.S. Army Corps of Engineers, New Orleans District.

———. 2009a. Circular No. 1165-2-211, Water Resource Policies and Authorities Incorporating Sea-level Change Considerations in Civil Works Programs, Expires July 1, 2011, EC 1165-2-211, 3 pp. and appendices.

———. 2009b. USACE Campaign Plan. http://www.usace.army.mil/about/campaignplan/Pages/Home.aspx.

U.S. Climate Change Science Program. 2009. Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region. Synthesis and Assessment Product 4.1. 298 pp.

U.S. Coast Guard (USCG). 2004. Automatic Identification System Carriage Requirements. http://www.navcen.uscg.gov/enav/ais/AIS_carriage_reqmts.htm.

———. 2007. "State of the Waterway" presentation by USCG, Marine Safety Office, Port Arthur, at Southeast Texas Waterways Advisory Council meeting. January 28, 2007.

———. 2008a. Vessel Traffic Management, Navigation Center, U.S. Department of Homeland Security, United State Coast Guard. http://www.navcen.uscg.gov/mwv/vts/vts_home.htm (accessed March 9, 2008).

———. 2008b. VTS Port Arthur Operating Procedures Guide. http://www.uscg.mil/d8/VTSPortArthur/Documents/VTS%20Port%20Arthur_Opertating-Guide.pdf (accessed March 9, 2008).

———. 2008c. Actions for Change. Available on the internet at https://maps.crrel.usace.army.mil/ AFC/.

U.S. Department of Agriculture (USDA). 1983. Water Tupelo in the Atchafalaya Basin Does Not Benefit from Thinning. Research Note SO-298, by H. E. Kennedy, Jr.

———. 1990. Silvics of North America. Agriculture Handbook 654, R.M. Burns and B.H. Honkala, technical coordinators. http:// www.na.fs.fed.us/spfo/pubs.

———. 2006. USDA Agricultural Baseline Projection Tables, USDA Baseline Projections Report (OCE-2006-1). Released February 2006/silvics_manual/.

U.S. Department of Commerce and the National Oceanic and Atmospheric Administration. 2006. NOAA Tides and Currents, Sea Levels Online: Mean Sea Level Trends for Stations in Texas. http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml.

———. 2009. NOAA Tides and Currents, Sea Levels Online: Mean Sea Level Trends for Stations in Texas. http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml.

U.S. Department of Energy. 2009a. 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.

———. 2009b. Annual Energy Outlook, March.

U.S. Fish and Wildlife Service (USFWS), U.S. Department of the Interior. 1980. Habitat Evaluation Procedure (HEP) Manual (102 ESM). U.S. Fish and Wildlife Service, Washington, D.C.

———. 2001a. McFaddin National Wildlife Refuge Vegetation/Habitat Units. USFWS – R2 – Division of Technical Services – GIS, September 6.

———. 2001b. Texas Point National Wildlife Refuge Vegetation/Habitat Units. USFWS-R2, Division of Technical Services – GIS, September 6.

———.2002a. The 2001 National Survey of Fishing, Hunting and Wildlife Associated Recreation. http://fa.r9.fws.gov/surveys/ surveys.html. Last revised October 1, 2002.

———. 2002b. Coastal Wetlands Planning, Protection and Restoration Act, Wetland Value Assessment Methodology, Introduction. Prepared by Environmental Work Group, CWPPRA Technical Committee, USFWS, Lafayette, Louisiana.

———. 2002c. Coastal Wetlands Planning, Protection and Restoration Act, Wetland Value Assessment Methodology, Procedural Manual. Prepared by Environmental Work Group, CWPPRA Technical Committee, USFWS, Lafayette, Louisiana.

———. 2002d. Coastal Wetlands Planning, Protection and Restoration Act, Wetland Value Assessment Methodology, Emergent Marsh Community Models. Prepared by Environmental Work Group, CWPPRA Technical Committee. USFWS, Lafayette, Louisiana.

———. 2002e. Coastal Wetlands Planning, Protection and Restoration Act, Wetland Value Assessment Methodology, Swamp Marsh Community Model. Prepared by Environmental Work Group, CWPPRA Technical Committee. USFWS, Lafayette, Louisiana.

———. 2003. "2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Texas"; revised March 2003. http://www.census.gov/prod/2003pubs/01fhw/fhw01-tx.pdf (accessed November 18, 2005).

———. 2004. Final Environmental Assessment: East Sabine Lake Hydrologic Restoration, Project Construction Unit 1 (CS-32), Cameron Parish, Louisiana. 32 p. plus appendices. U.S. Fish and Wildlife Service, Ecological Services, Lafayette, Louisiana.

———. 2005. Threatened and endangered species of Louisiana, parish list. U.S. Fish and Wildlife Service, Louisiana Ecological Services Office, Lafayette, Louisiana. July 14.

———. 2008. Texas Chenier Plain National Wildlife Refuge Complex Final Environmental Impact Statement/Comprehensive Conservation Plan/Land Protection Plan (May) http://www.fws.gov/southwest/refuges/Plan/LINKS.pdf (accessed July 2009). Southwest Region, Albuquerque, New Mexico.

U.S. Fish and Wildlife Service (USFWS) and Texas General Land Office (GLO). 1992. National Wetland Inventory (NWI).

U.S. Geological Survey (USGS) – Louisiana Department of Natural Resources (USGS-LDNR). 1993. Geographic information system land loss and habitat change data. USGS/LDNR GIS Laboratory, Department of Natural Resources, Baton Rouge, Louisiana.

U.S. Geological Survey (USGS) – National Wetlands Research Center. 2004. Louisiana Coastal Areas Mapping Units for the Calcasieu-Sabine Basin. U.S. Department of the Interior, U.S. Geological

Survey, National Wetlands Research Center, Lafayette, Louisiana and Coastal Restoration Field Station, Baton Rouge, Louisiana.

Walther, P. 2005. Personal communication to Janelle Stokes from Pat Walther, USFWS, Texas Point National Wildlife Refuge.

Wamsley, T.V. 2008. Memorandum from CEERD-HR-C to CESWG, Subject: CHL Response to Galveston District Information Request Related to Sabine-Neches Waterway Channel Improvement Project, Draft Feasibility Report, External Peer Review Comments.

Wamsley, T.V., M.A. Cialone, J.M. Smith, J.H. Atkinson, and J.D. Rosati. 2009a. The potential of wetlands in reducing storm surge. Ocean Engineering. DOI 10.1016/j.oceaneng.2009.07.018.

Wamsley, T.V., M.A. Cialone, J.M. Smith, and B.A. Ebersole. 2009b. Influence of landscape restoration and degradation on storm surge and waves in southern Louisiana. Journal of Natural Hazards 51(1):207–224.

Wamsley, T.V., M.A. Cialone and T.O. McAlpin. 2010. Sensitivity Analysis for Sabine-Neches Waterway Navigation Project. USACE, ERDC-CHL, Vicksburg, Mississippi.

Webb, D. 2003. Ship Simulation Study for Sabine-Neches Improvement Project (revised March 2007). Coastal and Hydraulics Laboratory, ERDC. Vicksburg, Mississippi.

Wells, J.T., and G.P. Kemp. 1986. Interaction of surface waves and cohesive sediments: Field observations and geological significance. Estuarine Cohesive Sediment Dynamics, A.J. Mehta, editor. Springer-Verlag, New York. Pp 43–65.

White, R.A., R.A. Morton, and T.A. Tremblay. 1996. Recent wetland losses at the GSU marsh restoration site, Neches River valley. Prepared for TPWD by Bureau of Economic Geology, The University of Texas at Austin.

White, W.A., T.R. Calnan, R.A. Morton, R.S. Kimble, T.G. Littleton, J.H. McGowen, and H.S. Nance. 1987. Submerged lands of Texas, Beaumont-Port Arthur area: sediments, geochemistry, benthic macroinvertebrates, and associated wetlands. Geology Special Publication, Bureau of Economic Geology, The University of Texas at Austin.