Final Report

Phase 2
Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project



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Louisiana Department
of Natural Resources

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Acronyms and Abbreviations

bpd	barrels per day
cfs	cubic feet per second
cm/year	centimeter per year
cy	cubic yard
CWPPRA	Coastal Wetland Planning, Protection, and Restoration Act
DEM	digital elevation model
EFH	essential fish habitat
EPA	U.S. Environmental Protection Agency
GIS	geographic information system
GIWW	Gulf Intracoastal Waterway
GMFMC	Gulf of Mexico Fishery Management Council
HNC	Houma Navigation Canal
LCA	Louisiana Coastal Area
LCWCRTF	Louisiana Coastal Wetlands Conservation and Restoration Task Force
LDNR	Louisiana Department of Natural Resources
LMOGA	Louisiana Mid-Continent Oil and Gas Association
LSUCES	Louisiana State University Center for Energy Studies
m^3/year	cubic meters per year
mcy	million cubic yards
mg/L	milligrams per liter
MMS	Minerals Management Service
MRGO	Mississippi River Gulf Outlet
msl	mean sea level
NAVD	North American Vertical Datum
NGDC	National Geophysical Data Center
NGVD	National Geodetic Vertical Datum
NOAA Fisheries	National Oceanic and Atmospheric Administration Fisheries

NORM	naturally occurring radioactive materials
OCS	outer continental shelf
PPL	project priority list
ppt	parts per thousand
ROW	right-of-way
SAV	submerged aquatic vegetation
TDCC	Third Delta Conveyance Channel
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WCRA	Wetlands Conservation and Restoration Authority
WMA	Wildlife Management Area

SECTION 1.0

Introduction

1.1 Purpose and Objectives

This report documents the second phase of a two-phase, reconnaissance-level evaluation of the Third Delta Conveyance Channel (TDCC) concept. On behalf of the Louisiana Department of Natural Resources (LDNR), CH2M HILL has undertaken this evaluation of the engineering feasibility of the TDCC concept, as originally proposed by Gagliano and van Beek (1999), and of basinwide restoration alternatives to the TDCC that could accomplish the same ecosystem restoration goals as the original TDCC concept.

Development of the TDCC project parallel to Bayou Lafourche is specifically incorporated as a Coast 2050 strategy. The Coast 2050 initiative was formed, in part, by the request of the Coalition to Restore Coastal Louisiana to develop a single, comprehensive, strategic coastal plan. The Coast 2050 initiative is a collaborative planning effort between federal, state, and local agencies, as well as private citizens, academics, and the scientific community. The goal of the Coast 2050 initiative is "to sustain a coastal ecosystem that supports and protects the environment, economy, and culture of southern Louisiana, and that contributes greatly to the economy and well-being of the nation" (Louisiana Coastal Wetlands Conservation and Restoration Task Force [LCWCRTF] and Wetlands Conservation and Restoration Authority [WCRA], 1998).

The TDCC concept proposed by Gagliano and van Beek involves creating a new delta between the Atchafalaya River and Mississippi River deltas. The new delta would have two distinct lobes. It would be formed by sediment carried through a constructed conveyance channel, which would follow the eastern slope of the natural Bayou Lafourche levee system and split into two channels near Raceland. The first channel would terminate in Little Lake in Barataria Basin, and the second would carry sediment to Terrebonne Basin, ending near the Pointe au Chien Wildlife Management Area (WMA), north of Lake Felicity and Lake Raccourci (Figure 1-1). A full description of the TDCC concept is in the report, *Proposed Mississippi River Diversion Channel and Subdelta Building in the Barataria-Terrebonne Area of Coastal Louisiana* (Gagliano and van Beek, 1999). This report is appended to *Coast 2050: Toward a Sustainable Coastal Louisiana* (LCWCRTF and WCRA, 1998).

LDNR authorized this reconnaissance-level evaluation to determine the general feasibility of the TDCC project concept. The Phase 1 evaluation included analysis of the following:

- Engineering design and construction feasibility
- Channel conveyance
- Delta building

To evaluate the general feasibility of the conceptual project, several fundamental questions had to be answered, including the following:

1. Given the underlying geology and constraints in the project area, can the conveyance channel and flood-protection levees be constructed?

2. Is there adequate sediment load in the Mississippi River for delta building at the two sites?
3. Can the sediments be conveyed to the proposed delta areas in the Barataria and Terrebonne Basins?
4. Will the proposed pilot channel erode to the proposed channel capacity and discharge of 200,000 cubic feet per second (cfs)?
5. Will the proposed project result in the formation of new subdeltas on both the Barataria and Terrebonne sides of Bayou Lafourche?

The following results were published in the Phase 1 report:

1. The diversion structure, channel, and flood-protection levees can be constructed. The channel levees can be constructed to U.S. Army Corps of Engineers (USACE) design standards by using in situ materials and typical levee-construction practices.
2. Adequate sediment load is available in the Mississippi River for delta building.
3. Sediment and sand from the Mississippi River and the eroded pilot channel can be transported to the proposed delta-building sites.
4. A pilot channel with a discharge of at least 40,000 cfs is necessary to produce the desired channel erosion.
5. The proposed delta-building sites could potentially receive more sand, retain more sand, and build land faster than is currently being exhibited at the Wax Lake Delta in Atchafalaya Bay (a design example for the TDCC concept).

Phase 1 essentially verified that the TDCC project is technically feasible. Phase 2 focuses on identifying and analyzing alternatives to the TDCC project. At the onset of the Phase 2 evaluation, LDNR emphasized that the alternatives selected must be fundamentally different in nature than the TDCC concept. In other words, modifications to the basic TDCC project criteria (e.g., channel alignment or capacity modifications) would not be considered as alternatives.

The primary objectives of Phase 2 of the project are as follows:

- To develop project alternatives that can accomplish the same ecosystem restoration goals as the TDCC, namely the creation and maintenance of land and a sustainable, diverse ecosystem in the Barataria and Terrebonne Estuaries
- To analyze the engineering, environmental, and economic aspects of the project alternatives and the original TDCC concept
- To document scientific and technical uncertainties associated with implementation of the restoration alternatives for use in guiding future research and analysis

1.2 Approach

Local technical experts and key stakeholders helped identify and evaluate alternatives during a 2-day workshop, held at Nicholls State University in Thibodaux. The first day of

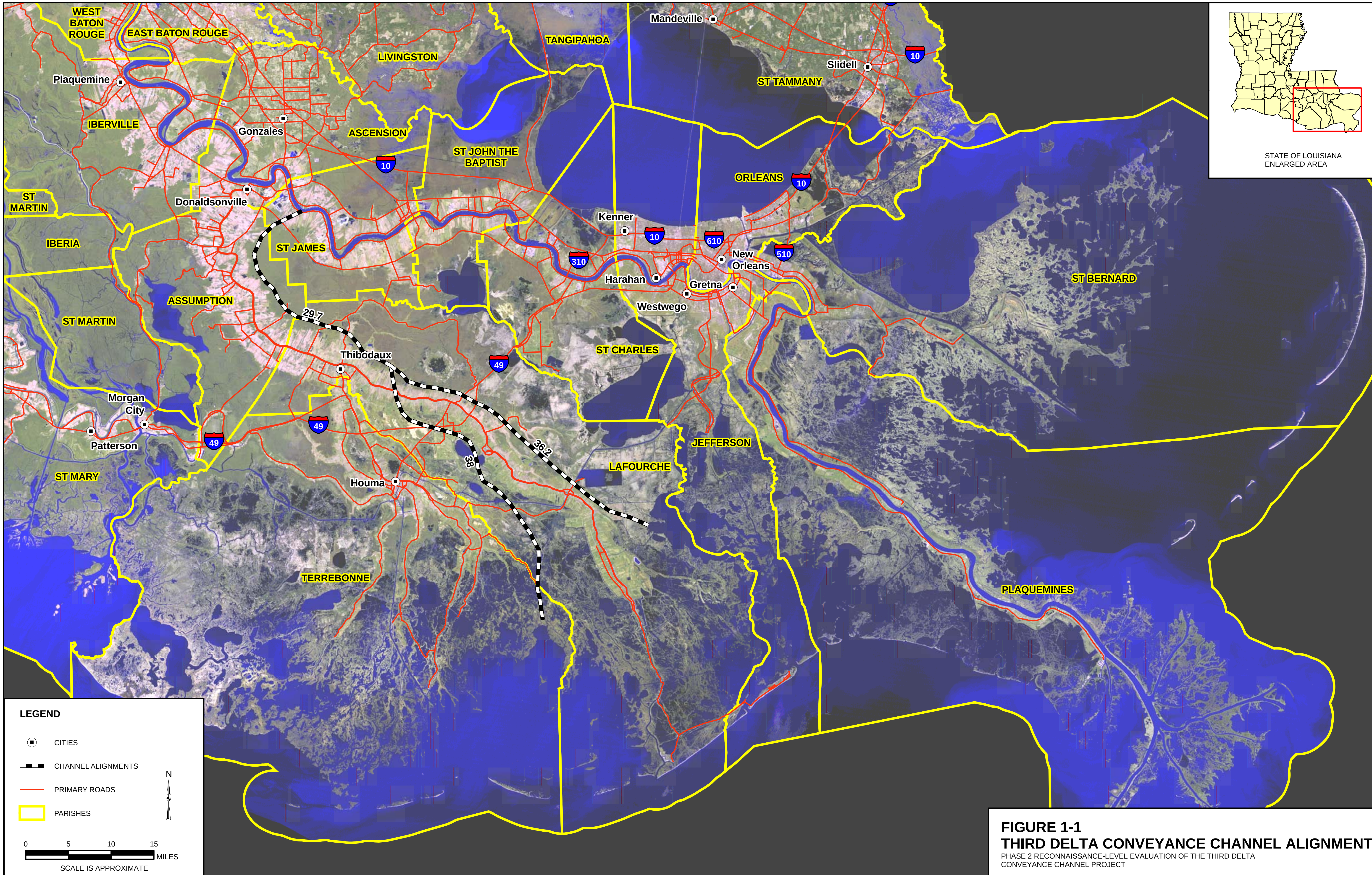

FIGURE 1-1

THIRD DELTA CONVEYANCE CHANNEL ALIGNMENT

PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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the workshop focused on defining project goals, objectives, and performance measures. The second day focused on identifying and refining possible alternatives. The workshop was invaluable in obtaining feedback on project expectations from local experts and stakeholders in preserving Louisiana's coast. It generated many ideas about ways to meet project objectives. The workshop summary is presented in Appendix A to this report. One of the primary workshop conclusions was that a major component of any alternative to the TDCC would include pipeline conveyance of dredged materials from the Mississippi or Atchafalaya Rivers or from offshore sources in the Gulf of Mexico coast. The general approach for the Phase 2 analysis includes the following steps:

- Identify ecosystem restoration project components
- Establish performance measures and evaluation criteria
- Establish the TDCC performance and land-building capacity
- Develop components and establish engineering parameters and design criteria
- Develop project alternatives and evaluate economic and environmental impacts of the TDCC and restoration alternatives
- Identify and document scientific and technical uncertainties associated with the alternatives

This project approach, presented to LDNR in a technical memorandum before analysis began, allowed for an established and endorsed method by which the alternatives developed during this project could be defined, evaluated, and compared to the Phase 1 TDCC concept.

1.2.1 Identify Ecosystem Restoration Project Components

Identification and understanding of key technologies and restoration techniques are necessary to formulate larger scale strategies and alternatives. Project components are the basic coastal restoration technologies and methods that are currently in use or under development. They range from large project features, or diversions, to smaller applications of restoration principles (e.g., marsh ridge restoration or shoreline protection technologies).

1.2.2 Establish Performance Measures and Evaluation Criteria

To compare alternatives, quantitative and qualitative performance measures and evaluation criteria were established. Performance measures were established in the early stages of the project to ensure consistency in the development and evaluation of the alternatives. Figure 1-2 is a preliminary list of performance measures and project expectations, identified during and immediately after the workshops. This initial list of performance measures was identified, using input from the following sources:

- The project expectations and performance measures identified in the Task 1 workshops
- Criteria used in the Phase 1 evaluation (e.g., infrastructure impacts)
- General criteria, such as cost and economic impacts

The performance measures identified include both qualitative and quantitative criteria used to evaluate each alternative. Qualitative evaluations include items such as adaptive management (e.g., degree of adaptability compared to other alternatives), public acceptance,

consumption of limited resources, constructability, and economic impacts. Quantitative evaluations pertain to measurable parameters, such as rate of land gain, environmental impacts, infrastructure impacts, and cost. This initial list was eventually reduced to a smaller number of specific performance measures that could be applied to all the alternatives.

1.2.3 Establish Third Delta Conveyance Channel Performance and Land-building Capacity

The existing TDCC concept was examined to determine its performance relative to criteria such as the rate of land gain, geographic extent of marsh development, and temporal influences of the potential land-building rate of the TDCC relative to ongoing land loss. Defining the land-building performance of the TDCC was necessary so that a baseline could be established against which to measure the alternative restoration plans developed in this evaluation. A comparative study of land-building potential was then conducted for the TDCC and the project alternatives.

1.2.4 Develop Components and Establish Engineering Parameters and Design Criteria

The generalized alternatives identified in the initial planning workshops contain various individual project components, which, when combined, would produce a viable, basinwide ecosystem restoration alternative. For instance, an alternative might contain components such as barrier island restoration, marsh creation with pipeline sediment transport, and increased freshwater diversions for sustainability. An initial step in the project approach was to identify and develop possible project components for use in developing the alternatives. This was done to ensure that each potential component of an alternative would be fully understood and properly characterized.

Alternatives discussed in this report are distinctly different from those developed in the Task 1 workshop because the Task 1 alternatives were characterized and limited by sediment source to generate ideas from workshop participants. Viable alternatives likely will use components from each of the alternatives developed in the Task 1 workshop.

A list of project components is presented on Figure 1-3. The components are grouped into five major categories, as follows:

1. Barriers
2. Marsh/habitat formation
3. Freshwater diversions
4. Sediment conveyance
5. Restorative features

Individual components in each of these categories were characterized to varying levels of detail. For instance, the barrier category includes restoration components, such as barrier island restoration, ridge formation, interbasin barrier berm creation, ridge restoration, subtidal barriers, and rim reinforcement. Performance, effectiveness, construction and design requirements, costs, and other impacts were characterized for each of these components. Component development also included identifying relevant characterization information to logically apply each component to a larger scale alternative.

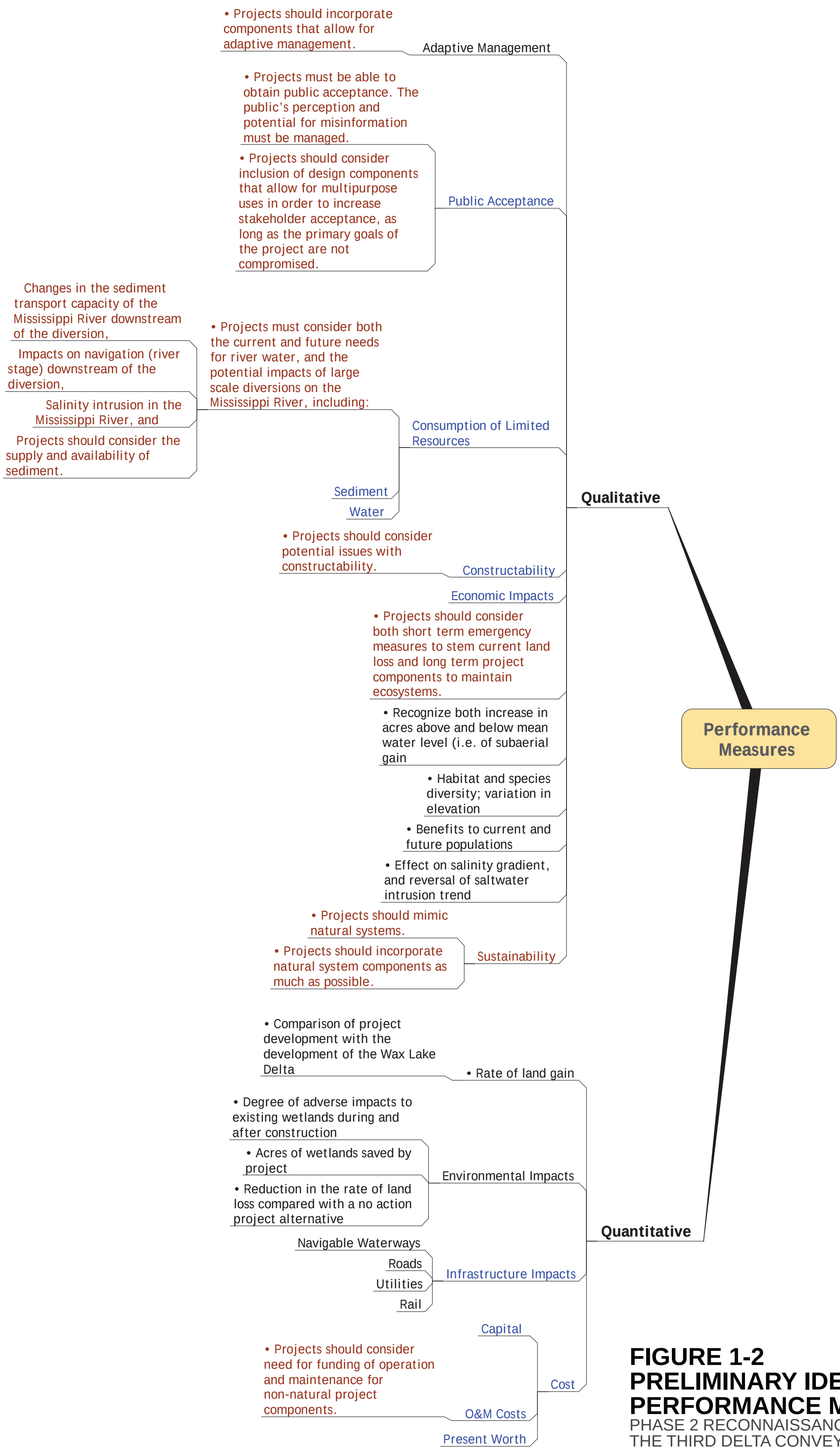

FIGURE 1-2
PRELIMINARY IDENTIFICATION OF PERFORMANCE MEASURES
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

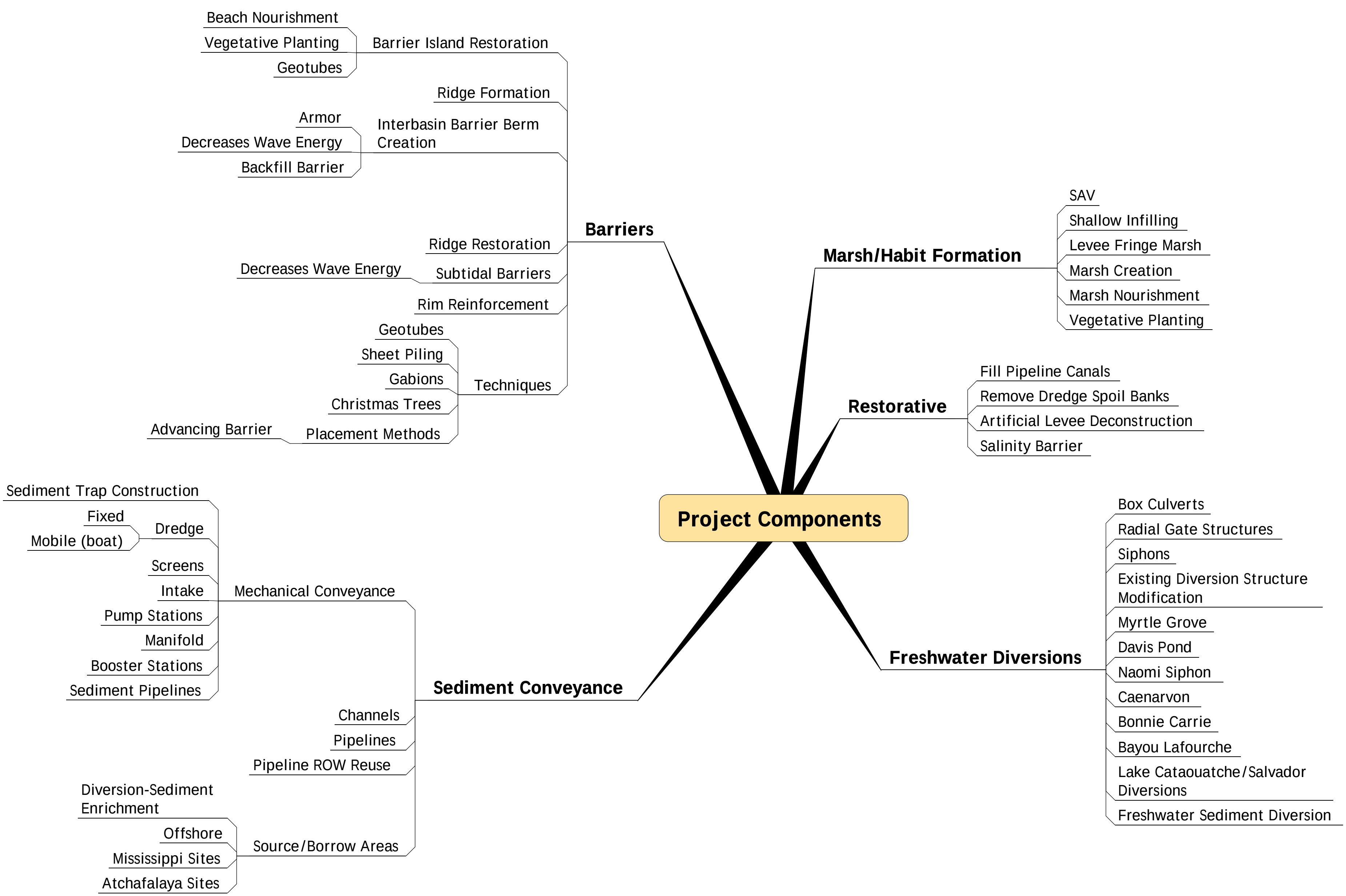

FIGURE 1-3
PROJECT COMPONENTS
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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The components shown on Figure 1-3 may be further researched and developed in future project phases to more fully identify the methods and techniques available for their implementation. Engineering parameters and design criteria will be established for use in decisions regarding sizing, material selection, and design as the alternative development progresses beyond the planning level. For this evaluation, the main focus during component development was fully developing sediment sources and conveyance methods, because these are the primary components of any basinwide ecosystem restoration alternative to be implemented.

1.2.5 Develop Project Alternatives and Evaluate Environmental and Economic Impacts

Three project alternatives were developed. Main attributes of the alternatives considered included cost, limited supply of restoration material, degree of land nourished or created, degree of infrastructure protection provided, degree of hydrologic influence provided, and relative performance compared to the TDCC. New alternatives were developed with the goal of maintaining or exceeding the TDCC level of performance in terms of potential land creation or nourishment.

The alternatives were developed after considering all input, including a menu of project components or features, from the 2-day workshop conducted during the early stages of the Phase 2 evaluation. These components were applied on a basinwide geographic scale, so that the alternatives developed would be applicable basinwide.

After basic criteria and descriptions of the alternatives were established, the alternatives were developed in more detail. This development included establishing technologies, pumping capacities, material sources, volume requirements, and costs. Alternatives were evaluated and differentiated according to the physical constraints imposed by the geography and the supply of restoration material. Environmental and economic impacts were described in relation to Existing Conditions, No Action, the TDCC, and the pipeline conveyance alternatives. Further quantification of performance criteria and environmental and economic impacts made it possible to compare the TDCC and pipeline conveyance alternatives.

1.2.6 Identify and Document Scientific and Technical Uncertainties Associated with the Alternatives

The following types of scientific and technical uncertainties associated with the alternatives were identified as they were developed:

- Type 1 – Uncertainties associated with physical, chemical, geological, and biological baseline conditions
- Type 2 – Uncertainties associated with engineering concepts and operational methods
- Type 3 – Uncertainties associated with ecological processes, analytical tools, and ecosystem response
- Type 4 – Uncertainties associated with socioeconomic and political conditions and response

These uncertainties were identified to clearly identify information gaps for subsequent project development.

SECTION 2.0

Establishment of Performance Measures and Evaluation Criteria

2.1 Introduction

Performance measures used for alternative evaluation and comparison against the TDCC project can be characterized either quantitatively or qualitatively. The goal in developing these performance measures was to identify criteria that address key attributes of the alternatives and can be characterized sufficiently to compare the alternatives in a consistent, unbiased, and systematic manner.

Quantitative performance measures, such as construction cost, are some of the easiest to characterize because of their specificity. Qualitative performance measures, such as adaptive management or public acceptance, are more difficult to rank. Performance measures were identified and characterized, with particular regard for the definability of qualitative measures. In addition, the number of measures was limited to avoid redundancy. The project team worked with the list on Figure 1-2 to refine criteria and create a shortlist of performance measures that would be applied to each alternative to facilitate comparison. The team then defined the final performance measures in greater detail.

2.2 Quantitative Criteria

This subsection discusses quantitative performance criteria used to compare the TDCC project to alternative restoration concepts presented in this report.

2.2.1 Net Land Gain

Net land gain, for a particular point in time, can be defined as the difference between land created (by the project) minus land lost through land-loss processes. The current land-loss rates statewide are on the order of 25 square miles of land per year. The U.S. Geological Survey (USGS) estimates that the average annual statewide wetland-loss rate for the next 50 years will be approximately 10 square miles. This estimate is considerably less than the current land-loss rates, which are, in turn, lower than historical land-loss rates of more than 35 square miles per year. According to "100+ Years of Land Change for Coastal Louisiana" (USGS, 2003) (a geographic information system [GIS]-based analysis), the vast majority of the predicted land loss over the next 50 years is expected to occur in the Barataria and Terrebonne Estuaries. Barataria Basin (Subprovince 2 Figure 2-1) is expected to lose an average of 3.7 square miles of land per year, and Terrebonne Basin (most of Subprovince 3) is expected to lose an average of 4.6 square miles of land per year.

Land creation was estimated for each alternative and the TDCC project. Basinwide net land gain was calculated from land creation estimates and projected land-loss rates. The GIS-based analysis of projected land loss was used to adjust the net land gained per

alternative compared to the future condition with no action. Building land in open water while losing land elsewhere could result in no net land gain; nourishing land projected to be lost would have a positive net land gain. Net land gain (acres or square miles) for each alternative is presented on an annual basis and for the life of the project.

2.2.2 Project Cost

Planning-level costs were estimated for both the TDCC project and the restoration alternatives developed in this study. Total estimated project costs provide a quantitative measurement with which to compare restoration alternatives. Contingencies are included in the estimates, as appropriate, to reflect the planning-level nature of the cost estimates.

Extensive use was made of the following resources in developing planning-level costs:

- Louisiana Coastal Area (LCA) Draft Study, Appendix C – Engineering Investigation
- LCA Final Study, Main Report – Attachment
- Coastal Wetland Planning, Protection, and Restoration Act (CWPPRA) projects
- USACE cost estimates for the TDCC
- Personal communications with USACE personnel

2.3 Qualitative Criteria

This subsection discusses qualitative performance criteria that will be used to compare the TDCC concept to alternative restoration concepts presented in this report.

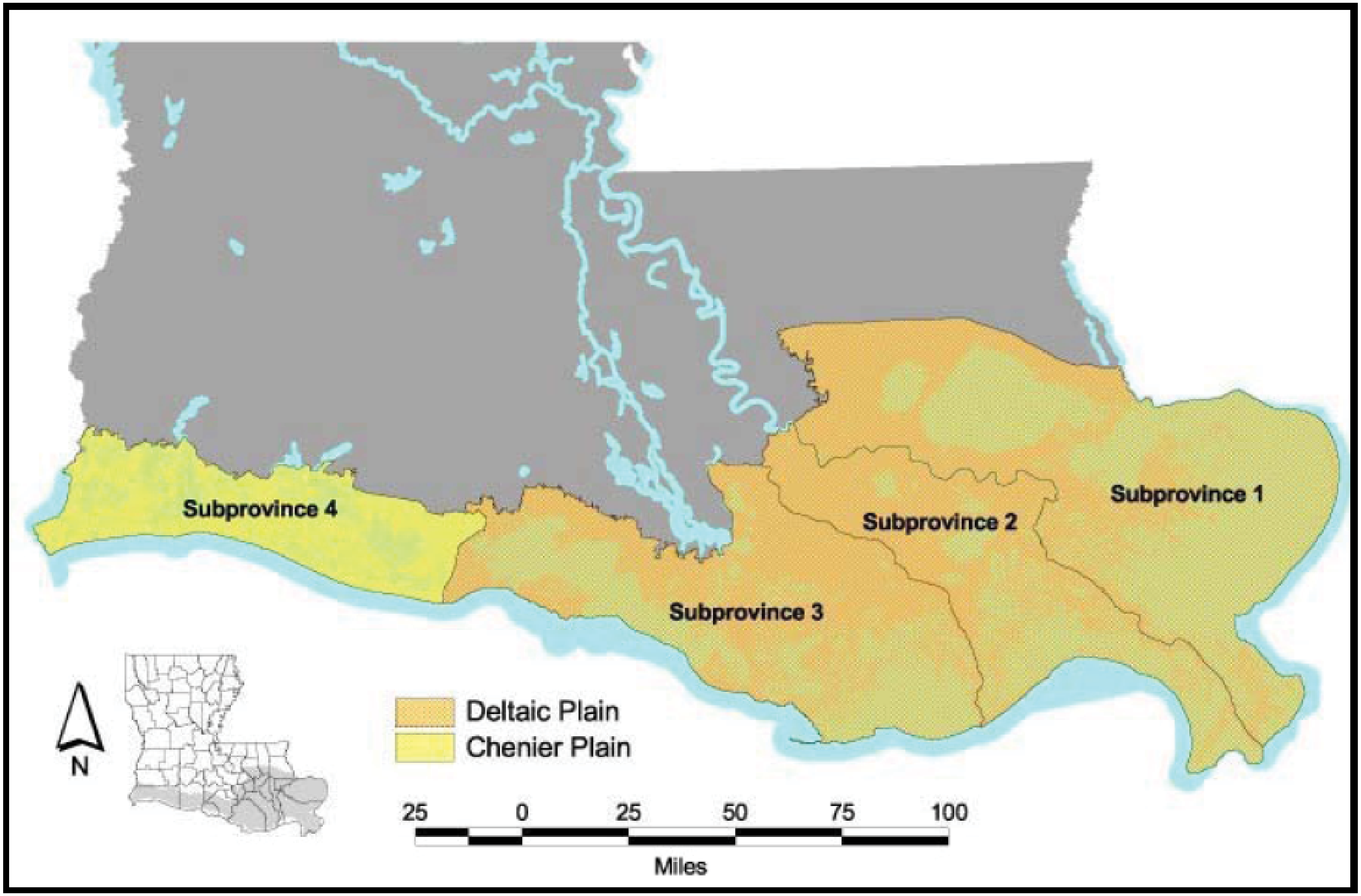
2.3.1 Infrastructure Impacts

Infrastructure impacts for both the TDCC and the restoration alternatives developed in this report were characterized with GIS-based analyses, when possible. With a more detailed level of analysis, infrastructure impacts could be characterized accurately enough to be considered quantitative. However, because detailed information was limited, impacts had to be defined qualitatively. Land use and infrastructure impacts for the TDCC were catalogued in the Phase 1 report (CH2M HILL, 2004), as part of a GIS-based analysis.

2.3.2 Environmental Impacts

For this analysis, environmental impacts are grouped into the following areas:

- Biological environment (wildlife resources, vegetation, and habitat)
- Water quality conditions (primarily salinity)
- Hydrology and coastal processes (hydrology, barrier island development, and sediment resources)
- Historical and cultural resources



Source: LCA Ecosystem Restoration Study Final Report (USACE, 2004)

FIGURE 2-1
LOUISIANA COASTAL AREA STUDY AREA AND SUBPROVINCES
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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Environmental impacts and benefits in these four broad groups are discussed qualitatively for both the TDCC and the pipeline conveyance alternatives.

2.3.3 Adaptive Management

Adaptive management refers to the ability to change operation of or re-engineer a system to adapt to unforeseen events or conditions. For example, a mobile, temporary sediment slurry pipeline would be more adaptable to unforeseen environmental impacts than a permanent sediment conveyance channel. A qualitative discussion of the adaptive management capabilities of both the TDCC and the restoration alternatives is included in Section 5.0.

2.3.4 Public Acceptance

The magnitude and impacts of the restoration projects discussed in this report are of a large scale. Not only will these projects permanently alter the landscape (their intended purpose), they will also require the commitment of significant financial resources. Certain alternatives might be more acceptable than others, depending on the public's perception of the project's impacts on private property, livelihoods, and local culture.

Public acceptance is vital to the implementation and success of a large-scale coastal restoration program and, therefore, is an appropriate performance measure. Characterizing public acceptance is fairly subjective. For this study, public acceptance, both positive and negative, is assumed to reflect the following factors:

- Urban impacts and benefits from construction and related facilities
- Ability to restore wetlands to a degree that more closely reflects historical conditions before major land-loss trends
- Economic costs and benefits resulting from implementation of the particular alternative

2.3.5 Socioeconomic Impacts

Continued degradation of the wetlands in the Barataria and Terrebonne Basins will eventually cause collapse of key economic resources, such as Louisiana's fisheries and petroleum support industry. Such impacts will not only affect the local economies, but will also have state and national repercussions. Socioeconomic costs and benefits from large-scale ecosystem restoration projects are complex and difficult to estimate or project. For this study, socioeconomic costs and benefits are assumed to reflect the following conditions:

- The alternative's influence on fisheries
- The alternative's influence on petrochemical infrastructure
- The alternative's influence on navigation
- The alternative's influence on residential structures

A qualitative discussion of the socioeconomic impacts of both the TDCC project and the alternative restoration projects is included in Section 5.0.

2.3.6 Project/Performance Risk

The level of risk associated with the implementation of a coastwide restoration alternative cannot be quantified by a planning-level study. As a qualitative measure, however,

performance risk can be addressed for both the TDCC and the pipeline conveyance alternatives. Project performance risks were assessed based on the following:

- Constructability – Alternatives will be reviewed based on construction methods used for the particular alternative and the risk associated with those methods.
- Funding – Alternatives will be reviewed based on estimated likelihood of funding.
- Duration – Project duration is an important factor in assessing overall project/ performance risk. The longer project implementation takes, the more land would be lost to coastal erosion processes. The alternatives will be evaluated based on estimated risk associated with project timeline and duration.
- Uncertainties in projected outcomes – Scientific and technical uncertainties exist for all the potential alternatives. Alternatives will be evaluated based on the estimated risk associated with the certainty of projected outcomes or performance of the particular alternative.

SECTION 3.0

Characterization of Third Delta Performance and Land-building Capacity

3.1 Introduction

This section presents land-building capacity estimates of the TDCC concept proposed by Gagliano and van Beek (1999). Estimates account for a 16-year daily varying hydrology in the Mississippi River and the associated diversion into the TDCC, coincident daily sediment data from a calibrated sediment transport model, and bathymetry of the receiving areas provided by the National Geophysical Data Center's (NGDC) Coastal Relief Model, Version 4.1. This analysis established a baseline, or quantifiable set of criteria, which can be used to compare against project alternatives.

3.2 Description of Project Features

The concept proposed by Gagliano and van Beek involves creating a new delta between the Atchafalaya River and the Mississippi River Birdfoot deltas (1999). The new delta would have two distinct lobes. It would be formed by sediment carried through a constructed conveyance channel, which would follow the eastern slope of the Bayou Lafourche natural levee system, and split into two channels near Raceland. One channel would terminate in Little Lake in Barataria Basin, and the second would carry sediment to Terrebonne Basin, ending near the Pointe au Chien State WMA, north of Lakes Felicity and Raccourci.

Following are the conceptual design parameters for the project:

- Initial channel capacity of 20,000 cfs
- Final channel capacity of 200,000 cfs
- Channels to be self-scouring
- A Bayou Lafourche crossing, creating a lake upstream of the crossing
- Gulf Intracoastal Waterway (GIWW) crossing for each channel downstream of the bifurcation
- Reliance on the Wax Lake Outlet as a design analog

3.3 Diversion Capacity

The land-building estimates rely heavily on both freshwater and sediment entering the upstream end of the conveyance channel. This subsection discusses the calculation of both freshwater and sediment inputs into the conveyance channel.

3.3.1 Flow Diversion

The first variable analyzed was the quantity of flow diverted from the Mississippi River into the TDCC. Daily flow data for the Mississippi River at Tarbert Landing for water years 1983 to 1998 were used for this analysis. These data are available online at the New Orleans District, USACE website. This 16-year range is assumed to reasonably represent river flow variance.

Table 3-1 presents the average annual flow in the Mississippi River at Tarbert Landing for the 16-year hydrograph. Figure 3-1 presents the 16-year Mississippi River hydrograph used in this study. Average annual flows ranged from 380,000 cfs in 1988 to 730,000 cfs in 1993. An investigation of annual average flows in the Mississippi River back to 1936 indicates that the 16-year period chosen for this study is representative of long-term average conditions.

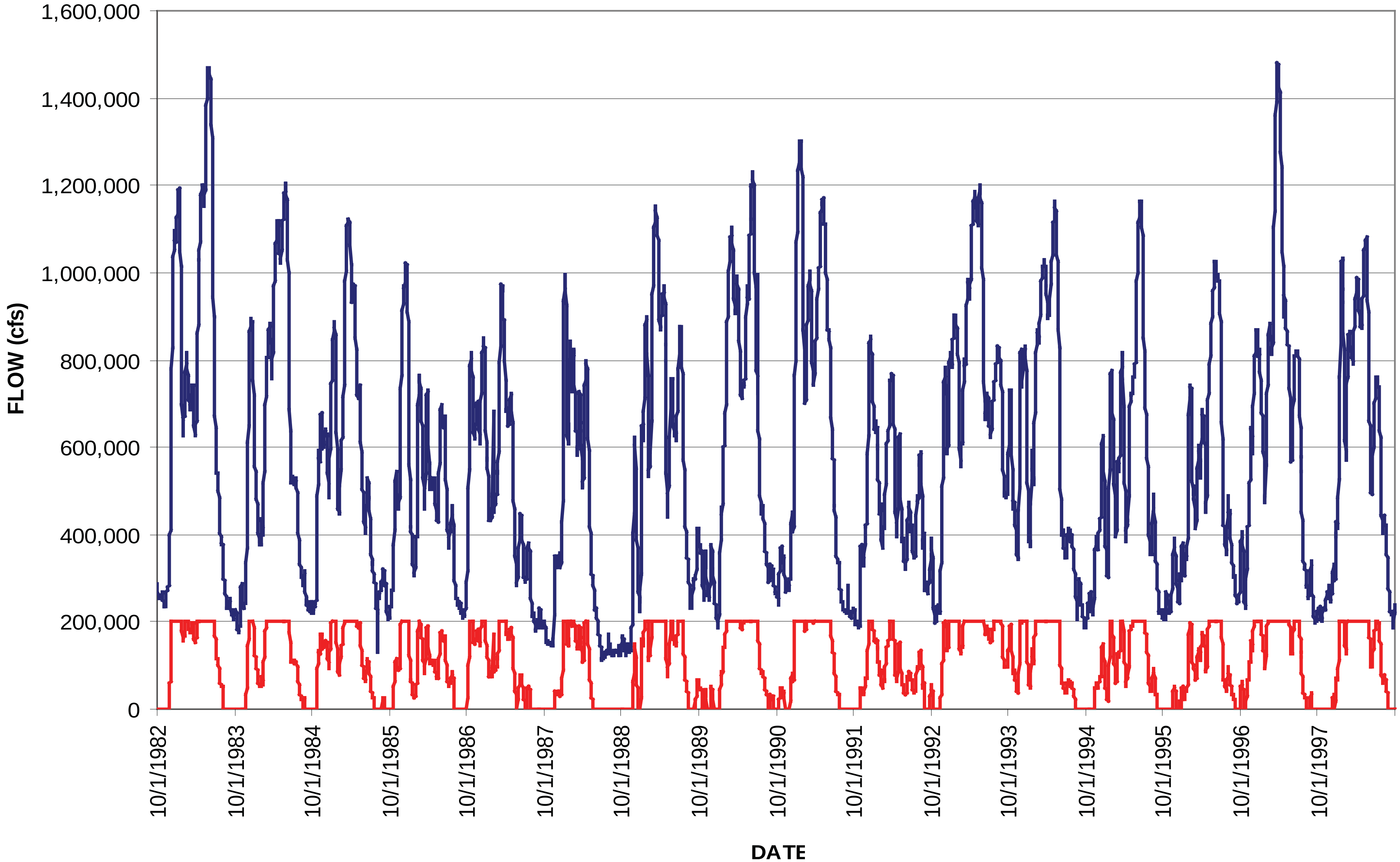
TABLE 3-1
Annual Average Flows in Mississippi River at Tarbert Landing
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Water Year	Average Flow (cfs)	Water Year	Average Flow (cfs)
1983	696,931	1991	630,242
1984	595,064	1992	464,608
1985	563,446	**1993**	**728,248**
1986	502,804	1994	623,309
1987	511,892	1995	532,290
1988	**379,349**	1996	493,189
1989	561,818	1997	673,409
1990	604,592	1998	579,262

Note:
Bold text indicates highest and lowest values.

The original project concept defined a maximum and minimum flow in the TDCC of 200,000 and 20,000 cfs, respectively. To derive the diversion hydrograph from the Mississippi River hydrograph, it was assumed that 40 percent of the Mississippi River flow in excess of 250,000 cfs would be diverted into the TDCC. Considering the 20,000-cfs minimum TDCC flow requirement, diversions would not occur unless flow in the Mississippi River was greater than 300,000 cfs (40 percent of 50,000 cfs equals 20,000 cfs). Diversions reach the maximum of 200,000 cfs when flow in the Mississippi River reaches 750,000 cfs. The diversion hydrograph with the constraints described above is presented on Figure 3-2. A frequency distribution for the flow diverted into the TDCC for this hydrograph is presented on Figure 3-2. For approximately 23 percent of the 16-year planning period (1983 to 1998), Mississippi River flows were below 300,000 cfs and no flows were diverted into the TDCC.

The assumption to divert 40 percent of the Mississippi River flow above 250,000 cfs was made to increase the land-building potential of the TDCC, while maintaining the flow split between the Atchafalaya and Mississippi Rivers at the Old River Control Structure. The assumption for leaving a 250,000-cfs minimum flow was quoted in a previous study addressing freshwater diversions from the Mississippi River. USACE indicated that a flow of 250,000 cfs in the Mississippi River would sufficiently protect freshwater supply from salinity intrusion and provide for safe navigation (Templet and Meyer-Arendt, 1988).



LEGEND

FLOW IN MISSISSIPPI RIVER, TARBERT LANDING

FLOW DIVERTED INTO TDCC

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FIGURE 3-1
FLOW TIME SERIES - 16 YEARS (WY83-98)
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF
THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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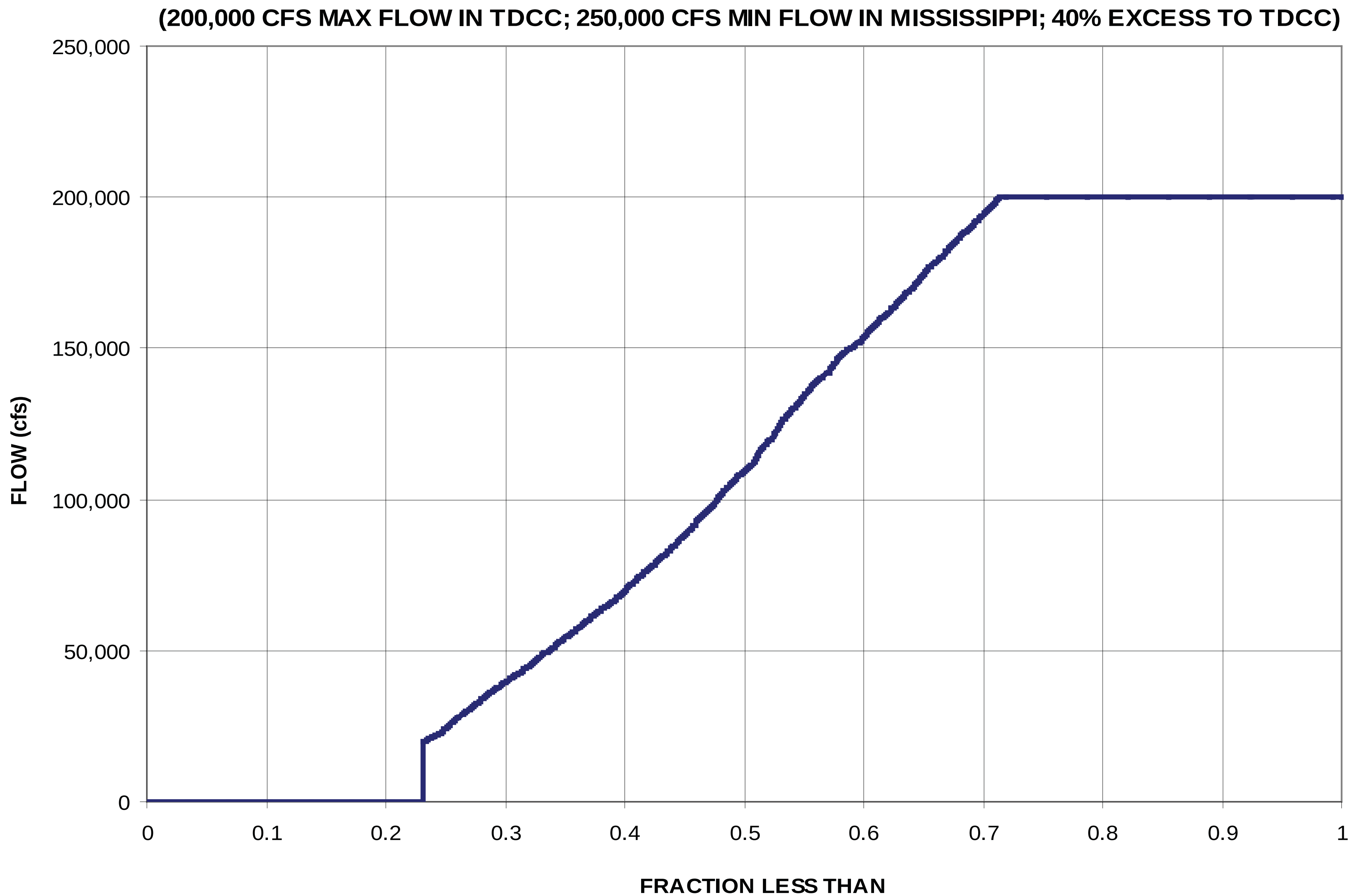

FIGURE 3-2
FREQUENCY DISTRIBUTION OF FLOW INTO TDCC
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF
THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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A second diversion scenario was calculated in which the maximum discharge to the TDCC was raised to 300,000 cfs from 200,000 cfs. Results of the Phase 1 analysis (CH2M HILL, 2004) indicated that increasing the maximum channel capacity could increase the sediment transported to the coast and the potential for land building. The results of this second diversion scenario are provided for comparison.

Table 3-2 presents the annual average flow diverted into the TDCC for the 16-year period. Results are presented for the 200,000 cfs maximum flow diversion baseline and the 300,000-cfs maximum flow diversion scenario.

TABLE 3-2
Annual Average Flows Diverted to the Third Delta Conveyance Channel
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Water Year	Max = 200,000 cfs	Max = 300,000 cfs	Percent Increase
1983	121,533	154,164	27
1984	106,920	132,185	24
1985	108,207	123,124	14
1986	94,783	101,740	7
1987	101,393	107,202	6
1988	**66,038**	70,678	7
1989	109,435	127,212	16
1990	108,199	135,326	25
1991	110,328	141,568	28
1992	85,095	86,518	2
1993	**155,914**	183,883	18
1994	120,919	146,733	21
1995	99,947	110,742	11
1996	85,543	96,995	13
1997	131,234	154,769	18
1998	110,487	131,730	19

Notes:

Bold text indicates highest and lowest values for Baseline scenario.

3.3.2 Sediment Diversion

After the inflow hydrographs for the TDCC were developed, the accompanying sediment inflows were calculated. In the Phase 1 analysis, Tony Thomas of Mobile Boundary Hydraulics provided CH2M HILL with the results of a sediment transport model he developed to route measured sand concentrations at Tarbert Landing to Donaldsonville, near the proposed entrance to the TDCC. Mr. Thomas used the HEC-6T computer program and created a 16-year simulation period (water years 1983 to 1998) (Thomas, 2003). The calibrated NEWCALIB.t5 model was used for this study.

This model was calibrated and verified by the New Orleans District USACE for the 1985 to 1991 period (Thomas, 2003). Model results provided by Mr. Thomas contain daily sediment concentrations broken down by size class (three sand classes and one fines class). The predicted sediment concentrations in the Mississippi River were used to develop the

sediment loads diverted into the TDCC. Initially, two assumptions were made concerning the diverted load: the ratio of the diverted concentration to that in the Mississippi River for both sand-sized sediment and silt/clay sediment. For this report, the sand concentration in water diverted into the TDCC is assumed to be only 90 percent of the sand concentration in the river. Thus, water diverted from the Mississippi River, where the suspended sand concentration was 100 milligrams per liter (mg/L), was assumed to only contain 90 mg/L of sand once in the TDCC. Sediment concentration is expected to increase with depth, and the diversion structure will not be able to divert near-bottom water with the highest sand concentrations. No difference is assumed to exist in the fines concentration between the river and the water diverted into the TDCC. These assumptions are based on measured sediment concentrations in the Mississippi River and downstream of the Old River Control Structure (CH2M HILL, 2004).

Table 3-3 summarizes the average annual sediment transport into the TDCC for the baseline diversion case (200,000 cfs maximum). The annual sediment load carried by the Mississippi River is also presented for comparison. For the baseline diversion, an average of 36.5 million tons of sediment will be diverted into the TDCC each year, with a range of 23.6 million to 50.7 million in the 16-year sample period. This equates to an average of 100,000 tons of sediment per day. This average is sensitive to the assumption relating the suspended sand concentration in the diversion to that of the Mississippi River.

TABLE 3-3
Annual Average Sediment Load in the Third Delta Conveyance Channel and Mississippi River for Baseline Inflow Hydrograph
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Water Year	TDCC	Mississippi River	Percent of Mississippi River
1983	41,914,125	239,253,959	18
1984	40,125,305	217,870,180	18
1985	37,436,020	191,770,369	20
1986	31,378,111	161,926,775	19
1987	34,215,191	166,923,893	20
1988	23,570,647	115,972,505	20
1989	36,865,623	183,539,117	20
1990	37,737,454	205,457,775	18
1991	38,782,714	216,884,057	18
1992	27,098,264	143,792,316	19
1993	50,709,219	239,433,857	21
1994	41,760,351	213,434,377	20
1995	33,594,212	176,766,077	19
1996	28,813,066	159,919,331	18
1997	44,025,614	230,620,320	19
1998	36,261,409	185,889,554	20

Note:

Flows: 200,000 cfs maximum in the TDCC; 250,000 cfs minimum in Mississippi River.

3.4 Land-building Capacity Estimates

Net land-building capacity estimates were calculated for the TDCC. These calculations account for current estimates of future land loss, impacts during conveyance channel construction (project footprint), and estimates of gross land-building potential of the TDCC. A correction for subsidence is provided to bookend the analysis.

The land-building estimates are sensitive to certain variables used in the calculations. Assumptions were made to quantify the following:

- Water and sediment diverted into the TDCC
- Sediment retained in the receiving areas
- Average depth at the receiving locations
- Deposition patterns of delta formation

3.4.1 Project Footprint Impacts

The Phase 1 report (Task 3 – Engineering Design and Construction Feasibility) contains a detailed discussion of the project footprint and a full catalogue of the major impacts to infrastructure, development, and natural resources along the right-of-way (ROW) for the proposed TDCC. A brief summary of that discussion is provided in this subsection. Findings of the ROW analysis are representative of an alignment that generally follows the route identified by Gagliano and van Beek (1999). Limited modifications were made in an effort to avoid major impacts.

For evaluation and catalogue purposes, the TDCC is divided into three primary channel reach lengths, as shown on Figure 3-3. River stationing is defined as and referred to throughout this report in terms of miles from the point of diversion at the Mississippi River (i.e., Station 10+10 represents 10.10 miles).

Reach 1 begins at the diversion structure downstream of Sunshine Bridge, in Donaldsonville. River Station 0+00 represents the diversion on the western bank of the Mississippi River. Reach 1 terminates at the bifurcation point at approximately River Station 30+00, where the TDCC splits into Reaches 2 and 3. Reach 2 continues southeast through the Barataria Basin. Reach 3 follows a more southerly route, crossing Bayou Lafourche into the Terrebonne Basin.

Reach 2 extends from River Station 30+00 along a primarily southeastern route, generally parallel to the existing natural levee of Bayou Lafourche. It extends along the northeastern fringes of development in the townships of Raceland, Mathews, and Lockport. Reach 2 crosses Company Canal between River Stations 48+00 and 49+00 and the GIWW at River Station 54+00 before terminating at Little Lake at River Station 67+00.

Reach 3 extends south from River Station 30+00, across Bayou Lafourche, and into the Terrebonne Basin. Downstream of the bifurcation, Reach 3 crosses the Bayou Lafourche levee at River Station 33+00, Company Canal at River Station 48+00, and the GIWW at River Station 53+00, before entering the Pointe au Chien WMA near River Station 58+00. Once clear of Bayou Lafourche, Reach 3 affects markedly lower density areas than Reach 2 and terminates at River Station 68+00 at Lake Felicity.

Land Use and Coverage Impacts

Construction of the TDCC would directly affect over 19,000 acres (30 square miles). This estimate conservatively assumes that the width of the ROW, including the levees, is 1,500 feet over the 105-mile route. The minimum vacated area would have direct impacts on a wide range of existing land uses, each having specific mitigation needs. Figure 3-4 shows the channel alignment, with colors representing the land use types affected along the length of the channel. Table 3-4 summarizes potential direct and indirect land use impacts.

TABLE 3-4
Summary of Land Use Impacts
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

	Land Use					
	Developed	**Undeveloped**	**Open-water Bodies (Lakes)**	**Watershed/Isolated Acreage**	**Refuge**	**WMA (acres)**
Reach 1	735 acres ~13.2%	4,770 acres ~86%	45 acres ~0.8%	Barataria 57,600	NA	0
Reach 2	1,320 acres ~20%	5,783 acres ~78.3%	113 acres ~1.7%	Barataria 30,000	NA	0
Reach 3	>1,191 acres ~18%	4,778 acres ~71%	769 acres ~11%	Terrebonne >6,500	NA	1,200
Total	>3,200 acres (5 square miles)	15,331 acres (24 square miles)	927 acres (1.4 square miles)	94,100 acres (147 square miles)	NA	1,200 acres (1.9 square miles)

Developed Property. The proposed route of the TDCC would affect more than 3,200 acres (5 square miles) of developed property. Developed land includes private and public lands altered by human uses, such as commercial, municipal, high- and low-density residential, and agricultural.

Although no township main streets or city centers would be directly affected along the proposed TDCC route, relatively significant impacts are anticipated in some areas. Because of the anticipated population concentration and development along the river, improved waterways, canals, and highway junctures, the TDCC would require mitigation measures. The TDCC project would result in approximately 1,000 acres of direct impacts in the following four concentrated areas:

- Adjacent to the Mississippi River
- Regional highway crossings along River Stations 20+00 to 28+00 on Reach 1
- Crossing of Highway 90 along River Stations 40+00 to 43+00 of Reach 2, near Raceland Township
- Crossing of Bayou Lafourche levee between River Stations 31+00 and 36+00 of Reach 3, east of Thibodaux Township

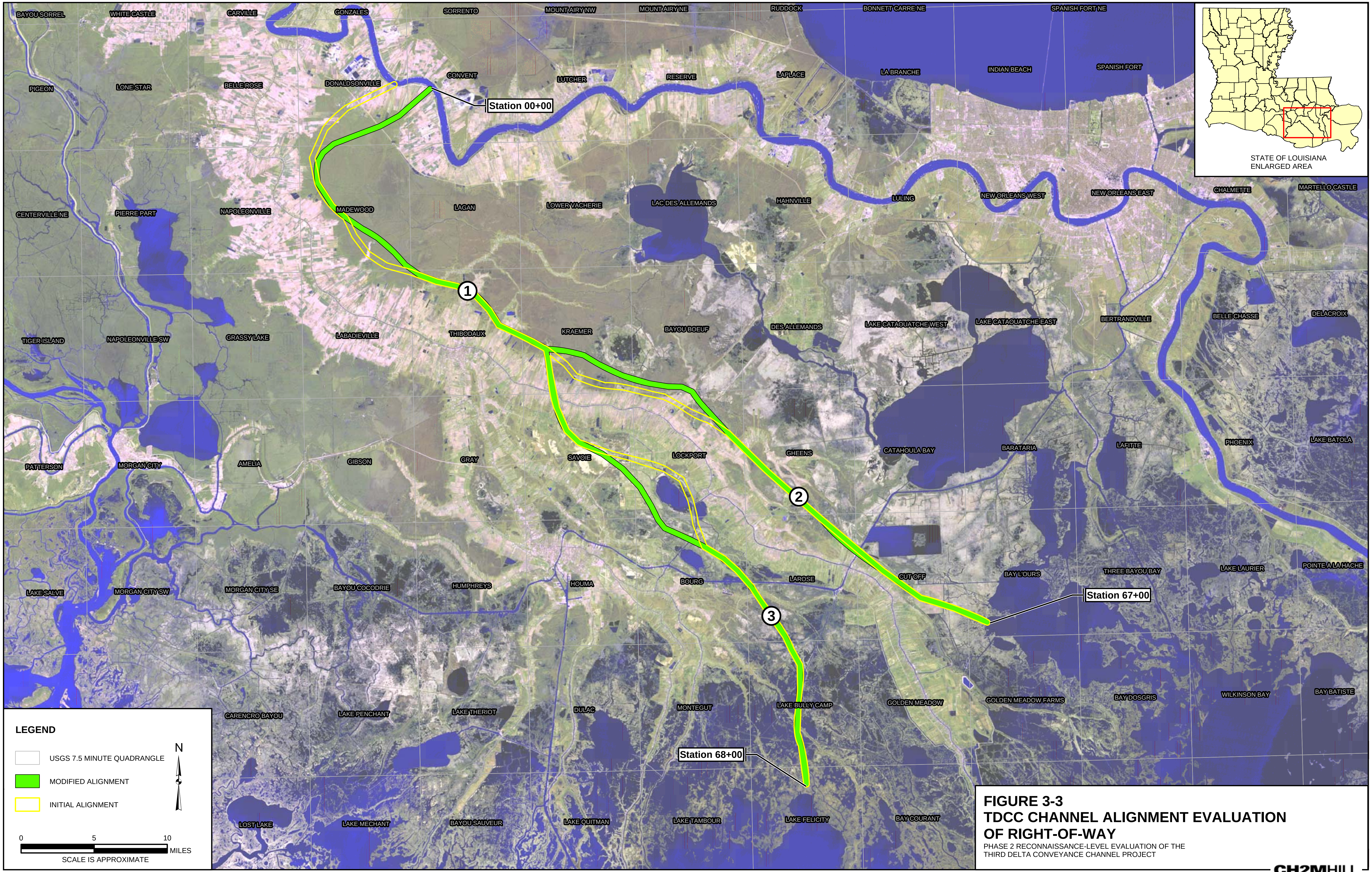

FIGURE 3-3
TDCC CHANNEL ALIGNMENT EVALUATION OF RIGHT-OF-WAY
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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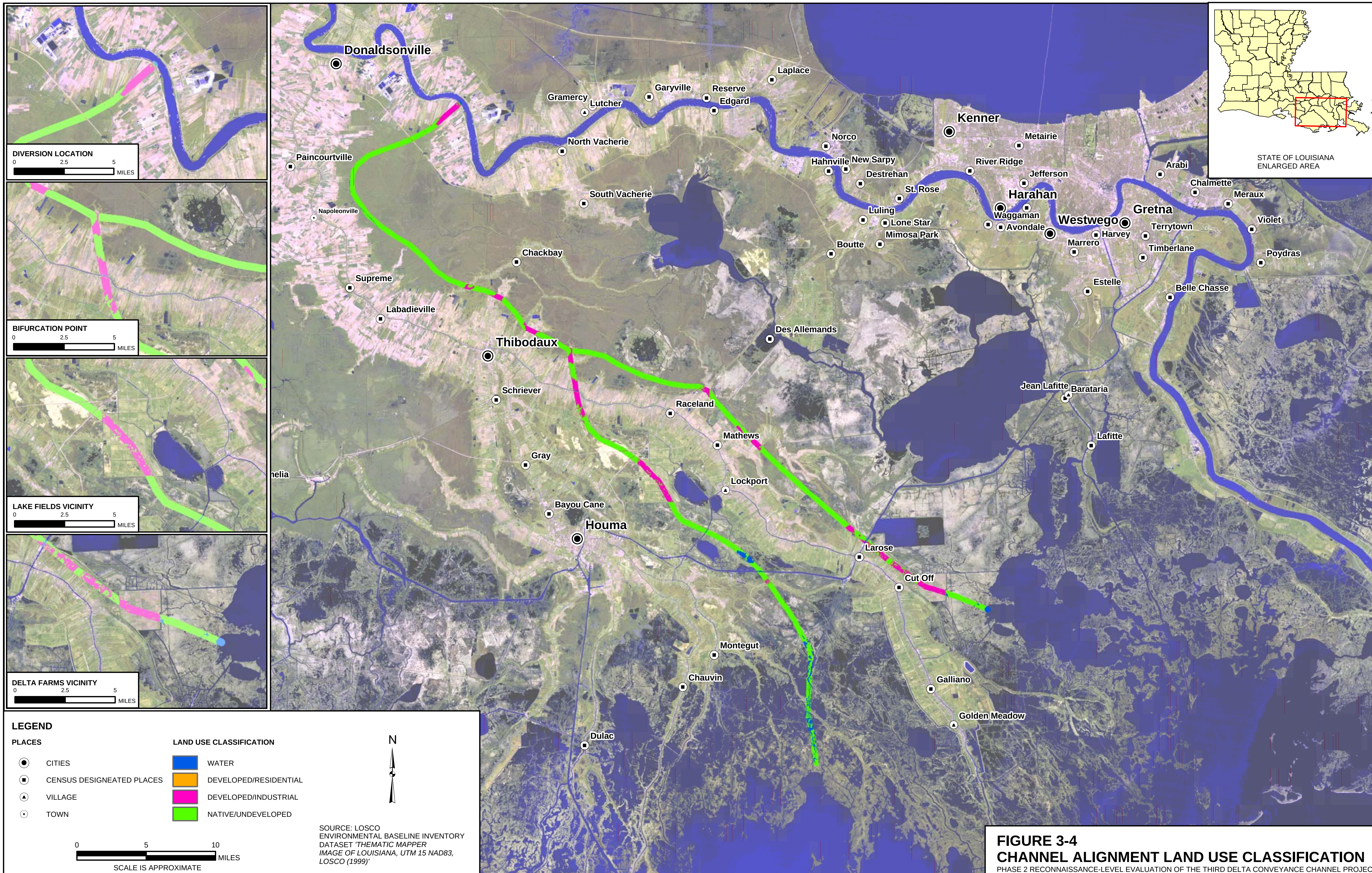

FIGURE 3-4
CHANNEL ALIGNMENT LAND USE CLASSIFICATION
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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Undeveloped Property. The TDCC project potentially could affect approximately 15,300 acres (24 square miles) of undeveloped property. Based on initial review, approximately 80 to 95 percent of the undeveloped land is identified as emergent wetland or woody wetlands. The remainder of the undeveloped property includes lowland grasslands and sloughs, swamp areas, and other natural waterway canals and marshland.

Six designated refuges and WMAs are widely distributed across the Barataria and Terrebonne watersheds. The Pointe au Chien WMA is composed of approximately 32,000 acres of protected emergent wetland, canals, and open water. Approximately 1,200 acres of the Pointe au Chien WMA would be affected by the route of the TDCC along a 5-mile length of Reach 3, near the terminus discharge into Lake Felicity.

Open-water Impacts. The proposed TDCC extends adjacent to and potentially through a number of open-water resources along the 105-mile route. The proposed TDCC alignment would directly affect approximately 900 acres (1.4 square miles). Potential impacts are anticipated to occur in the following areas:

- River Station 56+00 to River Station 61+00 of Reach 2, extending to the south of Delta Farms would affect numerous related open-water areas in the immediate vicinity.
- River Station 50+00 to River Station 65+00 of Reach 3, extending south from Lake Fields would affect numerous bayous and open-water areas, including Bayou Pointe au Chien, Bayou Jean Lacroix, Bayou Blue, Grand Bayou Canal, and the Pointe au Chien WMA.

Drainage. The proposed TDCC alignment roughly parallels Bayou Lafourche. The construction of a flood control levee would intercept natural runoff from land along the Bayou Lafourche Ridge. Within the Barataria Basin, a drainage area of 94,000 acres (147 square miles) would be affected along Reaches 1 and 2. A system of collector ditches and pump stations might be required to convey the water to the TDCC. Specific requirements will depend on the operating water surface elevations in the channel and will be a consideration in channel design.

3.4.2 Projected Land-loss Rates

Projected future land-loss rates were used to define future conditions with no action to provide a basis for comparing various ecosystem restoration proposals. The most recent estimates of projected land loss in the Louisiana coastal zone were compiled by USGS and discussed in Appendix B of the LCA Study (Barras et al., 2003). USGS conducted a detailed GIS-based analysis with digitized aerial photographs and USGS Lands at Thematic Mapper satellite imagery.

Tables 3-5 and 3-6 summarize the results of the USGS analysis. Table 3-5 summarizes historical land-loss trends by subprovince and Table 3-6 summarizes projected future land-loss trends by subprovince (Figure 2-1). The Barataria Basin is Subprovince 2, while the majority of Subprovince 3 is the Terrebonne Basin.

TABLE 3-5
Net Land-loss Trends by Subprovince from 1978 to 2000
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Subprovince	1978 – 1990 Net Loss (square miles)	1990 – 2000 Net Loss (square miles)	1978 – 2000 Net Loss (square miles)	1978 – 2000 Annual Loss (square miles)	Percent Total Loss by Area
1	52	48	100	4.5	15.2
2	148	65	213	9.7	32.4
3	134	72	206	9.4	31.3
4	85	54	139	6.3	21.1
Total	**419**	**239**	**658**	**29.9**	**100**

Source: Barras et al., 2003.

TABLE 3-6
Projected Net Land-loss Trends by Subprovince from 2000 to 2050
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Subprovince	Land in 2000 (square miles)	Land in 2050 (square miles)	Net Land Loss (square miles)	Percent Land Loss Between 2000 and 2050	Land Loss (square miles/year)	Percent Total Loss by Area
1	1,331	1,270	61	4.61	1.23	12
2	1,114	928	186	16.68	3.71	36
3	1,975	1,746	229	11.59	4.58	45
4	1,431	1,394	37	2.59	0.74	7
Total	**5,851**	**5,338**	**513**	**8.77**	**10.26**	**100**

Source: Barras et al., 2003.

Statewide land-loss rates (1990 to 2000) are approximately 24 square miles per year, with almost 14 square miles per year of loss in Subprovinces 2 and 3 (Barras et al., 2003). The current rate is considerably smaller than the average loss rate from 1978 to 1990 (35 square miles per year, with 23.5 square miles in Subprovinces 2 and 3), indicating that the land-loss rate is decreasing.

Projected coastwide land losses total 10.26 square miles per year, on average, for the next 50 years. Projected land losses in the Barataria Basin (Subprovince 2) are expected to average 3.71 square miles per year for the next 50 years; while losses in Subprovince 3 (containing Terrebonne Basin) are expected to average 4.58 square miles per year. More than 80 percent of the projected land loss in Louisiana is expected to occur in these two subprovinces.

3.4.3 Estimated Land Gain

Annual average sediment transport for the baseline (200,000 cfs maximum flow) TDCC is approximately 36.5 million tons. Assuming the newly deposited sediment has a specific gravity of 1.4, it will take 1.13 tons of material to fill in one cubic yard. Thus, in an average year, 32.3 million cubic yards (mcy) can be filled in by sediment transported down the TDCC, assuming no losses, subsidence, or compaction. However, a portion of the sediment

will stay in suspension and be carried out to sea. Previous work has demonstrated that the trapping efficiency in Atchafalaya Bay is approximately 25 to 40 percent (previous work determined that, of the sediment carried through the lower Atchafalaya River and the Wax Lake Outlet, only 25 to 40 percent was deposited in Atchafalaya Bay) (CH2M HILL, 2004).

Land created by the TDCC would not exceed the predicted loss rate in Barataria and Terrebonne Basins, assuming reasonable retention rates of 35 to 50 percent and fill depths between 3 and 6 feet. Considering an average, basinwide subsidence of 4 feet per century (Penland et al., 1989), the land growth estimates can be corrected, assuming an additional 0.8 foot of subsidence every 20 years. Therefore, current best estimates for delta growth are between 1 and 2 square miles of land per year per delta lobe.

Table 3-7 presents the volume required to fill an acre of open water with various depths. For the shallow open-water areas targeted for land growth, the average fill depths of 3 to 6 feet indicate that between 3,000 and 10,000 cubic yards of material are required for every acre of marsh created. Table 3-7 also includes an estimate of the annual amount of land that the TDCC could build with 50 and 35 percent sediment retention. Land-building estimates are sensitive to the assumed retention rate. Because the sediment carried through the TDCC is larger, on average, than the sediment exiting into Atchafalaya Bay, and because the receiving areas of the TDCC are more protected from wind and wave energy than Atchafalaya Bay, it is assumed that the TDCC receiving areas will trap sediment more efficiently than Atchafalaya Bay. A trapping efficiency of between 35 and 50 percent is assumed to be reasonable for the TDCC receiving areas. Calculations in Table 3-7 reflect the baseline (200,000 cfs maximum flow) scenario.

TABLE 3-7
Volume Required for Land Creation Based on Depth and Estimates of Land-building Capacity of the Third Delta Conveyance Channel
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Average Fill Depth (feet)	Sediment Volume required to create 1 acre (cubic yards)	Land-building Capacity of Final TDCC (square miles per year)	
		50 percent Retention	35 percent Retention
3	4,840	5.21	3.65
4	6,453	3.91	2.74
5	8,067	3.13	2.19
6	9,680	2.61	1.82

As previously detailed, land loss in the Barataria and Terrebonne Basins averages approximately 8.3 square miles per year, or 5,312 acres per year (Barras et al., 2003). USGS calculated these rates as average annual expected land-loss rates through the year 2050. For this study, the land-loss rates are assumed to be valid through 2100, because previous investigations have demonstrated that the TDCC eroding to full capacity could take up to 40 years (CH2M HILL, 2004). The original concept paper (Gagliano and van Beek, 1999) provided a similar estimate of 50 years for the channel to erode to its maximum capacity. Extending the project horizon to 50 years would allow for the TDCC to contribute as a fully functioning system and not one that is still evolving from its initial capacity.

The land-building capacity of the 36.5 million tons of sediment carried by the TDCC on an average year (summarized in Table 3-7) demonstrates that the TDCC can build a maximum

of 5.2 square miles of land per year, if 50 percent of the sediment material transported to the receiving areas remains at the receiving areas and the average fill depth at the receiving areas is 3 feet. For more realistic depths (6 feet of fill), the TDCC can build a maximum of 2.6 square miles of land per year, with a retention rate of 50 percent, and 1.8 square miles of land per year, with a retention rate of 35 percent. These calculations assume that the land created by the TDCC does not influence the predicted continual loss of 8.3 square miles of land per year in the two basins. Furthermore, the land-building rates are considered maximum rates because no compaction or subsidence is taken into account. Finally, the placement calculations represent vertical thickness of fill placed, such that a placement to 2 feet above mean sea level (msl) in 4 feet of water would require 6 feet of fill.

The assumed lack of influence of the TDCC on predicted loss rate (i.e., the loss of 8.3 square miles of land per year will continue while the TDCC builds land elsewhere) ignores the contribution of the TDCC in maintaining existing wetlands through the distribution of suspended sediments throughout the basin. A portion of the material transported to the coast and assumed lost from the delta-building regions adjacent to the channel terminus will actually be dispersed and settle out in existing wetlands. The difficulty in quantifying such an influence led to this assumption.

Table 3-8 summarizes the CWPPRA marsh creation projects conducted in southeastern Louisiana in the past decade to compare the fill required in real-world restoration projects. The total volume of sediment delivered to the site and the total acres created during the project are listed, providing a range of estimates of how many cubic yards of material are required to create an acre of marsh. As demonstrated in the table, recent project experience indicates that an average of 4,400 cubic yards are required to build an acre of marsh; the range is approximately 2,000 to more than 10,000 cubic yards per acre.

TABLE 3-8
Comparison of Recent Wetland Creation Projects in Coastal Louisiana
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Project	Year	Sediment Volume (cubic yards)	Acres	Cubic Yards per Acre
Bayou Labranche Wetlands Creation	1994	2,500,000	300	8,333
Atchafalaya Sediment Delivery	1998	720,000	185	3,892
Big Island Mining	1998	3,400,000	922	3,688
Lake Chapeau	1999	500,000	260	1,923
Dustpan Dredge Demo Project	2002	220,000	20	11,000
Sabine Refuge Marsh Creation	2002	1,000,000	200	5,000
Total		**8,340,000**	**1,887**	**4,420**

After the land-building capacity of the TDCC was converted to annual square miles, time-series graphs were constructed to compare the land loss in Terrebonne and Barataria Basins until 2100. The predicted loss rate of 8.3 square miles per year is assumed constant and not reduced by the TDCC project. This is a simplification of projected land-loss rates, because rates in the past decade were approximately 13.7 square miles per year. The cumulative land loss is shown as a change from the land present in 2005.

Figures 3-5 and 3-6 were constructed with two additional assumptions: (1) designing, permitting, and constructing the TDCC will take 15 years, and (2) an additional 40 years will be needed for the channel to evolve to its full capacity. These estimates imply that the TDCC will not be operational until 2020, by which time 125 square miles of land will have been lost; and the TDCC will not be fully functional until 2060, by which time 457 square miles will have been lost in the future conditions with no action scenario. Calculations summarized in Figures 3-5 and 3-6 reflect the baseline (200,000 cfs maximum flow) scenario.

Figure 3-5 demonstrates that, for a reasonable range of fill depths (3 to 6 feet) and a retention assumption of 50 percent, by 2060, the TDCC will have reduced the land loss by 26 to 82 square miles from a baseline of 457 square miles. Figure 3-6 indicates that, if the retention rate is lowered to 35 percent, the land built by the TDCC between 2020 and 2060 would only be 48 square miles, assuming an average 3-foot-thick placement. Both time-series plots account for the additional land loss during project construction (project footprint). As the TDCC fills in shallow areas near the terminus of the constructed channel, the average depth to be filled in (the inland portions of Terrebonne and Barataria bays) inevitably will increase and the rate of land gain will decrease.

Visualization of Land Gain

A tool has been developed to estimate and visualize the rough evolution of land creation from the TDCC. The NGDC's Coastal Relief Model was used to develop a digital elevation model (DEM) on a square grid, with 6-arc-second (600 feet) spacing. This DEM was then brought into Microsoft Excel, along with a JPEG image of a satellite photo mosaic of coastal Louisiana. The JPEG image was prepared in GIS, such that the portions of the image representing open water, based on elevations in the DEM, were set as transparent. Figures 3-7 and 3-8 show the bathymetry in Terrebonne and Barataria Basins, respectively, as represented in the DEM. The figures only show water depth; surface topography has been replaced with the satellite image.

The tool tracks the volume and surface area within a user-defined boundary in one of two distinct 600- by 600-foot grids representing Terrebonne and Barataria Basins. Figure 3-9 shows the tool being used to estimate the volume of Lake Felicity in Terrebonne Basin, near the terminus of the proposed western branch of the TDCC. The tool gives a volume of 85 mcy and a 15.9-square-mile surface area for the shaded portion.

Table 3-9 summarizes the sediment delivered to both lobes (not each lobe) of the TDCC for an assumed 40-year period in which the TDCC evolves to full capacity. Also included is an estimate of the material that would erode from the channel during the period. This estimate was made from the length of the channel and the difference between the 20,000-cfs cross section and the 200,000-cfs cross section. Information defining the original and final channels, as presented in the concept report, indicate that approximately 550 mcy of material will erode during the channel evolution phase of the project. It is also assumed that the channel will be stable after the 40-year period of evolution. The values presented in Table 3-9 are cumulative; the total contribution from channel erosion, for example, no longer increases past 550 mcy (year 2060). Table 3-10 presents the sediment retained at the receiving sites for two assumed retention rates, 50 and 35 percent. Values in Table 3-10 are totals for both lobes, not each individual lobe.

TABLE 3-9
Cumulative Sediment Delivered to Both Receiving Areas
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Year	Cumulative Sediment Carried Through TDCC from Mississippi River (mcy)	Cumulative Contribution from Erosion of Channels (mcy)	Cumulative Total Sediment to Both Receiving Areas (mcy)
0 (2020, completion of construction)	0	0	0
20 (2040)	186	275	461
40 (2060, end of channel evolution phase)	694	550	1,246
60 (2080)	1,340	550	1,890
80 (2100)	1,986	550	2,536

TABLE 3-10
Cumulative Sediment Delivered and Retained at Both Areas
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Year	Cumulative Total Sediment to Both Receiving Areas (mcy)	Cumulative Sediment Retained at 50% (mcy)	Cumulative Sediment Retained at 35% (mcy)
0 (2020, completion of construction)	0	0	0
20 (2040)	461	231	161
40 (2060, end of channel evolution phase)	1,246	623	436
60 (2080)	1,890	945	662
80 (2100)	2,536	1,268	888

Figure 3-10 presents a simplistic rendering of the potential delta growth in Terrebonne Bay, assuming the terminus of the TDCC is in Lake Felicity. One half of the total sediment retained (see Table 3-10) was applied to this delta lobe. An assumed retention rate of 50 percent was applied. To visualize the possible delta growth, the delta is assumed to progress in a somewhat predictable pattern and some training of the delta may be undertaken. The following colors mentioned in Figure 3-10 represent successive 20-year snapshots of delta growth:

- Red represents year 2040, 20 years after initial diversions begin
- Orange represents year 2060, after 40 years of channel evolution
- Green represents year 2080, 20 years after full capacity has been realized

Cumulative aerial growth, represented on Figure 3-10, is as follows:

- 2040: 21.8 square miles of land
- 2060: 64.4 square miles of land, an increase of 42.6 square miles
- 2080: 101.3 square miles of land, an increase of 36.9 square miles

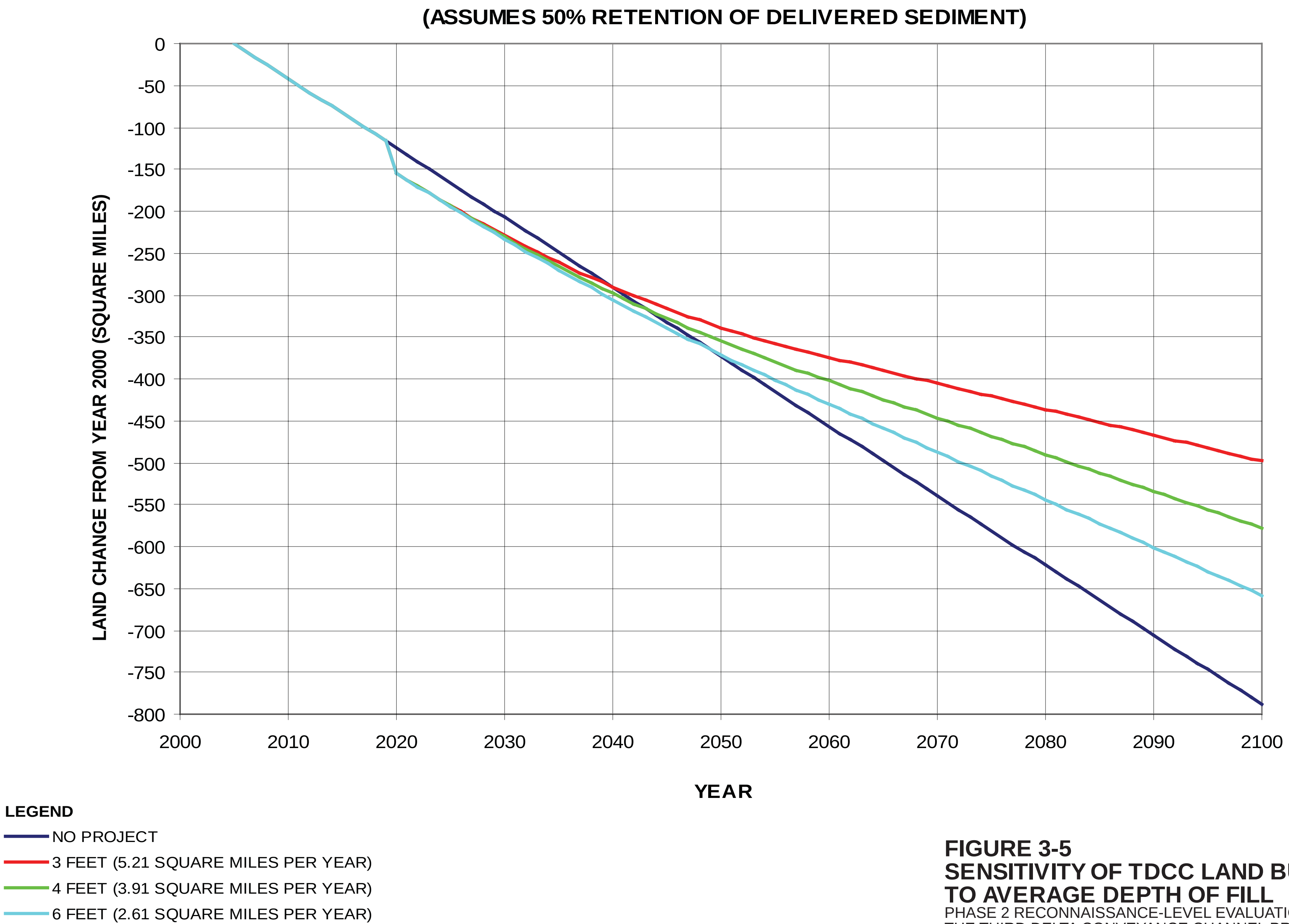

FIGURE 3-5
SENSITIVITY OF TDCC LAND BUILDING TO AVERAGE DEPTH OF FILL
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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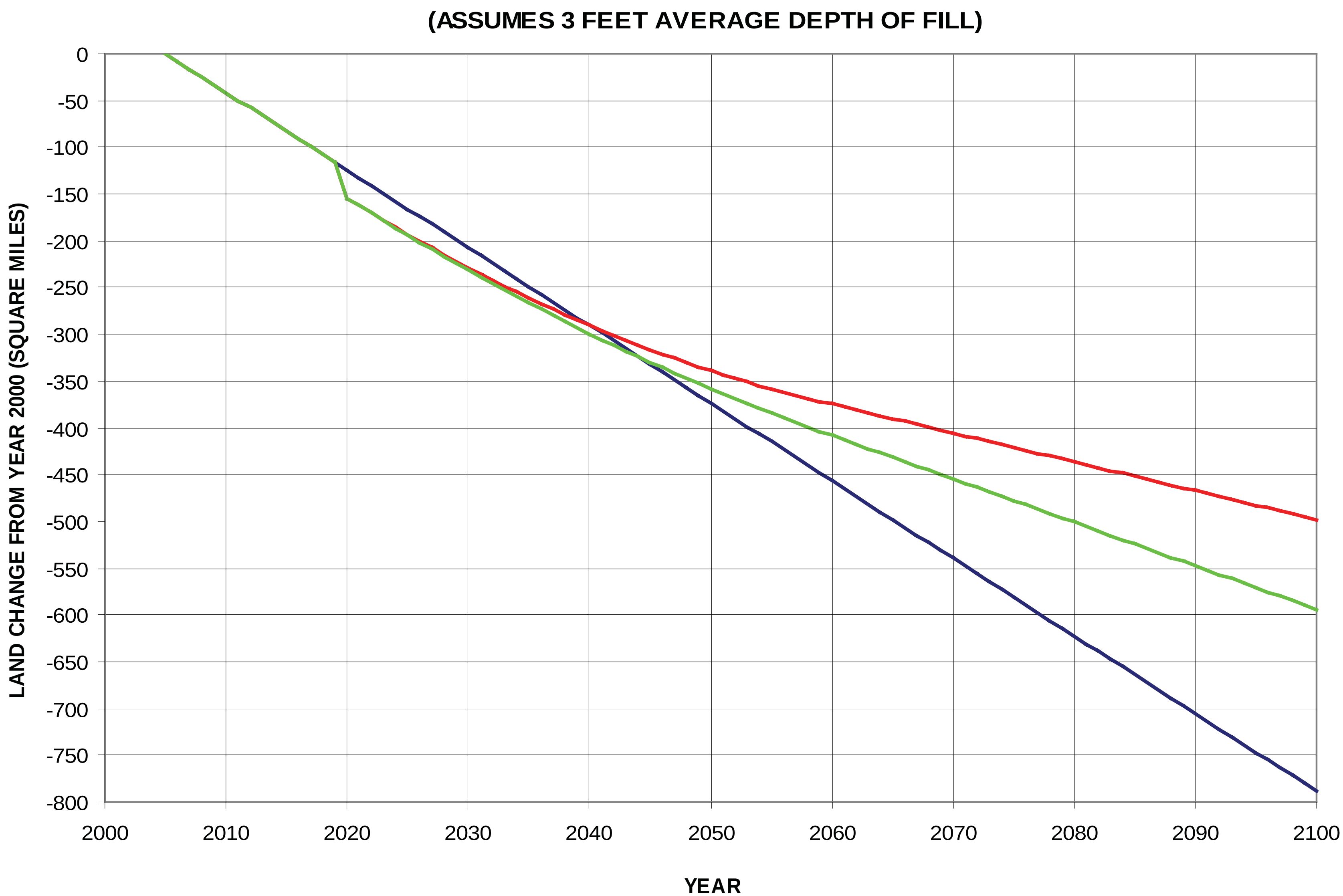

LEGEND

- NO PROJECT
- 50% (5.21 SQUARE MILES PER YEAR)
- 35% (3.65 SQUARE MILES PER YEAR)

FIGURE 3-6
SENSITIVITY OF TDCC LAND BUILDING TO RETENTION FACTOR

PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF
THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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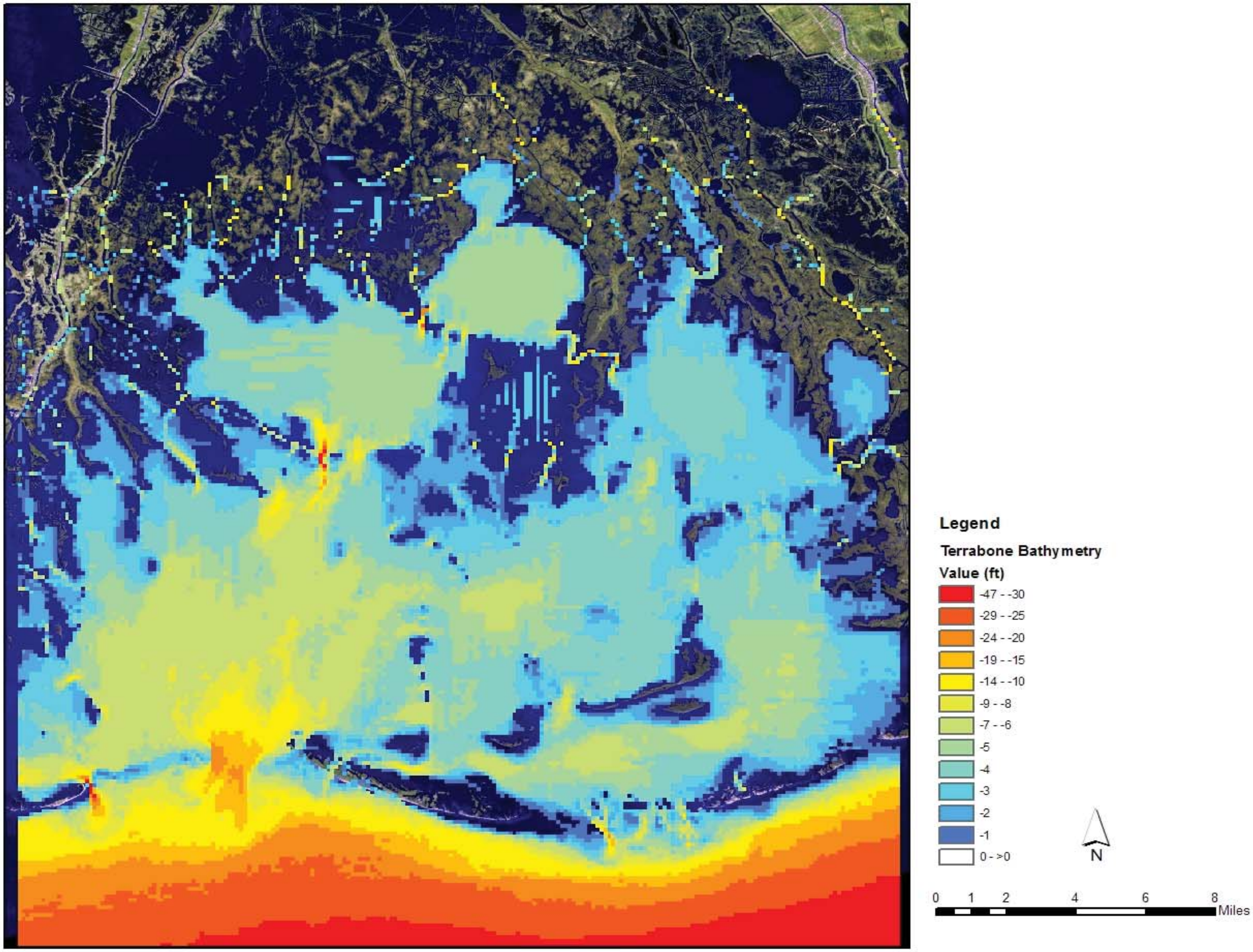

FIGURE 3-7
TERREBONNE BASIN BATHYMETRY FROM NGDC COASTAL RELIEF MODEL
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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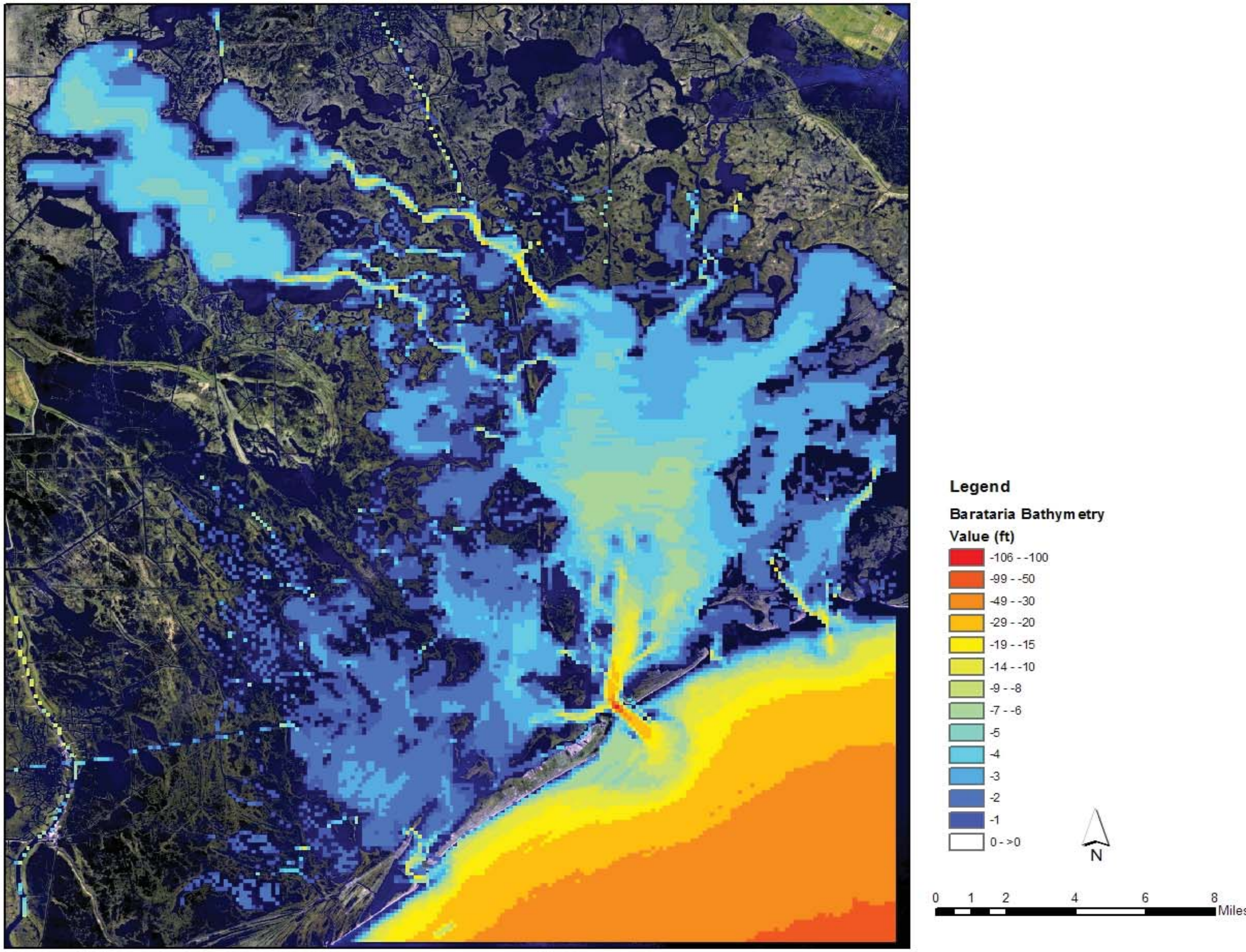

FIGURE 3-8
LOWER BARATARIA BASIN BATHYMETRY FROM NGDC COASTAL RELIEF MODEL
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

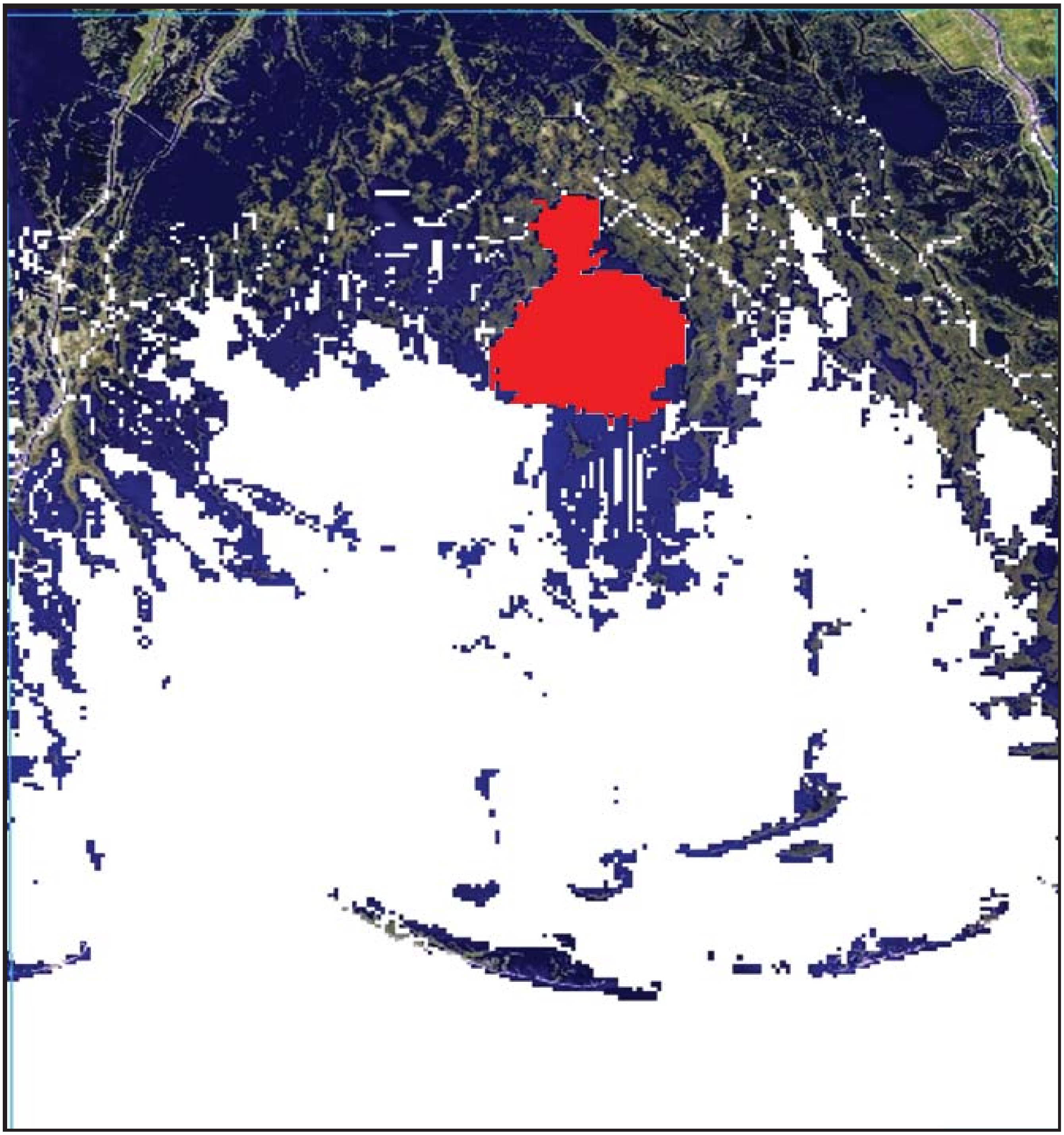

FIGURE 3-9
VOLUME ESTIMATING TOOL
LAKE FELICITY EXAMPLE
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF
THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

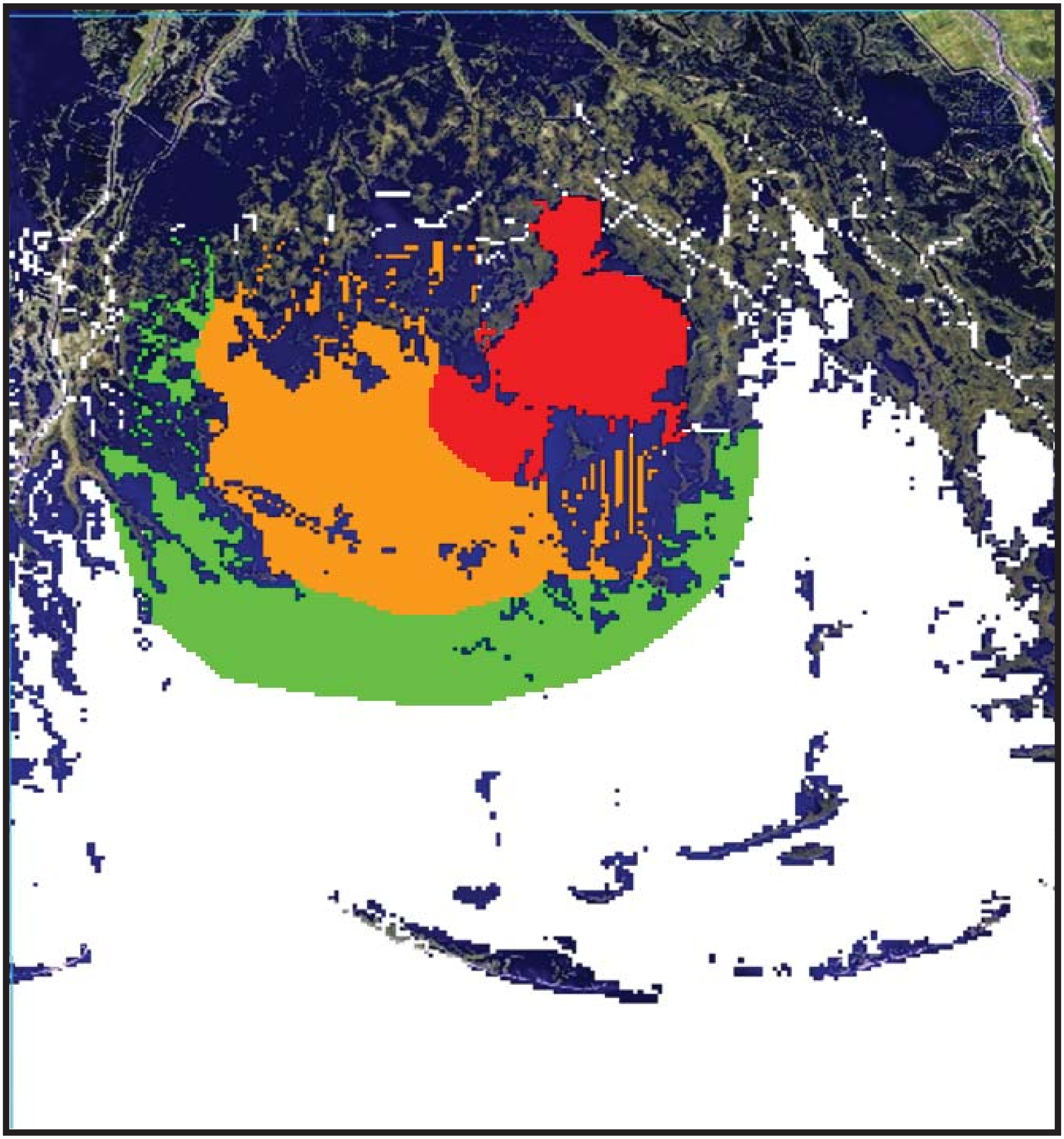

FIGURE 3-10
SCHEMATIC OF POTENTIAL DELTA GROWTH IN TERREBONNE BASIN
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

WB062006002RDD_11 (6/26/06)

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These predicted aerial growth rates demonstrate a slight decrease in the final 20-year snapshot. In the period 2060 to 2080, the channel should be fully evolved to its maximum capacity and no longer contributing sediment to the delta-building areas through channel erosion. As the delta continues to grow, it will have to fill in progressively deeper water to create land; the growth rate likely will continue to decrease with time, as the delta progrades farther into Terrebonne Bay. The schematic presented on Figure 3-10 is from a visualization tool of possible land gain; it does not represent hydrodynamic and sediment transport processes associated with delta development.

Subsidence, while not accounted for in the visualization tool, can be included by correcting the land estimates derived from the visualization tool. Considering an average basinwide subsidence of 4 feet per century (Penland et al., 1989), the land growth estimates can be corrected assuming an additional 0.8 foot of subsidence every 20 years.

The 21.8 square miles of land predicted to be built by 2040 needs to be corrected for the subsidence occurring during that period. Assuming the seafloor will subside uniformly from the depths provided in the Coastal Relief Model used to develop the visualization tool described above, the 21.8 square miles of land is corrected to 16.6 square miles, considering the extra depth to be filled (scaled by 5.1/[5.1+1.6]). Likewise, the 42.6 square miles predicted to be built between 2040 and 2060, corrected for 2.4 feet of subsidence, is reduced to 27.8 square miles. Finally, the 36.9 square miles predicted to be built between 2060 and 2080 is reduced to 20.9 square miles, considering the 3.2 feet of subsidence by 2080.

The calculations should also account for the continued sinking of the land built in the previous period. For example, between 2040 and 2060, the land built between 2020 and 2040 will have sunk an additional 0.8 foot. To fill this would require 13.7 mcy of material, reducing the calculated 27.8 square miles to 25.9 square miles. During the 2060 to 2080 period, the 42.5 square miles of land built through 2060 will sink another 0.8 foot, requiring 35 of the 161 mcy delivered to the receiving area to restore the elevation. Thus, the 20.9 square miles of land built between 2060 and 2080 is reduced to 16.4 square miles. Table 3-11 summarizes these calculations and Figure 3-11 presents a graphical comparison of the results. These calculations are somewhat conservative because they ignore any natural marsh accretion. However, they do provide a reasonable outside estimate of the TDCC's delta-building capacity.

TABLE 3-11
Corrections to Account for Subsidence in Terrebonne Basin
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Period	MCY of Sediment Delivered to Terrebonne Basin	Land Built in Terrebonne before Subsidence Correction (square miles)	Ave Depth of Fill (feet)	Subsidence by End of Period (feet)	Corrected Land-building Estimates (square miles)
2020 to 2040	115	21.8	5.1	1.6	16.6
2040 to 2060	197	42.6	4.5	2.4	25.9
2060 to 2080	161	36.9	4.2	3.2	16.4

3.5 Summary

The TDCC will carry an average of approximately 36.5 million tons of sediment per year, or approximately 100,000 tons per day, to the receiving areas in Terrebonne and Barataria Basins for the baseline (200,000 cfs maximum flow) scenario. The land-building capacity of this sediment depends on the retention rate of the sediment near the receiving areas and the water depth that must be filled to achieve the desired marsh elevation.

Land created by the TDCC will not exceed the predicted loss rate in Barataria and Terrebonne Basins, assuming reasonable retention rates of 35 to 50 percent and fill depths between 3 and 6 feet. As the TDCC fills in the shallower areas near the receiving zones and extends into deeper waters, the rate of land creation likely will decrease. Current best estimates for delta growth are between 1 and 2 square miles of land per year per delta lobe.

A visualization tool has been developed to enable estimation of areas filled in by the TDCC in Barataria and Terrebonne Basins. The tool, developed with the NGDC's Coastal Relief Model, calculates the volume and surface of a user-defined area. This enables the visualization of progressive land building by a point source of sediment added to the system, such as the TDCC.

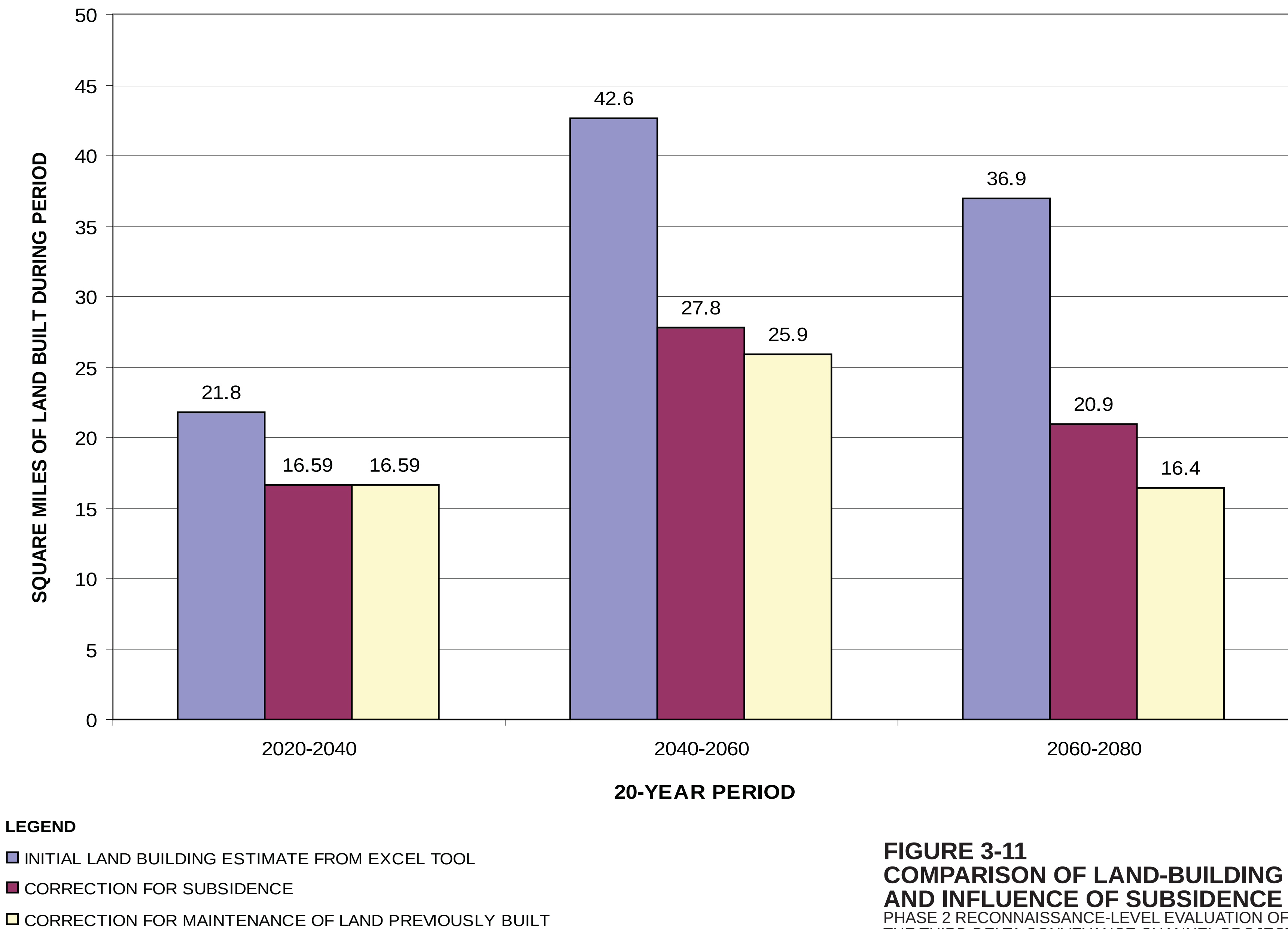

FIGURE 3-11
COMPARISON OF LAND-BUILDING ESTIMATES AND INFLUENCE OF SUBSIDENCE
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

SECTION 4.0

Development of Project Components and Establishment of Engineering Parameters

4.1 Introduction

Any large-scale, land-building and ecosystem restoration plan for the Barataria and Terrebonne Basins will contain several distinct components. The complex nature and shear magnitude of the land-loss problem in the coastal zone demand a complex, multi-faceted solution. The individual components discussed in this section will contribute synergistically to meeting the overall goals of a restoration plan, which include the following:

- Large-scale land building in the Barataria and Terrebonne Basins
- Restoration of a sustainable and dynamic ecosystem
- Increased freshwater input to reverse recent trends of salinity intrusion northward in Barataria and Terrebonne Basins

In addition, components of any large-scale restoration program for the Barataria and Terrebonne estuary systems will include the following:

- Freshwater delivery for sustainability
- Sediment conveyance for marsh and habitat creation
- Barriers to reduce storm surge and protect infrastructure, and restorative features to address natural hydrology and land loss that is directly attributable to human impact on the coastal zone

This section describes these components. A general overview and discussion of each component is presented, followed by a listing of CWPPRA projects in which one or more of these components has been applied. Successes and challenges associated with the implementation of these components in CWPPRA projects should be analyzed to guide future development of restoration project alternatives to repeat past successes and avoid past mistakes.

4.2 Primary Restoration Components

Freshwater, nutrients, and sediments are the primary building blocks of a healthy, diverse, estuarine ecosystem. Without any one of these three inputs, the health and sustainability of a diverse coastal ecosystem is compromised. Sediment supply is a particular concern in the present system, considering the magnitude of current land-loss rates. At this late stage in the deltaic cycle, the goal of rebuilding coastal marshes cannot be accomplished through freshwater inputs alone. Massive quantities of sediment must be introduced into the coastal marshes if land building is to occur. Freshwater flows are vital to the sustainability of any

newly created wetlands because the marsh vegetation cannot generate enough organic material to compete with relative sea-level rise without proper nutrient inputs.

4.2.1 Freshwater

Freshwater and the nutrients it carries are vital to the health and sustainability of diverse, estuarine ecosystems. Freshwater flows into estuaries adjacent to the Mississippi River assist in regulating the estuarine salinity gradient, and, thus, strongly influence the distribution of vegetative species in the estuary. Decreases in freshwater inputs to the coastal ecosystem associated with historical flood protection and navigation improvements have allowed for the inland progression of salt-tolerant species at the expense of intermediate and freshwater species. Recent freshwater diversion projects, such as the Davis Pond Diversion and the West Pointe a la Hache Siphon, have helped control the estuarine salinity gradient and the intrusion of saltwater into the interior marshes. Historical problems with the operation of the Davis Pond Diversion structure currently are being addressed, and average flows through the structure this year are considerably higher than in years past.

As part of the Mississippi River Water Reintroduction into Bayou Lafourche project (CH2M HILL, 2006), CH2M HILL developed a model that quantifies the acreage of marsh benefited by freshwater diversion flows. Results of the model indicate that between 36 and 72 acres of marsh can be benefited by every cfs of flow. These results assume that the flow is distributed more or less uniformly throughout the marsh area, and a channelized marsh that isolates portions of the marsh plain from the freshwater flow will have a lower benefit per unit of flow.

A goal of restoration measures in coastal Louisiana is the restoration of natural hydrology patterns throughout the system. Because altered hydrology is a leading cause of land loss in coastal Louisiana, freshwater diversions into the estuaries are an important component in addressing this goal. The restoration of natural hydrology will assist in re-establishing a more natural (historical) salinity gradient in the estuary, and limit the deleterious effects on saltwater ponding in interior marshes following high water events.

The construction of navigation channels, such as the GIWW and the Barataria Waterway, has modified natural drainage patterns. Extensive dredging of canals by the oil and gas industry for exploration, construction of pipelines, and access to pipelines and well installations has degraded the natural hydrology in two primary ways. First, the exploratory and access channels serve as conveyance pathways for both freshwater leaving the wetland system and saltwater entering the wetland system. These non-natural conveyance systems are often linear and provide a more favorable conveyance pathway than sinuous natural channels. Saltwater intrusion into intermediate and freshwater marsh areas is common through constructed channels. Second, the construction of these canals frequently leaves behind a levee composed of dredge spoil materials. These levees interrupt natural drainage patterns and often lead to ponding in marshes. Prolonged ponding can lead to land loss, if the tolerance for submergence of the local vegetation is exceeded. Increased freshwater inputs to the system are necessary to limit the intrusion of saltwater deep into historical intermediate and freshwater marshes in the estuaries.

4.2.2 Sediment

Sediment delivery is an integral component to sustaining a viable estuarine ecosystem faced with increasing levels of relative sea-level rise. Primary contributing factors to the large-scale land loss in coastal Louisiana since the early- to mid-20th century are the decrease in sediment delivered to the coastal wetland areas, and the inability of the marsh vegetation to keep pace with relative sea-level rise. The reduction of sediment supply to the marshes adjacent to the Mississippi River is caused by several factors, including: the confinement of the Mississippi River for flood control, which has disturbed the seasonal supply of sediments during flood events; a reduction in the suspended sediment concentration and annual sediment transport by the Mississippi River, which can be attributed to changes in land use practices and the construction of reservoirs and dams on major tributaries; and the bathymetry offshore of the mouth of the Mississippi River.

The Mississippi River carries an average of 159 million tons of sediment per year to the coast (Templet and Meyer-Arendt, 1988; USGS, 2005, quoted by National Academy of Sciences, 2005). Currently, the majority of this sediment is lost to the coastal zone because the Mississippi River Delta has prograded to the edge of the continental shelf. Larger sand-sized sediment exiting the mouth of the Mississippi River is primarily lost to the deep ocean, whereas sediment delivered to shallow areas, such as that carried by the Atchafalaya River to Atchafalaya Bay, is retained in the coastal zone to nourish marshes and build land.

To reduce the current rate of land loss in coastal Louisiana and reclaim previously lost land, massive quantities of sediment must be delivered to the coastal marshes. Mechanisms of delivery of large quantities of sediment to the coastal zone include large conveyance channels, such as the proposed TDCC and the Wax Lake Outlet; crevasse splays, such as the West Bay Sediment Diversion project; or sediment conveyance through pipelines or barges.

A limitation in the use of sediment for extensive land building in the coastal zone is the availability of sediment. For projects in the Barataria and Terrebonne Basins, prospective sediment sources include the Mississippi River, the Atchafalaya River, and offshore borrow sites. Riverine sources are replenished over time, whereas offshore borrow sites are considered finite in their capacity to supply sediment for land building. A sediment budget for the lower Mississippi River should be constructed to ensure all proposed restoration projects account for this finite supply. A complete discussion quantifying sediment availability at various sources is presented in Section 5.

The quantity of sediment delivery to the coastline for restoration purposes depends on the land-building goals of the project. Current projected loss rates for the Barataria and Terrebonne Basins total 8.3 square miles per year through 2050. Estimates of probable sediment delivery though the TDCC indicate 32 mcy per year can be delivered once the channel has reached a 200,000 cfs capacity.

4.2.3 Structures

The current state of the coastal wetland ecosystem is strongly related to the constructed influence on the system for the past century. For example, the construction of the Mississippi River levee system during the early 20th century drastically limited the freshwater, nutrient, and sediment supply to freshwater marshes, and provided an efficient conduit for transport of suspended sediment to the deep waters of the Gulf of Mexico. This

loss of vital nutrients contributed to the decline of the estuarine ecosystem. In this instance, engineering structures detrimentally affected the coastal ecosystem. To restore the ecosystem, engineering structures must be employed that positively affect the system. Examples of structures that allow for adaptive management and engineering control for the benefit of the ecosystem include the Caernarvon and Davis Pond freshwater diversions.

Structures in the coastal zone that contribute to the health and viability of the estuarine ecosystem can be either natural or constructed. Natural structures in the coastal zone include features such as ridges, submerged reefs, shoals, shorelines, and barrier islands. Barriers in the coastal zone serve several functions, including the maintenance of natural drainage patterns, significant damping of hurricane storm surges, influence on the estuarine salinity gradient, flood protection, and creation of upland habitat. Furthermore, population density in coastal Louisiana is concentrated on natural ridges.

Barrier islands are the coastline’s first line of defense against the erosive capacity of wave energy from the Gulf of Mexico. The barrier islands also influence the nearshore salinity regime, damping the influx of saltwater carried by the tides and retaining freshwater in the interior bays. Natural ridges are remnants of historical distributaries of the Mississippi River. These ridges control the local hydrology, defining hydrologic basins and controlling runoff and drainage patterns. Submerged reefs and shoals damp incident wave energy and reduce shoreline erosion. The decrease in water depth over the reef or shoal limits the height of a wave that is able to travel past the reef without breaking.

Large-scale coastal restoration projects likely will involve the creation of new barriers and the strengthening of existing natural barriers. CWPPRA projects have demonstrated success with smaller scale barrier island restoration projects. Constructed barriers are also becoming more prevalent in the coastal zone. These barriers, which are often deployed as a means of shoreline protection both seaward of the barrier island chain and in interior lakes and bays, may include offshore structures, such as terraces, jetties, groins, breakwaters, and submerged reefs, or onshore structures, such as dunes or geotubes.

4.3 Structures, Methods, and Project Features

The ecosystem restoration endeavor envisioned for coastal Louisiana must contain several inter-related components because of the complexity of the system, the degree of ecosystem degradation, and the multiple uses currently supported by the coastal zone.

4.3.1 Diversions

Freshwater diversions have been used successfully to introduce water, nutrients, and sediment to degraded wetland areas. Large diversions, such as Caernarvon, have shown that freshwater diversions are an important component in the ecological restoration of coastal marshes. Caernarvon, the first major freshwater diversion project, has been operating since 1991. Other diversions have been designed and constructed since that time, including the diversion at Davis Pond, the Naomi Siphon, and the West Pointe a la Hache Siphon. Projects such as the uncontrolled channel at West Bay take advantage of both freshwater inputs and an increased sediment load. This subsection discusses existing freshwater diversions and their capacity to sustain newly created marshes. In a successful restoration effort, freshwater diversions will be used to compliment other wetland

restoration techniques, such as the delivery of sediment via pipelines, to optimize the re-establishment of wetlands and enhance wetland preservation.

Existing Freshwater Diversions

Davis Pond. The "Freshwater Diversion to the Barataria and Breton Sound Basins" report (USACE, 1983) and subsequent technical appendices (USACE, 1984), recommend diverting Mississippi River water into the Breton Sound Basin, near Caernarvon, and into Barataria Basin, near Davis Pond, to increase habitat quality and improve fish and wildlife resources. The Davis Pond Freshwater Diversion was completed in 2002, with a maximum design capacity of 10,050 cfs. The Davis Pond project is anticipated to preserve 33,000 acres of wetlands and to benefit over 700,000 acres.

Davis Pond is the largest freshwater diversion project in the world and was completed at a cost of $119.6 million. The reinforced-concrete diversion structure is built into the mainline Mississippi River levee and contains 4 14-by-14-foot gates. Water flows through a 2-mile outflow channel to a ponding area that covers most of the project's 10,084 acres. By improving marsh conditions, Davis Pond was projected to provide annual average benefits of $15 million per year for fish and wildlife, including $300,000 for recreation. Davis Pond currently operates well below its design capacity.

The structure began operations in spring 2002, and has only recently been able to overcome constraints that have limited the diversion flows to levels well below design capacity. Problems with drainage in the outflow pond had capped flows at roughly 1,000 cfs. In 2002, the structure was closed 65 percent of the time, for such reasons as tropical storms, oil spills, and maintenance. The closure frequency increased to 77 percent of the time in 2003. Average flow (regardless of whether the structure was open or not) was 217 cfs in 2003. Average flow during operations was 893 cfs (LDNR, 2004).

Recent maintenance on the ponding area, including creation of breaks in an outfall weir structure and lifting guide levee crest elevations, has allowed for significant increases in average flows in the past year. Average flows through the structure between February and May 2006 were between 3000 and 4000 cfs. However, the diversion flow is still controlled by stage in the Mississippi River, and extended periods of low elevation in the river preclude operation of the diversion structure.

Modification of the Davis Pond Diversion is 1 of the 10 features of the LCA Study that is recommended for more study and future congressional authorization. (According to LCA, this group of projects could begin construction within the next 10 years.) Modifications would include reauthorization of the project so that the defined project purpose could shift from salinity control to wetland creation and restoration. The annual average flow through the structure would increase to 5,000 cfs.

Caernarvon. The Caernarvon Freshwater Diversion, located on the eastern bank of the Mississippi River near Caernarvon, was completed in 1991 and has a maximum design capacity of 8,000 cfs. Since its construction, the Caernarvon structure has been operated as a salinity control measure, with freshwater introduction ranging between 1,000 and 6,000 cfs but, in general, averaging less than half of the structure's capacity. The Caernarvon project is anticipated to preserve 16,000 acres of wetlands and benefit over 70,000 acres.

The Caernarvon diversion structure consists of 5 gated box culverts, with each culvert measuring 15 feet by 15 feet. The culverts can allow a maximum flow of 8,000 cfs to Big Mar through an outflow channel that is approximately 1.5 miles long. The facility includes a 128-acre, dredged-material disposal area and a 1,790-acre overflow area. The water flow is controlled by 5 vertical lift gates. These 57,000-pound, cast-iron gates are operated by an electric hoist motor. Caernarvon is designed to pass flows primarily in the months of January through May.

Since 1991, monitoring has indicated significant gains in freshwater plants and decreases in salt marsh vegetation in the vicinity of the outfall. Results show a net increase in marshland of 406 acres within the sampled areas, which originally contained 2,289 acres of marsh. Oyster industry productivity on public seed grounds has increased more than 3 times. Since operations began, the average number of large mouth bass caught has almost doubled and the number of waterfowl using the marsh has increased dramatically.

The LCA-proposed restoration feature study would assess changes in the operation of the Caernarvon project to increase wetland creation and restoration outputs for this structure. Modified operation could allow an increase to 5,000 cfs, on average, to accommodate the wetland building functioning of the system. This project is located in the vicinity of a historical crevasse. The construction cost for the diversion was $25.9 million.

This diversion is on the eastern bank of the river and, thus, cannot nourish marshes in either Terrebonne or Barataria Basins. However, it can be used as a design analogue and an example of successfully influencing salinity regimes in estuaries adjacent to the Mississippi River.

West Pointe a la Hache. The diversion at West Pointe a la Hache consists of 8 parallel siphons, used to divert water from the Mississippi River into wetlands on the western bank of the river, near Point a la Hache. The maximum discharge of the siphons is 2,100 cfs. The project is expected to benefit 718 acres of wetlands.

The West Pointe a la Hache Outfall Management (CWPPRA Project BA-04c) has been approved to maximize the retention of freshwater, nutrients, and sediment within interior brackish marshes in the area adjacent to the siphon. The project will use water control structures to divert water from the main distributary channels to secondary channels and allow for more efficient flow over the marsh. Hydrologic modeling is currently underway to estimate resulting benefits and optimize design of proposed features.

Naomi Siphon. The diversion at Naomi consists of 8 parallel siphons used to divert water from the Mississippi River, over the west bank levee, and into adjacent wetlands near Naomi, Louisiana. The maximum discharge of the siphons is 2,100 cfs. The project is expected to benefit 1,318 acres of wetlands. A second project, Naomi Outfall Management, was completed in 2002 to reduce saltwater intrusion and enhance wetland productivity by revised management of the siphons.

Proposed Diversions

Several proposed diversions will add freshwater to the coastal system at various locations. These include the Bayou Lafourche Freshwater Reintroduction Project, The Myrtle Grove Siphon, and the operation of the proposed lock on the Houma Navigation Canal (HNC) to

redistribute freshwater from the Atchafalaya River (via the GIWW) to marshes in upper Terrebonne Basin.

Bayou Lafourche. The proposed Mississippi River Water Reintroduction into Bayou Lafourche project consists of a 1,000-cfs diversion into the head of Bayou Lafourche near Donalsonville. The diversion would be controlled by a pumping plant and would not be influenced by low stage events in the Mississippi River, unlike the siphons at West Pointe a la Hache and Naomi. The diversion would benefit wetlands in both the Barataria and Terrebonne Basins, with the majority of benefits occurring in Barataria Basin, between the GIWW and Little Lake. Benefits in Terrebonne Basin are limited by hydraulic connections between the GIWW and several north/south trending bayous, including Grand Bayou Canal, Bayou Terrebonne, Bayou Pointe au Chien, and Bayou Petit Caillou.

Morganza to the Gulf and Houma Navigation Canal Lock. The proposed Morganza to the Gulf Hurricane Levee system includes a lock structure on the HNC, downstream of Bayou Petit Caillou. This lock structure, if closed during periods of high flow on the Atchafalaya River, may help distribute freshwater through the GIWW into numerous north/south bayous in Terrebonne Basin, including Bayou Terrebonne, Grand Bayou Canal, Bayou Pointe au Chien, and Bayou Petit Caillou. In addition, the Grand Bayou/GIWW Freshwater Diversion Project (CWPPRA TE-10) proposes hydraulic modifications to Grand Bayou Canal, south of the GIWW, to route more freshwater south to the Grand Bayou marshes.

Myrtle Grove. A medium diversion (5,001 to 15,000 cfs), with dedicated dredging at Myrtle Grove, is one of the LCA's 5 near-term critical restoration features. Dedicated dredging of sediment mined from the Mississippi River would complement the freshwater diversion. A large diversion (greater than 15,000 cfs), with sediment enrichment, was also considered by LCA. Work has been initiated on engineering and design. This project is located in the vicinity of a historical crevasse.

Lessons Learned

Operating and maintaining freshwater diversion projects presents many challenges. The following lessons learned for freshwater diversions are modified from the CWPPRA Adaptive Management Report, dated July 25, 2002:

1. DNR should maintain operation and maintenance control over operations to ensure consistency with restoration objectives.
2. More control is possible with gated structures. Siphons have had issues with losing and not being able to maintain prime. They have minimal utility when water levels are low.
3. Consideration of the benefits of using many smaller diversions versus fewer large ones may improve cost efficiency. Smaller diversions offer more flexibility in operations and can be constructed faster.
4. Measurement of actual discharge volumes is critical to operating diversions and evaluating their effects. Instrumentation to measure discharge should be built into the structure during the design phase.
5. Awareness and proaction can minimize or eliminate the potential for conflict and litigation with other resource groups.

Additional Considerations

The removal of freshwater from the Mississippi River in large quantities may deleteriously affect conditions in the river. Navigation impacts must be evaluated fully, and sufficient flow must remain in the river to provide safe passage for deep draft vessels. Sediment shoaling is likely to occur downstream of any large diversion from the Mississippi River, because sediment transport is a non-linear function of flow. This increased shoaling could also influence navigation. Finally, salinity intrusion in the Mississippi River must be analyzed to ensure that diversions are not allowing the saline wedge to impinge on industrial or municipal water supplies.

4.3.2 Sediment Dredging and Conveyance

The reduction in deposition of alluvial sediments within marshes of the Barataria and Terrebonne Basins is a leading cause for the high rate of land loss documented within the coastal area since the 1950s. Although natural process and anthropogenic activity have both contributed to the land-loss rate, large-scale marsh restoration and creation is not possible without the reintroduction of a significant volume of mineral sediments.

The creation or restoration of marsh in the Louisiana coastal zone can be achieved by restoring surface elevations and hydrologic processes that sustain a vegetated, emergent ecosystem. Although both sediment deposition and organic accumulation of plant material can result in a net gain in surface elevation, sediment deposition is needed to reclaim land and restore wetland habitat in the Barataria and Terrebonne Basins.

The proposed TDCC project was conceived as a method to deliver a sustainable sediment load from the Mississippi River to the lower Terrebonne and Barataria Basins via a large primary, and two secondary, dredged channels. As an alternative to this large conveyance channel, mechanical delivery of massive quantities of sediment (on the same scale as the TDCC, about 30 mcy per year) is investigated herein to determine if another viable option exists for delivering sediment to deteriorating marshes in the Barataria and Terrebonne Estuaries.

The use of pipeline networks to deliver sediments offers flexibility and precision in regard to the location and volume of sediment placement. Because of this flexibility, a full range of marsh restoration techniques and methods can be used to create, enhance, and protect coastal marshes within the Terrebonne and Barataria Basins. Furthermore, control over the elevation of created wetlands allows for creation of a range of habitats.

Project components for a basinwide pipeline sediment delivery project include the following:

- Construction of sediment traps in the Mississippi River, downstream of point bars
- Dedicated dredges offshore for mining sediment resources to supplement finite bedload transport in the Mississippi River
- Dedicated hopper dredges equipped with pump out capacity
- Pipeline networks placed in existing utility or oil and gas ROWs
- Construction of containment features at receiving areas

Issues of concern with this project concept include, but are not limited to, the following:

- Sediment availability in the Mississippi River and in offshore borrow locations
- Sediment size and quality
- Long-distance transport (decrease in productivity and increase in costs)
- Impact to Mississippi River (erosion downstream of sediment traps due to excess carrying capacity)
- Impacts to the navigation industry
- Environmental impacts
- Delivery rates
- Placement techniques

4.3.3 Barrier Island Restoration

Barrier islands serve a vital role in protecting interior marshes. A comprehensive barrier island restoration program, such as that outlined in the Louisiana Gulf Shoreline Restoration Report (LCA Study, Appendix D) or in the Barrier Island Plan (T. Baker Smith and Son, Inc., 1997), should be adopted as a key component in any coastwide restoration plan.

Numerous barrier island restoration projects have been completed in coastal Louisiana over the past few decades. Certain projects have seen more success than others. The short-comings of several projects can be used as a learning opportunity for future restoration projects. Several CWPPRA barrier island restoration projects are listed in Table 4-1.

Sediment needs for restoration projects along the barrier island chains in both Barataria and Terrebonne Basins will likely come from local borrow sites. Ship Shoal, located off the Isles Dernieres barrier island chain in western Terrebonne Bay, is the most likely borrow source for large-scale barrier island restoration projects in Terrebonne Bay. Several smaller potential borrow sources have been identified offshore of Barataria Bay (Kindinger et al., 2001), but the sparse nature of sediment cores used to quantify these sources raises doubts as to the initial estimates of usable material. A more detailed investigation of a few potential borrow sites has indicated that the preliminary volumes estimated by Kindinger et al. (2001) may be high by a factor of 10 to 20 (Syed Khalil, presentation at CREST Symposium, April 19, 2006, Baton Rouge, Louisiana).

Restoration of barrier islands will require a certain size range of sediments, whereas marsh restoration can use a wider size range of sediments. Silt-sized particles, while not useful for barrier island restoration projects, may be used for marsh creation projects.

A sediment budget that quantifies prospective sources (both riverine and offshore) needs to be developed, so that realistic restoration goals can be made that account for the limited availability of sediment. The offshore sediment availability would have to be balanced among all the prospective restoration features that require sediment input, including the interbasin segmented barriers discussed previously and marsh restoration projects.

An initial estimate of the volume required for barrier island restoration is provided in the Barrier Island Plan (T. Baker Smith and Son, Inc., 1997). This report presents two distinct restoration plans encompassing the barrier shoreline from Isles Dernieres to the Plaquemines shoreline, adjacent to the Mississippi River. The two plans, which differ in the extent of restoration, would require approximately 55 to 93 mcy of material. Cost estimates in this report were made using an average cost of $1.30 per cubic yard, assuming local borrow sources in ebb shoal deltas adjacent to the barrier islands.

TABLE 4-1
Summary of Barrier Island Restoration Projects in Coastal Louisiana
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

State Number	PPL	Agency	Project Name
BA-30	9	NOAA Fisheries	East/West Grand Terre Islands Restoration
BA-38	11	NOAA Fisheries	Barataria Barrier Island Complex Project: Pelican Island and Pass La Mer to Chaland Pass Restoration
BA-40	14	NOAA Fisheries	Riverine Sand Mining/Scofield Island Restoration
CS-31	11	NRCS	Holly Beach Sand Management
TE-20	1	EPA	Isles Dernieres Restoration East Island
TE-24	2	EPA	Isles Dernieres Restoration Trinity Island
TE-25	3	NOAA Fisheries	East Timbalier Island Sediment Restoration, Phase 1
TE-27	3	EPA	Whiskey Island Restoration
TE-30	4	NOAA Fisheries	East Timbalier Island Sediment Restoration, Phase 2
TE-37	9	EPA	New Cut Dune and Marsh Restoration
TE-40	9	EPA	Timbalier Island Dune and Marsh Creation
TE-47	11	EPA	Ship Shoal: Whiskey West Flank Restoration
TE-48	11	NRCS	Raccoon Island Shoreline Protection/Marsh Creation
TE-50	13	EPA	Whiskey Island Back Barrier Marsh Creation

Notes:
EPA = U.S. Environmental Protection Agency
NOAA Fisheries = National Oceanic and Atmospheric Administration Fisheries
PPL = project priority list

4.3.4 Large-scale Barriers

Aside from barrier island chains, other large-scale barriers can be included as a component of any coastwide ecosystem restoration component. Large-scale barriers can assist in limiting salinity intrusion, damping storm surges, and decreasing wind-wave-induced erosion in exposed marshes.

T. Baker Smith and Son, Inc., describe the concept of the “fall-back line” of new barriers in their Barrier Island Plan (1997). This concept involves the creation of a “second line of defense” inside Terrebonne and Barataria Basins to function as a barrier island chain. Their concept assumes that the existing barrier islands would be allowed to deteriorate. The inter-basin segmented barrier concept was discussed in the Phase 2 workshop conducted by CH2M HILL, in May 2005. The concept was modified with the following assumptions:

- The existing barrier islands would not be allowed to deteriorate.

- The new barrier would limit wave energy reaching the marshes from the ever-increasing fetch over the inland bays and water bodies.
- The new barrier would provide a protected area shoreward of the barrier island chain to allow for marsh construction.
- The new barrier would decrease storm surge and salinity intrusion.

The interbasin segmented barrier is proposed as a component to the ecosystem restoration program alternatives presented in this report. The interbasin segmented barrier will resemble a segmented chain of sand dunes arcing across Barataria and Terrebonne Basins, adjacent to the current marsh boundary. The sand dunes would be created through the transport, via pipeline, of sediments dredged from Ship Shoal in Terrebonne Basin and from either ebb shoal deltas in the Barataria Basin or the Mississippi River, below Nairn. The dunes would be constructed to an elevation of approximately 6 to 8 feet above msl. Figure 4-1 presents a planning-level sketch of the dune cross section. Plan view layouts of the interbasin segmented barrier alignment are presented in Section 5.

A pipeline would be constructed from the offshore borrow location to the receiving areas, and moved, as appropriate, as the barrier construction progresses. The pipeline could be selectively placed in trenches, so as not to interfere with navigation in Barataria and Terrebonne Basins. This procedure is considered standard in the dredging industry. Sediment slurry would be delivered at rates of 20,000 to 50,000 cubic yards per day, based on previous projects. A sand dune with a 30-foot crest width and slopes of 30:1 below water level and 60:1 above water level would be built. This yields an approximate cross section of 1,000 square yards. Dunes could be vegetated to increase their longevity.

Construction of the barrier could progress at approximately 1 mile per month, assuming a sediment slurry flow rate of 50,000 cubic yards per day, on average, and a dune cross section of 1,000 square yards. Operating from opposite sides of each basin, 2 dredges conceivably could build a 25-mile-long barrier in 2 years, assuming 200 working days per year. Barriers in both basins could be completed in 4 years. Total sediment required for each basin is approximately 50 mcy, allowing for a 20 percent loss.

Segmenting the sand barrier would allow for continued navigation in such channels as Bayou Terrebonne, HNC, Bayou Petite Caillou, and Barataria Waterway. The size and spacing of the openings in the barrier would be designed to control salinity and reduce storm surge inland of the barriers. Alignment of the berms would account for incident wave direction, wave refraction, and potential focusing of incident wave energy. The cross section of the berm could vary with the expected future wave climate at a given location.

With this project concept, potential issues that must be addressed include the following:

- Pipelines and navigation concerns
- Sediment quality and supply at offshore borrow locations
- Bearing capacity of soils to support barriers
- Saltwater conveyance in pipelines with slurry (flow rates of 100 to 150 cfs)
- Storm delays
- Barrier islands and their competing need for sand-sized material

4.3.5 Ecosystem Restoration and Enhancement Techniques

This subsection presents several techniques to either restore wetland vegetation and ecosystem functions or limit degradation of existing marshes. A brief list of CWPPRA projects employing these individual techniques follows each discussion, where applicable. The following techniques are discussed:

- Shallow infilling for interior marsh and hydrologic impoundments
- Shoreline protection
- Ridge restoration
- Land bridge/shoreline restoration and protection
- Marsh enhancement and thin layer placement

Shallow Infilling for Interior Marsh and Hydrologic Impoundments

The conversion of interior marshes to open water has been identified as one of the two main mechanisms of land loss in the Terrebonne and Barataria Basins during the past decade. Once converted to open water, most of these interior areas remain shallow water bodies or ponds, typically 1 to 2 feet deep. In addition to interior marshes, failed or abandoned agricultural areas, or properties historically managed for waterfowl represent shallow water bodies that are now permanently flooded. These open-water areas represent desirable locations for the deposition of dredged material because they are shallow and often partially or fully contained by a levee or natural land feature.

Relevant CWPPRA projects include Bayou LaBranche Wetland Creation (PO-17) and Sabine Refuge Marsh Creation Cycle 1 (CS-28).

Shoreline Protection Measures

Shoreline erosion is a major cause of land loss in coastal Louisiana. Most of the marshes in lower Barataria and Terrebonne bays are experiencing shoreline erosion. This mechanism of land loss is also prevalent on the shorelines of larger inland water bodies, such as Little Lake in Barataria Basin, Bayou Perot, Lake Salvador, and Lake Cataouatche.

Various shoreline protection measures have been employed as part of CWPPRA projects, including direct armoring with riprap and construction of barriers (e.g., offshore break-waters, terracing, and Christmas tree fences) adjacent to the shoreline to damp wave energy. Terracing has been particularly effective in lowering the wave energy at the shoreline.

Successful application of this method can be found in Little Vermilion Bay (TV-12) and Little White Lake, near Four Mile Canal (TV-18). Relevant CWPPRA projects include the following:

- Jonathan Davis Wetland Restoration (BA-20)
- Barataria Bay Waterway Wetland Restoration (BA-19)
- Atchafalaya Sediment Delivery Project (AT-02)
- Lake Chapeau Sediment Input (TE-26)
- Cameron Prairie National Refuge Shoreline Protection (ME-09)
- Falgout Canal Planting Demonstration (TE-17)

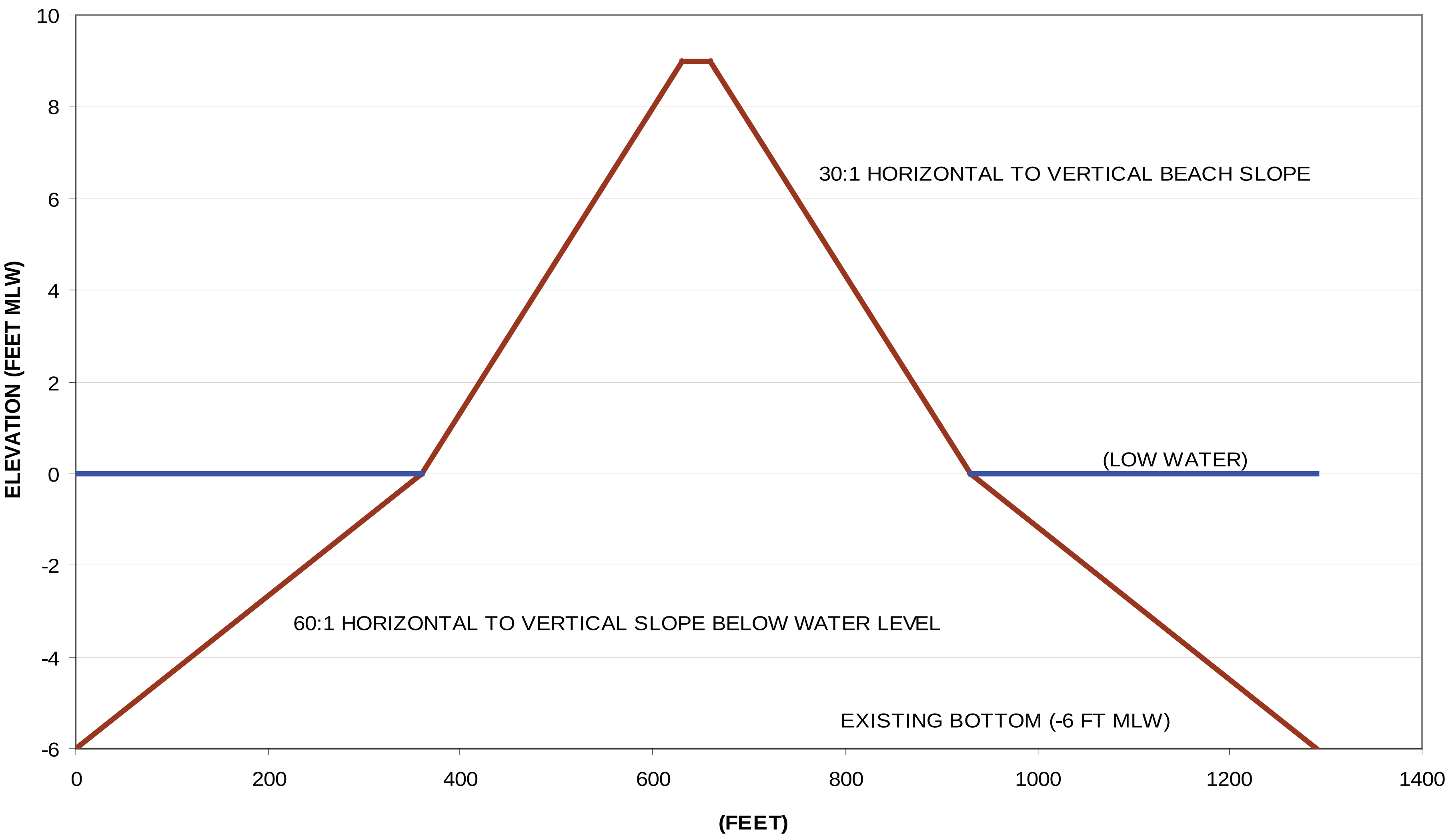

FIGURE 4-1
SCHEMATIC CROSS SECTION OF INTERBASIN SEGMENTED BARRIER
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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Ridge Restoration

As interior marshes are converted to open water, the adjacent ridges often experience land loss from erosion or subsidence. Natural ridges are typically underlain by mineral soil and subsoil. As they become submerged or eroded, such deposits represent a desirable skeleton on which to place dredge material to create or restore these coastal wetlands. In many cases, these areas were forested wetlands supporting cypress swamp or mixed hardwood. As with shallow infilling, a berm or natural elevated land feature is used for containment and the dredge material is placed, either hydraulically or by bucket dredge, behind the containment feature. Once dewatered, the containment feature is removed to allow for normal surface hydrology and the area is planted.

Land Bridge/Shoreline Restoration and Creation

Extended marshes, either natural or dredged, located between two parallel waterways can become isolated islands because of erosion of the shorelines and eventual merging of the two waterways. These extended marshes represent important land bridges or contiguous land masses that protect shorelines and, once lost, result in a significant conversion to open water. The creation or restoration of the shoreline and adjacent marsh is achieved in these areas using the methods outlined previously. Relevant CWPPRA projects include the following:

- Barataria Basin Land Bridge Shoreline (BA-27)
- Lake Portage Land Bridge (TV-17)
- North Lake Merchant Land Bridge Restoration (TE-44)
- Grand-White Lakes Land Bridge Protection (ME-19)

Barrier Island Dune and Marsh Restoration and Creation

The restoration of the barrier islands chain within the lower Terrebonne and Barataria Basins consists of both dune and marsh creation. Typically, the marsh is created directly behind the elevated dune. This marsh is created using the same methods of containment employed for shoreline and marsh restoration outlined previously. Typically, both the dune and marsh are replanted. Relevant CWPPRA projects include the following:

- Isles Dernieres Restoration Trinity Island (TE-24)
- East Timbalier Island Sediment Restoration (TE-25)
- Timbalier Island Dunes and Marsh Creation (TE-40)
- Whiskey Island Restoration (TE-27)
- Riverine Sand Mining/Scofield Island Restoration (BA-40)
- East/West Grand Terre Islands Restoration (BA-30)
- Barataria Barrier Island Complex Project (BA-38)

Marsh Enhancement and Thin Layer Placement

Marsh enhancement using sediments is achieved by providing sediment inputs to existing marsh. Marsh enhancement does not result in creating new marsh, but stabilizes the marsh by proving sediments for accretion and nutrients. Marsh enhancement practices typically do not require containment structures because the intent of the enhancement is to provide

some sediment inputs over a large surface area to stimulate vegetative growth and achieve elevation gain.

4.3.6 Project Examples

Long-distance pipelines have been used to transport large quantities of sediment in coastal zones in Louisiana and worldwide. Several industries have used this technology, including the mining, beach restoration, and transportation industries. Several projects on current CWPPRA PPLs use pipeline conveyance of dredged material for marsh creation, including the Riverine Sand Mining/Scofield Island Restoration Project (BA-40), and the Lake Hermitage Marsh Creation Project (PPL 15).

Several projects in coastal Louisiana also have used pipelines to transport sediment for marsh creation and beach nourishment. USACE has used dredged material for the creation and restoration of wetlands since 1969 (Streever, 2000). Although these projects did not use pipelines for extended distances, an extension of the pipeline length is primarily a matter of additional booster pumps and is not considered an issue with project feasibility. Projects include the following:

- Bayou Labranche Wetland Creation
- Holly Beach Restoration
- Dustpan Dredge Demonstration Project
- Pilottown Anchorage Dredging Demonstration Project

Bayou Labranche Wetland Creation Project

The Bayou Labranche Wetland Creation Project (PO-17) was constructed in 1994. This project dredged approximately 3 mcy of material from a local borrow area in Lake Pontchartrain and pumped the sediment through a pipeline to a confined receiving area. A 30-inch, cutter suction dredge was used for the project, and dredging operations lasted less than a month, yielding an average daily production of 100,000 cubic yards. Sediment was placed to elevations of approximately 1.6 feet North American Vertical Datum (NAVD) 88, and settled over 1 foot within 4 years. Over 300 acres of marsh were created with this project.

Holly Beach Restoration Project

The Holly Beach Restoration Project transported 1.75 mcy of sediment via a 4-mile-long pipeline to nourish a degraded beach in southwestern Louisiana. This project, conducted in 2003, used the Beachbuilder dustpan dredge, built by C.F. Bean, LLC, specifically for use in the shallow coastal waters of Louisiana. This dredge was later sold to Weeks Marine.

The Dustpan Dredge Demonstration Project

The Dustpan Dredge Demonstration Project used the Beachbuilder Dredge to show the feasibility of using a dustpan dredge to increase the beneficial use of material dredged during channel maintenance in the lower Mississippi River. The project took place during June 2002, a time of high water on the Mississippi River. Thus, the conditions included high currents, which can prove difficult to dredging operations. The project took place during routine maintenance dredging in the Head of Passes area; 4 hopper dredges were active at removing shoals in the vicinity of the Beachbuilder during the demonstration project.

The Beachbuilder is a shallow-draft (8.5-foot) dustpan dredge, with the capacity to dredge up to 70 feet deep. Dredging operations were conducted with a 1,400-foot-long flexible hose connected to a rigid pipe at a so-called “hard point”. The rigid pipe extended an additional 5,000 feet to the marsh building location. Extensive maneuverability tests were conducted to ensure the dredging operations could proceed without causing any impediments on navigation in the river. The demonstration project transported approximately 250,000 cubic yards of sediment to the marsh creation site.

Pilottown Anchorage Demonstration Project

C.F. Bean, LLC, is currently (as of June 2006) demonstrating the capacity of hopper dredges to contribute to wetland restoration projects by pumping dredged sediment through pipelines to restoration areas. The majority of the maintenance dredging in the lower Mississippi River is conducted with hopper dredges because of the flexibility and mobility they provide with respect to navigation traffic on the river. Most of the 15 to 20 mcy of material dredged annually from the Head of Passes area is moved to offshore disposal sites with hopper dredges. This demonstration project shows that hopper dredges routinely involved with maintenance dredging can, with the appropriate conveyance system, transfer their sediment for beneficial use and wetland creation in a cost-effective manner (the hopper dredge operation underbid cutter suction dredges in this particular instance). Average costs per cubic yard for the project are $4.50. Although this disposal method is more expensive than the offshore disposal, because productivity is decreased by the pump out time, productivity rates approach 40,000 to 50,000 cubic yards per day.

Figure 4-2 shows the hopper dredge Stuyvesant attaching the flexible discharge pipe to the bow of the hopper dredge. Figure 4-3 shows the equipment and machinery needed at the end of the pipe to maneuver the pipe into position.

Long-distance transport of sediment, via pipelines, has been used on various highway projects in Louisiana. These include the following:

- I-10 Sorrento to LaPlace (11-mile pipeline, 1969)
- Highway 3127 Killona to Boutte (6-mile pipeline, 1972)
- Larose – Lafitte Highway (8-mile pipeline, 1978)
- Poydras – Reggio Highway 46 (11-mile pipeline, 1979)

A final project example is from the Netherlands. It highlights the distance to which sediments can be moved via pipeline. For the Betuwe Route Project, 3.2 million cubic meters (4.2 mcy) of sand were pumped through a 100-mile pipeline to build a base for two railroad tracks (Hales et al., 2003).

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FIGURE 4-2
HOPPER DREDGE STUYVESANT
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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FIGURE 4-3
EQUIPMENT AND MACHINERY NEEDED TO MANEUVER PIPE INTO POSITION
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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SECTION 5.0

Alternatives Development

5.1 Introduction

This section develops the approach for characterizing and evaluating the pipeline conveyance alternatives. This section also evaluates the performance measures by which the alternatives can be compared to the TDCC.

The alternatives development process began with the goal of matching or exceeding the land-building capacity of the TDCC, taking into account net land built compared to future conditions with no action. The following quantitative performance measures are developed in this section:

- Net land gain
- Construction cost

Several qualitative performance criteria were considered during development of the alternatives, including the following:

- Infrastructure Impacts
- Environmental Impacts
- Adaptive Management
- Public Acceptance
- Socioeconomic Impacts
- Project/Performance Risk

Each of the three pipeline conveyance alternatives presented in this section was characterized and evaluated for these performance measures previously presented and discussed in Section 2.0. These performance measures were also applied to the TDCC for comparison against the alternatives.

5.2 Major Alternative Components

The three alternatives presented in this section share many components. The differences between the alternatives primarily lie in the magnitude of the restoration effort and in sediment and freshwater requirements. As the land-building goal of the alternatives increases, so does the number of borrow areas that must be used to deliver the required sediment and the amount of freshwater flow needed to sustain the newly restored and nourished wetlands.

Although the quantity of sediment transported to potential restoration areas varies with each alternative, other components are shared by all three. All three alternatives adopt barrier island restoration plans for both Barataria and Terrebonne Basins, increase freshwater diversion for sustainability, and include the construction of the interbasin segmented barriers presented in Section 4.3.4.

5.2.1 Large-scale Sediment Delivery

The large-scale delivery of sediments to the estuarine marshes in Barataria and Terrebonne Basins is the most vital component in any ecosystem restoration program. Annual sediment delivery of approximately tens of millions of cubic yards is needed to counteract current land-loss rates in the coastal zone. Options for delivering this quantity of sediment include the TDCC and pipeline slurry of dredged sediments.

5.2.2 Increased Freshwater Diversions

Increased diversions are vital to providing freshwater, nutrients, and sediments to the newly created wetlands. Recent work on the Mississippi River Water Reintroduction into Bayou Lafourche project (CH2M HILL, 2006) indicates that freshwater can provide adequate nutrients to marshes and wetlands at a ratio of 36 acres per 1 cfs. At this rate, 100 cfs will have to be brought in for every 6 square miles of land nourished or created.

Current freshwater diversion capacity in Barataria Basin consists of the following:

- Davis Pond (10,650 cfs of capacity, normal operation of approximately 2,000 cfs)
- Naomi Siphon (2,100 cfs)
- West Pointe a la Hache Siphon (2,100 cfs)

Proposed diversions in Barataria and Terrebonne Basins include the Mississippi River Water Reintroduction into Bayou Lafourche project and the diversion at Myrtle Grove. Furthermore, the HNC Lock, built as part of the Morganza to the Gulf Hurricane-Protection project, will assist in the distribution of freshwater from the Atchafalaya River through the marshes in Terrebonne Basin.

5.2.3 Reconstruction of Landform Features

The delivery and placement of dredged sediment offers a unique opportunity to reshape the landscape in southern Louisiana. Current weaknesses in the landscape contributing to the decline in the ecosystem, such as regions of altered hydrology and eroding land bridges, can be addressed through strategic placement of dredged material. In fact, land loss can be reduced by the restoration effort. The land built during program implementation can actually decrease the land-loss rate. The restoration of more natural hydrology through the reconstruction of landform features is likely the most efficient way to influence future land loss in the coastal system.

Ridges

The reconstruction of landform features will assist in restoring a more natural surface water hydrology to the Barataria and Terrebonne Estuaries. The deterioration of ridge structures by erosion, subsidence, and pipeline canal bisection has disrupted natural drainage patterns in the system. By restoring ridge systems, natural drainage patterns will more effectively control salinity intrusion in select areas and have a better chance of maintaining the current habitat distribution throughout the system.

Land Bridges

Land bridges are regions of land that separate two bodies of water. Erosion of land bridges can subject shorelines to significantly higher wind and wave energy as the fetch from one

open-water body combines with that from an adjacent open-water body. One example of this is the land mass at the south end of Bayou Perot, the so-called Barataria Land Bridge (PP BA-27).

5.2.4 Restoration of Barrier Islands

Barrier Islands serve a vital role in protecting interior marshes from erosive wave forces and influence salinity. Currently, the barrier island system from Isles Dernieres to Plaquemines is in great need of restoration. One set of estimates (T. Baker Smith and Son, Inc., 1997) indicates that between 50 and 90 mcy of sand would be required to implement a complete basin-scale barrier island restoration program for both Barataria and Terrebonne Basins.

5.3 Alternative Descriptions and Characteristics

Three pipeline conveyance alternatives were developed in this study. The preliminary difference between alternatives was the land-building goal of 5, 10, or 15 square miles per year for a 50-year project life. Potential restoration sites were outlined as individual polygons and assigned to one of the three alternatives based on a ranking methodology using multiple parameters. Characterizing the individual sites (polygons) by these parameters allowed the polygons to be ranked according to the efficiency and priority with which the different areas could be restored. For example, certain sites are more beneficial than others when issues such as infrastructure protection, habit type, and sustainability are considered.

The alternatives were subsequently refined after site parameters were analyzed. The primary reason for refinement was the availability of sediment from various sources and the proximity of those areas to the source. The initial layout of restoration polygons and a tabulation of the demand on each potential borrow source revealed that certain areas would likely not be able to supply sediment at the rate needed to rebuild up to 15 square miles of land per year across the Barataria and Terrebonne Basins.

The renewable supply of sediment from the Mississippi River for restoration is unknown. The majority of efforts to quantify the sediment transport in the Mississippi River have focused on measuring the suspended sediment, and even then results are often highly variable (Section 5.6.1).

The final three restoration alternatives are presented after a discussion of the selection and ranking of the individual restoration areas.

5.4 Restoration Area Evaluation

A preliminary map of potential restoration areas has been developed and is presented on Figure 5-1. An intensive analysis was conducted to determine these areas. This analysis included GIS-based investigations of historical, recent, and projected future land loss as well as current land/water interfaces. Recent (2004) aerial photography was consulted to define the areas to take advantage of existing confinement structures (e.g., historical ridges and spoil banks), limiting the need to create such structures to retain sediment delivered to the restoration sites. Site location and the ability to protect infrastructure were taken into

account, as was the potential for individual restoration sites to contribute to a return to more natural hydrologic conditions and drainage patterns in the system.

Figure 5-1 presents the 76 individual restoration areas, 30 in the Barataria Basin and 46 in the Terrebonne Basin. Two potential alignments of the interbasin segmented barriers are also included on Figure 5-1.

5.4.1 Description of Site-specific Parameters

After the restoration areas were determined, characteristics of each restoration area, or polygon, were tabulated. The following parameters were tabulated with GIS software:

- Size of restoration polygon
- Distribution of land and water in each polygon
- Historical land loss (1932 to 1990), broken down by process
- Projected future land loss (2000 to 2050)
- Habitat types per polygon
- Oyster leases per polygon
- Landowners per polygon
- Overlap with CWPPRA projects
- Location with respect to existing and planned hurricane-protection levees

In addition to the GIS-derived parameters, several other parameters were developed for each polygon, including the following:

- Degree of existing confinement
- Degree of infrastructure protection
- Degree of influence on natural hydrology
- Shoreline protection requirements
- Probable source of freshwater for maintenance of wetlands
- Distance to closest sediment sources
- Average depth of fill required and total sediment volume required by area

Detailed descriptions of these individual parameters, including graphical representations and tabular summaries where appropriate, are included in the following subsections.

Size and Land/Water Distribution

The present and recent distributions of land and water in the coastal zone were tabulated from USGS GIS layers obtained for use in this analysis. The land/water distribution in a given restoration area is an important factor in estimating the amount of sediment required to restore the site to a healthy marsh elevation. Table 5-1 presents a summary of the land/water distribution in the restoration areas for both 1990 and 2000.

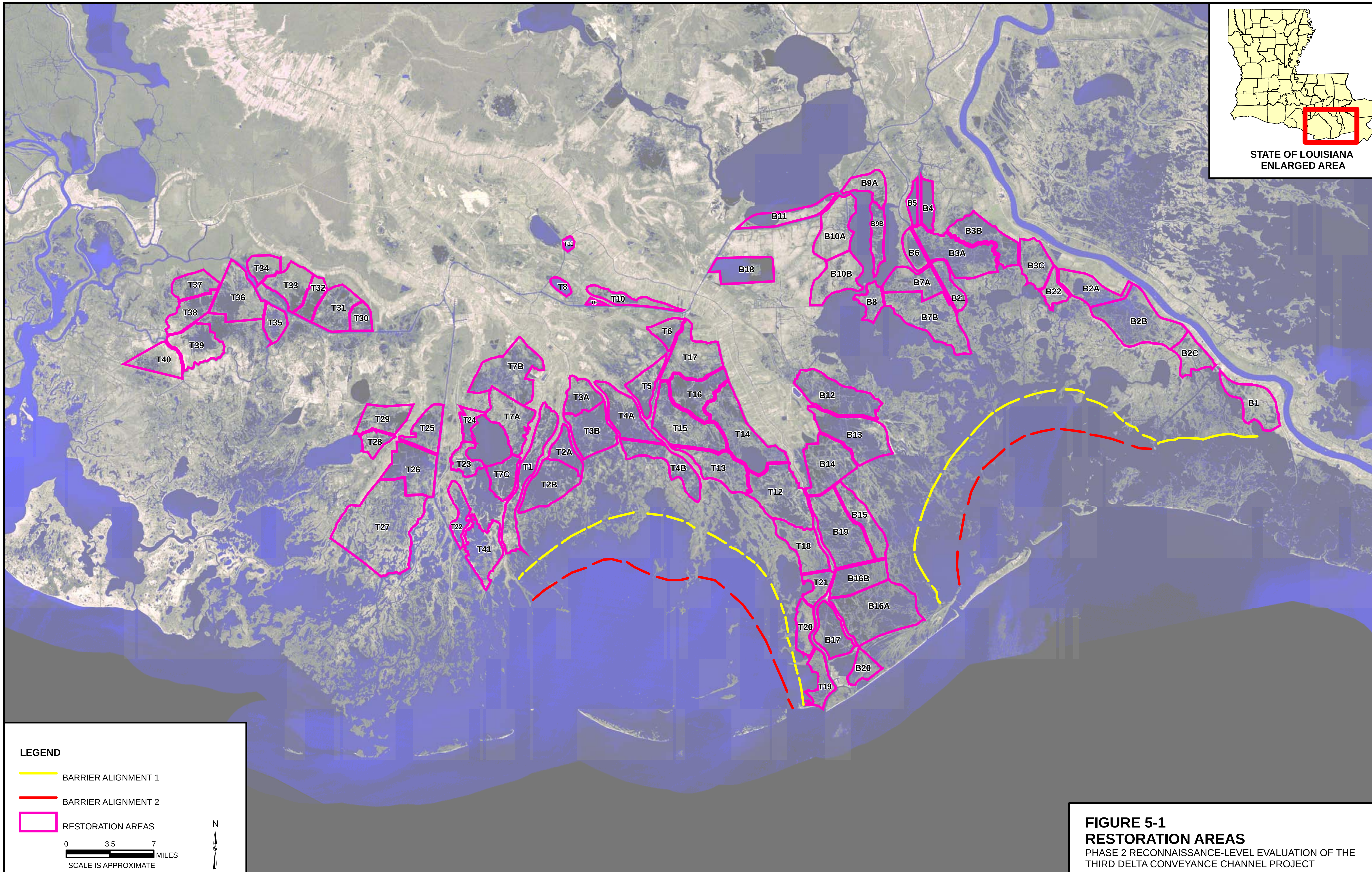

FIGURE 5-1
RESTORATION AREAS
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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TABLE 5-1
Comparison of Land/Water Distributions
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Restoration Polygon	1990 Land (square miles)	1990 Water (square miles)	2000 Land (square miles)	2000 Water (square miles)
B1	7.7	2.5	7.2	2.9
B2A	5.2	3.3	4.3	4.2
B2B	13.5	6.2	10.4	9.2
B2C	4.8	1.3	4.4	1.7
B3A	7.6	7.0	5.9	8.7
B3B	4.1	6.3	3.1	7.3
B3C	6.3	1.3	5.0	2.6
B4	0.1	3.6	0.0	3.6
B5	0.1	2.1	0.1	2.0
B6	1.4	2.4	2.1	1.7
B7A	6.0	2.4	5.0	3.3
B7B	12.6	4.8	10.4	7.0
B8	2.9	1.2	2.4	1.7
B9A	3.9	1.4	4.1	1.3
B9B	2.1	3.0	1.8	3.3
B10A	9.6	2.1	9.9	1.7
B10B	8.6	1.7	8.6	1.7
B11	3.7	3.1	3.5	3.3
B12	7.4	7.1	6.2	8.3
B13	7.7	7.3	4.8	10.2
B14	8.4	4.7	6.6	6.5
B15	6.1	2.0	4.8	3.3
B16A	13.1	9.7	5.7	17.1
B16B	4.7	4.3	2.9	6.0
B17	3.9	4.3	2.7	5.4
B18	0.6	8.6	0.6	8.6
B19	9.8	7.5	8.0	9.3
B20	3.0	1.0	1.8	2.3
B21	2.9	1.3	2.5	1.8
B22	3.2	0.5	2.8	0.8
T1	7.1	5.7	6.4	6.5
T2A	1.6	3.3	0.8	4.1
T2B	5.2	6.7	1.9	10.0
T3A	3.3	3.0	3.3	3.0
T3B	4.0	7.1	2.3	8.8
T4A	4.5	6.0	2.9	7.6
T4B	5.6	4.1	3.0	6.7
T5	3.6	2.6	3.0	3.2
T6	3.0	0.8	2.9	0.9
T7A	8.2	2.4	6.6	4.0

TABLE 5-1
Comparison of Land/Water Distributions
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Restoration Polygon	1990 Land (square miles)	1990 Water (square miles)	2000 Land (square miles)	2000 Water (square miles)
T7B	11.8	4.8	8.7	7.9
T7C	2.8	3.2	1.4	4.7
T8	0.1	1.4	0.1	1.4
T9	0.4	0.1	0.2	0.3
T10	4.0	0.7	3.4	1.4
T11	0.6	0.2	0.8	0.0
T12	10.7	6.3	8.2	8.8
T13	7.2	2.9	5.5	4.6
T14	10.4	7.3	7.3	10.5
T15	10.6	4.8	7.2	8.2
T16	4.0	6.0	3.0	7.0
T17	11.0	1.9	10.4	2.5
T18	8.0	1.7	6.9	2.8
T19	4.3	1.1	3.7	1.7
T20	4.1	1.2	3.7	1.6
T21	3.0	1.2	2.6	1.7
T22	2.2	2.5	2.2	2.5
T23	2.8	1.2	2.4	1.6
T24	1.8	1.0	1.5	1.3
T25	5.2	1.8	4.7	2.3
T26	5.2	7.1	4.9	7.4
T27	28.4	7.6	24.2	11.8
T28	2.4	0.9	2.4	1.0
T29	4.5	3.1	4.5	3.1
T30	2.2	1.1	1.7	1.7
T31	5.8	3.4	5.6	3.6
T32	2.3	2.0	2.2	2.1
T33	6.1	2.1	5.5	2.8
T34	3.1	1.2	2.8	1.4
T35	2.1	2.2	2.7	1.6
T36	4.4	8.6	7.1	5.9
T37	3.6	2.3	3.0	2.9
T38	2.9	3.8	3.8	3.0
T39	4.3	5.8	6.6	3.4
T40	5.0	2.4	5.9	1.4
T41	5.9	4.5	4.7	5.7
Barataria	170.8	113.7	137.7	146.8
Terrebonne	239.4	151.2	204.1	186.4
Total	410.2	264.9	341.9	333.2

Historical and Future Land Loss

Two GIS layers were obtained for this portion of the analysis. The first layer (Penland et al., 2001) details land loss throughout coastal Louisiana from 1932 to 1990. This layer was developed by analyzing digitized images at selected intervals over the 58-year period. A probable cause is assigned to the loss from one of several categories, including submergence, erosion, and direct removal. These groups are further dissected into individual causes, such as erosion by wind waves, navigation waves, or channel flow. The following land-loss mechanisms compose the submergence group:

- Altered hydrology by impoundment, oil and gas canals, navigation canals, or roadways
- Faulting
- Failed land reclamation
- Natural water logging (subsidence)
- Herbivory

Figure 5-2 presents the total land loss in the project area from 1932 to 1990. Figure 5-3 shows the breakdown of this land loss by specific process. Table 5-2 presents a summary of the 11 individual processes responsible for the measured land loss in the defined restoration areas presented on Figure 5-1. Table 5-2 also summarizes the land present in 1990, the water present in 1932, and the total land loss as a percentage of the land present in 1932. The dominant mechanism for land loss in the identified restoration areas was altered hydrology associated with oil and gas exploration and drilling (64 percent). The second largest process contributing to land loss was the direct removal of wetlands during the dredging of exploratory canals and wellhead access canals (12 percent). Approximately 8 percent of the land loss was associated with either wind waves or navigation waves. Table 5-3 presents a summary of the land-loss mechanisms by individual polygon. Interestingly, natural water logging (subsidence) only accounted for approximately 4 percent of the tabulated land loss in the defined restoration areas according to the USGS analysis.

The second GIS layer was obtained from USGS (USGS, 2003) and contains measured land loss and gain from 1932 to 2000, based on an analysis similar to that described for the first layer. This dataset also contains projected future land loss and land gain throughout coastal Louisiana for the years 2000 to 2050. Figure 5-4 presents the predicted land loss.

Table 5-4 summarizes the projected future land loss from 2000 to 2050. Predicted land loss as a percentage of land in 2000 is roughly equal between the two basins, at approximately 30 percent. Table 5-5 presents a full catalogue of the projected land loss by restoration area. No land loss is projected in the next 50 years for several polygons (i.e., B9A, B10A, B10B, and T25). This may be because CWPPRA projects protecting wetlands from loss were included in the analysis; Polygons B9A, B10A, and B10B contain or are adjacent to several CWPPRA projects (see Figure 5-8) and would likely also be positively influenced by flows from Davis Pond. However, there may also be estimation errors associated with the GIS analysis. The projected future land loss factors into calculations of net land change for a given project.

TABLE 5-2
Summary of Land-loss Processes in Restoration Areas (1932 to 1990)
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Class	Barataria Basin (square miles)	Terrebonne Basin (square miles)	Total (square miles)
Land Present in 1990	170.78	239.39	410.17
Water Present in 1932	28.62	29.04	57.66
Altered Hydrology: Oil/Gas	52.64	81.00	133.65
Oil/Gas Channels	11.98	13.61	25.59
Natural Waves	7.54	7.26	14.80
Altered Hydrology: Multiple	1.23	13.15	14.38
Natural Water Logging	2.46	6.33	8.78
Failed Land Reclamation	4.76	0.00	4.76
Altered Hydrology: Impoundment	3.88	0.00	3.88
Navigation Waves	0.61	0.76	1.37
Navigation Channels	0.00	0.04	0.04
Channel Flow	0.03	0.00	0.03
Burrow Pits	0.00	0.00	0.00
Total Land Lost (1932 - 1990)	85.12	122.14	207.26
Percent Land Lost (1932 - 1990)	33%	34%	34%

Vegetation and Fisheries Resources

Two GIS layers were obtained to quantify oyster leases near the proposed restoration areas and the current (recent) habitat distribution throughout the coastal zone.

The first GIS layer was obtained from the Louisiana Department of Wildlife and Fisheries, and was considered current as of November 2005. Figure 5-5 presents an overview of the current active oyster leases near the project site. Table 5-6 summarizes the number, total size, and average size of active oyster leases in the restoration areas. There are considerably more leases in restoration areas in the Terrebonne Basin (80 percent of the total area) than in the Barataria Basin, although most of the leases in the Terrebonne Basin are confined to a few restoration areas (T2A, T2B, T3B, T4B, and T14).

Figure 5-6 presents the distribution of different vegetation communities through southeast Louisiana. This GIS layer is a georeferenced version of Chabrek’s habitat maps. Table 5-7 summarizes the marsh types that make up the restoration areas in each basin. Brackish and saline marshes make up the majority of the area, followed by freshwater and intermediate marsh. The “water” entry indicates larger open-water bodies, not every square mile of surface water in the restoration polygons. Table 5-8 presents a breakdown of marsh types by individual restoration area.

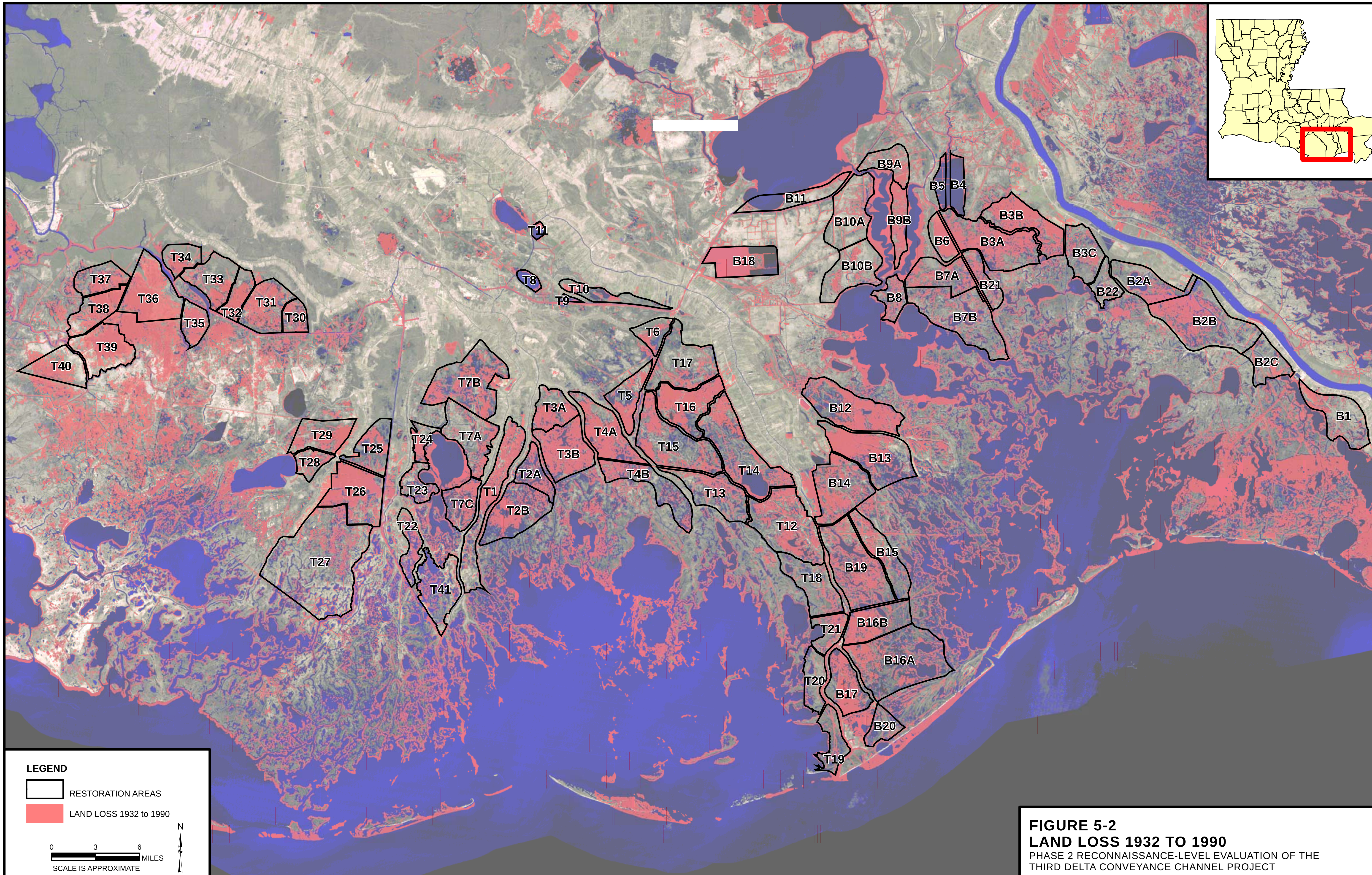

FIGURE 5-2
LAND LOSS 1932 TO 1990
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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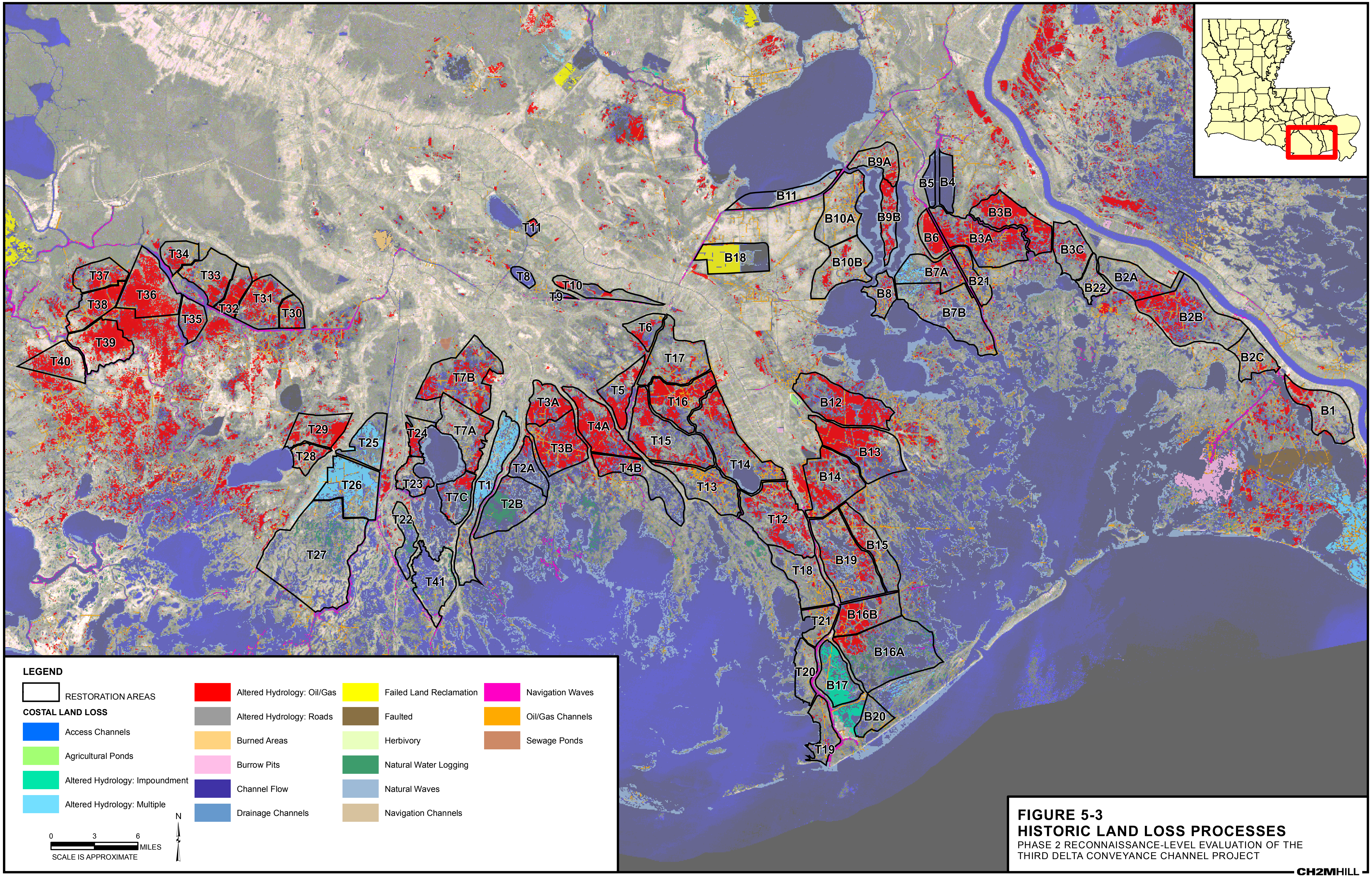

FIGURE 5-3
HISTORIC LAND LOSS PROCESSES
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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TABLE 5-3
Summary of Land-loss Processes in Square Miles (1936 to 1990)
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Restoration Polygon	Land (1990)	Water (1932)	Altered Hydrology: Oil/Gas	Oil/Gas Channels	Natural Waves	Altered Hydrology: Multiple	Natural Water Logging	Failed Land Reclamation	Altered Hydrology: Impoundment	Navigation Waves	Navigation Channels	Channel Flow	Burrow Pits	Land Lost (1932 - 1990)	Percent Land Lost (1932 - 1990)
Barataria	170.78	28.62	52.64	11.98	7.54	1.23	2.46	4.76	3.88	0.61	0.00	0.03	0.00	85.12	33
Terrebonne	239.39	29.04	81.00	13.61	7.26	13.15	6.33	0.00	0.00	0.76	0.04	0.00	0.00	122.14	34
Total	410.17	57.66	133.65	25.59	14.80	14.38	8.78	4.76	3.88	1.37	0.04	0.03	0.00	207.26	34
B1	7.69	0.57	1.53	0.20	0.13					0.02				1.89	20
B2A	5.16	1.29	1.19	0.35	0.43									1.96	28
B2B	13.47	0.69	4.29	0.90	0.28									5.46	29
B2C	4.77	0.34	0.48	0.46	0.03					0.02				1.00	17
B3A	7.63	0.78	5.08	0.89	0.10					0.18				6.24	45
B3B	4.08	0.09	5.80	0.35	0.02					0.03				6.21	60
B3C	6.29	0.16	1.10	0.02	0.05		0.00			0.00				1.17	16
B4	0.06	3.25		0.00	0.32					0.00				0.32	85
B5	0.05	1.79			0.27									0.27	84
B6	1.41		2.31	0.05						0.01				2.37	63
B7A	5.95	0.16	0.78	0.26	0.09	0.99				0.09		0.00		2.22	27
B7B	12.58	2.69	0.81	0.47	0.63	0.21				0.02				2.13	14
B8	2.86	0.24	0.51	0.35	0.08					0.00		0.03		0.97	25
B9A	3.94	0.04	0.98	0.35	0.03					0.02				1.37	26
B9B	2.11	0.15	1.99	0.10	0.75									2.84	57
B10A	9.58	0.16	0.32	1.47	0.07					0.04				1.90	17
B10B	8.65	0.24	0.96	0.39	0.07									1.41	14
B11	3.71	2.04	0.12	0.05	0.89					0.01				1.07	22
B12	7.36	0.27	6.45	0.40	0.03									6.88	48
B13	7.72	0.65	5.74	0.79	0.11									6.64	46
B14	8.42	0.18	3.83	0.50	0.18									4.50	35
B15	6.14	0.17	1.36	0.41	0.04		0.01			0.01				1.82	23
B16A	13.08	5.18	1.34	0.17	0.64		2.25			0.07			0.00	4.47	25
B16B	4.71	0.59	2.98	0.59	0.10					0.00				3.67	44
B17	3.87	0.21		0.23	0.02				3.83					4.08	51
B18	0.60	3.19	0.02	0.06	0.56			4.76						5.40	90
B19	9.82	2.59	2.21	1.21	1.50					0.01				4.93	33
B20	2.98	0.51		0.17	0.08	0.03	0.19		0.04					0.52	15
B21	2.91	0.25	0.40	0.59	0.05					0.03				1.06	27
B22	3.16	0.17	0.08	0.20	0.01					0.04				0.32	9
T1	7.14	1.01	0.05	0.21	0.04	4.23	0.14			0.03				4.70	40
T2A	1.59	1.96	0.38	0.08	0.85		0.04							1.35	46
T2B	5.21	3.10	0.18	0.09	0.84		2.47							3.58	41
T3A	3.34	0.05	2.75	0.15	0.03									2.93	47
T3B	3.98	0.83	5.21	0.94	0.15									6.30	61
T4A	4.48	0.20	5.63	0.15	0.01					0.01				5.79	56
T4B	5.55	2.17	1.32	0.13	0.42		0.02			0.05				1.94	26
T5	3.61	0.04	2.41	0.10										2.51	41
T6	2.95		0.76	0.06										0.83	22

TABLE 5-3
Summary of Land-loss Processes in Square Miles (1936 to 1990)
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Restoration Polygon	Land (1990)	Water (1932)	Altered Hydrology: Oil/Gas	Oil/Gas Channels	Natural Waves	Altered Hydrology: Multiple	Natural Water Logging	Failed Land Reclamation	Altered Hydrology: Impoundment	Navigation Waves	Navigation Channels	Channel Flow	Burrow Pits	Land Lost (1932 - 1990)	Percent Land Lost (1932 - 1990)
T7A	8.19	0.43	1.50	0.23	0.21		0.00							1.94	19
T7B	11.83	0.06	3.88	0.83										4.71	28
T7C	2.84	1.19	0.95	0.04	0.51		0.56							2.06	42
T8	0.08	1.19		0.01	0.16									0.17	69
T9	0.40		0.07							0.00	0.00			0.08	16
T10	4.04	0.01	0.68	0.04							0.01			0.73	15
T11	0.58		0.19	0.01										0.20	25
T12	10.68	1.24	4.12	0.47	0.43					0.02				5.04	32
T13	7.24	0.90	0.53	1.33	0.08		0.01			0.01				1.96	21
T14	10.42	2.73	2.79	0.99	0.85									4.62	31
T15	10.62	0.50	3.94	0.23	0.10					0.01				4.28	29
T16	4.02	0.18	4.94	0.83	0.05									5.82	59
T17	10.98	0.06	1.19	0.69										1.89	15
T18	7.99	0.68	0.30	0.65	0.08									1.02	11
T19	4.29	0.45	0.17	0.38	0.07					0.02	0.00			0.64	13
T20	4.11	0.81	0.05	0.12	0.16					0.01	0.00			0.34	8
T21	3.00	0.11	0.20	0.81	0.05					0.05				1.12	27
T22	2.25	1.37			0.43		0.65							1.08	32
T23	2.80	0.53	0.37	0.11	0.22					0.00				0.71	20
T24	1.77	0.00	0.98	0.03	0.02									1.03	37
T25	5.21	0.02		0.02		1.78				0.00				1.80	26
T26	5.23	0.06		0.49	0.01	6.50				0.03	0.00			7.03	57
T27	28.38	3.50	0.02	0.50	0.83	0.63	2.01			0.11				4.11	13
T28	2.42	0.00	0.76	0.18	0.01					0.00				0.95	28
T29	4.50	0.01	3.01	0.07	0.02					0.00				3.10	41
T30	2.25		0.89	0.23						0.00				1.12	33
T31	5.84		2.91	0.49						0.00				3.39	37
T32	2.25	0.00	1.90	0.14						0.00				2.04	47
T33	6.14	0.01	1.77	0.35						0.00				2.12	26
T34	3.06	0.00	1.08	0.14						0.00				1.23	29
T35	2.08	0.02	2.08	0.04						0.07				2.18	51
T36	4.40	0.13	8.25	0.13						0.07				8.45	66
T37	3.60	0.04	2.02	0.28						0.00				2.30	39
T38	2.94	0.02	3.31	0.47						0.00				3.78	56
T39	4.26	0.21	5.20	0.18						0.18				5.56	57
T40	4.95	0.00	2.25	0.15						0.01				2.40	33
T41	5.92	3.24		0.04	0.64		0.45			0.07	0.02			1.22	17

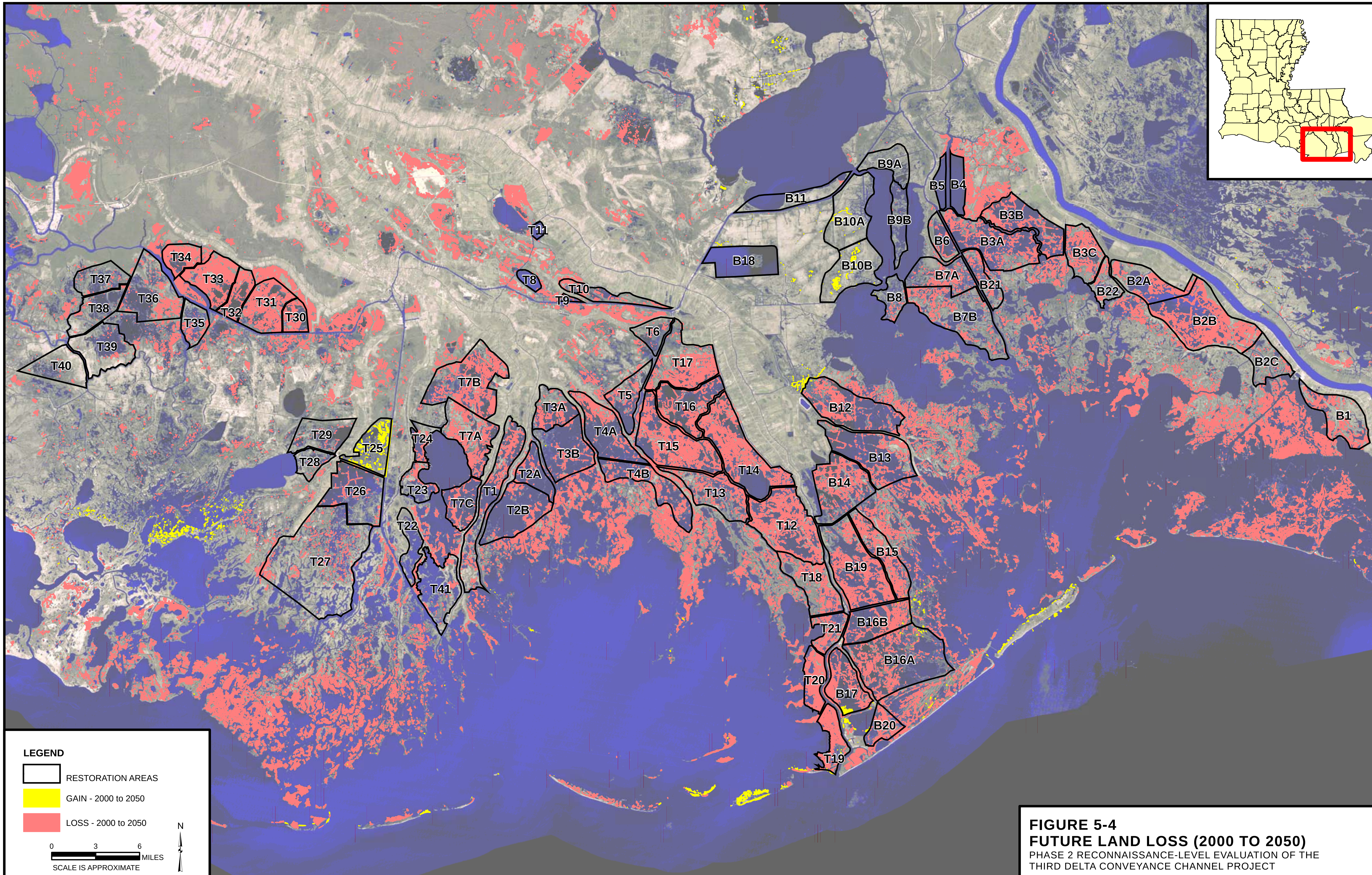

FIGURE 5-4
FUTURE LAND LOSS (2000 TO 2050)
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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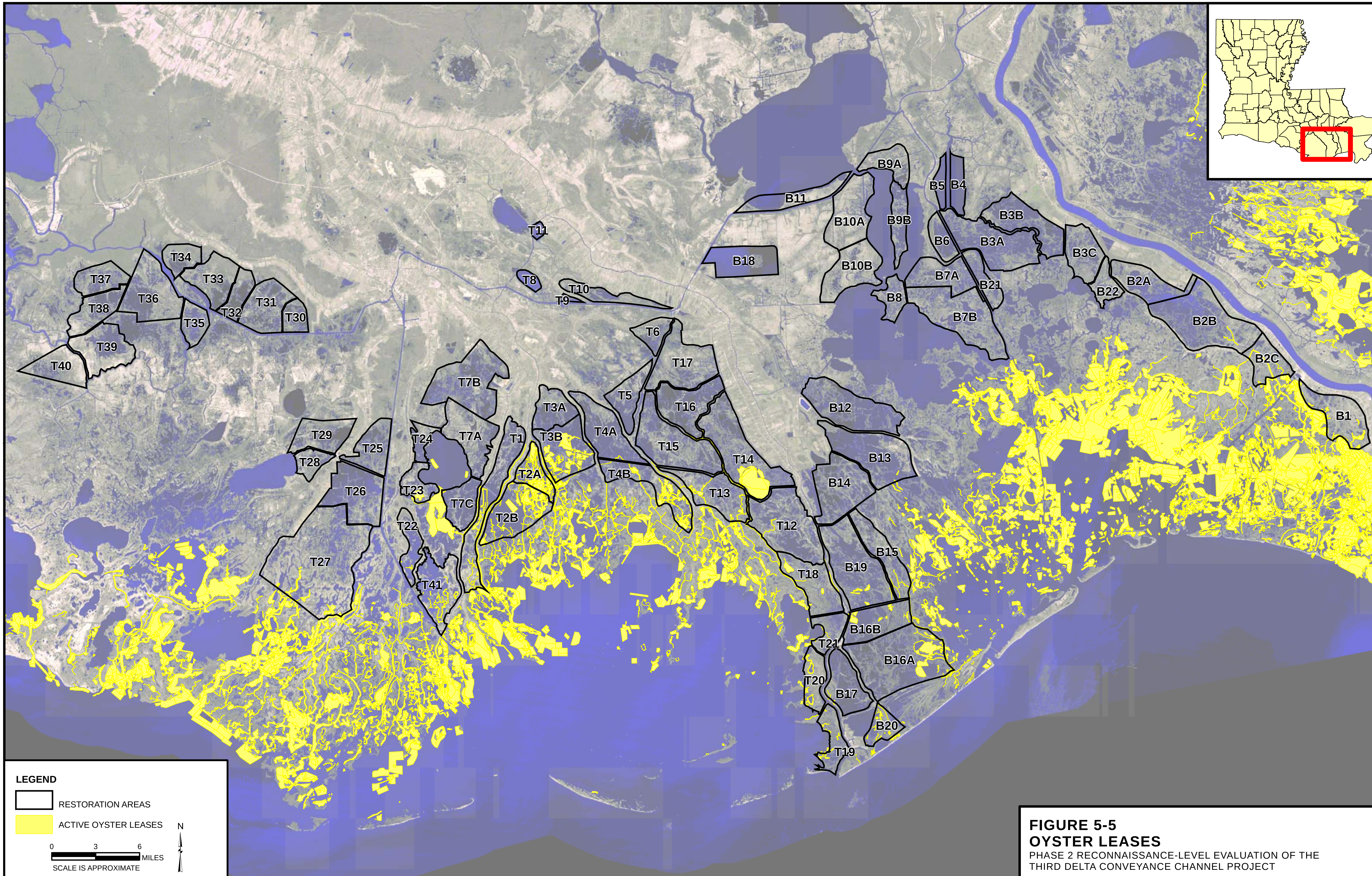

FIGURE 5-5
OYSTER LEASES
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE
THIRD DELTA CONVEYANCE CHANNEL PROJECT

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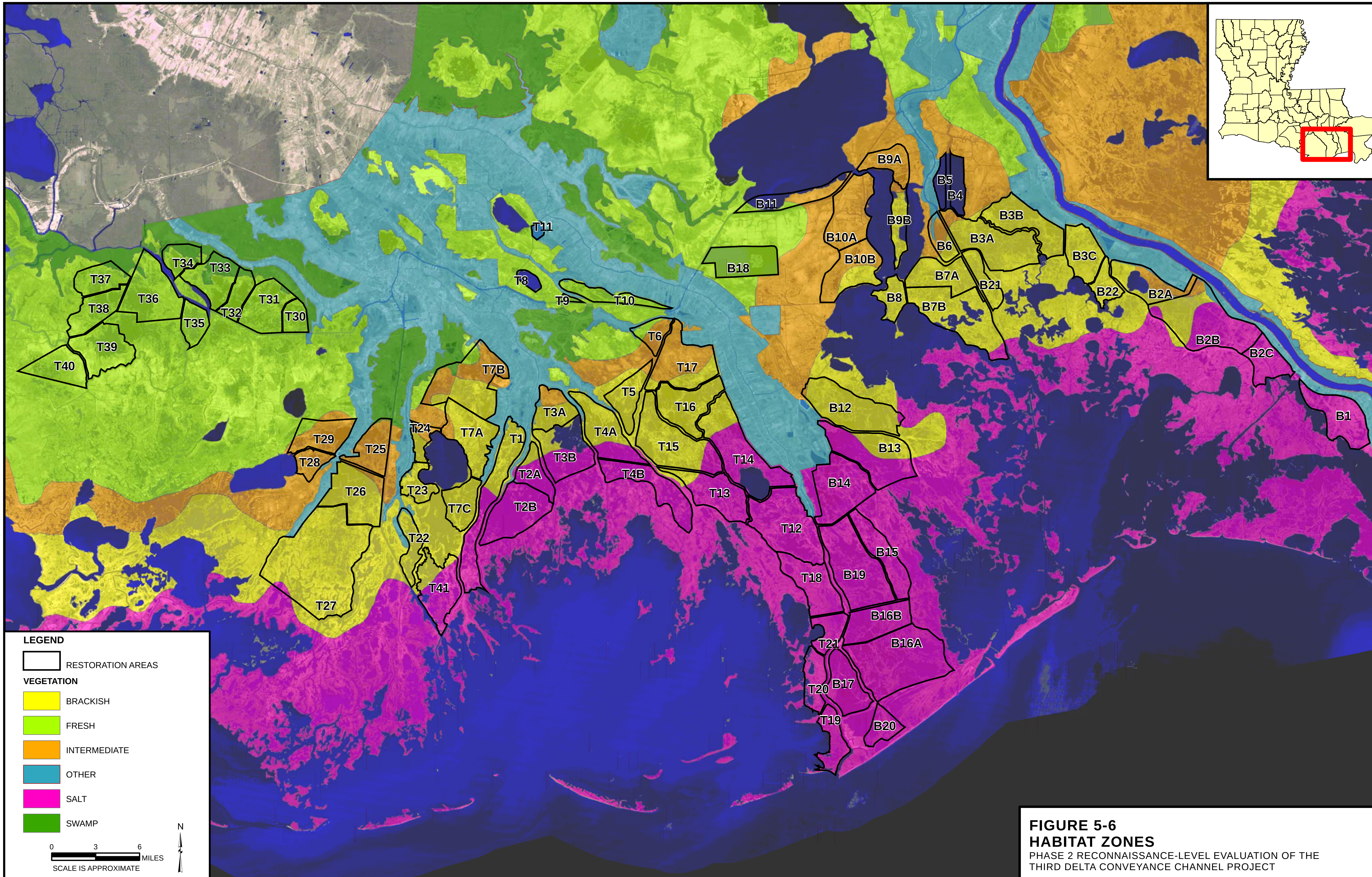

FIGURE 5-6
HABITAT ZONES

TABLE 5-4
Summary of Projected Land Loss in Barataria and Terrebonne Basins (2000 to 2050)
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

	Barataria	Terrebonne	Total
2000 Land	137.73	204.15	341.88
2000 Water	146.78	186.43	333.21
2050 Land	98.30	140.53	238.83
Land Loss 2000 - 2050	39.43	63.62	103.05
Percent Land Loss	29%	31%	30%

TABLE 5-5
Projected Land Loss by Restoration Area
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Restoration Polygon	2000 - 2050 Loss (square miles)	Restoration Polygon	2000 - 2050 Loss (square miles)	Restoration Polygon	2000 - 2050 Loss (square miles)
Barataria		Terrebonne (East HNC)		Terrebonne (West HNC)	
B1	1.82	T1	1.59	T25	
B2A	1.69	T2A	0.41	T26	0.64
B2B	6.24	T2B	1.22	T27	1.62
B2C	0.28	T3A	0.95	T28	0.08
B3A	2.19	T3B	0.92	T29	0.15
B3B	1.79	T4A	1.45	T30	1.16
B3C	1.91	T4B	1.59	T31	3.36
B4	0.00	T5	0.60	T32	1.42
B5	0.01	T6	0.16	T33	3.97
B6	0.35	T7A	2.41	T34	2.06
B7A	0.92	T7B	3.96	T35	0.39
B7B	1.49	T7C	0.87	T36	1.10
B8	0.15	T8	0.00	T37	0.12
B9A		T9	0.08	T38	0.15
B9B	0.00	T10	0.82	T39	0.16
B10A		T11		T40	0.06
B10B		T12	4.85		
B11	0.03	T13	1.57		
B12	2.24	T14	5.07		
B13	1.63	T15	5.06		
B14	2.50	T16	1.97		
B15	2.25	T17	3.49		
B16A	2.68	T18	1.86		
B16B	1.92	T19	2.46		
B17	2.07	T20	2.76		
B18	0.00	T21	0.90		
B19	4.26	T22	0.03		
B20	1.10	T23	0.39		
B21	0.48	T24	0.44		
B22	0.39	T41	0.45		

TABLE 5-6
Summary of Active Oyster Leases by Restoration Area
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

	Active Leases (acres)	Number of Active Leases	Acres per Lease
B1	468.3	57	8.2
B2B	58.5	4	14.6
B2C	194.9	10	19.5
B13	20.8	3	6.9
B15	56.4	3	18.8
B16A	1194.7	15	79.6
B16B	289.8	8	36.2
B17	8.1	2	4.1
B19	158.3	6	26.4
B20	169.0	16	10.6
T1	413.7	13	31.8
T2A	1200.1	59	20.3
T2B	1787.6	90	19.9
T3B	1645.8	23	71.6
T4A	27.2	2	13.6
T4B	1286.7	57	22.6
T7C	12.5	1	12.5
T12	43.8	5	8.8
T13	346.9	19	18.3
T14	1948.4	10	194.8
T15	0.1	1	0.1
T18	228.6	8	28.6
T19	116.9	11	10.6
T20	235.3	9	26.1
T21	14.6	4	3.6
T22	23.5	3	7.8
T23	205.1	1	205.1
T27	490.3	22	22.3
T41	291.4	29	10.0
Total	12937.2	491	26.3

TABLE 5-7
Distribution of Vegetation Types in Restoration Areas
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Type	Barataria Basin (square miles)	Terrebonne Basin (square miles)	Total (square miles)
Swamp	0.0	6.7	6.7
Fresh Marsh	10.4	78.9	89.2
Intermediate	34.0	41.8	75.7
Brackish	103.2	141.1	244.3
Saline	121.7	109.9	231.6
Water	13.7	9.6	23.3
Other	1.6	2.7	4.3
Total	284.5	390.6	675.1

TABLE 5-8
Summary of Habitat Distribution in Restoration Areas
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

	Square Miles by Habitat Type							
Restoration Polygon	**Swamp**	**Fresh**	**Intermediate**	**Brackish**	**Saline**	**Water**	**Other**	**Total**
Barataria	0.00	10.39	33.96	103.15	121.72	13.69	1.61	284.51
Terrebonne	6.66	78.85	41.78	141.12	109.88	9.62	2.67	390.58
Total	6.66	89.24	75.74	244.27	231.60	23.31	4.28	675.09
B1					9.87	0.25	0.03	10.1
B2A			2.82	3.68		1.54	0.38	8.4
B2B			0.83	6.40	11.81		0.60	19.6
B2C					6.09	0.01	0.00	6.1
B3A			0.99	13.63		0.02		14.6
B3B				10.33		0.02	0.03	10.4
B3C				7.60		0.01	0.01	7.6
B4			0.03			3.60		3.6
B5			0.03			2.04	0.04	2.1
B6			1.91	1.41			0.46	3.8
B7A			0.03	8.30				8.3
B7B				14.18	1.00	2.22		17.4
B8				3.98		0.09		4.1
B9A			5.35			0.01		5.4
B9B			0.51	3.71		0.88		5.1
B10A			11.58			0.06		11.6
B10B			6.90	3.31		0.10		10.3
B11		1.20	2.81			2.81		6.8
B12			0.19	14.08	0.23		0.01	14.5
B13				4.70	10.29		0.04	15.0
B14					13.10		0.01	13.1
B15					8.13			8.1
B16A					22.74			22.7
B16B					8.97			9.0
B17					8.17			8.2

TABLE 5-8
Summary of Habitat Distribution in Restoration Areas
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

	Square Miles by Habitat Type							
Restoration Polygon	**Swamp**	**Fresh**	**Intermediate**	**Brackish**	**Saline**	**Water**	**Other**	**Total**
B18		9.19	0.00					9.2
B19					17.34			17.3
B20					4.01			4.0
B21				4.23		0.00		4.2
B22				3.63		0.03	0.00	3.7
T1				6.07	6.45	0.10	0.23	12.8
T2A				0.97	3.91		0.02	4.9
T2B					11.89			11.9
T3A			1.90	4.20			0.22	6.3
T3B				2.25	5.55	3.31		11.1
T4A				7.05	3.35		0.07	10.5
T4B					9.66			9.7
T5			0.40	5.76				6.2
T6		1.04	2.53				0.21	3.8
T7A			0.94	9.51		0.03	0.07	10.6
T7B	0.49	0.93	8.02	6.99			0.17	16.6
T7C				6.09			0.00	6.1
T8		0.09				1.35		1.4
T9		0.47						0.5
T10		4.67					0.11	4.8
T11		0.01					0.77	0.8
T12					16.94		0.02	17.0
T13				1.31	8.79			10.1
T14				4.50	9.93	3.34		17.8
T15				13.16	2.25			15.4
T16				10.02				10.0
T17			8.90	3.97			0.06	12.9
T18					9.66	0.02		9.7

TABLE 5-8
Summary of Habitat Distribution in Restoration Areas
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

	Square Miles by Habitat Type							
Restoration Polygon	**Swamp**	**Fresh**	**Intermediate**	**Brackish**	**Saline**	**Water**	**Other**	**Total**
T19					5.18	0.20		5.4
T20					4.34	0.92		5.3
T21					4.21	0.01		4.2
T22				4.36		0.00	0.34	4.7
T23				3.94		0.00	0.09	4.0
T24			1.24	1.51		0.00	0.05	2.8
T25	0.14		6.86				0.03	7.0
T26			1.04	11.23			0.05	12.3
T27				35.39	0.54		0.06	36.0
T28			3.34			0.00	0.02	3.4
T29		0.93	6.60				0.08	7.6
T30	0.06	3.31						3.4
T31	0.19	9.05						9.2
T32	0.43	3.85						4.3
T33	3.03	5.24				0.01		8.3
T34	1.59	2.68				0.01		4.3
T35		4.27						4.3
T36	0.30	12.67						13.0
T37	0.42	5.52						5.9
T38		6.74						6.7
T39		10.03						10.0
T40		7.36						7.4
T41				2.83	7.22	0.32		10.4

Landowners

A GIS layer was obtained from the LDNR containing the parcels and landowners throughout southeast Louisiana. The restoration polygons were placed over the landowner layer to develop a list of landowners in each restoration area. Figure 5-7 shows the distribution of landowners in southeast Louisiana. Table 5-9 lists the number of landowners in each restoration area. An electronic database of owners by restoration polygon also has been developed.

TABLE 5-9
Number of Landowners by Restoration Area
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Restoration Polygon	Landowners	Restoration Polygon	Landowners	Restoration Polygon	Landowners
Barataria		**Terrebonne (East HNC)**		**Terrebonne (West HNC)**	
B1	1	T1	5	T25	4
B2A	6	T2A	2	T26	3
B2B	12	T2B	2	T27	5
B2C	3	T3A	1	T28	2
B3A	6	T3B	2	T29	3
B3B	16	T4A	3	T30	4
B3C	4	T4B	2	T31	3
B4	7	T5	4	T32	3
B5	3	T6	1	T33	4
B6	1	T7A	3	T34	3
B7A	2	T7B	6	T35	0
B7B	2	T7C	2	T36	4
B8	2	T8	0	T37	5
B9A	5	T9	1	T38	1
B9B	3	T10	3	T39	1
B10A	3	T11	0	T40	1
B10B	4	T12	3		
B11	1	T13	3		
B12	9	T14	4		
B13	9	T15	3		
B14	8	T16	3		
B15	3	T17	4		
B16A	10	T18	4		
B16B	3	T19	3		
B17	5	T20	2		
B18	6	T21	2		
B19	6	T22	3		
B20	4	T23	3		
B21	5	T24	3		
B22	3	T41	3		

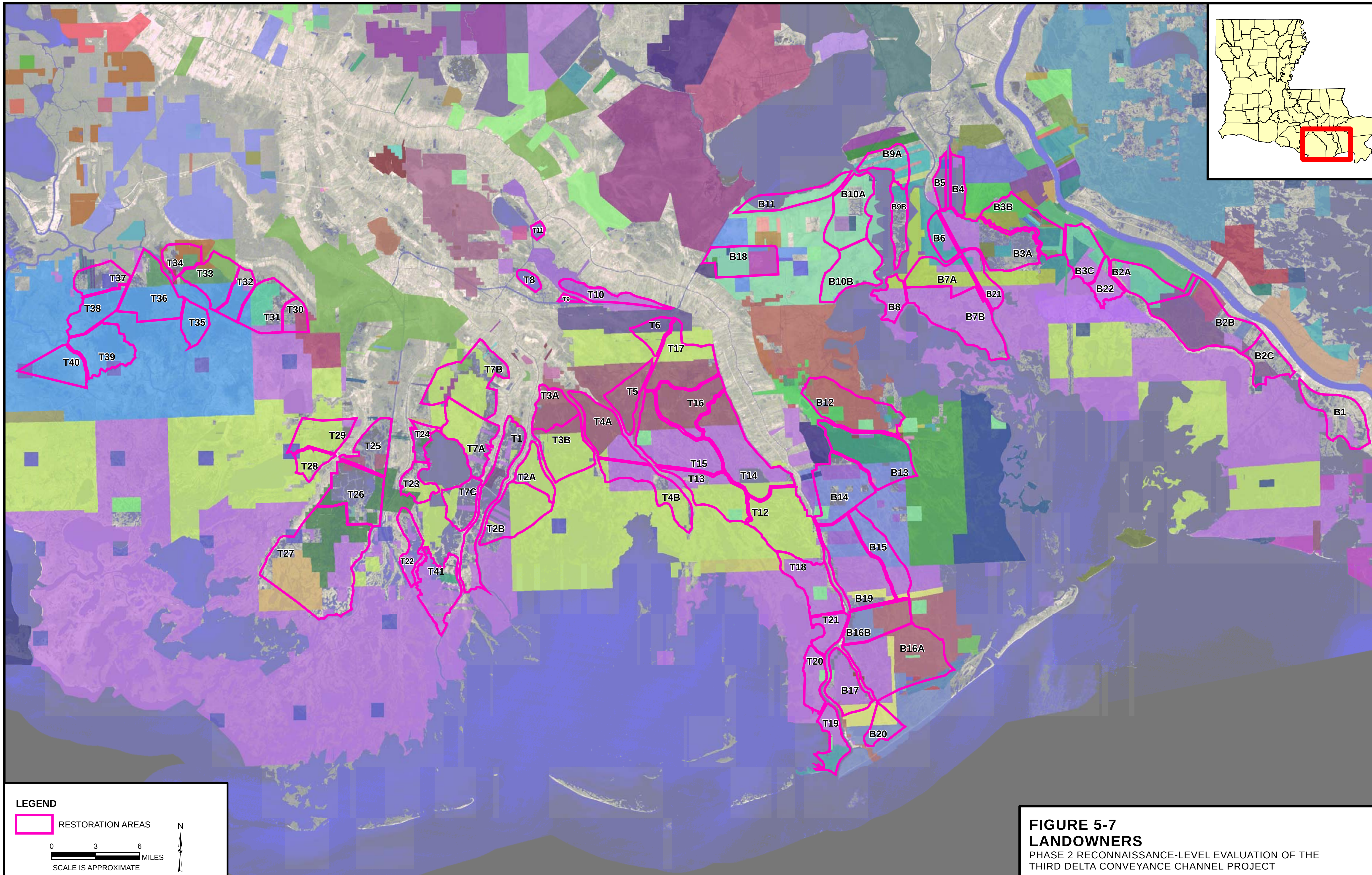

FIGURE 5-7
LANDOWNERS
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

RDD \\LOKI\PROJECTS\RDDGIS\THIRD_DELTA\MXDS\PHASE2_EVALUATION\FIG5-7_OWNERSHIP.MXD 6/26/2006 14:46:06

CWPPRA Projects

A GIS layer outlining CWPPRA projects in coastal Louisiana was obtained and compared with the restoration areas developed during this project. Table 5-10 lists the CWPPRA projects that share benefit areas with the proposed restoration areas. Figure 5-8 demonstrates the overlap between CWPPRA projects and the proposed restoration areas. This comparison is a useful means of determining which potential restoration areas may already be the site of existing or planned projects.

TABLE 5-10
CWPPRA Projects Overlap with Restoration Areas
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

	CWPPRA Project
1	Barataria Basin Landbridge Shoreline Protection, Phase 3
2	Barataria Basin Landbridge Shoreline Protection, Phases 1 and 2
3	Barataria Bay Waterway East Side Shoreline Protection
4	Barataria Bay Waterway West Side Shoreline Protection
5	Bayou L'Ours Ridge Hydrologic Restoration
6	Bayou Perot/Bayou Rigolettes Marsh Restoration (Deauthorized)
7	Central and East Terrebonne Freshwater Enhancement
8	Dedicated Dredging on the Barataria Basin Landbridge
9	Delta-building Diversion at Myrtle Grove
10	Falgout Canal Planting Demonstration
11	Flotant Marsh Fencing Demonstration (Deauthorized)
12	GIWW to Clovelly Hydrologic Restoration
13	GIWW Bank Restoration of Critical Areas in Terrebonne
14	Grand Bayou/GIWW Freshwater Diversion
15	Jonathan Davis Wetland Protection
16	Louisiana Highway 1 Marsh Creation
17	Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake
18	Lower Bayou LaCache Hydrologic Restoration (Deauthorized)
19	Mandalay Bank Protection Demonstration
20	Mississippi River Reintroduction into Bayou Lafourche
21	Mississippi River Sediment Delivery System – Bayou Dupont
22	Myrtle Grove Siphon
23	Naomi Outfall Management
24	North Lake Boudreaux Basin Freshwater Introduction and Hydrologic Management
25	Penchant Basin Natural Resources Plan, Increment 1
26	South Shore of the Pen Shoreline Protection and Marsh Creation
27	West Belle Pass Headland Restoration
28	West Lake Boudreaux Shoreline Protection and Marsh Creation
29	West Pointe a la Hache Outfall Management

Hurricane-protection Levees

Figure 5-9 presents existing, authorized, and proposed hurricane-protection levees in southeast Louisiana. Several of the restoration polygons in southwestern Terrebonne Bay are located inside (northward) of proposed and authorized hurricane-protection levees (T7A, T7B, T7C, T23, T24, and T25).

Shoreline Protection

Probable shoreline protection needs were estimated for each restoration area. Aerial photographs were used to identify shorelines, channels, and approximate distances of shore or channel front as presented in Table 5-11.

TABLE 5-11
Approximate Shoreline Protection Needs for Each Restoration Area
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Restoration Polygon	Shoreline Protection (miles)	Restoration Polygon	Shoreline Protection (miles)	Restoration Polygon	Shoreline Protection (miles)
Barataria		**Terrebonne (East of HNC)**		**Terrebonne (West of HNC)**	
B1	2	T1	0	T25	0
B2A	0	T2A	0	T26	0
B2B	0	T2B	0	T27	0
B2C	0	T3A	0	T28	1
B3A	3	T3B	0	T29	0
B3B	0	T4A	0	T30	2
B3C	0	T4B	0	T31	3
B4	4	T5	0	T32	2
B5	4	T6	0	T33	3
B6	3	T7A	4	T34	2
B7A	5	T7B	0	T35	2
B7B	9	T7C	6	T36	4
B8	10	T8	0	T37	0
B9A	4	T9	0	T38	0
B9B	12	T10	0	T39	0
B10A	7	T11	0	T40	0
B10B	7	T12	0		
B11	10	T13	0		
B12	0	T14	0		
B13	0	T15	0		
B14	0	T16	0		
B15	0	T17	0		
B16A	0	T18	2		
B16B	4	T19	5		
B17	0	T20	0		
B18	0	T21	4		
B19	3	T22	0		
B20	0	T23	4		
B21	4	T24	3		
B22	0	T41	0		

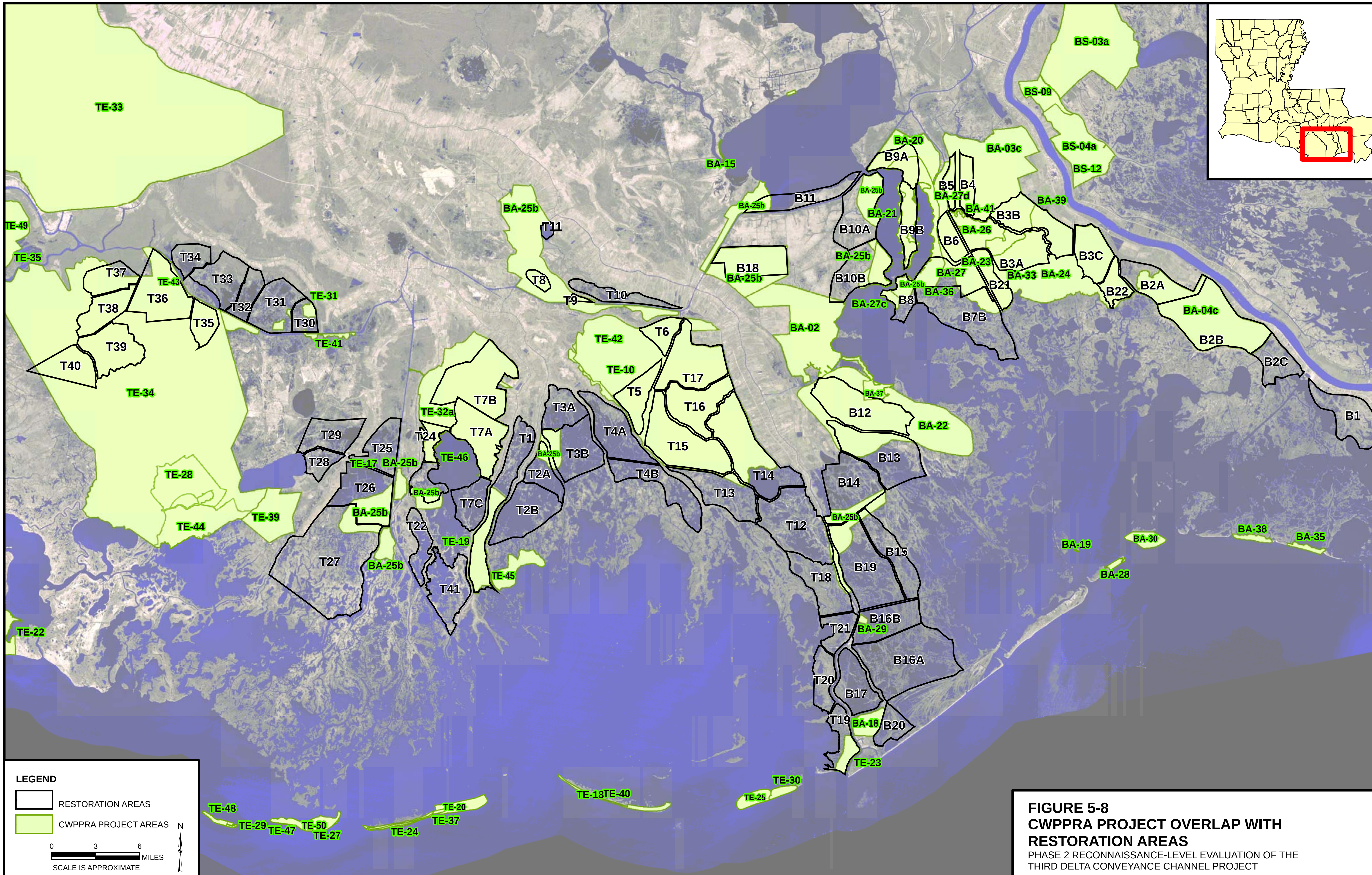

FIGURE 5-8
CWPPRA PROJECT OVERLAP WITH RESTORATION AREAS

PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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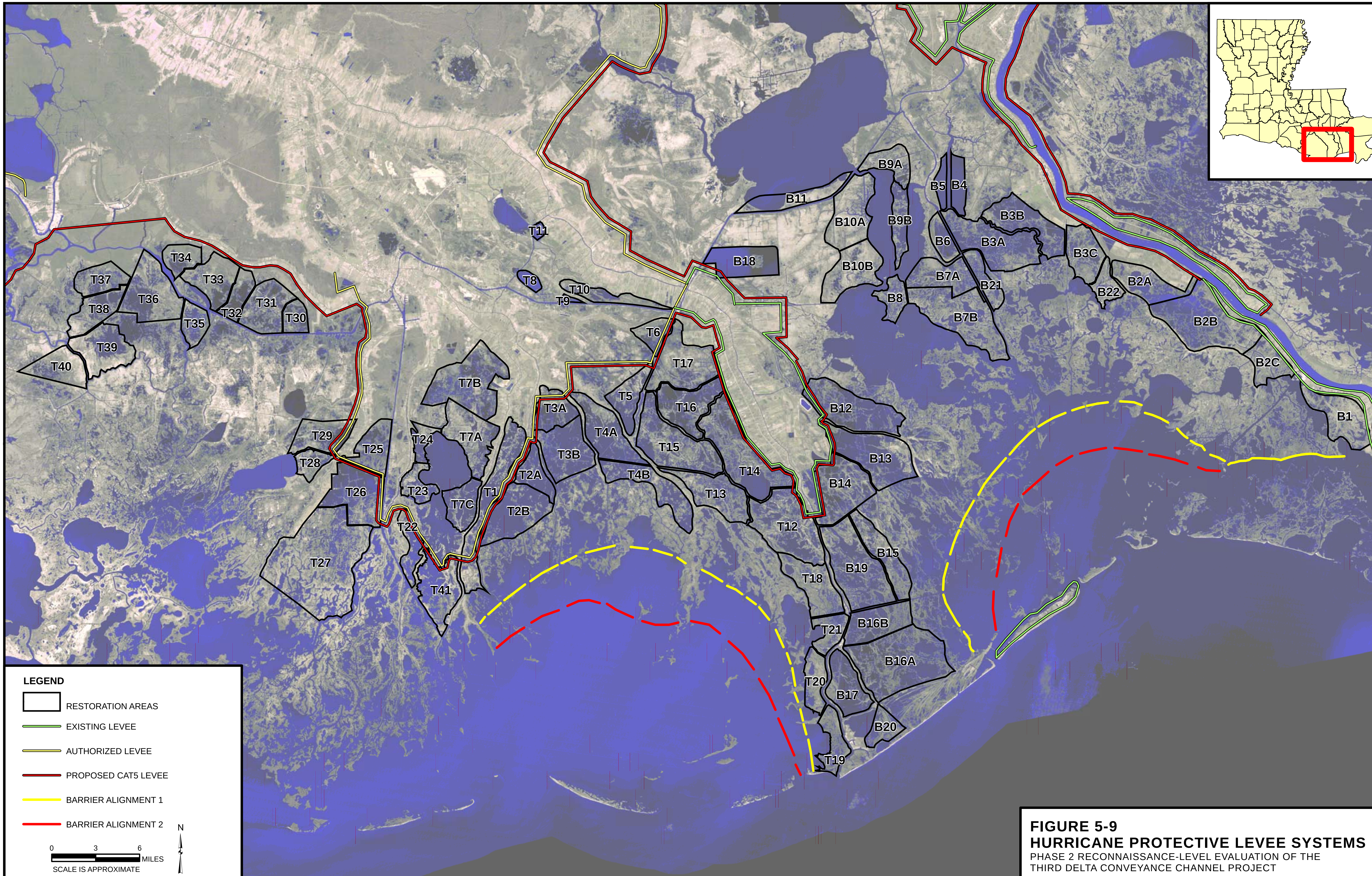

FIGURE 5-9
HURRICANE PROTECTIVE LEVEE SYSTEMS
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE
THIRD DELTA CONVEYANCE CHANNEL PROJECT

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Distances to Sediment Sources

The distance from the centroid of each restoration area to, generally, two sediment sources was tabulated to help screen restoration areas and develop cost estimates. In each case, a pipeline ROW was used from a designated source (or drop-off point) to the restoration area, if possible, or through adjacent areas that are also potential restoration sites. It is assumed that a ROW will be retained through all sites restored as part of this program so that a corridor will be available to reach sites farther from the original pipeline ROW.

Figure 5-10 shows several potential pipeline corridors that primarily take advantage of existing ROWs or open water. It is assumed that sediment sources may be at several locations on the Mississippi River, at Horseshoe Bend on the Atchafalaya River, at Ship Shoal off of Terrebonne Bay, and at ebb shoal deltas offshore of Barataria Bay.

Freshwater Sources

For each restoration area, a freshwater source was identified that would most likely contribute to the long-term sustainability of a restored wetland area. Both existing and proposed projects were considered: existing projects include Davis Pond, Naomi Siphon, and West Pointe a la Hache Siphon; proposed projects include the Myrtle Grove Diversion, Mississippi River Water Reintroduction into Bayou Lafourche, and the Morganza to the Gulf of Mexico Hurricane-Protection project, which includes the HNC Lock Complex. This final proposed project has the capacity to distribute freshwater through the wetlands in upper Terrebonne Bay.

Degree of Influence on Natural Hydrology

Each restoration area was given a relative score from 1 to 3 reflecting the influence of a restoration project on returning a more natural hydrologic regime to the project area. Figure 5-11 shows the scores applied to each restoration area. Lower scores indicate a more beneficial area for restoration.

Degree of Existing Confinement

In a similar fashion, each restoration area was given a relative score from 1 to 3 reflecting the degree of existing confinement at the project area. Lower values indicate more existing confinement. Confinement influences the trapping rate of sediments delivered to a project site. A high degree of confinement, from either natural ridges or spoil banks, will increase the retention of material delivered to the site. Figure 5-12 presents a map of the relative scores applied to each restoration area.

Degree of Infrastructure Protection

The ability of each restoration area to protect existing infrastructure (roads, businesses, houses) was also given a relative score from 1 to 3. A score of 1 indicates a high level of protection (i.e., backing up to a levee) and 3 indicates few or no direct infrastructure benefits. Figure 5-13 presents the relative scores assigned to each area.

5.4.2 Development of Ranking Matrix

A ranking matrix was developed with data for each restoration area presented on Figure 5-1. The ranking matrix was developed to allow quantitative scoring of each area, comparison with other areas, and to identify priority areas for restoration. The individual restoration areas were then assigned to the three alternatives. The polygons with the lower scores were placed higher on the priority list (lower scores = more beneficial or efficient to restore).

The following parameters were used in the ranking matrix:

- Recent land loss (square miles per polygon)
- Future land loss, based on USGS projections
- Distance from sediment sources along pipeline ROWs
- Influence from existing or planned freshwater sources
- Degree of existing confinement, based on review of aerial photographs
- Degree of infrastructure protection, based on review of aerial photographs
- Degree of influence on natural hydrology, based on engineering judgment and review of aerial photographs

Several of the parameters in the ranking matrix used quantitative measures that had to be converted to relative scores so that an unbiased numerical score could be assigned to each restoration area. Other parameters that had qualitative scores were given a relative score between 1 and 3 based on the qualitative score so that the parameters had equal weight.

Because some of the parameters may be more important than others in selecting potential restoration areas, a preliminary weighting formula was applied to the parameters in the ranking matrix. The ranking tool was designed so that the weights can easily be changed if needed. The following parameters were assigned twice the weight of the rest of the parameters:

- Relative distance to sediment source
- Average depth of fill
- Influence of freshwater diversions

5.4.3 Compilation of Restoration Areas into Three Alternatives

The final three alternatives were selected using an iterative process that relied on parameters contained in both the ranking matrix and the restoration area parameter file. Each alternative includes increases in freshwater diversions, construction of the interbasin segmented barriers, and restoration of barrier island chains offshore of both Barataria and Terrebonne Bays. The primary difference between alternatives is the magnitude of the land-building goal, which is shown on Figure 5-14. As illustrated on Figure 5-14, the restoration alternatives are cumulative in that they include the restoration areas of the previous alternative. For example, Alternative 2 includes the restoration areas labeled

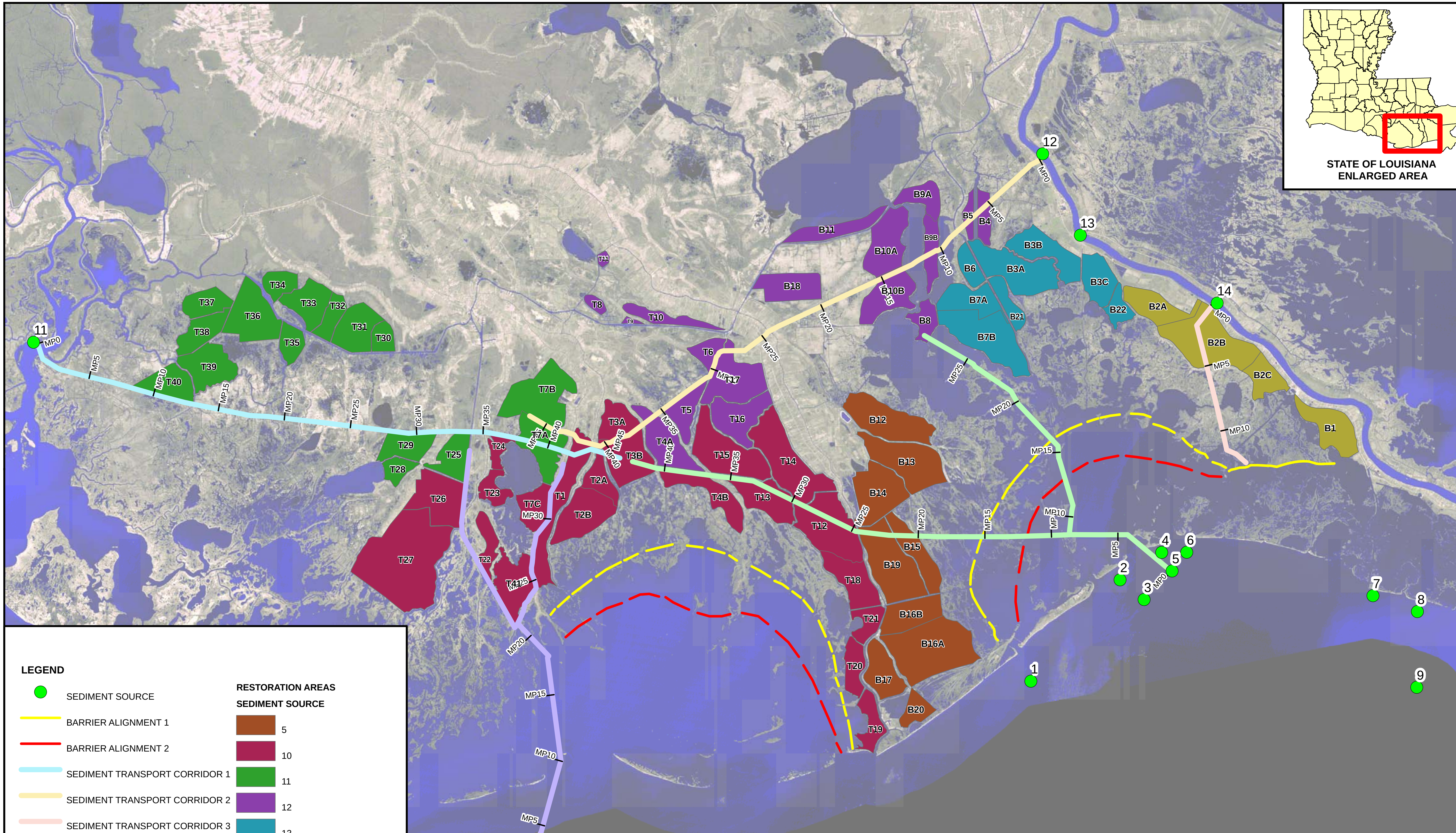

FIGURE 5-10
RESTORATION AREAS WITH PIPELINES AND SEDIMENT SOURCES
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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RDD \\LOKI\PROJECTS\RDDGIS\THIRD_DELTA\MXDS\PHASE2_EVALUATION\FIG5-10_SEDIMENTSOURCES_RESTORATION.MXD 6/22/2006 09:08:04

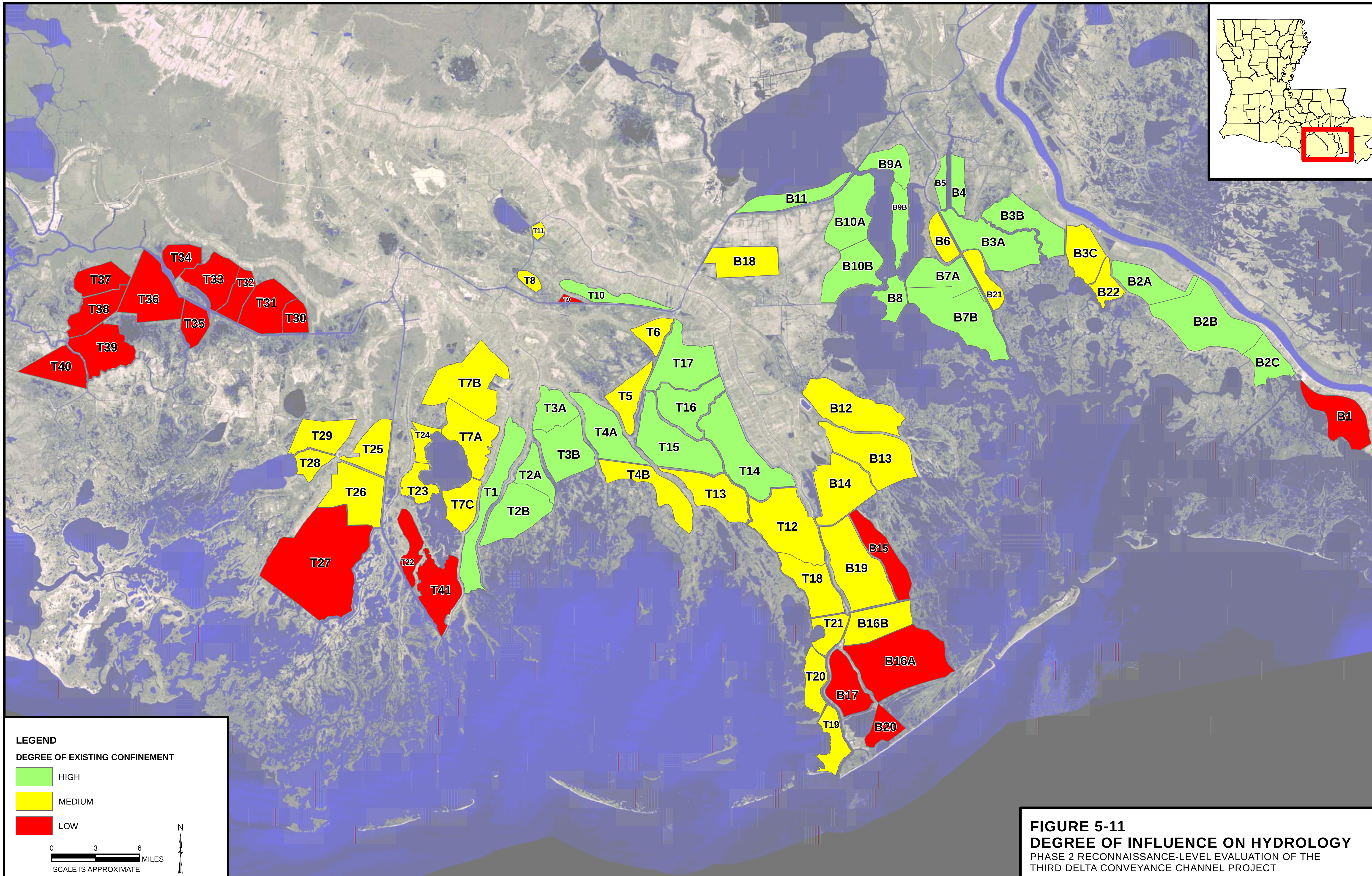

FIGURE 5-11
DEGREE OF INFLUENCE ON HYDROLOGY
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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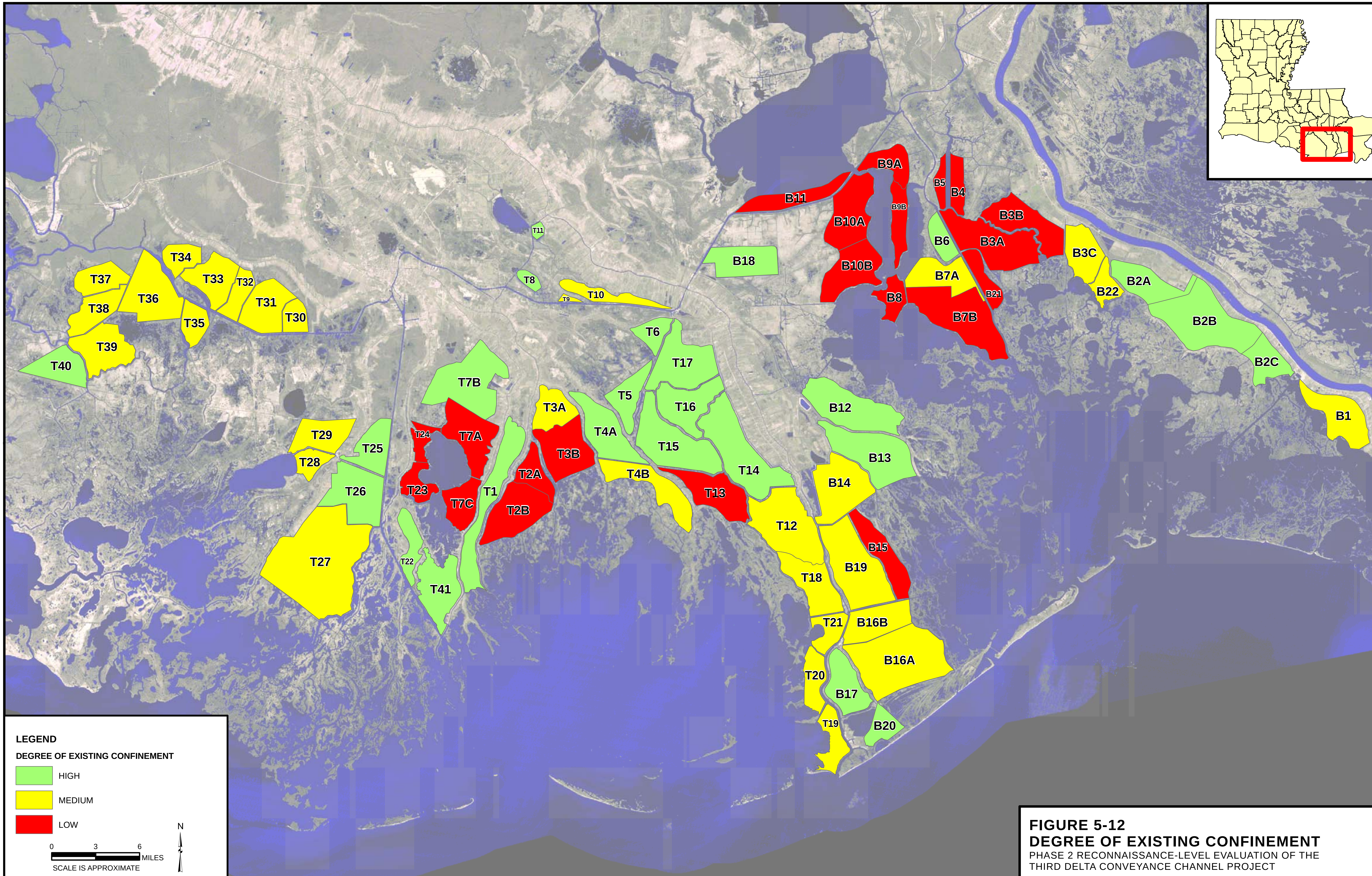

FIGURE 5-12
DEGREE OF EXISTING CONFINEMENT
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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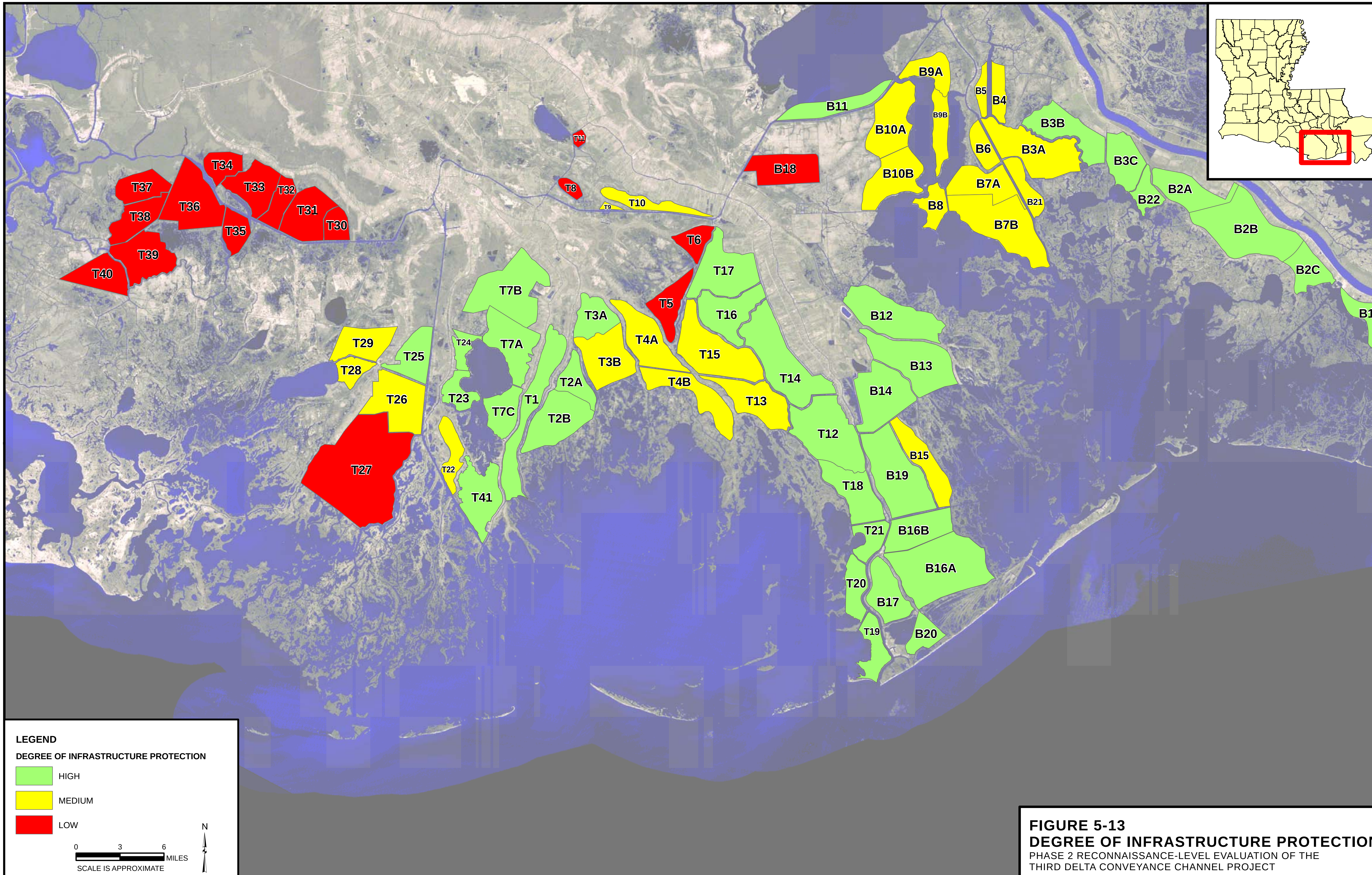

FIGURE 5-13
DEGREE OF INFRASTRUCTURE PROTECTION
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE
THIRD DELTA CONVEYANCE CHANNEL PROJECT

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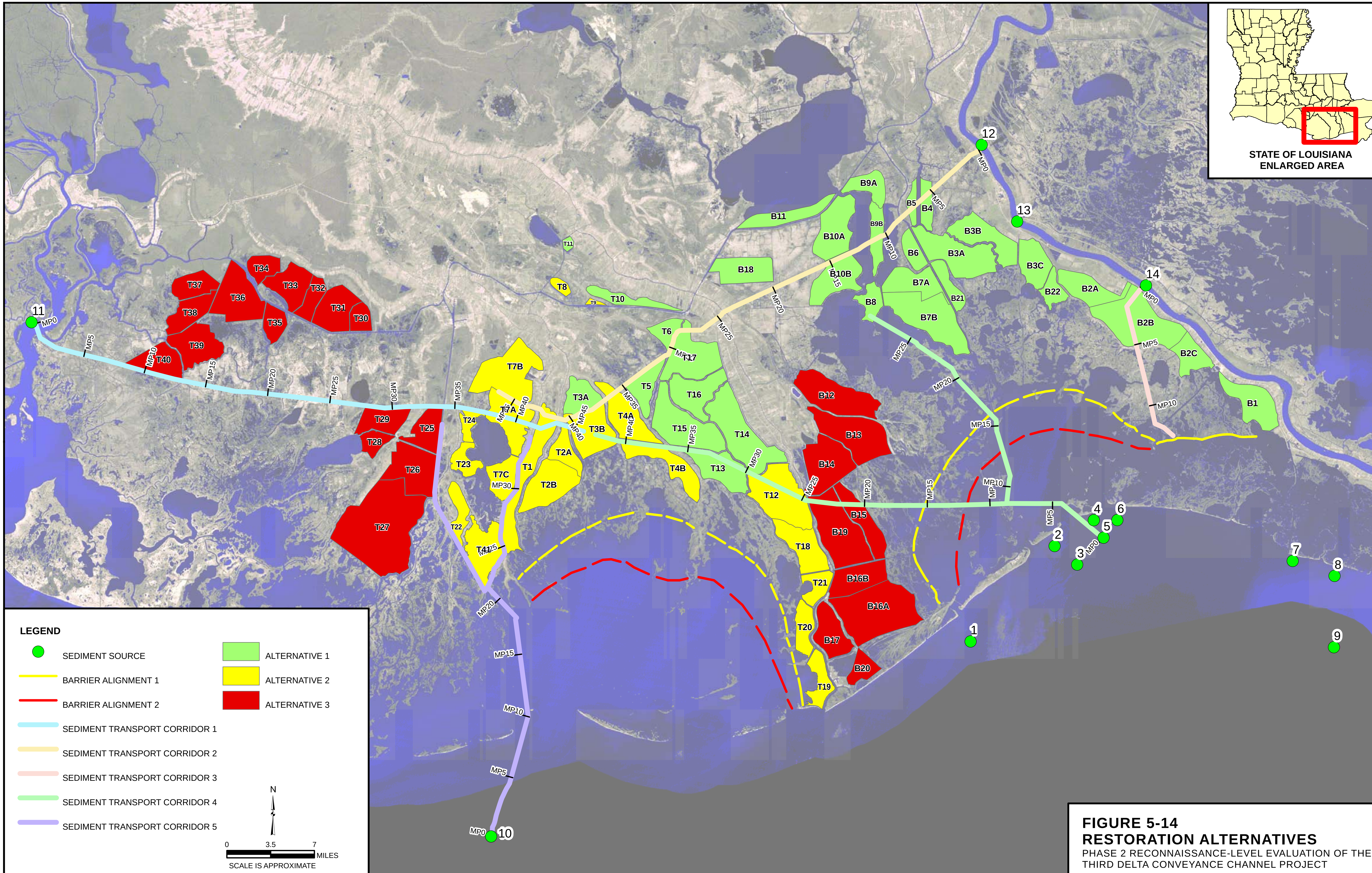

FIGURE 5-14
RESTORATION ALTERNATIVES
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE
THIRD DELTA CONVEYANCE CHANNEL PROJECT

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Alternative 2 and those labeled Alternative 1. Similarly, Alternative 3 includes all restoration areas. Table 5-12 presents a summary of which restoration areas go with each alternative (noted with an "X"). A description of the restoration areas included in each of the three alternatives follows.

TABLE 5-12
Catalogue of Restoration Areas in Each Alternative
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Barataria				Terrebonne (East of HNC)				Terrebonne (West of HNC)			
Area	Alternative			Area	Alternative			Area	Alternative		
	1	2	3		1	2	3		1	2	3
B1	X	X	X	T1		X	X	T25			X
B2A	X	X	X	T2A		X	X	T26			X
B2B	X	X	X	T2B		X	X	T27			X
B2C	X	X	X	T3A	X	X	X	T28			X
B3A	X	X	X	T3B		X	X	T29			X
B3B	X	X	X	T4A		X	X	T30			X
B3C	X	X	X	T4B		X	X	T31			X
B4	X	X	X	T5	X	X	X	T32			X
B5	X	X	X	T6	X	X	X	T33			X
B6	X	X	X	T7A		X	X	T34			X
B7A	X	X	X	T7B		X	X	T35			X
B7B	X	X	X	T7C		X	X	T36			X
B8	X	X	X	T8		X	X	T37			X
B9A	X	X	X	T9		X	X	T38			X
B9B	X	X	X	T10	X	X	X	T39			X
B10A	X	X	X	T11	X	X	X	T40			X
B10B	X	X	X	T12		X	X				
B11	X	X	X	T13	X	X	X				
B12			X	T14	X	X	X				
B13			X	T15	X	X	X				
B14			X	T16	X	X	X				
B15			X	T17	X	X	X				
B16A			X	T18		X	X				
B16B			X	T19		X	X				
B17			X	T20		X	X				
B18	X	X	X	T21		X	X				
B19			X	T22		X	X				
B20			X	T23		X	X				
B21	X	X	X	T24		X	X				
B22	X	X	X	T41		X	X				

Alternative 1

Alternative 1 uses only the Mississippi River as a sediment source of for the restoration areas. The offshore sediment resources (i.e., Ship Shoal and Barataria ebb shoal deltas) are

reserved for use in barrier island restoration programs and for construction of the interbasin segmented barriers in both Barataria and Terrebonne Bays. The number of restoration areas was limited to keep the demand on the Mississippi River to less than 20 mcy per year.

Alternative 1 includes 21 polygons in the Barataria Basin and 10 polygons in the Terrebonne Basin (T3A, T5, T6, T10, T11, T13, T14, T15, T16, and T17). Polygons in southwestern Barataria Basin, adjacent to Bayou Lafourche, are not included in this alternative.

Alternative 2

Alternative 2 includes Alternative 1 restoration areas and 20 restoration areas in Terrebonne Basin. Eight of these areas are near Lake Boudreaux and would use Ship Shoal as a sediment resource (T1, T7A, T7B, T7C, T22, T23, T24, and T41). Four additional areas (T18, T19, T20, and T21) are in southeastern Terrebonne Basin, adjacent to Bayou Lafourche. These four areas would also receive sediment from Ship Shoal. The last eight polygons added in Alternative 2 are in northeastern Terrebonne Basin and would receive sediment from the Mississippi River (T2A, T2B, T3B, T4A, T4B, T8, T9, and T12).

Four of the restoration areas added for this alternative (T2A, T2B, T4B, and T13) assumed that sediment transported to these areas would come from the Mississippi River, despite being closer to Ship Shoal. The decision to assign sediment from the Mississippi River to these restoration areas was based on an effort to minimize annual dredging needs from Ship Shoal.

Alternative 3

Alternative 3 includes all restoration polygons in Alternatives 1 and 2. Alternative 3 assumes borrow sources in the Mississippi and Atchafalaya Rivers, and offshore of both the Barataria and Terrebonne Bays.

Five areas near the HNC were added for this alternative; two with Ship Shoal as the sediment source (T26 and T27), and three with Horseshoe Bend on the Atchafalaya River as the source (T25, T28, and T29). In addition, 11 polygons near the Atchafalaya River were added (T30 to T40). Finally, nine polygons in southwestern Barataria Basin (adjacent to Bayou Lafourche) were added to this alternative, with the assumption that an offshore borrow area outside Barataria Bay would be used.

5.4.4 Characteristics of Restoration Alternatives and Results of Ranking Analysis

After the areas had been assigned to the restoration alternatives, net land-building potential, volumetric sediment requirements, and costs of the alternatives were calculated. Table 5-13 summarizes several of these calculations, including the following:

- Total land nourished (land that would receive 1 foot of thin-layer placement)
- Land loss predicted without project (land that would be lost under future conditions with no action; tabulated to compare net changes against the future conditions with no action scenario)

- Total land created (land built from open water and land that would have been lost in the future conditions with no action scenario)
- Average annual amount of land created and nourished (assuming a 50-year project life)
- Annual dredging required for each sediment source (in mcy)
- Estimated dredging costs (without contingency added)
- Average cost per acre restored compared to future conditions with no action (nourished and created or saved)

TABLE 5-13
Summary of Final Alternatives: Landbuilding Potential and Sediment Requirements
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Land Nourished or Created (square miles)	Alternative 1	Alternative 2	Alternative 3
Total Land Nourished	141	211	342
Land Loss Predicted without Project	39	68	84
Total Land Created	159	277	418
Total Net Nourished/Created	340	556	760
Total Land Nourished per year	2.8	4.2	6.8
Total Net Land Created per year	4.0	6.9	8.4
Total Nourished/Created per year	6.8	11.1	15.2
Dredging Required by Source (mcy) Per Year (50 years)			
Mississippi River	17.8	22.6	19.4
Atchafalaya River	0.0	0.0	5.8
Barataria Offshore	0.0	0.0	9.1
Ship Shoal	0.0	7.5	13.8
Total	17.8	30.1	48.1
Dredging/Transport Costs (million $) (No Contingency Added)			
Mississippi River	6,700	10,100	7,700
Atchafalaya River	0	0	2,200
Barataria Offshore	0	0	4,000
Ship Shoal	0	4,600	8,200
Total	6,700	14,600	22,000
Average ($ per acre)	$31,000	$41,000	$41,000

Land created differs from land nourished. For a given polygon, the current land/water distribution governs whether land is created or nourished. Existing land is estimated to receive 1 foot of thin-layer placement, and is considered nourished by the restoration effort. Open-water areas will receive 4 feet of sediment (after accounting for losses and compaction), and are considered land created by the project.

Alternative 3 would require 48 mcy of sediment per year. Although sand resources have not been identified offshore of Barataria Basin that would supply the average of 9.1 mcy of material per year need for this alternative, the assumption is that the project success does not hinge on finding only sand-sized sediments. It may be sufficient to nourish and create land by dredging and transporting silt-size particles from offshore borrow pits to the

wetland restoration areas. This way, the identified sand sources could be reserved for use with the Barrier Island restoration program and construction of the interbasin segmented barriers. Confined placement of dredged material will be necessary if this option goes forward. This will lead to an increase in overall costs, because the creation of confinement levees has not been addressed in this report.

Average Depth of Fill

Sediment requirements assume that an average of 1 foot of dredged material will be placed on existing land in the restoration areas, while the existing open-water areas will receive an average of 4 feet of fill. The volumes also account for a 20 percent loss of material delivered to the site, and an additional 16 percent compaction (roughly 1 foot of settlement for a 6-foot-thick fill). This compaction rate is estimated from monitoring data collected as part of the Bayou Labranche Wetland Creations project (PO-17).

An average depth of fill was calculated for each restoration area to compare the reasonableness of these assumptions. Table 5-14 provides a tabulation of wetland creation projects previously completed in southern Louisiana as a basis for comparison. Figure 5-15 illustrates the range in fill required for these projects. Figure 5-16 shows the range of fill required for the proposed restoration areas, sorted by fill required. The range of predicted cubic yards per acre of fill required for the restoration areas falls within the range of values presented for recent restoration projects in Coastal Louisiana. On this basis, the assumptions for fill required are deemed reasonable.

TABLE 5-14
Comparison of Wetland Creation Projects in South Louisiana and Proposed Pipeline Conveyance Alternatives
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Project	Year	Sediment Volume (cubic yards)	Acres	Cubic Yards per Acre
Bayou Labranche Wetlands Creation	1994	2,500,000	300	8,333
Lake Chapeau	1999	500,000	260	1,923
Big Island Mining	1998	3,400,000	922	3,688
Atchafalaya Sediment Delivery	1998	720,000	185	3,892
Dustpan Dredge Demo Project	2002	220,000	20	11,000
Sabine Refuge Marsh Creation	2002	1,000,000	200	5,000
Average		8,340,000	1,887	4,420[a]
Alternative 1	N/A	890,000,000	167,000	5,300
Alternative 2	N/A	1,500,000,000	269,000	5,600
Alternative 3	N/A	2,400,000,000	432,000	5,600

[a]Average cubic yards per acre calculated from total volume delivered and acres created.

Restoration areas were then sorted for each alternative by score. Figures 5-17, 5-18, and 5-19 show the results of this sorting for Alternatives 1, 2, and 3, respectively. Tables 5-15, 5-16, and 5-17 present the complete sorted matrix for Alternatives 1, 2, and 3, respectively. Both the average score and the average cost per acre restored increase as the alternatives increase in land-building goals. These ranking matrices can be used in more detailed planning of the restoration alternatives, particularly in the phasing of the restoration efforts.

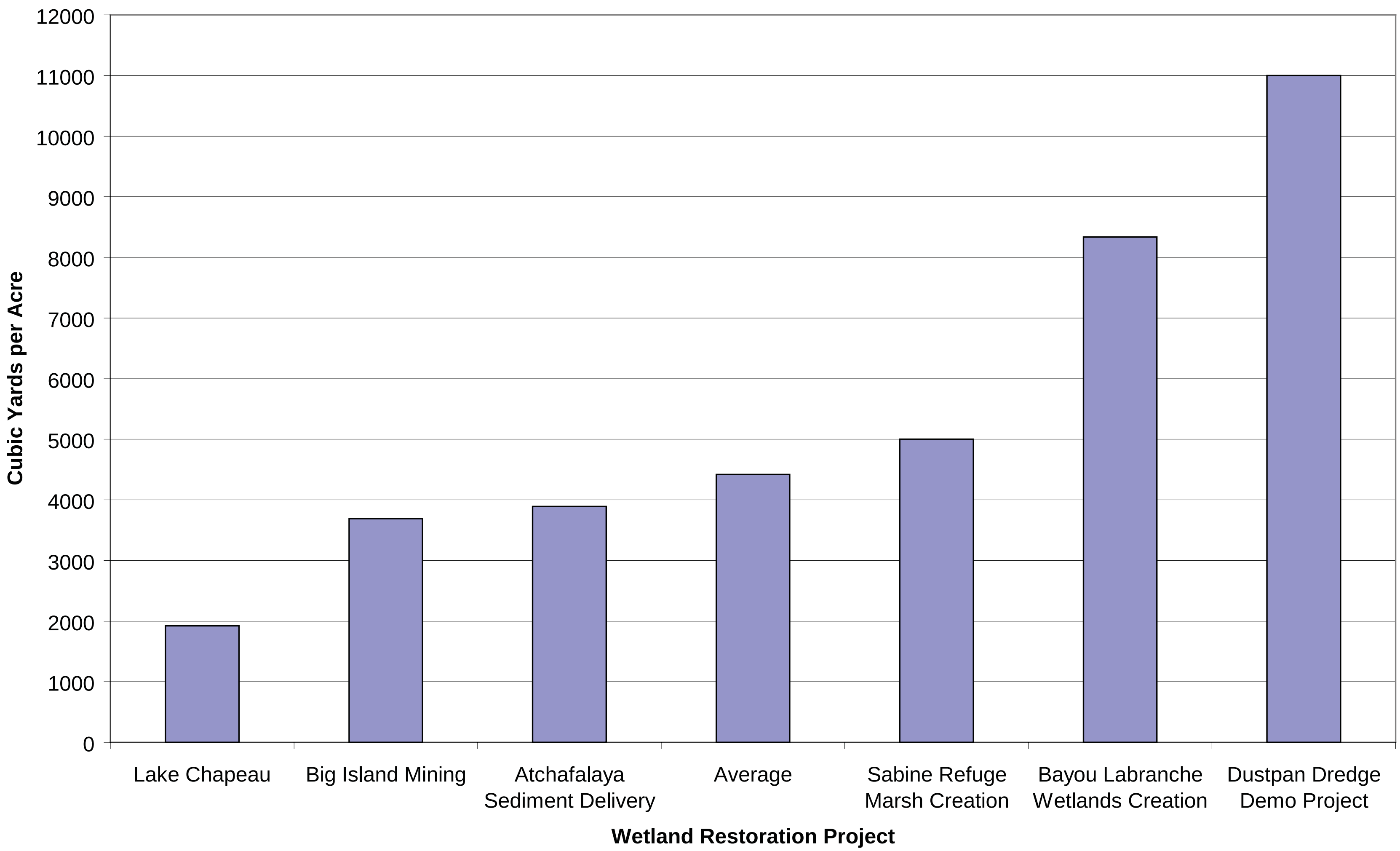


FIGURE 5-15
COMPARISON OF SEDIMENT REQUIRED FOR RECENT WETLAND RESTORATION PROJECTS IN COASTAL LOUISIANA
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

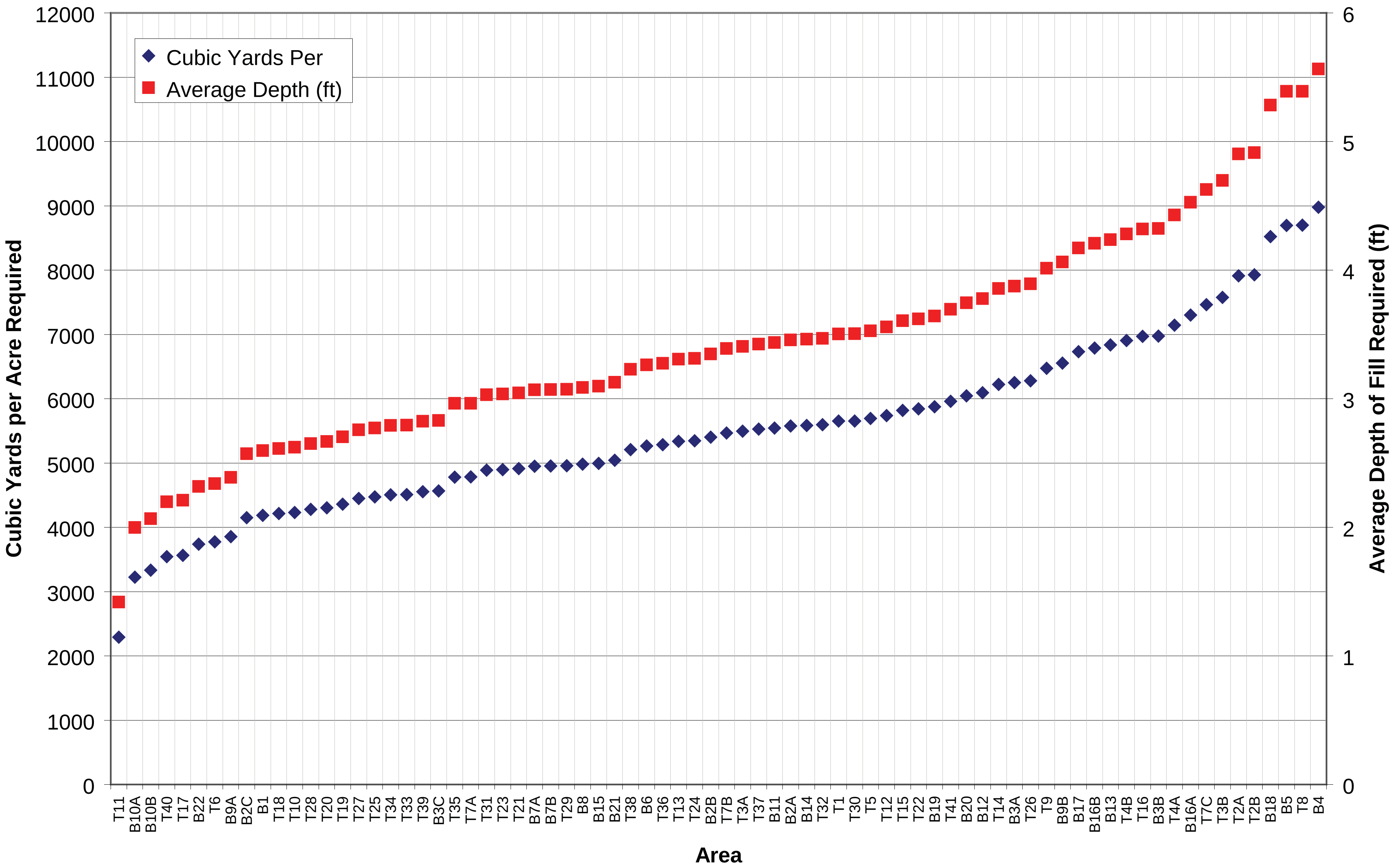


FIGURE 5-16
ESTIMATE OF FILL REQUIRED FOR RESTORATION AREAS
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

WB062006002RDD_19 (6/23/06)

CH2MHILL

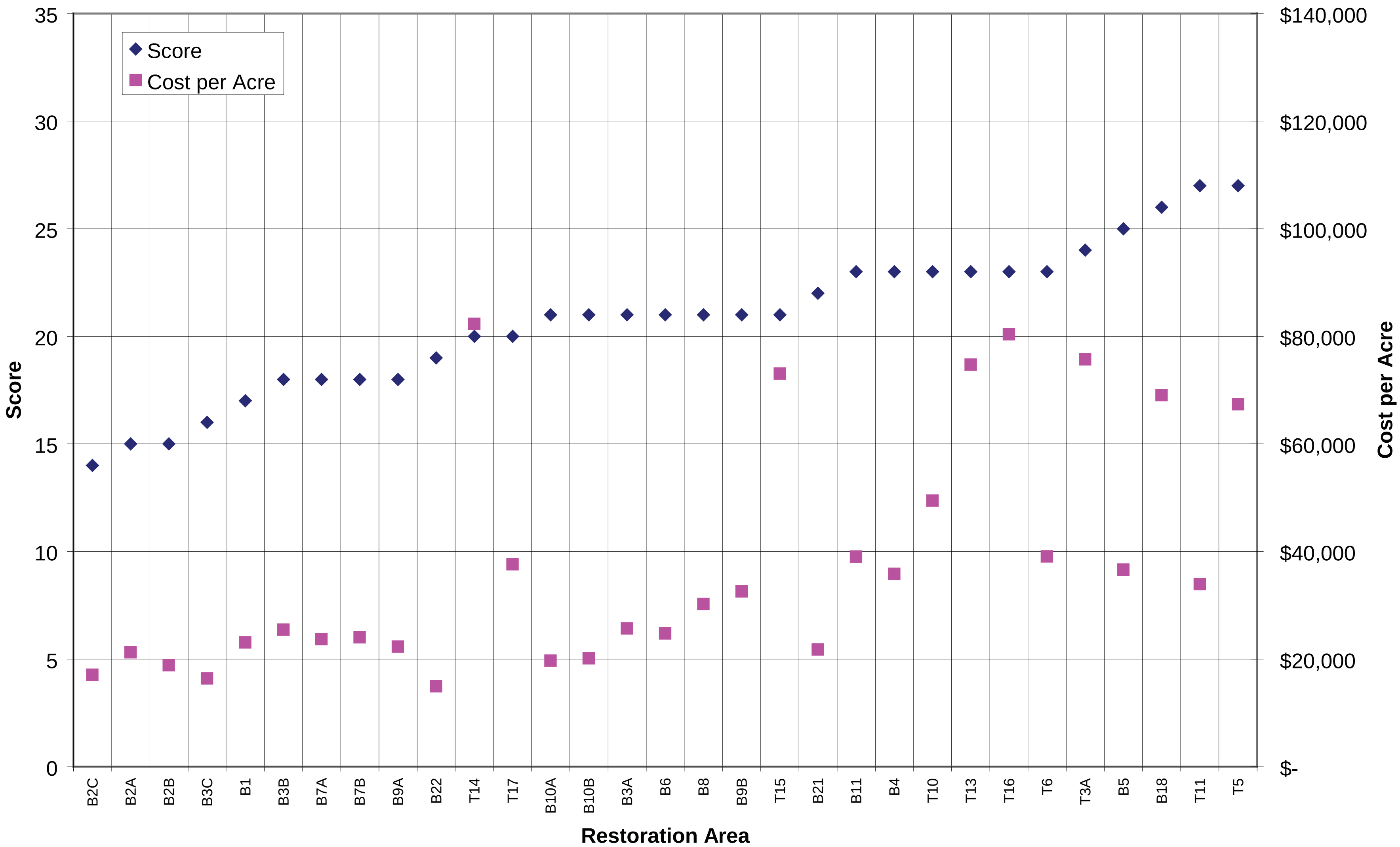


FIGURE 5-17
ALTERNATIVE 1
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

CH2MHILL

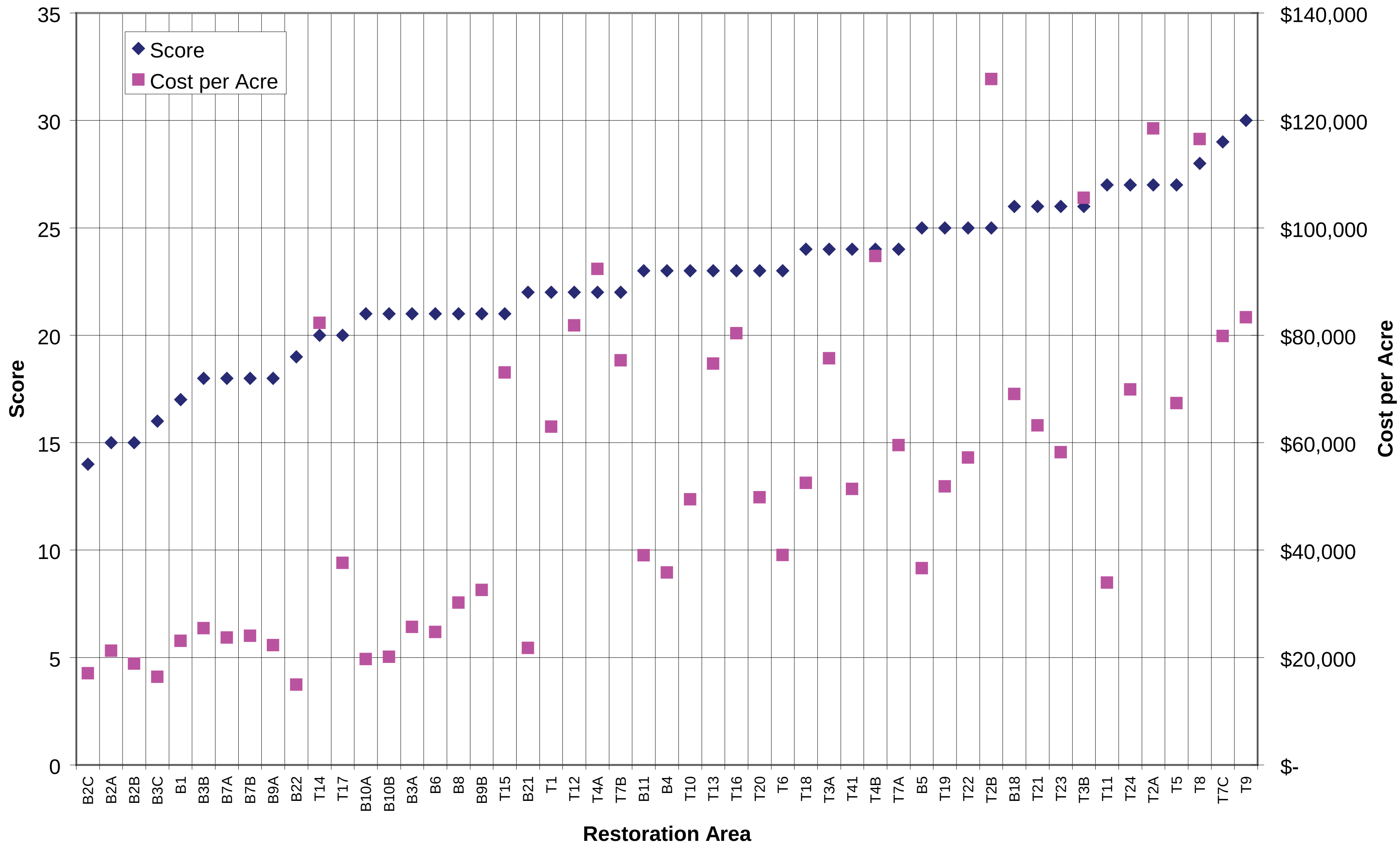


FIGURE 5-18
ALTERNATIVE 2
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

CH2MHILL

WB062006002RDD_22 (6/21/06)

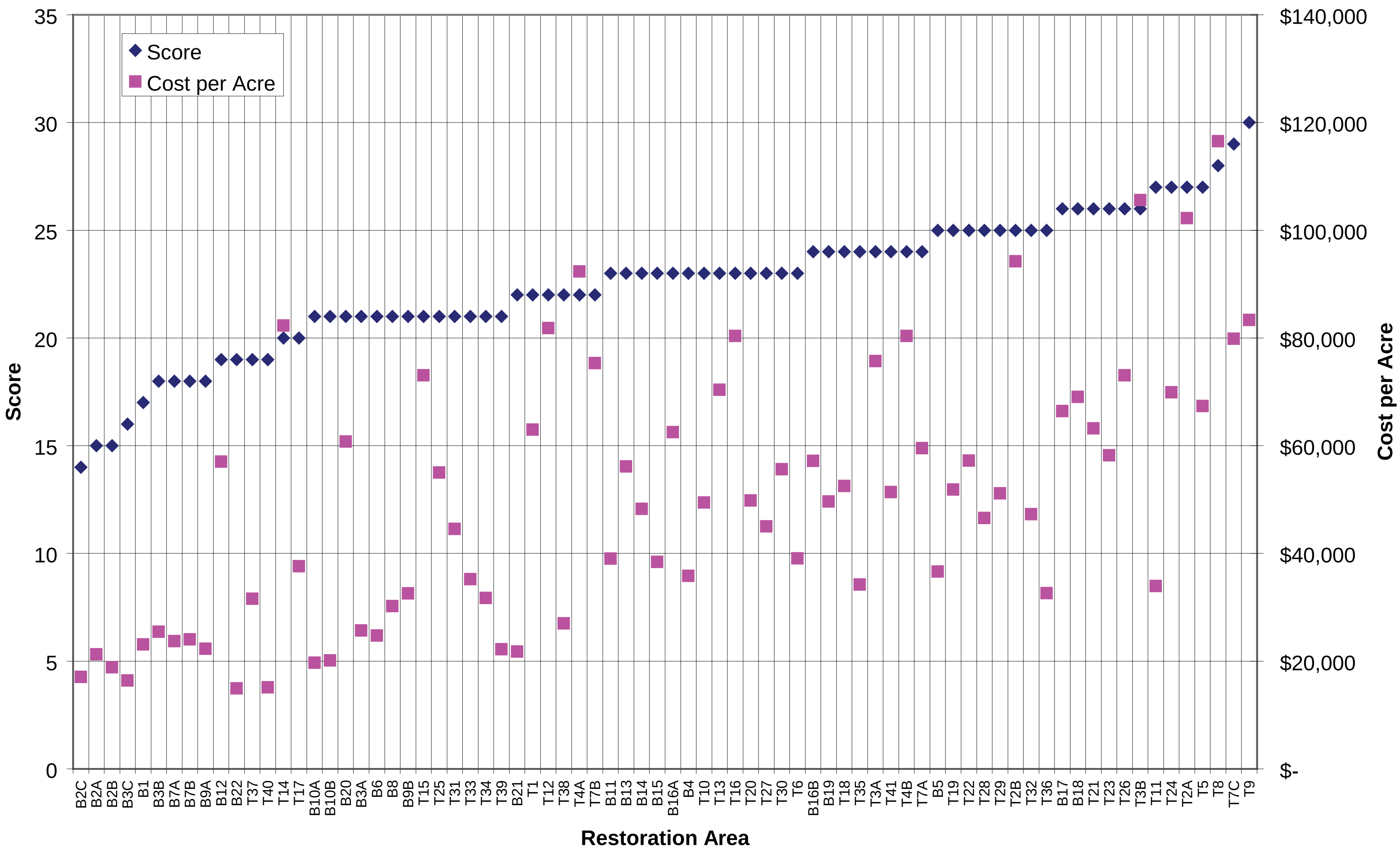


FIGURE 5-19
ALTERNATIVE 3
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

WB062006002RDD_23 (6/21/06)

CH2MHILL

TABLE 5-15
Ranking Matrix for Alternative 1
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Restoration Polygon	Shore Protection	Relative Distance to Sediment Source	Influence on Reduction of Predicted Land Loss	Recent Land Loss (1990 to 2000)	Degree of Infrastructure Protection	Degree of Existing Confinement	Average Depth of Fill	Natural Hydrology Restoration	Freshwater Diversion	Score (Lower Preferred)
	Weighting Factor									
	1	2	1	1	1	1	2	1	2	
B2C	1	1	3	1	1	1	1	1	1	14
B2A	1	1	1	2	1	1	2	1	1	15
B2B	1	1	1	2	1	1	2	1	1	15
B3C	1	1	1	1	1	2	1	2	2	16
B1	2	1	1	2	1	2	1	3	1	17
B3B	1	1	1	1	1	3	2	1	2	18
B7A	3	1	2	2	2	2	1	1	1	18
B7B	3	1	2	1	2	3	1	1	1	18
B9A	3	1	1	2	2	3	1	1	1	18
B22	1	1	3	2	1	2	1	2	2	19
T14	1	3	1	1	1	1	2	1	2	20
T17	1	3	1	3	1	1	1	1	2	20
B10A	3	2	1	3	2	3	1	1	1	21
B10B	3	2	1	3	2	3	1	1	1	21
B3A	2	1	1	2	2	3	2	1	2	21
B6	2	1	3	3	2	1	2	2	1	21
B8	3	2	3	1	2	3	1	1	1	21
B9B	3	1	3	1	2	3	2	1	1	21
T15	1	3	1	1	2	1	2	1	2	21
B21	3	1	3	1	2	3	1	2	2	22
B11	3	2	3	2	1	3	2	1	1	23
B4	3	1	3	1	2	3	3	1	1	23
T10	1	3	3	2	2	2	1	1	2	23
T13	1	3	2	1	2	3	1	2	2	23
T16	1	3	1	2	1	1	3	1	2	23
T6	1	2	3	3	3	1	1	2	2	23
T3A	1	3	2	3	1	2	2	1	2	24
B5	3	1	3	3	2	3	3	1	1	25
B18	1	2	3	2	3	1	3	2	2	26
T11	1	3	1	3	3	1	3	2	2	27
T5	1	3	3	3	3	1	2	2	2	27

TABLE 5-16
Ranking Matrix for Alternative 2
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Restoration Polygon	Shore Protection	Relative Distance to Sediment Source	Influence on Reduction of Predicted Land Loss	Recent Land Loss (1990 to 2000)	Degree of Infrastructure Protection	Degree of Existing Confinement	Average Depth of Fill	Natural Hydrology Restoration	Freshwater Diversion	Score
		Weighting Factor								
	1	2	1	1	1	1	2	1	2	
B2C	1	1	3	1	1	1	1	1	1	14
B2A	1	1	1	2	1	1	2	1	1	15
B2B	1	1	1	2	1	1	2	1	1	15
B3C	1	1	1	1	1	2	1	2	2	16
B1	2	1	1	2	1	2	1	3	1	17
B3B	1	1	1	1	1	3	2	1	2	18
B7A	3	1	2	2	2	2	1	1	1	18
B7B	3	1	2	1	2	3	1	1	1	18
B9A	3	1	1	2	2	3	1	1	1	18
B22	1	1	3	2	1	2	1	2	2	19
T14	1	3	1	1	1	1	2	1	2	20
T17	1	3	1	3	1	1	1	1	2	20
B10A	3	2	1	3	2	3	1	1	1	21
B10B	3	2	1	3	2	3	1	1	1	21
B3A	2	1	1	2	2	3	2	1	2	21
B6	2	1	3	3	2	1	2	2	1	21
B8	3	2	3	1	2	3	1	1	1	21
B9B	3	1	3	1	2	3	2	1	1	21
T15	1	3	1	1	2	1	2	1	2	21
B21	3	1	3	1	2	3	1	2	2	22
T1	1	3	2	2	1	1	2	1	2	22
T12	1	3	1	1	1	2	2	2	2	22
T4A	1	3	2	1	2	1	2	1	2	22
T7B	1	3	1	2	1	1	2	2	2	22
B11	3	2	3	2	1	3	2	1	1	23
B4	3	1	3	1	2	3	3	1	1	23
T10	1	3	3	2	2	2	1	1	2	23
T13	1	3	2	1	2	3	1	2	2	23
T16	1	3	1	2	1	1	3	1	2	23
T20	1	3	1	2	1	2	1	2	3	23
T6	1	2	3	3	3	1	1	2	2	23
T18	2	3	1	2	1	2	1	2	3	24
T3A	1	3	2	3	1	2	2	1	2	24
T41	1	2	3	3	1	1	2	3	2	24
T4B	1	3	2	1	2	2	2	2	2	24
T7A	3	3	1	2	1	3	1	2	2	24

TABLE 5-16
Ranking Matrix for Alternative 2
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Restoration Polygon	Shore Protection	Relative Distance to Sediment Source	Influence on Reduction of Predicted Land Loss	Recent Land Loss (1990 to 2000)	Degree of Infrastructure Protection	Degree of Existing Confinement	Average Depth of Fill	Natural Hydrology Restoration	Freshwater Diversion	Score
B5	3	1	3	3	2	3	3	1	1	25
T19	3	3	1	2	1	2	1	2	3	25
T22	1	2	3	3	2	1	2	3	2	25
T2B	1	3	2	1	1	3	3	1	2	25
B18	1	2	3	2	3	1	3	2	2	26
T21	3	3	3	1	1	2	1	2	3	26
T23	3	3	3	2	1	3	1	2	2	26
T3B	1	3	2	1	2	3	3	1	2	26
T11	1	3	1	3	3	1	3	2	2	27
T24	2	3	3	2	1	3	2	2	2	27
T2A	1	3	3	2	1	3	3	1	2	27
T5	1	3	3	3	3	1	2	2	2	27
T8	1	3	3	2	3	1	3	2	2	28
T7C	3	3	3	1	1	3	3	2	2	29
T9	1	3	3	3	2	2	3	3	2	30

TABLE 5-17
Ranking Matrix for Alternative 3
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Restoration Polygon	Shore Protection	Relative Distance to Sediment Source	Influence on Reduction of Predicted Land Loss	Recent Land Loss (1990 to 2000)	Degree of Infrastructure Protection	Degree of Existing Confinement	Average Depth of Fill	Natural Hydrology Restoration	Freshwater Diversion	Score
	Weighting Factor									
	1	2	1	1	1	1	2	1	2	
B2C	1	1	3	1	1	1	1	1	1	14
B2A	1	1	1	2	1	1	2	1	1	15
B2B	1	1	1	2	1	1	2	1	1	15
B3C	1	1	1	1	1	2	1	2	2	16
B1	2	1	1	2	1	2	1	3	1	17
B3B	1	1	1	1	1	3	2	1	2	18
B7A	3	1	2	2	2	2	1	1	1	18
B7B	3	1	2	1	2	3	1	1	1	18
B9A	3	1	1	2	2	3	1	1	1	18
B12	1	2	1	3	1	1	2	2	1	19
B22	1	1	3	2	1	2	1	2	2	19
T37	1	1	3	1	3	2	1	3	1	19
T40	1	1	3	2	3	1	1	3	1	19
T14	1	3	1	1	1	1	2	1	2	20
T17	1	3	1	3	1	1	1	1	2	20
B10A	3	2	1	3	2	3	1	1	1	21
B10B	3	2	1	3	2	3	1	1	1	21
B20	1	2	2	1	1	1	1	3	3	21
B3A	2	1	1	2	2	3	2	1	2	21
B6	2	1	3	3	2	1	2	2	1	21
B8	3	2	3	1	2	3	1	1	1	21
B9B	3	1	3	1	2	3	2	1	1	21
T15	1	3	1	1	2	1	2	1	2	21
T25	1	3	1	3	1	1	1	2	2	21
T31	2	2	1	2	3	2	1	3	1	21
T33	2	2	1	2	3	2	1	3	1	21
T34	2	2	1	2	3	2	1	3	1	21
T39	1	1	3	3	3	2	1	3	1	21
B21	3	1	3	1	2	3	1	2	2	22
T1	1	3	2	2	1	1	2	1	2	22
T12	1	3	1	1	1	2	2	2	2	22
T38	1	1	3	2	3	2	2	3	1	22
T4A	1	3	2	1	2	1	2	1	2	22
T7B	1	3	1	2	1	1	2	2	2	22
B11	3	2	3	2	1	3	2	1	1	23
B13	1	2	2	2	1	1	2	2	3	23
B14	1	2	1	2	1	2	2	2	3	23
B15	1	2	1	1	2	3	1	3	3	23

TABLE 5-17
Ranking Matrix for Alternative 3
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Restoration Polygon	Shore Protection	Relative Distance to Sediment Source	Influence on Reduction of Predicted Land Loss	Recent Land Loss (1990 to 2000)	Degree of Infrastructure Protection	Degree of Existing Confinement	Average Depth of Fill	Natural Hydrology Restoration	Freshwater Diversion	Score
B16A	1	2	1	1	1	2	2	3	3	23
B4	3	1	3	1	2	3	3	1	1	23
T10	1	3	3	2	2	2	1	1	2	23
T13	1	3	2	1	2	3	1	2	2	23
T16	1	3	1	2	1	1	3	1	2	23
T20	1	3	1	2	1	2	1	2	3	23
T27	1	2	2	2	3	2	1	3	2	23
T30	2	2	2	1	3	2	2	3	1	23
T6	1	2	3	3	3	1	1	2	2	23
B16B	3	2	1	1	1	2	2	2	3	24
B19	2	2	1	2	1	2	2	2	3	24
T18	2	3	1	2	1	2	1	2	3	24
T35	2	2	3	3	3	2	1	3	1	24
T3A	1	3	2	3	1	2	2	1	2	24
T41	1	2	3	3	1	1	2	3	2	24
T4B	1	3	2	1	2	2	2	2	2	24
T7A	3	3	1	2	1	3	1	2	2	24
B5	3	1	3	3	2	3	3	1	1	25
T19	3	3	1	2	1	2	1	2	3	25
T22	1	2	3	3	2	1	2	3	2	25
T28	2	3	3	2	2	2	1	2	2	25
T29	1	2	3	3	2	2	2	2	2	25
T2B	1	3	2	1	1	3	3	1	2	25
T32	2	2	2	3	3	2	2	3	1	25
T36	3	2	2	2	3	2	2	3	1	25
B17	1	2	1	3	1	1	3	3	3	26
B18	1	2	3	2	3	1	3	2	2	26
T21	3	3	3	1	1	2	1	2	3	26
T23	3	3	3	2	1	3	1	2	2	26
T26	1	3	3	3	2	1	2	2	2	26
T3B	1	3	2	1	2	3	3	1	2	26
T11	1	3	1	3	3	1	3	2	2	27
T24	2	3	3	2	1	3	2	2	2	27
T2A	1	3	3	2	1	3	3	1	2	27
T5	1	3	3	3	3	1	2	2	2	27
T8	1	3	3	2	3	1	3	2	2	28
T7C	3	3	3	1	1	3	3	2	2	29
T9	1	3	3	3	2	2	3	3	2	30

5.5 Freshwater Requirements

The magnitude of the land creation and nourishment estimates presented for the three alternatives controls the amount of freshwater required to sustain wetlands. The diversion flows required for each alternative are summarized in Table 5-18, using the ratio of 3,600 acres per 100 cfs. The total land created or nourished by the restoration project does not include the area of land saved that is predicted to be lost by 2050. Accounting for this land is appropriate when comparing net land change for alternatives against a future with no action, but not when calculating the freshwater required for nourishment because the total land created is already accounted for.

TABLE 5-18
Comparison of Freshwater Diversion Flows for Each Alternative
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

	Alternative 1	Alternative 2	Alternative 3
Total Created/Nourished (square miles)	261	420	675
Total Created/Nourished (acres)	166,774	268,832	432,058
Freshwater Flow Required (cfs)	4,633	7,468	12,002
Freshwater Flow Required (cfs per year)	93	149	240

The total freshwater diversion required to sustain wetlands built by the three alternatives ranges from 4,600 to 12,000 cfs, again assuming a requirement of 100 cfs for every 3,600 acres. This assumption, taken as a constant over all types of wetland habitats, is an oversimplification. Total flow requirements, however, are expected to be on this order of magnitude because freshwater marshes could require more than 100 cfs per 3,600 acres, but saltwater wetlands could require less.

Proposed diversions, including Myrtle Grove (5,000 to 15,000 cfs) and the Mississippi River Water Reintroduction into Bayou Lafourche project (1,000 cfs), could provide additional freshwater into Barataria Basin to nourish wetlands. The Morganza to the Gulf Hurricane-Protection project and the HNC Lock Complex will be able to redirect Atchafalaya River water to the east through the GIWW into marshes in central Terrebonne Basin. The amount of flow actually diverted to individual marshes, however, can only be determined through complex multidimensional modeling, which is beyond the scope of this planning-level study.

Increased delivery of freshwater to restoration sites in Barataria Basin is more realistic than delivery to restoration areas in Terrebonne Basin. The recent flow improvements through the Davis Pond diversion, coupled with the designation of the Myrtle Grove diversion as one of the five Near-term Critical Restoration Features in the LCA Study (USACE, 2004), indicate that freshwater diversions to Barataria Basin are likely to increase substantially compared to those in the recent past. The Terrebonne Basin, on the other hand, has fewer options for increasing freshwater delivery to wetlands. Construction of the Morganza to the Gulf Hurricane-Protection project, which includes the HNC Lock, was originally scheduled to continue through 2016. Hurricanes Katrina and Rita have likely set this schedule back because efforts are now focused on levees immediately surrounding New Orleans. Thus,

aside from the economic efficiencies with which restoration areas in Barataria Basin can be built (considering their proximity to sediment resources), the likelihood of freshwater for sustainability is also greater in Barataria Basin, especially for restoration sites higher in the basin that would be under direct influence of increased flows from Davis Pond.

5.6 Restoration Implementation

Implementation of the basinwide restoration alternatives is contingent on the availability of and means to transport sediment to potential receiving areas up to 40 miles away. This section discusses proposed sources and the physical components of the dredging operation that will transport the sediment to the restoration areas.

5.6.1 Material Source Availability and Suitability

The availability of sediment is considered a limiting factor in the design of large-scale restoration programs in coastal Louisiana. The current understanding of potential sediment resources, both riverine and offshore, is discussed in this subsection.

Riverine Resources

Sediment availability in the Mississippi River is difficult to measure and highly variable from year to year. Furthermore, the majority of sediment transport measurements in the Mississippi River reflect suspended sediment, not bedload transport. For the restoration programs presented herein, the bedload transported by the Mississippi River is more important than the suspended load. Bedload is more important for the dredging-based alternatives because bedload replenishes the material mined from the river bottom; bedload transport governs the rate at which material can be mined from the river.

A large range of estimates of the average annual sediment transport in the Mississippi River exists. The report *Drawing Louisiana's New Map, Addressing Land Loss in Coastal Louisiana* (National Academy of Sciences, 2006) tabulates the following estimates of annual sediment transport:

- 82 million metric tons, 60 mcy (suspended sediment for 1963 to 1982)
- 159 million metric tons, 116 mcy (Mississippi River long-term suspended)
- 621 million metric tons (Mississippi River sediment discharge)

The Lower Mississippi River Sediment Study (Louisiana Hydroelectric, 1999) modeled lower Mississippi River sediment transport using HEC-6T software. Results of this model were provided to CH2M HILL staff during Phase 1 of this study. Annual average suspended sediment load predicted by this model is 191 million tons per day, or 169 mcy per day. Although it would not be appropriate to use these predictions in place of measured field data, the calibrated model provides another rough estimate of annual average sediment transport and year-to-year variation in the Mississippi River. Table 5-19 presents results from the HEC-6T model for sediment transport at Donaldsonville, aggregated from daily values to water year averages (October 1 to September 30).

TABLE 5-19
Water Year Averaged Sediment Transport in the Mississippi River
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Water Year	Mississippi River Sediment (tons per year)
1983	239,300,000
1984	217,900,000
1985	191,800,000
1986	161,900,000
1987	166,900,000
1988	116,000,000
1989	183,500,000
1990	205,500,000
1991	216,900,000
1992	143,800,000
1993	239,400,000
1994	213,400,000
1995	176,800,000
1996	159,900,000
1997	230,600,000
1998	185,900,000

Maintenance dredging records offer the most reasonable estimate of available sediment for restoration. USACE performs maintenance dredging in the navigation channel in the lower Mississippi River every year. Quantifying this amount would provide a lower limit on the sediment available for restoration. Because USACE often dredges from shoals in the navigation channel and releases the sediment back into the water column to disperse as it is carried downstream, the same sediment is likely redredged many times. Thus, summing all dredging volumes would overestimate the sediment available for restoration projects.

Currently, USACE dredges between 15 and 20 mcy per year from the lower Mississippi River Head of Passes to Southwest Pass (USACE, 2001). The majority of this material is removed via hopper dredge and disposed of offshore in designated sites. These average annual dredging volumes in the lower Mississippi River can conservatively be used as a lower estimate of sediment available for restoration from the Mississippi River, because at least this much bedload sediment is available and is wasted to the gulf by either natural sediment conveyance or conveyance by hopper dredges. Beneficial use of dredged material could be increased if material routinely removed during navigation dredging were delivered to restoration areas.

Although smaller in scale, the lower Atchafalaya River also has a maintenance dredging program to maintain navigation depth. Beneficial use could include pumping the dredged material to wetland restoration areas in western Terrebonne Basin.

Offshore Resources

Offshore sediment resources have been surveyed for use in barrier island restoration projects. These surveys have focused on locating sand deposits. Preliminary surveys

conducted by USGS (Kindinger et al., 2001) indicate that more than 400 mcy of sand exist offshore of Barataria Basin, primarily in ebb shoal deltas. Ship shoal, offshore of the Isles Dernieres chain (southeast Terrebonne Basin) is composed of roughly 1 billion cubic yards of sand. However, significant oil and gas infrastructure exist throughout Ship Shoal and only a small percentage of the volume may be available for coastal restoration projects.

Recently, LDNR's Costal Restoration Division has conducted project-level analyses on several of the offshore sand resources detailed in the Kindinger report, and have significantly revised the potential borrow volumes (Syed Khalil, pers. comm.). These project-level surveys took sediment cores at a finer interval than the previous study, providing a more accurate description of the complex sediment layers.

There are a number of concerns about using offshore sediment resources for coastal restoration, specifically wetland creation projects. First, the offshore resources are finite and must be considered one-time use resources, as opposed to the riverine sources that are replenished from upstream. The limited supply of sand in the coastal zone necessitates that offshore sand resources be used primarily for barrier island nourishment projects rather than wetland restoration projects. Second, the removal of sediment from offshore borrow sites will influence the wave climate shoreward of the borrow site. For example, the dredging of Ship Shoal would increase the magnitude of waves reaching the barrier island chain, and theoretically increase the erosion of these valuable natural structures. Third, the dredging of offshore resources could impact habitat and marine organisms.

Ability to Meet Demand of Restoration Alternatives

Sediment requirements for the three alternatives are presented in Table 5-20. Maintenance dredging records for the Mississippi River indicate that roughly 15 to 20 mcy of sediment are available for restoration projects during an average year. It is likely that the use of sediment traps would increase this amount by promoting the settling of suspended sands into the dredged sediment trap (USACE, 2001), so that the Mississippi River could supply the 18 to 23 mcy per year required by the restoration alternatives. Similarly, the maintenance dredging program on the Lower Atchafalaya River near Horseshoe Bend will likely produce more than the 6 mcy needed for Alternative 3.

TABLE 5-20
Summary of Sediment Required Annually from Various Sources
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Dredging Required by Source (mcy)	**Alternatives**		
Per Year (50 years)	**1**	**2**	**3**
Mississippi River	17.8	22.6	19.4
Atchafalaya River	0.0	0.0	5.8
Barataria Offshore	0.0	0.0	9.1
Ship Shoal	0.0	7.5	13.8
Total	17.8	30.1	48.1

Recent sediment surveys offshore of Barataria Basin have indicated that no large sand deposits capable of yielding considerable quantities of material for coastal restoration projects exist. However, the proposed TDCC project does not depend solely on these large quantities of offshore sediment. The material required for barrier island restoration must be fine sand or larger sized particles, which are in short supply in the coastal zone. The ecosystem restoration projects presented herein, however, are not completely dependent on

sand-sized sediment. For locations that have a high degree of natural confinement, the hydraulic placement of silt-sized sediments may be adequate for wetland creation (i.e., Bayou Labranche Wetland Creation Project). It is understood that smaller particles will likely undergo more consolidation than sand sized particles. Thus, the required sediment demands from offshore borrow sites (peaking at 9 mcy per year from sites offshore of Barataria Bay and 14 mcy per year from Ship Shoal) are assumed to be available. However, sediment will more likely be silt and not sand.

5.6.2 Dredging and Conveyance System Components and Operation

This section discusses the components of a pipeline conveyance system designed to deliver sediment from defined borrow sources, both riverine and offshore, to prospective wetland restoration sites in Barataria and Terrebonne Basins.

Riverine Operations

A standard riverine dredging operation that mines sediment from the Mississippi River and delivers it through a network of pipes to wetland restoration sites basinwide would include the following:

- Sediment traps constructed in the rivers to promote settling of suspended material and increase the amount of material available for coastal restoration projects
- Dredges and support equipment, including cutter-head, hopper, or dustpan dredges
- Riverside fixed connection facilities for dredge off-load and a pipeline conveyance system, constructed in existing pipeline ROWs that intersect the Mississippi or Atchafalaya Rivers
- Booster pumps, the number of which will be determined by the distance between the hard point and the restoration site
- Construction equipment at the restoration area to handle and advance the pipeline and earth-working equipment to assist in achieving design elevations at the restoration site

Riverine dredging operations can be conducted by cutter-head, hopper, or dustpan dredges. Recent demonstration projects have shown that both hopper and dustpan dredges can safely operate in the lower Mississippi River during spring flows. Dredges would use a flexible pipeline connected to the hard point to pump sediment into the conveyance network. Dustpan and cutter-head dredges would remain connected to the floating line and hard point during dredging operations, whereas a hopper dredge would only connect to the system while the sediment in the dredge is offloaded. Cycle time for hopper dredges in the lower Mississippi River is approximately 4 hours. This includes time for filling the dredge, transporting the load to the hard point, offloading the material (which takes approximately 1 hour), and returning to the borrow location. The distance between the borrow location and the hard point will influence the daily production rate because transport time decreases daily production.

Riverine Sediment Traps

The construction of sediment traps on the Mississippi River is considered an integral part of the pipeline conveyance alternative. Considering both the finite quantity of sediment

available for coastal restoration and the fact that most (approximately 90 percent) of the annual sediment transport in the Mississippi River is carried as suspended load, sediment traps should increase the total annual amount of sediment available for dredging from the river by promoting settling of suspended sediments. Hydraulic and sediment transport modeling will have to be conducted to optimize the design and placement of the sediment traps.

USACE has performed three-dimensional modeling to investigate locations and configuration of sediment traps in the lower Mississippi River between Venice and Head of Passes. Preliminary model results indicate that a sediment trap measuring 3 miles long by 1,500 feet wide by 20 feet deep (below existing riverbed) would maximize sediment deposition (USACE, 2001).

Three potential locations for the sediment trap (or traps) include downstream of channel bends near Naomi, adjacent to the Wilkinson Canal, and Nairn. The area between Venice and Head of Passes is another potential location because of the annual amount of navigation channel maintenance dredging conducted by USACE in this area. This location was the subject of a USACE three-dimensional numerical modeling study conducted in support of the MR-12 CWPPRA project, also known as the Mississippi River Sediment Trap Project (USACE, 2001).

In addition to continued multi-dimensional modeling efforts, continued detailed field studies, similar to those being conducted by LDNR (Syed Khalil, presentation at CREST Symposium, April 19, 2006, Baton Rouge, Louisiana), are necessary to determine the most ideal sites for sediment trap construction. The study area should include locations in the Mississippi River as far upstream as Naomi. The previous study (USACE, 2001) limited the area to locations below Venice. One reason given was a concern with landowners in prospective receiving sites adjacent to the river farther upstream; prospective receiving sites closer to Head of Passes were owned by the state. A second reason was increasing the beneficial use of dredged material removed from the system to ensure safe navigation.

Offshore Operations

Offshore dredging operations, outside the barrier island chains in Terrebonne and Barataria Bays, would share many of the same components as riverine operations. All three major dredge types can be used in the offshore environment.

Offshore operations would include the construction of a fixed riverside connection where either a hopper dredge would offload sediment or a flexible hose would be attached for use with either a cutter-head or dustpan dredge. A steel pipe would extend inland from the connection point to the restoration area, where low-tread-pressure equipment (e.g., marsh buggies) would be used to move and extend pipeline segments as the sediment is placed. Routes would be confined to existing pipeline or utility ROWs, and would allow navigation near any shipping channels or waterways. It is assumed that pipelines originating from offshore sediment sources would be used to create the interbasin segmented barriers in both Barataria and Terrebonne Basins.

Because offshore dredging operations are more susceptible to inclement weather events, annual dredging volumes calculated using daily capacities should take into account the reduced number of days per year in which dredges can operate.

5.7 Sustainability and Adaptive Management

Sustainability and adaptive management are two issues that must be addressed for a project of this scale. Sustainability, in this context, refers to the availability of resources in quantities sufficient to ensure the long-term success of the ecosystem restoration project. Adaptive management refers to the ability to change system operations to adapt to changing conditions to either reduce negative impacts or maximize benefits of unforeseen events.

5.7.1 Sustainability

Freshwater Supply

Freshwater supply is an important factor in the sustainability of newly created wetlands. The TDCC will supply up to 100,000 cfs of freshwater from the Mississippi River to both the Barataria and Terrebonne Basins, ensuring that ecosystem restoration through creation of subdeltas will not be limited by freshwater supply. Over-freshening is a potential issue with the TDCC project. The Davis Pond diversion will reduce salinity levels in Barataria Bay, and an additional 100,000-cfs diversion into Little Lake will further reduce the salinity regime in the system, affecting fisheries and intermediate, brackish, and saline habitat communities.

Freshwater supply will be needed to sustain restored wetland sites. A number of existing and proposed diversion projects, including projects that will provide increased flows to freshwater wetlands without the use of diversions from the river (i.e., operation of the HNC Lock with the Morganza to the Gulf Hurricane-Protection project), will aid in supporting the sustainability of wetlands created by the conveyance pipeline alternatives.

Sediment Supply

Sediment supply for the TDCC comes from suspended and bedloads in the Mississippi River. Although historical trends show a decrease in suspended sediment concentration, thus lower volumetric transport rates in the Mississippi River, suspended sediment concentrations are leveling off. The TDCC is limited in its ability to restore wetlands by the rate at which it can transport sediment to the coast, which is primarily a function of the suspended sediment concentration in the river.

Sediment supply for the pipeline transport alternatives comes from dredging bedload on the Mississippi and Atchafalaya Rivers and dredging offshore sediment along the coast of southeast Louisiana. Sediment supply in the rivers will be replenished, and as long as annual dredging does not exceed annual replenishment rates, riverine sediment supply for the pipeline restoration projects is considered sustainable. Offshore sediment must be considered a limited, finite resource. Offshore sand is in extremely limited supply, and competing uses may preclude the use of sand by the alternatives presented herein, except for the creation of interbasin segmented barriers and for restoration of the barrier island chains in coastal Louisiana.

Funding

The TDCC will require continued funding for operation of the following:

- The diversion structure on the Mississippi River
- The diversion structure at the channel bifurcation

- The lock structures on the GIWW
- The pump stations to drain the areas impounded by the TDCC flood control levees

Furthermore, the TDCC will require significant up-front funding for construction of diversion structures, locks, levees, and the channel itself.

The pipeline transport restoration project alternatives will require a more constant level of funding throughout the duration of the project. Increases in annual costs, assuming a somewhat constant annual production from dredging operations, will be tied to increases in labor and fuel costs and transport distances. It is expected that areas closer to sediment sources will be rebuilt first, to both demonstrate the successful application of this technology and limit costs. Pipeline transport projects do not have high up-front costs like the TDCC because the restoration program can be approached as 76 individual restoration projects.

5.7.2 Adaptive Management

Adaptive management was defined by the Oregon Plan for Salmon and Watersheds as a "process of testing alternative hypotheses through management action, learning from experience, and making appropriate change to policy and management practice." The Oregon Plan stresses the flexibility of adapting to lessons learned as a result of a targeted experimental program designed to gain knowledge of system processes and interactions. Adaptive management is a six-step cycle involving problem assessment, design, implementation, monitoring, evaluation, and adjustment (www.for.gov.bc.ca).

Third Delta Conveyance Channel

The TDCC would require a permanent system of structures that influence natural hydrology, salinity regimes, and habitats. The magnitude of the project limits its flexibility. The strict design requirement to create a self-scouring channel that ceases to scour upon reaching an equilibrium profile further limits the adaptability of the project because it places narrow constraints on channel operation. Furthermore, the land-building estimates for the project assume full capacity. Any reduction in diversions into the TDCC to limit freshwater impacts to Barataria or Terrebonne Basin will reduce the land-building estimates.

Pipeline Conveyance Alternatives

Creating a network of pipelines from sediment mining sites to restoration sites throughout Terrebonne and Barataria Basins is a flexible approach to coastal restoration that will cause only temporary impacts along the pipeline routes. The mobile pipelines will not leave a permanent impact on the landscape because they will be routed through existing ROWs.

Large-scale wetland restoration projects need the flexibility to create a variety of land elevations, thus a variety of habitats. Pipeline transport operations have this flexibility, whereas more natural systems, like the TDCC, would not unless earth-working equipment were brought to the newly created delta lobes.

5.8 Planning-level Cost Development

5.8.1 Cost Estimate for Third Delta Conveyance Channel

The cost estimate for the TDCC, presented in Table 5-21, is based on an estimate developed by the USACE New Orleans District and published in the LCA Study (USACE, 2004). The current analysis provides a planning-level cost estimate for a design consisting of a 104-mile-long bifurcating channel with two levees on each side (sacrificial and guide/flood control). For this estimate, the initial pilot channel was assumed to be trapezoidal with a bottom width of 50 feet, and depths below grade of 35 feet at the Mississippi River and 47 feet at the end of the channel. The outer flood-protection levees were assumed to be 12.5 feet tall on average in the upper reach and 6 feet tall along the lower reaches, with a 10-foot top width. The inner sacrificial levees were assumed to be 17 feet tall along the upper reach and 7.5 feet tall along the lower reaches (CH2M HILL, 2004). The sacrificial levees are taller to maintain the greater head required to achieve erosive velocities in the pilot channel. All channel and levee slopes were set to be at a ratio of 1:3, and the volumes for the final and the sacrificial levees were based on compaction ratios for semicompacted and uncompacted levees, respectively. This accounts for the large difference in estimated volumes between the compacted and uncompacted levees, despite the similar cross sections of the two systems.

Unit costs and quantities were adapted from the USACE cost estimate and updated to reflect recent changes in construction costs and design, if information was available. Unit costs were updated from fiscal year 2005 (the USACE report was published in November 2004) to fiscal year 2007 using the USACE Civil Works Construction Cost Index System. Increased workloads for the construction industry and reduced workforce in southern Louisiana in the aftermath of Hurricanes Katrina and Rita have increased construction costs by as much as 300 percent (Ellsworth Pilie/USACE, pers. comm.) This means that unit cost projections based on construction cost indicies might lead to an underestimation of total costs, depending on the time of construction. However, the future development of construction costs in southeast Louisiana is unknown. Prices are expected to fall as emergency repair projects are completed and workers return to the area, but it is reasonable to assume that they could stay well above average for months or years to come.

Unit costs for levee construction were set at $12 per cubic yard, which is below current market value according to information recently obtained from the USACE New Orleans District. In the USACE cost estimate for the TDCC, unit costs for dredging and hauling ranged from $3 to $12 per cubic yard, depending on location in the channel. For the cost estimate prepared in this evaluation, dredging costs were assumed to be $6 per cubic yard for all locations. Lack of detail in the USACE cost estimate precluded use of their figures for the dredging unit costs.

TABLE 5-21
Cost Estimate for Third Delta Project (60,000-cfs Pilot Channel)
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Number	Item	Description	Unit	Quantity	Unit Cost ($)	Total ($)	Comments
1	Diversion Structure	200,000-cfs Control Structure	lump sum	1	375,000,000	375,000,000	Pricing analog to Old River Auxiliary Control Structure (completed in 1986 at a cost of $206,000,000; costs adjusted using USACE Civil Works Construction Cost Index System)
2	Bifurcation	100,000-cfs Control Structure	lump sum	1	250,000,000	250,000,000	Two-thirds of diversion structure
3	Crossing Bayou Lafourche	500-cfs Pump Station/Siphon	each	2	25,000,000	50,000,000	Pumps/control structure
4	GIWW Crossing	Locks	each	4	425,000,000	1,700,000,000	Price approximate, based on completed locks
5	Clearing and Grubbing		acre	20,000	3,000	60,000,000	
6	Dredging	Mobilization/Demobilization	each	15	800,000	12,000,000	
		104 miles Total Length		163,100,000	6	978,600,000	Unit cost derived from LCA Study (values range from $3/cubic yard (cy) to $12/cy; $6/cy selected, assuming lower/no transportation costs); 50-foot bottom width, 35-foot depth
7	Levees	Mobilization/Demobilization	each	5	110,000	550,000	
		Final	cy	41,800,000	12	501,600,000	Volumes based on required borrow material, not final levee volume; unit cost adapted from LCA Study
		Temporary	cy	73,900,000	12	886,800,000	
		Fertilizer/Seeding	acre	1,050	600	630,000	
8	Erosion Protection	Mobilization/Demobilization for Stone Contract	each	1	60,000	60,000	
		Armor	ton	800,000	27	21,600,000	
		Channel Revetment	lump sum	1	341,100,000	341,100,000	
9	Stormwater Drainage	Pump Stations	cfs	10,000	7,470	74,700,000	
10	Contingencies (Land leases; underground storage tank (UST) removal; easements; utilities; demolition and construction of roads and bridges; relocation of residences, businesses, other; oil and gas pipeline coordination; local permits; debris disposal; demolition of buildings; traffic rerouting; community involvement; local government agency coordination; other)		s	1	525,300,000	525,300,000	Contingency 10% of total construction costs (Items 1 to 9) for described line items

Subtotal	$5,800,000,000
Contingency (50%)	$2,900,000,000
Total	$8,700,000,000

USACE cost estimate in LCA Study (green)
CH2M HILL (yellow)

Assumptions:

- All USACE unit costs were updated from fiscal year 2005 to fiscal year 2007 using USACE Civil Works Construction Cost Index System
- Levee-construction unit costs were assumed based on information obtained from USACE

Unit Cost ($/cy)	Summer 2005	Summer 2006
Semicompacted	8-10	31
Uncompacted	5-7	29

- Costs for items 1 and 10 are assumptions, based on experience.

Several control structures were added to the cost estimate because it is assumed that flow control will be required at the Mississippi River diversion, the channel bifurcation, and the crossings of the GIWW. Cost estimates for these structures were obtained from completed projects with similar structures that were adjusted to fiscal year 2007 using USACE Civil Works Construction Cost Index System.

The proposed channel route crosses several highways, local roads, railways, pipelines, private properties, and other obstructions. Costs for relocation, easements, compensation, and other contingencies were incorporated into the cost estimate as 10 percent of the total construction costs. A contingency of 50 percent was added to the final costs to account for the high level of uncertainty due to the planning-level status of this cost estimate, resulting in final costs of approximately $8.7 billion for construction of this project.

Cost estimates do not include maintenance and operation of the TDCC, the bifurcation structure, the lock structures, or the flood-protection levees.

5.8.2 Cost Estimate for Pipeline Conveyance Alternatives

Construction costs for the pipeline conveyance alternatives were calculated for the three alternatives defined in Section 5.4. The main differences between the three alternatives are the number and locations of areas to be restored (Figure 5-14).

Unit costs for dredging and conveyance across varying distances were estimated from conversations with dredging industry contacts and include daily costs labor; supplies and equipment including dredges; booster pumps and fuel; pipeline construction and earth-moving equipment; and operators. Costs for initial and replacement pipelines were taken into account. Tables 5-22 through 5-24 summarize the unit costs for each alternative and reflect a unit cost per cubic yard per source and average transport distance. The costs assume that dredges do not operate during low-flow periods because of reduced sediment loads. Hence, construction companies would be required to mobilize and demobilize once per year per dredge location for the duration of the project, which is expected to be 50 years. The total number of mobilization/demobilization events equates to 50 times the number of active sediment borrow locations.

Ten percent of the construction costs were added to account for contingencies, such as relocation, easements, and compensations. The calculated amount might overestimate actual costs because pipelines require less space than a conveyance channel and can be routed around obstructions. A contingency of 30 percent was added to the total costs, to account for uncertainties in the estimates.

The total construction costs differ greatly, from more than $9 billion for Alternative 1 to almost $32 billion for Alternative 3. These costs would be generated over a period of 50 years; yearly expenses would range from $190 million to $650 million.

5.8.3 Cost Estimates for other Project Components

These planning-level cost estimates are presented separately from the actual cost of the pipeline conveyance portion of the restoration alternatives to allow for direct comparison with the TDCC. They are presented in this section for completeness.

TABLE 5-22
Components for Cost Estimate of Dredging and Pipeline Conveyance Alternative 1
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

No.	Item	Description	Unit	Quantity	Unit Cost ($)	Total ($)	Comments
1	Dredging	Mobilization/Demobilization	each	100	750,000	75,000,000	
	Source:	Destination:					
	Mississippi River	Barataria Bay	cy	585,630,000	4.9	2,855,200,000	Unit cost includes dredging and transportation of sediment via pipeline
		Terrebonne Bay	cy	304,690,000	12.5	3,800,600,000	
2	Contingencies		lump sum	1	471,200,000	471,200,000	
	(Land leases; UST removal; easements; utilities; demolition and construction of roads and bridges; relocation of residences, businesses, other; oil and gas pipeline coordination; local permits; debris disposal; demolition of buildings; traffic rerouting; community involvement; local government agency coordination; other)						10% of construction costs (here: Item 1 – dredging)

Subtotal	$7,200,000,000
Contingency (30%)	$2,200,000,000
Total	$9,400,000,000

USACE cost estimate in LCA Study

CH2M HILL

TABLE 5-23
Components for Cost Estimate of Dredging and Pipeline Conveyance Alternative 2
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

No.	Item	Description	Unit	Quantity	Unit Cost ($)	Total ($)	Comments
1	Dredging	Mobilization/Demobilization	each	150	750,000	112,500,000	
	Source:	Destination:					
	Mississippi River	Barataria Bay	cy	585,630,000	4.9	2,855,200,000	Unit cost includes dredging and transportation of sediment via pipeline
		Terrebonne Bay	cy	544,220,000	13.3	7,231,600,000	
	Ship Shoal	Terrebonne Bay	cy	376,580,000	12.1	4,552,000,000	
2	Contingencies		lump sum	1	1,475,200,000	1,475,200,000	
	(Land leases; UST removal; easements; utilities; demolition and construction of roads and bridges; relocation of residences, businesses, other; oil and gas pipeline coordination; local permits; debris disposal; demolition of buildings; traffic rerouting; community involvement; local government agency coordination; other)						10% of construction costs (here: Item 1 – dredging)

Subtotal	$16,200,000,000
Contingency (30%)	$4,900,000,000
Total	$21,100,000,000

USACE cost estimate in LCA Study
CH2M HILL

TABLE 5-24
Components for Cost Estimate of Dredging and Pipeline Conveyance Alternative 3
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

No.	Item	Description	Unit	Quantity	Unit Cost ($)	Total ($)	Comments
1	Dredging	Mobilization/Demobilization	each	250	750,000	187,500,000	
	Source:	Destination:					
	Mississippi River	Barataria Bay	cy	585,630,000	4.9	2,855,200,000	Unit cost includes dredging and transportation of sediment via pipeline
		Terrebonne Bay	cy	381,920,000	12.6	4,819,900,000	
	Ship Shoal	Terrebonne Bay	cy	690,830,000	11.8	8,154,000,000	
	Barataria Offshore	Barataria Bay	cy	456,190,000	8.7	3,964,590,000	
	Atchafalaya River	Terrebonne Bay	cy	292,480,000	7.5	2,198,000,000	
2	Contingencies		lump sum	1	2,218,000,000	2,218,000,000	
	(Land leases; UST removal; easements; utilities; demolition and construction of roads and bridges; relocation of residences, businesses, other; oil and gas pipeline coordination; local permits; debris disposal; demolition of buildings; traffic rerouting; community involvement; local government agency coordination; other)						10% of construction costs (here: Item 1 - dredging)

Subtotal	$24,400,000,000
Contingency (30%)	$7,300,000,000
Total	$31,700,000,000

USACE cost estimate in LCA Study

CH2M HILL

Construction costs for the interbasin segmented barriers can be derived from assumptions of the total length and the cross-sectional area of the barriers, and estimates of pipeline distances from borrow sources. The total volume required to construct the interbasin segmented barriers in both Barataria and Terrebonne Basins is approximately 70 to 100 mcy. Considering an average transport distance of 20 miles at $7.50 per cubic yard, the total dredging cost to construct the interbasin segmented barriers would be $500 to $750 million.

Cost estimates for the Barrier Island Plan (T. Baker Smith and Son, Inc., 1997) range from $550 to $950 million (1997 dollars), depending on the magnitude of the restoration effort and the return period for maintenance factored into the project costs.

5.9 Environmental and Economic Evaluation

Section 5.9 presents an overview of environmental and economic impacts that could result from the TDCC and the pipeline conveyance alternatives. The TDCC and pipeline alternatives share the goals of development and sustainability of a restored wetlands ecosystem in the Barataria and Terrebonne Basins. The pipeline conveyance alternatives are not separated into the three individual alternatives presented earlier in this report because the differences cannot be quantified to that level of detail at this time. The evaluation presented in this section focuses on how the TDCC and pipeline conveyance alternatives differ, by reviewing environmental and economic conditions for existing conditions, future conditions with no action, and the TDCC and pipeline conveyance alternatives. Several key differences between the TDCC and the pipeline conveyance alternatives must be factored in when assessing the overall impacts to the environment and economy. Some of these include the following:

- TDCC:
  - A complex, fixed system of engineered components dependent on large volumes of diversion flow from the Mississippi River.
  - Sediment source input is primarily from a single point, at the control structure at the Mississippi River and would include suspended sediment and bedload material. The other sediment source for land creation would include materials scoured and transported to the TDCC outfalls during channel development.
  - Once built, the outfalls of the TDCC system are fixed; therefore, sediment and freshwater input locations are fixed.
  - Implementation requires design, construction, and funding as a single project.
  - Project performance and subsequent land-building/ecosystem restoration results require complete construction of the project and time necessary for channel development and sediment deposition.
- Pipeline Conveyance Alternatives:
  - A construction methodology of mobile operations focused on restoration of targeted areas, allowing the creation of specific restorative features in each area.
  - Sediment could come from multiple sources, including different areas along the Mississippi River, the Atchafalaya River, or offshore.

- Implementation is likely to be undertaken as many smaller projects under the umbrella of a program.
- Project performance and subsequent land-building/ecosystem restoration results are accomplished relatively rapidly on a project-by-project basis as individual areas are targeted and restored.
- Freshwater input is dependent on operation of strategically located diversions.

5.9.1 Environmental Evaluation

The objective of the project is to restore coastal land through marsh creation and restoration. This analysis evaluates environmental conditions and impacts for the following conditions:

- Existing – characteristics of the existing environmental condition
- Future with No Action – characteristics of the projected environmental condition if the TDCC or pipeline conveyance alternatives are not implemented
- TDCC Concept – characteristics of the projected environmental condition if the TDCC concept is implemented
- Pipeline Conveyance Alternatives – characteristics of the projected environmental condition if one of the three pipeline conveyance alternatives is implemented

Biological Environment

The biological environment includes wildlife, threatened and endangered species, fisheries, oysters, plankton, benthic organisms, and vegetation.

Existing Conditions.

Wildlife. Coastal Louisiana contains approximately 40 percent of the vegetated estuarine wetlands in the contiguous United States. The diverse wildlife resources found within these estuaries, including birds, mammals, amphibians, and reptiles, are of aesthetic, recreational, and commercial importance. Approximately 735 species of birds, fish, shellfish, reptiles, amphibians, and mammals spend all or part of their life cycle in Louisiana's estuaries. Coastal habitat provides resting sites and food for millions of neotropical and other migratory avian species before and after they cross the Gulf of Mexico during migration. Of the estimated 353 bird species known to occur within the Barataria-Terrebonne estuary, 185 migrate annually to coastal Louisiana. Over the past 10 to 20 years, the duck population in the Barataria Basin area has declined as a result of marsh loss and conversion to saltier marsh types. Louisiana's coastal zone supports 19 percent of the United States' winter population for 14 species of ducks and geese. The North American Waterfowl Management Plan identified coastal Louisiana as one of the most important regions for the maintenance of continental waterfowl populations in North America (USACE, 2004).

Threatened and Endangered Species. Of the 25 animal and 3 plant species listed by Louisiana as threatened and endangered, 16 animal and 1 plant species occur along the coast. Threatened and endangered species occurring along the coast include the piping plover (*Charadrius melodus*), bald eagle (*Haliaeetus leucocephalus*), brown pelican (*Pelicanus*

occidentalis), Kemp's Ridley sea turtle (*Lepidochelys kempii*), loggerhead sea turtle (*Caretta caretta*), diamondbacked terrapin (*Malaclemys terrapin*), Gulf sturgeon (*Acipenser oxyrinchus desotoi*), and Louisiana black bear (*Ursus americanus luteolus*). Coastal Louisiana has the nation's largest concentration of colonial nesting wading birds and seabirds, approximately 197 colonies (Michot et al., 2003). Louisiana's barrier system, which has approximately 300 miles of shoreline, provides critical habitat for some threatened and endangered species, such as the piping plover and sea turtles. Coastal land loss has resulted in competition between threatened and endangered species along the coast for fewer available resources (USACE, 2004).

Fisheries. Even though coastal land loss has occurred in Louisiana, it has not diminished commercial and recreational catches of most fisheries species. Fisheries production has not decreased because, as marshes deteriorate, organic matter is released into the estuaries, increasing primary and secondary productivity. In addition to organic matter being released, marsh deterioration increases marsh-to-water interface (marsh edge) and the formation of shallow, protected ponds, which are growth and development areas for estuarine species. However, this increase in productivity is a short-term effect, and these conditions will eventually lead to fisheries decline (Figure 5-20).

Coastal Louisiana provides essential fish habitat (EFH), which is defined as "those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity," for a variety of fish and shellfish (USACE, 2004). EFH in Louisiana includes, but is not limited to, estuarine wetlands (marsh edge, inner marsh, marsh ponds, and tidal creeks); sub-merged aquatic vegetation; seagrasses; mud, sand, shell, and rock substrates (oyster reefs and barrier island flats); mangrove wetlands; and the estuarine water column. All tidally influenced waters and substrates along the coast, including subtidal and tidal vegetation, are designated EFH. The general trend in coastal Louisiana has been to convert highly productive EFH, such as marsh edge and inner marsh, to less productive EFH, such as the estuarine water column or mud, sand, or shell substrates. More than 8 million acres of marsh and water habitat are considered EFH in Louisiana. EFH designated in Louisiana for brown shrimp (*Farfantepenaeus aztecus*), white shrimp (*Litopenaeus setiferus*), red drum (*Sciaenops ocellatus*), red snapper (*Lutijanus campechanus*), vermilion snapper (*Rhomboplites aurorubens*), Spanish mackerel (*Scomberomorus maculates*), and bluefish (*Pomatomus saltatrix*) is managed by the Gulf of Mexico Fishery Management Council (GMFMC).

Submerged aquatic vegetation (SAV) is a type of EFH of great importance as a nursery for fish in coastal Louisiana. Marine SAV, also known as seagrass beds, occurs primarily in shallow, relatively clear offshore marine systems where unconsolidated substrates are present. Species include turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*), sea grass (*Halophila engelmanii*), shaol grass (*Halodule wrightii*), and widgeon grass (*Ruppia maritima*). Estuarine SAV occurs primarily in shallow, protected, low-turbidity brackish communities where sand and mud bottom substrates are present. Species include water celery (*Vallisneria americana*), southern naiad (*Najas guadalupensis*), and horned pondweed (*Zannichellia palustris*). Estuarine fish species depend on habitat such as estuarine SAV for all or part of their life cycle. Resident species, such as killifishes, reside in the estuaries for their entire life cycle. Transient species, such as blue crab and shrimp, reside within the estuaries for only part of their life cycle. For example, brown shrimp use SAV during the postlarvae/juvenile life stage, as do white shrimp and red drum.

Louisiana ports produce a catch comparable to those along the entire Atlantic coast, and triple that of the remaining states along the Gulf of Mexico (National Marine Fisheries Service, 2001). Since 1981, 4 Louisiana ports rank among the top 10 in the United States in value of commercial fisheries (USACE, 2004). In 2001, revenues for commercial fisheries in coastal Louisiana were $343 million, the largest for any state except Alaska (National Marine Fisheries Service, 2003; USACE, 2004).

Oysters. Oysters prefer firm substrate bottoms in shallow tidal to subtidal areas with salinities between 5 and 15 parts per thousand (ppt). In a bottom side-scan sonar survey of oyster substrates in subtidal reef areas conducted in 2000, approximately 6.6 percent of the 9,600 acres of leases present in the Barataria Basin were suitable for oyster production (USACE, 2004). The remaining acreage lacked the hard substrate needed for oyster production. As salinity has increased, leases in the Barataria Bay have migrated northward into the upper estuaries. Saltwater intrusion has also caused an increase in salinity, which increases disease and predation. Barataria Basin and the areas east of the Mississippi River dominate oyster production in Louisiana. Louisiana is the top producer of the eastern oyster (*Crassostrea virginica*) in the United States. The average annual value for the 11.4 million pounds of oysters harvested from Louisiana is $25.8 million. Land loss has reduced the amount of marsh available for providing shelter to oyster reefs (USACE, 2004).

Plankton. Plankton (zooplankton and phytoplankton), a food source for aquatic invertebrates and larval fish, form the base of the estuarine food web. Salinity appears to be a primary controlling factor in plankton distribution and composition. High concentrations of certain plankton (e.g., dinoflagellates), however, can be detrimental to the ecosystem and can result in fish kills due to high levels of toxins produced by plankton. Plankton toxins can also accumulate in shellfish and be detrimental to humans. High concentrations of phytoplankton, called algae blooms, occur in areas where excess nutrients are present. Phytoplankton rapidly die off after consuming nutrients and during the night, as respiration and oxygen consumption increase. Low concentrations of zooplankton have been encountered in several bays, including Terrebonne (USACE, 2004).

Benthic Organisms. Benthic organisms (e.g., bacteria, fungi, microalgae, meiofauna, microfauna, and macrofauna) are major consumer groups of detritus (organic and inorganic nutrients) in saltwater marshes and adjacent estuaries. According to Mitsch and Gosselink (1993), the detritus generated by benthic organisms is more important to estuaries than phytoplankton-based production. The diversity, taxonomic composition, and presence of opportunistic species indicate that existing benthic communities found along Ship Shoal are stressed (USACE, 2004).

Vegetation. Vegetation provides habitat for wildlife and fisheries and minimizes erosive forces of winds, waves, currents, and tides. Environmental factors regulating the occurrence and distribution of vegetation include, but are not limited to, soil and water salinity, soil type, elevation, hydrology and flooding regime, tidal influence, climate, competition from invasive species (e.g., water hyacinth, alligator weed, hydrilla, salvinia, giant salvinia, and variable-leaf milfoil), herbivory, and human disturbances (such as controlled burning, levee construction, and drainage for development). Invasive species flourish in disturbed areas free of insects and diseases, limit native plant growth, and decrease vegetative biodiversity. Invasive species also interfere with drainage and flood-control structures, impede

navigation and recreational activities, degrade water quality, and reduce habitat quality, often decreasing food and habitat for wildlife.

As salinity decreases from saline to freshwater marshes with increasing distance from the coast, vegetation communities change. In some areas, transitions in habitat types toward more salt-tolerant communities have been recorded over the past 50 years. In other areas, there was no change toward salt-tolerant communities; however, species dominance changed. Subsiding marsh surface elevations and the resulting increase of flooding, erosion, and saltwater intrusion have resulted in the conversion from freshwater marsh to saltwater marsh or open-water habitats. In 2000, marsh dieback in Terrebonne and Barataria saline marshes increased because of prolonged periods of drought (USACE, 2004).

Future Conditions with No Action.

Wildlife. Soil erosion, subsidence, and land loss would continue, which would decrease available habitat and food sources for wildlife communities and decrease wildlife abundance. As subsidence continued, forested habitat along coastal ridges, which are critical to migrating bird populations, would decrease, negatively affecting neotropical bird populations. In the Barataria Basin and Western Mississippi River Delta, marsh habitat quality is expected to decline in areas not influenced by freshwater diversion systems. Habitat quality decline is expected to decrease wildlife populations, including waterfowl, seabirds, wading birds, shorebirds, migratory birds, furbearers, other game mammals, reptiles, and amphibians. In the Terrebonne Basin, forested wetlands are expected to change to a less diverse community because of a greater frequency of flooding, which would decrease bird populations using this habitat type. Most wildlife populations are expected to decline because of high land loss in the central and eastern portions of Terrebonne Basin. Wildlife populations are expected to remain steady in the western portion of Terrebonne Basin (USACE, 2004).

Threatened and Endangered Species. Soil erosion and coastal land loss would continue, which would decrease available habitat for threatened and endangered species. The brown pelican, bald eagle, piping plover, and all sea turtles are expected to decrease as barrier islands deteriorate (USACE, 2004).

Fisheries. Habitat suitability, diversity, population size, and harvest rates influence fishery productivity. The current trend of converting highly productive EFH to less productive EFH would continue, which would result in less complex, biologically less diverse habitat and unsustainable fishery productivity (USACE, 2004). The short-term effects of coastal land loss would increase open-water habitats. In the long term, the increase in open-water habitat from wetland habitat would decrease the marsh-to-water interface and decrease fishery productivity. Coastal land loss would likely require additional flood-control structures, such as levees, water control structures, and hurricane-protection features to protect residents. Such structures would alter water flow, block fishery access, and change habitat types to those less favorable for fisheries.

Oysters. In the short term, oyster productivity is expected to increase as erosion increases open-water habitat. However, in the long term, oyster resources would decrease because of saltwater intrusion, predation, and the erosion of sheltering interior and barrier island habitats. The band of intermediate salinity areas would decrease significantly with continued land loss and saltwater intrusion. As erosion increased, saltwater intrusion farther

into the basins would increase, which would negatively affect oyster production (USACE, 2004).

Plankton. Plankton communities are likely to shift to an estuarine-dominant structure in the Barataria and Terrebonne Basins with continued coastal land loss.

Benthic Organisms. Short-term increases in benthic community diversity are expected with continued land loss because communities are more diverse in higher salinities. However, land loss leads to more intertidal and shallow subtidal environments, which are less favorable to benthic communities than deeper water environments. Increases in coastal land loss, subsidence, and relative sea-level rise would increase water depth and decrease benthic communities. The decrease in benthic communities would contribute to a decline in fisheries populations (USACE, 2004).

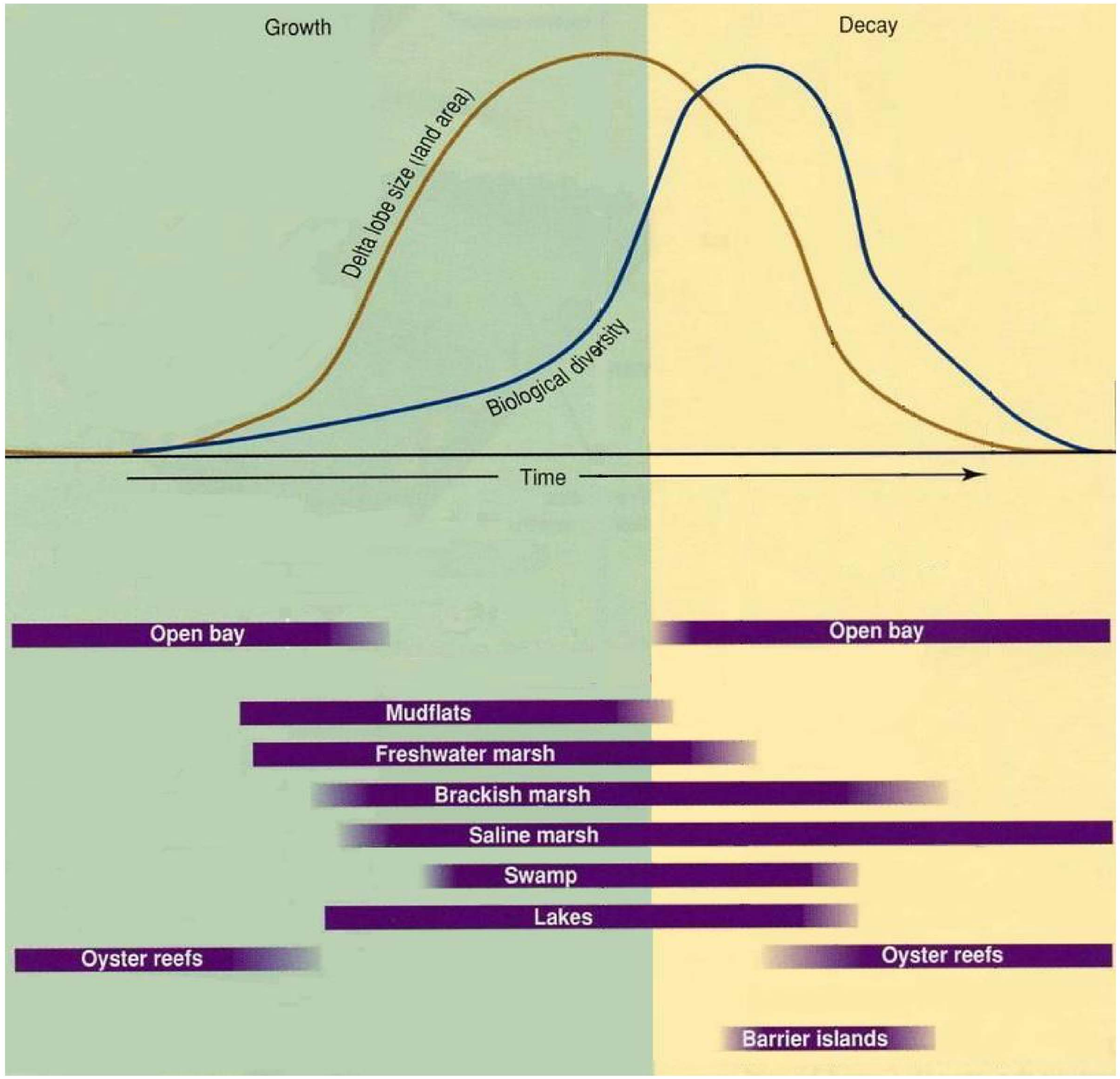
Vegetation. Vegetation loss would continue to occur because of erosion, increased wave energies, and increased herbivory. This, in turn, would decrease available nesting habitat for waterfowl and wildlife. Impacts or stress from subsidence and saltwater intrusion that occur too quickly or beyond a plant's ability to adapt or succeed, would cause vegetative dieback and a conversion to open water. Expected conditions such as extreme salinities, poor sediment quality, and nutrient limitations would severely restrict productivity, species diversity, species distribution, community structure, and habitat quality. Decreases in plant growth and biomass (organic carbon) accumulation would decrease the vertical accretion of soils, resulting in increased soil erosion. According to the USACE, a net loss of the total acreage of emergent wetland habitat is expected along the coast and within the Barataria Basin, Western Mississippi River Delta, and Terrebonne, Atchafalaya, and Teche/Vermilion Basins through the conversion to open-water habitat.

Third Delta Conveyance Channel Concept.

Wildlife. Increased sediment and freshwater influx from the TDCC and creation of subdeltas would create additional habitat for wildlife. Increased noise from construction could temporarily displace wildlife, disrupt breeding patterns, and lead to an abandonment of nesting colonies; however, wildlife would likely return to areas after construction. Clearing, dredging, and filling would destroy habitat and displace wildlife. Sediment deposition would create additional habitat, which would positively affect wildlife species (USACE, 2004). Duck populations are expected to increase or remain steady in areas receiving freshwater from the TDCC.

Threatened and Endangered Species. Increased sediment and freshwater from the TDCC diversions and creation of subdeltas would increase habitat for threatened and endangered species. Construction would temporarily increase noise and displace threatened and endangered species. The overall project footprint would destroy certain occupied habitats. However, subdelta creation would eventually provide a net increase in species habitat (USACE, 2004).

Fisheries. The introduction of freshwater into Terrebonne and Barataria Basins would likely shift composition from saline-tolerant to more freshwater-tolerant species and displace saline species farther offshore. The construction of the TDCC would disrupt natural



SOURCE: USACE, 2004

FIGURE 5-20
DELTA CYCLE GRAPH
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

CH2MHILL

hydrologic features, and could lead to isolated pockets of fishery impacts and limit accessibility for commercial and recreational fishing. These structural features could also displace some species and change fishing patterns. Large isohaline shifts resulting from the increased freshwater input would affect certain fish species more than others; for example, brown shrimp may be negatively affected. Freshwater would also introduce sediment into the basins. The introduction of sediment would create marsh and increase the marsh-to-open-water interface ratio, increasing fishery productivity. The combined influx of freshwater and sediment from diversions would likely increase vegetative habitat (SAV). Long-term introductions of sediment can lead to long-term increases in turbidity, which is a serious threat to estuarine SAV. Long-term beneficial effects are likely from sediment influxes. Effectively regulating freshwater flow would likely increase fishery habitat diversity and productivity by lengthening the salinity gradient in the estuaries. The large volumes of freshwater introduced into the basins from the TDCC would likely cause short-term species displacement and mortality (USACE, 2004).

Oysters. Freshwater diversions could stabilize salinities and increase productivity in Terrebonne and Barataria Basins. However, large-scale freshwater diversions could adversely impact localized oyster populations by lowering salinity concentrations. Increased sediment load from the TDCC discharging into Terrebonne and Barataria Basins could result in localized areas of high turbidity, which could bury existing oyster populations (USACE, 2004).

Plankton. Increases in freshwater to select parts of Barataria and Terrebonne Basins would likely shift plankton abundance from marine to freshwater species. It is uncertain whether the added freshwater would increase algal blooms near the TDCC outfalls. When approximately 740 to 7,500 cfs were diverted monthly from the Mississippi River for the Caernarvon Freshwater Diversion Project, no significant nitrate and nitrite affects were recorded at any of the water quality monitoring stations. Total nitrogen and total phosphorus in the diverted freshwater increase algal blooms. Suspended sediment from freshwater influx would increase turbidity, decrease dissolved oxygen, and decrease shallow-water habitat, which would negatively impact plankton populations. Introductions of sediment would lead to a long-term loss of shallow-water habitats available for plankton populations, which would then decrease the plankton populations. A decrease in population could also result from the introduction of freshwater because some zooplankton prefer saline environments (USACE, 2004).

Benthic Organisms. Sediment influx from the TDCC might negatively impact benthic organisms by displacing, disturbing, and smothering existing populations. However, the benthic community is likely to temporarily burrow into and recolonize the new sediment. This sediment would likely benefit benthic communities because it would likely contain additional nutrients and be fine-grained. Freshwater influxes decrease benthic species richness and shift composition from marine to more freshwater and estuarine species (USACE, 2004).

Vegetation. Channel dredging, levee construction, and the installation of flood-control structures for the TDCC would remove existing vegetation along the construction footprint. The creation of dredged material spoil banks and use of dredged material to fill in areas adjacent to channels could result in either a shift in species composition or vegetation die-

back. The introduction of significant volumes of freshwater could significantly reduce the diversity of habitats within the receiving basin because the freshwater would likely shift composition from salt-tolerant to freshwater-tolerant species. The shift in salinities and introduction of sediment from the freshwater might lead to temporary vegetative stress and diebacks until areas are recolonized; however, it is expected that vegetative stress and diebacks would be temporary and that freshwater marsh vegetation would flourish in the future. Subdelta formation in the Barataria and Terrebonne Basins from the diversion channels would provide additional habitat for vegetation (USACE, 2004).

Pipeline Conveyance Alternatives.

Wildlife. The introduction of sediment would convert open-water habitat into wetland habitat, which would increase habitat for wildlife. Sediment additions to barrier islands would prevent coastal erosion and habitat loss farther inland. Increased noise from construction activities and sediment placement could temporarily displace wildlife. However, it is expected that wildlife would return after construction. Some short-term impacts may include a decrease in the marsh-water interface caused by filling in canals and depressions. Coastal restoration efforts, both along barrier islands and farther inland, would result in additional habitat (nesting, brood-rearing, and foraging), providing a positive effect on wildlife species, including migratory avian species, waterfowl, game mammals, furbearers, reptiles, and amphibians (USACE, 2004).

Threatened and Endangered Species. The introduction of sediment would convert open-water habitat to wetland habitat in Barataria and Terrebonne Basins, increasing food sources and habitat for threatened and endangered species. The addition of sediment to barrier islands would prevent coastal erosion and increase habitat for the piping plover, sea turtles, and the brown pelican. Increased noise from dredging and filling could temporarily displace threatened and endangered species. However, restoration efforts would provide a net increase in habitat for threatened and endangered species (USACE, 2004).

Fisheries. The initial creation of new marsh areas might cause short-term decreases in fisheries productivity; however, it would increase productivity in the long term. Short-term turbidity increases from material placement could result in negative effects to fisheries, including gill irritation and clogging of feeding apparatus for certain species. Short-term displacement of species might occur because of habitat disturbance and noise levels; however, species are expected to return after the project is constructed (USACE, 2004).

Oysters. Marsh creation operations in the Terrebonne and Barataria Basins would likely result in short-term increases in turbidity, which could negatively impact oyster productivity. Creation of new land could displace some existing oyster beds. Salinity regime changes from the associated freshwater diversions could negatively affect some existing oyster beds, but would likely benefit oyster production overall.

Plankton. Suspended sediment from marsh creation operations would temporarily increase turbidity. Shallow-water habitat would decrease in the long term, affecting plankton populations. The increased flow of freshwater would likely shift plankton communities, and abundance, from marine to freshwater species.

Benthic Organisms. Benthic organisms tend to favor sandier substrates, and placement of materials from offshore sites may benefit benthic communities. However, dredging and

filling practices may negatively, but temporarily, impact species by displacing and disturbing existing populations. Benthic communities would likely adapt over time to increased marsh habitat.

Vegetation. Conveyed sediments would be placed strategically and at specific elevations to promote preferential hydrologic patterns and vegetation habitats. Initial material placement could cause short-term vegetative stress and diebacks until areas are recolonized. It is expected that vegetative stress and diebacks would be temporary and that vegetation would flourish in the future. Sediment would increase land creation, provide additional habitat for vegetation, and provide nutrients to existing vegetation (USACE, 2004).

Habitats

The Louisiana coastal zone can be classified into five habitat types: freshwater marsh, intermediate marsh, brackish marsh, saline marsh, and swamp/wetland forest.

Existing Conditions.

Freshwater Marsh. Freshwater marshes are dominated by emergent, herbaceous plant species adapted to intermittent through continuous flooding and include floating freshwater marsh (USACE, 2004; Kadlec and Knight, 1996). Freshwater marshes are the farthest inland of the habitat types discussed in this section. Salinities range from 0.1 to 6.7 ppt in freshwater marshes (USACE, 2004). Common freshwater marsh species include *Panicum hemitomum, Hydrocotyle sp., Pontederia cordata, Sagittaria sp.,* and *Althernantera philoxeroides* (Visser et al., 1998).

Intermediate Marsh. Intermediate marshes are generally low-energy systems because they are typically located away from strong tides and local upland drainages. Salinities range from 0.4 to 9.9 ppt in intermediate marshes. Intermediate marshes include small bands of vegetation between freshwater marsh and brackish marsh where saltwater slightly mixes with freshwater. The low salinity causes fewer species to be present than in freshwater marshes. Plants found in these marshes can tolerate slightly salty water (USACE, 2004). Common intermediate species include *Spartina patens, Vigna luteola, Scirpus californicus, Echinochloa walteri, Sagittaria sp., Cladium jamaicense,* and *Phragmites australis* (Visser et al., 1998).

Brackish Marsh. Brackish marshes include brackish three-cornered grass marsh, floating three-cornered grass marsh, and leafy three-cornered grass or coco marsh. The brackish marsh occupies a broad band between salt and intermediate marshes, inland of the salt marsh. Brackish marshes are generally low-energy systems because they are located away from strong tides and local upland drainage; however, they are periodically flooded. Brackish marshes are influenced by slightly salty tidal waters and freshwater migration from freshwater marshes. Plant diversity and soil organic matter are higher in brackish marshes than salt marshes. Salinities range from 0.4 to 28.1 ppt in brackish marshes (USACE, 2004). Common brackish marsh vegetation includes a combination of *Spartina patens, Scirpus americanus, Scirpus robustus*, and *Eleocharis parvula* (Visser et al., 1998).

Saline Marsh. Saline marshes are dominated by emergent, herbaceous plant species and include excessively drained salt marsh and sea rims (USACE, 2004; Kadlec and Knight, 1996). These marshes are located closest to the shorelines and are influenced mostly by daily

tidal flushing and marine waters. Salinities could range from 0.6 to 51.9 ppt in saline marshes (USACE, 2004). Vegetative communities are typically composed of 90 percent grasses, 5 percent woody plants and trees, and 5 percent forbs. Diversity is low because few plants have the physical and physiological adaptations to grow and reproduce in high-salinity areas with periodic flooding. Common salt marsh species include *Spartina alterniflora, Juncus roemerianus, Batis maritima*, and *Distichlis spicata* (Visser et al., 1998).

Swamp/Wetland Forest. Swamp/wetland forests are located in low-lying areas that have saturated soils and are inundated with water either part or all of the growing season. Vegetation includes trees and aquatic vegetation and can be broken into two subcategories: bottomland hardwood forests and swamps. Bottomland hardwood forests are typically closer to higher elevational features, such as levees, and occasionally flood. Typical plants include a variety of hardwoods (e.g., hackberry, elm, maple, ash, honey locust, and elderberry). Swamps are farther away from higher elevational structures and typically pond or retain water for long periods, especially during the growing season, and contain woody vegetation. Key species include the cypress and tupelo-gum. Cypress/tupelo swamps are present in the upper Barataria Basin.

Future Conditions with No Action.

Freshwater Marsh. Land loss would continue to increase because of increases in relative sea-level rise, subsidence, sediment compaction, and tectonic faulting. Such activities would increase saltwater intrusion and the conversion of freshwater marshes to saltier marshes. Freshwater marshes would degrade and convert to other habitat types, such as open water. Freshwater marshes like those adjacent to existing freshwater diversion projects, such as the Caernarvon Freshwater and Davis Pond Diversion projects, would increase with continued freshwater introductions. In Barataria Basin and Western Mississippi River Delta areas, a net gain of freshwater marsh is expected to result from a freshening trend caused by increasing influence of freshwater diversion projects, such as Davis Pond. In the Terrebonne, Atchafalaya, and Teche/Vermilion Basins, conversion to intermediate marsh could cause a net decrease of freshwater marsh (USACE, 2004).

Intermediate Marsh. Land loss would continue to increase, which would increase saltwater intrusion and convert intermediate marsh to saltier marsh types. In Barataria Basin and Western Mississippi River Delta areas, a net decrease of intermediate marshes is expected with the actual decrease dependent on freshwater diversions, such as Davis Pond. Some wetland loss is expected because of the conversion of marsh to open water; however, most of the decrease would be due to a freshening effect from existing freshwater diversion projects. In the Terrebonne, Atchafalaya, and Teche/Vermilion Basins, a net increase of intermediate marsh habitat is expected because of the conversion of freshwater to intermediate marsh. Net gains are expected to occur in the lower southwestern Terrebonne Basin because of the freshening influence of the Atchafalaya River; however, some net loss is expected in the basin because of the conversion to brackish habitat and from land loss (USACE, 2004).

Brackish Marsh. Land loss would continue to increase, which would increase saltwater intrusion and the conversion of brackish marsh into saline marsh. Brackish marshes may increase in acreage as saltwater intrusion increases salinity in the basins. The net change would be influenced by existing and planned freshwater diversion projects.

Saline Marsh. According to the USACE, accelerated rates of land loss along the coast would significantly reduce saline marsh because of a narrowing of salinity zones from saltwater intrusion. Other factors, such as subsidence, relative sea-level rise, and tectonic influences, would also decrease saline marsh along the coast. Even with the slight increase in saline marsh from conversion of fresher to saltier marsh types farther inland, the net effect would be a loss of saline marsh.

Swamp/Wetland Forest. As land loss continued, increasing saltwater intrusion into the upper basin would negatively affect swamp/wetland forest habitat.

Third Delta Conveyance Channel Concept.

Freshwater Marsh. The introduction of freshwater, sediments, and nutrients from the TDCC is likely to shift habitat types in the receiving basins and increase freshwater marsh habitat. Habitat creation from the influx of freshwater and sediment in the receiving basins is expected to be fresh- or intermediate-type marsh habitat. Nutrient and freshwater introductions would enhance vegetative productivity. Large volumes of freshwater are expected to create additional freshwater marsh habitat. Each particular marsh habitat type would be impacted to some degree by the TDCC construction footprint (USACE, 2004).

Intermediate Marsh. The introduction of freshwater, sediments, and nutrients from the TDCC is likely to shift habitat types in the receiving basins and increase intermediate marsh habitat. Habitat created by the influx of freshwater and sediment in the receiving basins is expected to be fresh- or intermediate-type marsh. Each marsh habitat type would be impacted to some degree by the TDCC construction footprint (USACE, 2004).

Brackish Marsh. The introduction of freshwater from the TDCC is expected to decrease salinities in localized areas of the receiving basins and convert brackish marsh to fresher marsh types. Each marsh habitat type would be impacted to some degree by the TDCC construction footprint (USACE, 2004).

Saline Marsh. The introduction of freshwater from the TDCC is expected to decrease any existing saline marshes within localized areas of the receiving basins and convert them to fresher marsh types. Each marsh habitat type would be impacted to some degree by the TDCC construction footprint (USACE, 2004).

Swamp/Wetland Forest. The introduction of freshwater, sediments, and nutrients from the TDCC is not likely to affect swamp/wetland forest because these habitat types are typically located in the upper parts of the basins. However, swamp/wetland forest habitat located in the upper parts of the basins would decrease because of the TDCC construction footprint.

Pipeline Conveyance Alternatives.

Freshwater Marsh. Restoration efforts would be largely focused on marshes in the northern part of the basins, which are predominantly freshwater marsh habitat, resulting in a net gain of freshwater marsh. Additionally, the increased sediment and nutrient influxes from the freshwater diversions from the pipeline conveyance alternatives and the dredging and filling activities would increase land available for freshwater marsh habitat and vegetative growth. The introduction of sediment farther south in the basins would decrease habitat flooding and increase vegetative growth within freshwater marsh habitat (USACE, 2004).

Intermediate Marsh. Restoration efforts would result in a net gain of intermediate marsh in the upper parts of the basins. Increased sediment and nutrient influxes would increase land available for intermediate marsh habitat and vegetative growth. The introduction of sediment farther south in the basins would decrease habitat flooding and increase vegetative growth in intermediate marsh habitat. Additional freshwater vegetative composition would likely shift from intermediate to freshwater marsh habitats.

Brackish Marsh. Increased sediment and nutrient influxes from the freshwater diversions from the pipeline conveyance alternatives and the dredging and filling activities would increase land available for brackish marsh habitat and vegetative growth. The introduction of sediment farther south in the basins would decrease habitat flooding and increase vegetative growth within intermediate marsh habitat. However, there would likely be a shift in vegetative composition from brackish to fresher marsh habitat because of salinity gradient changes and localized elevational changes.

Saline Marsh. Increased sediment and nutrient influxes from the freshwater diversions from the pipeline conveyance alternatives and the dredging and filling activities would increase land available for saline marsh habitat and vegetative growth. The introduction of sediment farther south in the basins would decrease habitat flooding and would likely change local elevations, causing a shift in vegetative composition from saline to fresher marsh habitat. It is uncertain whether there would be a net increase or decrease in saline marsh habitat.

Swamp/Wetland Forest. Restoration efforts would largely focus on creating additional marsh habitat in the northern parts of the basins. Additional marsh habitat would decrease storm surges and saltwater intrusion farther inland, which would preserve existing swamp/ wetland forested habitat.

Water Quality

Coastal Louisiana waters are used for recreation, fish and wildlife propagation, and drinking water. Water quality for the coastal area can be measured using salinity and nutrients.

Existing Conditions.

Salinity. Salinity in coastal Louisiana is affected by freshwater inflow, tides, wind, and coastal shelf processes. Generally, high-inflow/low-salinity periods are typical from late winter to late spring in Louisiana estuaries. Most of Louisiana's estuarine systems are shallow, wind-driven systems with small tidal action that prevents salinity stratification. Salinity directly affects distribution, abundance, and composition of biological resources in estuaries. Extreme salinity can lead to a conversion of fresh and intermediate marshes to open water. USACE estimates that current salinity conditions east of Barataria Bay waterway extending from Myrtle Grove south to the western part of the Mississippi River Delta range from 4 to 6 ppt. The interior part of Terrebonne Bay ranges from 6 to 8 ppt.

Nutrients. The construction of levees and dams has decreased overbank flooding from the Mississippi River, which has increased nutrient conveyance in the Mississippi and Atchafalaya Rivers to the Gulf of Mexico. Before levees were constructed, overbank flooding allowed wetlands and marshes to take up sediment and nutrients before they reached the Gulf of Mexico. Additionally, the increased use over time of commercial fertilizers for agriculture has resulted in excess nitrogen being introduced into the Gulf of Mexico. Nitrate

concentrations of approximately 1.4 to 1.6 mg/L present in the lower Mississippi River can cause excessive algal growth and contribute to hypoxic conditions in the Gulf of Mexico. Some algae produce toxins; therefore, excessive algal growth (algal blooms) in hypoxic areas can result in fish kills. Algal blooms occur when high nutrients, high temperatures, and light winds cause low turbidity and light penetration deeper into the water column. Algal blooms can occur in freshwater hypoxic environments and in more saline hypoxic environments, referred to as red tides. Immobile organisms, such as oysters, cannot leave hypoxic conditions and would either die or be seriously harmed. Toxins can accumulate in shellfish and can be toxic to humans if ingested. Fish, shrimp, zooplankton, and benthic organisms are less abundant in hypoxic waters (CENR, 2000; USACE, 2004). It can take from 1 to 2 years for benthic communities to recover from hypoxic (less than 2 mg/L of dissolved oxygen) or anoxic (no dissolved oxygen) environments (Baker et al., 1981; USACE, 2004).

Sediment cores taken from hypoxic areas show that algal production and deposition were much lower in the early 1900s and that significant increases occurred in the latter half of the twentieth century (CENR, 2000; USACE, 2004). Year-to-year variations in hypoxic conditions are due to variations in saltwater and freshwater stratification and variations in river discharge. In 2002, Terrebonne Basin supported all designated uses except fish and wildlife propagation because of excess nutrients, including phosphorus, nitrogen, and mercury.

Future Conditions with No Action.

Salinity. Continued relative sea-level rises, subsidence, sediment compaction, tectonic faulting, and construction access channels (such as those for oil and gas activities and flood control) would increase salinity levels farther into the upper parts of the basins. Increased salinity levels farther inland would likely shift fishery and vegetation composition to more salt-tolerant species. Increases in salinity decrease biological diversity and productivity; therefore, fishery and vegetation productivity would likely decrease. Vegetation would decrease because it could not recolonize before erosion eliminated soil substrate, and vegetated habitat would convert to open water.

Nutrients. Continued coastal erosion and land loss is expected to increase nutrient concentrations and hypoxic conditions in the Mississippi River Delta area because less marsh would be available to absorb nutrients before reaching the delta. Nutrients would likely increase higher in the basin as marsh were lost through coastal erosion, which could lead to algal blooms and fish kills in the estuaries.

Third Delta Conveyance Channel Concept.

Salinity. The TDCC would introduce large volumes of freshwater, which would decrease salinity in the receiving basins and help push the salinity gradient farther toward the Gulf of Mexico. The introduction of freshwater should help prevent saltwater intrusion farther into the upper basins. Colder river water entering the receiving basins could change circulation and stratification/density patterns of receiving basin waters (USACE, 2004). However, freshwater diversion projects may lead to greater interannual salinity variations within the receiving basins and increase stress on vegetation and fisheries. Salinity variations are likely to be greater with water volume fluctuations, which are dependent on the Mississippi River water levels. The creation of conveyance channels would increase salinity farther into

interior habitats because of saltwater intrusion during low flows, which could flow into the GIWW during routine nautical navigation (USACE, 2004).

Nutrients. Freshwater and sediment introductions from conveyance channels would benefit vegetative habitats within the receiving basins. These large volumes of water would introduce more nutrients and reside longer in estuaries, which could result in hypoxic conditions farther into the upper basins. Sediment entering the basin from the TDCC would increase marsh habitat, which would increase the ability of the marsh to absorb the nutrients before reaching the receiving basins. Even with some scientific uncertainties regarding nutrient removal and adverse water quality impacts, such as algal blooms, it is expected that large-scale freshwater introductions into the Terrebonne and Barataria Basins would reduce nutrients discharged into the Mississippi River Delta, thereby likely reducing the potential for hypoxic conditions (USACE, 2004).

Pipeline Conveyance Alternatives.

Salinity. Strategic freshwater diversions would be an integral part of the pipeline conveyance alternatives. Adequate freshwater sources are required to sustain newly created and restored marsh. Salinity encroachment would, therefore, be mitigated and the salinity gradient would likely return toward its historical pattern prior to major land loss. Salinity regimes are not expected to change significantly in the upper receiving basins because these areas are predominantly fresh and intermediate marsh habitats. The introduction of freshwater from the pipeline conveyance alternatives is expected to decrease saltwater intrusion into the upper basins. The stabilization of salinities or the relocation of saltier waters farther into the Gulf of Mexico by introducing freshwater higher in the basin from existing and future diversion projects would benefit most users of coastal Louisiana (USACE, 2004).

Nutrients. Freshwater and sediment introductions from the pipeline conveyance alternatives would benefit vegetation by creating additional habitat and providing additional nutrients within the receiving basins. Additional habitat would increase the amount of nutrients absorbed and decrease the amount of nutrients entering the Barataria and Terrebonne Basins. However, the introductions of water and nutrients could result in hypoxic conditions farther into the upper basins and estuaries where the water flows in. Similar scientific uncertainties regarding nutrient removal and adverse water quality impacts, such as algal blooms, in the receiving basins to those for the TDCC concept are expected with the pipeline conveyance alternatives.

Hydrology and Coastal Processes

Existing Conditions.

Flood Control and Navigation Infrastructure. Flood control and navigation infrastructure along the Mississippi River have significantly impacted the natural hydrology, which efficiently conveyed nutrients and sediments to the wetlands. For example, levee systems have mostly eliminated seasonal flooding, thus the distribution of freshwater, sediments, and nutrients to wetland habitats. Structures have changed the hydraulics and hydrology between the Mississippi River and the Louisiana coast near the Terrebonne and Barataria Basins. These structures consist of the Mississippi River levee system near Donaldsonville and a levee system near Grand Isle (USACE, 2004). Levees have been built along the

Mississippi River in coastal Louisiana since the 1700s. There are approximately 2,250 miles of levees in coastal Louisiana (USACE, 2004).

In 1904, a dam was placed across Bayou Lafourche to prevent the Mississippi River from flooding and damaging Donaldsonville. The dam removed the hydrologic connection between the Mississippi River and the Barataria Basin.

Improvements in agriculture and bank stabilization management practices have decreased the average sediment load in the Mississippi River by approximately 67 percent since the 1950s (Kesel, 1988; USACE, 2004). The average sediment load of the Mississippi River is 436,000 tons per day and 159 million tons per year. Averages have ranged from 1,576,000 tons per day in 1951 to 219,000 tons per day in 1988. Average flow rate is approximately is 600,000 cfs, although flows have reached 1,250,000 cfs downstream of New Orleans. Peak flow of 1,250,000 cfs is expected to occur approximately once every 16 years (http://www.lacoast.gov/geography/basins/mr).

Hydrology has also been affected by road crossings, channels, and associated spoil banks. Such structures restrict or redirect water movement, and cause surface water impoundments and longer periods of flooding, leading to waterlogging and plant mortality. Plant mortality leads to habitat loss and increased saltwater intrusion.

Future Conditions with No Action.

Flood Control and Navigation Infrastructure. Even with freshwater diversion projects, such as Davis Pond, the wetlands in the western Barataria Basin and northwestern and eastern portions of Terrebonne Basin are experiencing the greatest and most accelerated land losses along coastal Louisiana. Continued land loss from subsidence, sediment compaction, increased wave erosion, and tectonic faulting would create a need to increase the number of hurricane-protection levees, pumping stations, and flood-control facilities along the coast. These structures would increase the number of spoil banks, which would lead to more surface impoundments, flooding, waterlogging of adjacent marshes, and ultimately, marsh dieback. Without these structures, increased wave erosion and deterioration of elevated spoil banks and landbridges would limit the buffering effect and protection of some vegetative habitats, which would lead to habitat conversion or loss (USACE, 2004).

Third Delta Conveyance Channel Concept.

Flood Control and Navigation Infrastructure. The construction of canals and levees, other flood-control structures, and dredged material banks would likely alter hydrology within and adjacent to the construction footprint, potentially creating impoundments and flooded areas, and degrading water quality (USACE, 2004). North-south canals increase saltwater intrusion into the GIWW during routine nautical navigational travel, especially during times of low flow. Forced drainage systems, which would be needed on the land sides of constructed spoil banks and freshwater diversion channels, drain soils, which increases organic matter oxidation, soil compaction, and subsidence. Any alteration that allowed marsh soils to be excessively waterlogged would cause chemical changes, vegetative growth dieback, and could lead to increased open-water habitat. Spoil banks alter water exchange across wetlands and could cause fewer and longer flood events resulting in vegetation dieback, and block sediment movement resuspended during storm event. Wetland communities within the eastern portions of Terrebonne Basin are hydrologically isolated;

however, the southwestern portion of the basin is still influenced by the Atchafalaya River (USACE, 2004).

Pipeline Conveyance Alternatives.

Flood Control and Navigation Infrastructure. Sediment introductions would increase marsh habitat along the coast and within the upper basins. Marsh creation, barrier island restoration, and the creation of interbasin segmented barriers would decrease storm surges inland (USACE, 2004). Marsh hydrology would not likely be negatively altered because sediment would be strategically placed to minimize any hydrologic impacts. Sediment would be deposited near existing levees to rebuild marsh and fill in old oil and gas canals. Sediment would not be deposited within main navigational channels. Using sediment from the Mississippi River for restoration would decrease the amount of material needing to be dredged to maintain nautical navigational traffic.

Barrier Island System

Existing Conditions. Barrier shorelines, headlands, and islands, collectively called barrier systems, provide habitat for birds, wildlife, oysters, and fish; act as natural protective storm buffers by reducing wave energy and limiting storm surge heights; and regulate the exchange of high-salinity waters of the Gulf of Mexico and lower salinity inland waters. There are approximately 300 miles of barrier systems along the coast of Louisiana. Two primary barrier systems are present in Louisiana, Deltaic Plain (consisting of Chandeleur, Plaquemines, Bayou Lafourche, and Isles Dernieres barrier systems) and Chenier Plain (consisting of ridges between Sabine Pass, Texas, to Southwest Point, Louisiana). Many of the barrier systems are part of national wildlife refuges or WMAs (USACE, 2004).

The Atchafalaya River supplies the Chenier Plain with fine-grained sediments. Ship Shoal is located southwest of the Atchafalaya River Delta and bay areas, which are west of Terrebonne and Barataria Bays. According to Stone (2000), the sediment flux of Ship Shoal, located southwest of Isle Derneries, tends to be seaward during strong winter storms when winds are toward the south. Thus, winter storms cause accretion and fair weather with westerly winds causes erosion on Ship Shoal. According to the same study, wave height was higher at an offshore measuring station than at a nearshore station, which proves that Ship Shoal attenuates wave energy. Morton et al. (2002) determined that frequent oscillation in water levels due to cold fronts erodes both sides of barrier islands, mainlands, and bay shores. Cold fronts occur approximately once every 7 to 10 days from November to April along the Louisiana coast. As cold fronts approach, low barometric pressure creates onshore winds, pushing water along the coast and exposing shores to eroding waves. As cold fronts pass, offshore winds push water away from the beaches. The average rate of long-term (100 to 200 years) and short-term (10 to 35 years) shoreline changes are -19.9 feet per year and -30.9 feet per year, respectively (USACE, 2004). According to the LCA Study (USACE, 2004), future land loss between the years 2000 and 2050 for Louisiana is projected to be 513 square miles.

Future Condition with No Action. Lack of sediment influx on barrier islands would result in continued land loss due to wave erosion from storms and hurricanes, which leads to a decrease and eventual loss of the natural protective storm buffering. Overwash and fragmentation of barrier islands during storms may eliminate some low-lying barrier islands and cheniers by the year 2050. Because barrier islands, such as the Barataria Basin Barrier

Islands, Isles Dernieres, and Timbalier Islands, decrease wave energy before the waves reach coastal Louisiana marshes, barrier island loss would lead to greater land loss along the coast and the conversion from fresher to saltier marsh types. This land loss would lead to decreased habitat for threatened and endangered species, migratory birds, and other wildlife (USACE, 2004). It would also decrease spawning, nursery, nesting, and feeding habitats for a variety of fish and shellfish. Barrier island land loss and the resulting increased wave energy along exposed marshes would add to the removal of sediments near structures, thus decreasing the integrity of oil and natural gas pipelines and structures. The greatest rates of land loss are expected to occur on the Barataria and Terrebonne shorelines. Coastal erosion and the failure to maintain or improve barrier islands would increase storm surges and flooding, thereby damaging vegetation and structures farther inland. However, land building would continue in the two existing deltas and the Atchafalaya River and Mississippi River Basins (USACE, 2004).

Third Delta Conveyance Channel Concept. Without specific restoration activities aimed at depositing more sediment on the existing barrier island system, the system would continue to erode. Barrier island loss would lead to decreased habitat for threatened and endangered species, migratory birds, and other wildlife. It would also decrease spawning, nursery, nesting, and feeding habitats for a variety of fish and shellfish. Without barrier island restoration, continued land loss due to wave erosion from storms and hurricanes and the increase in relative sea level would decrease the natural storm buffer protecting interior wetland habitats, including those created through the TDCC outfalls.

Pipeline Conveyance Alternatives. All of the pipeline conveyance alternatives assume that current planned restoration activities for the existing natural barrier island system would be carried out. Barrier island restoration, and the creation of interbasin segmented barriers, would decrease coastal erosion and habitat loss, storm surges, and wave energy, and prevent saltwater intrusion. Restoration would also protect wetlands, bays, and estuaries along the coast, and prevent undermining and erosion of oil and gas pipelines located throughout the coast. It would also increase the physical diversity of the barrier system, which would increase biological vigor and diversity on the islands. Threatened and endangered species, such as the piping plover, would benefit from the creation and restoration of barrier islands. Material deposited during barrier island restoration would benefit the coastline environment by introducing material through littoral drift (USACE, 2004).

Sediment Sources

Existing Conditions. Material sources available for restoration include suspended sediment from the Mississippi River, nine nearshore sand resources, and four offshore sand resources. Suspended sediments in the Mississippi River have declined since the early 1900s as land use has changed from forests and grasslands to agriculture. Also, the introduction of the Old River Control Complex, which regulates flow between the Mississippi River and Atchafalaya River, and the construction of dams and other sediment-retention structures along the Mississippi River and Arkansas River, have affected the sediment load that reaches the lower Mississippi River. Average suspended sediment loads have decreased 79 percent from 1851 to the present (Keown et al., 1981; Kesel, 1988; USACE, 2004). Over the past 20 years, an average of 15 to 20 mcy of material has been dredged annually from the

Mississippi River navigation channel, specifically the Head of Passes and Southwest Pass areas (USACE, 2004).

A preliminary quantification of nearshore sediment resources was conducted by USGS (Kindinger et al., 2001). Nine sand sources offshore of the Barataria Basin were identified, and preliminary volume estimates based on widely spaced sediment cores indicate that 400 mcy of sand may be present. However, almost 570 mcy of overburden must be removed to access these resources. Kindinger et al. (2001) suggests using the sand for barrier island restoration and the overburden for marsh restoration. According to James (1975), an overfill factor must be considered when a source material is determined potentially viable for restoration. The overfill factor is the ratio of a unit volume of natural material to a volume of source material required. McBride et al. (1989) used the overfill factor and determined that sand from Ship Shoal would be a good material source for the regeneration of Isles Dernieres shoreline because the ratio was 1:1.03. Offshore sand resources include Trinity Shoal (18 miles long and 3 to 6 miles wide), Outer Shoal (approximately 22 miles long and 3 to 6 miles wide), St. Bernard Shoals (several 3- to 4-mile-wide shoals), and Ship Shoal (31 miles long and 3 to 7 miles wide). The volume of sand composing Ship Shoal alone is estimated to be 1.2 billion cubic meters.

Future Conditions with No Action. Sediment sources available for restoration, both nearshore and offshore, are likely to remain largely undisturbed; however, some erosion of the sources might occur over time (USACE, 2004). Suspended sediment load within the Mississippi River should remain relatively constant, depending on river management policies.

Third Delta Conveyance Channel Concept. Nearshore and offshore sediment sources are likely to remain undisturbed, because the sediment source for this alternative is suspended sediment from the Mississippi River. Mississippi River sediment would be smaller grained, less likely to be retained in the receiving basins, and would compact more than larger grained sediment and require more volume to create the same amount of habitat. Conveyance channels for this alternative would remove freshwater from the Mississippi River, which would decrease available sediment downstream.

Pipeline Conveyance Alternatives. Nearshore and offshore sediments, such as on Ship Shoal, would likely be used for barrier island restoration, interbasin segmented barriers creation, and shoreline stabilization. Nearshore and offshore sediment sources would decrease in size with an increase in restoration because the sediments would be dredged and used to fill in shallow-water areas farther north in the Terrebonne and Barataria Basins, and restore coastal shorelines and barrier islands. Sediment would be removed through dredging, which could disturb or destroy any existing cultural resources, disturb any adjacent oil and gas pipelines, and alter bottom topography of the Gulf of Mexico. Altering the bottom gulf topography could lead to changes in wave dynamics, which could increase wave energies, increase coastal erosion, and change littoral drift patterns. Sediment influx from the pipeline conveyance alternatives could temporarily negatively affect the benthic community by displacing, disturbing, and smothering existing populations through increases in turbidity or direct burial. However, it is likely that the benthic community would temporarily burrow into the sediment during deposition and then recolonize the new sediment. This sediment is likely to benefit benthic communities because it would likely contain additional nutrients and would be fine-grained. Dredging would impact the biological community by removing

the existing benthic community within the dredged areas, increasing turbidity and decreasing dissolved oxygen content of adjacent waters, but this is considered a short-term negative effect. There is potential for inadvertent mortality of sea turtles, a threatened and endangered species, from dredging (USACE, 2004).

There is potential to use existing Mississippi River freshwater diversions and Mississippi River sediment to restore habitat higher in the basins. The sediment would be predominantly bedload, which is coarser grained, and would likely remain in place after deposition. Coarser-grained sediment from the three resources (offshore, nearshore, and Mississippi River bedload) is likely to remain in place after deposition because of the size of the material being deposited. The levee-protection system for the Mississippi and Atchafalaya Rivers would likely prevent delta growth in the areas being dredged and used for restoration (USACE, 2004), such as Ship Shoal. Removing sediment from nearshore and offshore sources and the Mississippi River would prevent future uses of the resources.

Historical and Cultural Resources

Existing Conditions. Over the last 50 years, coastal land loss from subsidence, compaction, and erosion, construction of navigation channels, and inundation have put many of Louisiana’s cultural resources at risk, and many have been lost. Cultural resources and historic sites have been lost to the climate’s severe storms, dredging and filling projects, and wave action from boats. Types of cultural resources include historic sites, prehistoric sites, and historic shipwrecks. Historic and prehistoric sites are typically located along the natural levees of rivers and bayous, which were primary transportation routes. Shipwrecks are primarily located offshore near barrier islands and shoals.

Prehistoric sites include hunting and food-processing camps, hamlets, and villages. Geomorphic features, such as barrier islands, back-barrier embayments, river channels, floodplains, terraces, and salt-dome features have a high probability of containing prehistoric sites. Historic sites include domestic buildings, plantation sites, farmsteads, military sites, commercial and industrial sites, boat landings, and hunting and fishing camps. Historic resources offshore on the outer continental shelf (OCS) consist of shipwrecks. Statistical analysis of more than 4,000 potential shipwrecks indicates that they are predominantly located in areas of natural geological navigation hazards and port entrances. Ship Shoal has one of the densest concentrations of shipwrecks (33 known wrecks) in the Gulf of Mexico. A higher potential for shipwreck preservation exists in areas of thick deposits of Holocene sediments than in thinner deposits.

Future Conditions with No Action. As barrier islands erode and subside, it is likely that cultural resources existing on them will be damaged or destroyed by storms. As relative sea-level rises, existing cultural resources could be inundated (USACE, 2004). Increased land loss would increase salinities farther into the Barataria and Terrebonne Basins and could affect the structural integrity and increase decay of existing sites. Increased salinity could cause a net loss of vegetation surrounding existing sites and lead to increase erosion and destruction of the sites (USACE, 2004).

Third Delta Conveyance Channel Concept. Even with surveys and detailed feasibility-level investigations, there would be an increased risk of damaging or destroying cultural resources from depositing sediment on existing sites. The construction of spoil banks and

water-control structures could cause surface impoundments and negatively affect existing sites (USACE, 2004). However, construction of the TDCC footprint may provide access to sites previously unrecoverable or unknown, and may allow for the restoration of those sites.

Pipeline Conveyance Alternatives. Even with surveys and detailed feasibility-level investigations, there would be an increased risk of damaging or destroying cultural resources from dredging and depositing sediment on existing sites. However, there is the opportunity to prevent or slow coastal land loss near existing sites by depositing sediment in specific areas to act as buffers against further erosion (USACE, 2004).

5.9.2 Economic Evaluation

The majority of land in coastal Louisiana consists of wetlands. Louisiana contains about 40 percent of all coastal wetlands in the continental United States and makes up 64 percent of wetland productivity along the Gulf of Mexico. Most coastal wetland losses in the nation (80 percent) occur in Louisiana; annual land-loss rates peaked between 1956 and 1978 at more than 40 square miles per year. Currently, Louisiana loses approximately 24 square miles per year (USACE, 2004).

Louisiana's wetlands and coastal areas are a highly productive part of the state. The oil and gas, fishing, and agriculture industries generate most of their revenue in these areas. The coastal parishes are also more densely populated than the northern parishes; between 60 and 75 percent of Louisiana's population lives within 50 miles of the coast.

If the land loss continues at unchanged rates, another 500 square miles of wetland could be lost in the next 50 years (USACE, 2004). This is of growing concern not only because of the implied ecological consequences, but because so many industries in the area directly depend on wetland resources. Economic impacts, such as increased gas prices, would affect local, regional, and even national industries.

Oil and Gas Industry Production

Existing Conditions. Louisiana's oil and gas production is an important part of the national energy supply industry. Since 1901, over 1 million wells were drilled in Louisiana, including land-based wells, wells in state waters within the 3-mile zone, and wells in federal waters greater than 3 miles offshore. In 2000, Louisiana produced more oil than any other state (Figure 5-21) and was second only to Texas in natural gas production. While the oil production on land is slowly declining, the offshore production is steadily increasing, resulting in an increase in total oil production for the State of Louisiana (Figure 5-22).

In 2000, onshore oil production contributed approximately 16 percent of the total oil production in Louisiana, and onshore gas production accounted for 26 percent of the statewide gas production. The statewide oil and gas production consists of production onshore, in state waters, and on the OCS (USACE, 2004).

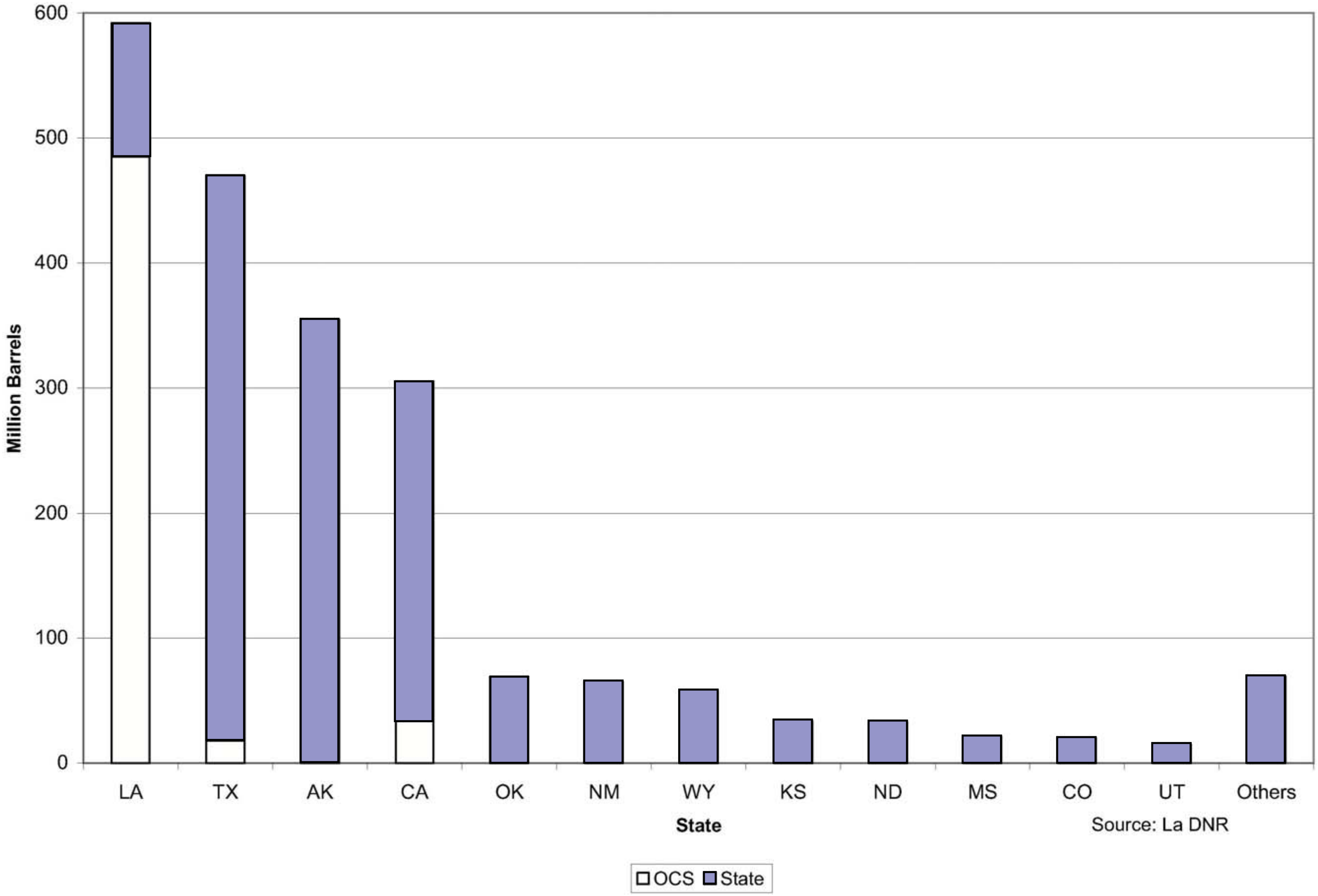


FIGURE 5-21
2000 U.S. OIL PRODUCTION BY STATE (FROM LCA 2004)
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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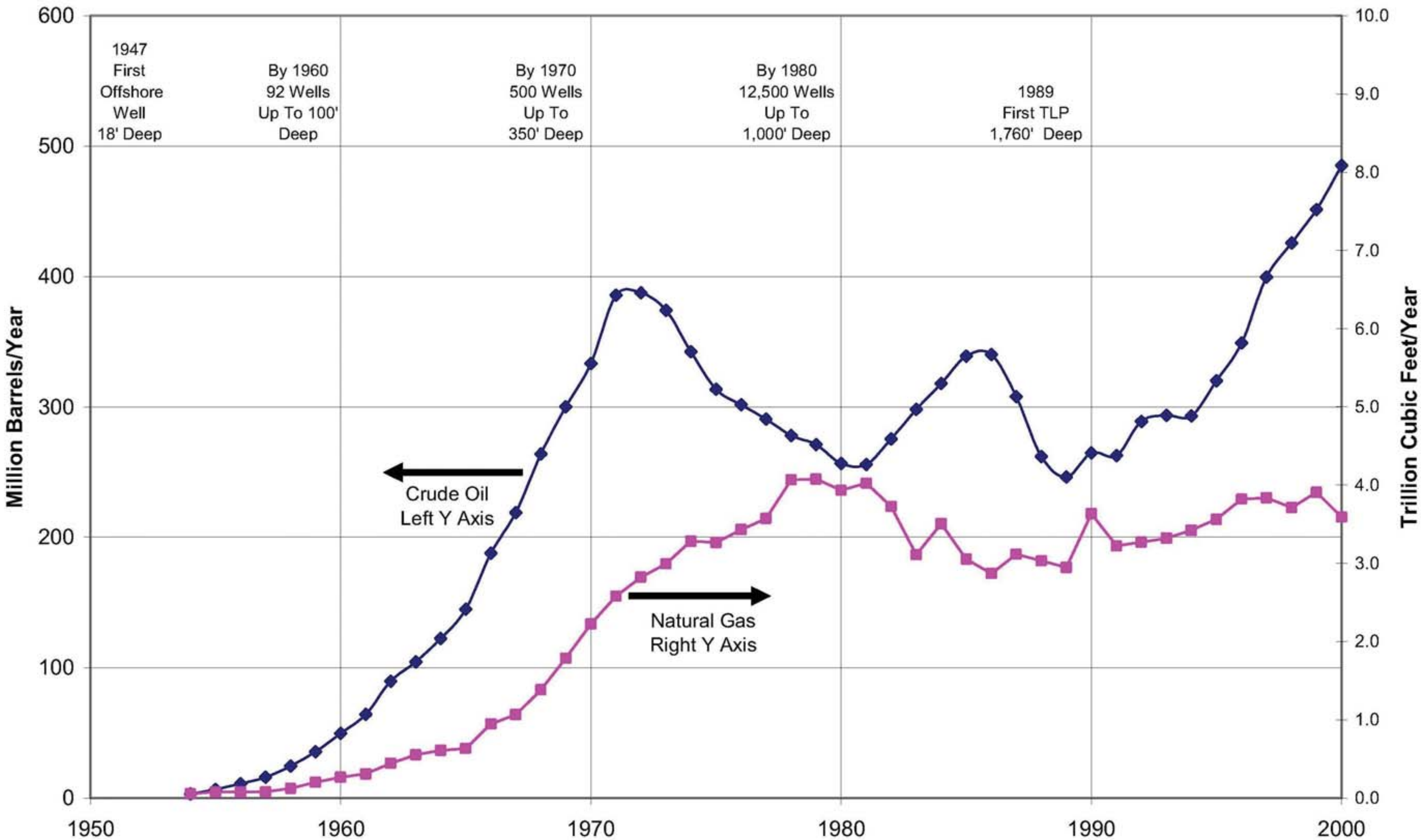

FIGURE 5-22
LOUISIANA FEDERAL OCS OFFSHORE PRODUCTION OF CRUDE OIL & NATURAL GAS (FROM LCA 2004)
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

A study by the Louisiana State University Center for Energy Studies (LSUCES) has shown that direct economic impacts from oil and gas production activities amount to more than $730 million in a typical year. Indirect impacts add another $250 million, so it can be estimated that the total yearly economic impact is approximately $1 billion (LSUCES, 2002). Some sources even estimate total revenues of over $3 billion per year, which would be almost 25 percent of Louisiana's revenue (USACE, 2004).

The impacts to state and federal governments are significant. The Louisiana total mineral revenue in 2001 was over $920 million and the revenue to federal government in 2001 was almost $5.5 billion (LDNR, 2004). For the same period, total net collections by the Louisiana Department of Revenue were approximately $6 billion (Louisiana Department of Revenue, 2004). This means that the oil and gas industry contributes approximately 15 percent to the total yearly collected revenue of Louisiana. Because these collections fund all state operations, an impact to the oil and gas industry would have significant negative impacts on the state (USACE, 2004).

But Louisiana is not only an important contributor to the United States oil and gas production; it also serves a major role in refining and distributing oil, gas, and derived products. Figure 5-23 shows that since 1993, the United States has imported more petroleum than it has produced, much of which arrives at the ports and refineries in southern Louisiana. Hence, the degradation of coastal wetlands will not only disrupt local oil production, but will likely affect the import of foreign oil as well.

Future Conditions with No Action. To assess the economic impacts of this alternative, onshore and offshore facilities were analyzed.

Onshore Facilities. The majority of onshore oil and gas production facilities are located in areas susceptible to coastal degradation. Many of these structures were built under the assumption that they would not experience wind and wave loads, and were not designed to withstand conditions commonly experienced in such environments (USACE, 2004). The vulnerability of these structures was exposed during recent hurricanes, when several platforms were severely damaged. If no action is taken to restore coastal marshes, most of these structures will have to be either reinforced or abandoned. Both alternatives would cause financial expenditures for businesses and consumers.

Offshore Facilities. The effects of coastal erosion on offshore production facilities do not concern the structures themselves, but the supply base and transportation infrastructure. There are very few supply bases along the coast of Louisiana serving offshore facilities in state and federal waters. The largest base is Port Fourchon, located in Lafourche Parish (USACE, 2004). These bases are crucial for keeping offshore platforms working at maximum efficiency. They deliver the supplies for operation and maintenance work and also serve as a hub for most of the employees working on those platforms (USACE, 2004).

If one of these bases were impacted by coastal erosion to a degree that might prevent regular operation, the negative impacts would be manifold. Apart from costs for rebuilding the base at the same or another location, the production cost would likely increase because of a short-term increase in transportation costs. Another negative impact might be the loss of skilled labor if low-lying communities near the bases were also damaged. A reduction in

the experienced employment base would further negatively impact the operational cost of offshore oil and gas production (USACE, 2004).

The LCA Study (USACE, 2004) identified possible scenarios for impacts of continuing coastal erosion on the oil, gas, and pipeline industry, including effects on the national economy. The following investigated scenarios include short-term and long-term effects (USACE, 2004):

1. The supply of crude oil from offshore production experiencing a short-term disruption because of damage to pipelines or shore-based facilities.
2. A long-term reduction in onshore crude oil or gas production resulting from either (1) companies electing to shut-in production because of rising costs of operation, or (2) storm-induced damage to onshore facilities taking several weeks or months to repair and place back into production.
3. The supply of natural gas to other parts of the country being disrupted for a short term because of damage to major interstate pipeline facilities.

The following paragraphs provide a brief summary of the effects of all three scenarios on local industries and the national economy:

1. Short-term decrease of oil and gas production resulting from storm-induced damage

   This scenario was developed by LCA in partnership with the Shell Oil Company (USACE, 2004). It is assumed that two facilities are affected by storm-induced wind or water damages, resulting in a temporary production disruption of 625,000 barrels per day (bpd). This is approximately 11 percent of the total United States production and 4 percent of the total United States production including imports.

   The production downtime would cause a crude oil shortage that could increase crude oil prices by up to 30 percent. It has been observed in the past that supply disruptions cause almost instantaneous increases in prices, and that the return to normal market prices takes much longer. According to experts, an increase of $1 per barrel of crude oil increases the gas price at the pump by 2.4 cents per gallon (USACE, 2004). With crude oil prices of $70 per barrel and more (June 2006), a 30 percent increase would cause gas prices to increase by 50 cents. The United States consumes more than 380,000,000 gallons of gasoline per day (U.S. Department of Energy, 2006), so a shortage would incur additional costs of $190 million each day for gasoline alone.

   Recent events like Hurricanes Ivan and Katrina prove that Scenario 1 is realistic, and even conservative, according to data published by the Minerals Management Service (MMS) (MMS, 2006). As of September 2, 2005, the total daily shut-in amounted to 1,327,953 bpd, which is equivalent to 88.53 percent of the daily oil production in the Gulf of Mexico. Gas prices surged to over $3 per gallon nationwide and remained at that level for weeks.

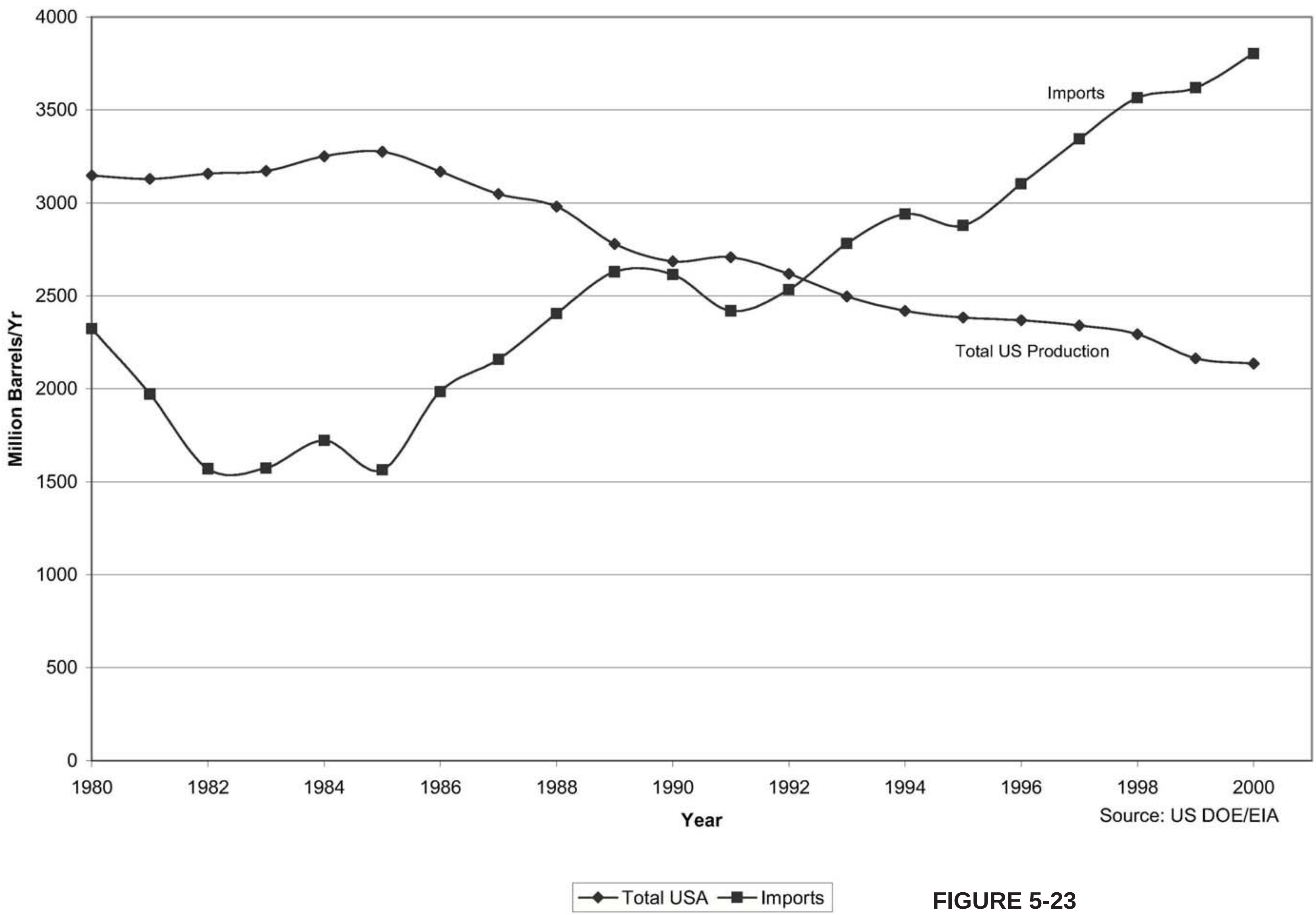

FIGURE 5-23
U.S. AND LA CRUDE OIL PRODUCTION VS. IMPORT (FROM LCA, 2004)
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

2. Long-term reduction of oil and gas production

   The scenario for a long-term reduction assumes a decrease of Louisiana's oil and gas production by 20 percent (58,000 bpd), which is approximately 1 percent of the United States production. The associated increase of crude oil would be 2.43 percent. At current crude oil prices, the consumer would have to expect gas prices to increase by approximately 4 cents per gallon. The daily cost nationwide would amount to $15.2 million. Although the daily costs are much less than in Scenario 1, the increased duration would cause severe financial damages (over $4 billion per year).

3. Short-term disruption of natural gas supplies from damages to the pipeline network

   LCA developed this scenario based on discussions with El Paso Corporation, the largest transporter of natural gas in southern United States. El Paso transports approximately 25 percent of natural gas delivered to the United States market through pipelines going to the Midwest and states along the East Coast (USACE, 2004).

   It is assumed that storm-related damages to one of the compression and dehydration facilities would cause a reduction of treatment and transportation capacities by 1 billion cubic feet per day, which is about 1.6 percent of the total United States natural gas production (including imports). Scenario 3 is reasonable because many of these facilities were built near ground level with little protection against increased tides or storm surges (USACE, 2004).

   Such a disruption could increase natural gas prices by more than 11 percent, which would be directly passed on to the consumers. But homeowners using natural gas would not be the only ones affected; fertilizer manufacturers would also have to increase their prices (i.e., ammonia prices would go up 9.1 percent; urea prices would go up 8.5 percent) (USACE, 2004).

   Another impact of this scenario might be the shutting-in of combined oil and gas wells because the natural gas cannot be handled onshore. Financial losses caused by disrupted oil production could amount to more than $1 million per day (USACE, 2004). If other natural gas or oil facilities in the area were also damaged, the negative impacts could be significantly increased.

Third Delta Conveyance Channel Concept. Conveyance of sediments to Lake Felicity and Little Lake as described in previous sections will increase the land mass on both sides of the lower Fourchon corridor. This corridor is an important route for transporting materials and personnel to and from offshore production facilities, mainly through Port Fourchon. It is also a main corridor for pipelines coming from offshore platforms. The newly created land will decrease future erosion and protect oil and gas production facilities in this area.

However, the projected TDCC land-creation rate is less than the projected land-loss rate. Therefore, the TDCC project cannot achieve a positive net-land-creation rate, which would be essential for long-term protection of coastal oil and gas facilities.

Without further distribution of the sediments, the TDCC concept might reduce access to wellheads in the project area by silting up channels leading to the wellheads. This would increase production cost and might render smaller wells unprofitable.

Pipeline Conveyance Alternatives. Distribution of sediments through pipelines is a more precise approach to creating land that can target specific, well-defined areas. Although the goal of this project is to create wetlands, existing structures and facilities in the project area could be incorporated into the rebuilding effort to prevent further or future damage.

The amount of land creation is primarily limited by budgetary restrictions and sediment availability, rather than technological limitations. The pipeline conveyance alternatives could create more wetlands than are eroded every year, resulting in a net gain of land. A positive wetland mass balance would improve protection for all structures and facilities located in these areas by reducing storm surges and wave action. Hurricane-related damages could be significantly reduced.

Oil and Gas Infrastructure

Existing Conditions. Louisiana has close to 40,000 miles of pipeline, with an estimated 33,000 miles onshore and 7,000 miles offshore. The pipelines range in size from small-flow lines (3- to 4-inch diameter) connecting production wells with storage tanks to interstate pipelines of 30 inches or more. Some pipelines extend up to 100 miles into the Gulf of Mexico (LDNR, 2006a). Louisiana has 13 major crude oil pipelines, 9 major product pipelines, and 13 liquefied petroleum gas pipelines. There are 18 petroleum refineries in Louisiana that distill more than 2.7 million bpd (USACE, 2004). Natural gas pipelines deliver more than 1 trillion cubic feet per year to consumers in Louisiana (LDNR, 2006a).

According to the Louisiana Tax Commission, the assessed value for the interstate pipelines alone amounts to over $605 million. The pipeline industry employs almost 5,000 persons in Louisiana with an annual payroll of more than $250 million (Louisiana Mid-Continent Oil and Gas Association [LMOGA], 2006). The pipelines are an important link in the national energy supply network. Continuing coastal erosion will have significant negative impacts on the pipelines in affected areas.

Future Conditions with No Action. A major economic impact of damages to the pipeline network is the disruption of oil and gas production, as previously described. Reduced conveyance capacities would ultimately increase national energy prices, resulting in significant costs for businesses and consumers.

Another impact of continuing erosion of coastal wetlands is the exposure of subsurface pipelines. Land loss from coastal erosion increases the open-water areas in coastal wetlands, resulting in an increase in tidal exchange volume. A greater exchange volume increases the flow velocities in tidal passes and channels. Greater velocities increase the erosion potential and have already let to the exposure of buried pipelines. Like production facilities in coastal wetlands, buried pipelines were not designed to withstand open-water conditions. Failure might occur because of anchor dragging, contact with vessels, or structural instability. LCA reported the following incidents in which fishing vessels struck exposed pipelines (USACE, 2004):

- In 1989, near Sabine Pass, 11 lives were lost when a fishing vessel struck a natural gas pipeline that had become exposed, causing an explosion.
- In April 2002, near Lafitte, Louisiana, 75,000 gallons of crude oil were released into the marsh. It was suspected that a vessel struck an exposed section of a pipeline.

- Other recent incidents involving vessel related damage to recently exposed pipelines occurred in Catfish Lake near Golden Meadow, Louisiana (70 barrels of crude oil), and in Terrebonne Bay (160 barrels of crude oil).

These incidents show that there is not only a severe ecological risk involved with continuing coastal erosion; there are also economic impacts to the pipeline and oil and gas production industry, and ultimately the consumer.

Third Delta Conveyance Channel Concept. Initially, construction of the TDCC will disrupt oil and gas production, because many oil and gas pipelines crossing or paralleling the channel would have to be closed off and relocated. However, the associated costs should be considered construction costs rather than economic impacts.

Conversion of open water to wetlands would cause smaller channels leading to wellheads to be filled or silted up so that the wellheads could not be accessed by boat. Uncontrolled placement of large amounts of sediments at the mouth of the TDCC might even silt up larger navigation channels.

Pipeline Conveyance Alternatives. No severe economic impacts are anticipated for this set of project alternatives. Pipelines can be routed to avoid interference with oil and gas infrastructure.

Although wetland creation through dredging and piping would leave most navigational channels open, some channels leading to wellheads might have to be filled in to create continuous wetland areas.

Agricultural and Residential Land Use Infrastructure

Existing Conditions.

Agriculture. The agricultural industry is an important source of revenue for the State of Louisiana. Agricultural revenue represents 18.6 percent of the total state revenue (USACE, 2004). The total output for the agricultural sector, including crops, animals, and forestry, amounted to $2.5 billion in 2004 (U.S. Department of Agriculture, 2006).

The dominant crop cultivated in southeast Louisiana is sugar cane, followed by rice and soy beans. Table 5-25 shows that sugar cane makes up about 45 percent of the total crop production in this area. Another important source of revenue is livestock production, accounting for almost 25 percent of the total agricultural revenues.

The significant feature of agriculture is that it requires large amounts of farmland and freshwater – two commodities that are threatened by coastal erosion. The annual damage to cropland (330 million acres) is already estimated to be more than $80 million (USACE, 2004).

TABLE 5-25
Agriculture Revenues by Parish, 2001
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

	Crop		Livestock		
Parish	Sugarcane	Other[a]	Cattle and Calves	Horses	Total
Terrebonne	$8,034,826	$3,391,174	$922,324	$269,000	$12,617,324
Lafourche	$24,828,775	$3,965,375	9,433,154	$956,000	$39,183,304
Jefferson	$0	$20,374,510	$388,849	$10,925,000	$31,688,359
Plaquemines	$0	$12,974,093	$998,886	$140,000	$14,112,979
Total	$32,863,601	$40,705,152	$11,743,213	$12,290,000	$97,601,966
State Total	$377,865,930	$1,985,465,227	$283,013,109	$174,358,125	$2,820,702,391
Percent of State	8.7	2.1	4.1	7.0	3.5

[a]Other includes soybeans, corn, tomatoes, other vegetables, and citrus produce.
Source: USACE, 2004.

Residential Land Use. Currently, more than 2 million residents live in Louisiana's coastal parishes. They make up more than 50 percent of Louisiana's population and 44 percent of the state's workforce (USACE, 2004). As shown in Table 5-26, population in the coastal parishes in southeast Louisiana has increased since 1950. Most parishes registered at least a twofold increase in population. Not all of this growth occurred in areas susceptible to flooding or erosion. But, with continuing degradation of coastal wetlands, more and more residential areas will be adversely impacted.

The total value of residential and commercial structures in coastal Louisiana is estimated at $11.8 billion (42,000 structures), and annual damages to structures are assumed to be approximately $1.5 billion (USACE, 2004).

TABLE 5-26
Population Trends in Study Area
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Parish	1950	1960	1970	1980	1990	2000
Terrebonne	43,328	60,771	76,049	94,393	96,982	104,503
Lafourche	42,209	55,381	68,941	82,483	85,860	89,974
Jefferson	103,873	208,769	337,568	454,592	448,306	455,466
Plaquemines	14,239	22,545	25,225	26,049	25,575	26,757
Total	203,649	347,466	507,783	657,517	656,723	676,700
State Total	2,683,516	3,257,022	3,641,306	4,205,900	4,219,973	4,468,976
Percent of State	7.6	10.7	13.9	15.6	15.6	15.1

Source: USACE, 2004

Infrastructure. The assessment of existing infrastructure can only be a gross estimation at this level of investigation. Table 5-27 summarized the infrastructure within the study area that is considered to be at risk. Areas considered safe from negative impacts caused by coastal erosion are not included (USACE, 2004).

Costs for pipelines, highways, and railroads were computed using replacement costs. Agriculture and private buildings were assessed according to fair market values. The values

of navigable waterways were derived from their operation and maintenance costs, assuming that the value of the waterway is at least as much as the costs to maintain it (USACE, 2004).

Table 5-27 demonstrates that the total value of infrastructure in coastal Louisiana amounts to about $95 billion. Even without oil and gas production facilities and pipelines, which were assessed in the previous section, the asset value would be significant.

TABLE 5-27
Summary of the Valuation of Assets in the Louisiana Coastal Area
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Asset Category	Value
Oil and Gas Production Facilities	$3,207,000,000
Pipelines	3,204,000,000
Highways	5,981,000,000
Railroads	386,000,000
Navigable Waterways	2,600,000,000
Ports	869,000,000
Industrial and Manufacturing Facilities	30,819,000,000
Transmission Lines	417,000,000
Municipal and Parish Utility Infrastructure	4,296,000,000
Municipal and Parish Private Buildings	42,756,000,000
Agricultural Interests – Lands	161,000,000
Agricultural Interests – Products	163,000,000
Total Asset Value	94,859,000,000

Source: USACE, 2004

Future Conditions with No Action. The historical erosion of marshes has already caused significant damage to agricultural production in the coastal areas of Louisiana. Traditionally, farmers received water for irrigation from local bayous. In recent years, these bayous have experienced increased salinity levels, which is detrimental to crop production. But not only coastal erosion is to blame for this development; navigation channels cut by the oil and gas industry provide a direct connection between inland freshwater bodies and saline gulf water, enabling saltwater intrusion deeper into the wetlands (USACE, 2004).

Financially, this development will result in increased production costs for farmers. Short-term effects include decreased productivity and long-term effects would require exploration of alternative freshwater sources, both associated with significant costs.

This process is expected to continue in the future with increased intensity if no measures are taken to stop coastal erosion and saltwater intrusion.

Third Delta Conveyance Channel Concept. The most apparent effect of building a large conveyance channel is the substantial construction footprint and the associated land loss. In particular, valuable real estate will be lost north of Thibodaux.

Dredging channels and building levees alter the natural hydrology of Bayou Lafourche and adjacent areas. As a result, forced drainage systems have to be installed west of the channel, which might adversely impact agriculture in that area.

Pipeline Conveyance Alternatives. The creation of wetlands as proposed for the pipeline conveyance alternatives would alter the hydrology in the project areas. However, creating smaller areas with open water in between would match previously existing conditions more closely. When combined with increased freshwater diversion into the wetlands, this approach would likely reduce the salinity to concentrations that are acceptable for agricultural use. Furthermore, pipeline alternatives could be used to specifically target eroding marshland whose loss would negatively impact agricultural and residential areas.

Routing pipelines from dredging locations along the Mississippi River or offshore to the project areas would require only small ROW corridors. It is assumed that existing pipeline and utility ROWs will be used for the placement of the pipelines. Impacts on agricultural or residential areas would be minimal, and could be reversed after project completion.

Fishing Industry

Existing Conditions. Louisiana is one of the largest suppliers of fish and shellfish for the United States market. In 2001, dockside revenues for commercial fisheries were $342 million. These revenues make Louisiana the largest producer in the contiguous United States, and second only to Alaska (USACE, 2004). Around the Gulf of Mexico, Louisiana contributes 43 percent of the total dockside revenue.

The coastal wetlands in Louisiana are important habitats for many fish and shellfish species. It is estimated that 75 percent or more of the commercial catch in Louisiana has spent parts of its lifecycle in Louisiana's coastal wetland system (USACE, 2004). The most important species caught or produced off the coast of Louisiana are shrimp, menhaden, oysters, and blue crabs. Following are short descriptions of the financial values and importance of each species (USACE, 2004):

- Shrimp:
  - In 2001, 125 million pounds were caught in Louisiana, with dockside revenues of $188 million (over 43 percent of total United States landings).
  - Louisiana catches more shrimp than any other state, and the Gulf Region catches more than 70 percent of all shrimp caught in the United States.
- Menhaden:
  - In 2001, more than 971 million pounds were caught in Louisiana. This was 83 percent of the total catch in the Gulf Region and 55 percent of the total catch in the United States.
  - Louisiana catches more menhaden than any other state, and in 2001 landed twice as much as Virginia, the second highest producer.
- Oysters:
  - Louisiana contributes almost 50 percent of the total United States eastern oyster production and 37 percent of the total United States oyster meat production for all species.
  - Louisiana's position as the primary eastern oyster producer is becoming stronger, because production in other East Coast states continues to decrease.

- Blue Crabs:
  - In 2001, Louisiana landed 41.7 million pounds of blue crabs with a dockside value of $35.9 million, approximately 26 percent of the total United States production.
  - Louisiana is becoming the largest producer of blue crabs, surpassing states such as Maryland, Virginia, and North Carolina.

Louisiana has a large fleet of fishing vessels and boats, second only to Alaska. In 2000, 14,223 vessels and boats were registered. Eighty-three percent of the fleet are fishing crafts under 5 tons, compared to 60 percent in Alaska. This is an indication of the importance of coastal wetlands for the local fishing industry; small boats are predominantly used for in-shore fishing in coastal wetlands and estuaries.

Although the wetlands are important to the small-scale local fishing industry, their collective effect on the economy should not be overlooked. At the end of the 1990s, there was an attempt to estimate the economic contributions of Louisiana gulf and south Atlantic region commercial landings. Based on an analysis developed a decade before, a regional economic multiplier was developed that resulted in a $2.8 billion total economic effect being credited to the fishing industry, generated from a dockside value of $315 million, and over 31,000 jobs being created in Louisiana (USACE, 2004).

Future Conditions with No Action. With the loss of marsh and wetlands, habitat changes will affect the critical life stages of the fish and shellfish species heavily relied on by the harvesting and processing sectors in Louisiana. These changes may initially cause temporarily increased access to food for nekton and refuge by increasing the length of degrading land-water interface, but the boundary is only temporary (USACE, 2004). As a result, an increased fishing effort might prove successful in the short term, but devastating in the long term. Increased fishing with a declining catch population will only speed the downfall of the entire Louisiana fishing industry. Evidence has been presented to suggest that this decline has already begun in certain species, such as the important blue crab (USACE, 2004).

Third Delta Conveyance Channel Concept. The construction of channels and levees and the introduction of large amounts of freshwater and sediments into relatively saline waters would considerably alter the existing fish and shellfish habitats. As described before, local species are very sensitive to habitat changes, particularly changes in salinity. Such large-scale habitat changes might introduce a shock to the system that would significantly reduce fish and shellfish population.

Pipeline Conveyance Alternatives. Land creation farther inland and across a longer stretch of coastline would change fish and shellfish habitats more gradually. Furthermore, introduction of freshwater farther inland create a larger mixing zone between freshwater and saltwater with smaller salinity gradients. These changes might keep the fish and shellfish populations constant during the initial phases of project implementation. However, the decrease of land-water interfaces would likely cause a decrease in fish and shellfish populations because productivity peaks during the degredation phase of the delta cycle (Figure 5-20).

Navigation

Existing Conditions. The waterways and ports in southern Louisiana are another important resource for local and national businesses. The Mississippi River between Baton Rouge and New Orleans is occupied by three large ports: New Orleans, South Louisiana, and Baton Rouge. When comparing annual tonnage per port nationwide, New Orleans, South Louisiana, and Baton Rouge are ranked fourth, first, and ninth, nationwide. All three ports together line 172 miles of both banks along the lower Mississippi River. Located downriver of New Orleans is the port of Plaquemines, stretching from river mile 0 at the mouth of the Mississippi to mile 81.2. It is ranked eleventh by annual United States port tonnage (USACE, 2004). The dominant cargos handled in each port are listed in Table 5-28.

TABLE 5-28
Dominant Cargo for Southeastern Louisiana Ports
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

	Dominant Cargo	
Port	**Inbound**	**Outbound**
New Orleans	Steel, Crude Oil, Refined Petroleum Products	Grain, Forest Products, Steel
South Louisiana	Crude Oil, Petroleum Products	Corn, Wheat, Animal Feed
Baton Rouge	Petroleum, Chemicals	Grain, Chemicals, Petroleum Products
Plaquemines	Crude Petroleum, Petroleum Products	Food Products, Farm Products

The main transportation routes for boats and vessels are the GIWW and the Mississippi River. The GIWW stretches from Texas to Florida, providing a safe route for local and interstate transportation and access to the Gulf of Mexico. The GIWW crosses the Mississippi River at the Port of New Orleans. The GIWW and the Mississippi River combine to be the top waterway in tonnage transportation nationwide and in grain exports worldwide.

Two other important waterways in the area are Bayou Lafourche and Barataria Bay Waterway. Bayou Lafourche is a 100-mile-long natural distributary of the Mississippi River that connects the Gulf of Mexico at Port Fourchon, which is one of the main ports for the oil and gas industry. Barataria Bay Waterway is a 41-mile-long channel connecting the GIWW to the Gulf of Mexico, primarily servicing the oil, gas, and fishing industries.

Future Conditions with No Action. The LCA Study has evaluated two separate scenarios involving the major navigation industry of southern Louisiana if no actions are taken to prevent wetland erosion. In Scenario 1, 10 percent of the GIWW would become open bays because of erosion. This increase would cause a yearly loss of $8.3 million by impacting 75 percent of the waterway traffic and increasing the safety cost of hazardous commodities. An increased burden of safety regulations and cost would result in seeking alternative modes of transportation, for traditionally water-moved commodities leading to further losses to the navigation industry (USACE, 2004).

In contrast, Scenario 2 involves the impact from a hurricane that was exacerbated by the loss of marshland resulting from coastal erosion. The impact would effectively shut down the Mississippi River between New Orleans and the Mouth of Passes. Additionally, erosion would threaten the lower Mississippi River navigation channel as a result of silt movement and channel loss caused by hurricane forces. A 1- to 2-week closure of the lower Mississippi is estimated to cost the United States up to $200 million. This estimate does not include the cost of additional storage, spoilage, contract defaults resulting from undelivered goods, or

commodity flow restrictions. Delays could prove detrimental to retailers, shippers, manufactures if they could not receive or ship products. Additionally, all industries could be affected if domestic fuel prices rose because of restricted oil imports (USACE, 2004).

Both of these scenarios would be extremely costly, not only for the navigation industries, but also for the nation as a whole considering the trickle-down effect that would occur if the ports or waterways were obstructed. Without any damages, the southern Louisiana navigation industry is projected to experience positive growth rates for the next half of the century. The importance of navigation to the economy of south Louisiana and the nation should not be underestimated in terms of actual cost or impact to the economy (USACE, 2004).

Third Delta Conveyance Channel Concept. The TDCC concept's plan to excavate a large conveyance channel from the Mississippi to Terrebonne and Barataria Bay would involve placing a pair of locks on the east and west crossings of the GIWW. There is an estimated 1-hour delay for a vessel going through one of these locks, meaning a 4-hour total delay to travel past both locations. The location of the locks has not yet been determined, but the general consensus is to the east and west of Houma, Louisiana. The estimated time delays would be expected to cost navigational users an additional $14.8 million in transportation yearly. These costs may be underestimated because other events, such as outages and increased traffic, speed changes, or longer-than-expected delay times while going through the locks, are not included (USACE, 2004).

Pipeline Conveyance Alternatives. Introduction of dredged material into marshes is expected to have minor economic impacts on navigation in the project area. The proposed wetland areas can be designed so that negative impacts on major navigational channels are minimal.

Dredged sediments from riverine sources are relatively large in size and would settle quickly, so that the distribution of sediments would primarily be confined to the selected restoration areas. Flexibility in the conveyance system would allow for adaptive management practices to be employed if shoaling in navigation channels occurs as a result of the project.

Flood Control

Existing Conditions. Another economic consideration of continuing coastline erosion is the damage caused by water surges from hurricane and tropical storms that pass over southern Louisiana. The major hurricane-protection levees were authorized and constructed in the 1960s and 1970s. Since then, subsidence and sea-level rise have accelerated and, together with continuing coastal erosion, have weakened the hurricane-protection system.

LCA analyzed the effects of coastal erosion on flood control in Southeast Louisiana based on water surface elevations that would be encountered during a 100-year storm event as computed the USACE-MNV Hydrology and Hydraulics Branch (USACE, 2004). LCA estimated damages for existing conditions as well as future conditions with and without coastal restoration projects.

Since completion of the LCA Study, the flood-control situation has changed significantly. On August 29, 2005, Hurricane Katrina made landfall in Southeast Louisiana. Although Katrina was downsized to a Category 3 storm after analysis of recorded data, its surge overtopped a large number of hurricane-protection levees and breached levees protecting Orleans, St. Bernard, and Plaquemines Parishes. The devastating effects of this hurricane

included loss of more that 1,000 lives and billions of dollars in damages to properties, infrastructure, and flood-control structures.

Currently, flood-control structures are still weakened in many places, increasing the risk of damages from tropical storms and hurricanes. However, plans are in place to reinforce the hurricane-protection system, resulting in increased protection. Because of this transition phase, a proper analysis of existing conditions and economic impacts of future developments is associated with an element of uncertainty.

Future Conditions with No Action. As a result of the hurricane damages suffered in 2005, future conditions will likely include an upgraded flood- and hurricane-protection system. After completion of these upgrades, most low-lying areas in southeast Louisiana will be adequately protected even if coastal erosion continues. However, a long-term sustainable coastal protection system requires coastal wetlands as buffer zone to dampen tidal movement and storm surges.

Third Delta Conveyance Channel Concept and Pipeline Conveyance Alternatives. The factor that determines the economic impact regarding flood control is the same for both projects. The ratio of land creation to land loss and the location of sediment placement determine whether a project can provide increased levels of flood control.

The TDCC concept, with its current design, cannot build enough land to overcome the predicted future land loss. Furthermore, sediment placement cannot be controlled and directed to specific areas. Pipeline conveyance alternatives are primarily limited by budgetary constraints and restricted sediment availability. Land-building estimates for the pipeline conveyance alternatives exceed those of the TDCC. Placement of sediment could be directed to target levees and other flood-control structures. Hence, the pipeline conveyance alternatives are likely to provide better support for the flood-control system for both short-term and long-term scenarios.

5.10 Comparison of Third Delta Conveyance Channel and Pipeline Conveyance Alternatives

This section presents a comparison between the TDCC and the pipeline conveyance alternatives. Comparisons are made using the performance measures discussed in Section 2 of this report. Both quantitative and qualitative performance measures are evaluated and consist of the following:

- Quantitative
  - Land Gain
  - Project Cost
- Qualitative
  - Infrastructure Impacts
  - Environmental Impacts
  - Adaptive Management
  - Public Acceptance
  - Socioeconomic Impacts
  - Project/Performance Risk

This comparison is not intended to support a preferred alternative recommendation.

5.10.1 Quantitative Performance Measures

Land Gain

Estimates of land gain for the TDCC concept were presented in Section 3, which also contained a discussion of predicted land loss. Considering the number of assumptions required in estimating land-building potential of the TDCC, a range of values (1 to 2 square miles of land per lobe, per year) was presented. Estimates of land gain for each of the three pipeline conveyance alternatives were presented in Table 5-13. The main difference among the three pipeline conveyance alternatives is the magnitude the land created and nourished by the project.

This section presents estimates of net land gain; land gain is measured with respect to the future with no action condition, and takes into account projected land loss. Thus, if land built by a project does not exceed predicted land loss, the net land gain is negative.

Table 5-29 summarizes the land-building potential of the three pipeline conveyance alternatives. To assess land changes against the future with no action condition, the influence of the projects on the estimated ongoing land-loss rates was quantified. For the pipeline conveyance alternatives, a GIS analysis identified the projected land loss in each restoration area. This was summed for each alternative, and is tabulated in Table 5-29 as "Land Saved by Project." In addition to accounting for land created by filling open-water areas (tabulated separately), each project alternative gets credit under "Land Saved by Project" for nourishment of land that would have converted to open water without the project. Thus, the total land created by the project versus the future condition with no action ("Total Land Created vs. Future with No Action") is the combination of the open water converted to land by the project and the maintenance of land that would have converted to open water without the project.

TABLE 5-29
Summary Land-building Potential for Pipeline Conveyance Alternatives
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

	Alternative		
Land Built/Nourished (square miles)	**1**	**2**	**3**
Land Nourished	141	211	342
Land Saved by Project	39	68	84
Land Created from Open Water	159	277	333
Total Land Created vs. Future with No Action	196	346	418
Total vs. Future with No Action	340	556	760
Land Built/Nourished (square miles per year[a])			
Land Nourished	2.8	4.2	6.8
Land Saved by Project	0.8	1.4	1.7
Land Created from Open Water	3.2	5.5	6.7
Total Land Created vs. Future with No Action	4.0	6.9	8.4
Total vs. Future with No Action	6.8	11.1	15.2

[a]50-year project life

Table 5-29 also tabulates the land built and/or nourished on an annual basis. These values, assumed to be representative of any given year during the 50-year project life, were used to develop time-series plots of net land gain versus present day and land growth versus the future with no action condition.

Figure 5-24 illustrates the individual components presented in Table 5-29 for Alternative 3. Cumulative land gains are presented as they compare to the future with no action condition. These values are the difference between future land quantities with and without the project.

The green line on Figure 5-24 represents the amount of land nourished over the 50-year project life by thin-layer placement of dredged material on existing marsh. This land (342 square miles at 6.8 square miles per year) is not counted as land created because it technically already exists, but is included as a project benefit. The blue line on Figure 5-24 represents the amount of land created from open water. This land is created at a rate of approximately 6.7 square miles per year.

The red line on Figure 5-24 represents land that would have been lost without the project (Figure 5-4) but is instead nourished by the project. This is counted as "Land Saved by Project." As described previously, the projected land loss (USGS, 2003) in each restoration area was tabulated for each of the three pipeline conveyance alternatives. For Alternative 3, this project would reduce the expected land loss by an average rate of 1.7 square miles per year.

The purple line on Figure 5-24 represents the total land change versus the future with no action condition, accounting for both land created from open water and land saved by the project. For Alternative 3, the net land change versus the future with no action condition would be 8.4 square miles per year, slightly more than the projected land-loss rates for all of Barataria and Terrebonne Basins (Barras et al., 2003). This value includes both the land created from open water by the project and the land saved from future loss by the project. Accounting for marsh nourishment, 15.2 square miles of land per year would be created or nourished over the future condition with no action. After 50 years, the land change versus the future with no action condition would be 418 square miles, just accounting for land created from open water and saved from loss. Taking into account the land nourished by the project, the land directly benefited by the project would total more than 750 square miles. To allow direct comparison with the TDCC, land nourishment for the pipeline conveyance alternatives is presented separately from land created.

Figure 5-25 presents the change in land for the future condition with no action, the TDCC concept, and the three pipeline conveyance alternatives. Land change is measured from 2005. The cumulative effect of the assumed average land-loss rate of 8.3 square miles per year for the Barataria and Terrebonne Basins is presented on Figure 5-25 for reference.

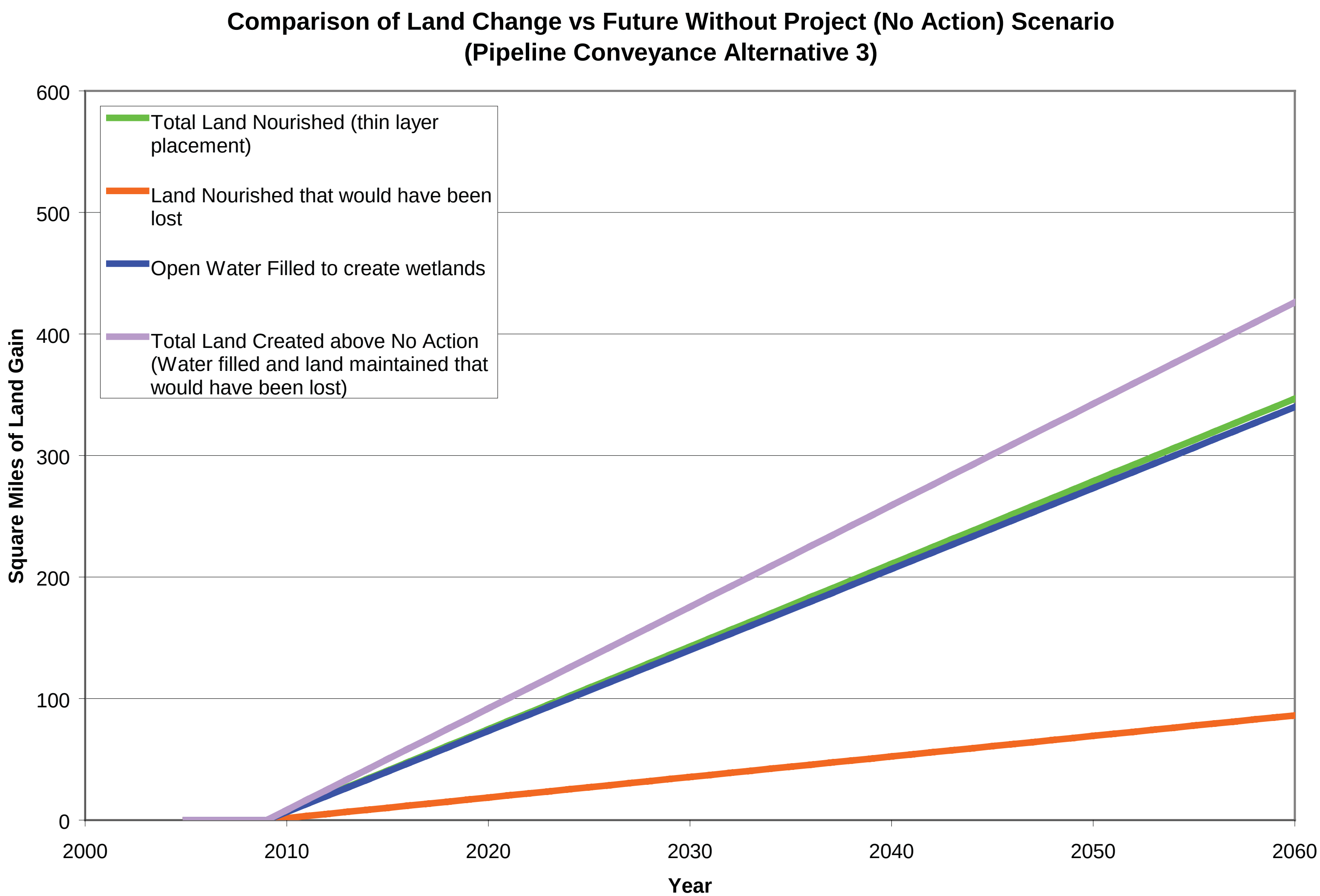

FIGURE 5-24
COMPONENTS OF NET LAND BUILDING CALCULATIONS (ALTERNATIVE 3)
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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It is assumed that the TDCC concept would build 2.6 square miles of land per year, excluding losses for subsidence but accounting for a sediment-trapping efficiency of 50 percent and an average fill depth of 6 feet. The land-change projections for the TDCC also assume that the project will take 15 years to design and construct (through 2020), that 30 square miles of land will be lost to the project footprint during the channel construction phase (shown on Figure 5-25 at year 2020), and that the channel will take 40 years to evolve from its initial cross section. Land growth is pro-rated during the channel evolution period. Thus, in 2060, the TDCC will have reached full capacity and will begin building land at a rate of 2.6 square miles per year.

Assuming a constant loss rate of 8.3 square miles of land per year, the Barataria and Terrebonne Basins will have lost more than 400 square miles of land from present levels by the time the TDCC achieves full capacity. At full capacity in 2060, the land-loss rates will decrease to 5.7 square miles per year from 8.3 square miles per year. Furthermore, the land-building capacity of the TDCC is expected to decrease over time as the delta extends to deeper waters in the lower Barataria and Terrebonne Estuaries. Finally, as the deltas extend farther south, they will likely be subjected to higher wave-energy climates, thus the sediment-retention rate and ultimately the land-building capacity of the TDCC will decrease.

The pipeline conveyance alternatives demonstrate the impact of targeted and efficient placement of sediment in the coastal zone on the future of coastal Louisiana. Estimates of land change from the present are provided for three increasingly aggressive ecosystem restoration alternatives, the most aggressive of which could stop the trend of land loss in Barataria and Terrebonne Basins.

Figure 5-26 presents a second comparison of the land gain for the TDCC and three pipeline conveyance alternatives. Here, the y-axis is land change versus the future with no action condition, whereas on Figure 5-25, the land change was compared to present conditions.

On Figure 5-26, the TDCC project is shown to have a positive influence only after 2048. Until that time, the land built by the TDCC is making up for the 30 square miles of land lost during its construction. After 2048, the TDCC will build land at a rate equal to one-third of the projected land-loss rate.

The pipeline conveyance alternatives are assumed to begin operating within 5 years, instead of the 15 years assumed for the TDCC. Furthermore, there would be no extensive land losses during the pipeline conveyance operations. Net land changes as compared to the future with no action condition were found to be between 4.0 and 8.4 square miles per year. An additional 2.8 to 6.8 square miles of land per year would be nourished with the application of a 1-foot layer of sediment, taking into account losses from compaction and sediment retention.

This analysis demonstrates that the pipeline conveyance alternatives have the capacity to build considerably more land than the TDCC with considerably less sediment because of the judicious selection of restoration sites and efficient placement of material. Sediment diverted into the TDCC would average approximately 32 mcy per year (Section 3), but annual sediment requirements for Alternatives 1 through 3 would be approximately 18, 30, and

48 mcy per year. Efficiency in land building would be achieved through filling shallow water and maximizing retention of sediment delivered to the restoration areas.

Construction Costs

Preliminary, planning-level cost estimates for both the TDCC and the pipeline conveyance alternatives were presented in Section 5.8. These costs are summarized in Table 5-30. Costs for the pipeline conveyance alternatives only include the pipeline conveyance component; costs for barrier island restoration, creation of interbasin segmented barriers, and increased freshwater diversions are not included in these estimates to allow a consistent comparison with the TDCC concept. Cost estimates are considered at a planning level, and contingencies applied to the estimated costs reflect the uncertainty associated with these estimates. A planning-level cost estimate for the construction of the interbasin segmented barriers is also presented in this section.

TABLE 5-30
Summary of Planning-level Project Costs
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Restoration Project	Cost (billion $)	Cost per Acre vs. Future with No Action (at 2060 $)
Third Delta Conveyance Channel	8.7	535,000
Pipeline Conveyance Alternative 1	9.4	72,000
Pipeline Conveyance Alternative 2	21.1	94,000
Pipeline Conveyance Alternative 3	31.7	116,000

Table 5-30 also contains estimated costs per acre for land created through the end of the 50-year project life assumed for the pipeline conveyance alternatives. Costs per acre were developed with the project costs, including contingencies. The acres used in the calculation did not include those nourished by the project, only acres created or saved from loss by the project in the case of the pipeline conveyance alternatives.

Operation and maintenance costs were not considered for the TDCC estimates. It is anticipated that these costs will be required for the diversion structure, the bifurcation structure, the pumping plant at the downstream end of Bayou Lafourche, the lock structures on the GIWW, and the pumping plants to drain areas impounded because of the project. After dredging operations for the pipeline conveyance alternatives, there will not be any ongoing operational requirements associated with the project, aside from costs for operation and maintenance of freshwater diversion structures. However, it is likely that the interbasin segmented barriers will need periodic maintenance and replenishment, especially if tropical storm or hurricane events degrade these structures.

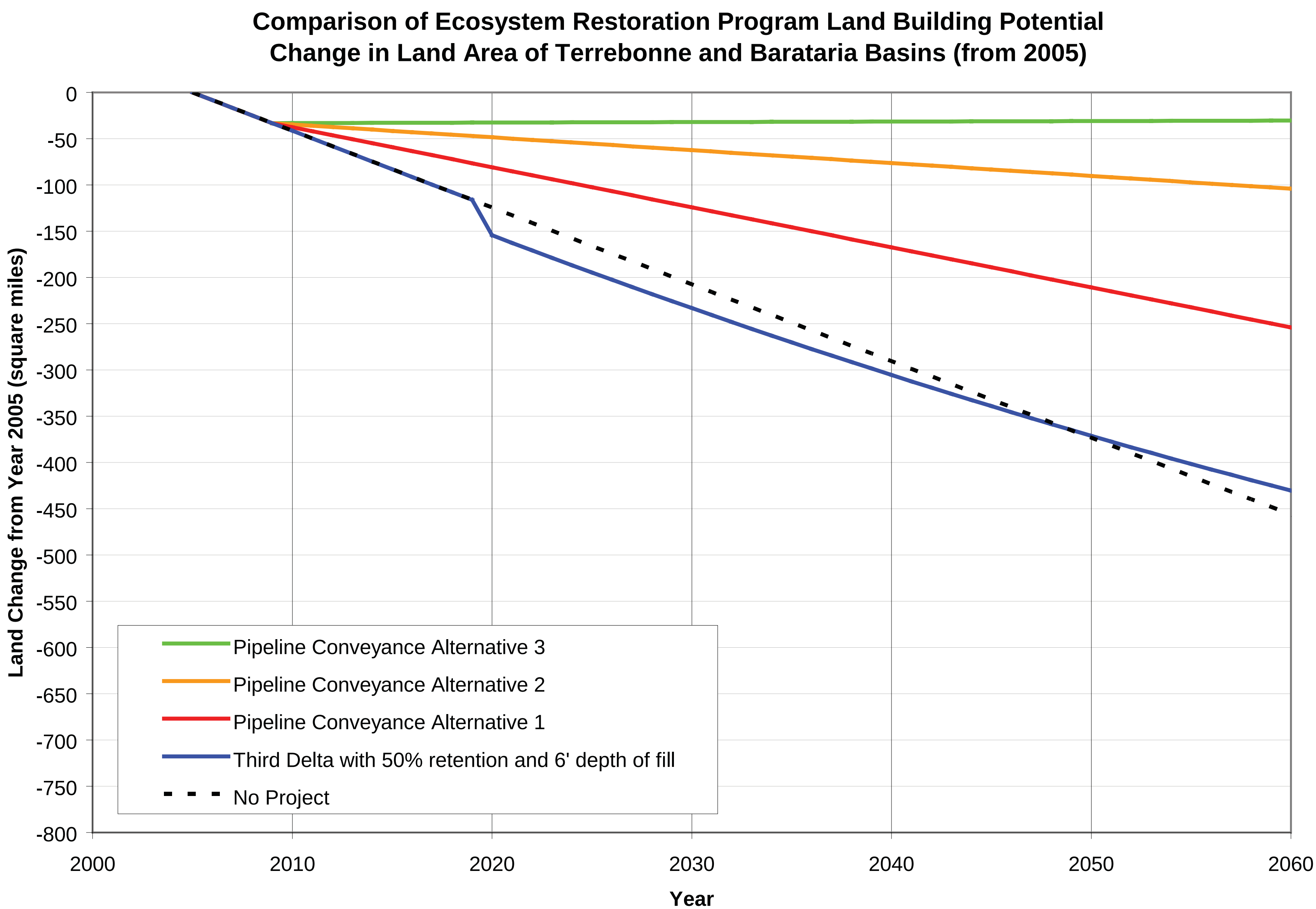

FIGURE 5-25
COMPARISON OF LAND-BUILDING POTENTIAL OF RESTORATION PROJECTS
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

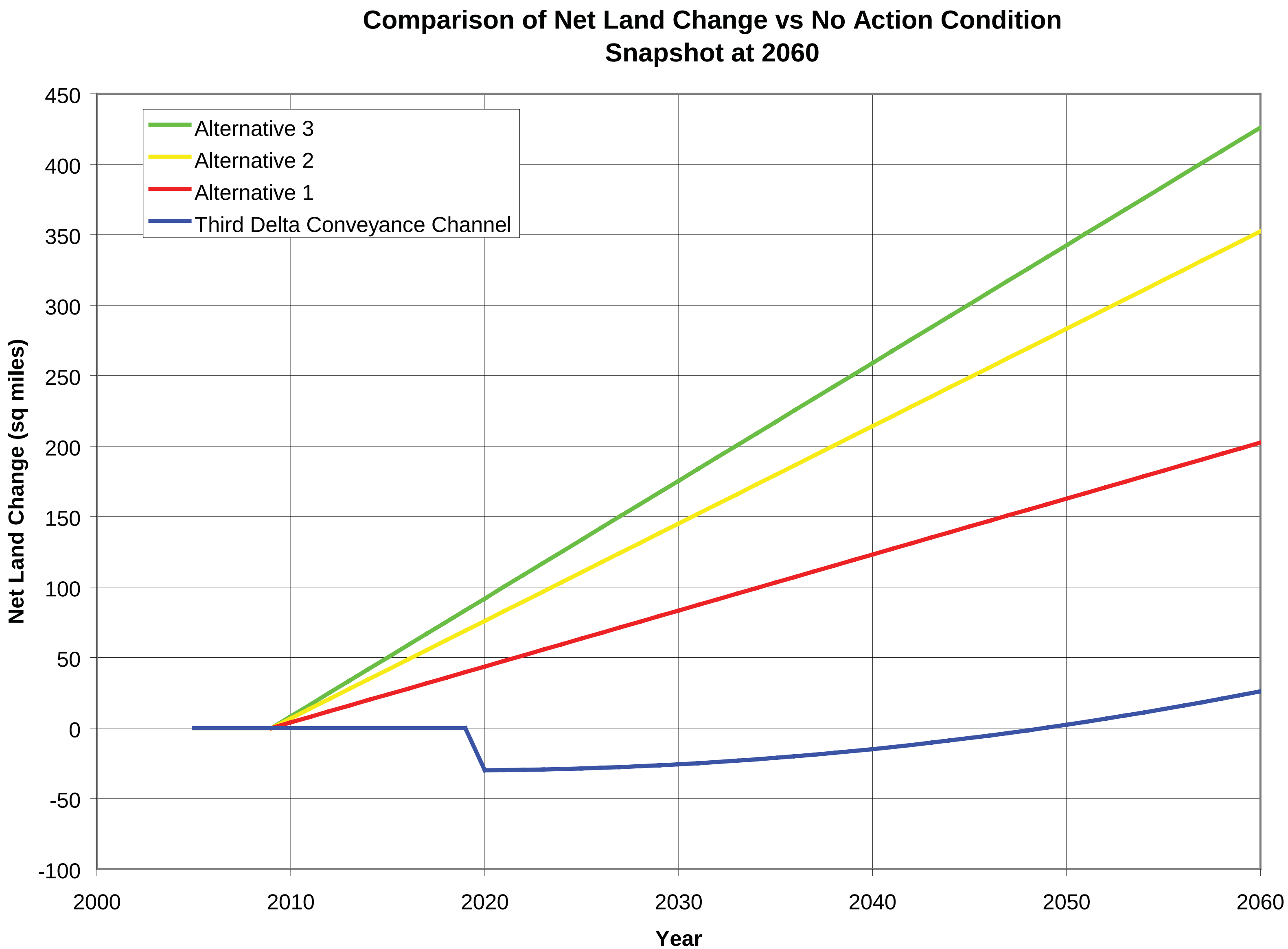

FIGURE 5-26
CHANGE IN LAND VERSUS NO ACTION CONDITIONS FOR RESTORATION PROJECTS
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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Costs for construction of the interbasin segmented barriers can be derived from assumptions of the total length and the cross-sectional area of the barriers, and estimates of pipeline distances from borrow sources. The total volume required to construct the interbasin segmented barriers in both Barataria and Terrebonne Basins would be approximately 70 to 100 mcy. Considering an average transport distance of 20 miles at $7.50 per cubic yard, the total dredging cost for construction of the interbasin segmented barriers would be approximately $500 to $750 million.

5.10.2 Qualitative Performance Measures

Qualitative performance measures are subjective. Issues associated with the performance measures described in this subsection are complex because of the scale and magnitude of the projects discussed in this report. However, a relatively simple methodology was needed to compare attributes of the TDCC and pipeline conveyance alternatives. As mentioned previously, this analysis is not intended to present hard data for selection of a preferred alternative. It is useful, however, in documenting the strengths and weaknesses of these projects, as currently understood, so that further investigations can clarify the scientific and technical uncertainties of the more promising options.

Infrastructure Impacts

Infrastructure impacts for the TDCC were discussed in Section 3. Impacts include crossings of highways, roadways, railroads, and navigation canals, as well as land use impacts to more than 30 square miles of wetlands and swamps. Navigation canal crossings will require the operation of lock structures, which will likely hinder navigation. A dam will be constructed in Bayou Lafourche at the site where the TDCC crosses into Terrebonne Basin, preventing any vessel traffic upstream in Bayou Lafourche. Numerous pipelines will have to be relocated during construction of the 200,000-cfs-capacity conveyance channel. Residential areas will be affected along the Bayou Lafourche corridor at the location where the TDCC crosses into Terrebonne Basin. However, the creation of subdeltas will provide some localized infrastructure protection from storm surge affects.

Infrastructure impacts for the pipeline conveyance alternatives are generally limited because the pipelines will be placed in existing utility or other ROWs. The first few thousand feet of pipeline extending from the Mississippi River bank toward the receiving areas will have to cross Belle Chasse Highway and the hurricane levee bordering the wetland. Several navigation channels will be crossed by the pipeline network, including the Barataria Waterway, Bayou Lafourche, and Bayou Perot. Care must be taken to not hinder or compromise safe navigation throughout the coastal zone during the project.

Probable infrastructure impacts for both project concepts are summarized in Table 5-31.

Environmental Impacts

A qualitative discussion of environmental impacts and benefits of the TDCC and the pipeline conveyance alternatives, as compared to existing conditions and the future with no action condition, was presented in Section 5.9.1. Section 5.9.1 demonstrated that the assessment of the environmental impacts and benefits of the TDCC and the pipeline conveyance alternatives is extremely complex, and that there are significant scientific and technical uncertainties associated with any of the alternatives. Table 5-32 was prepared to

help summarize the pros and cons of some of the more obvious environmental impacts for the TDCC and the pipeline conveyance alternatives.

Adaptive Management

As discussed in Section 5.7, adaptive management refers to the systematic process of continually improving management policies and practices by learning from the outcomes of operational programs. In this context, adaptive management policies are more readily applied to the pipeline conveyance alternatives than to the TDCC, for the following reasons:

- Limited ability (relative to the pipeline alternatives) to apply adaptive management methodologies to the TDCC because of the inherent lack of control over the system. Upon construction, the conveyance channel outfalls are fixed, limiting adjustment of sediment placement. Water flows can be adjusted to some degree after channel development.
- Maximum ability to apply adaptive management methodologies to the pipeline conveyance alternatives as individual restoration areas are planned, designed, constructed, and monitored. The long-term restoration process allows continual feedback on problems and successes that can be applied to ongoing operations.

Public Acceptance

Public acceptance is crucial for the success and implementation of basinwide ecosystem restoration program. Public acceptance may be influenced primarily by perceived risks and impacts by the local community. The certainty of outcomes may be a priority for state and national citizens, whose taxes will indirectly pay for much of the efforts. Table 5-33 lists some of the possible pros and cons of the two project concepts.

Socioeconomic Conditions

A qualitative discussion of economic impacts and benefits of the TDCC and the pipeline alternatives, as compared to existing conditions and the future condition with no action, was presented in Section 5.9.2. Table 5-34 summarizes the pros and cons discussed in that analysis.

The protection of vital oil and gas industry infrastructure requires the restoration of wetland habitat. The TDCC and pipeline conveyance alternatives will provide land growth, but the pipeline conveyance alternatives have the ability to achieve more land growth to serve as protection, and target growth in specific areas, whereas the more natural TDCC system will not have as much flexibility. Construction of the TDCC will impact numerous oil and gas pipelines.

TABLE 5-31
Infrastructure Impacts – Pros and Cons
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Third Delta Conveyance Channel		Pipeline Conveyance Alternatives	
Pros	**Cons**	**Pros**	**Cons**
	Significant impacts to existing infrastructure from construction of channels and associated systems.	Impacts to existing infrastructure from construction of marshes can be eliminated or minimized.	
Will provide protection for infrastructure near created subdeltas.	Limited extent of infrastructure protection due to inability to control placement of sediment.	Targeted infrastructure protection can be designed and constructed.	

TABLE 5-32
Environmental Impacts – Pros and Cons
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Third Delta Conveyance Channel		Pipeline Conveyance Alternatives	
Pros	**Cons**	**Pros**	**Cons**
Creates subdeltas, mimics natural deltaic system.	Limited control of sediment placement and elevations.	Precise placement of sediments to elevations required for specific habitat.	Overall system must be designed carefully for sustainability.
Diverts a large volume of renewable sediment supply.		Harvests a large volume of renewable sediment supply.	
Water diversion provides flood protection for communities on the Mississippi River downstream of the diversion site.	Large diversion flow required for sediment transport may over-freshen receiving waters, negatively affecting fisheries.	Smaller multiple diversions can be more closely controlled to benefit fishery habitats.	
Provides freshwater input for sustainability of subdelta habitat.			Multiple, smaller freshwater diversions will be required for freshwater input and marsh sustainability.
	Large diversion flow required for sediment transport may reduce flow available for diversions in downstream reaches.	Multiple, smaller freshwater diversions allow more efficient use of water resources while maintaining sustainability of created wetlands.	
Subdelta creation will provide additional habitat for threatened and endangered species.		Creation of marsh will provide additional habitat for threatened and endangered species.	
	Large impacts to habitat from construction footprint.	No long-term adverse affects from construction footprint.	

TABLE 5-33
Public Acceptance – Pros and Cons
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Third Delta Conveyance Channel		Pipeline Conveyance Alternatives	
Pros	**Cons**	**Pros**	**Cons**
	Public uncertainty about project-performance risk (e.g., Mississippi River Gulf Outlet [MRGO]).	Projects can be performed incrementally, demonstrating results to the public, alleviating fears of project-performance risk.	
	Public perception concerning environmental impacts of construction footprint.	Construction impacts are minimal and short-term, and can be demonstrated to public before full-scale implementation of program.	
	Public perception concerning damming of Bayou Lafourche.	Major impacts to natural landmarks not necessary.	

TABLE 5-34
Socioeconomic Conditions – Pros and Cons
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Third Delta Conveyance Channel		**Pipeline Conveyance Alternatives**	
Pros	**Cons**	**Pros**	**Cons**
Conveyance of sediments to Barataria and Terrebonne Basins will increase the land mass on both sides of the lower Fourchon corridor, protecting infrastructure and port operations.	The TDCC project cannot achieve the positive net land creation rate essential for long-term protection of coastal oil and gas facilities.	There are no severe economic impacts anticipated for this set of project alternatives. Pipelines can be routed to avoid interference with oil and gas infrastructure.	
	Without further distribution of the sediments, the TDCC might reduce access to wellheads in the project area by silting up channels leading to the wellheads. This would increase production cost and might render smaller wells unprofitable.	Although many wellhead access channels will be targeted for closure and filling as part of an area restoration, active wellheads can be accommodated through the design of the restoration area.	
	The TDCC project's substantial construction footprint will result in the loss of valuable real estate, with potential impacts to agricultural and residential properties and associated infrastructure.	Failed agricultural areas could be reclaimed (e.g., Delta Farms). Minor impacts from changed hydrology are expected.	
	The introduction of large amounts of freshwater and sediments into relatively saline waters may significantly impact existing fish and shellfish habitats. Local species are sensitive to habitat changes, in particular, changes in salinity. Such large-scale habitat changes might introduce a shock to the system that significantly impacts commercial fish and shellfish population.	Marsh creation farther inland and across a longer stretch of coastline would change fish and shellfish habitats gradually. Introduction of freshwater farther inland creates a larger mixing zone between freshwater and saltwater with smaller salinity gradients. These changes might keep fish and shellfish population constant during the initial phases of project implementation.	

TABLE 5-34
Socioeconomic Conditions – Pros and Cons
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

	The TDCC is not compatible with navigational interests because of control structure requirements at the bifurcation point and the Mississippi River.	Pipeline conveyance alternatives can be designed to function with existing or future navigation projects.
	Locks required for GIWW crossing will cause navigation impacts resulting from delays.	Introduction of dredged material into marshes is expected to have minor, localized economic impacts on navigation. The proposed wetland areas can be designed to minimize negative impacts on major navigation channels.
	Flood control – The TDCC sediment placement cannot be controlled and directed to specific areas. The TDCC cannot provide a positive net land creation balance.	Pipeline conveyance alternatives are limited only by budgetary constraints and restricted sediment availability. Placement of sediment could be directed to target levees and other flood-control structures. Likely to provide better support for the flood-control system for short-term and long-term scenarios.

Wildlife and fisheries impacts associated with the TDCC and large volumes of freshwater in the system are not fully understood. Complex numerical modeling can be used to assist in determining expected systemwide salinity changes for a 100,000-cfs diversion in Barataria or Terrebonne Bay. It is likely that the magnitude of freshwater inputs to the system will cause shifts in habitat and species diversity.

The TDCC will impact the navigation industry both during and after construction. Transit times on the GIWW will be extended following construction because travel through lock structures will be required during periods of higher flow in the TDCC. Pipeline conveyance alternatives will have relatively less impact on the navigation industry. Demonstration projects have shown the ability of dredges to operate safely in the Mississippi River alongside navigation. Impacts on navigation in Barataria Bay, specifically Barataria Waterway and Bayou Perot, will be minimized through strategic pipeline placement. Dredging industry representatives consider traversing navigation channels with pipelines a routine matter (Ancil Taylor, pers. comm.).

Agricultural zones will be directly impacted by the TDCC footprint. Residential areas along Bayou Lafourche will be negatively impacted during construction of the TDCC. Residents near the intersection of the TDCC and Bayou Lafourche will have to be relocated. Pipeline alternatives, however, would remain confined to existing ROWs and have less relative impact. Wetland creation accomplished by pipeline conveyance projects can protect hurricane levees through targeted sediment placement.

Civil infrastructure will be severely impacted by construction of the TDCC. Roadways, bridges, railroads, and navigation channels will be negatively impacted by the TDCC. The pipeline conveyance alternatives are relatively unobtrusive compared to the TDCC. Minor infrastructure impacts are expected while laying the first 0.5 mile of the pipeline network from the Mississippi River to the back levees.

Project/Performance Risk

The level of risk associated with the implementation of a coastwide restoration alternative cannot be quantified by a planning-level study. As a qualitative performance measure, however, performance risk can be addressed for both the TDCC and the pipeline conveyance alternatives. The following issues are discussed in this section:

- Constructability
- Project Duration
- Familiarity with Techniques Employed in the Project
- Uncertainties in Projected Outcomes

Constructability. Both project concepts have been demonstrated to be constructible. The TDCC construction likely involves more construction failure risk because of the nature of building large diversions and control structures on the Mississippi River. However, a large part of the construction (dredging, levee construction, infrastructure replacement) is commonly performed. The pipeline conveyance alternatives also employ commonly used technologies, although there is more experience with this technology in other parts of the world than in southeast Louisiana.

Landowners. Successfully working with landowners to implement either of the project concepts could be an enormous challenge. The TDCC project footprint covers more than 30 square miles and is more than 100 miles long. The pipeline conveyance alternatives require access and agreement to modify every acre of restored land. Many of the navigational features that have contributed to coastal land loss (e.g., wellhead access canals) will require filling and potential loss of easy access.

Duration of Project. Construction of the TDCC, including two diversion structures, four locks, numerous pump stations, and more than 400 miles of levees, is expected to take 15 years. Considering, for example, the difficulty in the construction and funding of the 10,000-cfs Davis Pond Diversion, which was authorized in 1965, started construction in 1997, and was finally operable in spring 2002, the 15-year estimate may be too conservative.

Should the pipeline conveyance alternatives be implemented, the first sites likely to be selected as restoration areas are those on the east bank of the Mississippi River near West Pointe a la Hache. The planning, design, and mobilization of dredging equipment would likely take 6 months to 1 year. At that point, land creation would be limited only by costs and the availability and supply rate of sediment.

Uncertainties in Projected Outcomes. At this time, there are many uncertainties related to the TDCC that will require further investigation before proceeding to design. For example, the idea of the TDCC was conceived based on the performance of the Wax Lake outfall. This system, which is a dredged channel, feeds an actively prograding delta in Atchafalaya Bay, may not be an appropriate design analog for interpreting the behavior of the TDCC. Also, interrupting flow on the GIWW with the lock structures may increase salinity in Barataria Bay because flows in the GIWW are predominantly west to east.

The pipeline conveyance alternatives have considerably fewer uncertainties than the TDCC because recent projects in southeast Louisiana have demonstrated successful use of this technology in wetland creation.

Pros and cons of project performance risk are summarized in Table 5-35.

TABLE 5-35
Project/Performance Risk – Pros and Cons
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Third Delta Conveyance Channel		Pipeline Conveyance Alternatives	
Pros	**Cons**	**Pros**	**Cons**
	Actual TDCC performance can only be modeled/estimated until the actual system is built and functional. Minimal prior history with an engineered delta-building system of this magnitude (Wax Lake Outlet).	Performance histories well documented for similar projects. Implementation on a project-by-project basis allows adaptive management of lessons learned as an ongoing part of the process.	
	Upfront commitment of total project funds required for project implementation.	Individual projects can be undertaken as a part of a large program. Commitment of costs can be undertaken on an incremental/project basis and expanded as confidence in approach and technology improves.	
	Existing history of major design/performance risk on large-scale water resource/navigation projects in southeast Louisiana (i.e., Old River Control Structure, Davis Pond, MRGO).	Similar projects already performed have demonstrated the viability of the approach and technology. Potential restoration design errors entail significantly less risk than those associated with major river diversions.	

SECTION 6.0

Scientific and Technical Uncertainties

6.1 Introduction

Both concepts evaluated in this study, the TDCC and pipeline conveyance alternatives, are unique in terms of the magnitude or size of the projects themselves, and the magnitude of the goals the projects seek to achieve. Numerous scientific and technical uncertainties remain at the conclusion of this reconnaissance-level evaluation. These uncertainties relate to the current understanding of the physical system and the engineering concepts and assumptions made during the analyses presented in this report. For example, the analytical tools used in this evaluation, such as the NGDC Coastal Relief Model, rely on data that have associated uncertainty.

The development of the restoration alternatives discussed herein required the adoption of numerous assumptions. In certain cases, the results of the analysis are sensitive to the assumptions made. For example, the total amount of sediment required to restore a given area depends on parameters such as the depth of placement on land and in water, and the assumed loss rates from compaction and retention. A change in the assumed depth of fill in water, for example, would change the volume of sediment required to restore the selected site and the cost of the restoration effort.

This section details several data gaps and scientific uncertainties related to coastal restoration projects in southern Louisiana. The LCA Study (USACE, 2004) contains a detailed discussion of scientific and technical uncertainties for the coastwide restoration effort proposed in that document. A degree of overlap exists between the two discussions, because parameters such as sediment availability and relative sea-level rise are important to both restoration efforts. The Section 3 of the LCA Study provides another discussion on scientific and technical uncertainties.

The uncertainties discussed are grouped into one of the following four categories:

- Type 1 – Uncertainties associated with physical, chemical, geological, and biological baseline conditions
- Type 2 – Uncertainties associated with engineering concepts and operational methods
- Type 3 – Uncertainties associated with ecological processes, analytical tools, and ecosystem response
- Type 4 – Uncertainties associated with socioeconomic and political conditions and response

6.2 Type 1 – Uncertainties Associated with Physical, Chemical, Geological, and Biological Baseline Conditions

6.2.1 Availability of Sediment from Riverine Sources

A limiting factor relative to the scale of the proposed restoration programs is the availability of sediment for restoration. Literature values for sediment transport rates in the Mississippi River span almost an order of magnitude. Furthermore, the majority of sediment transport rates are for suspended sediment because bedload sediment is notoriously difficult to quantify.

Recent research by Mead Allison at Tulane University has attempted to quantify sediment transport through the use of acoustic imaging of sand dunes (bedforms) on the river bottom. Sediment transport rates were estimated by capturing consecutive images of the river bed showing downstream propagation of bedforms. These efforts should be extended in frequency for a more accurate understanding of the non-linearity between sediment transport and flow, and the natural variability in the system.

The available bedload transport rates in the Mississippi River must be quantified with improved accuracy over a range of hydraulic conditions. The limited quantity of renewable sediment deposits must be better understood before a full coastwide restoration plan allots any significant portion of this resource to individual projects or programs. For example, restoration efforts in Barataria and Terrebonne Basins cannot commandeer the entire bedload supply from the river because of competing demands in the Breton Sound Basin and the Birdfoot Delta.

An additional uncertainty associated with sediment dredged from the river for restoration purposes is the quality of the sediment, both in terms of grain size and the presence of contaminants.

6.2.2 Availability of Sediment from Offshore Sources

The proposed pipeline conveyance-based restoration plans included quantification of sediment volumes needed from offshore sources. These annual requirements are summarized in Table 6-1.

The availability of offshore sediment for restoration purposes must account for all competing needs for sediment, including marsh restoration, barrier island restoration, and construction of the interbasin segmented barriers, if adopted as a component of a coastwide restoration plan. Sediment grain size must be accounted for in the sediment budget. Wetland restoration projects likely can use a much wider range of grain sizes than is required for barrier island restoration projects.

Table 6-2 details results of some preliminary sand surveys conduced off the coast of Barataria and Terrebonne Basins, in an attempt to quantify the availability of sediment for restoration purposes. Subsequent to this study, scientists from the Coastal Restoration Division at LDNR have conducted studies that indicate that preliminary estimates were extremely high. A better understanding of existing sand resources, combined with

expansion of the search for sand sources offshore of the barrier island chains, will enable development of a sediment and sand budget.

TABLE 6-1
Summary Of Final Alternatives: Sediment Requirements
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

	Dredging Required per Year (50 years) (mcy)		
Source	**Alt 1**	**Alt 2**	**Alt 3**
Mississippi River	17.8	22.6	19.4
Atchafalaya River	0.0	0.0	5.8
Barataria Offshore	0.0	0.0	9.1
Ship Shoal	0.0	7.5	13.8
Total	17.8	30.1	48.1

Finally, offshore borrow sites that contain finer sediments (silts) should be considered for use in wetland restoration projects. One such source of this material would be the overburden on currently identified sand sources offshore of Barataria Bay. This acknowledges that wetland restoration projects do not necessarily rely solely on sand delivered from offshore sources, but from sediment in general. This is important for potential restoration projects in Terrebonne Bay, which lie a considerable distance from the Mississippi and Atchafalaya Rivers.

TABLE 6-2
Summary of Offshore San Volume Estimates
Phase 2 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Number	Source	Est. Volume Sand (low) (cy)	Est. Volume Sand (high) (cy)	Location
1	Caminada	3,800,000	5,100,000	West end of Grand Isle
2	Barataria Inshore	18,400,000	26,100,000	Outside Barataria Pass
3	Barataria Offshore	34,700,000	46,300,000	SE offshore of Barataria Inshore
4	Quatre Bayou Shallow	6,100,000	8,100,000	Outside Quatre Bayou Pass
5	Quatre Bayou Deep	92,800,000	132,600,000	Below Quatre Bayou Shallow
6	Quatre Bayou D2	7,400,000	9,800,000	Below Quatre Bayou Shallow
7	Empire	5,900,000	7,800,000	Offshore of the Empire jetties
8	Scofield	7,400,000	8,400,000	Offshore of Scofield Bay
9	Sandy Point	220,600,000	294,200,000	Plaquemines delta lobe
10	Ship Shoal	1,276,700,000	1,595,900,000	15 km offshore of Isles Dernieres

Source: Kindinger et al., 2001

6.2.3 Subsidence and Relative Sea-level Rise

Until recently, there has been a general agreement that the magnitude of relative sea-level rise, a combination of ground subsidence and eustatic sea-level rise, was approximately 1 centimeter per year for most of southeastern Louisiana (Penland and Ramsey, 1990). This estimate comes from long-term (multi-decade) analysis of tide gage measurements, primarily at Eugene Island and Grand Isle. Eustatic sea-level rise has increased in the

nineteenth and twentieth centuries, but still remains a minor component in relative sea-level rise (approximately 10 percent).

Subsidence is primarily responsible for relative sea-level rise. Subsidence is the expression of several processes, including compaction of deltaic deposits, tectonic activity (regional downwarping), faulting, and extraction of hydrocarbons causing a decrease in pore volume. Subsidence rates are both spatially and temporally variable, and are currently the subject of much debate.

Recent work by Kurt Shinkle and Dr. Ray Dokka, executive director for the Center for GeoInformatics in the Department of Civil and Environmental Engineering at Louisiana State University, indicates that subsidence rates may be considerably higher than previously thought. Dokka used the Global Positioning System to reevaluate benchmarks in the coastal zone and found that subsidence averaged 0.5 inch per year in coastal parishes, which is equivalent to 4 feet per century. Subsidence rates as high as 1 to 2 inches per year (the equivalent of 8 to 16 feet per century) were reported in areas around New Orleans (Shinkle and Dokka, 2004). Furthermore, the inland extent of the subsidence data presented by Shinkle and Dokka indicate that geologic processes of regional downwarping are causing subsidence not just in the coastal zone, but throughout much of the state.

In the analysis previously discussed, estimates of subsidence (4 feet per century) were made in adjusting preliminary land-building estimates of the TDCC to account for extra sediment needs. If actual subsidence rates are considerably larger than those used in the analysis previously discussed, the land growth estimates will have to be revised downward.

It is critical that the recent work on subsidence rates be confirmed or refuted with additional research. The difference between 2 to 4 feet of subsidence per century versus 8 to 12 feet per century could mean the difference between a feasible restoration effort and a futile one.

6.2.4 Bathymetry and Topography

Design of individual restoration efforts requires an understanding of current bathymetric and topographic conditions at the project site. Calculation of fill volumes necessary to bring a marsh plain to a desired elevation with respect to a sea level or other datum requires information on the present elevation. Although recent advances in technology, specifically the routine use of LIDAR in coastal Louisiana, have provided a database of ground elevations, there is still a lack of a comprehensive bathymetric data source for use in engineering design and numerical modeling applications in coastal Louisiana. The NGDC's Coastal Relief Model is severely lacking in inshore survey data in Barataria and Terrebonne Basins.

6.3 Type 2 – Uncertainties Associated with Engineering Concepts and Operational Methods

Uncertainties associated with engineering analysis conducted in this study are discussed in this subsection. This includes assumptions made with regards to the TDCC and the pipeline conveyance alternatives. These will be discussed individually in the following subsections.

6.3.1 Third Delta Conveyance Channel Analysis

Evolution of Third Delta Conveyance Channel

One major disadvantage of the TDCC concept is the time required for the channel to erode to its full capacity. Previous work by both CH2M HILL and the concept author indicate that the evolution period may be 40 to 50 years (CH2M HILL, 2004; Gagliano and van Beek, 1999). The continued land loss during this 50-year period would approach 400 square miles in the Barataria and Terrebonne area, emphasizing the necessity of considering the time requirements for engineering studies, design, and construction of any basinwide restoration project.

Subsequent to the presentation of the concept, somewhat recent press articles quote Gagliano as saying the evolution period may be much shorter, closer to 10 to 15 years (Masson, 2003; Kenworthy, 2005). The influences on this change in estimating how long the channel would take to develop are unclear. If the TDCC is to remain a viable option for coastal restoration, additional engineering studies must provide better estimates to these sorts of crucial project details.

Levee Construction/Pilot Channel

The original concept of the TDCC is to dredge a pilot channel only as large as required to build guide levees. The evolution of the channel over time will transport not only the sediment entering the upstream end of the channel, but also the sediment comprising the difference in the channel cross section between the pilot channel and the final channel. Previous engineering feasibility investigations (CH2M HILL, 2004) indicate that the pilot channel concept did not produce enough erosive force to scour the clay sediment through which the channel would pass. Recommendations following preliminary engineering investigations were that the initial channel would have to be 35 to 50 feet deep and flows would have to be between 40,000 and 60,000 cfs for erosion to occur, not 20,000 cfs as originally proposed.

The cost estimates and the land-building estimates previously discussed account for these assumptions. Uncertainty regarding the erosive strength, or stream-power, needed for channel evolution will influence the cost and land-building estimates previously discussed. Finally, a cut-to-fill ratio that is appropriate for construction of semicompacted levees was assumed. Uncertainty in this ratio will affect cost estimates.

Effects of Diversion on the Mississippi River

The removal of up to 200,000 cfs and the associated sediment load from the Mississippi River will influence the river downstream of the diversion location. Diversion flows off the river reduce available freshwater for restoration projects downstream, and allow for salinity intrusion farther up the river. A minimum flow requirement of 250,000 cfs in the Mississippi River was assumed during the generation of the inflow hydrographs to the TDCC. This assumption was based on a discussion in Templet and Meyer-Arendt (1988) to reflect what was necessary to maintain navigation and protect water quality in the Mississippi River. Concerns with navigation arise during periods of low flow because of the decrease in channel depth. Water quality concerns are specifically related to salinity intrusion up the

Mississippi River; the distance to which density flows of salt propagate upstream is governed by river depth and flow.

A comprehensive hydrodynamic model of the Mississippi River, from the Old River Control Structure downstream to the Birdfoot Delta, should be developed to assist in determining the proper constraints for future diversions from the Mississippi River, so as to provide proper protection for navigation and water quality.

Impacts on Existing Oil and Gas Facilities in Delta-building Locations

There are more that 30,000 oil and gas wells in the 25 parishes composing the Louisiana coastal zone (Coalition to Restore Coastal Louisiana, 2000). These wells generally have open-water access for maintenance and operation. Any large-scale wetland restoration program likely will decrease the ease in which these wells are accessed. A comprehensive plan will have to be devised to minimize impacts to the oil and gas industry, while still restoring wetland habitat. Some of the wetland habitat was lost through direct removal during the construction of access canals; the majority was lost as a result of altered hydrology attributable to spoil banks from both pipeline canals and well access canals.

Figures 6-1 and 6-2 show the concentration of the existing oil and gas wells in both delta-building locations (Terrebonne Basin, near the Pointe au Chien WMA, and Little Lake in Barataria Basin).

6.3.2 Pipeline Conveyance Alternatives

Construction of Sediment Traps on the Mississippi River

The pipeline conveyance restoration alternatives rely on between 18 and 23 mcy of sediment per year from the Mississippi River to accomplish the land-building goals of the individual alternatives. Currently, between 15 and 20 mcy are dredged on an annual basis from the navigation channel in the vicinity of Head of Passes during routine maintenance dredging events.

Sand transport in the Mississippi River occurs as both suspended load and bedload. As the velocity of the river decreases, suspended load either settles out of the water column or transfers to bedload. Either way, sediment removed from suspension becomes available for mining. A sediment trap would effectively promote settling of sand-sized particles in suspension by increasing the cross-sectional area of the flow path, thus decreasing the average velocity. Furthermore, sediment transported by bedload (particles moving along the river bottom) would fall into the sediment trap and bottom velocities would hopefully remain below those critical to continue transporting the material downstream past the sediment trap.

Multi-dimensional sediment transport modeling is necessary to investigate the location, size, and shape of the sediment traps that will most efficiently increase the sediment available for ecosystem restoration projects.

Placement Techniques for Marsh Creation and Marsh Nourishment

The ecosystem restoration alternatives previously discussed assume that approximately one foot of dredged material will be placed on existing, fragmented wetlands to increase their

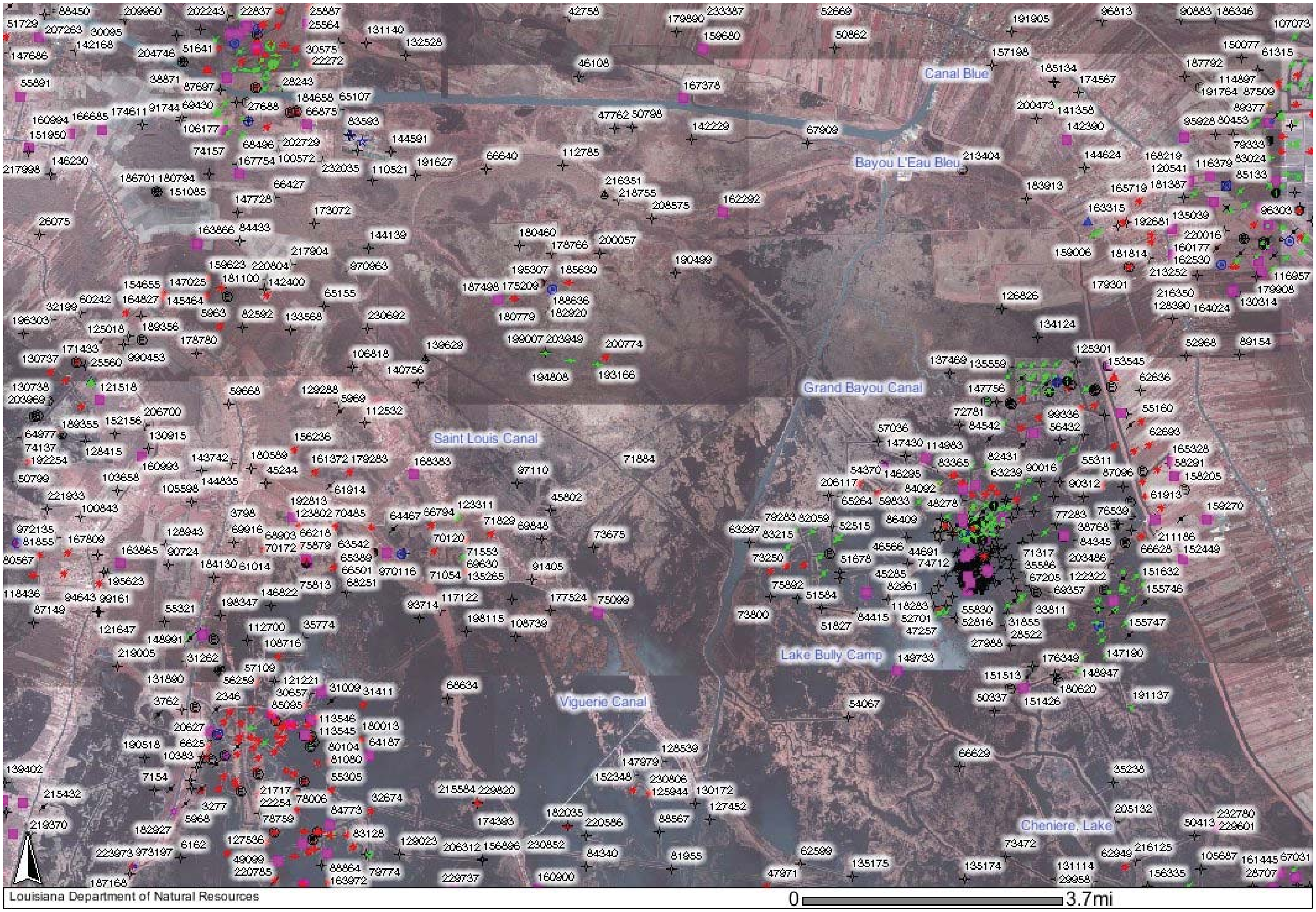

FIGURE 6-1
OIL AND GAS WELLS IN THE VICINITY OF POINTE AU CHIEN WMA, TERREBONNE BASIN
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

CH2MHILL

FIGURE 6-2
OIL AND GAS WELLS IN THE VICINITY OF LITTLE LAKE, BARATARIA BASIN
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

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CH2MHILL

base depth and provide a buffer against expected relative sea-level rise. The placement of dredged material on existing marsh may have a negative impact on existing vegetation; the duration of the negative impact may or may not be short. Thin layer placement in varying thicknesses should be tested and monitored. A critical need exists to determine the most appropriate placement technologies for minimizing prolonged impacts to existing marsh. A demonstration project would allow for the testing of several different placement techniques, including spray placement, the use of pipeline diffusers, and standard end-of-pipe discharge.

Creation of Interbasin Segmented Barriers

Section 4 presented a discussion of a secondary line of defense inside the barrier island chains in the Barataria and Terrebonne Basins. These interbasin segmented barriers will require sand-sized sediments for construction (40 to 59 mcy of sand per basin). Intuitively, these barriers will help reduce wind-wave erosion in marshes near the vast open-water areas in southern Barataria and Terrebonne Basins. Furthermore, they will decrease salinity intrusion by damping storm surges and meteorological tides (pressure induced changes in water surface elevation, as opposed to astronomical tides), and increasing the residence time of freshwater inputs into the marshes inland of the barrier system.

The full impact of these interbasin segmented barriers on the salinity regime of the Barataria and Terrebonne Estuaries system cannot be determined without the application of a multi-dimensional hydrodynamic and constituent transport model. Proper design of the spacing of the segments will need to consider inland increases in water levels associated with an increase in residence time of freshwater inputs to the system.

Long-distance Transport of Dredged Sediments

Several assumptions were made during the analysis of the pipeline conveyance alternatives. These assumptions include unit cost increases with pipeline transport distance and the suitability of riverine and offshore sediments for use in various areas.

An additional concern is the use of saline sediments for construction of habitat in intermediate and freshwater marsh zones. Specifically, the leaching of salts from the mineral sediment may hamper the colonization of newly created marsh platforms by freshwater vegetation. Based on information presented on Figures 5-6 and 5-14, this would be of particular concern in Alternatives 2 and 3, where sediment from Ship Shoal would be transported to restoration areas adjacent to Lake Boudreaux (primarily Areas T7B and T24).

6.4 Type 3 – Uncertainties about Ecological Processes, Analytical Tools, and Ecosystem Response

6.4.1 Ecosystem Response to Freshwater Inputs

A significant uncertainty for all the restoration projects previously discussed is the reaction of the ecosystem to increases in freshwater inputs. The TDCC will add up to 100,000 cfs at peak flows to both the Barataria and Terrebonne Estuaries. This magnitude of freshwater input will likely overpower the tidal exchange, and freshening both basins for an unknown length of time.

A related unknown element is the colonization of vegetation in the vicinity of the two downstream ends of the TDCC. Considering the planned range in freshwater flows down the TDCC, from no flow approximately 23 percent of the time to peak flows of 100,000 cfs, the type of vegetation that eventually will take root in this highly-variable salinity environment is unknown.

A multidimensional hydrodynamic model should be used to determine the system response, with respect to salinity, to varying levels of freshwater input. The hydraulic interactions between the Barataria and Terrebonne Basins necessitate that the hydrodynamic model include both basins.

6.4.2 Organic Soil Production and Land-building Estimates

The role of organic matter production in the growth of wetland habitats remains a scientific uncertainty that directly affects the land-building estimates presented in this report. Fresh marshes contain a greater percentage of organic soils than salt marsh habitats, and thus have the capacity to overcome relatively larger increases in sea level.

6.4.3 Miscellaneous Uncertainties Pertaining to Ecological Responses to Restoration Projects

The following list presents some additional uncertainties relating to ecological processes. Further research may reduce the uncertainty associated with these processes.

- How will local plankton respond to increased nutrient loading from freshwater diversions?
- What will be the net change of saline marsh resulting from coastal erosion and conversion of freshwater marsh to saline marsh farther in the basin?
- To what extent will SAV species colonize areas where large amounts of sediment are introduces?
- How will oyster populations react to increased turbidity from large-scale freshwater diversions and sediment introductions?
- How much subsidence can be overcome by organic accretion in healthy, freshwater, and intermediate marshes?

6.5 Type 4 – Uncertainties Associated with Socioeconomic and Political Conditions and Responses

The analysis presented and discussed in this report was primarily based on engineering and science. However, any project of this magnitude will have socioeconomic and political consequences that are likely to be as influential as the engineering analysis. For example, the TDCC may alter salinity regimes in the Barataria and Terrebonne Estuaries to the extent that entire communities are adversely affected by changes in fisheries and habitat types. The displacement of local fishermen and oyster harvesters is a real possibility with the TDCC.

The LCA Study discusses the need for a better understanding of how individuals and industries would react to changing conditions in the coastal zone (USACE, 2004). The development of a behavioral analysis database is suggested in the LCA Study as a means of identifying and quantifying risks and uncertainties related to socioeconomic concerns.

Significant uncertainties are associated with landowner response and cooperation relative to any large-scale restoration program.

SECTION 7.0

Summary and Recommendations

This section summarizes the analysis performed during the Phase 2 Reconnaissance-level Evaluation of the TDCC concept. Recommendations for future work are also discussed. This report does not recommend a specific project or alternative, but rather provides results of a comprehensive, impartial, and transparent multi-year scientific and engineering analysis of potential basinwide restoration project concepts. Assumptions made throughout the analysis are discussed, as are the potential impacts of such assumptions on results. This transparent approach was undertaken to expedite adoption of this work by various parties (academics, agency personnel, and consultants) who may have differences of opinion regarding these assumptions.

7.1 Summary of Approach Used to Meet Goals and Objectives

The following approach was used to generate the information from which conclusions and recommendations were made:

- Defined goals and objectives
- Solicited input from experts on appropriate alternative concepts
- Defined performance measures to be used for evaluating and comparing the TDCC and the alternatives
- Defined the methodology to objectively develop and analyze the alternatives
- Executed the analysis, compilation, and evaluation of results
- Defined project objectives and goals. Specifically, project objectives included the following:
  - To develop project alternatives that can accomplish the same ecosystem restoration goals as the TDCC, namely the creation and maintenance of land and a sustainable, diverse ecosystem in the Barataria and Terrebonne Estuaries
  - To analyze the engineering, environmental, and economic aspects of the project alternatives and the original TDCC concept
  - To document scientific and technical uncertainties regarding implementation of the restoration alternatives to help future research and analysis

The approach and progression of the evaluation are summarized on Figure 7-1.

7.2 Summary of Analysis

This section summarizes the analysis conducted during this Phase 2 Reconnaissance level evaluation. Following are the major tasks completed as part of this evaluation:

- Calculated TDCC land-building estimates for comparison to project alternatives
- Developed components of project alternatives that meet the land-building goals and ecosystem preservation capacity of the TDCC project
- Compiled GIS database of characteristics of potential restoration sites throughout the Barataria and Terrebonne Basins
- Constructed ranking matrix for potential restoration areas based on weighted scores for parameters such as recent land loss, expected future land loss, distance from prospective sediment sources, influence from existing or proposed freshwater sources, degree of existing confinement, degree of infrastructure protection provided by restoration effort, and degree of influence on natural hydrology of restoration area
- Generated three basinwide restoration alternatives distinguished by the magnitude of the restoration effort, and quantified by the location and volume of annual sediment required for each effort
- Calculated land-building estimates for three distinct alternatives focusing on pipeline transport of sediment for marsh creation
- Calculated cost estimates for TDCC project and three pipeline conveyance projects
- Discussed environmental impacts and benefits for both the TDCC and the pipeline conveyance projects
- Discussed scientific and technical uncertainties associated with the analysis of both the TDCC and the pipeline conveyance projects.

Land-building estimates of the TDCC (Section 3.4.3), for the set of assumptions documented in the analysis, range from 1.8 to 2.6 square miles of land per year for reasonable ranges in assumed sediment retention and an average of 6 feet of sediment required (vertical height) to create land from open water. Timelines are presented for cumulative land growth from the TDCC taking into account time required to design and construct the channel, as well as time for the channel to evolve to its design capacity.

Alternative project concepts were developed that met the land-building and ecosystem preservation capacity of the TDCC, namely the creation of a sustainable ecosystem in the lower Barataria and Terrebonne Basins. The goal of land building can only be accomplished through the transport of vast quantities of sediment to the restoration areas. Aside from a constructed conveyance channel transporting suspended sediments in concentrations similar to those in the Mississippi River, there are few mechanisms for transporting the required sediment. Local, small-scale success with pipeline transport of riverine sediments led to the adoption of this strategy as another viable means of transporting massive quantities of sediment to the restoration areas. This transport mechanism provided the foundation for the project alternatives developed and presented in this Phase 2 effort.

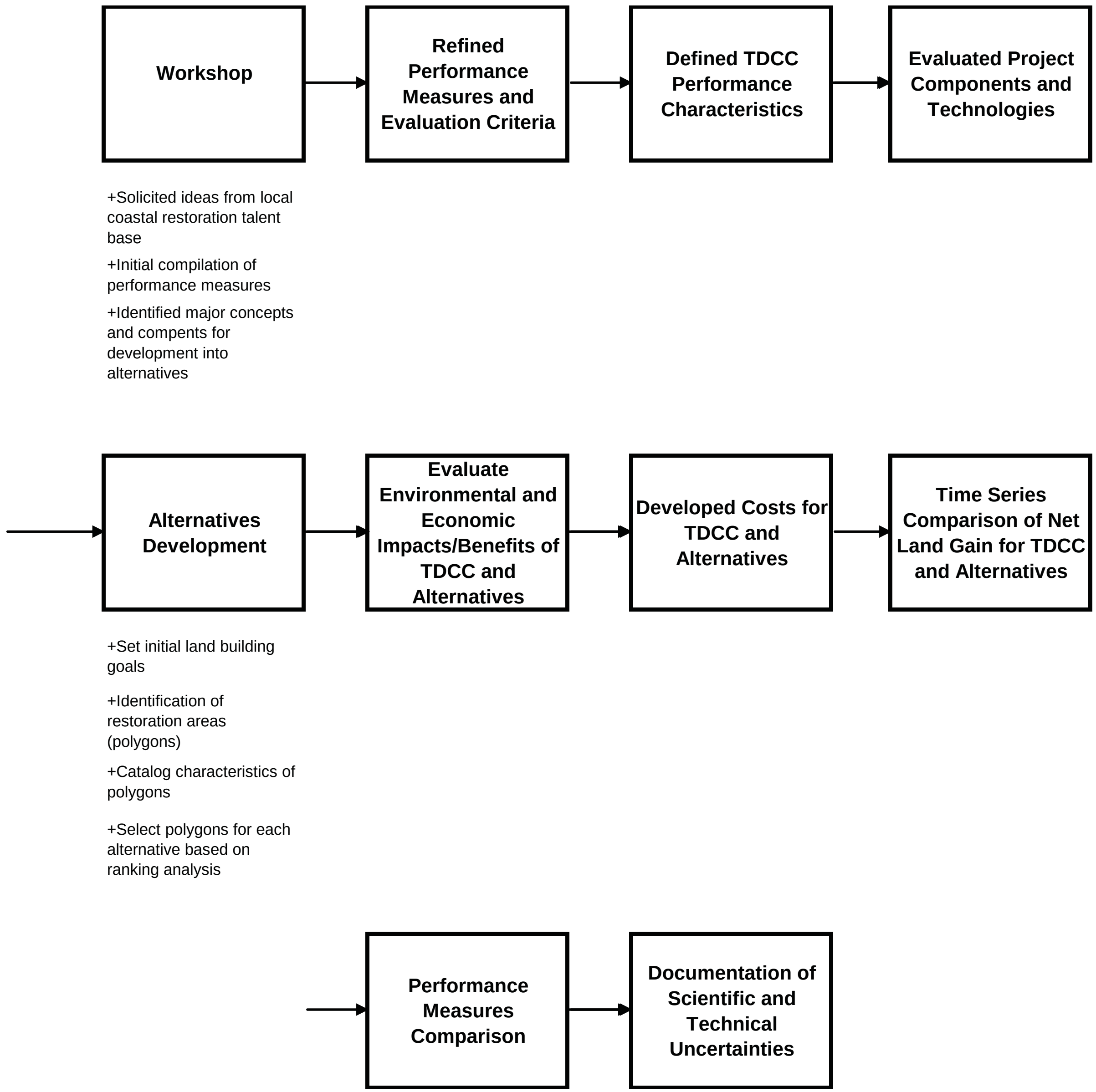

FIGURE 7-1
ANALYSIS APPROACH
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT

CH2MHILL

A database detailing characteristics of potential restoration areas was generated for use in a ranking exercise to determine the relative benefit of each area. The database is primarily composed of GIS layers, and includes important contributions from work conducted by the USGS in quantifying historical land-loss rates and projected future land loss for the individual restoration areas. The database also scores, on a relative basis, the importance of each restoration area to restoration of natural hydrology and infrastructure protection.

The prospective restoration areas were grouped into three progressively larger basinwide restoration alternatives. Each alternative assumes an increase in freshwater diversions to sustain newly created wetlands. The primary difference among the alternatives is the magnitude of the annual land-building goal. The sources used to mine sediment for each restoration alternative increase with the land-building goals. The smallest alternative relies only on sediment from the Mississippi River, while the largest alternative mines sediment from the Mississippi River, offshore resources, and the Atchafalaya River.

The GIS database was used to populate a ranking matrix for each of three restoration alternatives. Results of the ranking matrix, presented in Tables 5-15 through 5-17, provide a preliminary guide to the implementation strategy of each alternative, with a focus on cost effectiveness, environmental, and economic benefits of each area. The matrices prioritize areas for restoration according to user-defined weights for a list of parameters. For example, a cost-based parameter can be given more weight than infrastructure protection.

Land-building estimates for each pipeline conveyance restoration measure were calculated, taking into account sediment loss rates at the restoration site, and compaction of unconsolidated sediments placed in open water (Section 5.4.4). Assumptions were also made regarding the average depth of fill required over open-water areas and existing wetlands; both land creation (from open water) and wetland nourishment (through shallow-layer sediment placement) were considered in the pipeline conveyance alternatives.

Planning-level cost estimates for both the TDCC concept and the three pipeline conveyance restoration measures were compiled (Section 5.8). Contingencies were provided in the cost estimates; the estimates for the TDCC assumed a 50 percent contingency, while those for the pipeline conveyance restoration measures assumed a 30 percent contingency. This variation in assumed contingencies is considered reasonable because of the complexity and uncertainties associated with the TDCC project, and the fact that recent dredging costs were supplied to CH2M HILL staff from dredging industry personnel as part of the Phase 2 effort.

Environmental and economic impact and benefit evaluations were conducted for both the TDCC concept and the pipeline conveyance alternatives (Section 5.9). There is understandably a considerable amount of uncertainty in how the environment and the economy will be affected by such large-scale restoration measures. As a result, the discussion was primarily qualitative.

A discussion of scientific and technical uncertainties was provided in Section 6 to qualify portions of the analysis that relied heavily on assumptions made during the evaluation and to point out that there are many issues still unresolved regarding basin-scale restoration efforts in southern Louisiana. The more important assumptions, particularly those related to sediment supply and regional subsidence, are discussed in detail. Other uncertainties

discussed include the construction of sediment traps in the Mississippi River, the effects of sediment placement on existing marshes, and the ecosystem's response to massive freshwater inputs.

7.3 Recommendations

Although a tremendous amount of research, analysis, design, construction, and monitoring of coastal restoration projects has been conducted in southern Louisiana, a significant number of uncertainties still exist. These uncertainties influenced the analysis presented herein to the extent that they affect assumptions used in the calculations and cost estimates. A number of the scientific and technical uncertainties affecting the projects can be addressed through further engineering studies. Two such studies are described in the following subsection.

7.3.1 Hydrodynamic Study of the Lower Mississippi River

A multi-dimensional hydrodynamic modeling study needs to be conducted to provide further insight on the effect of large-scale freshwater diversion on the Mississippi River. The effects on navigation and water quality can be investigated with this modeling study. Salinity intrusion up the Mississippi River is a function of river flow, among other things. A multi-dimensional hydrodynamic model that considers density gradients associated with temperature and salinity would address the issue of minimum instream flow requirements to protect municipal and industrial water quality.

7.3.2 Sediment Transport Study of the Lower Mississippi River

A sediment budget quantifying prospective sources (both riverine and offshore) needs to be developed so that realistic restoration goals can be defined that take into account the limited availability of sediment. The offshore sediment availability would have to be balanced among all the prospective restoration features that require sediment input, including the barrier island restoration program, the interbasin segmented barriers, and marsh restoration projects.

A three-dimensional numerical sediment transport modeling study needs to be conducted to assist in designing and locating sediment traps on the Mississippi River. This model will help estimate the rate of accumulation of sediment in traps, thus the rate at which material can be mined from the river.

SECTION 8.0

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Appendix A
Workshop Summary Report

Workshop: Phase 2 - Reconnaissance Level Evaluation of the Third Delta Conveyance Channel Project

ATTENDEES: See Appendix A

FROM: CH2MHILL

DATE: June 27, 2005

Introduction and Overview

As part of initiating Phase 2 of the Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project, a workshop was held on May 11 through 12, 2005 at Nicholls State University. The workshop was put on by CH2M HILL and their subconsultant Mussetter Engineering, Inc. on behalf of the Louisiana Department of Natural Resources. Invitees to the workshop included experts on land loss and the relevant sciences from the private sector, academia and government.

The purpose of the workshop was to generate ideas and formulate viable alternatives to the Third Delta Conveyance Channel Project for further characterization as part of this Phase 2 analysis. It was emphasized that alternatives selected for further evaluation should be limited to those that are significantly different in nature from the original Third Delta Conveyance Channel (TDCC) project concept. In the broadest sense, the goal of the workshop was to develop alternatives that meet the land building and preservation capacity benefits of the Third Delta Conveyance Channel. These benefits include, but are not limited to:

- Large scale land building in the Barataria and Terrebonne basins,
- Restoration of a sustainable and dynamic ecosystem
- Increased freshwater input to reverse recent trends of salinity intrusion northward in Barataria and Terrebonne basins

Prior to the workshop, the following materials were distributed:

- Agenda
- Directions to workshop location
- Bio's on workshop project team members
- Summary of the findings of the Phase 1 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project
- Memo titled "Description of Alternative Project Concepts to the Third Delta Conveyance Channel"

The distributed information package is attached as Appendix B.

Day One

Introductions

Steve Mathies with CH2M HILL opened and thanked Restore or Retreat, Nicholls State University, the Louisiana Department of Natural Resources and CH2M HILL and Mussetter Engineering staff for workshop planning and coordination. The project team was introduced and Steve asked everyone in the audience to introduce themselves and briefly describe their background and professional experience.

Overview

John Rogers then took over as lead facilitator for the project team and explained the general ground rules and format of the workshops:

Day 1

- All participants are encouraged to participate as openly and fully as possible
- A background presentation of the Phase 1 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel project will be presented
- A decision making framework will be developed to define "success" and develop performance measures by which to evaluate and compare alternatives by
- Expectations of the attendees will be requested upfront

Day 2

- Review of Day 1
- Split into break-out sessions, with three groups defined by sediment source and delivery method
- Review results of break-out sessions, discuss technical challenges and identify potential data collection and analysis needs for proposed alternatives
- Day 2 wrap up and discussion of next steps

After the workshop, the results will be summarized and distributed to the attendees for review and comment. Analysis of the selected alternatives will then proceed, culminating in the release of the Phase 2 study report.

Background Presentation of the Phase 1 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Kyle Winslow presented a power point presentation giving a summary overview of the results and findings of the Phase 1 analysis. A copy of the presentation is presented in Appendix C.

Workshop and Project Expectations

John Rogers led a discussion of expectations of the workshop and the project in general. This included a preliminary definition of project goals and objectives, and ways in which to measure the performance of a given project alternative.

Workshop participants developed a list of expectations they had concerning the workshop and any project concepts considered in the evaluation of alternatives.

Workshop Expectations

- Be clear in the documentation of the workshop that the goal of the workshop was to gather ideas, and that the documentation of potential project alternatives in no way implies a consensus opinion of workshop participants.
- Produce a broad range of alternatives and refrain from eliminating any alternatives from consideration at this stage of the analysis.
- Focus on using the best available science and judgment, and do not compromise or water down the primary goals of sustainability and functionality of the ecosystem.

Project Expectations

- There should be clarity in the definition of project goals and expected outcomes.
- Projects should be viewed as providing a foundation for continued and future land building and ecosystem restoration.
- Projects should be sustainable and functional.
- Projects should incorporate natural system components as much as possible.
- Projects should mimic natural systems.
- Projects should consider need for funding of operation and maintenance for non-natural project components.
- Projects should consider both short term emergency measures to stem current land loss and long term project components to maintain ecosystems.
- Projects should keep in mind use of restoration funding for restoration projects.
- Development of alternatives should be technically based and not politically based.
- Workshop participants should refrain from considering potential project funding, as this is a future component of the project and should not be considered in the discussion of potential alternatives.
- Projects must consider both the current and future needs for river water, and the potential impacts of large scale diversions on the Mississippi River, including:
  - Changes in the sediment transport capacity of the Mississippi River downstream of the diversion,
  - Impacts on navigation (river stage) downstream of the diversion,
  - Salinity intrusion in the Mississippi River, and
  - Projects should consider the supply and availability of sediment.

- Projects should consider inclusion of design components that allow for multipurpose uses in order to increase stakeholder acceptance, as long as the primary goals of the project are not compromised.
- Projects should consider potential issues with constructability.
- Projects must be able to obtain public acceptance. The public's perception and potential for misinformation must be managed.
- Projects should incorporate components that allow for adaptive management.

Performance Measures

Workshop participants developed a list of performance measures for the project alternatives. These measures provide a means of comparing the various project alternatives and their ability to meet the project goals. Specific measures that would quantify the performance of a given alternative include:

- Life of the project (i.e., greater than 50 years)
- Acres of wetlands saved by project
- Comparison of project development with the development of the Wax Lake Delta
- Adaptive management
- Effect on salinity gradient, and reversal of saltwater intrusion trend
- Rate of land gain
- Reduction in the rate of land loss compared with a no action project alternative
- Benefits to current and future populations
- Recognize both increase in acres above and below mean water level (i.e. of subaerial gain
- Habitat and species diversity; variation in elevation
- Degree of adverse impacts to existing wetlands during and after construction

Stakeholders

Workshop participants assisted in the development of a list of stakeholders that should be included in communications about this project. Also included are organizations that may assist in disseminating the information.

- Management conference members
- Parish officials
- Davis Pond Advisory committee
- Commercial fisheries, shrimpers, oyster harvesters
- Wildlife and Fisheries Task Force

- Fin-fish harvesters
- Jean Roussell with Governor's office (best source for all task force leads, e.g., Crab TF, Oyster TF, Shrimp Advisory panel)
- Marine extension
- Sea grant program
- Coastal Conservation Association (CCA)
- Louisiana Department of Environmental Quality (LDEQ)
- Louisiana Department of Transportation and Development (LDOTD)
- US Fish and Wildlife Service
- Cultural, recreational and tourism organizations
- Oil right of ways: Federal task force (Interstate pipeline commission),
- GIWW users
- Oil and gas industry organizations
- Louisiana Forestry Association
- Louisiana Department of Economic Development
- State Historic Preservation Office (SHPO)
- Local and state legislators
- State Government office of coastal activity
- Media organizations
- Chambers of commerce

Progress on the project could be communicated to the stakeholders through the use of email newsletters and BTNEP meetings.

Day Two

The second days focus was to divide into breakout groups defined by groupings of potential alternatives with common features. Each group would come up with alternatives and present them to the entire group near the end of the day. Attendees were told that each alternative should be compared to the following performance measures relative to a time scale:

Performance Measures	10 Years	25 Years	50+ Years
Reduce land loss rate			
Increase rate of land gain (acres/yr)			
Optimize habitat and species diversity			
Sustainability			
Reduce saltwater intrusion			
Ability to implement			

Project Alternative Groupings and Components

Potential alternatives first focused on the goal of large-scale land creation in the Barataria and Terrebonne basins. As a means to this end, each project requires a sediment transport component. Potential sources of this sediment were grouped into either offshore sources (considered offshore of present barrier island system) or riverine sources. Both the Mississippi River and the Atchafalaya River were considered as potential sources of sediment. Delivery mechanisms for the sediment include either pipeline conveyance of sediment slurry or the use of natural or existing open channel systems to transport large quantities of sediment to the receiving areas.

The workshop participants were divided into three groups, and each group was to focus on project alternatives that had one dominant mechanism of sediment transport to the receiving areas and one primary source of sediment. The groups were basically divided by sediment source and transport mechanism and consisted of the following:

- Transport of offshore sediments via pipeline to receiving areas
- Transport of sediments from either the Mississippi River or the Atchafalaya River via pipelines to receiving areas
- Transport of Mississippi River sediments through natural conveyance systems to receiving areas

A strategy table (shown below) was developed with the goal of delineating potential project components to be considered in the development of alternatives. Each column contains various ways to address the topic at the head of the column. There is no implied relationship from one column to the next.

Strategy Table: Project Components

Sediment Delivery for Land Building	Freshwater Delivery	Wetland Restoration	Aquatic Habitat Restoration	Shoreline Protection	Storm/Flooding Protection	Navigation Concerns
Open Channel Systems	Open Channels MR (110,000-130,000 cfs)	Marsh Nourishment	Salinity Gradient	Placement of Manmade structures	Barrier Island Restoration	
Sediment Enrichment (with or without)		Reinforcement of natural banks and overspill areas	Consider edge length	Creation of supra-tidal berms	Marsh creation	
Pipelines from Mississippi sources	Pipelines from Mississippi (for sed export)	Restore ridges	Oyster Reef construction	Creation of sub-tidal berms	New barriers	
Pipelines from Atchafalaya River	Atchafalaya River	Repair broken marshes		Linear berms in basins		
Pipelines from Offshore		Convert open water areas to wetlands				

Strategy Table: Project Components

Sediment Delivery for Land Building	Freshwater Delivery	Wetland Restoration	Aquatic Habitat Restoration	Shoreline Protection	Storm/Flooding Protection	Navigation Concerns
Nearshore	Diversions from MR (West Bay, Myrtle Grove)	Fill canals to restore hydrology				
Barges	Operation of Houma Navigation Canal to bring more water into system	Remove artificial impoundments				

Transport of Offshore Sediments via Pipeline Areas

Interbasin Barriers

The primary component of this alternative group is the creation of a segmented chain of barrier berms arcing across Barataria and Terrebonne basins adjacent to the current marsh boundary. Features of this alternative group are presented in Figure 1. The barrier would provide immediate protection of existing ecosystems from storm induced wave energy, and function as barrier, behind which, marsh ecosystems could be rebuilt. The berms would be created through the placement of dredged sediment, from offshore locations. The berms would be constructed to an elevation of approximately 6 to 8 feet above MSL.

Sediment slurry would be conveyed to the specific areas required by pump and pipeline systems. A pipeline would be constructed from the offshore location to the receiving areas. The pipeline could be selectively placed in trenches so as not to interfere with navigation in Barataria and Terrebonne Basins.

Sediment slurry would be delivered at rates on the order of 20,000 to 50,000 cubic yards per day based on previous project experience. Berms with slopes of 30:1 below water level and

60:1 above water level could be built. This yields an approximate cross section of 1,000 square yards. The berms could be vegetated to increase their longevity.

Construction of the barrier could progress at approximately 1 mile per month assuming a sediment slurry flow rate of 50,000 cubic yards per day and a berm cross section of 1,000 square yards. Multiple dredges operating from opposite sides of each basin (4 in total) could conceivably be used to build the barriers in both Barataria and Terrebonne basins (50 miles in total)

A 25 mile berm in Terrebonne Basin would require about 43 million cubic yards of material. With a single borrow location, it would take approximately 2.5 to 3 years to construct the berm, assuming a single pipeline operation and allowing for downtime for storms and

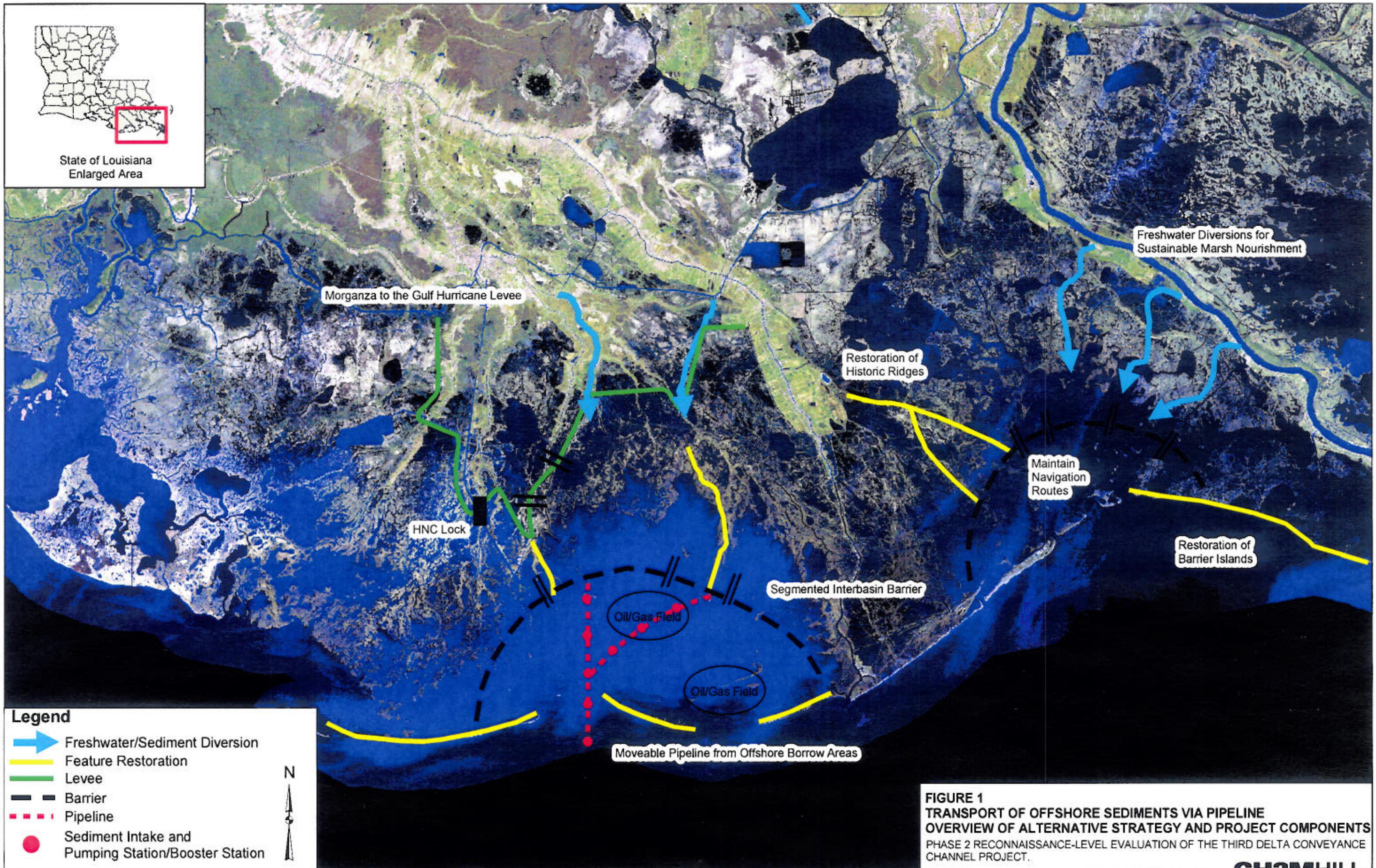

FIGURE 1
TRANSPORT OF OFFSHORE SEDIMENTS VIA PIPELINE
OVERVIEW OF ALTERNATIVE STRATEGY AND PROJECT COMPONENTS
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT.

equipment maintenance. Approximate lengths and times for the Barataria Basin are identical.

Segmenting the barrier would allow for continued navigation in such channels as Bayou Terrebonne, Houma Navigation Canal, Bayou Petite Caillou, Barataria Waterway, etc. The size and spacing of the openings in the barrier would be designed to control salinity and reduce storm surge inland of the barriers.

Alignment of the berms would take into account incident wave direction, wave refraction, and potential focusing of incident wave energy. It is possible that the cross section of the berm would vary with the expected future wave climate at a given location.

Marsh Creation, Nourishment and Sustainability

Once the berms were complete, sediment would be carried via pipelines from either offshore or riverine sources to be strategically placed for maximum benefit and sustainability. Restoration strategies would likely focus on rebuilding historic ridges as well as using dredged material for accepted marsh creation and nourishment techniques for areas behind the barrier. The amount of sediment required and the time required to place the sediment would depend on the distance between the berm and the wetland fringe. Considering a distance of 1 mile and an average depth of 4 feet, it would take approximately 1 year to fill in the area behind a four mile length of the berm. This would create approximately 4 square miles (2,500 acres) of land per year at a sediment delivery rate of 50,000 cubic yards per day. Assuming a one mile buffer between 50 miles of berms in both basins, a total of 50 square miles of land could be created in 15 years. Four independent systems could accomplish the task in under four years. A total of 200 million cubic yards of sediment (above the 80 million required for the berms) would be required to fill in 50 square miles at an average depth of 4 feet.

Sustainability of the system would primarily depend on existing and new freshwater and sediment diversions. The pipelines could be continued to be used, however they have a finite life and offshore sediment supply would be limited.

Barrier Island Restoration

A component of this alternative would be the continued restoration of barrier island chains in both Terrebonne and Barataria Basins. The offshore sediment availability would have to be balanced among all the alternative components that require sediment input.

Issues and Technical Uncertainties

Potential problems with the project include:

- Pipelines and navigation concerns
- Sediment supply
- Bearing capacity of soils
- Saltwater conveyance in pipelines with slurry (flow rates on the order of 100 to 150 cfs)
- Storm delays
- Barrier islands and their need for sand material

Transport of Riverine Sediments via Pipelines

The general concept for this alternative category is the strategic placement of riverine sediments within the degrading areas of the Barataria and Terrebonne basins. Features of this alternative group are presented in Figure 2. The primary component of this alternative is the establishment of a network of pipelines throughout Terrebonne and Barataria Basins for the delivery of sediment slurry dredged from either the Mississippi River or the Atchafalaya River.

Placement Strategy and Areas of Need

There was considerable discussion on what the strategy should be regarding the placement of dredged materials. Basic issues that would need to be better defined as specific alternatives are developed:

- Re-establishment of low-lying ridges, or skeletal framework of the marshes in both basins
- Understanding the geological processes, such as faulting, and how these processes affect the sustainability of any marsh creation strategies
- Confined, non-confined, marsh nourishment placement methods
- Temporal and locational strategies for placement of material relative to fault lines, land bridges, and immediate storm protection needs (e.g., segmented barrier construction)

During the workshop, it was noted that placement strategies would be refined as the alternative is developed more, with the more immediate focus being to establish locations of sediment sources and broad scale alignments of the primary pipeline routes.

Sediment Sources and Supply

Mississippi River

Sediment would be mined from the bedload of the Mississippi River. Sediment traps could be constructed (assumed approximate dimensions of 1,000 ft by 5,000 ft) along the lower Mississippi River, from which dedicated dredging operations could feed a pipeline conveyance / distribution system. Sediment trap construction would serve as a source of dredged material and the depressions could be continually dredged as they filled. As part of the USACE maintenance dredging program, dredged material could conceivably be transported by barge and dumped in the sediment traps instead of offshore.

Four areas for mining bedload on the Mississippi were identified as potential locations for sediment traps:

- Naomi
- Myrtle Grove
- Pointe A La Hache
- Port Sulphur

Dredging operations at these points could feed directly into a fixed intake and pumping station for pipeline conveyance, or barged to a facility up or downstream.

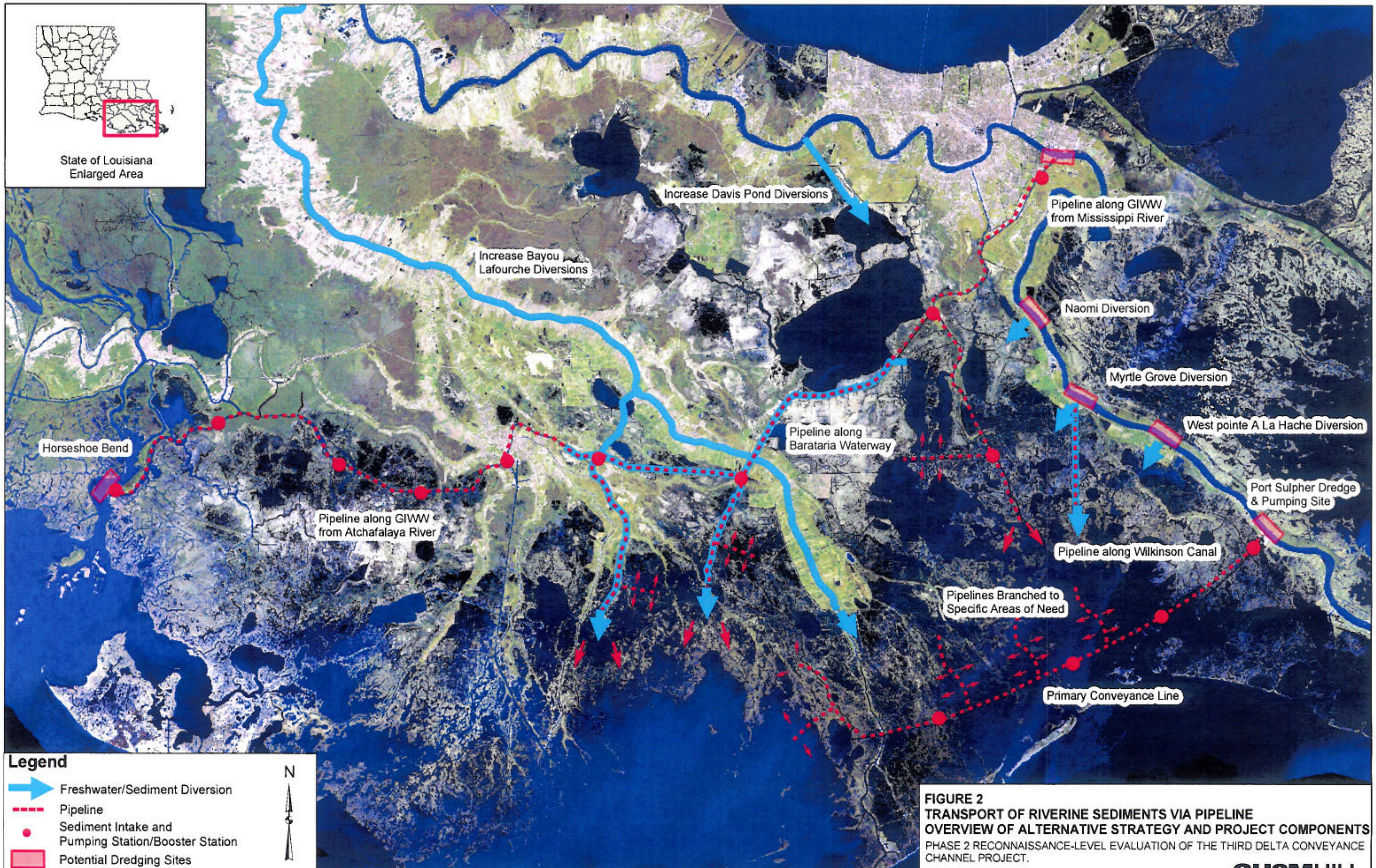

FIGURE 2
TRANSPORT OF RIVERINE SEDIMENTS VIA PIPELINE
OVERVIEW OF ALTERNATIVE STRATEGY AND PROJECT COMPONENTS
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT.

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Atchafalaya River

A potential area identified for sediment mining within the Atchafalaya River system was the Horseshoe bend near Morgan City as well as Grand Lake. A similar concept as proposed on the Mississippi River could be utilized for mining and conveying material. It was acknowledged that there are potential impacts on both the Wax Lake Delta and Lower Atchafalaya River Delta associated with sediment mining on the Atchafalaya River.

Pipeline Layout and Routes

Pipeline networks for conveyance of dredged material would be laid out to move material from the dredged sources to the proposed placement areas, as efficiently as possible. From the dredged material source, the pipeline system would likely pump into a manifold pipe from which smaller diameter distribution pipelines could target specific areas. Larger pipelines could be placed in the bottom of primary and secondary navigation canals to minimize environmental impacts to existing marsh areas, allow for maintenance access to pipelines, and minimize land rights issues. Some concern was expressed for placement of pipes in navigable waterways, referencing problems with pipelines off Grand Isle and constant vessel interactions.

Barataria Basin has several options for pipeline routes, including the Freeport Sulfur Company Canal, Wilkinson Canal, Barataria Waterway, GIWW, etc. Terrebonne Basin is more of a challenge; potential routes include Bayou Terrebonne, Grand Bayou Canal, and GIWW.

Freshwater Flows for Salinity Control

To ensure sustainability of any ecosystem built by pipeline conveyance, freshwater diversions must be maintained for salinity control, sediment supply, and nutrient input. Freshwater input is vital for the continued health and sustainability of the ecosystem. Freshwater diversions including Bayou Lafourche, Davis Pond, Myrtle Grove, West Pointe A La Hache, and the Naomi siphon would be operated to obtain the desired salinity gradients in Barataria Bay. Salinity control in Terrebonne Bay would require increased flows down Bayou Terrebonne and Grand Bayou Canal.

Transport of Riverine Sediments without Pipelines

Four alternatives were discussed under this broad heading. These are described individually below.

Alternative 1

This alternative is intended to increase land gain in the northern part of the Barataria Basin by increasing the efficiency of the Myrtle Grove diversion project. The alternative could also include use of the Davis Pond Freshwater Diversion Structure and the Bayou Lafourche projects to provide additional freshwater to the Barataria system.

The current concept for the Myrtle Grove project calls for the installation of gated box culverts on the west bank of the Mississippi River in the Vicinity of Myrtle Grove; dedicated dredging from the river to create marsh in the vicinity of Myrtle Grove; dedicated dredging from the Mississippi River to create marsh in the vicinity of Bayou Dupont, the Barataria

Bay Waterway, and the Wilkinson Canal; or a combination of these actions. Supporting features might include a conveyance channel with parallel mainline flood control levees and an outflow channel with guide levees. The alternatives that have been studied to-date involve diversion of 5,000 and 15,000 cfs, and the net benefit after 20 years is estimated to be approximately an additional 8,900 acres of wetland.

Because the primary area of land loss in Terrebonne Basin is far from the river, the group felt that it would be impractical to move substantial amounts of sediment through the existing open-channel conveyance system. The beneficial effects of additional freshwater to this area could be achieved by modifying the flow patterns in the Atchafalaya River and Gulf Intracoastal Waterway.

Alternative 2

This alternative involves restoring the flow capacity of Bayou Lafourche to +/-100,000 cfs to provide a conveyance channel that would push fresh water and sediment farther to the south. A series of side-splits would be constructed in appropriate locations along the lower reach of the channel to provide local sub-deltas/splays for land-building purposes. The group recognized that this alternative would likely be impossible to implement because of the significant effect on the ridge communities in the project area. The alternative was included to illustrate that the impact of the Third Delta or other similar projects, while significant, are likely much less than options that might be technically feasible, but entirely unacceptable from a socio-economic and political perspective.

Alternative 3

This alternative involves construction of a large (+/-150,000 cfs) capacity diversion channel from the Mississippi River directly into Lake Cataouatche and Lake Salvador. This diversion would create a delta that would initially fill Lake Cataouatche, eventually prograding into and through Lake Salvador. Issues in the western part of the basin would be addressed by diverting water from the Mississippi and Atchafalaya Rivers through the Verret Basin.

Alternative 4

This alternative involves construction of levees around the ridge communities to provide flood protection and then creating large diversions into both the Barataria and Terrebonne basins that would provide freshwater and sediment in a manner similar to the natural delta-building process in these areas in the absence of the flood control works.

Summary

A two-day workshop was conducted with approximately 30 participants from local, state, and federal agencies, academics, and consultants. The workshop developed conceptual alternatives to the Third Delta Conveyance Channel project. The primary goal of the alternatives was the restoration of a sustainable, diverse ecosystem; the primary pathway to this goal was the large-scale creation of wetland habitat in the Barataria and Terrebonne Basins. Alternatives were developed with varying means of sediment delivery (pipelines

and natural systems) and sediment supply (rivers and offshore). Figures 1 through 3 demonstrate the primary components of the alternatives as developed in the workshop. Project components and features shown in Figures 1 through 3 can be "mixed" to provide a potentially more effective combination of project features to better meet the overall goals.

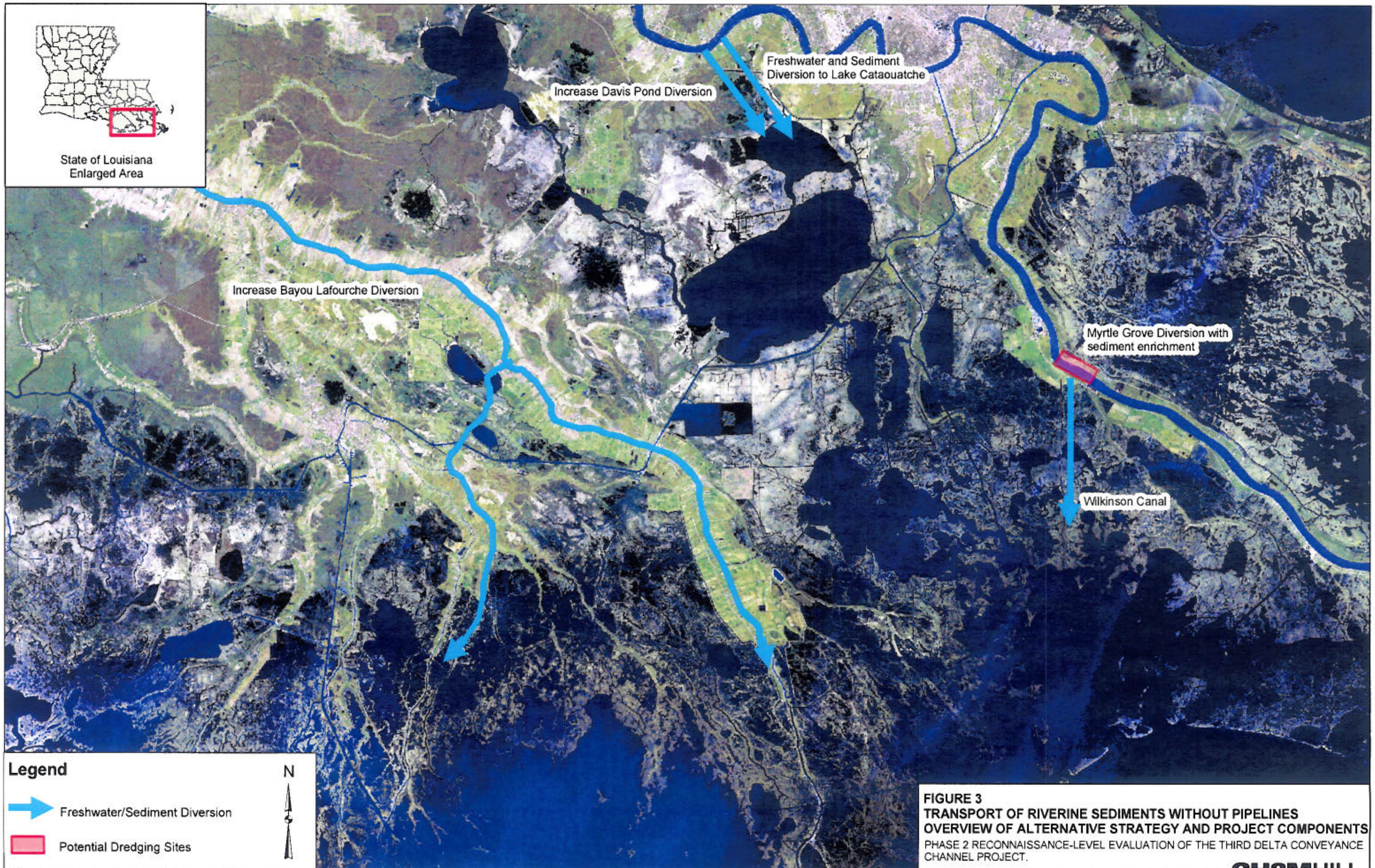

FIGURE 3
TRANSPORT OF RIVERINE SEDIMENTS WITHOUT PIPELINES
OVERVIEW OF ALTERNATIVE STRATEGY AND PROJECT COMPONENTS
PHASE 2 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT.

APPENDIX A

Final Attendance List

APPENDIX A

Third Delta Phase 2 Workshop - List of Participants
May 11-12, 2005
Nicholls State University, Thibodaux, Louisiana
List of Participants

Name	Organization	Title	Expertise	E-Mail	Phone
Armand, Jennifer	Restore or Retreat		Marketing	jbarmand@bellsouth.net	(985) 448-4485
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Zeringue, Jerome	Terrebonne Levee & Conservation District	Director		jzee@tlcd.org	(985) 594-4104

APPENDIX B

Workshop Handout Material

Agenda

Phase 2 - Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

May 11 - 12, 2005
Nicholls State University, Thibodaux, LA

	Agenda Topics
	Day 1
8:30 – 9:00	Complimentary Continental Breakfast
9:00 – 9:20	Welcome and Introductions Ground Rules Expectations Agenda Review
9:20 – 9:50	Background Presentation on Phase 1 Evaluation
9:50 – 10:00	Break
10:00 – 12:00	Decision-Making Framework • Project Goals and Objectives • Performance Measures
12:00 – 1:00	Lunch (provided)
1:00 – 2:00	Goals and Performance Measures - continued
2:00 – 3:00	Validation of Initial Proposed Alternatives (strategy table) • Data Availability and Analysis Needs • Preliminary Development of Criteria for Evaluation
3:00 – 3:15	Break
3:15 – 3:45	Identification of Stakeholders and Discussion
3:45 – 4:30	Day 1 Wrap-Up • Parking Lot Issues • Preview of Day 2
4:30 – 6:30	Reception Sponsored By Restore & Retreat

	Day 2
7:30 – 8:00	Continental Complimentary Breakfast
8:00 – 8:30	Review of Day 1 Progress • Review of Performance Measures
8:30 – 9:15	Review of Initial Proposed Alternative Groups (three sources of sediment: Mississippi River, Atchafalaya, and offshore) • Technical Feasibility and Potential Challenges/Areas of Scientific and Technical Uncertainties • Comparison to Goals, Objectives and Performance Measures (defined on Day 1)
9:15 – 9:30	Break
9:30 – 12:00	Breakout Sessions – Conceptual Project Development (three groups, each group handles one of three main alternative groups)
12:00 – 1:00	Lunch (provided)
1:00 – 2:30	Report Results of Breakout Sessions to Group (20 minutes each, then discussion)
2:30 – 3:15	Discussion of Technical Challenges (potential emphasis on dredging and conveyance/long distance transport)
3:15 – 3:30	Break
3:30 – 4:00	Identification of Data Collection and Analysis Needs for Proposed Alternatives
4:00 – 4:30	Day 2 Wrap-Up • Parking Lot Issues • Next Steps

DIRECTIONS TO NICHOLLS STATE UNIVERSITY
Nicholls State University Physical Address:
906 East First St. Thibodaux, Louisiana

Directions from New Orleans

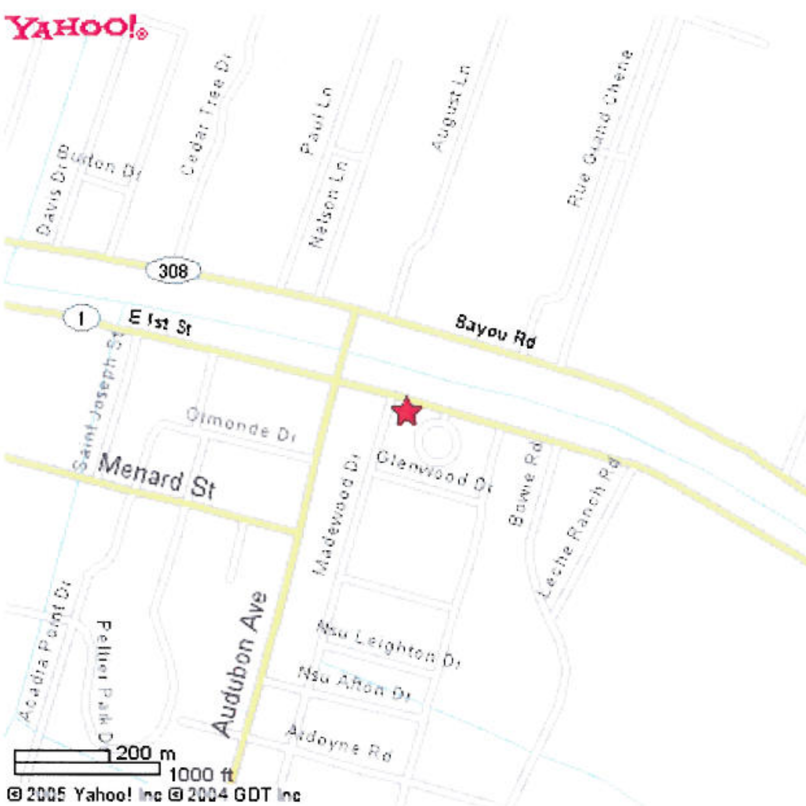
1. Left on Interstate 310 South via I-310 bridge over Mississippi River for 8.6 miles.
2. Exit 1-310 right at Houma/Raceland exit onto U.S. Hwy. 90 West for 13.8 miles.
3. Take the Thibodaux/Lockport exit onto La. 1 northbound for 16 miles. The Nicholls campus is on the left.

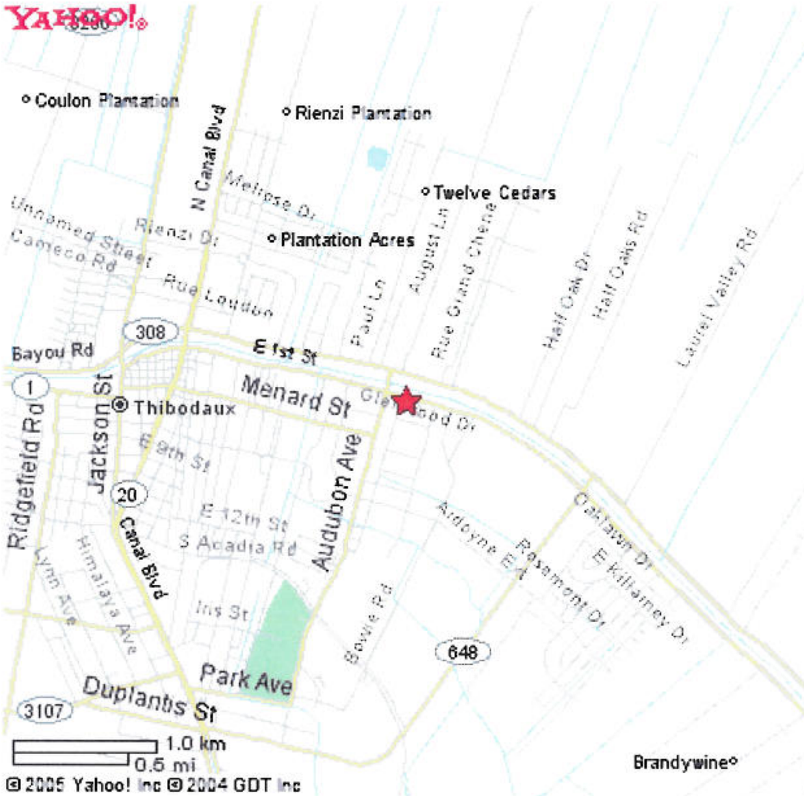
Directions from Baton Rouge

1. Take I-10 East (right) to New Orleans at the split with I-12.
2. Drive I-10 East 22.6 miles to Exit 182 (Sunshine Bridge exit) and exit to right on La. Hwy. 22. Drive 6/10ths of a mile and turn left on La. Hwy. 70.
3. Drive 9.4 miles crossing Sunshine Bridge (pay $1 toll) to Spur 70 split from La. Hwy. 70 (left fork). Watch out for four-way stop right after split.
4. Drive 6.7 miles and Spur 70 splits again. Get in left lane and take left Spur 70 for 2.6 miles where it deadends at La. Hwy. 1. You will cross Bayou Lafourche.
5. Take a left and drive La. Hwy. 1 for 21.8 miles to front of Nicholls State campus. La. Hwy. 1 parallels Bayou Lafourche all the way to Nicholls State.

Directions from Lafayette

1. Interstate 49 (I-49) East/LA Hwy 90 East.
2. Pass through Morgan City continuing on LA Hwy 90 East.
3. Take the Thibodaux/Houma Exit and turn left towards Thibodaux onto Hwy. 24.
4. Drive on Hwy 24 (road turns into Hwy. 20 for 8.7 miles into the city of Thibodaux and La. Hwy. 1.
5. Turn right onto Hwy. 1 South and drive 1 mile to the Nicholls campus.
6. Turn right onto Audubon Drive (Nicholls State University sign) or you can drive through the campus by turning onto Acadia Drive.




Coulon Plantation
Rienzi Plantation
Twelve Cedars
Plantation Acres
N Canal Blvd
Melrose Dr
Rienzi Dr
Cameco Rd
Rue Loudon
August Ln
Rue Grand Chene
Paul Ln
Half Oak Dr
Half Oaks Rd
Laurel Valley Rd
308
Bayou Rd
E 1st St
1
Menard St
Thibodaux
Ridgefield Rd
Jackson St
E 9th St
20
Audubon Ave
Canal Blvd
E 12th St
S Acadia Rd
Ardoyne Ext
Rosemont Dr
E Killarney Dr
Himalaya Ave
Lynn Ave
Iris St
Bowie Rd
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Park Ave
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Brandywine
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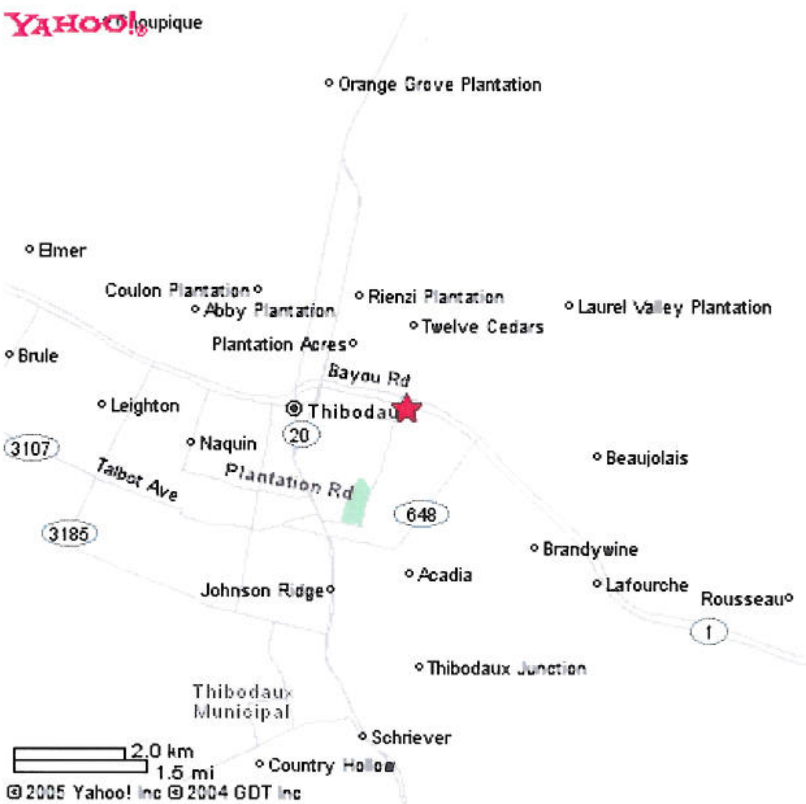
Orange Grove Plantation
Elmer
Coulon Plantation
Abby Plantation
Rienzi Plantation
Twelve Cedars
Laurel Valley Plantation
Brule
Plantation Acres
Bayou Rd
Leighton
Thibodaux
20
3107
Naquin
Beaujolais
Talbot Ave
Plantation Rd
648
3185
Brandywine
Acadia
Lafourche
Johnson Ridge
Rousseau
1
Thibodaux Junction
Thibodaux Municipal
Schriever
2.0 km
1.5 mi
Country Hollow
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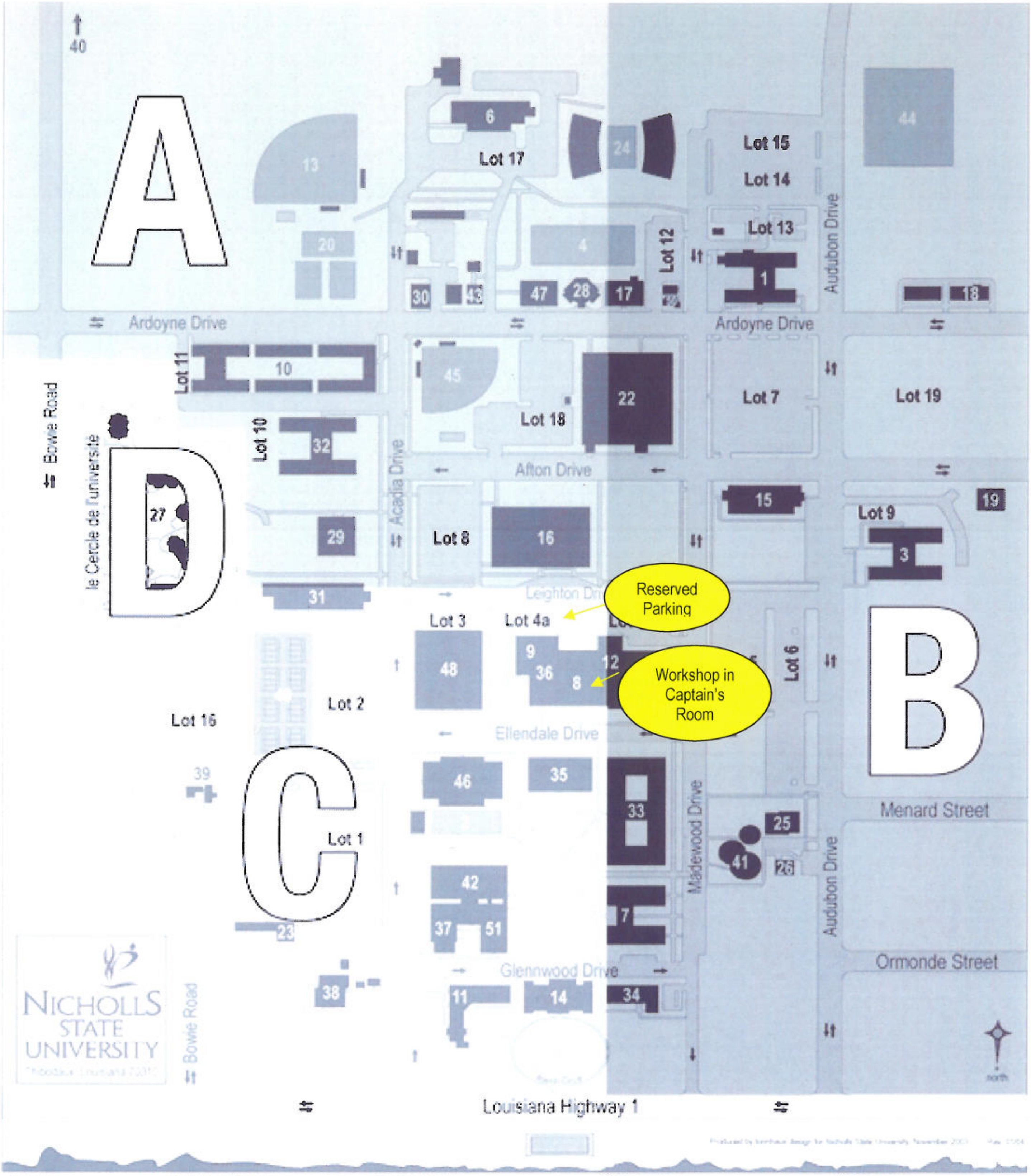


1 Ayo Hall
2 Ayo Swimming Pool
3 Babington Hall
4 Band Practice Field
5 Baptist Student Center
6 Barker Hall and Annex
7 Beauregard Hall
8 Bollinger Student Union
9 Bookstore
10 Calecas Hall
11 Candies Hall
12 Cotillion Ballroom
13 Didier Field (Baseball)
14 Elkins Hall
15 Ellender Hall
16 Ellender Memorial Library
17 Family and Consumer Sciences
18 Family Housing
19 Family Service Center
20 Football Practice Field
21 Galliano Hall (Cafeteria)
22 Gouaux Hall
23 Greenhouse
24 Guidry Stadium
25 Historical Research Center D.H.T.
26 James Alumni House
27 La Maison du Bayou
28 Lindsley Hall (Music Annex)
29 Long Hall
30 Maintenance Buildings
31 Meade Hall
32 Millet Zeringue Hall
33 Peltier Hall
34 Picciola Hall
35 Polk Hall
36 Post Office
37 Powell Hall
38 Presidents Residence
39 Pupil Appraisal Center L.P.S.B.
40 Safety and Environmental Building
41 St. Thomas Aquinas Center (Chapel)
42 Shaver Gymnasium
43 SLEC / Region III Service Center
44 Soccer Field
45 Softball Field
46 Stopher Gymnasium
47 Student Publications & Printing
48 Talbot Hall
49 Tennis Courts
50 University Police (Information Center)
51 White Hall

Workshop Project Team Members

Bob Roberts is with the Louisiana Department of Natural Resources. Bob is trained as a civil engineer and has over 10 years experience in structural engineering, project planning, management, and design of coastal restoration projects. He received his bachelor's degrees in Civil Engineering and Economics from Louisiana State University. Bob is the Department of Natural Resources' Project Manager for the Third Delta Conveyance Channel Project and the Mississippi River Reintroduction into Bayou Lafourche projects.

John Rogers is with CH2M HILL and will be the workshop facilitator. John is trained in planning, biology and management science. His 30 years of experience in environmental issues includes over 140 projects working with corporations, government agencies and foundations. Throughout John's career he has had the opportunity to be involved with nationally recognized environmental issues. He developed the critical areas inventory for the Chesapeake Bay. He was the scientific coordinator for the New Jersey Pineland Comprehensive Plan. He worked on the development of the Maryland Critical Areas program. He facilitated the Vision for the Executive Committee for the Governors agreement to clean up the Chesapeake Bay. John coordinated the NW Watershed Partnership, a three day meeting of 750 stakeholders to help find solutions to the "spotted owl" issue. He worked on several major projects related to scientific research and funding of the Florida Everglades restoration. During that same period he helped develop the solution strategies methodology for the CALFED water supply plan in California. John recently directed studies on several research projects for the Great Lakes Protection Fund related to water diversions and Annex 2001. Additionally, he also directed effluent trading feasibility studies in Michigan, Pennsylvania and Mississippi. John is also helping to find ways to encourage a market-based approach to ecosystem restoration with EPA, and the State of Pennsylvania.

Steve Mathies is with CH2M HILL and has worked in coastal Louisiana for more than 20 years. He worked for the U.S. Army Corps of Engineers, New Orleans District, for about 18 years, leaving as Chief of their Breaux Act Project Management Branch and Executive Assistant to the Breaux Act Task Force. Steve served as Director of the Barataria-Terrebonne National Estuary Program during the development of their Comprehensive Conservation and Management Plan from 1991 to 1996. He also served as Deputy Secretary of the Louisiana Department of Natural Resources from 1996 thru 1997. He received a Ph.D. from Mississippi State University in 1981.

Chris Arts is with CH2M HILL and has worked as a civil engineer and manager for water resource projects for over 20 years. His experience encompasses planning, design and construction management of water resource and water/wastewater utility projects across the U.S. and abroad. Chris is currently the project manager for the Reconnaissance-level Evaluation of the Third Delta Conveyance Channel project and the Mississippi River Water Reintroduction into Bayou Lafourche project. He received his bachelor's degree from the University of Texas and his master's degree from the University of Washington in Seattle. Chris is a Registered Professional Engineer in three states.

Kyle Winslow is with CH2M HILL and received his Ph.D. from UC Berkeley in environmental fluid mechanics. He specializes in numerical modeling of coastal and estuarine processes and has 10 years of project experience in the application of multi-dimensional numerical models for coastal and estuarine circulation, contaminant transport, and sediment transport. Dr. Winslow served as the lead project engineer in the Phase 1 Reconnaissance Level Evaluation of the Third Delta Conveyance Channel Project. He is also involved in the numerical modeling effort being conducted for the Bayou Lafourche Freshwater Reintroduction Project, serving as senior QA/QC engineer.

Bob Mussetter. Dr. Mussetter is President and Principal Engineer at Mussetter Engineering, Inc. (MEI), and has over 25 years of experience in analysis and design for a broad range of water-resource and civil engineering projects. He has a Ph.D. in Civil (Hydraulic) Engineering from Colorado State University, and is a Registered Professional Engineer in 11 states. His primary area of technical expertise involves the integration of surface-water hydrology, multi-dimensional hydraulic analysis, sediment-transport modeling and river mechanics with fluvial geomorphology to solve river stability, instream habitat and flooding problems. His experience includes hydraulic and sediment transport modeling studies on many rivers and stream in the southeastern U.S., including the Mississippi, Red and Yazoo Rivers. Dr. Mussetter was a technical advisor to CH2M Hill on the Phase I Reconnaissance Level Evaluation of the Third Delta Conveyance Channel Project.

Executive Summary - Phase 1 Reconnaissance-level Evaluation of the Third Delta Conveyance Channel Project

Overview and General Conclusions

The Third Delta Conveyance Channel (TDCC) concept proposed by Gagliano and van Beek (1999) involves creating a new delta between the Atchafalaya River and Mississippi River Birdfoot Deltas. The new delta would have two distinct lobes, and would be formed by sediment carried through a constructed conveyance channel, following the eastern slope of the natural Bayou Lafourche levee system, and split into two channels near Raceland. One channel would terminate in Little Lake in Barataria Basin, and the second would carry sediment to Terrebonne Basin, ending near the Pointe au Chein Wildlife Management Area, north of Lake Felicity and Lake Raccourci.

Sherwood M. Gagliano and Johannes L. van Beek describe the concept of the TDCC in their report *Proposed Mississippi River Diversion Channel and Subdelta Building in the Barataria-Terrebonne Area of Coastal Louisiana* (Gagliano and van Beek, 1999). This report is included in an appendix to *Coast 2050: Towards a Sustainable Coastal Louisiana* (LCWCRTF and WCRA, 1998).

The Louisiana Department of Natural Resources authorized the Phase 1 reconnaissance-level study to evaluate the general feasibility of the TDCC project concept. The evaluation included submission of the following four intermediate draft reports, which made up the overall Phase 1 report:

- Task 2 – Data Collection and Review
- Task 3 – Engineering Design and Construction Feasibility
- Task 4 – Channel Conveyance Assessment
- Task 5 – Delta Building Analysis

In order to evaluate the general feasibility of the conceptual project, answers to several fundamental questions needed to be answered, including:

1) Given the underlying geology and constraints within the project area, can the conveyance channel and flood protection levees be constructed?

2) Is there adequate sediment load in the Mississippi River for delta building at the two sites?

3) Can the sediments be conveyed to the proposed delta areas in the Barataria and Terrebonne Basins?

4) Will the proposed pilot channel erode to the proposed channel capacity and discharge of 200,000 cubic feet per second (cfs)?

5) Will the proposed project result in new subdeltas being formed on both the Barataria and Terrebonne sides of Bayou Lafourche?

Our evaluation found the following:

1) The diversion structure, channel, and flood protection levees can be constructed. The channel levees can be constructed to USACE design standards by using in situ materials and typical levee construction practices.
2) Adequate sediment load is available in the Mississippi River for delta building.
3) Sediment and sand from the Mississippi River and eroded pilot channel can be transported to the proposed delta building sites.
4) A pilot channel with a discharge of at least 40,000 cfs is necessary to produce the desired channel erosion.
5) The proposed delta building sites can potentially receive more sand, retain more sand, and build land faster than is currently being exhibited at the Wax Lake Delta in Atchafalaya Bay.

Engineering Design and Construction Feasibility

Evaluation of Right-of-Way

The alignment identified by Gagliano and van Beek extends approximately 105 miles. Assuming a total project right-of-way of 1,500 feet, the project would impact approximately 15,000 acres of undeveloped land (90 percent of which is emergent or forested wetlands), 3,200 acres of developed land, and 900 acres of open water.

The project will require extensive relocation of oil, gas, and petrochemical pipelines and will impact several roadways (state and federal highways, regional and local roads) and two railroad alignments at three locations.

In addition, the project will cross Bayou Lafourche and result in the upper portion of the bayou becoming an impounded lake, and will cross the Gulf Intracoastal Waterway (GIWW) at two locations, possibly requiring lock systems to prevent major impacts to navigation.

The levee construction would intercept natural runoff from land along the Bayou Lafourche Ridge. Within the Barataria Basin, a drainage area of approximately 80,000 acres would be impacted.

Diversion Structure

For the TDCC project, a control structure or multiple structures will be required to divert water and sediment from the Mississippi River. It was determined that the Old River Control Complex (ORCC) serves as an appropriate design analog for the proposed diversion structure. For an effective discharge of 200,000 to 300,000 cfs, a structure similar to the ORCC Auxiliary Structure with seven gate bays would be adequate to divert the flows.

Designs for the proposed diversion structure may incorporate special features to manage sediment and sand intake, allowing for variable sediment loads during the erosional phase of the initial pilot channel and the equilibrium conditions of the final design channel.

Channel Excavation/Levee Design

Based on the initial investigations, it is anticipated that the in situ materials are generally suitable for constructing both sacrificial and flood control levees for the TDCC. It is assumed that levees will be designed and constructed in accordance with USACE design standards. To obtain materials suitable for construction, it may be necessary to stockpile preferable near surface natural levee, point bar, and interdistributary and backswamp materials, and waste the highly organic materials within the inland swamps and marsh areas.

It is anticipated that sacrificial and flood control levees for the TDCC project will be constructed using a combination of uncompacted and semi-compacted methods. Both types of levees are commonly designed and constructed in southeast Louisiana by USACE. Our review of geologic conditions along the proposed channel route indicates that a pilot channel could be constructed over the entire length of the proposed project, and that suitable material would be available locally to construct necessary guide and flood protection levees.

Channel Conveyance Assessment

Assessment of Pilot Channel

The initial channel design was evaluated to ensure that the grain shear stress in the channel exceeds the threshold for erosion, and that the flow is capable of conveying the sediment from the diversion at the Mississippi River to the delta building areas. A matrix of design scenarios uniquely defined by the geometry and discharge was set up for evaluation of the pilot channel. A HEC-RAS model was employed to conduct the hydraulic calculations, based on the assumptions of steady-state and non-uniform flow. A spreadsheet tool was developed for calculating the grain shear stress from the HEC-RAS model results. The USACE SAM Hydraulic Design Package for Channels was used for sediment transport capacity evaluations.

The analysis found that pilot channel designs with a discharge of 20,000 cfs fail to exceed the critical erosive stress. The average channel velocity under the scenarios evaluated ranged from 3 to 3.6 feet per second (fps). Numerous different initial channel geometries were subsequently investigated. For a given channel width and invert location, erodibility increases with the value of the design discharge. The minimum discharge for a channel design resulting in an erosive flow regime was 40,000 cfs, with an average channel velocity of 4.3 fps. Channel geometries with deeper invert location and design discharge values up to 120,000 cfs were evaluated. For a given design discharge, the available stage in the Mississippi River was found to be the limiting factor for the channel instability.

The sediment transport capacity calculations were performed for the pilot channel designs that satisfied the erodibility criterion. The Toffaletti transport function was employed for these calculations. The analysis determined that all the selected pilot channel designs would

maintain a sediment transport capacity in excess of the expected sediment supply, at the design discharge conditions. Furthermore, the stream power in these designs was found to exceed the stream power for the Wax Lake Outlet channel. The selected designs, with bottom widths ranging from 50 to 200 feet and discharge values ranging from 40,000 to 120,000 cfs, are presented in the Task 4 report.

Assessment of Final Channel

The final channel was evaluated to ensure that the sediment supply required for building the sub-delta lobes can be conveyed under the conditions of long-term equilibrium. HEC-RAS and SAM modeling tools were used for the design evaluations for the final channel, consisting of a common initial reach splitting into two distributary reaches. It was assumed that a diversion structure would regulate the flow and sediment discharge into the lower reaches.

The design approach for the final channel is based on the "effective" discharge principle. Numerous geometries with effective discharge values of 200,000 and 300,000 cfs were investigated for the final channel design. Based on initial investigations, a design with a bottom width of 700 feet and an effective discharge of 300,000 cfs was found to realize the maximum sediment transport capacity, under the conditions of long-term equilibrium. Furthermore, the transport capacity was commensurate with the expected sediment loads in the TDCC. This design was also evaluated by using the SAM tools for dimensional stability analysis. The design dimensions of the common initial reach were found to match the stable dimensions predicted by the Copeland method.

Although a uniform side slope of 3:1 was assumed for the modeling investigations, the side slopes for the final channel may be more gradual, as exhibited at Wax Lake Outlet (documented by the 1996 cross section to have side slopes on the order of 5:1 or 6:1). The results of the stability analysis demonstrate that stable channel geometry may be achieved for the proposed effective discharges. Although the channel geometry would be altered, the overall feasibility of the design would not be affected by changes in the channel side slope. The change in lateral extent of the channel and levee footprint, if the side slopes evolved to a 6:1 side slope, is an increase of about 16%, to an average footprint width of 1700 feet. Also, in comparisons to the Wax Lake Outlet, one must keep in mind that the Atchafalaya River system is not managed to maximize sediment transport. The TDCC will be managed to maximize sediment transport to the subdeltas, and the evolution of the channel side slopes may or may not proceed in a similar fashion to the Wax Lake Outlet.

Channel Evolution

A key feature of the TDCC project is that the full conveyance capacity of the channel will be developed over time, as the pilot channel erodes to the dimensions of the final design channel. The pilot channel is designed with the objective of maximizing the erosive shear stress and the sediment transport capacity of the flow, within the constraints of available flow and stage at the diversion point from the Mississippi River.

The mechanisms and extent of channel growth depend on the hydraulic flow regime and the physical and geotechnical properties of the channel. The TDCC channel course will pass through mainly interdistributary and back swamp deposits, which are characterized by high clay fractions and are generally classified as cohesive sediments. The channel growth in

cohesive material is a combined result of the processes of fluvial erosion and bank failures because of mass instability.

Over the long-term, the channel can be expected to erode if the operational regime for the channel includes flows that produce a fluvial grain shear stress exceeding the critical erosive stress of the native materials, and the sediment transport capacity of the flow exceeds the combined sediment load from the Mississippi River and from erosion of native channel sediments.

The following two methods were employed to estimate potential erosion of the TDCC:

- The empirical method derived from laboratory studies
- The use of a reference channel

An initial estimate of an annual erosion rate applicable to the TDCC was derived from a grain shear stress cumulative frequency distribution for the initial pilot channel with a bottom width of 200 feet and an invert elevation of -35 feet NGVD. The annual erosion rate following this procedure is estimated to be 269 kilograms per square meter (kg/m^2), which equates to approximately 18 cm/year (0.6 feet/year). A second estimate of erosion is made based on the premise that Wax Lake Outlet may serve as an analog to the lower reaches of the TDCC. Based on the maximum vertical and area erosion rates in the Wax Lake Outlet, the channel would be expected to evolve over a period of 40 to 44 years. Because of the range of erosion rates and the level of uncertainty that the estimates are based on at the screening level stage, it is concluded that the channel may be expected to evolve over 20 to 60 years.

Delta Building Analysis

Wax Lake Delta Design Analog

Extensive comparisons were made between existing conditions in Atchafalaya Bay, the location of two actively prograding deltas, and the proposed delta building locations in Barataria and Terrebonne Bays. The Wax Lake Delta, and to a lesser extent the Lower Atchafalaya River Delta, were used as design analogs to the proposed deltas expected to build at the terminal ends of the TDCC.

Analyses were conducted to quantify the total sediment and the sand portion carried to both the Wax Lake and the Lower Atchafalaya River Deltas. The wind and wave climates in Atchafalaya Bay, which play a large role in delta growth, were calculated for comparison to the proposed delta building locations. Growth rates of the deltas in Atchafalaya Bay were summarized for use in comparative predictions to the proposed deltas.

Comparison of Third Delta Lobes with Wax Lake Delta

The study demonstrated that the proposed delta building locations have several advantages over Atchafalaya Bay. The two sites in Terrebonne and Barataria Bays are generally very shallow, with average depths of 3 to 6 feet. Both sites are sheltered from wind by historical marshes, and protected from open ocean by a historical barrier island chain. Additionally, the sheltered locations have a lower wind-induced wave energy climate than exists in Atchafalaya Bay. The predicted wave energy in Atchafalaya Bay is 134 percent of that in

Lake Felicity, and 494 percent of that in Little Lake. The lower wave climates at the proposed delta building locations indicate that sediment and sand delivered to those locations will be more likely to remain there than it would in Atchafalaya Bay. The sediment retention in Barataria and Terrebonne Bays is expected to be higher than in Atchafalaya Bay.

A range of proposed sediment diversion scenarios were investigated to determine the sensitivity of the results to the sediment load being diverted into the channel. Calculated sand transport rates demonstrate that more sand can be carried to each of the proposed delta building locations than is currently carried to the Wax Lake Delta. The potential annual average sand transport to each subdelta lobe under Diversion Scenario C (300,000-cfs peak flow) would be 5.68 million tons per year (tons/year), compared to 3.18 million tons/year carried to the Wax Lake Delta and 8.60 million tons per year carried towards the Lower Atchafalaya River Delta. For diversion Scenario A, with a peak flow of 200,000 cfs, the estimated average sand load drops to 4.18 million tons/year.

Delta Building Rates

The governing variables of delta growth and sustainability, such as sediment supply, wave and current energy regime, subsidence, bathymetry, and sediment characteristics, were compared to demonstrate that the proposed delta building locations are each more conducive to delta building than the locations in Atchafalaya Bay. The conclusion of the delta building analysis is that the selected delta building locations will receive more sand, retain more sand and build land faster than the Wax Lake Delta has built land in Atchafalaya Bay. Table ES-1 presents the historical growth rates for comparison.

TABLE ES-1
Summary of Subaerial Delta Land Mass and Growth Rates

	Delta Area Above −2.0 feet (square miles)			Growth Rates (square miles per year)		
	1981	1989	1994	1981-1989	1989-1994	1981-1994
Wax Lake Delta	7.6	18.5	24.3	1.4	1.2	1.3
Lower Atchafalaya River Delta	26.0	33.0	39.2	0.8	1.2	1.0

Description of Alternative Project Concepts to the Third Delta Conveyance Channel

The Louisiana Department of Natural Resources (LDNR) has tasked CH2M HILL with investigating alternatives to the Third Delta Conveyance Channel (TDCC) Project as part of a reconnaissance-level feasibility study of the project concept. Out project team is requesting your assistance in formulating viable alternatives to characterize in further detail. At this stage in the study, the emphasis will be placed on identification of alternatives that are significantly different in nature from the original TDCC project concept. This means that modifications specific to the TDCC project concept discussed in the Phase 1 report, such as alternative alignments and variations to inflow hydrology, will not be included in this current investigation. The goal is to develop alternatives that meet the land building and preservation capacity of the Third Delta project, by alternate means, as input into a more detailed feasibility analysis.

Alternatives to the TDCC project that will accomplish the goals of sediment conveyance and extensive land building in the Barataria and Terrebonne basins can be categorized into three general groups of project alternatives:

- Group 1 - the use of existing, natural conveyance systems (i.e. Atchafalaya River system, Mississippi River) and diversions from these systems, to transport freshwater and sediment to Barataria and Terrebonne basins,
- Group 2 - the use of manmade conveyance systems (pipeline conveyance and dredged channel systems) to transport freshwater and sediment from the Mississippi River to Barataria and Terrebonne basins, and
- Group 3 - the use of manmade conveyance systems (pipelines) to transport sediment to Barataria and Terrebonne bays from the south (both inshore, near shore, and offshore locations).

The first group of potential alternatives to the Third Delta concept groups projects that transport freshwater and sediment from the Mississippi River or the Atchafalaya River to marshes in the Barataria and Terrebonne Basins. The LCA report presents several potential diversion locations where freshwater and sediment could be taken from the Mississippi and delivered to adjacent marshlands. Locations further down the Mississippi (i.e. Fort Jackson, Myrtle Grove, Empire, etc) are directly adjacent to marshes in Barataria Basin that would benefit from additional sediment without the need for extensive pipelines. However, without long distance transport of sediment the potentially benefited areas are limited to those immediately adjacent to the bank of the Mississippi River.

The concept of using the Atchafalaya River to transport sediment to the marshes in Terrebonne Basin would require significant transport west to east, whereas the predominant drainage systems in the vicinity are aligned roughly north to south. A significant feasibility analysis effort will be required for this concept, as increased flows in the GIWW traveling towards the east have a tendency to travel south down waterways such as the the Houma Navigation Canal, Bayou Terrebonne and others before reaching the easternmost marshes in the Terrebonne Basin. A potential solution may be the installation of gated control

structures to help control these losses and maintain the eastward flow towards Barataria Basin. It is likely that increased sediment transport via the Atchafalaya River and the GIWW will benefit marshes in Terrebonne Basin more so than marshes in the Barataria Basin.

The second group of alternatives is comprised of projects that would use mechanical means (e.g., dredging and pipelined conveyance systems) to transport sediment slurry from the Mississippi River to degrading marshes or to increase the sediment transported by proposed freshwater diversions. The LCA report details expected sediment delivery rates for several potential sediment enrichment projects that derive sediment from the Mississippi River, the largest of which include sediment diversions at Fort Jackson (150,000 cfs diversion and 6,293,000 cubic yards of sediment in 3 months via 30-inch dredge) and Myrtle Grove (150,000 cfs diversion and 6,293,000 cubic yards of sediment in 3 months via 30-inch dredge). Smaller sediment enrichment projects are proposed at Donaldsonville, Edgard, Lac des Allemands, and Pikes Peak. Several projects have also been proposed that would deliver sediment by pipeline, namely those at Bastian Bay, Empire, Main Pass, and Myrtle Grove, all of which are located in Subprovince 2 (see Figure 1, below).

To date, the LCA report has not listed any projects that carry sediment through pipelines to locations in Subprovince 3. Additionally, there are no long-distance sediment delivery systems, with length or capacity scales on the order of the proposed TDCC project, included in the LCA alternatives. Investigations regarding the potential use of oil and gas pipelines for the delivery of sediment to marshes have been undertaken (Woodward-Clyde Consultants, 1991; Pyburn & Odom, 1992). More recent projects have demonstrated the viability of transporting dredged sediments via pipeline for the creation of marshland (i.e. Bayou La Branche Wetland (1994, 203 acres), Atchafalaya River Delta Sediment Delivery (1998, 185 acres), Big Island Mining (1998, 922 acres), Lake Chapeau Project (1999, 260 acres), Sabine Refuge Marsh (2002, 200 acres)). The latest available information on slurry transport systems will be used to investigate the potential alternative of long distance pipelines carrying sediment from the Mississippi River to marshes in the Barataria and Terrebonne basins.

The third group of alternatives includes the use of dredging systems to supply sediment slurry via pipeline to marshes in Barataria and Terrebonne basins. The distinction between this group of alternatives and the second group of alternatives is the locations of the sediment borrow areas. In the second group of alternatives, sediment is mined from the Mississippi River. For Group 3 alternatives, sediment is mined from inshore, near shore, or offshore locations. The LCA report details several barrier island restoration projects in both Subprovinces 2 and 3. The location of borrow pits for these barrier island restoration projects are generally adjacent to the barrier islands themselves to minimize the effort of transporting sediment. For the same reason, it is likely that dredging borrow pits, for slurry transport of sediment to degraded marsh areas, will likely be adjacent to the marsh areas, limiting the distance for transport. The feasibility of offshore borrow pits and the preferential use of these locations for barrier island restoration projects as opposed to inland marsh restoration projects will be investigated. Impacts of local deepening of inshore open water areas by dredges as well as the quantity and composition of usable material should be investigated.

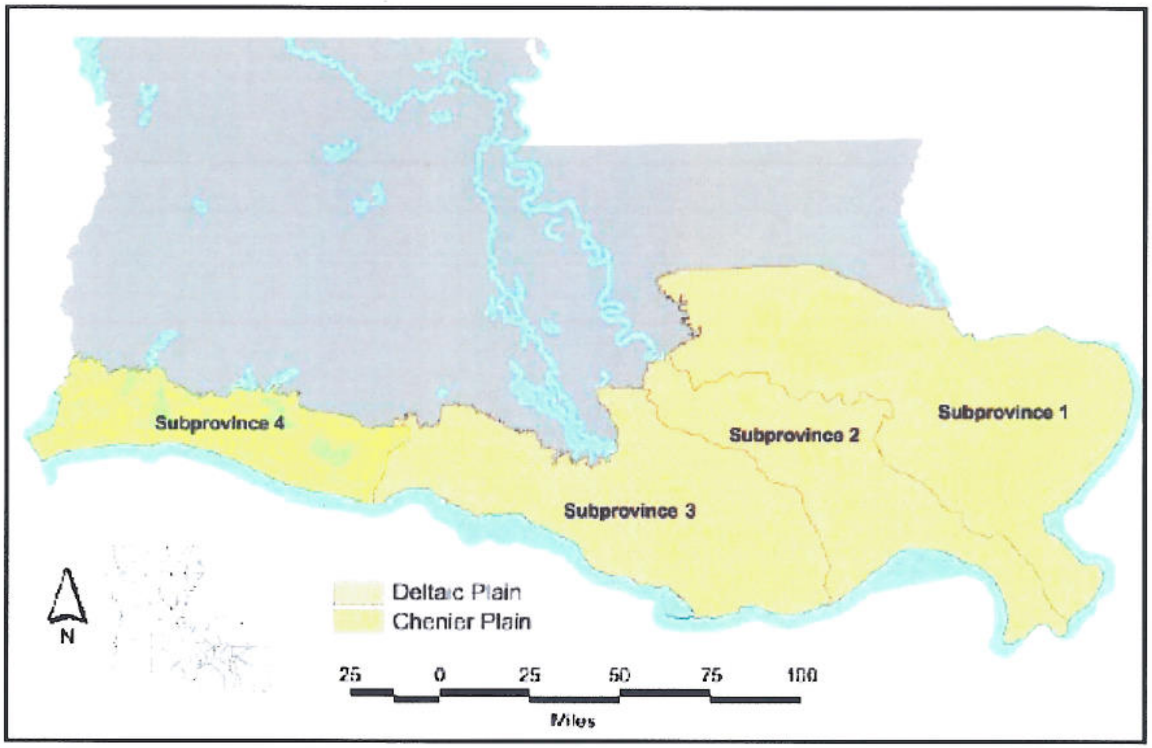


Figure ES-1. LCA Study Area and Subprovinces.

From: LCA Ecosystem Restoration Study Final Report – November 2004. U. S. Corps of Engineers, New Orleans District

APPENDIX C

Phase 1 PowerPoint Presentation

CH2MHILL

Third Delta Conveyance Channel Phase 1 Summary

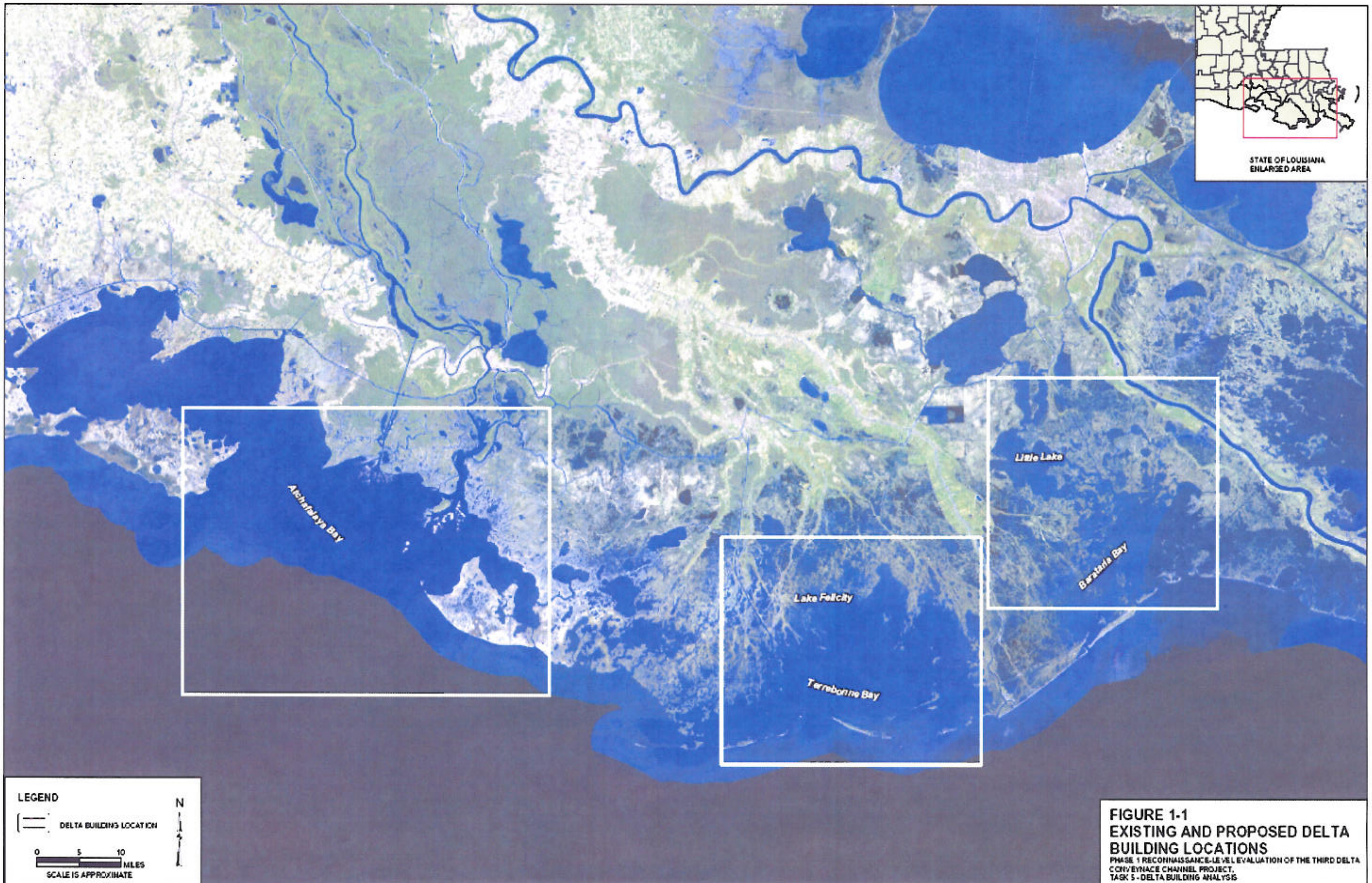
Wednesday, May 11, 2005

Nicholls State University

THIRD DELTA: Original Concept

- Diversion structure at the Mississippi River
- Parallel Bayou Lafourche for 65 miles
- Bifurcation to Terrebonne 35 miles
- Dam across Bayou Lafourche
- Initial flow 20,000 cfs, maximum flow 200,000 cfs

Existing and Proposed Delta Building Locations



RDD \\LOKI\PROJECTS\REDGIS\BLP\MXDS\THS\182503_46.MXD FIGURE_1_1.PDF 05/26/2004 17:54:38

Figure 4.2.1.1
USGS 7.5' Quadrangle Coverage of Potential Channel Alignments
Third Delta Conveyance Channel
Mississippi River, Louisiana

Legend
Channel Alignment

State of Louisiana
Enlarged Area

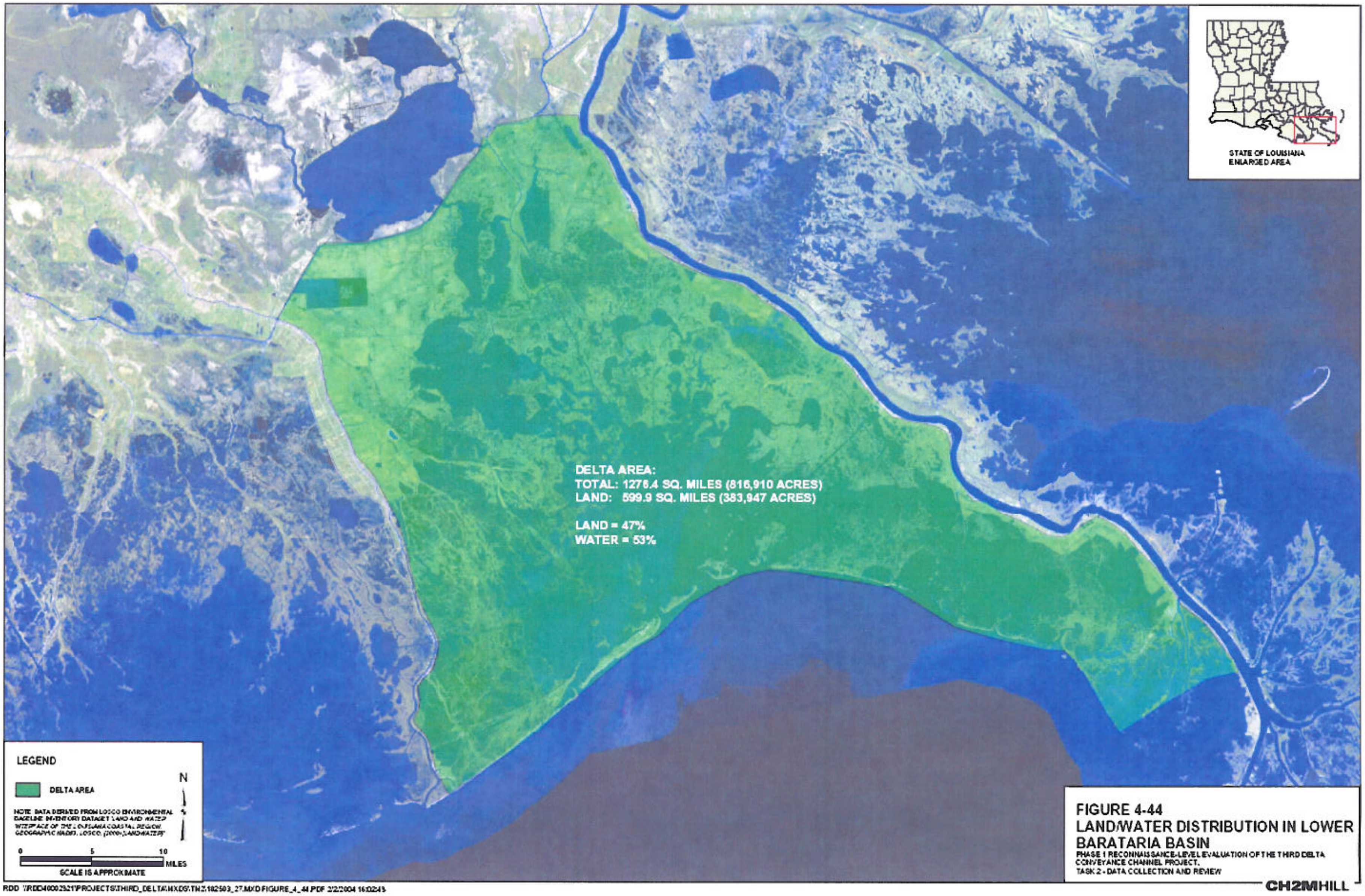
N

CH2MHILL

Sheet Number

Miles

Lower Barataria Basin Acreage



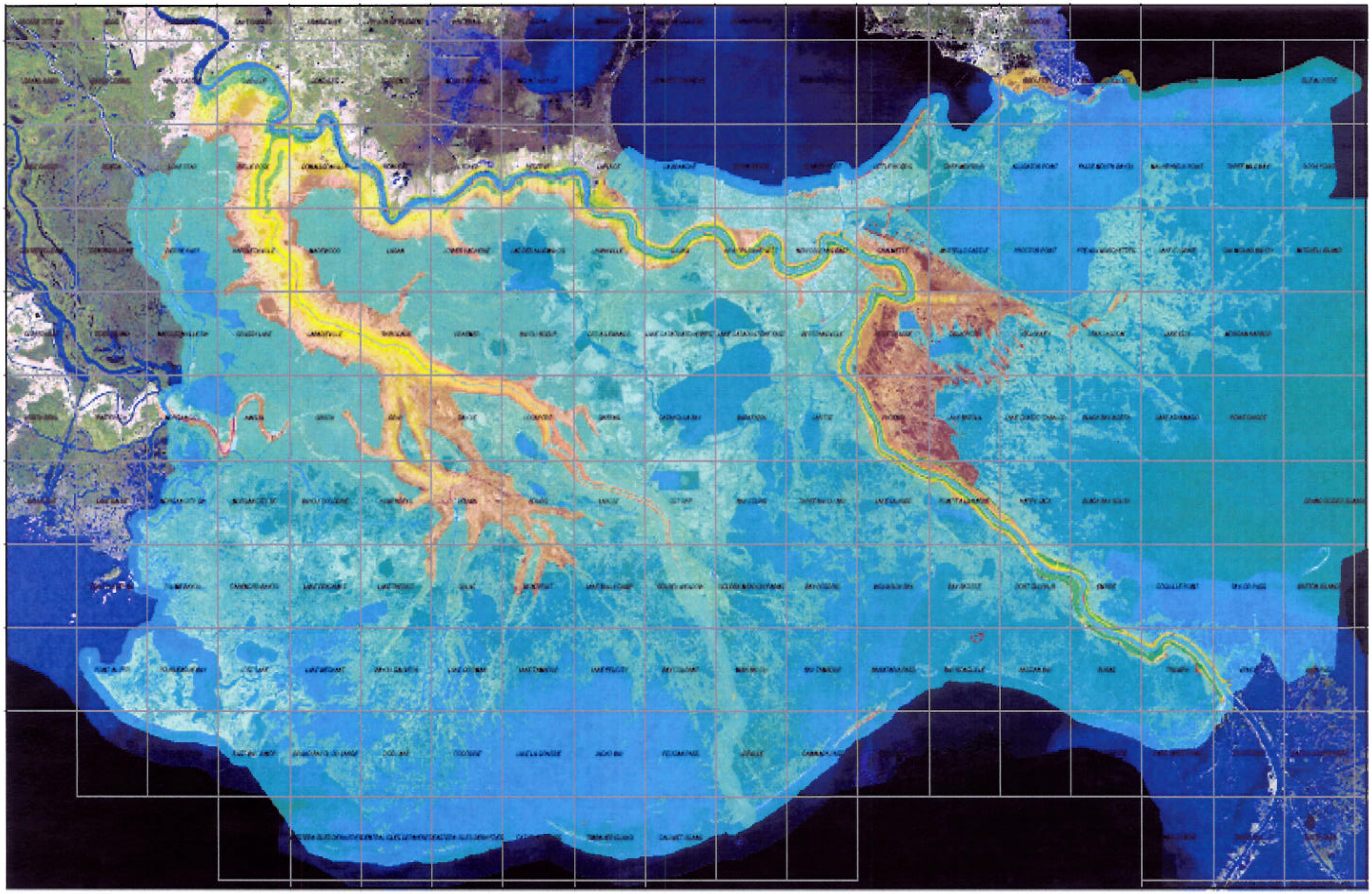
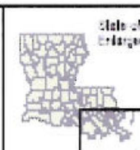


Figure 4.2.1.2
Elevation Countours from
USGS 30m DEM
Third Delta Conveyance Channel
Mississippi River, Louisiana

Legend
Elevation (m)



Sheet Number

Miles
0 2.5 5 10 15 20

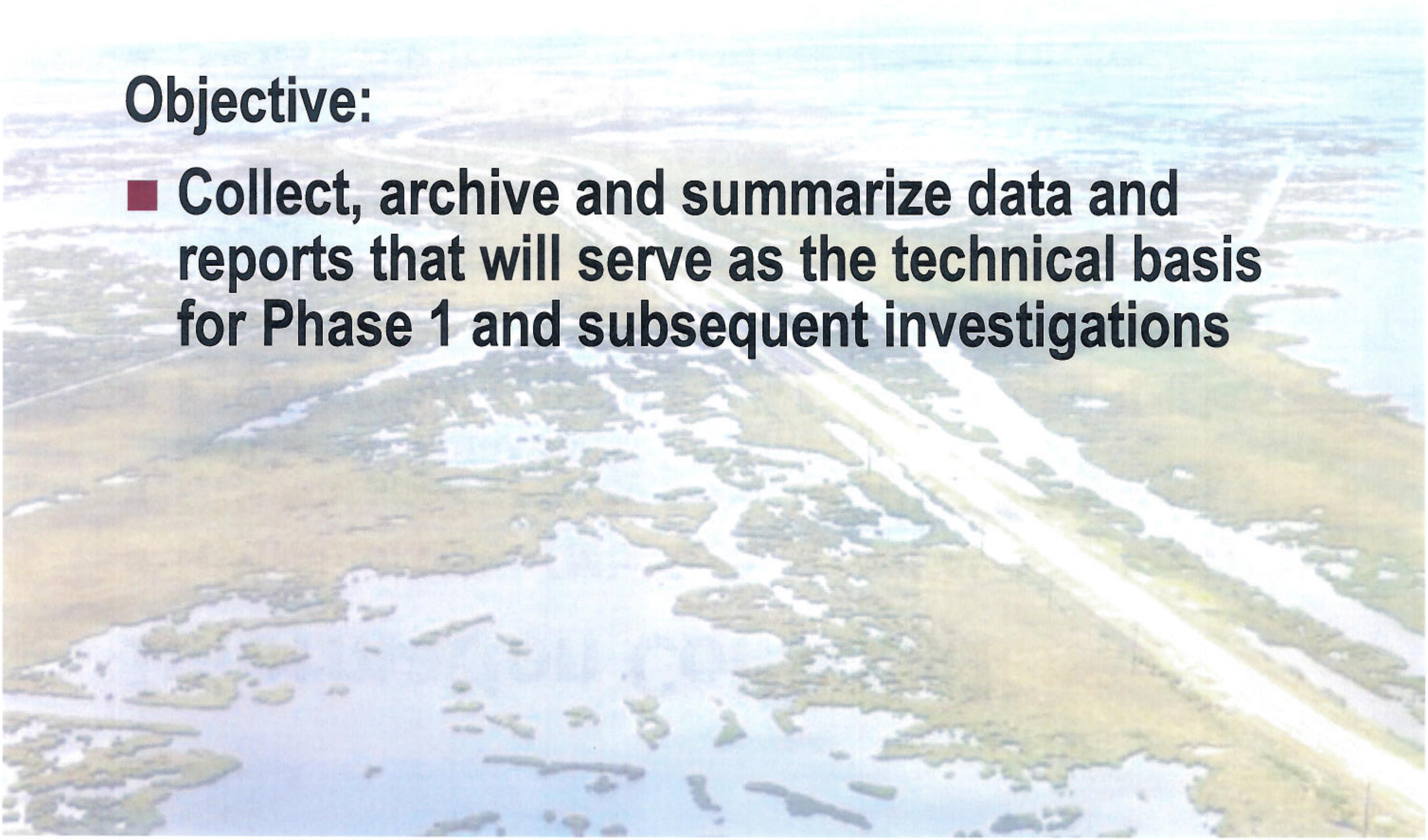
Reconnaissance Level Evaluation

- Phase 1: Is the proposed concept viable?
  - → Can the channel be constructed?
  - → Can the channel transport required sediment?
- Phase 2:
  - → Identify and evaluate project alternatives
  - → Environmental, engineering, and economic impacts
  - → Economic feasibility of implementation

Ph 1 Work Plan & Approach

- Task 1 - Project Management
- Task 2 - Data Collection and Review
- Task 3 - Engineering Design and Construction Feasibility
- Task 4 - Conveyance Channel Assessment
- Task 5 - Delta Building Evaluation

Task 2: Data Collection



Objective:

- Collect, archive and summarize data and reports that will serve as the technical basis for Phase 1 and subsequent investigations

Information Collected

- Hydraulic Data (Mississippi and Atchafalaya)
- GIS Database (Bathymetry, Land Use, Pipelines, Structures, Land/Water Interface)
- Existing Hydraulic Models and Documentation
- Soil surveys and geotechnical information
- Calculations and assumptions on concept project
- Sediment transport data
- Data and information on reference projects
- Coastal, meteorological, and oceanographic data

Reference Library Sources

- Louisiana Department of Natural Resources
- US Geologic Survey
- US Army Corps of Engineers, New Orleans District
- US Army Waterways Experiment Station, Vicksburg, Mississippi
- Louisiana State University
- National Ocean and Atmospheric Administration (NOAA)
- University of New Orleans
- Tulane University

Task 3: Construction Feasibility and Engineering Design

Objective:

- Generally assess the feasibility of constructing the TDCC project, identify potential impacts to existing infrastructure

Results of Task 3 Investigation

- Evaluation of right-of-way
- Discussion of diversion structures
- Summary of regional geology
- Levee design considerations

Right-of-way Evaluation

- Reviewed original proposal alignment
- Catalogued impacts to Federal highways, regional and local roads, railways
- Catalogued impacts to petrochemical and utility infrastructure
- Investigated land use impacts

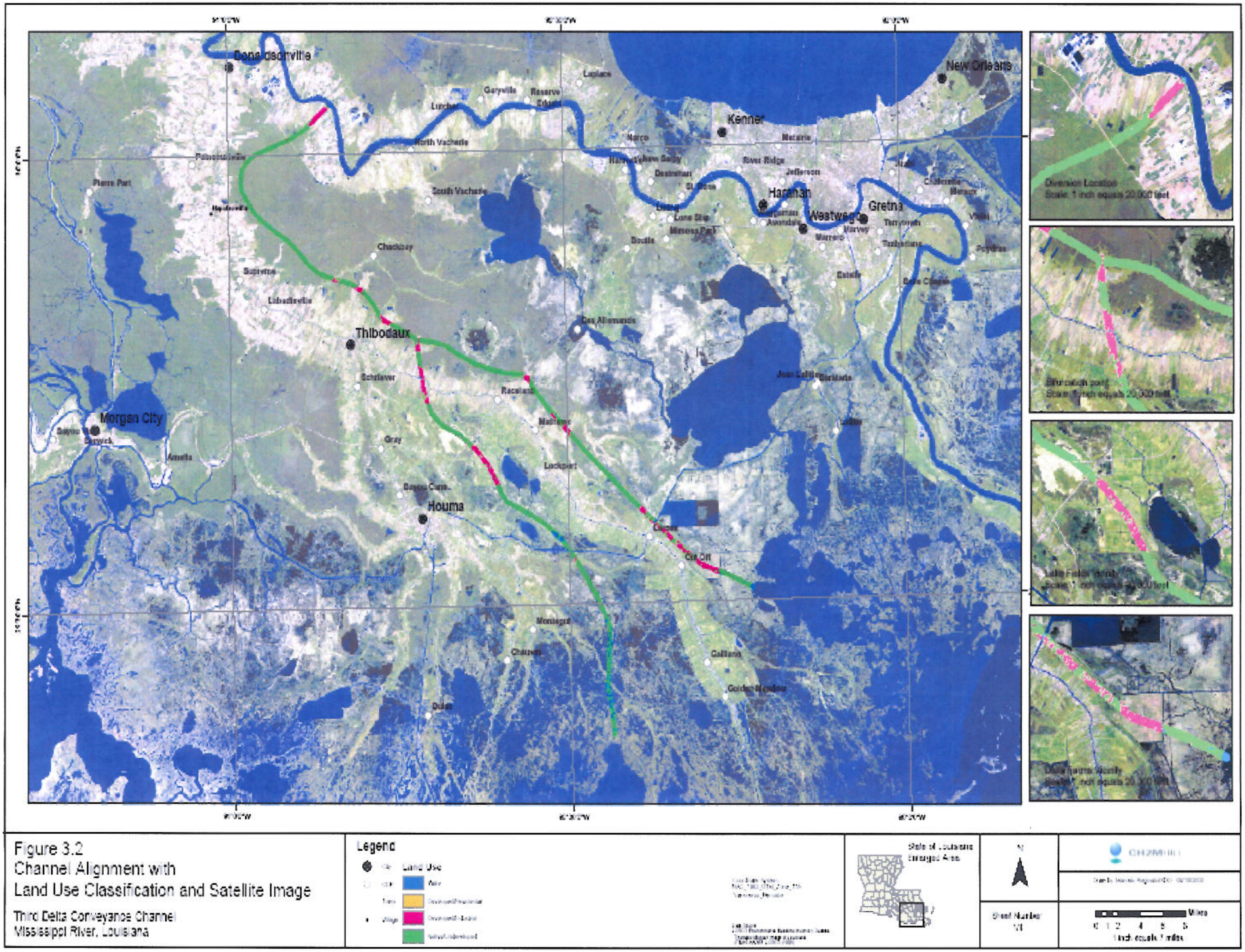
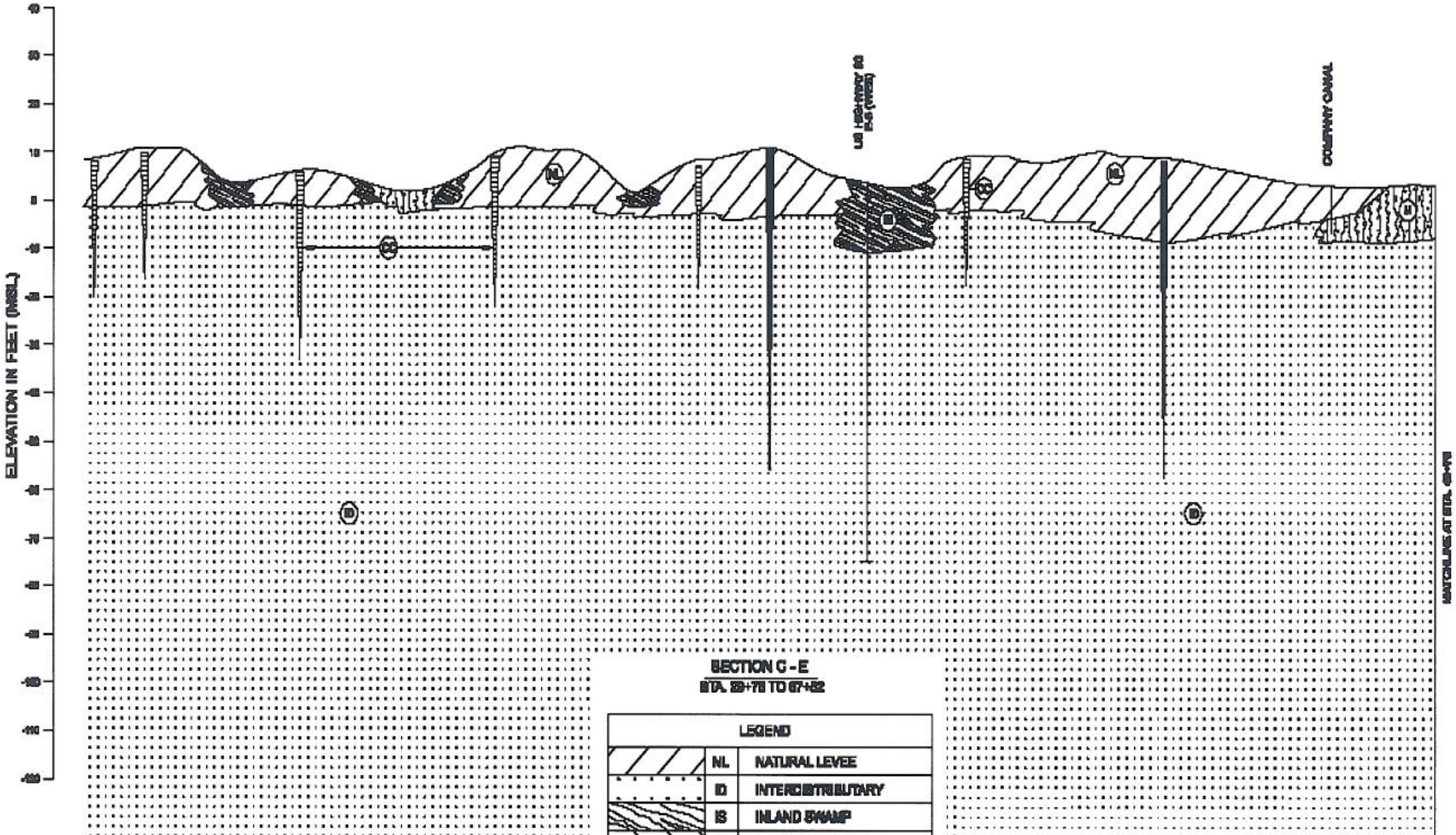


Figure 3.2
Channel Alignment with
Land Use Classification and Satellite Image

Third Delta Conveyance Channel
Mississippi River, Louisiana

Regional Geology

- Proposed route runs through numerous historic courses of the Mississippi River
- Landforms are primarily low-lying flatlands with intermittent natural levees
- Alignment traverses Mississippi River Alluvial Valley and Deltaic Plain
- Soils primarily composed of interdistributary soils and backswamp deposits



SECTION C - E

STA. 29+75 TO 67+52

LEGEND		
	NL	NATURAL LEVEE
	ID	INTERDISTRIBUTARY
	IS	INLAND SWAMP
	AL	ARTIFICIAL LEVEE
	AD	ABANDONED DISTRIBUTARY
	BS	BACKSWAMP
	M	MARSH
	CC	CREVASSE CHANNEL
	P	PLEISTOCENE
	AC	ABANDONED COURSE

HORIZONTAL SCALE - 1" = 1.6 MILES

EUSTIS ENGINEERING COMPANY, INC.

3011 28TH STREET — METAIRIE, LOUISIANA

GEOLOGIC PROFILE
REACH 2
BIFURCATION TO LITTLE LAKE (SECTION C - E)

RECONNAISSANCE LEVEL EVALUATION
OF THE THIRD DELTA CONVEYANCE CHANNEL
MISSISSIPPI RIVER, LOUISIANA

DRAWN BY: D. LAFONT	PLOT DATE: 10 NOV. 99	CADD FILE: FIGURE 4.DGN
CHECKED BY: J.J.H.	JOB NO.: 16088	FIGURE A.1 SHEET 1 OF 5

Construction Feasibility / Levee Construction

- **Interdistributary soils** - considered excellent suitability for construction of uncompacted levees, and of good suitability for construction of semi-compacted levees
- **Backswamp soils** - considered suitable for construction of uncompacted levees, and not suitable for construction of semi-compacted levees
- Assumed that the highly organic upper layer of marsh deposits will not be used for levee construction

Task 4: Conveyance Channel Assessment

Objectives

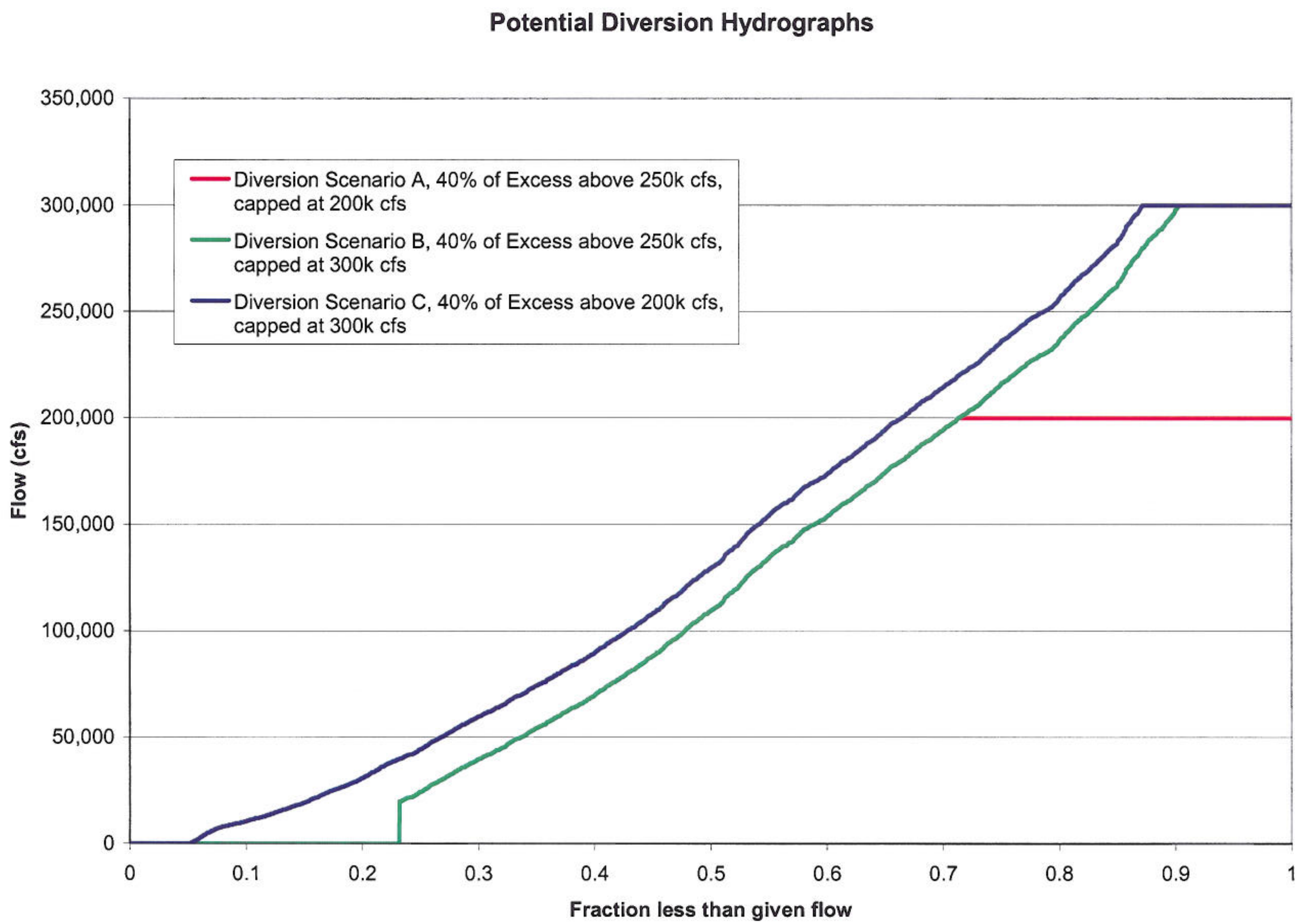
- Characterize the hydraulics and sediment transport potential in the proposed pilot channel for a range of hydrologic conditions
- Estimate the spatial and temporal evolution of a pilot channel as it erodes toward the ultimate configuration.
- Evaluate hydraulics and sediment transport potential for fully developed (200,000 cfs capacity) channel.

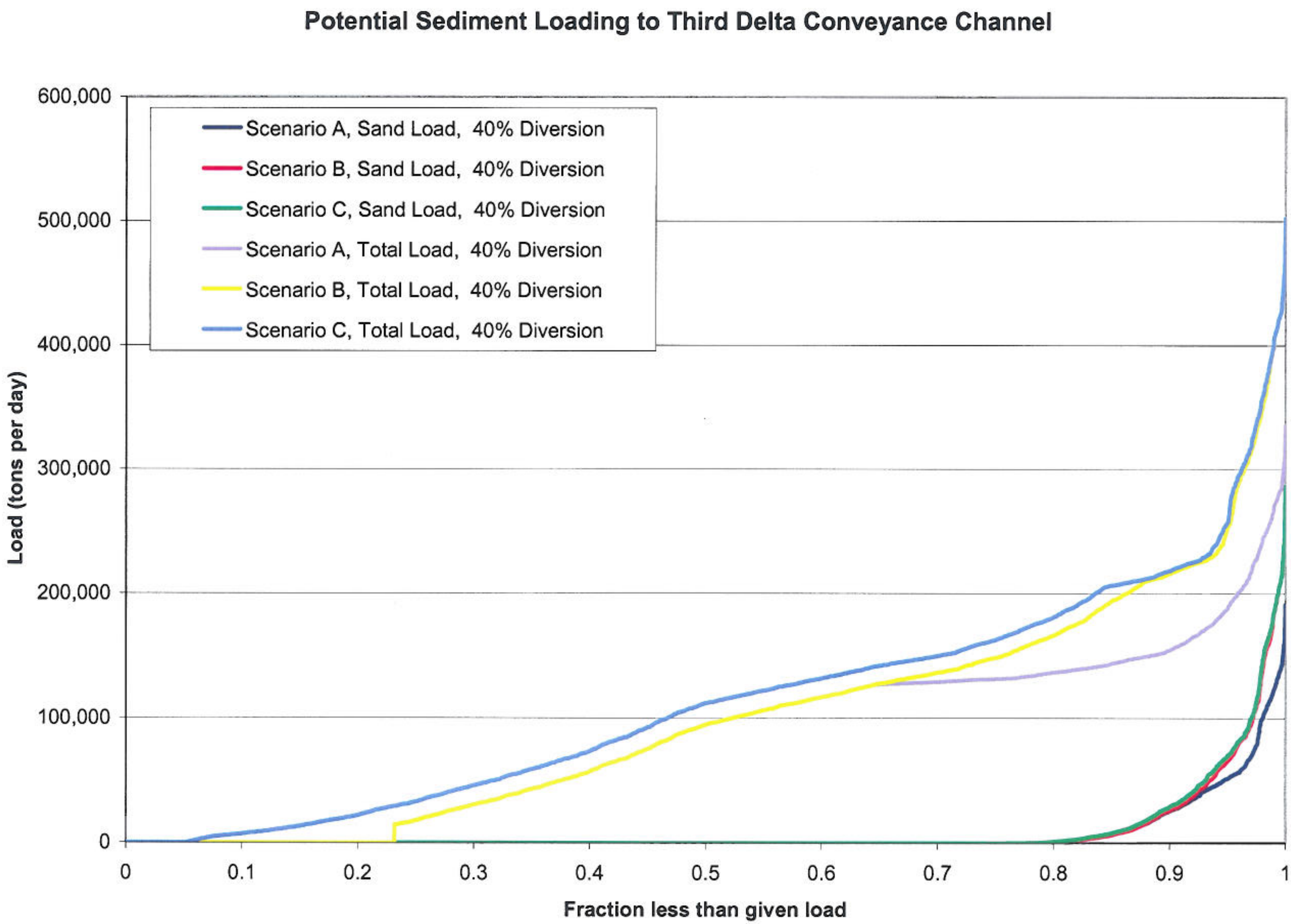
Reference Channels – Wax Lake Outlet

- Investigated physical characteristics, channel evolution, and hydraulics
- Used survey data from 1967 to 1996 to bracket long-term evolution
- Average bed degradation was 9 cm/year, maximum was 19 cm/year
- Average change in cross sectional area was 291 square feet/yr, maximum was 606 square feet / year in upstream reaches of the channel

Inflow/Diversion Hydrographs

- Several hydrographs investigated
- Based on flow in Mississippi River
- Retain minimum flow in Mississippi River for navigation and salinity control
- 200,000 to 250,000 cfs minimum left in Mississippi River
- 40% of excess diverted to TDCC
- Diversions capped at either 200,000 cfs or 300,000 cfs


Potential Diversion Hydrographs
Diversion Scenario A, 40% of Excess above 250k cfs, capped at 200k cfs
Diversion Scenario B, 40% of Excess above 250k cfs, capped at 300k cfs
Diversion Scenario C, 40% of Excess above 200k cfs, capped at 300k cfs
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
Flow (cfs)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Fraction less than given flow


Potential Sediment Loading to Third Delta Conveyance Channel
Scenario A, Sand Load, 40% Diversion
Scenario B, Sand Load, 40% Diversion
Scenario C, Sand Load, 40% Diversion
Scenario A, Total Load, 40% Diversion
Scenario B, Total Load, 40% Diversion
Scenario C, Total Load, 40% Diversion
Load (tons per day)
600,000
500,000
400,000
300,000
200,000
100,000
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Fraction less than given load

Initial Channel

- 20,000 cfs (proposed initial flow) does not provide shear necessary for erosion
- 40,000 cfs required to achieve erosion
- Stage in Mississippi River found to be the limiting factor
- Dimensions of pilot channel: bottom widths ranging from 50 to 100 feet, invert elevations range from –10 to –35 feet NGVD
- Found that all the selected pilot channel designs would maintain a sediment transport capacity in excess of the expected sediment supply, at the design discharge conditions.

Final Channel

- 200,000 cfs maximum flow originally proposed would carry less sand than is currently delivered to the Wax Lake Delta
- 300,000 cfs maximum flow was added as an alternative in order to bring more sediment to delta building locations
- Dimensions of final channel: bottom width ranged from 600 to 800 feet in Reach 1, invert elevations range from –50 to –65 feet NGVD
- Channel stability was checked with Copeland method and the SAMwin Hydraulic Design software
- Long-term stability of channel at final capacity was supported by calculations

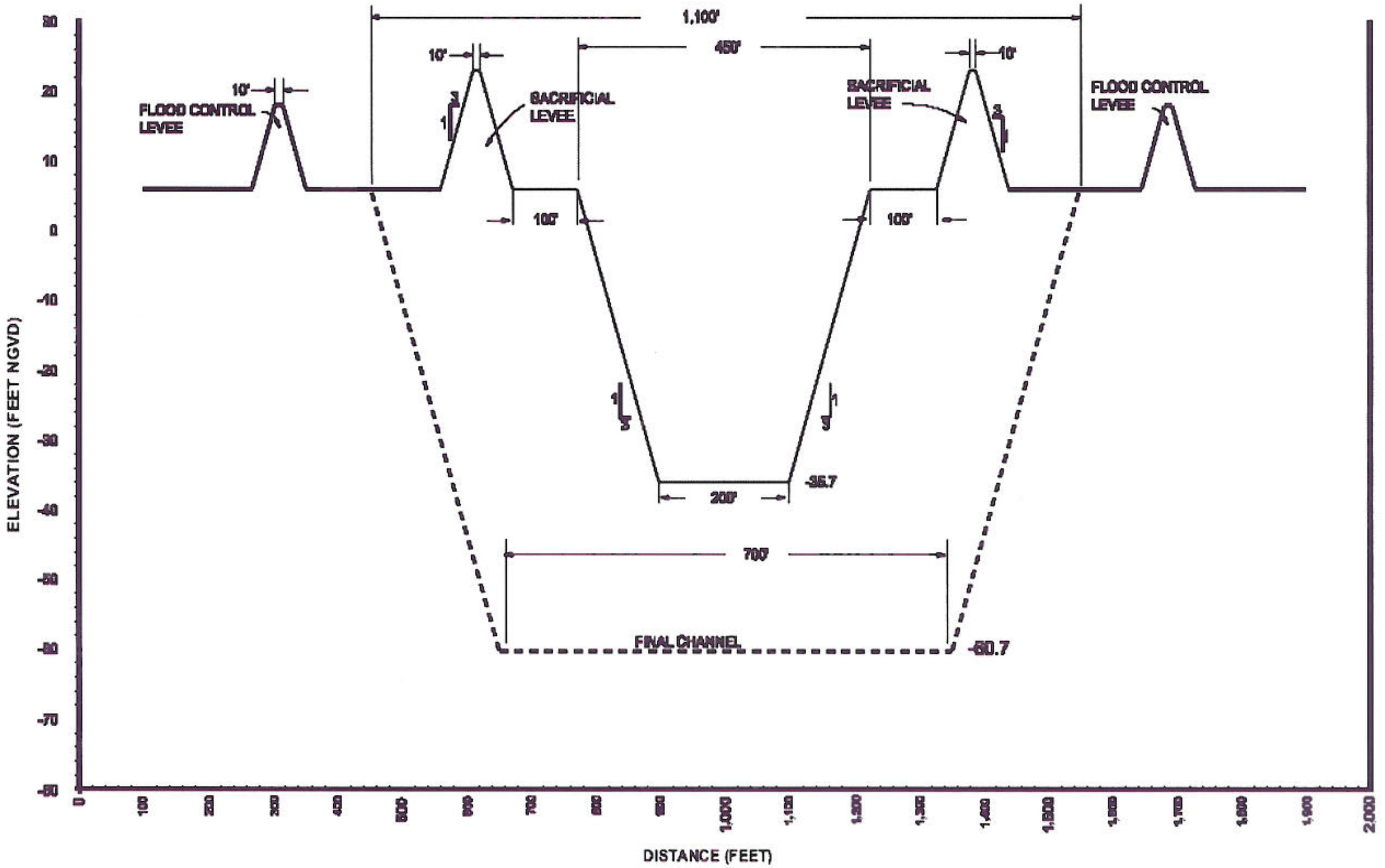


FIGURE ES-2
TYPICAL TDCC CROSS SECTION
PHASE 1 RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE CHANNEL PROJECT
EXECUTIVE SUMMARY

W012004011RDD_21 (5/26/04)

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Estimates of Channel Evolution

- Used two methods, empirical and field data from reference channel
- Empirical method, based on Parthenaides, yields 18 cm/year
- Wax Lake yields 9 cm/year on average, 18 cm/year maximum rate
- Based on maximum vertical and area erosion rates in Wax Lake Outlet, the evolution period is expected to be on order of 40 years
- Allowing for uncertainty, best estimate for channel evolution is 20 to 60 years

Task 5: Delta Building Evaluation

Objectives

- Assess sediment transport regime under tidal, wind, and wave-induced circulation

Analysis

- Sediment supply rates compared to reference deltas in Atchafalaya Bay
- Wind and wave climate compared to reference deltas in Atchafalaya Bay
- Bathymetry and geometry of proposed delta building locations compared to reference sites in Atchafalaya Bay

Characteristics of proposed delta building locations

- Generally very shallow, with average depths of 3 to 6 feet
- Sheltered from wind by historic marshes
- Protected from open ocean by historic barrier island chain

Atchafalaya Bay Bathymetry

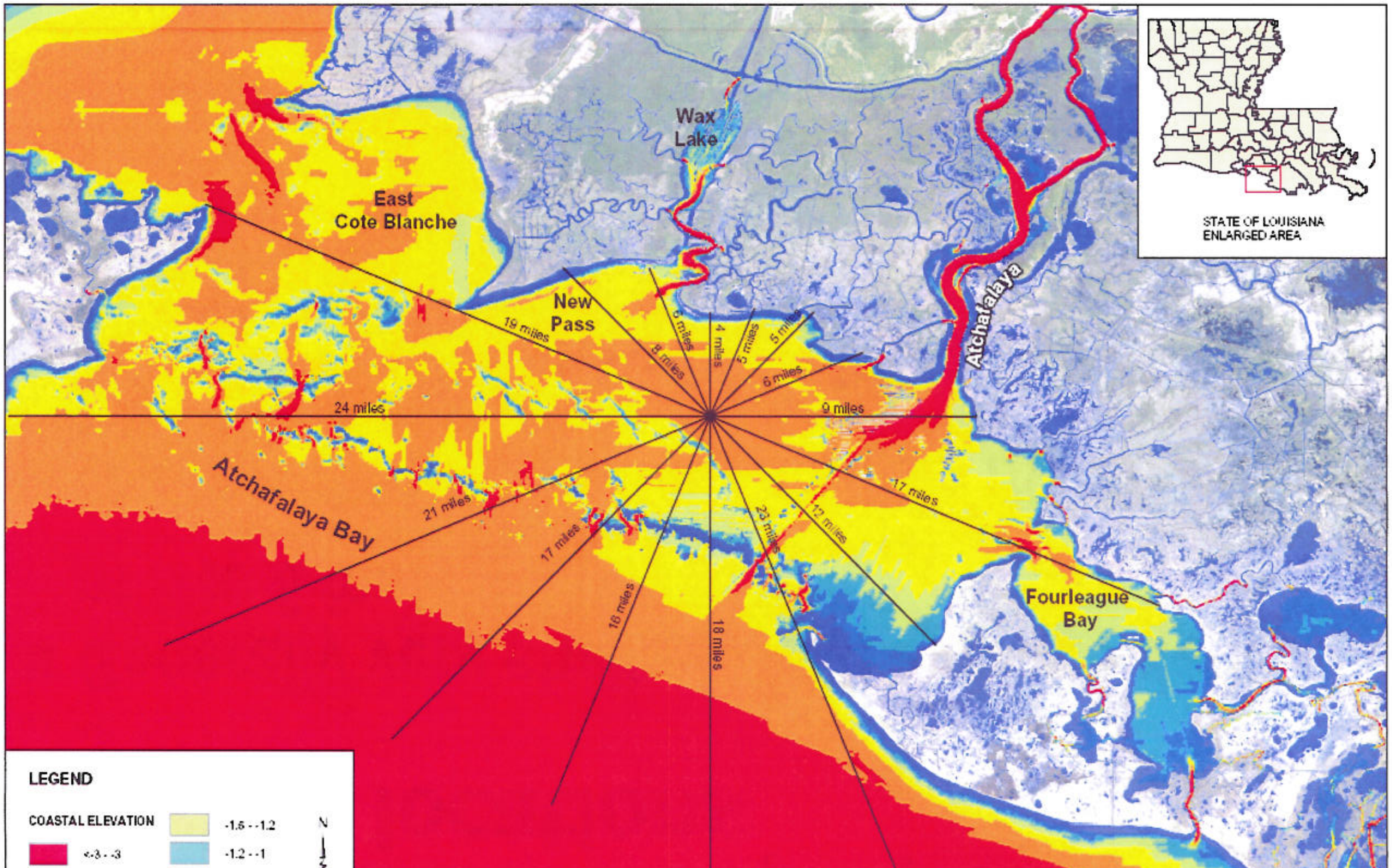
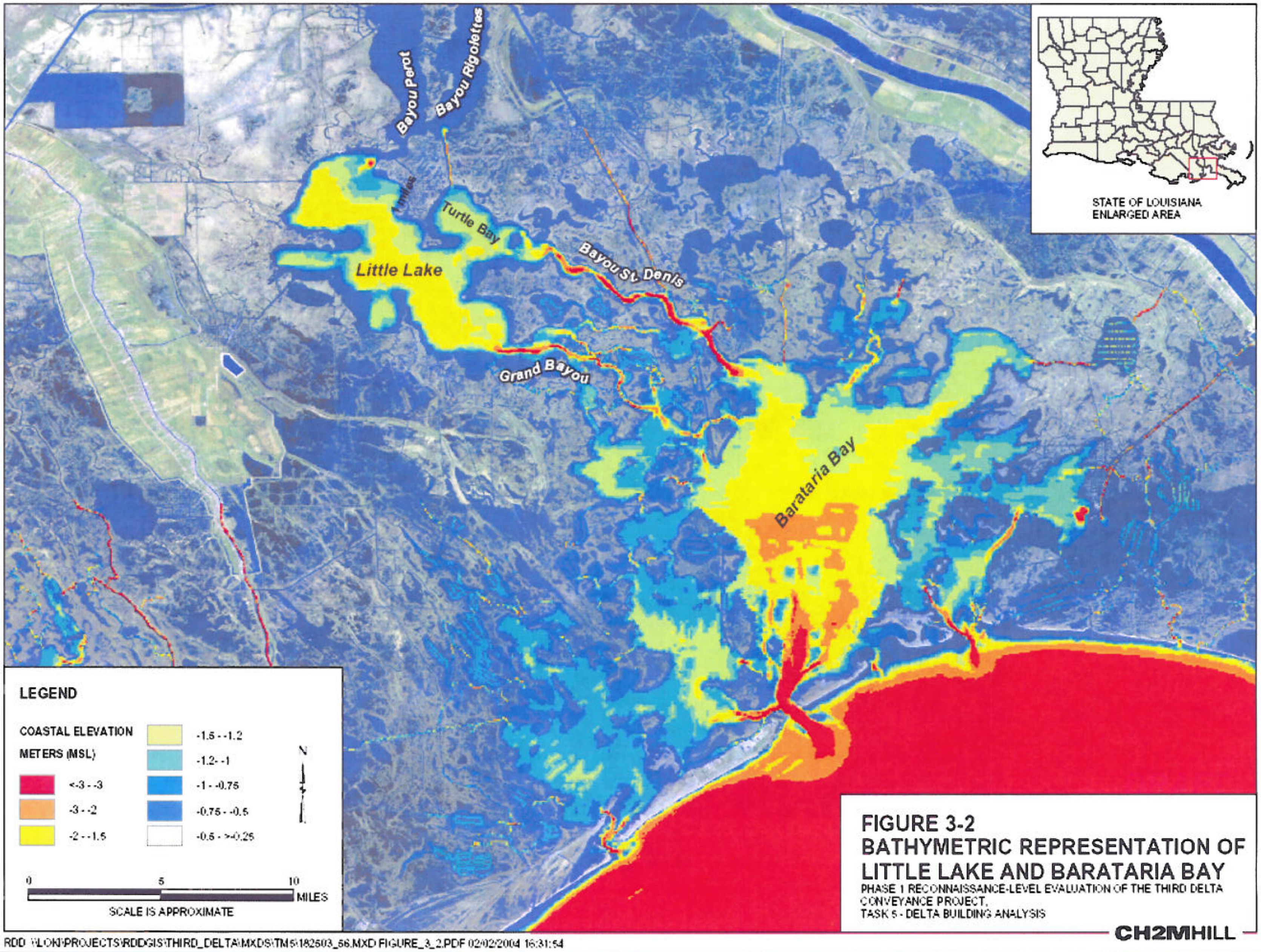
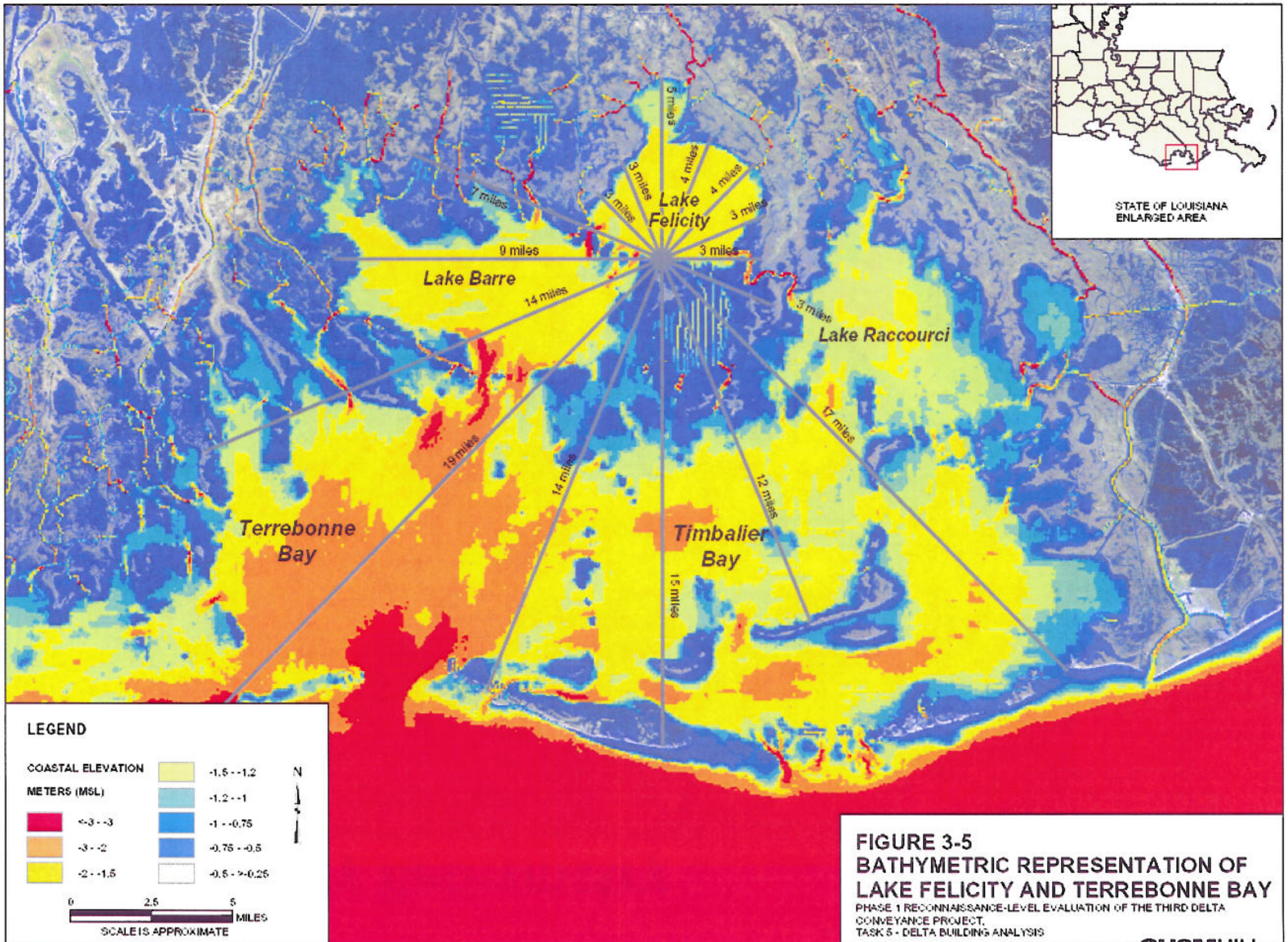


FIGURE 3-7
BATHYMETRIC REPRESENTATION OF ATCHAFALAYA BAY
PHASE I RECONNAISSANCE-LEVEL EVALUATION OF THE THIRD DELTA CONVEYANCE PROJECT.
TASK 5 - DELTA BUILDING ANALYSIS
CH2MHILL

Barataria Bay Bathymetry



Terrebonne Bay Bathymetry



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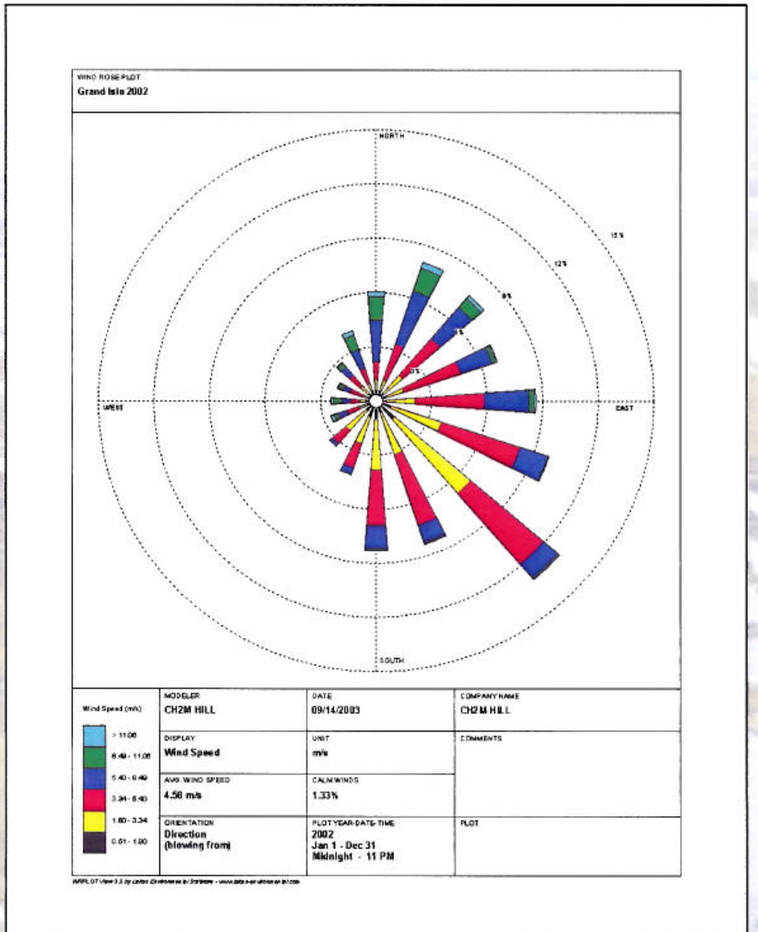
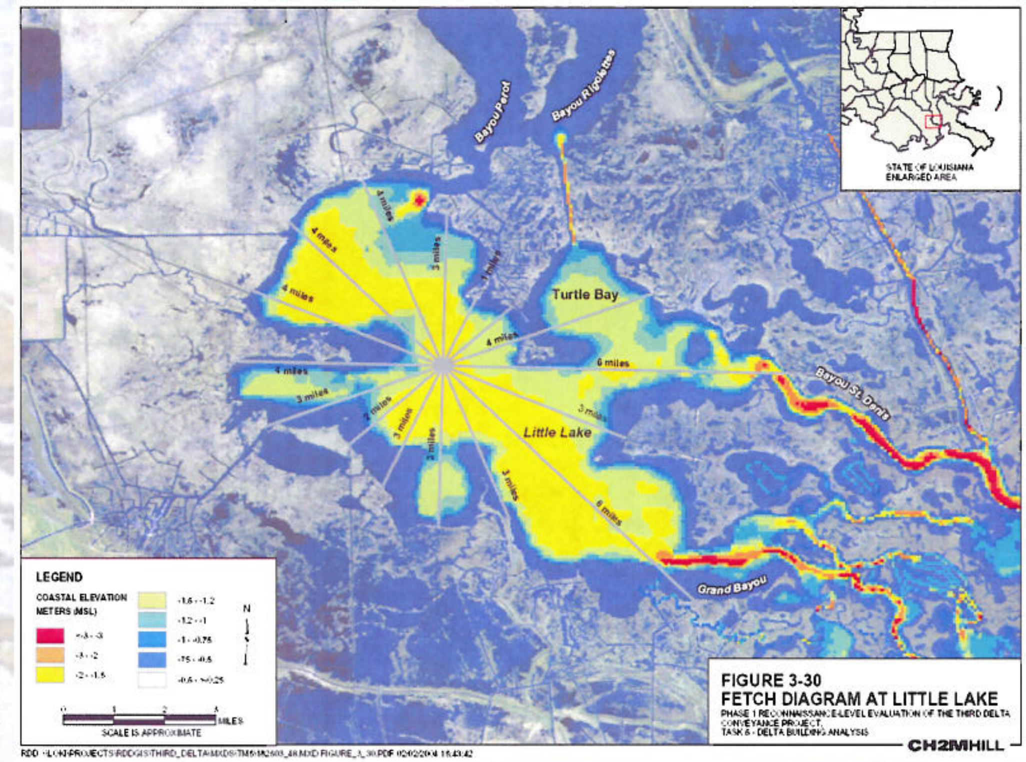
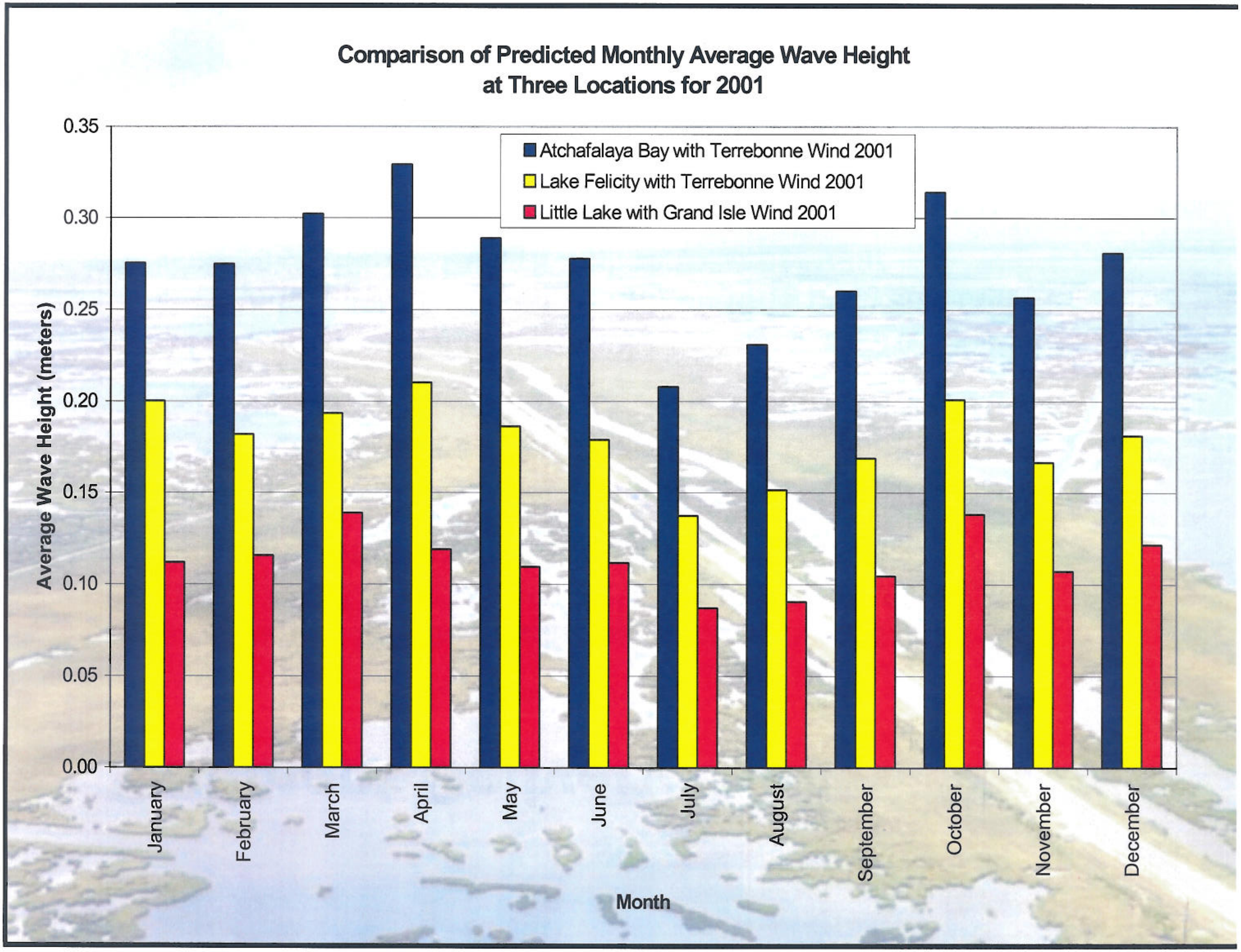
Wave climates in Coastal Louisiana

- Atchafalaya Bay: 10th, 50th, and 90th percentile wave heights are 0.11, 0.27, and 0.43 meters, respectively
- Terrebonne Bay (Lake Felicity): 10th, 50th, and 90th percentile wave heights are 0.08, 0.18, and 0.27 meters, respectively
- Barataria Bay (Little Lake): 10th, 50th, and 90th percentile wave heights are 0.05, 0.11, and 0.19 meters, respectively
- Sediment retention at proposed delta building sites will be higher because of lower waves (resuspension)

Wind Rose and Fetch Diagram



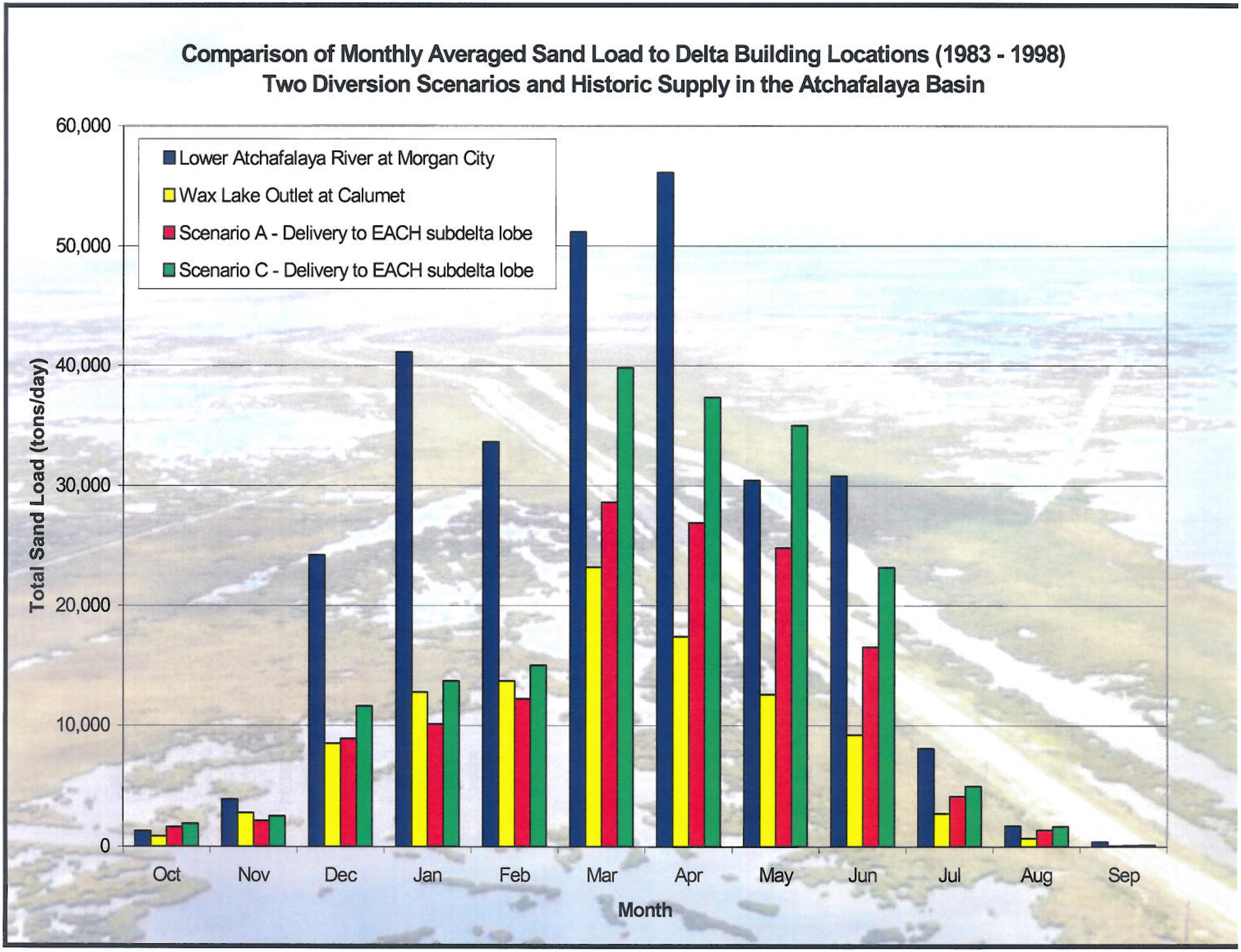




Comparison of Predicted Monthly Average Wave Height
at Three Locations for 2001
Atchafalaya Bay with Terrebonne Wind 2001
Lake Felicity with Terrebonne Wind 2001
Little Lake with Grand Isle Wind 2001
Average Wave Height (meters)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
January
February
March
April
May
June
July
August
September
October
November
December
Month

Sediment Delivery

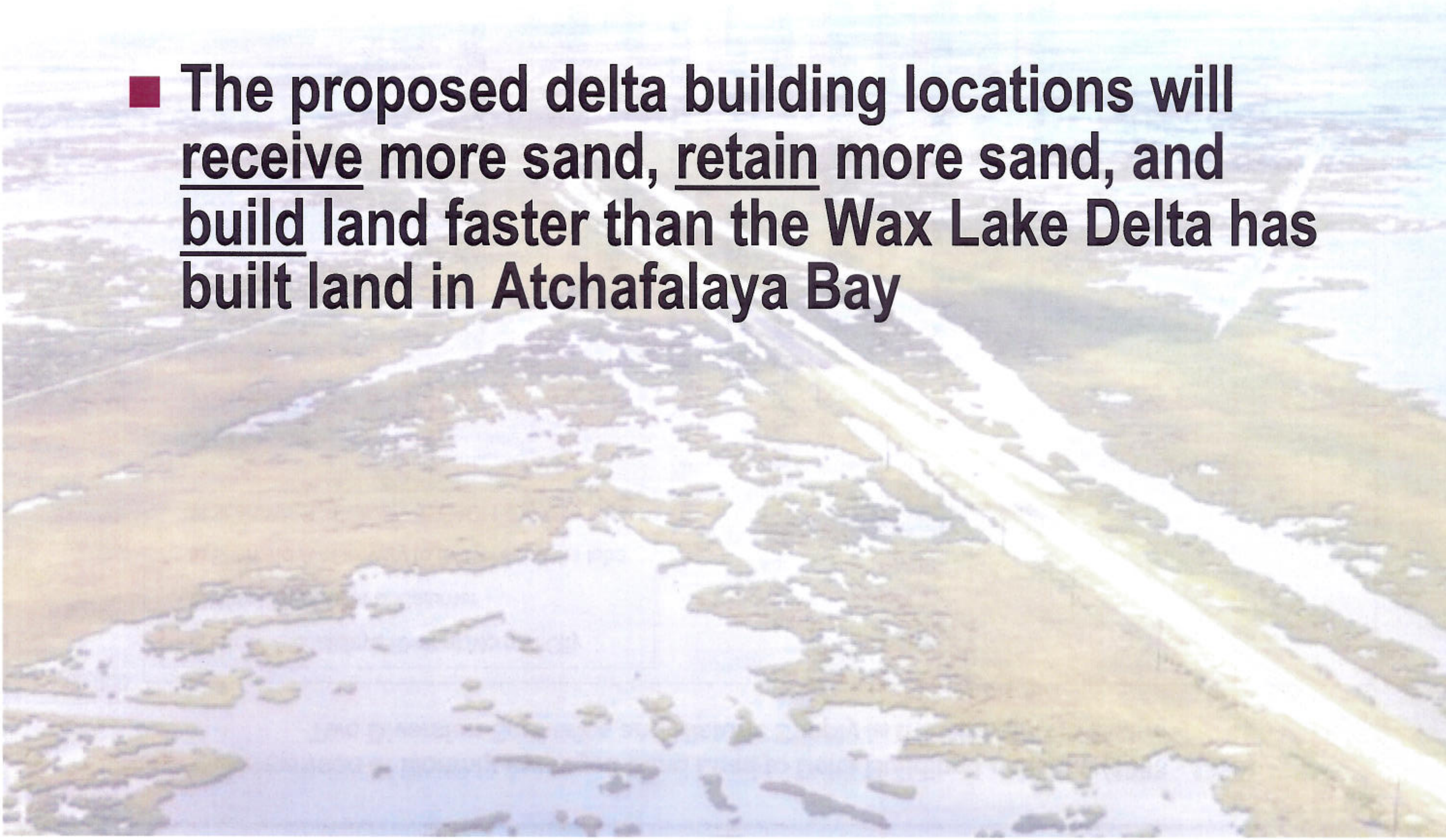
- A range of proposed sediment diversion scenarios were investigated to determine the sensitivity of the results to the sediment load being diverted into the channel.
- Calculated sand transport rates demonstrate that more sand can be carried to each of the proposed delta building locations than is currently carried to the Wax Lake Delta.
- Annual average sand transport:
  Diversion Scenario C = 5.68 million tons per year, compared
  Wax Lake Delta = to 3.18 million tons per year
  Lower Atchafalaya River Delta = 8.60 million tons per year



Comparison of Monthly Averaged Sand Load to Delta Building Locations (1983 - 1998)
Two Diversion Scenarios and Historic Supply in the Atchafalaya Basin
Lower Atchafalaya River at Morgan City
Wax Lake Outlet at Calumet
Scenario A - Delivery to EACH subdelta lobe
Scenario C - Delivery to EACH subdelta lobe
Total Sand Load (tons/day)
60,000
50,000
40,000
30,000
20,000
10,000
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Month

Conclusion

- The proposed delta building locations will receive more sand, retain more sand, and build land faster than the Wax Lake Delta has built land in Atchafalaya Bay



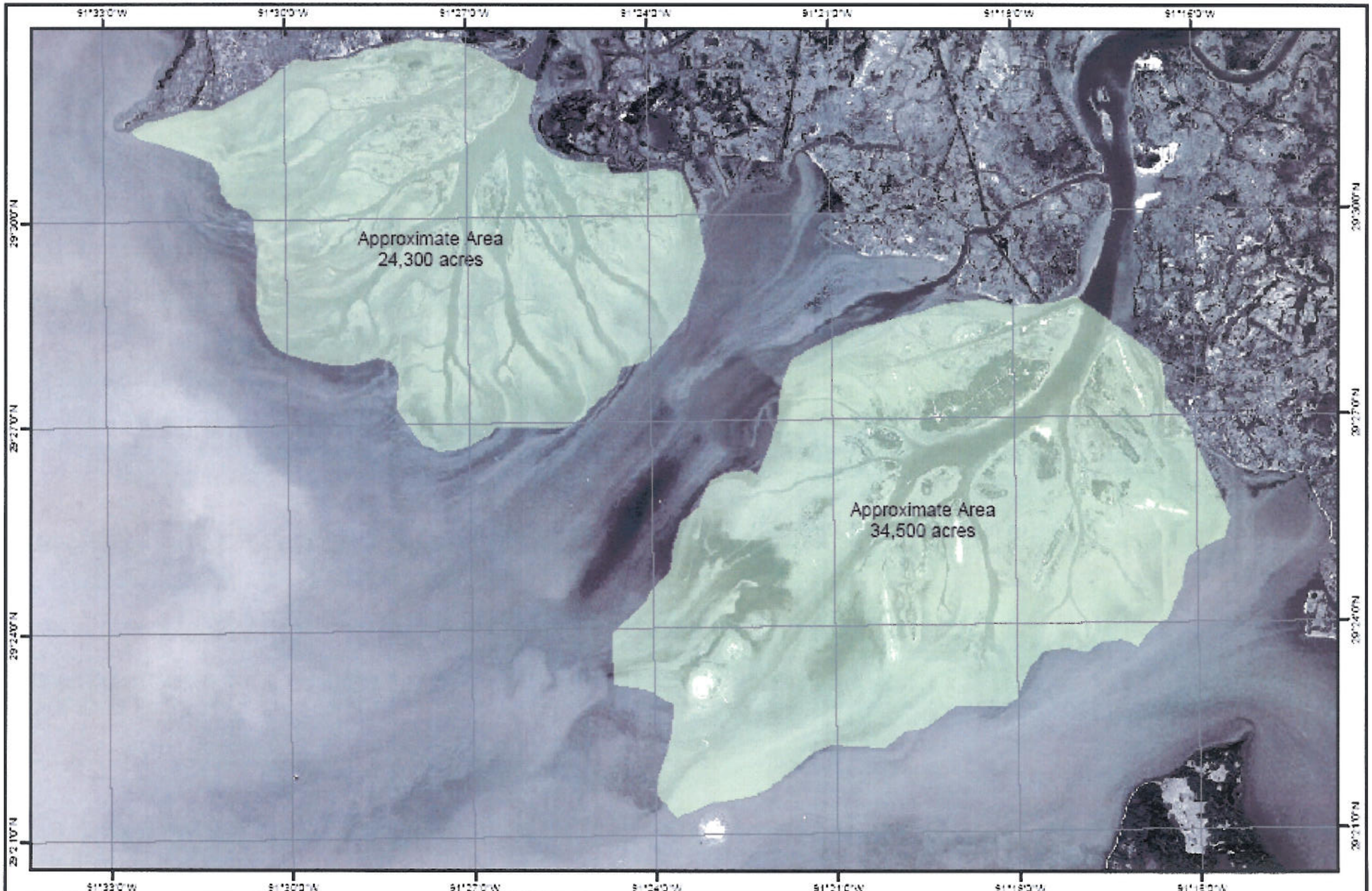


Figure 2.4.1
Existing Deltas in Atchafalaya Bay
SPOT Image 2000

Third Delta Conveyance Channel
Mississippi River, Louisiana

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Phase 2 - Alternative Project Concepts

- Conveyance of sediment through pipelines from the Mississippi River
- Dredging offshore sediment resources
- Hydraulic dredging of local sediment resources
- Use of Atchafalaya River and GIWW

Proposed Delta Building Locations