111th Congress, 2d Session – – – – – – – – – – – – House Document 111–129

LOUISIANA COASTAL PROTECTION AND RESTORATION (LACPR) REPORT

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY (CIVIL WORKS), THE DEPARTMENT OF THE ARMY

TRANSMITTING

NOTIFICATION OF THE FINAL TECHNICAL REPORT FOR LOUISIANA COASTAL PROTECTION AND RESTORATION (LACPR), PURSUANT TO PUB. L. 109–103 PUB. L. 109–148

PART 1 OF 4

JULY 1, 2010.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

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Honorable Nancy Pelosi
Speaker of the House
of Representatives
U.S. Capitol Building, Room H-232
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Dear Madam Speaker:

I am providing the Louisiana Coastal Protection and Restoration (LACPR) Final Technical Report, dated August 2009, in response to the Energy and Water Development Appropriations Act of 2006 (Public Law (P.L.) 109-103), and the Department of Defense Appropriations Act, 2006 (P.L. 109-148). These laws directed that a technical report be prepared to develop and present a full range of flood control, coastal restoration, and hurricane protection measures exclusive of normal policy considerations. The report presents a full range of potential alternative plans for South Louisiana that could reduce the risk of damages from hurricanes and storms, including a Category 5 storm event. It presents the various types, as well as the potential magnitude of tradeoffs that would be required to implement each plan. The alternative plans presented in this report do not include the appropriate level of engineering detail or environmental documentation for project recommendations by the Chief of Engineers. It should be duly noted that this study was conducted prior to the Deepwater Horizon incident. Accordingly, the Secretary of the Army is not requesting any additional authorization or action at this time.

This report and the 2005 Louisiana Coastal Area (LCA) Near Term Plan report provide valuable information that will allow the State and Federal partners to pursue their shared goal of integrating the State's Master Plan and the Comprehensive Plan envisioned by Section 7002 of the Water Resources Development Act of 2007 into a single planning effort. Through collaboratively identifying specific desired outcomes and priorities, and establishing the framework of a long-term program to achieve those outcomes, the integrated plan will guide the development of individual projects intended to produce those desired results.

We recognize that further coordination between the State and Federal agencies is required to develop the LACPR-identified alternatives into a long-term vision for the coast and to establish priorities for study or project implementation. The Corps therefore intends to implement additional collaborative measures, such as embedding staff for technical support with the State's Master Plan development team, in order to address those key issues that have not been fully developed in this report. Meanwhile, both the U.S. Army Corps of Engineers (Corps) and the State are committing significant resources toward completing construction of numerous hurricane and storm damage

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risk reduction works that were initiated subsequent to hurricanes Katrina and Rita, as well as construction of ecosystem restoration projects pursuant to the LCA Near Term Plan.

The LACPR report resulted from the efforts of the Corps and the Coastal Protection and Restoration Authority of Louisiana, along with other state agencies, Federal agencies, non-Corps scientists and academics, non-governmental organizations, the Dutch Rijkswaterstaat, the Dutch Water Partnership, independent technical reviewers, independent external peer reviewers, private engineering firms, landowners, stakeholders, and the public. A multiple lines-of-defense approach which focused on reducing hurricane and storm damages through barrier island restoration, levee construction, wetland restoration, and floodplain evacuation was used throughout the planning process. The report presents the need for shared responsibility among Federal, State and local entities, and an approach for coordinated decision making. It emphasizes the State and local government responsibilities in evacuation and land use planning; zoning and permitting; and creation of conservation easements.

The cost of potential coastwide plans could range from approximately $59,000,000,000 to $139,000,000,000 and would impact the coast and the people who visit, live, and/or work in South Louisiana over decades to come. Before a comprehensive plan for hurricane risk reduction could be selected, the alternative plans identified in the LACPR require decisions about tradeoffs and implementation options. The complex social, environmental and economic impacts of these potential plans require further evaluation by our local and State partners, as well as prioritizing and sequencing approaches for implementation. Additional engineering and environmental documentation would be required to evaluate the system-wide interaction with the Mississippi Coastal Improvements Program.

The report was reviewed through the Corps' Independent External Peer Review (IEPR) process. The IEPR comments and the Corps' responses are an enclosure to this letter. The Corps understands the urgency expressed by the public, non-governmental organizations, and the National Research Council and stands ready to move forward with other Federal and State agencies to define and resolve tradeoffs as soon as possible. The Corps, along with associated Federal agencies and the State of Louisiana are currently working together to develop a common vision for a sustainable Louisiana coast. The Corps can then complete detailed planning which would allow for a construction authorization. Regardless of whether plans are ultimately authorized under a single authority or multiple authorities, implementation of comprehensive risk reduction plans will require a long-term commitment and an adaptive management approach.

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress and concludes that the report is consistent with the policy and programs of the President. However, OMB concurs with the Secretary that the report does not provide an appropriate level of engineering detail or

environmental documentation for any project recommendations. A copy of its letter is enclosed. I am providing a copy of this transmittal and the OMB letter, dated June 29, 2010 to the House Committee on Appropriations' Subcommittee on Energy and Water Development, and House Committee on Transportation and Infrastructure's Subcommittee on Water Resources and Environment.

Very truly yours,

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

5 Enclosures

1. State of Louisiana Letter, April 28, 2010
2. National Research Council, 2009
3. USACE Response to IEPR, April 2010
4. OMB Letter, June 25, 2010
5. Louisiana Coastal Protection and Restoration Final Technical Report, August 2009

CPRA
Coastal Protection and Restoration Authority of Louisiana

State of Louisiana

BOBBY JINDAL
GOVERNOR

April 28, 2010

The Honorable Jo Ellen Darcy
Assistant Secretary of the Army (Civil Works)
United States Army
108 Army Pentagon
Room 3E446
Washington, DC 20310-0108

Dear Secretary Darcy:

Thank you for your efforts to include construction funding for the Louisiana Coastal Area ecosystem restoration project (LCA) in the President's Fiscal Year 2011 budget. As you know, the LCA represents one of only two "new start" construction projects nationwide in the President's budget and it represents a significant opportunity to make tangible progress towards restoring Louisiana's coast. We appreciate your efforts and those of the Gulf Coast Ecosystem Restoration Working Group to ensure that this critical initiative advances from conceptual to construction as quickly as possible.

We are very encouraged by the efforts of the Gulf Coast Ecosystem Restoration Working Group to address the critical issues identified in the roadmap and we look forward to working with you and the entire Working Group to dedicate additional resources and to solve the policy and process challenges that are slowing crucial restoration, enhancement and protection of the ecosystems and coastal communities in Louisiana and Mississippi.

As you are well aware, Gulf Coast ecosystems are nearing collapse, low-lying communities across South Louisiana are increasingly vulnerable from tropical events and other factors and many communities are becoming increasingly unsustainable. We must redouble our efforts to work together to reduce or eliminate these vulnerabilities to our coastal communities. The state has fundamentally restructured its coastal program and has taken action with our levee districts and parishes to advance hundreds of millions of dollars in protection and restoration projects. In the very near term, we must collectively take aggressive action and make quantifiable progress on the ground.

In addition to quickly moving authorized projects to construction, we should concurrently focus upon future efforts. Specifically, we would like to explore options for completing longer-term planning strategies.

Undoubtedly, you are aware that the development of Louisiana Coastal Protection and Restoration plan (LACPR) has been a source of frustration to us for quite some time. The LACPR statute, included in the Energy and Water Develop Appropriations Act for Fiscal Year 2006 (Public Law 109-103), was first enacted on November 19, 2005. It required the Chief of Engineers to develop a "comprehensive analysis and design" to yield a "full range of flood

control, coastal restoration and hurricane protection measures" within six months (119 STAT. 2247-2248). A final plan was to be submitted by December of 2007 under amendments to the original statute (119 STAT. 2814). Initial coordination on the development between the Corps of Engineers

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and State of Louisiana produced significant results that enjoyed the strong support of the state. However, a number of policy guidance memorandums from your predecessor's office, caused a fundamental and unilateral redirection in the report resulting in cost increases of 300 percent above the 2005 estimate. Despite the 2007 statutory deadline, to date, this report remains under development within the Corps of Engineers.

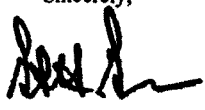
After receiving briefings from the Corps of Engineers in 2006 and 2007, it became clear to Congress that the Corps' interpretation of the LACPR statute varied quite differently from that of the state and the intent of Congress. In response, Congress passed Section 7014 of the Water Resources Development Act of 2007 (WRDA 07) requiring the Corps of Engineers to provide "specific project recommendations" within the LACPR (121 STAT. 1281). The current draft of the report includes several thousand pages, but no project recommendations as suggested by the National Academies and required by law. Section 7014 also provided that any project identified in the LACPR could receive an expedited construction authorization from Congress through a unique and privileged protocol. Unfortunately, this provision sunsets in December of this year; thereby eliminating any opportunity to expedite protection and restoration features identified in the plan and furthering the risk to our coastal population, infrastructure, economy and ecosystem.

While the state remains frustrated with the development of the LACPR, we believe that an opportunity exists to move this initiative forward together with the comprehensive coastal plan required pursuant to Section 7002 of WRDA 07 (121 STAT. 1270-1271) and due in December of 2008. In accordance with state law, the Coastal Protection and Restoration Authority must update the State of Louisiana's coastal master plan every five years. The next update is due to the Louisiana Legislature by 2012. We have commenced internal efforts to stand up a planning team and develop a strategy to produce an updated comprehensive coastal master plan by developing a visioning process and a prioritization tool.

In an effort to advance our collective mid and long-term goals and in an attempt to satisfy congressional requirements pursuant to Sections 7002 and 7014 of WRDA 07, the LACPR and the state's master plan, we recommend that the state, Corps and other federal resource agencies embed staff into a common planning team. The goal of the planning team would be to produce one document representing the common vision of federal, state and local governments. Since the Louisiana Legislature and CPRA have fully funded our master plan revision effort we believe that this joint initiative could be completed with significant cost savings to the federal government.

We strongly urge you to consider this request. This unique opportunity will lay the foundation for the collective resources of all levels of government to be dedicated to fulfilling a common vision of a sustainable Louisiana coast.
Please contact me at any time if you require additional information. Thank you for your consideration.

Sincerely,



Garret Graves, Chair

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Committee on the Review of the Louisiana Coastal Protection and Restoration (LACPR) Program

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Summary

The U.S. Army Corps of Engineers released the Louisiana Coastal Protection and Restoration (LACPR) draft final technical report in March, 2009 (USACE, 2009). The Corps of Engineers conducted this planning study in response to federal legislation passed in November 2005. Public Law 109-103 directed the Corps to "conduct a comprehensive hurricane protection *analysis and design* at full federal expense to develop and present a full range of flood control, coastal restoration, and hurricane protection measures to provide ". . . protection for a storm surge equivalent to a Category 5 hurricane within the project area" and with the provision that ". . . the analysis will be conducted in close coordination with the State of Louisiana and its appropriate agencies" (P.L. 109-103; emphasis added).

The following is the second and final report from the National Research Council (NRC) Committee on the Review of the Louisiana Coastal Protection and Restoration (LACPR) Program. The committee's first report was released in 2008. The committee was charged to review two draft reports from the LACPR team and to assess "the hurricane risk reduction framework, alternatives for flood control, storm protection, coastal restoration, and risk analysis" (the committee's full statement of task is listed in Appendix A). This report presents this committee's review and advice for improvements of the LACPR March 2009 draft final technical report.

The proposed comprehensive hurricane protection planning for southern Louisiana entails implementation of a variety of structural, nonstructural, and coastal restoration measures. Examples of structural measures include levees and floodwalls; examples of nonstructural measures include flood insurance and buyouts; examples of coastal restoration measures include the creation or enhancement of wetlands or barrier islands. Evaluating various combinations of these measures, and identifying a preferred plan or course of action, represents considerable technical and other challenges due to the complex natural environment of

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coastal Louisiana and the tremendous power of land-falling hurricanes that beset the Gulf of Mexico.

Coastal Louisiana covers a vast areal extent and consists of a variety of physiographic features such as estuaries, wetlands, rivers, urban areas, and flood control structures. Furthermore, this is a dynamic landscape that is subject to ongoing sea level rise and future changes in climate. Not only will environmental conditions in this vast region change over time, but social and demographic conditions will change and initiatives such as nonstructural measures for reducing flood risk reduction (e.g., rates of flood insurance purchases; elevating buildings in vulnerable areas; and adoption of zoning measures) will change and evolve in unforeseen ways. LACPR projects thus should be designed with some capacity to adapt to future, changing conditions.

At the same time, it is important that the Corps of Engineers utilize the best technical advice and professional judgment to identify priority protection and restoration alternatives and actions. The Corps of Engineers is the federal government's expert on hydrology and hurricane protection issues in this region and, with this project, the U.S. Congress requested the Corps' expertise and recommendations regarding future hurricane protection *analysis and design*.

Despite being given authority from the U.S. Congress for this project over three years ago, the LACPR draft final technical report does not offer a comprehensive long-term plan for structural, nonstructural, and restoration measures across coastal Louisiana, nor does it suggest any initial, high-priority steps that might be implemented in the short term. Instead, a variety of different types of structural and nonstructural options are presented, with no priorities for implementation.

The lack of a comprehensive long-term hurricane protection and coastal restoration plan, and the lack of advice on initial high-priority steps and projects, represent substantial shortcomings of the LACPR draft final technical report.

Comprehensive and effective hurricane protection and restoration in coastal Louisiana will entail cooperation among several entities, but especially between the Corps of Engineers and the State of Louisiana (as called for in the federal legislation). The Corps and the State of Louisiana have issued separate reports on hurricane protection and coastal restoration with what appears to be only limited efforts to synchronize them. Closer cooperation and collaboration between the Corps and the state will be essential for financing, technical planning and project implementation, monitoring, and adaptation.

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To help promote cooperative federal-state hurricane protection and restoration, the Corps of Engineers and the State of Louisiana should initiate joint deliberations immediately to agree upon a long-term comprehensive plan—including structural, nonstructural, and restoration projects—and also identify a small number of high-priority projects for initial implementation. It will be important that this cooperative effort not be a lengthy and expensive planning exercise; rather, it should draw upon the voluminous existing research and data on project alternatives derived in the course of the LACPR study, along with previous studies by the Corps, the State of Louisiana, and others. These deliberations should include discussion of the long-term sustainability of project alternatives given past trends and future projections of Louisiana wetland losses owing to erosion and relative sea level rise.

Before the end of 2009, the Corps of Engineers and the State of Louisiana should agree on the elements of a single comprehensive plan for long-term hurricane protection and coastal restoration. As part of that plan, the Corps and the state should agree on a number of high-priority projects for immediate implementation.

Other key findings and recommendations from this report include:

- There is a need for more detailed description of sediment availability, including better justification for the assumption that the current shoreline can be maintained in place. The LACPR team should complete a sediment budget for coastal Louisiana and provide better explanation of potential costs and environmental impacts of dredging alternatives.
- There should be a more explicit acknowledgement of ongoing and future coastal erosion trends and their implications for restoration priorities. Rather than focusing energy and resources into trying to maintain the current configuration of southern Louisiana's eroding coastline, the LACPR team is encouraged to focus its protection and restoration plans on high-priority projects.
- The LACPR report should provide a better and more quantitative explanation of the scientific uncertainty associated with projections of marsh and wetlands restoration (including diversions), surge attenuation by wetlands, numerical modeling efforts, and the implications of Mississippi River diversions.
- The high level of uncertainty of the effects of proposed river diversions suggests the need for careful monitoring and evaluation of existing diversions. It also suggests the importance of an

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adaptive strategy that can adjust to and build upon new information as more is learned about the responses of these coastal wetlands systems to human interventions.

- Storm surge protection for the City of New Orleans should be designed for a hurricane storm surge event with an expected return interval of 400 to 1,000 years.
- The LACPR team should perform a quantitative risk assessment of the structural protection systems that includes the probability of system failure of the various components including floodwalls, levees, ring levees, and floodgates.
- The LACPR team (and the Corps) should take a more aggressive leadership role in promoting a variety of nonstructural measures that are important to reducing flood risks in coastal Louisiana. Examples of these nonstructural measures include limiting development in flood-prone areas and stronger public education efforts regarding flooding risk in different sections of New Orleans.
- Multi-Criteria Decision Analysis is a potentially useful approach to evaluate projects with important environmental, social, and cultural impacts; however, flaws in the application of these methods to the LACPR study have prevented any convincing results. As applied, the methods do not support the identification of a preferred alternative for any of the planning areas. Furthermore, they do not support the rankings of alternative plans as presented in the LACPR report.
- The LACPR team should more specifically identify and explain the trade-offs between commercial navigation and river diversions for coastal restoration.
- It is encouraging that the LACPR draft final technical report describes the importance of preventing induced development. The report, however, does not adequately demonstrate how these principles will be a prominent part of hurricane protection and coastal restoration actions. Discouraging development in particularly vulnerable areas, whether or not they are protected by levees, is a fundamental principle of flood risk management and reduction. The LACPR should strengthen its cooperation with state and local entities to ensure that the prevention of induced development is accorded a more prominent and meaningful role in future plans.
- The multiple authorizations that govern ecosystem restoration

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and hurricane protection in southern Louisiana represent a piecemeal approach and may hinder integrated, adaptive restoration and protection improvements across the region.

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1

Introduction

The National Research Council (NRC) Committee on the Review of the Louisiana Coastal Protection and Restoration (LACPR) program was charged to review two draft reports from the LACPR team and to assess "the hurricane risk reduction framework, alternatives for flood control, storm protection, coastal restoration, and risk analysis" (the committee's full statement of task is listed in Appendix A). This NRC committee's first report was issued in 2008 (NRC, 2008). This is the committee's second and final report and it represents the committee's review of the 'Louisiana Coastal Protection and Restoration Program,' a draft technical report issued by the Corps of Engineers in March 2009 (USACE, 2009). Before discussing and evaluating the LACPR 2009 draft final report, this chapter summarizes this committee's first report (NRC, 2008).

FIRST REPORT FROM THE NRC COMMITTEE ON THE REVIEW OF THE LACPR PROGRAM

This committee's first report consisted of a review of a draft LACPR report issued in February 2008 (USACE, 2008). This committee met with LACPR staff in New Orleans in March 2008 to discuss that report and the committee's report was issued in May 2008 (NRC, 2008). The NRC report identified areas for improvement in the three main sections—restoration, structural, and nonstructural—of the LACPR draft report (Figure 1 shows the LACPR study region). It also included advice regarding the presentation of key assumptions that were important to the study.

One overarching comment pertained to congressional intent within the 2006 authorizing legislation for the LACPR study. The 2006 Energy and Water Development Appropriations Act (P.L. 109-103) states:

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Provided further, That using $8,000,000 of the funds provided herein, the Secretary of the Army, acting through the Chief of Engineers, is directed to conduct a comprehensive hurricane protection analysis and design at full federal expense to develop and present a full range of flood control, coastal restoration, and hurricane protection measures exclusive of normal policy considerations for South Louisiana and the Secretary shall submit a preliminary technical report for comprehensive Category 5 protection within 6 months of enactment of this Act and a final technical report for Category 5 protection within 24 months of enactment of this Act: *Provided further,* That the Secretary shall consider providing protection for a storm surge equivalent to a Category 5 hurricane within the project area and may submit reports on component areas of the larger protection program for authorization as soon as practicable: *Provided further,* That the analysis shall be conducted in close co-

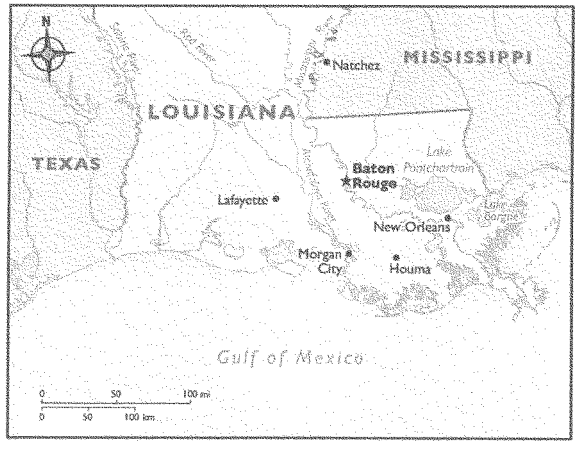

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FIGURE 1: LACPR study area of southern Louisiana

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> ordination with the State of Louisiana and its appropriate agencies.

The 2006 Defense Appropriations Act (P.L. 109-148) states:

> that none of the $12,000,000 provided herein for the Louisiana Hurricane Protection Study shall be available for expenditure until the State of Louisiana establishes a single state or quasistate entity to act as local sponsor for construction, operation and maintenance of all of the hurricane, storm damage reduction and flood control projects in the greater New Orleans and southeastern Louisiana area.

The 2008 report from this NRC committee acknowledged that, "The congressional language authorizing the LACPR study and report presents some ambiguities for the LACPR team." It also stated that "It is not clear to the NRC committee that the intent of Congress was that, owing to the urgency of providing hurricane protection to the State of Louisiana, the LACPR team was to provide a design for immediate implementation..." The NRC report also states that "The congressional language, despite ambiguities, does request "...analysis and *design*."" (NRC, 2008, emphasis in original).

The report noted that the LACPR draft technical report presented alternatives and methods for comparing various plans, but did not identify a single best course of action. The prior 2008 report from this NRC committee concluded that "The lack of some prioritization of alternatives—based upon their relative merits in terms of costs and restoration and risk reduction potential—constitutes a weakness with the draft technical report." The NRC report also recommended that "Future versions of the LACPR report will be of greater value to the extent that they identify projects of higher priority that promise to yield greater and more immediate benefits in terms of flood risk reduction and ecosystem restoration."

Other key findings and recommendations from the 2008 NRC report include:

Restoration — The report noted that the LACPR draft report "provides no evidence that it will be possible to maintain the current landscape given current and prospective future rates of subsidence, degradation, and sea level rise. At the most basic level, there is no analysis of

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the amount of available sediment relative to the amount that will be required to sustain the wetlands. If wetlands cannot be maintained, the draft report misleads the public into believing that the present coastline can be held in the face of relative sea level rise. All plans that would rely upon maintenance of the existing shoreline then are suspect. Also, if wetlands cannot be maintained, this implies that decision makers and citizens ultimately will have to make hard choices about where restoration can take place and where it cannot."

The report also recommended that "The LACPR study team should develop sediment budgets for the wetlands of coastal Louisiana to determine the feasibility of maintaining coastal Louisiana in roughly its present condition."

Nonstructural — The NRC report noted that "The LACPR draft technical report calculates risk reductions from nonstructural measures *assuming 100 percent compliance* by residents of the region. Yet, participation in these programs will be voluntary and actual compliance is likely to be far less than 100 percent." It also stated, "The technical report does not rigorously assess the degree of risk reduction that would be achieved if more realistic participation and compliance rates are applied." The NRC report also found that "Although a great deal of public opinion has been solicited to date by the LACPR staff, the draft technical report provides little evidence of a unified planning effort among these different governmental levels and bodies." The NRC report also noted that the LACPR draft report did "not suggest policies and programs that could be employed to encourage high rates of adoption of nonstructural measures."

Structural — The NRC report found that the LACPR draft technical report did "not consider the *potential for structural failure* of levees and floodwalls. As a consequence, the true risk to homes and businesses and people behind structures has not been determined."

That report also included discussion of possible realignment of the lower Mississippi River. Such a proposal would divert sediments that now are lost to the deep water of the Gulf of Mexico, to wetlands across the Mississippi River delta. This type of realignment likely would entail substantial disruptions and costs to commercial navigation. The report noted that "given the scale of coastal restoration envisioned within the LACPR report, and the large amounts of sediment necessary to achieve this restoration, changes to the alignment and levee system of the lower Mississippi River may be required for restoration actions" (NRC, 2008). The report went on to recommend that an evaluation of how a major re-

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alignment of the river's mouth may affect sediment capture and diversion be conducted.

The remainder of this report constitutes a review of the LACPR 2009 draft final technical report and is divided into three main sections: the future course of action; key scientific, engineering, and other technical topics; and future hurricane protection planning and project implementation[1].

[1] The LACPR 2009 draft final technical report did not identify any preferred plan or plans. This committee's report thus does not examine cost estimates in the LACPR report, as a review of cost estimates for all the plans that were considered would have had little value.

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2

The Future Course of Action

The authorizing legislation for the LACPR—P.L 109-103—was passed in November 2005. It directed the Corps to "present a full range of flood control, coastal restoration, and hurricane protection measures." It also requested the Corps to "conduct a comprehensive hurricane protection analysis and design," implying that Congress expected a proposal for implementation—not just a list of possibilities—by the end of 2007. For its part, the LACPR team has interpreted its project authority as requiring it to present only a range of plans. The LACPR has not proposed, and apparently does not intend to propose, a single plan or a preferred initial course of action. This means that actions for improving hurricane storm surge protection for southern Louisiana will be further delayed.

A Dutch planning team, with modest support from the U.S. Army, conducted its own planning study and issued a 2007 report that included a comprehensive conceptual design for restoration and hurricane protection (Dijkman, ed., 2007). Although that study may not necessarily represent an optimal approach to restoration and protection, it is an example of a clear proposal with a long-term vision on which immediate actions can be based. Furthermore, it appears to be a reasonable effort to address the congressional directive. The LACPR took a different approach, producing a report with no actionable project recommendations.

To design a program for integrated hurricane protection and restoration measures for coastal Louisiana clearly is a complex task. Nevertheless, Congress and the citizens of Louisiana look to the Corps of Engineers and the LACPR for leadership and direction on these issues, and it is incumbent upon the LACPR team to provide advice on future strategic direction and actions. These points were alluded to in this committee's 2008 report, which stated, "Unless some advice regarding promising initial projects for ecosystem restoration, hurricane protection, and buyouts and relocations is provided, the LACPR planning effort will fall short of

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its potential to offer science-based, analytical advice on hurricane protection and coastal ecosystem restoration."

Whatever the ultimate intent of Congress in the 2006 legislation, and whatever the Corps' interpretation of its authority, it is clear that there is no preferred plan, or even any part of a preferred plan in the LACPR draft final technical report. Nor does the draft final technical report suggest clear priorities for initial restoration, structural, and nonstructural projects and activities. Moreover, in part because of deficiencies in the LACPR methodology for ranking alternatives, there is no reason to think that any of the 27 alternative planning unit-level plans listed by the Corps can be described as a preferred plan.

The authorizing legislation for the LACPR study called for a final technical report to be submitted within 24 months—or in November 2007. The LACPR report, however, still is in draft form as of mid-2009. It is important that the LACPR report be completed with due speed. Any recommendation for a date on which the report should be completed will include a degree of judgment and opinion. In this committee's view, the submission of a final report by the end of 2009 would strike a balance between allowing for additional time to finalize the document while at the same time encouraging the Corps and the State of Louisiana to move quickly to agreement on next steps.

The lack of a comprehensive long-term hurricane protection and coastal restoration plan, and the lack of advice on initial high-priority steps and projects, represent substantial shortcomings of the LACPR draft final technical report. Before the end of 2009, the Corps of Engineers and the State of Louisiana should agree on the elements of a single comprehensive plan for long-term hurricane protection and coastal restoration. As part of that plan, the Corps and the state should agree on a number of high-priority projects for immediate implementation.

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3

Key Scientific, Engineering, and Other Technical Topics

SUSTAINABILITY OF THE COASTLINE

Trends in and Causes of Coastal Erosion

An important assumption underlying the LACPR draft final technical report is that the current configuration of the Louisiana coastline is sustainable:

> Extensive coastal landscapes in Louisiana can be constructed and maintained at a pace sufficient to offset expected future landscape degradation (USACE, 2009, p. 43, main report).

Any program or assessment regarding the future sustainability of Louisiana's coastline must consider historical and future trends in erosion and sea level rise. For instance, Louisiana has lost 1,900 square miles of land since the 1930s (Barras et al., 1994; Barras et al., 2003; Dunbar et al., 1992). Between 1990 and 2000, wetland loss was approximately 24 square miles per year. The projected loss over the next 50 years, with current restoration efforts accounted for, is estimated to be approximately 500 square miles (Barras et al., 2003). As the late coastal expert Shea Penland stated, and as noted in this committee's 2008 report, "The state is rapidly disappearing into the Gulf of Mexico" (Penland, 2005). The Science Board of the Louisiana Coastal Area (LCA) ecosystem restoration program made a similar observation, stating "It is obvious that not all of the coastline can be maintained, much less restored, and not all coastal communities can be adequately protected" (Science Board of the LCA, 2009). Figure 2 illustrates the impact of these rates of

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land loss and how much additional land is forecasted to be submerged by the year 2050.

Several factors have contributed to these losses, including:

- A reduction in sediment delivery volumes from the Mississippi River as compared to historical rates. The construction of several large dams on the Missouri River in the 1950s and 1960, and the construction of the Missouri River Bank Stabilization and Navigation Project (authorized in 1945) have greatly reduced sediment deliveries from the Missouri River. Prior to those actions, the Missouri River had been the largest contributor of sediment to the Mississippi River of all its tributaries (see Figure 3).
- Construction of flood control structures along the mainstem Mississippi River in Louisiana that prevent the flooding of wetlands by sediment-laden waters, a process that previously helped build and replenish wetlands. Rather, the sediment-laden waters have been confined to move through the lower Mississippi delta to the edge of the continental shelf and then to the deep waters of the Gulf of Mexico permanently removing this sediment from the littoral zone.
- Wetland edge erosion by storms that likely are exacerbated by the larger open water fetch in ever-enlarging interdistributary bays (e.g., Barataria, Terrebonne, Atchafalaya).
- Natural consolidation of soils in Louisiana's coastal wetlands.
- Navigation and pipeline canals cut through the wetlands by the oil and gas industry.
- Offshore disposal of clean dredged materials by the Corps of Engineers.

Treatment of Coastal Erosion Issues in the LACPR Report

An assumption that "extensive coastal landscapes in Louisiana can be constructed and maintained" (USACE, 2009; main report, p. 43) in the face of these erosion trends will require that the State of Louisiana be provided annual volumes of sediment comparable to a significant fraction of the Mississippi River's historical sediment load. That is, millions of cubic of yards of sediment will have to be provided annually to the

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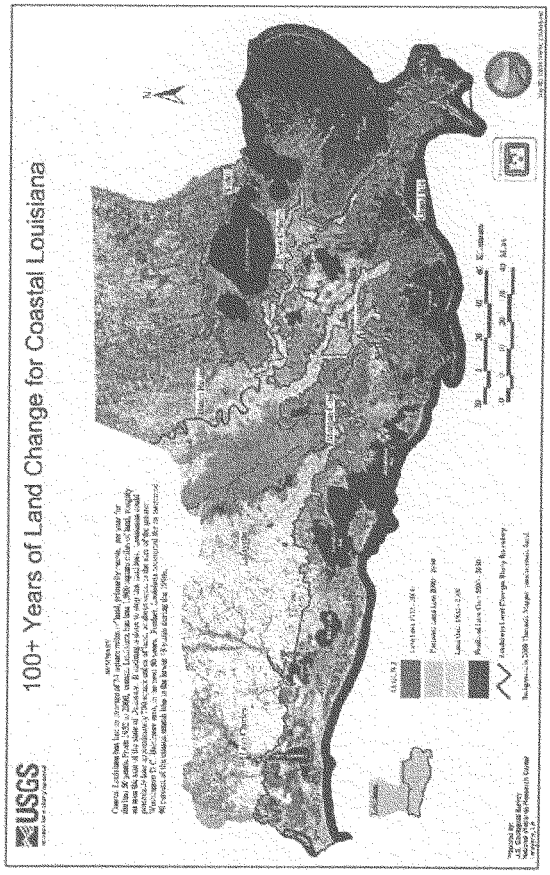

FIGURE 2: 100+ years of land change for coastal Louisiana.
SOURCE: U.S. Geological Survey (2003).

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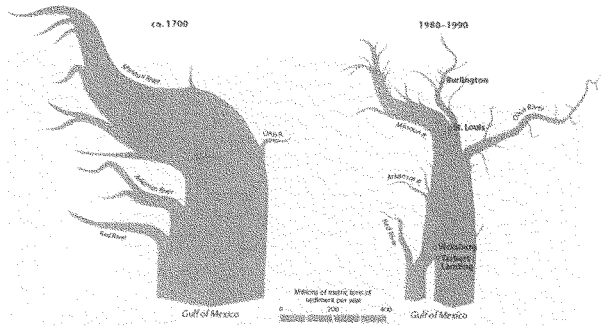

FIGURE 3: Mississippi River suspended sediment discharge, around 1700 (estimated) and 1980-1990. Values in millions of metric tons per year. Widths of the river and its tributaries are exaggerated to reflect relative sediment loads.
SOURCE: Meade (1995).

coast, whether from the Mississippi River or from other sources. Furthermore, these required amounts will increase over time because of the increasing rate of sea level rise. These materials will have to be placed in a way that fosters marsh growth with its attendant organic contribution to wetlands accretion.

The LACPR draft final technical report suggests, but does not convincingly demonstrate, that wetlands losses can be countered and the current Louisiana coastline sustained. The LACPR draft final technical report proposes a dredging program with six dredges working around the clock, 365 days per year (USACE, 2009, p. 44, main report). Each dredge was assumed to produce 900 acres of land per year, with the six dredges thus producing 5,400 acres. This is equivalent to 8.4 square miles—an amount less than rate of annual erosion losses of roughly 24 square miles. Moreover, although this dredging program may be theoretically possible, the question is whether it is economically feasible or environmentally acceptable, particularly since
offshore sources and lake bottoms are identified as the source of some of the dredge materials (and therefore would entail long and costly transport of sediment).

There is no existing sediment budget that accounts for the amounts and the locations of sediment sources and sediment losses to erosion each year in coastal Louisiana. Results from this sediment budgeting can

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be used to provide a best estimate of the amount of material necessary to maintain the coast. The LACPR team currently is developing a regional sediment budget for coastal Louisiana, which is explained as:

> The USACE is currently developing a Regional Sediment Budget for coastal Louisiana; however, the final budget is not expected to be completed until July 2010. Based on rough calculations, the LACPR team concluded that adequate sediment sources are available to implement proposed no net loss coastal restoration plans but acquiring those resources involves trade-offs (e.g. costs and environmental impacts) (USACE, 2009, p. 10, main report).

Without a credible sediment budget, a goal to achieve "no net loss" (USACE, 2009; main report, p. 43) seems questionable, even with extensive dredging. It is worth noting that a sediment budget is not simply a calculation of inflows vs. outflows but also would consider the distribution and character of wetlands and barrier shorelines being considered for future maintenance.

A previous report from the National Research Council entitled *Drawing Louisiana's New Map* (NRC, 2006) reviewed the Corps of Engineers' 2004 Louisiana Coastal Area (LCA), Louisiana—Ecosystem Restoration Study. That NRC report concluded that it is not feasible to maintain coastal Louisiana in its current form and that the Corps should modify its plans and educate stakeholders about other approaches that will need to be taken:

> The Mississippi River delta is inherently dynamic and large. Even maintenance of the status quo would require unreasonable quantities of sediment to travel great distances at unreasonable cost. No reasonably scoped effort will bring back the Mississippi River delta of historical times. Those responsible for restoration efforts in Louisiana will have to clarify that if these projects are executed successfully, the future delta will contain all of the landform types that exist today; however, those landforms will be smaller in size, and some will be located in different places than today. To conserve resources and focus effort where it will be most beneficial, some presently inhabited regions may have to be abandoned or re-

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> located. If this is undertaken in a carefully planned manner that view processes on the scales of decades rather than years, the impacts to individuals and communities can be minimized (NRC, 2006. p. 41).

That report also found that:

> Achieving no net loss is not a feasible objective because the social, political, and economic impediments are extensive; the sediment supply is limited; and the affected area is large. . . These facts have to be broadly appreciated to avoid widespread disappointment with the LCA projects (NRC, 2006, p. 162-163).

The LACPR team maintains that the goal of achieving no net loss of the coastal landscape of south Louisiana is technically feasible. This NRC committee, however, is skeptical whether such an effort is achievable or economically sustainable in the long run and whether it can be accomplished without substantial adverse environmental impacts. Further, the pursuit of this goal would consume considerable levels of financial resources for restoration and protection efforts, some of which might be better spent on other high-priority projects as determined by the LACPR and the State of Louisiana.

The LACPR team should complete a sediment budget for coastal Louisiana. They also should provide a better explanation of potential costs and environmental impacts of dredging alternatives.

Rather than focusing energy and resources into trying to maintain the current configuration of southern Louisiana's eroding coastline, the LACPR team is encouraged to focus its protection and restoration plans on high-priority projects.

ADDRESSING SCIENTIFIC UNCERTAINTIES IN RESTORATION

Restoration efforts in ecosystems as large and complex as those in coastal Louisiana entail many scientific uncertainties and unknowns. The mean and the oscillating water levels required to sustain various types of habitat are not known to a great level of precision. Sedimentation rates necessary to establish specific ecosystems are not well known. Most importantly, the prediction of the location and extent of coastal

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wetlands that can provide a given level of storm surge reduction involves processes and parameters that are not fully understood or quantified. This section addresses some examples of scientific uncertainties that require more detailed consideration in the LACPR planning study.

There are many contributions to uncertainty in the modeling of waves and surge and in the modeling of marsh creation by diversion. With modeling efforts of this magnitude, the level of uncertainty is understandably high. Therefore, it is important for model uncertainty to be quantified and to be propagated through the decision process. With regard to marsh creation, the uncertainty must acknowledge and reflect the lack of validated predictive models. The existing models, as applied within the LACPR study, contain unsupported assumptions (see below), and the lack of validation needs to be recognized and accounted for when utilizing model results.

Uncertainty in surge/wave models

Most of the LACPR evaluations regarding both structural and nonstructural alternatives are based on the estimations of water levels along the Louisiana coastal area. These water levels are obtained from numerical models. It thus is important that these models represent all important physical processes in trying to emulate natural conditions.

The LACPR team used reasonably well-tested numerical models for tide and storm surge modeling and for modeling short waves in deep and shallow environments. The ADCIRC model was used to calculate water level associated with storm surge and the WAM and STWAVE models were used to calculate wave heights. The LACPR study does not consider the frictional dissipation due to bottom and vegetation interaction in STWAVE simulations. The LACPR report justifies this decision by stating that the STWAVE results that include friction have been known to underestimate wave heights at "some locations inshore of coastal marsh areas." This argument suggests that STWAVE does not properly model the physical processes in these areas. Because waves are important factors in structural performance and also contribute to hurricane surge, modeling them accurately is important to the LACPR study and its results. Further analysis of the sensitivity of both surge and wave model friction would provide additional insight into the role of wetlands and associated nearshore areas in attenuating waves and surge.

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Marsh Modeling

A significant portion of the LACPR coastal restoration plans relies on the use of diversions of sediment-laden flows from the Mississippi River channel into adjacent wetlands. Although such diversions may ultimately be efficient in helping create and restore wetlands ecosystems, the efficacy of such diversions has not been demonstrated clearly in the LACPR report, either through a study of existing diversions or via modeling analyses. Given that restoration activities are affected by nutrient reintroduction, water quality issues are of great importance and also should be accounted for and tracked in restoration planning, projects, and monitoring (Twilley and Rivera-Monroy, 2009).

The modeling of marsh-creation contains several poorly supported assumptions. First, the estimation of the areal footprint impacted by a given diversion is chosen by subjective consideration only (USACE, 2009, p. 59, Summary). These estimates would be more reliable if they had a strong quantitative basis for estimating the area of a footprint of a given project, based either on derived estimates or on observations of existing marsh-building diversions. Second, the sedimentation model assumes a turbulence structure that is identical to open channel flow. This is inappropriate in a vegetated system, and will likely produce significant errors in the estimation of how marsh-building sediment is distributed from a diversion. Third, the total amount of river water diversion—525,000 cubic feet/second—is over 40 percent of the total channel flow. Because of the obviously large impact on main channel flow, the extent to which upstream diversions impact downstream diversions and promote sedimentation within the main channel should be considered; that is, the presence of upstream diversion creates greater uncertainty regarding the potential success of downstream diversions and may affect river sedimentation.

Finally, the success of diversions will be predicated on the impact of future sea level rise, as newly created wetlands will need to keep pace with rising sea levels. Increased sedimentation as a result of diverting water from the river already is a concern to maritime interests. For example, the construction of the West Bay diversion, near Head of Passes, has been blamed by some for increased shoaling near the Pilottown Anchorage.

The LACPR report should provide a better and more quantitative explanation of the scientific uncertainty associated with projections of marsh and wetlands restoration (including diversions), surge attenuation by wetlands, numerical modeling efforts, and the

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implications of Mississippi River diversions.

The high level of uncertainty of the effects of proposed river diversions suggests the need for careful monitoring and evaluation of existing diversions. It also suggests the importance of an adaptive strategy that can adjust to and build upon new information as more is learned about the responses of these coastal wetlands systems to human interventions.

ENGINEERING CONCEPTS

Levels of Protection

The Corps of Engineers has been authorized by Congress to make repairs to the New Orleans hurricane protection system. Repairs and strengthening of the system are being carried out by the Corps of Engineers' "Task Force Hope" team with a goal to provide protection against hurricane storm surge with a 100-year recurrence interval, or the surge associated with a hurricane expected to occur on average once in 100 years, for New Orleans by 2011. The term "100-year recurrence interval" is a frequently used term to describe an event that has a one per cent chance of occurring in any given year. Similarly, a 500-year recurrence interval refers to an event that has a 0.2 percent chance of occurring in a given year, while a 20-year recurrence interval refers to an event that has a 5 per cent chance of occurring in a given year. These are average measures and a storm surge with a 100-year return period may occur more, or less than, once in a given 100-year period.

The probabilistic nature of hurricane statistics is complicated by long-term changes in climate and other environmental variables. Changes and variability in the behavior of the climate system imply that long-term averages and extreme values may shift over time—a concept referred to as 'nonstationarity' (for further discussion of hydrologic nonstationarity and its implications for water management, see Milly et al., 2008).

The standard of providing protection against the 100-year flood is an important one within the National Flood Insurance Program. It has been applied both in New Orleans and widely across the nation as a *de facto* safety standard. In areas in which storm surges that exceed the capacity of the hurricane protection system (e.g., levees) do not pose a major public safety concern, cause extraordinary property damage, or imperil

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evacuation routes, this 100-year standard may be reasonable. However, for heavily populated cities such as New Orleans, where hurricane protection system failure has been shown to be catastrophic—this level of protection is insufficient.

The Association of State Floodplain Managers (ASFPM) 2007 report, *Levees: The Double-edged Sword,* provides helpful guidance on this subject. That report explains, for example:

> In those cases in which a levee is found to be an appropriate measure to protect urban areas or to be credited for protection, the levee should be constructed to a high level of protection. As described in various reports, the level of the 500-year flood, plus freeboard, is considered an appropriate *minimum* protection standard with urban areas. . .
>
> There is now widespread misunderstanding of the true risks associated with levees. This in turn has helped lead to the current over-reliance on structural solutions to reduce the impact of flooding, and to the creation of a false sense of security among those living, working, or seeking to build in areas behind levees. .... Communication of the residual risk associated with any levee is key to public understanding and acceptance of appropriate public safety and flood risk reduction policies in the nation (ASFPM, 2007; italics added).

In addition to the ASFPM report, the National Research Council recently issued a report on the New Orleans hurricane protection system, including the presentation of key lessons learned during Hurricane Katrina (NRC, 2009). That report considered the issue of flood protection criteria for New Orleans, concluding that:

> The 100-year level of flood protection is a crucial flood insurance standard. . . For areas in which catastrophic levee failure is not a major public safety concern, and where large floods would not imperil evacuation routes, the 100-year standard may be appropriate. For heavily-populated urban areas, where the failure of protective structures would be catastrophic—such as New Orleans—this standard is inadequate (NRC, 2009).

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This committee agrees that providing protection from storm surge with an expected recurrence interval of 100 years is inadequate for New Orleans. In its first report (NRC, 2008), this committee noted that the LACPR draft technical reports defined 'Category 5' protection as falling in the range of a 400-year to a 1,000-year event, a point that the LACPR reiterated in its 2009 draft technical report:

> USACE policy guidance memorandums directed that a set of measures be presented that could reduce risk across a range of storm surge events including 100-year risk reduction, a "low Category 5" event or Hurricane Katrina-like event (estimated as a 400-year surge event) and a "high Category 5" event (estimated as a 1000-year event) (USACE, 2009; p. 3, main report.).

In its 2008 report this committee recommended that the LACPR team focus on producing designs and plans based on storms with return intervals associated with Category 5 storms. As defined by the LACPR, this would encompass storm surges from 400 to 1,000-year recurrence intervals, consistent with the authorizing 2006 legislation. This design standard would provide New Orleans with protection from storm surge that is comparable to the level of protection provided to the city from the levees along the Mississippi River, which provide protection against riverine floods with a 700- to 800-year recurrence interval.

The first priority of comprehensive hurricane protection and coastal restoration for southern Louisiana should be to ensure protection against storm surges with 400- to 1,000-year recurrence intervals in the City of New Orleans, where the population density and the property at risk are the highest. This level of protection could be provided by raising and strengthening levees alone or by a combination of levee repair and elevating structures behind them.

Storm surge protection for the City of New Orleans should be designed for a hurricane storm surge event with an expected return interval of 400 to 1,000 years. The 2007 report from the Dutch engineers found that even higher levels of protection are economically justifiable.

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Limited Consideration of System Failure

The low-lying, and in many areas subsiding, topography of southern Louisiana makes the region particularly vulnerable to flooding. Although low-lying areas above sea level may flood during severe storms, many areas in southern Louisiana lie below the average level of the adjacent waterbodies of Lake Pontchartrain, Lake Borgne, and the Mississippi River. There is an elaborate system of flood control structures, such as levees and floodwalls, in the region to help protect against storms and high water.

A breach of the hurricane protection system will have very different consequences for land areas above sea level as compared to those below sea level. In the former case, inundation will occur only during the event itself with water receding thereafter; flood depths will depend on the duration of the storm, the size of the breach, and the surge elevation outside the protection system. However, in areas below sea level, inundation will continue until the breach is repaired and the water is pumped out; flood depths will depend primarily on the water level in the adjoining waterbody. The flooding of New Orleans after Hurricane Katrina—via waters from Lake Pontchartrain that flowed through breaches in floodwalls that line the city's outfall and navigation canals—is a poignant example of this and a sobering reminder that failure of the hurricane protection system is a key component of the residual risks that attend hurricane and flood protection systems.

The LACPR draft final technical report does not consider the possibility of failure when evaluating water levels and flooding associated with storm surge. Rather, all analyses presented in this report, whether to determine system configurations that meet 100-, 400-, and 1,000-year water levels, or to evaluate these system configurations for different storm occurrence frequencies, assume perfect system performance. Although well-designed protective structures together with diligent maintenance and repair efforts will reduce the likelihood of failure, assuming zero probability of failure is unrealistic and unacceptable, especially for areas where such failure would subject lands to unabated filling from an adjacent waterbody.

A significant portion of the hurricane protection plans within the LACPR draft final technical report call for the construction of levees protecting different cities and municipalities. New Orleans is one of the nation's largest metropolitan areas protected by levees and many of the structures within its hurricane protection system are being raised and strengthened in the wake of Hurricane Katrina. In addition to levees (or

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ring levees) being proposed for Houma and Morgan City, costly levees are proposed for even smaller communities such Delcambre and Erath.

In assessing flood risks for coastal Louisiana, the LACPR draft final technical report does not incorporate the probability of system failure as part of the risk assessment. The current approach highlights the use of a "qualitative" assessment of failure potential based on the total levee length, number and size of hydraulic structures, and overtopping. Moreover, the LACPR draft final technical report assumes that structural measures can be built to perform reliably to specified risk reduction levels; therefore, hydrologic stages assume no possibility of structural failure or breaching of levees. Abundant historical experience shows, however, that structural failure can occur, with an increasing likelihood in larger storms. This has been recognized in the work of the Interagency Performance Evaluation Task Force (IPET), which conducted an extensive evaluation of the performance of the New Orleans hurricane protection system during Hurricane Katrina and under future storm conditions (IPET, 2008).

It is likely that any conclusions regarding overall system performance of the proposed protection systems will be grossly misleading without appropriately (and quantitatively) accounting for the probability of failure of the structural protection systems. By not accounting for the possibility of structural failure in its analysis, the LACPR draft final technical report underestimates the residual risk in the hurricane protection options that have been presented. Depending on the significance of this underestimate, it may discourage supplemental nonstructural mitigation efforts such as voluntary relocation and the elevation of structures, and may enhance a false sense of security for those living behind these structures.

The LACPR team should perform a quantitative risk assessment of the structural protection systems that includes the probability of system failure of the various components including floodwalls, levees, ring levees, and floodgates. These probabilities of failure should be performed for a range of hazard levels and a range of structural designs.

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OTHER TECHNICAL ISSUES

Formulation and Evaluation of Alternatives

The LACPR planning area is divided into five planning units (PU1, PU2, PU3a, PU3b, PU4; see Figure 4) based on geographic areas and delineated such that there is minimal interaction between units. Within each planning unit, numerous potential plan components were identified. These potential components were combined into a large number of alternative plans. The best-performing alternative plans were then identified on the basis of analysis, experience, and judgment. The result was a total of 111 alternative planning unit-level plans, ranging from 33 alternative plans in PU2 to 13 alternative plans in PU3a.

The alternative plans fall into five categories:

- **No-action alternatives**, which assume continued loss of coastal lands.

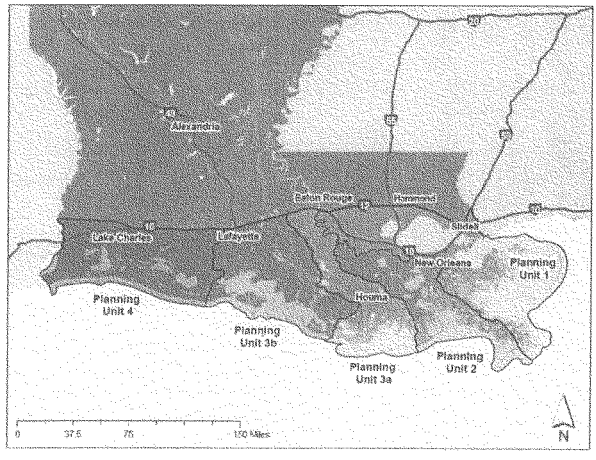

FIGURE 4: LACPR planning area and planning units.
SOURCE: USACE (2009).

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- **Coastal restoration alternatives**, where the only actions taken are preservation and restoration of coastal lands.
- **Nonstructural alternatives**, which combine nonstructural measures with coastal restoration. The nonstructural measures considered consist of buyouts and/or raise-in-place measures for structures that meet certain criteria.
- **Structural alternatives**, which combine levees, floodwalls, flood gates, etc., with coastal restoration.
- **Comprehensive alternatives**, which combine coastal restoration, structural measures, and complementary non-structural measures.

Alternative plans are further differentiated by the level of protection provided. Plans assume protection from storm surges having recurrence intervals of 100 years, 400 years, or 1,000 years. As the level of protection rises, implementation costs increase but expected residual damages decrease.

The result of the evaluation phase should be to identify the preferred alternative plan for each planning unit. The LACPR team elected to stop short of this outcome. Instead, the report narrows the list to five or six alternative plans for each planning unit (27 in all). This is followed by some discussion of the tradeoffs existing among these plans. Finally, the 27 alternative planning unit-level plans are assembled into seven coast-wide plans.

Evaluation

As a basis for evaluation, the LACPR team characterized each of the alternative plans in terms of ten metrics. Five of these are relatively direct cardinal measures of plan impact, such as the average number of people impacted per year, lifecycle cost of the plan (annualized $/year), or residual damages (annualized $/year). Four metrics are cardinal proxies for actual impact, such as number of archeological sites protected or acres of wetland impacted. One metric (indirect environmental impact) is measured on an arbitrary ordinal scale, ranging from -8 to +8. An ordinal scale differs from a cardinal scale in that ordinal measures reveal only rank (1st, 2nd, 3rd, etc.) and provide no information on the difference between alternative measures. For example, a horse might win a race by a nose or by ten lengths; the ordinal measures for the first two horses are still 1st and 2nd.

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The LACPR team first attempted to identify preferable alternative plans through the use of Multi-Criteria Decision Analysis (MCDA). It was intended that stakeholder workshops could be used to assign weights to the ten metrics and that these weights could then be applied to the actual values of the metrics for each alternative plan. The weighted sums of the metric scores would then be used to rank the alternatives. This committee's prior 2008 report addressed the first estimates of metric weights, noting flaws in the process of obtaining these weights through direct elicitation. The Corps subsequently employed, in a single set of workshops, a swing weighting approach that produced somewhat better results.

Swing weighting is considered preferable to direct elicitation because it provides respondents with an understanding of the possible range of each of the metrics. To determine swing weights, respondents are asked to rank metrics based on the relative desirability of "swinging" the value of each metric from its least preferred to its most preferred level, compared to the swing from least to most preferred for each of the other metrics. The metric which is judged to have the most desirable "swing" is assigned a weight of 100. Then the respondent is asked to compare the importance of the range ("swing") of the next most important metric and to state the relative desirability of this range as a fraction of the desirability of the most favored metric. The weight for the second metric is 100 times this fraction. This process continues until weights have been derived for all metrics. Swing weighting is considered to be a reasonable compromise between the need for rigor and ease of use (Edwards and von Winterfeldt, 1986)

In retrospect, the resulting stakeholder weights exhibit a number of inconsistencies. The implied tradeoffs between cost and benefit are suspect because of the low priority that stakeholders gave to life cycle costs. Application of the same weights to nonstructural and structural projects may be inappropriate since the metrics do not reflect plan characteristics such as political and social acceptability, visual amenity, or other factors that may diverge significantly between the two kinds of approaches. There is also some concern that respondents may have been confused by some metric definitions, especially where signs reversed (some metrics were to be minimized while others were to be maximized). Finally, the number of stakeholders that participated in this process was very low—there were 114 stakeholder participants (USACE, 2009, p. 12, Summary). The fundamental issue of how adequately a group of 114 stakeholders represent the interests of the roughly 2.3 million people that in-

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habit the coastal Louisiana study area was not addressed in the draft final technical report.

As a result of these and other shortcomings, the LACPR-defined metrics combined with the stakeholder weights did not produce a ranking of alternative plans that the LACPR team had confidence in, or that seems reasonable (USACE, 2009, p. 12, Summary). The LACPR team noted that further iterations of the MCDA process could improve the result, but that available time and resources did not permit that option. This committee is more skeptical, believing that substantial redesign of the MCDA process is needed, including extensive use of focus groups to redefine and refine metrics, not just additional iterations of the existing process.

Nevertheless, the LACPR team attempted to make use of the MCDA results by combining them with other scoring and ranking approaches. Nine additional decision criteria were defined, including direct and indirect environmental impacts, various measures of cost and cost effectiveness, and various measures of residual risk. These criteria are measured in various ways, including dollars, risk/cost ratios, wetland acres, and ordinal rankings (MCDA results, indirect environmental impact).

All of the measures, both cardinal and ordinal, are normalized to a 0-1 scale. Note that the MCDA results are already the result of rescaled metric measures, which are then weighted and summed, and rescaled again in this exercise. Armed with these additional criteria and rescaled results, the LACPR team performed 13 different rankings of the alternative projects in each planning unit. All these rankings included the MCDA results, but with a relatively minor weight. Four rankings were performed on the basis of weighted ordinal ranks; the number of included criteria and the weights applied differed from one to the other. Next, nine more rankings were performed where weights were applied, not to ordinal ranks, but to the normalized scores (in some cases derived from ordinal ranks). Again, these rankings differed in that they included different sets of criteria and applied different weights. The final choice of the preferred projects was based on observed consensus among the 13 rankings. Those projects (usually five) were chosen that appeared most often at the top of the individual rankings. The effect of this is to reduce the number of planning-unit level projects from 111 to 27. Unsurprisingly, given the method used, the rankings were quite consistent.

The deficiencies in the application of MCDA have been noted above and are acknowledged by the LACPR study team. Unfortunately, the attempt to salvage the results of this flawed exercise has introduced more problems, rendering the end result even less useful. One problem that

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runs through this process is the repeated weighting of ordinal numbers. Since an ordinal number reveals only order (1st, 2nd, etc.) it is, strictly speaking, not possible to perform arithmetic operations on such a measure. To do so is to treat the ordinal number as though it were cardinal. This may be acceptable in limited circumstances. For example, an MCDA approach may use an ordinal metric measure that is roughly proportionate to the true cardinal value, so that treating it as cardinal number does not significantly bias the result. But the LACPR report rankings begin with a weighted ordinal measure, combine it into another ordinal measure, then weight it again before combining it into still another ordinal measure. Whatever information was revealed by the first measure is likely to be significantly distorted, if not lost altogether.

The 13 rankings produced in the LACPR report contain no useful information regarding the relative desirability of the alternative plans. The apparent consensus among the rankings simply reflects the commonality of the metric definitions and underlying assumptions. It does not provide any corroborating evidence for the rankings. Accordingly, the 27 alternative plans presented in Table 15-1 of the Technical Report may not necessarily be preferable to the 111 alternatives from which they have been chosen.

Multi-Criteria Decision Analysis is a potentially useful approach to evaluate projects with important environmental, social, and cultural impacts; however, flaws in the application of these methods to the LACPR study have prevented any convincing results. As applied, the methods do not support the identification of a preferred alternative for any of the planning areas. Furthermore, they do not support the rankings of alternative plans as presented in the LACPR report.

Nonstructural Measures

The draft final technical report lacks specificity with regard to a number of the alternatives it proposes for further consideration. For example, many of the alternatives suggested for further consideration involve nonstructural protection. Simply announcing that a nonstructural measure—such as elevating buildings—can reduce flood damages will not necessarily result in buildings being elevated. The LACPR report does not deal with actions needed to actually persuade households to voluntarily take part in such a nonstructural protection program, such as informing households of the risks they face, formulating standards for

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cost-effective elevation and other nonstructural mitigation measures, training and certifying contractors/inspectors to conducting on-site audits to identify appropriate actions households might take to reduce risk, providing financial assistance to households to undertake cost-effective actions, and so forth. The report also lacks clarity as to who should undertake such a program (i.e., the state, local governments, nonprofit entities, or the Corps).

The LACPR draft final technical report acknowledges many of the recommendations offered in this committee's previous, 2008 report—such as the need for measures to counter induced development behind levees and to prevent new and more intensive development from occurring in the future in high hazard areas whether or not protected by levees. However, recognition of a problem does not necessarily solve it. These problems are also not solved by stating that the issues of induced development and prevention of development in high hazard areas are a state, not federal, responsibility. Since the State of Louisiana lacks state regulations that address either issue, they likely will not be addressed without more direct federal action.

The previous, 2008 report from this committee noted that there was precedent to employ many different nonstructural measures to help reduce development in areas subject to frequent flooding:

> The LACPR draft technical report would be stronger if it proposed an integrated set of measures for limiting future increases in vulnerability. These would include comprehensive plans prepared by parishes and municipalities that assess the suitability of land for development and propose policies for limiting development in areas deemed unsuitable due to the risk of flooding. Potential policies that are regularly used for this purpose throughout the United States include: (1) zoning regulations that limit the intensity of development to a level appropriate for the degree of flood risk; (2) subdivision regulations with flood-hazard mitigation provisions; (3) building regulations that require additional freeboard beyond that mandated by the National Flood Insurance Program; (4) public acquisition of land for open space, habitat protection, and outdoor recreation; (5) public acquisition of easements that limit the amount of development possible in the future; and (6) location of new public infrastructure (e.g., roads and water and sewer lines)

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such that it does not induce or support unsafe new development in flood-hazard areas (NRC, 2008).

There is ample precedent for federal requirements of state and local land-use planning and regulation to limit induced development and prevent development of high hazard areas as a condition for federal participation in the construction of hurricane protection levees (see ASFPM, 2004 for case studies of contemporary flood risk management actions in several U.S. communities). This would be similar to the National Flood Insurance Program's requirement of local regulations to prevent development in floodways and to elevate buildings to the 100-year base flood level as a condition for offering flood insurance to the residents of a community.

Implementation of a variety of nonstructural measures will be essential in better managing and reducing flood risks in southern Louisiana. The LACPR team and the Corps of Engineers should take a more aggressive leadership role in a variety of nonstructural measures that are important to reducing flood risks in coastal Louisiana. Examples of these nonstructural measures include limiting development in vulnerable areas and stronger public education efforts regarding flooding risk in different sections of New Orleans.

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4

Future Planning and Project Implementation for Coastal Restoration and Hurricane Protection

ADAPTIVE PLANNING AND IMPLEMENTATION

Due to the complex interactions of estuaries, wetlands, rivers, levees, sea level rise, and future changes in climate, plans within the LACPR project should be designed with some capacity to adapt to future, changing conditions. Not only will environmental conditions in this vast region change over time, but social and demographic conditions will change and initiatives such as nonstructural measures for reducing flood risk reduction (e.g., the adoption of flood insurance; the elevating of buildings in vulnerable areas; the number of structures that are relocated) will change and evolve in unforeseen ways.

Monitoring of various physical and ecological change, as well as compliance with and success of various nonstructural programs, will be an important part of successful future adjustments in coastal restoration and hurricane protection. Monitoring of the performance of the hurricane protection system should be part of the system's ongoing maintenance and there should be regular considerations for altering the system in response to any adverse impacts. This is particularly true in the face of the LACPR study assumptions of no net loss of coastal lands. The outcomes from diversions will have to be monitored in order to adjust and improve future actions. Following up and adjusting programs related to compliance with nonstructural flood risk reduction initiatives and incentives will also be important to their future performance and effectiveness.

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TRADE-OFFS BETWEEN DIVERSIONS AND NAVIGATION

The LACPR draft final technical report proposes nearly two dozen diversions to permit up to 525,000 cubic feet/second of sediment-laden water to leave the Mississippi River and flow into the wetlands for land building (USACE, 2009, p. 43, main report). These diversions would operate during the flood season. The diversion of this much water from the river would cause the river's flow rate to decrease. This would reduce the river's scouring ability and would lead to additional shoaling.

Diversions are featured within the LACPR report as a major supplier of sediment for restoration purposes (USACE, 2009, p. 219-220, main report). Diversions have large implications for the navigation sector, however, and the trade-offs between diversions and keeping water in the channel to support navigation are prominent, important issues. Removing river water to create diversions for wetlands restoration, while also maintaining full navigational uses of the river, means that dredging costs will rise. Increased diversions imply reduced benefits for navigation, and vice versa. Despite the importance of these trade-offs, the LACPR team has conducted little analysis of them to date:

> It should be noted that the LACPR team has not determined the cumulative impacts that multiple diversions may cause on the system. Nor has the team quantified the impacts on navigation or flood control on the Mississippi River (USACE, 2009, p. 219-220, main report).

The LACPR team should more specifically identify and explain the trade-offs between commercial navigation and river diversions for coastal restoration.

Current dredging in order to support commercial navigation yields large amounts of sediment from the bed of the Mississippi River. This sediment, if not contaminated, constitutes a valuable resource for the replenishment of wetlands and where possible should be put to beneficial use. The importance of capturing sediment or limiting its loss is a point that has been made previously in a number of reports. Historically, overbank flooding has provided sediment to the wetlands, but flood protection by levee fortification has eliminated overbank flooding and consequently resulted in the loss of most sediment to the deep waters of the Gulf of Mexico. Minimizing the loss of this sediment off the continental shelf will be important to the success of efforts to preserve and restore Louisiana's coastal wetlands.

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FUTURE SETTLEMENT AND INDUCED DEVELOPMENT

A frequent consequence of levee construction is human settlement of areas behind levees, as these areas may be seen as safe for development and habitation. This phenomenon may take place in previously undeveloped and uninhabited areas; similarly, it may occur in flood-damaged areas such as New Orleans, where settlement or resettlement may take place behind strengthened and raised levees.

The negative consequences of this 'induced development' were noted in this NRC committee's 2008 report, where it was stated that "Plans that encourage people to move into hazardous areas put them at risk in future hurricanes" (NRC, 2008). The Association of State Floodplain Managers likewise has concluded that levees "are inappropriate as a means of protecting undeveloped land for proposed development" (ASFPM, 2007).

The LACPR draft final technical report explains the importance of preventing induced development behind levees (USACE, 2009, p. 25, main report). The LACPR report explains the ways in which induced development was addressed in its report and the LACPR team deserves credit for recognizing the importance of limiting new settlement in hazardous areas. The LACPR report also appropriately recognizes the value of other related nonstructural measures, such as relocations, in significantly and reliably reducing flood risk (USACE, 2009, p. 36, Summary).

Even though the concept of preventing induced development is endorsed, another portion of the LACPR report explains that "the population of South Louisiana is expected to increase" (LACPR, 2009, p. 38, main report). Population growth and redevelopment policies are of course beyond the Corps' responsibilities; nevertheless, a program for reducing flood risks that sought to prevent induced development in vulnerable areas would state clearly the reasons why the most vulnerable areas of southern Louisiana should be avoided and not resettled. There are of course many parties encouraging population growth in the region, but efforts to resettle people back into vulnerable areas will increase the flood risks to the city and its inhabitants and will not improve public safety.

It is encouraging that the LACPR draft final technical report describes the importance of preventing induced development. The report, however, does not adequately demonstrate how these principles will be a prominent part of hurricane protection and coastal restoration actions. Discouraging development in particularly vulnerable areas, whether or not they are protected by

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levees, is a fundamental principle of flood risk management and reduction. The LACPR should strengthen its cooperation with state and local entities to ensure that the prevention of induced development is accorded a more prominent and meaningful role in future plans.

CONSTRAINTS OF THE CURRENT LEGISLATIVE SETTING

The Corps of Engineers has responsibilities for numerous restoration and hurricane protection projects in southern Louisiana, under multiple authorizations. Although this reflects the traditional process of project authorizations through federal Water Resources Development Acts, it represents a piecemeal and poorly coordinated approach to ecosystem restoration and hurricane protection. If these projects are to be developed and implemented in a coordinated fashion across all of coastal Louisiana, this current situation of multiple authorizations—which may entail lengthy re-authorization processes if the Corps wishes to adjust operational goals—will hinder comprehensive, collaborative, and adaptive restoration and protection.

The LACPR draft final technical report indicates that the majority of the improvements identified for final consideration therein could be implemented under the multiple, existing authorizations for hurricane protection across southern Louisiana, either directly or by utilizing project change orders and that the remainder could be handled by new authorizations; however, it is not clear that this is advisable.

A good precedent for authorizing legislation for large-scale, adaptive ecosystem management projects, such as those that are needed to protect southern Louisiana into perpetuity, is the Comprehensive Everglades Restoration Plan (CERP). Authorized in the Water Resources Development Act of 2000 (WRDA 2000), the CERP is a 50/50 funding partnership with the State of Florida with a goal to "restore, preserve, and protect the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection" (WRDA 2000, Section 601).

In addition to the enabling legislation, an accompanying report from the U.S. Senate Committee on Environment and Public Works explains the rationale and value of the CERP in promoting an adaptive approach to large-scale ecosystem management:

> The committee does not expect rigid adherence to the Plan as it was submitted to Congress. This result would

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> be inconsistent with the adaptive assessment principles in the Plan. Restoration of the Everglades is the goal, not adherence to the modeling on which the April, 1999 Plan was based. Instead, the committee expects that the agencies responsible for project implementation report formulation and Plan implementation will seek continuous improvement of the Plan based upon new information, improved modeling, new technology and changed circumstances (U.S. Senate Committee on Environment and Public Works, 2000).

From the outset of comprehensive restoration efforts in the Everglades, the Corps and the State of Florida recognized that they were charged to implement a large, complex portfolio of projects over decades and in the face of substantial scientific uncertainty. Their approach was to build in adaptation based on a major analytical and modeling effort and to seek congressional approval for a unique type of program authorization. The LACPR program is similar to the Everglades Restoration Plan in its spatial extent, hydrologic and ecologic complexity, and uncertainties regarding outcomes of future ecosystem restoration and hurricane protection efforts. The LACPR, however, presently lacks the kind of authorization that allowed CERP to move forward with a flexible, adaptive program.

Current legislation for coastal Louisiana hurricane protection and ecosystem restoration does not explicitly promote or provide for comprehensive and adaptive planning. Examples of important scientific and planning principles that could be more explicitly encouraged include:

- There is a need to shed many outdated concepts such as levee height specifications that are tied to the Saffir-Simpson scale or the standard or maximum probable hurricane;
- Protection should be cast in a risk-based framework (e.g., 1,000-year protection) that is coordinated although not necessarily equal throughout the region;
- A mechanism is needed to specifically monitor changing environmental conditions (e.g., due to sea level rise and subsidence) and incorporate the findings into ongoing protection and restoration efforts in order to achieve successful, long-term adaptation;
- It should be possible to modify plans as new technologies,

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such as improved hazard models, are developed;

- Projects should include beneficial use of all dredged materials (also see USACE, 2009, p. 225, main report);
- There should be a requirement of external review of new or substantially modified projects and periodic external review of existing projects;
- It is necessary to clearly delineate the roles of the federal and state governments in the collaborative design and development of a comprehensive system that includes coastal, structural, and non-structural protections and ties together initial system design and construction with long-term maintenance and operations using adaptive management.

The multiple authorizations that govern ecosystem restoration and hurricane protection in southern Louisiana represent a piecemeal approach and may hinder integrated, adaptive restoration and protection improvements across the region.

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Appendixes

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Appendix A

Statement of Task
Committee on the Review of the Louisiana Coastal Protection and Restoration (LACPR) Program

This NRC committee will review the evaluations being conducted as part of the Louisiana Coastal Protection and Restoration (LACPR) program. These studies are being conducted by the U.S. Army Corps of Engineers in close coordination with the State of Louisiana. Congress has directed the Corps of Engineers, New Orleans District, in partnership with the State of Louisiana, to compile a 24-month technical comprehensive hurricane risk reduction analysis and design. The Corps and the State of Louisiana thus are evaluating a wide range of flood control, coastal restoration, and hurricane protection measures in this study. The LACPR study began in early 2006 and an interim report was issued in July 2006. The LACPR team plans to issue a draft report in December 2007 and a final report in Spring 2008.

The NRC committee will review all aspects of these latter two reports, including assessment of the hurricane risk reduction framework, alternatives for flood control, storm protection, coastal restoration, and risk analysis. These two LACPR reports will include several technical appendixes (e.g., cost estimates, engineering studies, draft EIS, design appendixes, and public outreach strategy) that will be part of this review. Given the large number of supporting and supplemental documents that are being produced by the Corps and various other parties, the NRC committee will also review supplemental documents as the committee sees fit and within its time and resource constraints.

The NRC committee will issue two reports that include conclusions, findings, and recommendations for improving the LACPR study.

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This project is sponsored by the U.S. Army Corps of Engineers. The approximate start date for the project is June 11, 2007.

UPDATE 1-16-08: The project duration has been extended. The first report is expected to be issued by February 2008 and the final report by later in 2008.

UPDATE 3-17-08: The project duration has been further extended. The first report is expected to be issued by late April 2008.

UPDATE 03-24-09: The second report is expected to be issued in summer 2009, following review of the final report of the LACPR program which was provided to the NRC committee in early March 2009.

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Appendix B

Acknowledgement of Reviewers

This report was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise in accordance with the procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the NRC in making its published report as sound as possible, and to ensure that the report meets NRC institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We thank the following for their review of this report: Mead A. Allison, University of Texas; Donald F. Boesch, University of Maryland Center for Environmental Studies; John J. Cassidy (retired), Bechtel Corporation; Gerald E. Galloway, University of Maryland; Robert A. Holman, Oregon State University; David H. Moreau, University of North Carolina; William K. Nuttle; Denise J. Reed, University of New Orleans; and Robert R. Twilley, Louisiana State University.

Although these reviewers provided constructive comments and suggestions, they were not asked to endorse the report's conclusions and recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Frank H. Stillinger, Princeton University, who was appointed by the NRC's Report Review Committee and by David A. Dzombak, Carnegie Mellon University, who was appointed by the NRC's Division on Earth and Life Studies. Drs. Stillinger and Dzombak were responsible for ensuring that an independent examination of this report was conducted in accordance with NRC institutional procedures and that all review comments received full consideration. Responsibility for this report's final contents rests entirely with the authoring committee and the NRC.

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Appendix C

Water Science and Technology Board

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MICHAEL J. STOEVER, Research Associate
STEPHEN T. RUSSELL, Senior Program Assistant

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Appendix D

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ROBERT J. SERAFIN, National Center for Atmospheric Research, Boulder, Colorado
ANNE M. TREHU, Oregon State University, Corvallis
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Appendix E

Biographical Sketches for the Committee on the Review of the Louisiana Coastal Protection and Restoration (LACPR) Program

Robert A. Dalrymple (NAE) is the Willard and Lillian Hackerman Professor of Civil Engineering at the Whiting School of Engineering of Johns Hopkins University. He works in the area of coastal engineering, with specific interests in numerical modeling of coastal processes, including nearshore hydrodynamics. His current interests are water wave modeling, tsunamis and their impact on shorelines, and the interaction of water waves with the sea bed, specifically mud bottoms. The creation of appropriate waves in the laboratory setting–such as in three-dimensional wave basins–is a sideline activity. He received his A.B. in engineering sciences from Dartmouth College, his M.S. degree in ocean engineering from the University of Hawaii, and his Ph.D. degree in civil and coastal engineering from the University of Florida.

John J. Boland is a professor emeritus in the Department of Geography and Environmental Engineering at Johns Hopkins University. His fields of research include water and energy resources, environmental economics, and public utility management. Dr. Boland has studied resource problems in more than 20 countries, has published more than 200 papers and reports, and has coauthored two books on water demand management and three others on environmental management issues. Dr. Boland is a registered professional engineer. He has served on several NRC committees and boards, including the Water Science and Technology Board, of which he was a founding member (1982) and past chair (1985-1988). He is a life member of the American Water Works Association and past chairman of its Economic Research Committee. Dr. Boland

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received his Ph.D. degree in environmental economics from Johns Hopkins University.

Raymond J. Burby is a professor in the Department of City and Regional Planning at the University of North Carolina-Chapel Hill. Dr. Burby is a fellow of American Institute of Certified Planners. He has been an author or editor on 14 books and published extensively in planning and policy journals including, among others, *Journal of the American Planning Association, Journal of Planning Education and Research, Journal of Policy Analysis and Management,* and *Journal of Environmental Planning and Management.* He is currently principal investigator on a study of urban growth boundaries funded by the National Science Foundation and P.I. on another NSF-funded project designed to improve the quality of applied research on disasters and mitigation of natural and technological hazards. He received his Ph.D. degree in planning from the University of North Carolina-Chapel Hill.

John T. Christian (NAE) is a consulting engineer in Waban, Massachusetts. His primary area of interest is geotechnical engineering. Much of his early work involved developing and applying numerical methods such as the finite element method. He has also worked on reliability methods for geotechnical applications, soil dynamics, and earthquake engineering on a broad range of civil engineering projects. Dr. Christian's current interests are largely focused on the use of reliability techniques in geotechnical engineering and on earthquake engineering. Much of his work in industry was associated with power generating facilities, including but not limited to nuclear power plants. He received his B.S., M.S. and Ph.D. degrees in civil engineering from the Massachusetts Institute of Technology.

Reginald DesRoches is associate chair and professor in the School of Civil and Environmental Engineering at Georgia Tech University. Dr. DesRoches studies and develops mitigation strategies to reduce risks from earthquakes, particularly, earthquakes in the central and southeastern United States. His specific research interests include seismic resistant design and retrofit of bridges, protective systems for buildings and bridges, performance of transportation networks, and structural applications of smart materials. He is currently a member of the NRC Board for Infrastructure and the Constructed Environment. Dr. DesRoches received his Ph.D. degree in structural engineering from the University of California, Berkeley.

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Charles G. Groat is the John A. and Katherine G. Jackson Chair in Energy and Mineral Resources, Department of Geological Sciences, and professor of Geological Sciences and Public Affairs at the University of Texas. Dr. Groat has over 25 years of involvement in geological studies, energy and minerals resource assessment, groundwater occurrence and protection, geomorphic processes and landform evolution in desert areas, and coastal studies. From 1998-2005 he served as the 13th Director of the U.S. Geological Survey. At the USGS he emphasized integrated scientific approaches to understanding complex natural systems and the use of these understandings in management decisions. Dr. Groat is a member of the Geological Society of America, American Association for the Advancement of Science, American Geophysical Union, and the American Association of Petroleum Geologist. He received his Ph.D. degree in geology from the University of Texas at Austin.

Philip L.-F. Liu is a professor of civil and environmental engineering at Cornell University. Dr. Liu's current research interests include fluid dynamics and nonlinear water waves. He is also currently the Kwoh-Ting Li Chair Professor at the National Central University, Taiwan, which is the highest-level professorship in the university. Dr. Liu is also a fellow with the American Society of Civil Engineers and the American Geophysical Union, and is a member of the International Association for Hydraulic Research. He received his B.S. degree in civil engineering from National Taiwan University, his S.M. in civil engineering from the Massachusetts Institute of Technology, and his Sc.D. in hydrodynamics from the Massachusetts Institute of Technology.

Richard A. Luettich is director of the Institute of Marine Sciences at the University of North Carolina at Chapel Hill. His research deals with modeling and measurement of circulation and transport in coastal waters. Dr. Luettich's modeling efforts have emphasized the development and application of unstructured grid solution techniques for geometricaly complex systems such as sounds, estuaries, inlets and inundated regions. He has co-developed a circulation and storm surge model that has been applied extensively for modeling storm surge in the Southern Louisiana and New Orleans areas. Dr. Luettich has also participated in the development of components of the national Coastal Ocean Observing System. He received his B.S. and M.S. degrees in civil engineering at the Georgia Institute of Technology and his Sc.D. in civil engineering from the Massachusetts Institute of Technology.

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Robert H. Meade is research hydrologist emeritus at the U.S. Geological Survey. His studies have centered on land subsidence in central California; transport and storage of sediment in Orinoco and Amazon Rivers of South America; transport and deposition of sediment in estuaries (including Mississippi River mouth); assessment of pollutants and sediments in Mississippi River. He received his B.S. in geology from the University of Oklahoma and his M.S. and Ph.D. degrees in geology from Stanford University.

James T. Morris is a professor of biological and marine sciences at the University of South Carolina. Dr. Morris is also the director of the Belle W. Baruch Institute for Marine and Coastal Sciences and the Class of '32 Distinguished Professor of Marine Studies at the university. His research spans basic and applied aspects of the physiological ecology of plants adapted to wetland habitats and the biogeochemistry and systems ecology of wetlands, primarily salt and freshwater intertidal wetlands. He received his Ph.D. degree from Yale University.

Heidi Nepf is a professor in the Department of Civil and Environmental Engineering at the Massachusetts Institute of Technology. She focuses her research on physical mechanisms which affect transport and fate of contaminants and nutrients in lakes, wetlands, and coastal zones, as well as vegetated flow dynamics. Dr. Nepf received her B.S. degree from Bucknell University, and her M.S. and Ph.D. degrees from Stanford University.

Joan Oltman-Shay is president and senior research scientist at Northwest Research Associates, Inc. in Bellevue, WA. She has spent much of her career performing field and model studies of nearshore wave and current dynamics and the interplay with morphology and sediment dynamics. Her work has centered on the analysis of data from in-situ arrays of pressure and current sensors designed to study the surface gravity wave field and the wave-averaged current field. Her current research includes remote sensing of nearshore environmental parameters (satellite, airborne, and land-based). She received her B.A. degree in applied physics and electrical engineering from the University of California, San Diego, and both her M.S. degree in applied ocean sciences and Ph.D. degree in oceanography from the Scripps Institution of Oceanography.

Asbury H. Sallenger, Jr. is is a research oceanographer at the U.S. Geological Survey in St. Petersburg, FL and is also the Chief of the USGS

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National Coastal Change Hazards Assessment that examines the processes of storm and long-term coastal change hazards throughout the United States using innovative technology such as airborne lidar (light detection and ranging) mapping. His research interests include nearshore sedimentary and wave processes, coastal erosion, and sediment transport. He received both his B.A. degree in geology and his Ph.D. degree in marine science from the University of Viriginia.

NRC Staff

Jeffrey Jacobs is a scholar with the NRC Water Science and Technology Board. Dr. Jacobs's research interests include policy and organizational arrangements for water resources management and the use of scientific information in water resources decision making. He has studied these issues extensively both in the United States and in mainland Southeast Asia. Prior to joining the NRC he was a faculty member at the National University of Singapore and at Texas A&M University. Since joining the NRC in 1997, Dr. Jacobs has served as the study director for over twenty NRC reports. He received his B.S. degree in geography from Texas A&M University, his M.A. degree in geography from the University of California, Riverside, and his Ph.D. degree in geography from the University of Colorado.

Michael J. Stoever is a research associate with the Water Science and Technology Board. He has worked on a number of studies including Desalination: A National Perspective, the Water Implications of Biofuels Production in the United States, and the Committee on Independent Scientific Review of Everglades Restoration Progress. Mr. Stoever received his B.A. degree in political science from The Richard Stockton College of New Jersey in Pomona, New Jersey. He joined the NRC in 2006.

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Louisiana Coastal Protection and Restoration Program

USACE Response to Independent External Peer Review April 2010

Independent External Peer Review (IEPR) was conducted for the Louisiana Coastal Protection and Restoration Program in accordance with Department of the Army, the U.S. Army Corps of Engineers (USACE), guidance *Peer Review of Decision Documents* (Engineering Circular (EC) 1105-2-410) dated August 22, 2008 and subsequent updated guidance *Civil Works Review Policy* (EC 1165-2-209) dated December 31, 2009, CECW-CP Memorandum dated March 30, 2007, and the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* released December 16, 2004.

In December 2005, the U.S. Congress directed the Secretary of the Army through Public Laws 109-103 and 109-148 to

"*...conduct a comprehensive hurricane protection analysis and design at full federal expense to develop and present a full range of flood control, coastal restoration, and hurricane protection measures exclusive of normal policy considerations for South Louisiana and the Secretary shall submit a preliminary technical report for comprehensive Category 5 protection within 6 months of enactment of this Act and a final technical report for Category 5 protection within 24 months of enactment of this Act: Provided further, That the Secretary shall consider providing protection for a storm surge equivalent to a Category 5 hurricane within the project area and may submit reports on component areas of the larger protection program for authorization as soon as practicable: Provided further, That the analysis shall be conducted in close coordination with the State of Louisiana and its appropriate agencies.*"

In response to the authorization and appropriations, USACE produced the LACPR Final Technical Report that presents a full range of flood damage risk reduction (referred to in the authorization as flood control), coastal restoration, and hurricane and storm damage risk reduction (referred to in the authorization as hurricane protection) plans exclusive of normal policy considerations for South Louisiana. Included within this report are alternative plans that could provide risk reduction for a range of alternatives, including the Category 5 threshold of storm events. In addition to formulating and developing alternatives to reduce risk, the LACPR report strives to communicate the risks and the range of implications associated with managing those risks. The LACPR Final Technical Report engages leaders and stakeholders in a process of risk-informed decision-making. The report further indicates the types and potential magnitude of the tradeoffs required for implementation of each plan to assist local, regional, and national consideration and decision-making.

The goal of the USACE Civil Works program is always to provide the most scientifically sound, sustainable water resource solutions for the nation. The USACE review processes are essential to ensuring project safety and quality of the products USACE provides to the American people. In June 2007, USACE contracted with National Research Council (NRC) of the National Academies to establish a committee to review the LACPR Program documented in the LACPR Final Technical Report. The Committee first reviewed the February 2008 LACPR Draft Technical Report and provided comments, which were released in 2008, to be addressed in the

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March 2009 report. The Committee then reviewed the March 2009 LACPR Draft Technical Reports with the purpose of providing the Corps with a final external independent technical assessment, including an assessment of the economic, engineering, and environmental methods, models, data, and analyses used in the report. The committee was charged to review these two draft reports and assess "the hurricane risk reduction framework, alternatives for flood control, storm protection, coastal restoration, and risk analysis". The second NRC report dated July 2009 presents the committee's final review and advice for improvements of the LACPR March 2009 draft final technical report, which again considers the first NRC report's comments. USACE commends the independent external peer review panel for their grasp and understanding of this complex issue and their comments have been integral in the shaping of LACPR Final Technical Report as well as informing other coastal protection and restoration studies and projects in Louisiana. This document outlines what actions USACE has or will take to address the comments provided.

The following discussions present USACE Response to the IEPR comments.

1. IEPR Comment: The lack of a comprehensive long-term hurricane protection and coastal restoration plan, and the lack of advice on initial high-priority steps and projects, represent substantial shortcomings of the LACPR draft final technical report. Before the end of 2009, the Corps of Engineers and the State of Louisiana should agree on the elements of a single comprehensive plan for long-term hurricane protection and coastal restoration. As part of that plan, the Corps and the state should agree on a number of high-priority projects for immediate implementation.

USACE Response: Adopted

Action Taken. USACE concurs with the need to provide additional advice on initial high priority steps and projects. The LACPR Final Technical Report presents a range of comprehensive long-term hurricane and storm damage risk reduction plans that include structural, non-structural and coastal restoration measures. Inherent in each of these comprehensive plans are tradeoffs that need to be further addressed by USACE and the State of Louisiana prior to identifying a comprehensive plan. The steps to address these tradeoffs are included in the Path Forward section of the Main Report and Summary Report.

Action To Be Taken. USACE has provided the LACPR Final Technical Report to the State of Louisiana and will work with the State to identify tradeoffs and priorities in order to identify initial high-priority steps and projects. The complexity and magnitude of those decisions required to identify these steps and projects preclude resolution on the timeline suggested in the comment.

2. IEPR Comment: The LACPR team should complete a sediment budget for coastal Louisiana. They also should provide a better explanation of potential costs and environmental impacts of dredging alternatives. Rather than focusing energy and resources into trying to maintain the current configuration of southern Louisiana's eroding coastline, the LACPR team is encouraged to focus its protection and restoration plans on high-priority projects.

USACE Response: Adopted

Action Taken: USACE concurs that a more detailed sediment budget needs to be developed. The Preface and Summary Report sections of the LACPR Final Technical Report were revised to include a discussion on sediment availability. The initial findings clarify that adequate sediment resources may be available to implement proposed coastal restoration plans but acquiring those resources would involve significant tradeoffs in terms of cost and potential impacts to the ecosystem.

Action To Be Taken: The goal of maintaining the current shoreline was a starting point for more detailed future analysis. External to the LACPR effort, additional steps related to sediment allocation are being taken. The first step in determining this cost of utilization, will be the development of a sediment budget and a regional sediment input/output model. This budget is currently under development as part of the Corps Regional Sediment Management (RSM) program. This initial investigation is scoped as a two year effort and is contingent on availability of funding.

In order to complete an assessment of the coastal landscape contribution to risk management in a timely manner, a comparison of the existing versus future with no restoration condition was employed. The LACPR evaluation determined that the required amount of sediment necessary for specifically identified restoration measures to offset expected losses is available either in existing sources or through the expected delivery of riverine sediments over the period of construction. This finding was based on the identification of specific sediment sources for maintaining the shoreline and the technical feasibility of using this material. The results of hydrodynamic modeling of the current or existing condition provide indications of those landscape features that are critical relative to management of risk. The implication of these findings for risk management is that it may not be necessary to explicitly offset all expected future landscape loss. Additional analysis may identify specific landscape features and locations, requiring significantly less sediment resources to maximize risk management potential.

At this time, USACE is focusing its restoration plans on projects such as those that were identified in the Louisiana Coastal Area (LCA) near-term plan. The LCA near-term plan, which was incorporated into the LACPR study, was developed through a public involvement process and working closely with other Federal agencies and the State of Louisiana. A Chief of Engineers Report on this near-term plan was signed on 31 January 2005, and was then authorized in the Water Resources Development Act of 2007 (WRDA 2007). The plan emphasizes projects that involve diverting and managing freshwater and the associated sediment for restoration purposes. Wetlands created or sustained in this manner can help restore/sustain nesting, feeding and resting habitats for fish and wildlife, including threatened and endangered species (sturgeon, brown pelican, piping plover). The plan also includes barrier Island restoration, which can favorably impact nesting and resting cover for brown pelican and piping plover. Other high priority projects that are either undergoing additional analysis or being implemented are the: Morganza to the Gulf, LA Hurricane and Storm Damage Risk Reduction Project; Larose to Golden Meadows, LA Hurricane and Storm Damage Risk Reduction Project; Alexandria to the Gulf, LA, Hurricane and Storm Damage Risk Reduction Project; and Mississippi River Gulf Outlet Ecosystem Restoration Project.

3. IEPR Comment: The LACPR report should provide a better and more quantitative explanation of the scientific uncertainty associated with projections of marsh and wetlands restoration (including diversions), surge attenuation by wetlands, numerical modeling efforts, and the implications of Mississippi River diversions. The high level of uncertainty of the effects of proposed river diversions suggests the need for careful monitoring and evaluation of existing diversions. It also suggests the importance of an adaptive strategy that can adjust to and build upon new information as more is learned about the responses of these coastal wetlands systems to human interventions.

USACE Response: Adopted

Action Taken: USACE concurs, that additional project-specific modeling will need to be performed to further quantitatively address the uncertainties for specific project features and any linkages to common elements such as the Mississippi River. As an inherently dynamic system, the coastal landscape, and its restoration, is surrounded by large uncertainties. USACE has attempted to quantify, or qualify, these uncertainties to the extent practical at this level of analysis required for such a complex, large scale planning effort. The Summary Report section of the final LACPR Technical Report was revised to include a section on Key Findings that discusses how uncertainties are amplified in large-scale hurricane risk reduction planning. Some of the large uncertainties associated with relative sea level rise and land use/population growth have been accounted for through the use of scenarios. Uncertainty with water levels has been addressed as part of the development of the storm surge and hydrodynamic data and extrapolated to the performance metrics, however, there are additional uncertainties that cannot be quantified. In addition, the Adaptive Management Section of the report was expanded to address the adjustments that would been to be made as more information if learned about the responses of these coastal wetlands systems to human interventions. An adaptive management strategy will be crucial for ensuring that the program remains true to its basic objectives while also integrating valuable new information and allowing necessary shifts in priorities. The LACPR Final Technical Report discusses how the LCA Science and Technology Program could be modified to not only provide the necessary environmental and engineering science, but also include social and economic science and analyses, to completely and effectively address both coastal restoration and hurricane risk reduction needs. This programmatic approach will enable long-term consistency in application and transfer of knowledge and adaptive management as it also integrates risk reduction elements.

Action To Be Taken: Evaluation of the effect of the existing landscape on storm surge provides valuable insight to the types and configuration of landscape features that aid in managing risk. Additional research and modeling of specific features has been identified as a necessary component of a further plan development. More detailed quantitative assessments are needed and will be undertaken when the priority areas have been identified and the plans are further refined.

The Louisiana Coastal Area (LCA) projects and LCA Science and Technology office also provide the expertise and ability to monitor and evaluate existing diversions and to continue to learn from them. As specific coastal restoration projects are being developed under the LCA authority, the Science and Technology office is being utilized as the resource to develop both program and project specific adaptive management plans and criteria.

4. IEPR Comment: The level of storm surge protection for the City of New Orleans should be designed for a hurricane storm surge event with an expected return interval of 400 to 1,000 years. The 2007 report from the Dutch engineers found that even higher levels of protection are economically justified.

USACE Response: Adopted

Action Taken: The final LACPR Technical Report presents an array of alternatives for achieving 100-year (a one percent annual probability of being equaled or exceeded), 400-year (a 0.25 percent chance of being equaled or exceeded in any given year) to 1000-year (a 0.1 percent chance of being equaled or exceed in any given year) hurricane risk reduction for coastal Louisiana. The technical analysis in the final technical report has provided a clearer picture of the probability of large, storm related surge events that will significantly impact the population, property, and national and regional economy, taking into consideration the 2007 report from the Dutch. Scientists have concluded that the two primary parameters for estimation of maximum storm surges along the coast are storm intensity (related to the Saffir-Simpson scale) and storm size (not related to the Saffir-Simpson). As a representation of "Category 5" risk reduction, the final technical report presents alternatives at the 100-year, 400-year, and 1000-year design levels for all planning units, which include the City of New Orleans. The 400-year flood event is an approximation of Hurricane Katrina.

Action To Be Taken: The array of alternatives will continue to be developed as well as the benefits that are derived by their implementation.

5. IEPR Comment: The LACPR team should perform a quantitative risk assessment of the structural protection systems that includes the probability of system failure of the various components including floodwalls, levees, ring levees, and floodgates.

USACE Response: Adopted

Action To Be Taken. The final LACPR Technical Report qualitatively addresses potential failure of structural measures and acknowledges that more detailed quantitative risk analyses should continue to be performed under in the next phases or under additional project specific authorizations.

USACE concurs that a quantitative risk assessment is critical for a full understanding of a comprehensive risk reduction system. This type of analysis, however, requires a more detailed design than was developed for comparison of the 111 alternatives developed for LACPR across the entire Louisiana coast. An element of the tradeoff comparison presented in the LACPR report is a qualitative assessment of failure potential for both the structural and non-structural components of the alternatives. Structural components were gauged relative to levee length and numbers and sizes of structures, with increasing length and numbers of structures implying greater susceptibility to failure. Non-structural plan performance was tested against the relative level of participation, with diminishing public participation (in ten percent increments) correlating to potential failure of an overall plan. The results of these failure tests were included in the tradeoff analysis of the final array of alternatives. Further development of quantitative risk

assessments will be performed as priorities are established and projects are developed to a feasibility level of detail.

Even for the best performing plans presented in the final array, substantial residual risk remains for the most extreme surge events. In evaluating the performance of alternatives across a wide range of surge events an assumption of continuous resilience has been employed. In other words features designed based on a more frequent event are exceeded but would not fail for less frequent, larger events. This assumption was used to evaluate initial alternatives and would need to be further evaluated in future analyses. All structural measures are capable of providing significant risk reduction, particularly with increasing design levels. However, evaluation results have indicated that some 100-year level structural alignments could potentially provide significant risk reduction for the 400-year to 1000-year surge events if those features remains intact for these higher level events. The technical evaluation has indicated that levee alignments that allow some distance between the levee and the development footprint produce greater, and often significant residual protection above the indicated design level. The assumption of continuous resilience, the design requirements to support such an assumption, and the specific potential for system failure, should be investigated in detail at the planning unit scale.

6. IEPR Comment: Multi-Criteria Decision Analysis is a potentially useful approach to evaluate projects with important environmental, social, and cultural impacts; however, flaws in the application of these methods to the LACPR study have prevented any convincing results. As applied, the methods do not support the identification of a preferred alternative for any of the planning areas. Furthermore, they do not support the rankings of alternative plans as presented in the LACPR report.

USACE Response: Adopted

Action To Be Taken. The multi-criteria decision analysis approach evolved throughout the LACPR effort and will continue to be refined and improved. USACE agrees that the Multi-Criteria Decision Analysis is a potentially useful approach for USACE and its partners to compare projects with important environmental, social, and cultural impacts. The final LACPR report includes a clearer description of the purpose and limitations of the MCDA approach as applied to the LACPR effort. The MCDA tool did not provide fully useable results but the effort does highlight and reinforce the need for USACE to incorporate other factors in the decision besides damage reduction and dollars. In addition, the MCDA approach exposed potential tradeoffs involved in hurricane risk reduction decisions and the need for further dialogue to resolve the issues. Upon further coordination with the State of Louisiana, further comparison of alternatives using multiple criteria may be undertaken as priority plans are collaboratively identified.

7. IEPR Comment: Implementation of a variety of nonstructural measures will be essential in better managing and reducing flood risks in southern Louisiana. The LACPR team and the Corps should take a more aggressive leadership role in promoting a variety of nonstructural measures that are important to reducing flood risks in coastal Louisiana. Examples of these nonstructural measures include limiting development in flood-prone areas and stronger public education efforts regarding flooding risk in different sections of New Orleans.

USACE Response: Adopted

Action To Be Taken. USACE concurs with the importance of nonstructural measures for comprehensive risk reduction and the technical report recognizes them as viable options. Nonstructural measures can be an essential component for risk reduction in Southern Louisiana and nonstructural measures are included in the array of alternatives that are identified as promising alternatives in the LACPR Technical Report. Other types of nonstructural measures such as buyouts and limiting development involve socio-economic tradeoffs, which are discussed in the LACPR report, will need to be further explored. The USACE will work with the State and other Federal agencies to identify and clarify roles and responsibilities in developing and implementing nonstructural measures. Using the information in this technical report, USACE will continue to coordinate with the State of Louisiana and further develop options and priorities in each planning unit. USACE and the State will then jointly coordinate those options and priorities with other Federal agencies, local entities, non-governmental organizations, and the public.

8. IEPR Comment: The LACPR team should more specifically identify and explain the trade-offs between commercial navigation and river diversions for coastal restoration.

USACE Response: Adopted

Action Taken. USACE recognizes the importance of resolving the tradeoffs and management criteria associated with commercial navigation and river diversions. The LACPR Final Technical Report was revised to state that there are tradeoffs between commercial navigation and river diversions. The LACPR Final Technical Report describes alternatives with freshwater diversion features as a means to maintain the current coastal landscape and ecosystem functions. Most of those diversions could be classified as large diversions with high flow design capacities greater than 15,000 cfs with the largest diversion being over 175,000 cfs.

Action To Be Taken. USACE concurs that additional analysis is required to identify trade-offs between commercial navigation and river diversions. The LACPR team has not determined the cumulative impacts that multiple diversions may cause on the system. Nor has the team quantified the impacts on navigation or flood control on the Mississippi River. In addition, technical issues for freshwater diversions persist, particularly for the larger scale diversions. These issues include how well the measures may actually perform, how they should be operated, and the tradeoffs that will be required such as over-freshening of marsh areas and displacement of associated fisheries and wildlife. These proposed measures would be expected to evolve over time and be further studied as the USACE looks to improve its understanding of large-scale diversions. These issues are being addressed through ongoing Louisiana Coastal Area projects

and studies. USACE has continued the process of discussing and documenting these issues in recent forums involving a wide range of navigation and environmental stakeholders. Under the Louisiana Coastal Area authority in WRDA 2007, USACE and the State of Louisiana are initiating the development of a scope for the development of a comprehensive hydrodynamic study of the Mississippi River to support systemic assessment of diversion and navigation management.

9. IEPR Comment: It is encouraging that the LACPR draft final technical report describes the importance of preventing induced development. The report, however, does not adequately demonstrate how these principles will be a prominent part of hurricane protection and coastal restoration actions. Discouraging development in particularly vulnerable areas, whether or not they are protected by levees, is a fundamental principle of flood risk management and reduction. The LACPR should strengthen its cooperation with state and local entities to ensure that the prevention of induced development is accorded a more prominent and meaningful role in future plans.

USACE Response: Adopted

Action Taken: The LACPR Final Technical Report describes the importance of preventing induced development and presents several alternatives for achieving 400-year to 1000-year hurricane risk reduction for coastal Louisiana, which include nonstructural alternatives that could discourage development

Action To Be Taken. USACE will continue to work with the State and other Federal agencies to identify and clarify roles and responsibilities for the State in regulating smart development and managing associated risk.

USACE agrees that the potential for induced development is a concern. Encouraging development in hurricane prone areas may be directly counter to the coastal restoration goals of LACPR and the other Federal and State efforts to restore coastal Louisiana. The destruction of wetlands within levee systems can result in the loss of natural flood attenuation functions, while at the same time putting people and properties at greater risk of flooding during coastal storms, heavy rains and/or in the event of levee overtopping. Federal, State, and local entities have a shared responsibility to prevent induced development. Future increases in vulnerability can only be limited by an integrated set of measures, including land use planning, floodplain management, conservation easements, and strictly enforced zoning regulations. Hurricane and storm damage risk reduction measures should be designed and built in a way that contributes to the long-term sustainability of the region and encourage wise development in flood-prone areas. USACE will continue to work with Federal, State and local entities to strengthen this relationship.

10. IEPR Comment: The multiple authorizations that govern ecosystem restoration and hurricane protection in southern Louisiana represent a piecemeal approach and may hinder integrated, adaptive restoration and protection improvements across the region.

USACE Response: Adopted

Action Taken. The final LACPR Technical Report includes promising comprehensive plans for coastal Louisiana as well as comprehensive plans for each planning unit for hurricane and storm damage risk reduction that include coastal restoration features. A comprehensive authority for protection and restoration is identified as one approach to proceed forward.

Action To Be Taken. Multiple authorizations identified in the LACPR report are pointed to as a means of expediting implementation with minimal requirement for additional authorization. Currently USACE has multiple authorities that exist to address coastal protection and restoration. Examples of these are the Donaldsonville to the Gulf of Mexico, and Southwest Coastal authorities that have ongoing studies that are integrating LACPR findings. The Lake Pontchartrain and Vicinity and Morganza to the Gulf of Mexico authorities currently include or have previously included alternatives found in the LACPR final array. Each of these authorities effectively covers complete planning units. With a base of common storm surge modeling and application of consistent design criteria these authorities can support comprehensive system analysis and design.

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

June 29, 2010

The Honorable Jo-Ellen Darcy
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon, Room 3E446
Washington, D.C. 20310-0108

Dear Ms. Darcy:

As required by Executive Order 12322, the Office of Management and Budget has completed its review of the Louisiana Coastal Restoration and Protection Final Technical Report.

The report assessed the full range of potential plans that could reduce the risk of damages from hurricanes and storms in South Louisiana. OMB concurs with your conclusion that the report does not provide the appropriate level of engineering detail or environmental documentation for any project recommendations at this time. Our review concluded that the report's findings are consistent with the policy and programs of the President.

The Office of Management and Budget does not object to you submitting the report to Congress for informational purposes.

Sincerely,

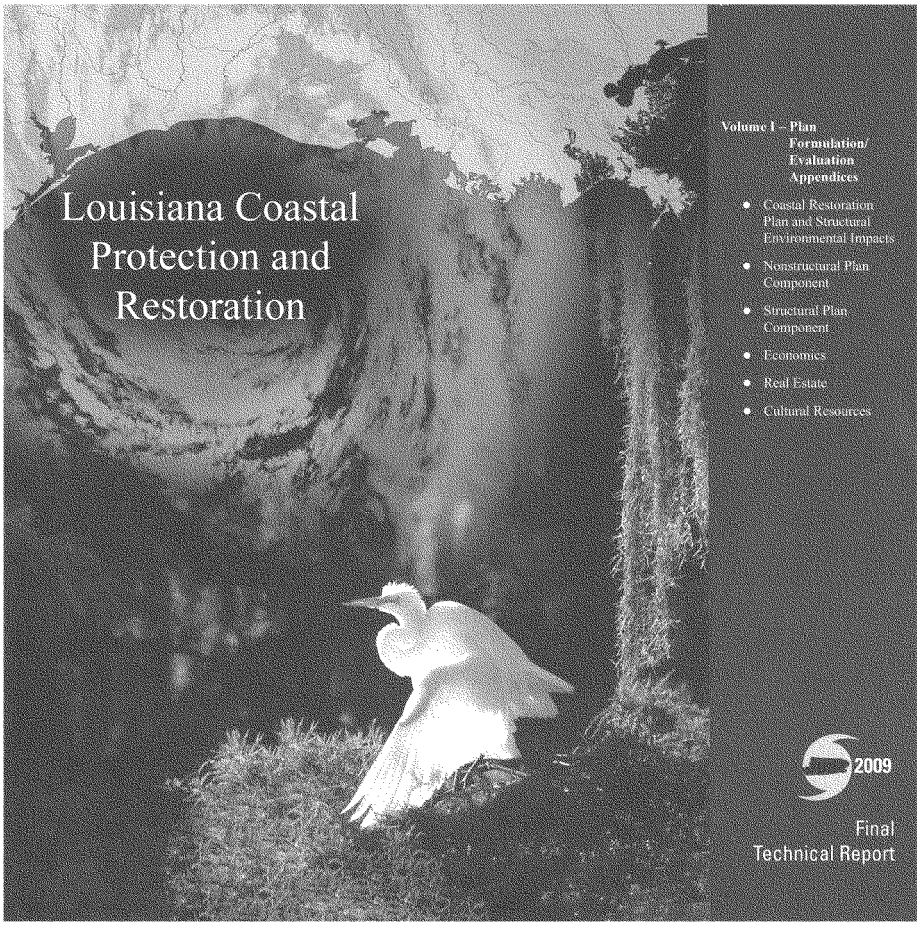
Richard A. Mertens
Deputy Associate Director
Energy, Science, and Water

Encl 4

NOTICE

Louisiana Coastal Protection and Restoration, Louisiana

The Army Corps of Engineers does not request that the report be printed. If there are any questions about this, please call (Joe Redican) at Corps Headquarters. You can reach (Joe Redican) at (202) 761-4523.


Louisiana Coastal Protection and Restoration
Volume I – Plan Formulation/ Evaluation Appendices
• Coastal Restoration Plan and Structural Environmental Impacts
• Nonstructural Plan Component
• Structural Plan Component
• Economics
• Real Estate
• Cultural Resources
2009
Final Technical Report

LOUISIANA COASTAL PROTECTION AND RESTORATION
FINAL TECHNICAL REPORT

COASTAL RESTORATION PLAN AND STRUCTURAL ENVIRONMENTAL IMPACTS

APPENDIX

June 2009

U. S. Army Corps of Engineers
New Orleans District
Mississippi Valley Division

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FINAL

Coastal Restoration Plan
and
Structural Environmental Impacts
Appendix

June 2009

PURPOSE

The Louisiana Coastal Protection and Restoration (LACPR) Technical Report has been developed by the United States Army Corps of Engineers (USACE) in response to Public Laws 109-103 and 109-148. Under these laws, Congress and the President directed the Secretary of the Army, acting through the Chief of Engineers, to:

- Conduct a comprehensive hurricane protection analysis and design in close coordination with the State of Louisiana and its appropriate agencies;
- Develop and present a full range of flood control, coastal restoration, and hurricane protection measures exclusive of normal policy considerations for South Louisiana;
- Consider providing protection for a storm surge equivalent to a Category 5 hurricane; and
- Submit preliminary and final technical reports.

The purpose of this appendix is to support *(Coastal Restoration evaluation)* for LACPR, which is discussed in the main Technical Report.

BACKGROUND

A determination was made by the LACPR team, with concurrence and guidance from the Corps Vertical Team, that adequate technical development of any alternative plan to a degree that would support specific recommendations for action was not feasible. Therefore at this stage of development no attempt is being made to indicate formulation or selection of a "preferred" alternative. Since a "preferred alternative" is not being proposed by this technical report, an environmental analysis is not being conducted as required by the National Environmental Policy Act and the Council on Environmental Quality regulations. However, the development of a basic understanding of the coastal landscape contribution to comprehensive and systemic risk reduction could be and was developed from the available hydrodynamic analyses. Based on this understanding alternative coastal plans were tested for their ability to perform effectively in maintaining long-term risk reduction capacity. Based on this assessment effective alternative plans have been applied to represent the general restoration need and approach could be presented as part of this report.

Sustaining the integrity of the estuarine environments in coastal Louisiana is critical to the ecological, social and economic welfare of the region. Model analyses of storm surge levels and wave magnitudes demonstrate the value of coastal features to lowering storm risks; allowing existing coastal features to degrade results in an increase in surge levels and wave heights. Thus, the planning goal was to achieve **"maximum sustainability"** to the greatest degree possible

The LACPR project area stretches across Louisiana's coast from the Pearl River on the Mississippi state line to the Sabine River on the Texas state line. The project area is comprised of two wetland-dominated ecosystems, the Deltaic Plain of the Mississippi River and the closely linked Chenier Plain, both of which are influenced by the Mississippi River.

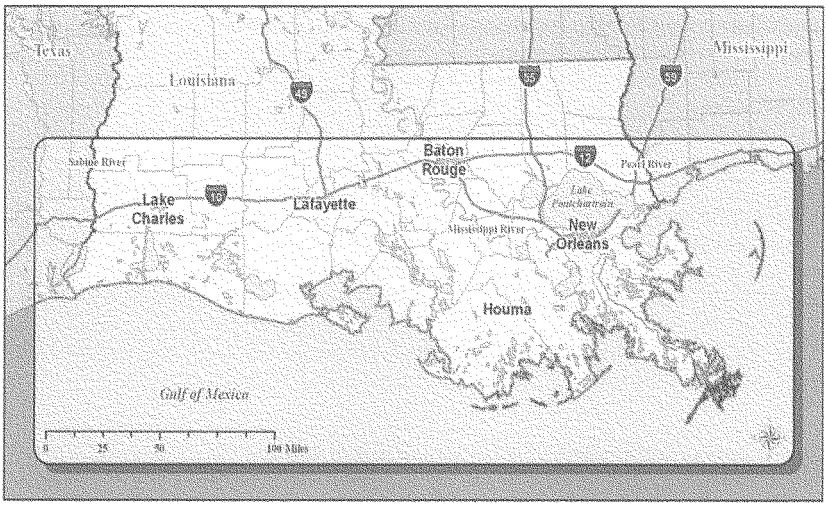


Figure 1 - LACPR General Project Area

Louisiana's coastal wetlands, which extend as much as 81 miles (130 km) inland and along the coast for about 435 miles (700 km), represent roughly 40 percent of the coastal wetlands of the continental United States. These wetlands are both regionally and nationally significant because they (a) provide protection from storm surge and wave erosion for a population of 2 million people and an infrastructure investment of more than $100 billion, (b) support a commercial marine fishery valued in excess of $250 million and recreational hunting and fishing expenditures of about $1 billion annually, (c) provide habitat for 4.4 million migratory waterfowl, and (d) are the site of a significant portion of U.S. oil and gas production.

Prior to human intervention, the state's coastal marshes were thought to be maintaining themselves through natural processes in spite of periodic hurricanes. Losses in some areas would be offset by gains in other areas. Riverine inputs to coastal marshes were especially critical for this assumed self-sustainability.

Subsidence, sea-level rise, decreased sediment and nutrient delivery, erosion, impacts from human activities and other factors have contributed to rates of coastal wetland loss in south Louisiana exceeding 25 mi^2/yr (65 km^2/yr) - about 80 percent of the total national losses (Boesch 1994). Barras et al. 2003, projected loss rates in 2003 at 10.3 mi^2/yr or 513 mi^2/yr between 2000 – 2050 when including restoration projects. Without restoration projects, the wetland loss rate is increased to approximately 13.48 mi^2/yr. Barras 2006, matched wetland loss trends with LCA trend data (all wetland loss) and determined a loss rate of approximately 500 mi^2 (10.63%) over a 50 year period. The total land loss rate (including non-wetland areas) is approximately 8.44%. Factoring in the impacts of the 2005 hurricanes on coastal Louisiana increases the wetland loss rates to 14.6 mi^2/yr to year 2050 (Barras 2007, PersCom). Not all the wetlands are receding; in fact some wetlands are stable, and others are growing. But the projected net loss over the next 50 years, with current restoration efforts taken into account, is estimated to be approximately 500 mi^2 (1295 km^2) (Barras et al. 2003). According to land loss estimates, Hurricanes Katrina and Rita transformed 217 mi^2 (562 km^2) of marsh to open water in coastal Louisiana (USGS 2006). Approximately 12.3% (730 mi^2) of the total land area within the project area was lost in 2004 (Barras 2007, PersCom).

Several efforts have been initiated to reduce the rate of wetland loss. In 1990, Congress passed the Coastal Wetlands Protection and Preservation Act (CWPPRA) to provide federal funding (approximately $50 million per year) for coastal restoration. This program has constructed a number of small to medium sized projects of varying types. The LCA plan (the Near-Term Plan (NTP)) developed by the U.S. Army Corps of Engineers (USACE), New Orleans District (MVN) and the Louisiana Department of Natural Resources (LADNR) was authorized in the Water Resources Development Act of 2007 by Congressional Presidential veto override. The NTP includes 15 specific coastal restoration projects and three programs (i.e., science and technology needs research).

As a result of the devastation caused by hurricanes Katrina and Rita in 2005, Congress directed the MVN, in partnership with the State of Louisiana, to initiate the LACPR project. A determination was made by the LACPR team, with concurrence and guidance from the Corps Vertical Team, that adequate technical development of any alternative plan to a degree that would support specific recommendations for action was not feasible. Therefore at this stage of development no attempt is being made to indicate formulation or selection of a "preferred" alternative. Since a "preferred alternative" is not being proposed by this technical report, an environmental analysis is not being conducted as required by the National Environmental Policy Act and the Council on Environmental Quality regulations. However, the development of a basic understanding of the coastal landscape contribution to comprehensive and systemic risk reduction could be and was developed from the available hydrodynamic analyses. Based on this understanding alternative coastal plans were tested for their ability to perform effectively in maintaining long-term risk reduction capacity. Based on this assessment effective alternative plans have been applied to represent the general restoration need and approach could be presented as part of this report.

The plan is to include restoration of the coastal landscape, and the USACE formed a Habitat Evaluation Team (HET) with representatives from 11 federal and state environmental- resource agencies to assist in plan formulation and to identify appropriate metrics for assessing the environmental benefits and impacts of proposed plans.

HABITAT EVALUATION TEAM

The HET is one of several teams formed to assist in the plan formulation and evaluation process for the LACPR. Membership on the HET included the following:

- Ronny Paille – United States Fish and Wildlife Service
- Craig Fischenich – United States Army Corps of Engineers, Engineer Research and Design Center, Environmental Laboratory
- Pat Williams – National Marine Fisheries Service
- John Ettinger – Environmental Protection Agency, Region VI
- Cindy Steyer – Natural Resource Conservation Service
- Troy Mallach – Natural Resource Conservation Service
- Heather Finley – Louisiana Department of Wildlife and Fisheries
- Manuel Ruiz – Louisiana Department of Wildlife and Fisheries
- Michael Massimi - Barataria-Terrebonne National Estuary Program
- Bren Haase – Louisiana Department of Natural Resources, Coastal Restoration Division
- Greg Steyer – United States Geological Survey
- Sean Mickal – United States Army Corps of Engineers, New Orleans District
- Sandra Stiles – United States Army Corps of Engineers, New Orleans District

Tasks and Goals

The HET was assigned several responsibilities in support of the LACPR, including 1) the formulation of coastal restoration alternatives to be combined with structural and non-structural measures to generate plans for the LACPR, 2) identification of environmental metrics for use in evaluating the LACPR plans, and 3) quantification of the environmental impacts and benefits of those plans. The HET determined that the goal of their combined efforts could be summarized as ***"Achieve ecosystem sustainability in coastal Louisiana to the greatest degree possible".*** This would be accomplished through:

- Examination of coastal restoration strategies that contribute to sustainable hurricane protection;
- Inclusion of individual measures of varying sizes to restore and maintain landscape features and essential wetland maintenance processes;
- Identification and programmatic assessment of combinations of individual measures which provide ecosystem-level synergistic benefits;
- Programmatic assessment of the potential of alternative plans to achieve or exceed no-net loss of coastal wetlands;
- Examination of the potential for trade-offs associated with various restoration alternatives (e.g. near-term protection vs. long-term sustainability and fisheries changes vs. deltaic processes).

Guiding Principles

An overarching principle established by the HET is that sustaining the integrity of the estuarine environments in coastal Louisiana, including the various landscape features that make up those environments, is critical to the ecological health and, by extension, the social and economic

welfare of the region. Model analyses of storm surge levels and wave magnitudes demonstrate the value of coastal features to lowering storm risks. While the models show benefits from additional marsh, island and landbridge habitat, the effects of allowing existing features to degrade are even more pronounced. Thus, sustaining the integrity of the estuarine environments in coastal Louisiana is a key component of a comprehensive storm risk reduction strategy for the region.

The HET identified several additional principles related to ecosystem quality and maintenance that served to guide plan formulation and assessment decisions. Included were (in no order of particular importance):

- Relatively intact estuarine ecosystems are a key attribute in coastal Louisiana, and alternatives should seek to enhance the resilience and self-sustainability of the estuarine environments, including protection of existing high-quality estuaries. Consequently, development of plans that would only reduce wetland losses were precluded from consideration.
- Because the driving processes and conditions are different, the Deltaic Province (Planning Units 1, 2, 3a, & 3b) and Chenier Plain (Planning Units 3b, & 4) should be viewed separately and different criteria may apply in plan formulation and evaluation. While several scales of assessment are important, the basin scale is the most relevant for analyses in the LACPR.
- Within the Deltaic Province, restoration of key processes and dynamics is critical to the long-term health of the ecosystem. However, it is important to recognize that these processes vary spatially and temporally, so some areas may experience losses while others are gaining. (See *Screening Criteria and Prioritization* in the PLAN FORMULATION section of this appendix for more information on ranking of critical marsh features)
- Because of drastically reduced Mississippi River sediment loads, riverine diversions must be carefully sited to maximize sediment retention within the coastal ecosystem and avoid sediment loss to the Gulf. Therefore, alternatives must seek to maximize the combined benefits of diversions that seek to restore natural processes with mechanical marsh creation measures. Additional sources of sediments should be sought wherever feasible; recognizing that such measures should not contribute to ecosystem degradation in the source area.
- Measures should be combined synergistically to maximize possible cumulative benefits. As such, the position of features within the landscape has a direct influence on the potential benefits.
- Wetland losses in coastal Louisiana occur from a number of factors. Many of those factors are beyond our control. However, causes of accelerated degradation, such as disrupted hydrologic functions; salinity intrusion, direct removal of wetland habitat; etc., should be directly addressed wherever possible.
- Our capacity to assess and quantify benefits and impacts from various measure combinations is limited at present due to the state-of-the-science, scheduling constraints in the LACPR process and uncertainty associated with future development, relative sea level rise (RSLR) and other factors. Flexibility is required in project design and

implementation to permit adaptive management as conditions change and more is learned.

- To address the above constraints, a concerted monitoring and adaptive management program should be a central component of the LACPR. Additional scientific investigation, model development, and programmatic re-evaluations will be required.

Approach

A number of studies and reports on Louisiana's coastal ecosystem and water resources development in the study area have been prepared by the USACE, other Federal, state, and local agencies, research institutes, and individuals. These previous studies established an extensive database for the LCA Study, which in turn served as a significant starting point for the State's Master Planning Process and the LACPR. Historical trends and existing conditions were identified to provide insight into future conditions, help isolate the problems, and identify the most critical areas for restoration.

Building upon this foundation, the HET held frequent meetings throughout the study period to discuss and reach consensus on critical issues. Subgroups of the HET developed analytical tools, conducted evaluations, assembled alternatives and otherwise executed the various work efforts associated with the assigned tasks. Working groups submitted findings to the full HET for approval.

The HET interacted with program managers for the LACPR and leaders from the working groups of other technical areas to coordinate activities and ensure integration of the plan components. Two formal workshops were held to elicit input from recognized regional experts in a broad range of disciplines, and numerous formal and informal interactions were held with regional, state, and Federal resource agency personnel; researchers from the academic community with expertise in the pertinent subject areas; and representatives of NGOs regarded as stakeholders in the LACPR.

Other Restoration Programs

- The **Louisiana Coastal Area (LCA) Ecosystem Restoration Plan** was established to reverse the degradation trend of the Louisiana coastal ecosystem. The LCA Plan emphasizes the use of restoration strategies towards achieving and sustaining a coastal ecosystem that can support and protect the environment, economy, and culture of southern Louisiana. The LCA Plan identified the most critical ecological needs and a near-term program of cost-effective projects to address them. A Science and Technology (S&T) Program has been executed as a partnership between the State of Louisiana, the US Army Corps of Engineers, the US Geological Survey, and other Federal agencies for the purpose of improving LCA program performance through application of the best available science, technology and engineering. The S&T Program supports the LCA Ecosystem Restoration Plan by:
    1. Providing the necessary science and technology to effectively address coastal ecosystem restoration needs

2. Providing analytical tools and recommendations to the Program Management Team for appropriate studies to reduce uncertainties
3. Integrating the roles and resources of the scientific community and other coastal protection agencies and partners at the state, local, and Federal level
4. Providing for internal and external technical review and a systematic approach for coordination with other ongoing and planned related research activities

- In 1990, passage of the **Coastal Wetlands Planning, Protection and Restoration Act** (CWPPRA; PL-101-646, Title 111), locally referred to as the Breaux Act, provided authorization and funding for a multi-agency task force to begin actions to curtail wetland losses. In 1998, after extensive studies and construction of a number of coastal restoration projects accomplished under CWPPRA, the State of Louisiana and the Federal agencies charged with restoring and protecting the remainder of Louisiana's valuable coastal wetlands adopted a new coastal restoration plan in 1998. The underlying principles of the new plan, "Coast 2050: Toward a Sustainable Coastal Louisiana," are to restore and mimic the natural processes that built and maintained coastal Louisiana. This plan necessitates basin-scale action to restore more natural hydrology and sediment introduction processes; it subdivides Louisiana's coastal zone into four regions with a total of nine hydrologic basins. The plan proposes ecosystem restoration strategies that would result in efforts larger in scale than any that have been implemented in the past.

  The Coast 2050 Plan report served as the basis for a Federal 905(b) Reconnaissance Report for undertaking feasibility studies in 2000 to seek Water Resources Development Act approval of a comprehensive plan and authorization of major projects beyond what was being pursued under CWPPRA. In 2000, it was envisioned that a series of feasibility reports would be prepared over a 10-year period. The first feasibility efforts focused on the Barataria Bay basin and involved marsh creation and barrier shoreline restoration. Early in fiscal year 2002, however, it was recognized that a more in-depth, comprehensive study was needed.

- The State of Louisiana also is a **Coastal Impact Assistance Program (CIAP)** was established by Section 384 of the Energy Policy Act of 2005 (Act) to assist producing states and their coastal political subdivisions in mitigating the impacts from Outer Continental Shelf (OCS) oil and gas production. The CIAP legislation appropriated $250 million per year for Fiscal Years 2007 through 2010 to be distributed among eligible producing States and their coastal political subdivisions. The State of Louisiana has worked cooperatively with the 19 coastal parishes to assemble a group of restoration, conservation and infrastructure projects that will produce significant results. The Plan components include the following major categories: Enhanced Management of Mississippi River Water and Sediment; Protection and Restoration of Critical Land Bridges; Barrier Shoreline Restoration and Protections; Interior Shoreline Protection; Marsh Creation with Dredged Material; Coastal Forest Conservation Initiatives; Infrastructure Projects to Mitigate Onshore OCS Impacts;

CONCEPTUAL ECOLOGICAL MODEL

Thom (2000) proposed that conceptual ecological models (CEM) are a key component of an adaptive management program associated with coastal ecosystem restoration projects and recommended them for planning projects, evaluating the effectiveness of the restoration, providing guidance on adjustments to improve projects success, and refining the understanding of the ecosystem being restored. CEMs are non-quantitative planning tools that can be used to identify major stressors on an ecosystem, the effects of those stressors, and the best way to measure those effects (Ogden et al. 2005:795-809). The objective of a CEM is to contribute to the determination of what needs to be restored, why, and perhaps where the restoration might be most effective. The CEM is used to identify the connection (cause-and-effect relationships) between the restoration actions (e.g., physical manipulations) and the physical and biological reactions to such actions, based on the best available information on qualitative and conceptual relationships (Barnes and Mazzotti 2005; Ogden et al. 2005:955-979)

Considerable scientific research into the form, function and change of the Louisiana coastline preceded the LACPR, and served as a basis for the formulation of the conceptual model for the LACPR. The HET formulated a CEM for coastal Louisiana on the basis of discussions during a series of meetings. The model is based upon widely-held views of the structure and function of the coastal ecosystem, and is supported by numerous technical publications, field studies, and the experience of the HET members. The following sections describe the model, including the scale, key processes and features, external drivers and stressors. The relationship between proposed restoration actions and ecosystem response is discussed in detail in later sections.

Geographic Scale

Louisiana's coastal wetland ecosystem is an interface between the Gulf of Mexico and the Mississippi River ecosystems. The Mississippi River drains 41% of the continental U.S. and brings nutrient- and sediment-rich runoff from 31 states and two Canadian provinces through Louisiana's coastal zone and into the Gulf of Mexico. While the Mississippi River, and its distributary the Atchafalaya River, is perhaps the most significant factor influencing the character of Louisiana's coast, other smaller rivers and streams supply nutrients and minerals to the coastal wetlands. Those upland and/or riverine inputs are reworked and distributed by marine processes of the Gulf of Mexico. Together with local climatological processes, they create the ever shifting landscape that is coastal Louisiana.

The central and eastern Louisiana coast consists of a deltaic system with fronting barrier islands built by the Mississippi River. Louisiana's western coast, or Chenier Plain, is a geologically distinct region formed through the deposition of littoral Mississippi River sediment along the shallow Gulf shoreline. Because the natural processes that occur in each planning unit differ, restoration plans for those respective areas will also differ. In order to have more manageable units for development of measures and alternative plans, as well as to present a more appropriate

scale for analysis, the deltaic province is further divided into its four distinct hydrologic basins. As a consequence of these divisions, the planning area has been divided into five planning units, as follows:

- **Planning Unit #1:** Pontchartrain Basin (area east of the Mississippi River and South Pass)
- **Planning Unit #2:** Barataria Basin (from the Mississippi River and South Pass, west to Bayou Lafourche)
- **Planning Unit #3a:** Eastern Terrebonne Basin (from Bayou Lafourche west to Bayou de West)
- **Planning Unit #3b:** Atchafalaya Influence Area (from Bayou de West to Freshwater Bayou Canal)
- **Planning Unit #4:** Chenier Plain (from Freshwater Bayou Canal to the Sabine River)

Key Processes

An estuary and its immediate catchment form a complex system of ecological, physical, chemical and social processes, which interact in a highly involved and, at times, dynamic fashion. The distribution and abundance of wetland habitats in the Deltaic Plain has been, and continues to be, in constant flux — a function of the differing salinity gradients that occur during the land building and degradation phases of the deltaic processes as well as the myriad other key processes that influence wetland and estuarine conditions. The following sections summarize the key processes involved in this ecosystem.

Deltaic Processes

The 186 mile wide (300 km) Mississippi River delta plain and its associated wetlands and barrier shorelines are the product of the continuous accumulation of sediments deposited by the river and its distributaries during the past 7,000 years. Regular shifts in the river's course have resulted in four ancestral and two active delta lobes, which accumulated as overlapping, stacked sequences of unconsolidated sands and muds. As each delta lobe was abandoned by the river, its main source of sediment, the deltas experienced erosion and degradation due to compaction of loose sediment, rise in relative sea level, and catastrophic storms. Marine coastal processes eroded and reworked the seaward margins of the deltas forming sandy headlands and barrier beaches. As erosion and degradation continued, segmented low-relief barrier islands formed and eventually were separated from the mainland by shallow bays and lagoons.

The result of the building and subsequent abandonment of these delta lobes by the river was the construction of a modern deltaic Coastal Plain. Each delta cycle lasts about 1,000 years, and the most recent delta (the Mississippi birdfoot) is approaching the end of that time scale. The natural progression of this process is for a new distributary, the Atchafalaya River, to draw increasing portions of the Mississippi River's water and sediment discharge forming a new Atchafalaya delta. These processes are discussed in detail in the LCA (2004) report.

Marine Processes

Water fluxes in the coastal marshes are driven by the water-level differences across the estuary. These change over the long term, seasonally, and daily. Long-term rises in sea level have been documented by many investigators, and recently average about .04 to .08 inches (1 to 2 millimeters) per year, but are projected to increase due to climate change (Titus and Richman 2001). Superimposed on this long-term trend is a mean water level that varies seasonally by .79 to .98 inches (200 to 250 millmeters), with peaks in the spring and late summer. Part of this seasonal variation is related to the dominant variable wind regime over the Gulf of Mexico; east and southeast winds in spring and fall move water toward the shore whereas westerly winds strengthen the Mexican Current and draw a return flow of water from the estuaries during winter and summer (Baumann 1980). Superimposed on the seasonal water level change is a diurnal tide, which averages about 11.81 inches (300 millimeters) at the coast. Because of the broad, shallow expanse of the coastal estuaries, the tides decrease inland.

These marine processes serve to redistribute sediments and nutrients, as well as regulate salinity levels and fluxes in the estuaries. Large, episodic storms can significantly alter the landscape developed as a consequence of the more normal marine processes. Tropical storm events can directly and indirectly contribute to coastal land loss through a variety of ways: erosion from increased wave energies, removal and/or scouring of vegetation from storm surges, and saltwater intrusion into interior wetlands carried by storm surges. These destructive processes can result in the loss and degradation of large areas of coastal habitats in a relatively short period of time (days and weeks versus years).

Fluvial Processes

The largest source of fresh water and sediment to the Louisiana coast is the Mississippi River and its major distributary, the Atchafalaya River. Other, smaller rivers contribute additional water and sediments from local watersheds. Flow is strongly seasonal, peaking in late spring, fed by melting snow and spring rains in the Upper Mississippi watershed. Flows on the Mississippi River are independent of local rainfall because of the size of the watershed, but fresh water and sediment from local rivers and streams along the coast is supplied mainly during periods of heavy local rainfall.

The inactive delta of the Mississippi River (the part that has been abandoned by the river) is isolated from direct riverine input by natural and artificial levees. The Mississippi and Atchafalaya rivers discharge into the Gulf of Mexico through the active Balize and Atchafalaya delta lobes. Most of their waters are carried westward along the coast, freshening the Gulf waters that move in and out of the Barataria, Terrebonne, and Vermilion estuaries. Thus, although these three estuaries have almost no direct freshwater inflow except from local runoff, the rain surplus and the moderated salinities offshore keep estuarine salinities much lower than that of seawater.

Chemical Processes

Elements and compounds can enter tidal wetlands by tidal exchange, precipitation, upland runoff, and groundwater flow. Once in the wetlands, they may be deposited on water bottoms, adsorbed to particles, or taken up and fixed in the tissues of rapidly growing vascular plants. These substances may be incorporated or otherwise transformed by microbial assemblages associated with the complex of surfaces provided by the sediment, live plants, litter, and detritus.

This conceptual model considers primarily exchanges and transformation of elements and compounds mediated by surface water flows from both tidal and upland sources. The potential for groundwater input is not specifically addressed, since nutrient exchange in marshes characterized by tidal ranges of less than 3.3 feet (1 meter) occurs primarily within marsh surface waters (Childers et al. 1993). Because tidal amplitude along the north-central Gulf of Mexico region is low (~ 1.64 feet (0.5 meters)), and larger tidal ranges are associated only with infrequent meteorological events, it is assumed that subsurface water exchanges can be ignored for regional applications.

Odum (1974) proposed that nutrient inputs via tidal waters were important in maintaining the characteristic high productivity of *S. alterniflora* in creekside salt marshes. This occurs as a result of direct infiltration of nutrient-laden surface waters, horizontal recharge driven by rise and fall of the tide and vertical recharge from below the root zone. Salt marsh vegetation is primarily nitrogen limited, with ammonium nitrogen being the form most readily available in interstitial waters for uptake by plant roots. Phosphorus is abundant in saline waters and marsh soils, and is generally not considered a limiting nutrient in salt or brackish marsh systems. Numerous studies have attributed variation in *S. alterniflora* growth form to gradients in chemical and physical characteristics of tidal marshes, including nutrient availability (Valiela and Teal 1974, Broome et al. 1975; DeLaune and Pezeshki 1988). This is particularly true for developing or restored salt marshes. Other workers suggest that, in mature marshes, edaphic factors affecting nutrient uptake are the primary determinants of *Spartina* growth form. Variables known to stress plants (high soil salinity and sulfide concentrations, waterlogging, low dissolved oxygen) reduce the uptake efficiency of nitrogen at the root-pore water interface, especially when multiple stressors are present.

Biogeochemical processes within the wetland are also affected by offsite inputs from the surrounding drainage area. Eutrophication caused by anthropogenic nutrient enrichment of coastal ecosystems has been a major concern for resource managers for the last few decades. The effects of nutrient enrichment include stimulation of primary production by algae and phytoplankton and depletion of oxygen, which can lead to hypoxia (a deficiency of oxygen while not being devoid of oxygen) (Deegan 2002). Nutrient enrichment can also cause shifts in plant species distribution and zonation in mixed species tidal wetlands, resulting in increased dominance of *S. alterniflora* at the expense of other tidal marsh species (Pennings et al. 2002).

Recent research has shown that anthropogenic eutrophication may cause shifts in benthic invertebrate and fish community food webs that are manifested long before actual loss of the habitat occurs (Deegan 2002). Furthermore, the cumulative effects of nutrient enrichment on a landscape scale may cause increased or decreased rates of subsidence, although these predictions have not yet been tested (Deegan 2002). Highly developed or industrial watersheds may also serve as sources of metals, hydrocarbons, and other toxins that is deposited in wetland sediments, posing risks for benthic organisms that inhabit them. As predators consume these organisms, food web dynamics may be altered through accumulation of toxins in the tissues of higher trophic level organisms. The accumulation of toxins in animal tissues may reduce growth and fecundity (or productivity), and may render them unsuitable for consumption as food.

Biological Processes

Coastal fringe marshes provide habitat for a variety of vertebrate wildlife including fish, birds, mammals, and reptiles. Teal (1986) stated that one of the most important functions of salt marshes is to provide habitat for migrant and resident bird populations. Some wildlife species inhabiting tidal marshes are important game animals (e.g., mallard (*Anas platyrhynchos*) and American wigeon (*A. americana*)), whereas the muskrat (*Ondatra zibethicus*) and raccoon (*Procyon lotor*) are valuable furbearers. The American alligator (*Alligator mississippiensis*) is harvested for both its skin and meat. Many of the birds that commonly use coastal fringe wetlands, especially larger species such as ospreys, herons, egrets, and Roseate Spoonbills (*Ajaia ajaia*) provide recreational opportunities for birdwatchers, nature enthusiasts, and wildlife photographers.

The majority of wildlife species that utilize the subclass have neither commercial nor recreational value, but simply are ecologically important members of the ecosystem. For example, the rice rat (*Oryzomys palustris*) and other small mammals play a key role in marsh trophic cycles, providing food for several species of avian and mammalian predators. Many of the vertebrates that use the marsh ecosystem are highly mobile and serve as a transfer mechanism for nutrients and energy to adjacent terrestrial or aquatic ecosystems. Some of the larger vertebrates, including the muskrat and nutria (*Myocastor coypus*), consume copious amounts of forage and at high densities may have significant impacts on marsh vegetation structure.

Tidal marshes provide forage habitat, spawning sites, and a predation refuge, and serve as a nursery for resident and nonresident fishes and macrocrustaceans. These organisms use tidal marshes or adjacent subtidal shallows either year round or during a portion of their life history as nurseries. A number of ecologically and economically important nekton species are dependent on the availability of suitable tidal marsh habitat. Estuarine-dependent species such as the penaeid shrimp (*Farfantepenaeus* spp., *Litopenaeus* spp.), the blue crab (*Callinectes sapidus*), the sciaenids (*Cynoscion* spp., *Sciaenops ocellatus*, *Leiostomus xanthurus*, *Micropogonias undulatus*, and *Bairdiella chrysoura*, etc.), and others use tidal marshes and shallow, subtidal bottoms as nurseries. The ubiquitous killifishes (*Fundulus* spp.), grass shrimp (*Palaemonetes* spp.), and gobies (*Gobiosoma* spp., *Gobionellus* spp., *Microgobius* spp., etc.) are characteristic residents of Atlantic and Gulf coast intertidal wetlands. These organisms are consumed by nektonic and avian predators and are considered to represent an important link in marsh-estuarine trophic dynamics.

Most evidence suggests that resident organisms (e.g., killifishes, grass shrimps) utilize the entire marsh surface across the range from low to high elevations, but that the dense vegetation characteristic of high marsh habitats may offer greater protection from natant predators than low marshes. However, resident nekton are also widely distributed throughout the lower intertidal marsh early and late in the tidal cycle in Louisiana and Mississippi (Rozas and Reed 1993, Fulling et al. 1999, Hendon et al. 2000), and may use these areas as staging areas prior to marsh flooding. Resident nekton can make extensive use of high marsh when spring tide conditions facilitate access to the upper intertidal zone. Several resident killifish species, including *Fundulus grandis, F. similis, F. pulverus*, and *Adinia xenica,* rely on availability of high intertidal marsh, coincident with spring tidal events, for use as spawning sites (Greeley and

MacGregor 1983, Greeley 1984, Greeley et al. 1986, Greeley et al. 1988). Killifishes also use tidal marshes for foraging sites; as Rozas and LaSalle (1990) noted, the Gulf killifish (*F. grandis*) consumed more prey when they had access to the marsh surface than when they were confined to subtidal areas by low tides.

Key Landscape Features

Barrier Islands

Barrier islands fronting the Mississippi River delta plain act as a buffer to reduce the effects of ocean waves and currents on associated estuaries and wetlands. Louisiana's barrier islands are eroding, however, at a rate of up to 20 meters per year; so fast that, according to recent USGS estimates, several will disappear by the end of the century. As the barrier islands disintegrate, the vast system of sheltered wetlands along Louisiana's delta plains are exposed to the full force and effects of open marine processes such as wave action, salinity intrusion, storm surge, tidal currents, and sediment transport that combine to accelerate wetlands deterioration.

Coastal Ridges and Cheniers

Natural levees of major and minor distributaries that diverge from larger distributaries as they trend toward the coast, and cheniers (elevated inland ridges) that run parallel to the coast, are key landscape features in Coastal Louisiana. Deposits of mostly linear dredged material that crisscross the coast may be included in this category if they mimic natural levees. These features do not encompass a large area compared with the coastal marshes, but in coastal basins they play an important ecological role through their function as barriers between the ocean and the estuary and as water regime barriers within an estuary and because they present the only elevated, sometimes forested land within a plain of wetland and water. They provide periodic or continuous habitat for nearly all mammals and birds in the coastal zone.

Wetlands

The vegetation mosaic in a given locale is primarily a function of climate, soil type, and suitable water conditions, including depth of water table, length and frequency of inundation, flow, and water quality. These plant communities, in turn, provide food and/or habitat for wildlife. Thus, changes in distribution, abundance, and species composition of plant communities have a direct effect upon type and quality of associated animal communities (Sharitz and Gibbons 1989). Habitat loss directly impacts availability of resources required by organisms that use these areas. However, distribution of these habitats across the landscape is even more important because few organisms use only one habitat type, particularly in a seasonally fluctuating landscape.

Since the source of salinity in coastal Louisiana is the Gulf of Mexico, salinity levels exist along a gradient, which declines as the saltwater moves inland. A distinct zonation of plant communities, or vegetative habitat types, differing in salinity tolerance exists along that gradient, with the species diversity of those zones increasing from salt to fresh environments. The dominant vegetative habitats with increasing distance from the coast are salt, brackish, intermediate, and freshwater organic marshes, swamp and bottomland hardwood communities.

Chabreck et al. (1968), Chabreck (1970, 1972), and later, Chabreck and Linscombe (1978, 1988) and Chabreck et al. (2001), subdivided and mapped Louisiana coastal wetlands into four marsh

zones on the basis of Penfound and Hathaway's (1938) and O'Neil's (1949) descriptions of the major vegetation types within salinity zones. This classification of marsh vegetation is widely recognized and often used in broadly describing coastal wetlands. Transition between adjacent zones is typically found to be an intergrading of communities rather than appearing as an abrupt change from one community to another (Penfound & Hathaway, 1938; Craig et al, 1987). The four marsh vegetation types are fresh, intermediate, brackish, and saline, and occur in zones that generally parallel the coast (figure 1). Coast wide, the range of salinity within each of these vegetation zones can vary drastically; however, as shown in the Coast 2050 Report (LADNR, 1998), the typical ranges of salinity that occur most frequently are much more narrow (table 1).

Table 1
Salinity ranges for the four coastal wetland types as reported by Chabreck (1972)

Marsh Type	Range (ppt)	Mean (ppt)	Typical Range (ppt)
Fresh	0.1 - 6.7	<3.0	0 – 3
Intermediate	0.4 - 9.9	3.3	2 – 5
Brackish	0.4 - 28.1	8.0	4 – 15
Saline	0.6 - 51.9	16.0	12+

(From Chabreck 1972 and Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority, 1998)

In a coastwide survey, Chabreck (1972) recorded a total of 118 species of vascular plants in all marsh types. The species found in the greatest abundance overall was marshhay cordgrass (*Spartina patens*), making up about one-fourth of the vegetation in the coastal marshes.

Saline marsh.

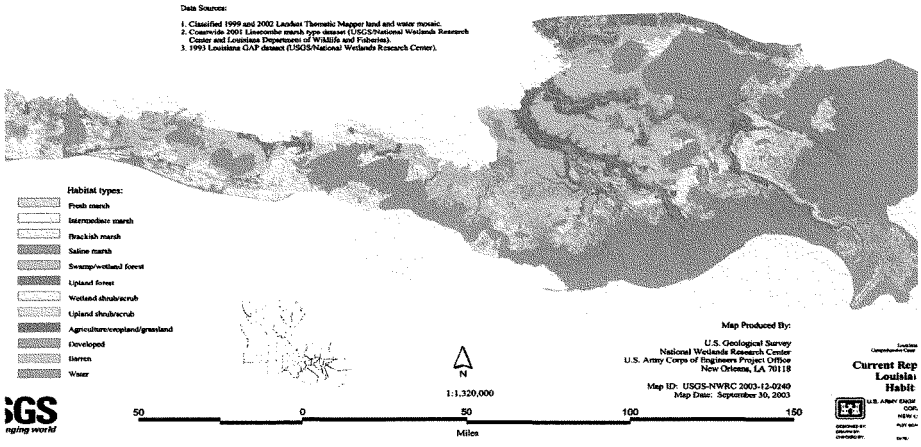
Nearest the coast and subjected to regular tidal inundation is salt marsh. Smooth cordgrass *(Spartina alterniflora)* the dominant plant in this marsh type, and often forms near-monotypic stands. Average salinity is approximately 16 parts per thousand (ppt). Relative to other marsh types, salt marsh typically supports fewer terrestrial vertebrates although some species like Seaside Sparrows and Clapper Rails are common.

Saline marshes are typically located adjacent to open water bodies such as bays and estuaries. Their salinity levels are the highest, usually falling in the mesohaline (5.0 - 18 ppt) [1] or polyhaline (18 - 30 ppt) [2] range. Herbaceous vegetation of the saline marsh is typically dominated by smooth cordgrass intermixed with saltgrass (*Distichlis spicata*), marshhay cordgrass, black needlerush (*Juncus roemerianus*), and saltwort (*Batis maritima*). Chabreck (1972) identified 12 species of emergent vegetation typically associated with this marsh type. Within the described marsh zones, many ponds and lakes support submerged and/or floating-leafed aquatic vegetation (SAV). Aquatic vegetation is rare in saline waters along the Louisiana coast (Chabreck, 1972; Chabreck et al., 2001). However, widgeon grass (*Ruppia maritima*) may occur in open water areas of saline marshes bordering on the brackish marsh zone and in saline areas where tidal flow has been decreased by structures or other changes in hydrology. In addition, submerged seagrass beds have occurred in waters behind some barrier islands,

[2] Classification of Wetlands and Deepwater Habitats of the United States FWS/OBS-79/31, DECEMBER 1979, Reprinted 1992

especially the Chandeleur Island chain. Seagrass species occurring in this area included shoal grass (*Halodule beaudettei*), turtle grass (*Thalassia testudina*), and manatee grass (*Cymodocea filiformis*) (Craig, 1987). These communities however have been severely impacted with the barrier island degradation.

Current Representation of Louisiana Coastal Habitat Types



Brackish marsh.
Inland from salt marsh, and subjected to reduced tidal influence, is brackish marsh. This marsh type is dominated by marsh-hay cordgrass, which grows in a relatively open condition, interspersed with numerous small ponds and water channels. Brackish marshes are extremely important as nurseries for fish and shellfish. Other characteristic species include muskrat and shorebirds. This marsh type is very susceptible to saltwater intrusion damage and conversion to open water.

Brackish marshes generally occur in association with freshwater input from coastal rivers and bayous. Salinity levels are usually within the mesohaline or oligohaline (0.5 – 5.0 ppt)[1] range and average salinity is in the range of 8 ppt. In the brackish marsh, marshhay cordgrass is the dominant herbaceous species. Saltgrass, three-cornered grass (*Schoenoplectus americanus*, formerly *Scirpus olneyi*), smooth cordgrass, black needlerush, and leafy three-square (*Schoenoplectus maritimus* formerly *Scirpus maritimus*) are often co-dominant or common in this zone. It should be noted that some of the species are the same as for saline marsh, but the order of dominance is changed. Chabreck (1972) identified forty species of plants in brackish marsh. Aquatic plants that commonly occur in brackish marsh waters include widgeon grass, Eurasian watermilfoil (*Myriophyllum spicatum*), water celery (*Vallisneria americana*), and horned pondweed (*Zannichellia palustris*) (Craig, 1987).

Intermediate marsh.
Intermediate marsh occurs in an oligohaline salinity range with year-round average salinities of 3-4 parts per thousand (ppt); but may be fresh for much of the year with higher salinity conditions occurring during the late summer and early fall. Intermediate marshes are characterized by near total ground cover of emergent wetland plants with scattered small open water ponds. Chabreck's (1972) identification of 54 species of plants in intermediate marsh indicates that plant species richness is relatively high. The intermediate marsh can be difficult to identify, as it sometimes may appear less as a distinct zone than a transitional mix between brackish and fresh zones. Marshhay cordgrass or bulltongue (*Sagittaria lancifolia*) is usually the dominant or co-dominant species. These are commonly accompanied by three-cornered grass, roseau or common reed (*Phragmites australis*), seashore paspalum (*Paspalum vaginatum*), coastal waterhyssop (*Bacopa monnieri*), bullwhip (*Schoenoplectus californicus* formerly *Scirpus californicus*), Walter's millet (*Echinochloa walteri*), sawgrass (*Cladium jamaicense*), deer pea (*Vigna luteola*), rush (*Eleocharis sp.*), dwarf spikerush (*Eleocharis parvula*), and fragrant flatsedge (*Cyperus odoratus*). Aquatic plant species found in intermediate marsh waters include widgeongrass, Eurasian watermilfoil, water celery, and southern naiad (*Najas guadalupensis*). Intermediate marshes are considered extremely important for many wildlife species, such as alligators and wading birds, and serve as important nursery areas for larval marine organisms. Although still a common natural community type in Louisiana, intermediate marsh appears to be declining in aerial extent, which has been attributed to a shift toward brackish marsh due to increased salinity levels.

[1] Classification of Wetlands and Deepwater Habitats of the United States FWS/OBS-79/31, DECEMBER 1979, Reprinted 1992

Fresh water marsh.

Freshwater marshes are quite heterogeneous, with local species composition governed by frequency and duration of flooding, micro-topography, substrate, current flow and salinity. This marsh type is typically dominated by maidencane, bulltongue, spikerushes, pennywort (*Hydrocotyle* sp.), Elephant-ear (*Colocasia esculenta*) and alligatorweed (*Alternanthera philoxeroides*). Other common plants are bullwhip, giant cutgrass (*Zizaniopsis miliacea*), fourchette (*Bidens laevis*) and cattail (*Typha* sp.). Fresh marshes are often very diverse with different species of grasses and broad-leaved annuals waxing and waning throughout the growing season. Chabreck (1972) documented 93 species of plants occurring in the fresh marshes of coastal Louisiana. Some fresh marshes, on the other hand, consist of nearly pure stands of maidencane. Aquatic plants commonly found in fresh marsh waters are duckweed (*Lemna minor*), coontail (*Ceratophyllum demersum*), Eurasian watermilfoil, southern naiad, water hyacinth (*Eichornia crassipes*), pondweeds (*Potamogeton* spp.), white waterlily (*Nymphaea odorata*), elodea (*Elodea canadensis*), hydrilla (*Hydrilla verticillata*), water celery, water shield (*Brasenia shreberi*), fanwort (*Cabomba caroliniana*), and American lotus (*Nelumbo lutea*). Fresh marsh salinity rarely increases above 2 ppt, with a year-round average of approximately 0.5-1 ppt. Freshwater marshes support extremely high densities of wildlife, such as migratory waterfowl. However, because of saltwater intrusion, freshwater marshes have undergone the largest rate of reduction in acreage of any of the marsh types in Louisiana over the past few decades.

The primary focus of Chabreck's (1972) and Chabreck and Linscombe's (1978, 1988, 2001) classification is the vegetative species of the natural marshes and interior water bodies of the coastal area. However, it is important to recognize that within or adjacent to those broadly delineated zones of marsh habitat types, other wetland areas with distinctive surface features and vegetative communities occur in association with the marshes. These include swamp and wetland forest, scrub/shrub, beach/barrier island, upland and other habitat. The following are descriptions of other major habitat types that compose and illustrate the diversity of the LCA (Ecosystem Restoration Study, Volume 2: Programmatic Environmental Impact Statement, November 2004).

Wetland Forests

Of the wetland forests in the Study area, the three major communities are swamp forest, bottomland forest, and wet pine flatwood forest. Cypress and cypress-tupelo swamp contains a mixture of bald cypress (*Taxodium distichum*), water tupelo (*Nyssa aquatica*), and swamp red maple (*Acer rubrum* var. *drummondii*) along with various understory plant species (Craig et al., 1987). Swamps with fairly open canopies sometimes support fresh marsh and scrub/shrub species as groundcover. Very often the water surface in cypress-tupelo swamps is covered by common duckweed, alligatorweed, and sometimes water hyacinth. Coastal swamp forests generally occupy the area between fresh marshes and developed areas of higher elevation. Bald cypress may occur in the upper end of interdistributary basins provided freshwater conditions are maintained year round. Cypress swamps may also border interdistributary ridges as a transition zone from higher elevation bottomland hardwood forests to lower elevation marshes. Healthy cypress

swamps occur only in fresh water areas experiencing minimal daily tidal action and where the salinity range does not normally exceed 2 ppt. Salinities of 3 ppt or higher may cause significant stress and mortality of cypress. However, short-term exposure to such salinities may be tolerated if the salts do not penetrate into and persist in the soil.

The bottomland hardwood forests and wet pine flatwoods occur only in fresh areas. Bottomland hardwood forests exist primarily in broad floodplains and distributary ridges of the Atchafalaya River and on the distributary ridges of the Mississippi River. Common tree species include sugarberry (*Celtis laevigata*), water oak (*Quercus nigra*), live oak (*Quercus virginiana*), nuttall oak (*Quercus nuttallii*), overcup oak (*Quercus lyrata*), bitter pecan (*Carya aquatica*), black willow (*Salix nigra*), American elm (*Ulmus americana*), swamp red maple, box elder (*Acer negundo*), green ash (*Fraxinus pennsylvanica*), and bald cypress (Craig et al., 1987).

Wet pine flatwoods are generally found on poorly drained flats and depressional areas in the "Florida Parishes" (Smith 1996). Common tree species include slash pine (*Pinus elliottii*), longleaf pine (*Pinus palustris*), water oak, laurel oak (*Quercus laurifolia*), sweet bay (*Magnolia virginiana*), and sweetgum (*Liquidambar styraciflua*). Wet pine flatwoods also contain a very diverse herbaceous community that can include many state rare species, and within in the coastal area, may include the threatened and endangered species Louisiana quillwort (*Isoetes louisianensis*).

Upland Forests

The three major communities of upland forest in the coastal area include chenier/maritime forest, mixed hardwood forest, and mixed pine-hardwood forest (Craig et al., 1987). Chenier/maritime forest occurs on abandoned beach ridges composed primarily of sand and shell. Common tree species include live oak, sugarberry, swamp red maple, sweetgum, and water oak. Red mulberry (*Morus rubra*), toothache-tree (*Zanthoxylum clava-herculis*), and sweet acacia (*Acacia farnesiana*) also occur on these elevated platforms. These ancient beaches were stranded behind prograding shorelines built during periods of sedimentation fed by the Mississippi River.

Mixed hardwood forest occurs adjacent to small stream floodplains in uplands protected from fire; common tree species include American beech (*Fagus grandifolia*), southern magnolia (*Magnolia grandiflora*), white oak (*Quercus alba*), Shumard oak (*Quercus shumardii*), sweetgum, and swamp white oak (*Quercus michauxii*).

Mixed pine-hardwood forest occurs on moist sites in the upper coastal area; common tree species include loblolly pine (*Pinus taeda*), sweetbay, southern magnolia, and red bay (*Persea borbonia*).

Scrub-Shrub

Scrub-shrub habitat is found along bayou ridges and on dredged material embankments, and is typically bordered by marsh at lower elevations, and by cypress-tupelo swamp or bottomland hardwoods (in fresh areas) or developed areas at higher elevations. Scrub-shrub communities are found throughout the coastal wetlands with their dominant species

and community composition associated with the respective habitat type with which it occurs.

Scrub-shrub communities occurring in saline habitat include those dominated by black mangrove (*Avicennia germinans*) on flooded saltmarsh edges and barrier islands, or by marsh elder (*Iva frutescens*) and eastern baccharis (*Baccharis halimifolia*) on low ridges, bayou banks, and spoilbanks and other disturbed areas. Brackish scrub-shrub wetlands are also dominated by eastern baccharis and marsh elder, although wax myrtle (*Morella cerifera*, formerly *Myrica cerifera*) is common on low ridges, bayousides, and spoilbanks as well. Typical scrub-shrub vegetation in intermediate and fresh areas includes elderberry (*Sambucus canadensis*), wax myrtle, buttonbush (*Cephalanthus occidentalis*), rattlebox (*Sesbania drummondii*), Drummond red maple (*Acer rubrum var. drummondii*), Chinese tallowtree, marsh elder, and eastern baccharis. Dwarf palmetto (*Sabal minor*) and prickly pear cactus (*Opuntia spp.*) are common in the understory of Chenier/maritime forest. Yaupon (*Ilex vomitoria*), dwarf palmetto, swamp privet (*Forestiera acuminata*) and Virginia willow (*Itea virginica*) also occur in thickets and the understory of swamps and bottomland hardwood forests.

Other Wetland Communities

Other less well-known unique wetland communities found within the above habitat types in this ecoregion include barrier island communities, maritime forests, floating marsh/scrub, and submergent estuarine vascular vegetation (SAV). SAV communities are extremely important breeding areas for many fish species and support tremendous numbers of wintering diving ducks. SAV is a critical food source for many species and foraging and hiding ground for others. It provides habitat for myriad animals, including juveniles of many commercially and recreationally valuable species. Aquatic species affect water quality through nutrient uptake and storage, binding of sediments by their roots, and trapping of particles within their leaf canopy. With growth of lush aquatic vegetation, these mechanisms drive the area towards a condition of clear water, lowering nutrients for algae growth and concentrations of suspended sediment in the water column. SAV requires sunlight to photosynthesize, thus murky water caused by silt, turbidity, color, or phytoplankton is stressful. SAV is intolerant of changes in salinity, toxicity, and water clarity and can be used to document changes within the ecosystem.

Streams and Rivers

The Deltaic and Chenier Plains contain all or part of ten hydrologic regions including Pontchartrain, Pearl, Breton Sound, Barataria, Terrebonne, Atchafalaya, Teche/Vermilion, Mermentau, and Calcasieu/Sabine basins and the Mississippi River Delta. Each of these is influenced to varying degrees by the timing, magnitude, duration and frequency of freshwater inflows from streams and rivers, and the nutrients and sediments associated with those inflows.

The Mississippi River and its distributaries historically provided immense volumes of land-building sediment and nutrients throughout Louisiana's coastal areas. For the last several thousand years, the dominance of the land building or deltaic processes resulted in a net increase of more than four million acres of coastal wetlands. In addition, there

was the creation of an extensive skeleton of higher natural levee ridges along the past and present Mississippi River channels, distributaries, and bayous in the Deltaic Plain and beach ridges of the Chenier Plain.

The Mississippi River has an annual average flow rate of 495,000 cubic feet per second (cfs) (14,000 cubic meters per second) and a freshwater discharge onto the continental shelf of 470,000,000 acre feet (580 cubic kilometers) per year. Today, most of the Mississippi River's fresh water, with its nutrients and sediment, flows directly into the Gulf of Mexico, largely bypassing the coastal wetlands. Deprived of landbuilding sediment, the wetlands are damaged by saltwater intrusion and other causative factors associated with relative sea level change and land subsidence, and will eventually convert to open water as the plants that define the surface of the coastal wetlands die off. Once the coastal wetlands are denuded of vegetation, the fragile substrate is left exposed to the erosive forces of waves and currents, especially during tropical storm events.

There are 10 major navigation channels, both deep draft and shallow draft, within the Louisiana coastal area. While these channels support the local, regional, and National economies, they also serve as conduits for saltwater intrusion in some areas and barriers to the distribution of freshwater, sediment, and nutrients to wetland habitats in other areas.

Canals

A vast network of canals, pipelines, and production facilities has been created to service the oil industry. Canals that stretch from the Gulf of Mexico inland to freshwater areas allow saltwater to penetrate much farther inland, particularly during droughts and storms, which has had severe effects on freshwater wetlands. Dredged material banks, which are much higher than the natural marsh surface, and the many smaller canals dredged for oil and gas exploration, alter the flow of water across wetlands. This hydrological alteration changes important hydrogeomorphic, biogeochemical, and ecological processes, including chemical transformations, sediment transport, vegetation health, and migration of organisms.

Because of the presence of dredged material banks, partially impounded areas have fewer but longer periods of flooding and reduced water exchange when compared to unimpounded marshes (Swenson and Turner 1987). This results in increased waterlogging and frequently in plant death. Importantly, dredged material banks also block the movement of sediment resuspended in storms, which play a major role in sustaining land elevations (Reed et al. 1997). By altering salinity gradients and patterns of water and sediment flow through marshes, canal dredging, which mostly occurred between 1950 and 1980, not only directly changed land to open water, but also indirectly changed the processes essential to a healthy coastal ecosystem. Elevated dredged material embankments may provide important wildlife refugia during storm events and valuable habitat for neotropical migratory birds, and the value of this habitat should be considered as restoration of these areas occurs (LCA 2004).

External Drivers

The combination of subsidence and sea level rise is an important non-societal driver affecting coastal features, and will act independently of other societal-driven stressors. Subsidence and sea-level rise are likely to cause the landward movement of marine conditions into estuaries and coastal wetlands (Day and Templet 1989, Reid and Trexler 1992). Societal-driven external drivers in coastal Louisiana include water management, land use and development, levees, locks/dams and navigation. Water management practices, including modification of river discharge, have resulted in drastic modifications to estuarine ecosystems (LCA 2004). These changes have caused large fluctuations in the location, volume, timing, and frequency of freshwater and sediment inflow to the ecosystem and, in turn, have had an impact on the ecology of the estuarine ecosystem through alteration of salinity zonation, spatial arrangements of wetland building and loss rates.

Climate change has been tied to RSLR, but could influence other factors that affect Louisiana's wetlands. There is widespread consensus today in the international scientific community that the world's atmosphere is warming. The Intergovernmental Panel on Climate Change, 2007,[1] reports that global average temperature has increased by about 1 degree F in the last 140 years, and is expected to rise by 2.5 to 10.4 degrees F by the end of this century. Uncertainty remains regarding the effects of this change on patterns of precipitation. The two climate models generally used by scientists differ dramatically on projections of rainfall. Because fresh water is an essential ingredient for the survival of wetlands, this will be a key issue for future restoration projects. Predictions of storm patterns are also uncertain. Even if the frequency and intensity of storms remain constant, those considered minor by current standards could have major consequences in Louisiana as rising sea levels intensify tidal surge, erosion, flooding and saltwater intrusion.

Ecological Stressors

Altered Hydrology, Water Quality and sediment delivery. Natural processes alone are not responsible for the degradation and loss of wetlands in the Mississippi River delta plain. Natural levees created by seasonal flooding of the river would invariably influence the path and flow of river waters. The seasonal flooding of river waters provided a seasonal input of sediment providing a renewable resource of substrate and nutrients for habitat behind the natural levees. As natural levees accreted in height and size, the location and course of distributaries, river meanders, and river channels would change over a geologic scale of time (beyond multiple human lifespans). Nowhere has this change been exacerbated more than by the construction of flood protection levees on top of existing natural levees within the watershed of the Mississippi River especially in coastal Louisiana. Seasonal flooding that once provided sediments and nutrients critical to the

[1] IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of WorkingGroup I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning,Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

healthy growth of wetlands of coastal Louisiana has been virtually eliminated by the addition of an extensive levee system, on top of the natural levee system, extending in part from the Old River Control Structure to Venice Louisiana, a distance of approximately 310 miles (500 kilometers); sediment carried by the river is now discharged far from the coast, thereby depriving wetlands of vital sediment. Altered hydrology and water quality is one predominant stressor on the ecosystem, taking the form of cumulative effects of levees, canals, and other physical alterations. This causes changes in quantity, timing, and quality of flows to the ecosystem, in addition to harm to wetlands and ground-water resources. Throughout the coastal wetland complex, an extensive system of dredged canals and flood-control structures, constructed to facilitate hydrocarbon exploration and production as well as commercial and recreational boat traffic, has enabled salt water from the Gulf of Mexico to intrude brackish and freshwater wetlands. Moreover, forced drainage of the wetlands to accommodate development and agriculture also contribute to wetlands deterioration and loss. Altered hydrology and water quality is exacerbated by physical changes made within the Mississippi River watershed that includes numerous large hydropower dams and reservoirs and flood control, land use patterns, agricultural practices and navigation projects.

Altered Estuarine Salinity.
Construction of flood protection levees, hydropower dams and reservoirs along the Mississippi River and its distributaries have had a system level impact on salinities. Construction of deep-draft and other navigation channels, pipeline canals, and oilfield canals have exacerbated those ecosystem level impacts. Additionally, forced drainage projects have altered the timing and location of freshwater inputs from adjacent distributary ridges and developed areas. Development and enhanced drainage of developed areas has also accelerated freshwater inputs into the coastal ecosystem. Canal-related hydrologic alterations allow those freshwater inputs to be quickly discharged from coastal wetlands and rapidly replaced with Gulf waters.

Physical Alterations.
In addition to the construction of flood control levees and canals of various sizes, the hydrology of coastal wetlands has also been altered through construction of highway embankments, railroad embankments, local flood protection levees, and impoundments. Levee failure of agricultural impoundments has resulted in creation of large open water lakes due to the oxidation and accelerated subsidence of the once drained soils. Extensive networks of oil and gas field canals have also altered hydrology and water quality resulted in substantial direct impacts to wetlands through dredging and dredged material placement impacts.

Herbivory.
During the 1930's, nutria (*Myocastor coypus)* were accidentally released into the coastal wetlands. Since then their population has rapidly expanded and their grazing and foraging for plant roots have been a major contributor to wetland losses. Although native, muskrats eat-outs may also result in significant local impacts to area marshes. Although eat-outs may recover under some conditions, tropical storm impacts on an eat-

out area may overnight convert such an area to permanent open water conditions (USGS 2000).

Invasive Species

Invasive plant species increase and spread rapidly because the new habitat into which they are introduced is free of insects and disease that are natural controls in their native habitats. The aggressive spread of invasive species decreases stands of native plants in many areas, rapidly altering ecosystem function. Different ecosystem types vary in the species that pose problems and the degree to which they are currently impacted or threatened by invasive species (USGS, 2000). Disturbed ecosystems are more vulnerable to invasive species than stable ecosystems. In coastal Louisiana, water hyacinth (*Eichhornia crassipes*), alligator weed (*Alternanthera philoxeroides*), and hydrilla (*Hydrilla verticilata*) are aquatic vegetative species that have long been considered invasive. More recently, common salvinia (*Salvinia minima*), giant salvinia (*Salvinia molesta*), and variable-leaf milfoil (*Myriophyllum heterophylum*) have become invasive, displacing native aquatics and degrading water and habitat quality. Invasive aquatic species interfere with drainage and flood control, and impede navigation and recreation activities (Westbrooks 1998). Chinese tallowtree (*Triadica sebifera*, formerly *Sapium sebiferum*) and sea-side cedar (*Tamarix gallica*) rapidly colonize higher disturbed open ground areas and interrupt natural succession of native prairie, scrub-shrub and woody species because of their tolerance to flooding and salt stress. Escaped populations of Chinese tallowtree have established extensive, self-replacing monocultures that have radically altered ecosystems (USGS 2000). Barrow et al. (2000) illustrates how the invasive tallowtree, in crowding out native species, provides less value to the foraging of migrating avian species. Cogongrass (*Imperata cylindrica*) is a fast-growing perennial grass that is infesting Gulf coast wetlands, savannas, and forests. Considered one of the top ten weeds in the world, cogongrass invades dry to moist natural areas and forms dense colonies with extensive root/rhizome systems that displace native plant and animal species. Cogongrass has been recorded as occurring in parts of Louisiana (Center for Aquatic & Invasive Plants 2000), but recently has been found to be locally severe in a very small number of areas (J. Pitre, USDA NRCS, 2002 – personal communication).

Storms

Wetlands already weakened by extreme weather conditions may be more vulnerable to damage from subsequent events as plant communities become stressed beyond their ability to recover or shift toward communities with more tolerant species. Hurricanes impact coastal vegetation communities with saltwater intrusion and flooding from storm surges. Hurricanes also cause immediate physical damage to emergent wetlands as increased wave action and currents cause tearing or uprooting of the live mat and substrate loss, and high winds sheer limbs and fell trees in wooded areas. Storms deposit smothering mats of wrack and detritus over large areas, causing temporary or permanent shifts in plant community composition. The erosion and breaching of emergent lands also deteriorates its buffering function that protects low-energy hydrologic regimes where aquatic vegetative communities may thrive.

Drought

Prolonged periods of drought can also impact coastal vegetation. In 2000, coinciding with the drought period, damage or dieback was reported in areas of unprecedented size in the Terrebonne and Barataria saline marshes. Areas sustaining the worst damage during this "brown marsh" phenomenon suffered complete dieback of above and belowground plant material and conversion to unvegetated mud flats (Linscombe et al., 2001). In addition, Visser et al. (2002), in comparing 1997 and 2000 vegetation survey data, found that salinity increases across all marsh types occurred. The response of estuarine plant communities to the hydrologic changes brought about by the 1999-2000 drought may provide a preview of changes in estuarine plant communities as global sea-level change causes marine intrusion into estuaries to increase (Visser et al., 2002). More recently, a severe nine-month drought following the 2005 hurricanes Katrina and Rita allowed for prolonged inundation of gulf-strength surge waters and its deep infiltration into marsh soils. One year post-storm, soils salinity levels in many coastal areas remain significantly increased (pers.comm. Jerry Daigle, USDA NRCS; Steyer et al., in prep.).

Important Linkages

One approach to restore Coastal Louisiana is to reverse the original alteration of the marsh landscape by removing man made levees and other hydrological constraints, filling in the extensive network of artificial channels, and letting the unconstrained physical processes re-create the wetlands, ridges and other features over time. This "idealized" approach is not possible for three main reasons:

1. The physical processes that formed the marsh are quite different than those operating now. For example, sediment loads in the Mississippi, Atchafalaya and other gulf tributaries is much lower now than in recent history and RSLR is greater and projected to increase with global climate change.

2. There are significant human constraints that limit the ability to restore natural processes. These include land development and property boundaries that define and limit how areas may evolve, flood protection requirements, and the presence of public infrastructure and travel corridors (including navigation channels and canals). Natural levees within the watershed of the Mississippi River especially coastal areas would still create a barrier limiting distribution of sediments into wetland areas. Dams that trap sediments, reservoirs that alter hydrology, basin land use practices and other related factors distributed over the entire drainage may also effectively constrain opportunities. However, ongoing research is in process to ascertain sediment loads/budgets of the Mississippi River in order to assist in development of future strategies to utilize existing resources in the river.

3. The economic investment in restoration is usually directed towards achieving restoration goals within a quick timeframe. Conversely, recovery through the restoration of key processes may require decades or even centuries to fully realize benefits. This may also mean trade-offs between created/restored landscape features that increase or

accelerate system sustainability versus the desire to allow unconstrained "natural" evolution.

PLAN FORMULATION

The aim of the LACPR was to formulate and justify a comprehensive plan that integrates coastal restoration with multiple lines of defense against hurricane surge risk for coastal Louisiana. Because of the complexity and size of the planning area, there may be hundreds of possible combinations of structural, nonstructural, and restoration measures that could be combined into alternative plans. In order to maintain the transparent problem-solving and opportunity focus of the analysis, it was essential to reduce the number of alternatives under consideration for LACPR to a manageable number.

The HET was charged with using measures contained in the Louisiana State Master Plan as the basis for formulation and evaluation of coastal restoration alternatives.

Early in the plan formulation process, the LACPR *Plan Formulation Atlas* presented three of the State Master Plan alternatives in addition to a fourth alternative developed by the HET. The "State Coastal Alternative 3" from the *Plan Formulation Atlas* is closest to the coastal restoration plan presented in the final State Master Plan and was carried forward as an alternative to be evaluated under LACPR as described in this appendix. The HET alternative "Coastal Alternative 4" from the *Plan Formulation Atlas* was carried forward as well as an alternative representing the LCA Plan that best meets the planning objectives (Plan PBMO).

Two additional alternatives were developed by the HET with the specific aim of sustaining the wetland area over a 100-year timeframe. Both alternatives achieve this aim through the restoration of coastal features (barrier islands, ridges, land bridges and marsh) in combination with Mississippi River diversions in PUs 1, 2 & 3a. The difference between the alternatives is in the design and operation of the diversion structures. One alternative incorporates the use of small to medium diversions operated on a relatively consistent basis, whereas the other alternative uses medium to large diversions with the capability for periodic (every four or five years) large pulsed flows. In PU 3a, an additional diversion alternative (PU3a R2) was included that involves the management and re-distribution of seasonally available Atchafalaya River fresh water from various points along the GIWW. To achieve "maximum sustainability" in the remaining planning units, one alternative employs heavy use of dedicated dredging to restore or sustain marsh with shoreline protection to reduce shoreline erosion. The other alternative also employs heavy use of dedicated dredging to restore or sustain marsh, but does not employ shoreline protection which significantly impacts the aim of reaching no net loss. The alternatives are summarized in Table 2.

Screening, Formulation and Prioritization Process

A two step screening and formulation process was utilized to develop the viable coastal restoration alternatives.

Two-Tiered Screening and Formulation Process

- **Tier 1 - Initial Screening of Measures and Formulation of Alternatives** eliminated coastal restoration measures that were not essential to sustaining the integrity of the landscape. The remaining measures were grouped (utilizing different rationales) to formulate five primary coastal restoration alternatives in each planning unit using several.
- **Tier 2 - Screening of Alternatives and Selection of a Representative Alternative** evaluated the five primary coastal restoration alternatives and selected the alternative that best represented the landscape and met the criteria of sustaining the existing landscape.

Tier 1: Initial Screening of Measures and Formulation of Alternatives

The HET considered implementing measures identified during the development of the State Master Plan. A range of features were considered that could maintain or restore natural deltaic processes and hydrology in coastal Louisiana; these included diversions off the Mississippi River, marsh creation, ridge or chenier (oak ridges) restoration and barrier islands restoration. These features were prioritized according to the anticipated degree of basin-level benefits they would provide. Factors considered for prioritization included:

- Distance to sediment sources, both riverine and offshore
- Availability of freshwater for sustainability
- Existing structures to aid in sediment confinement during construction
- Average depth of open water areas
- Land/water distribution
- Need for shoreline protection
- Preferred sediment grain size for restoration
- Processes responsible for wetland loss
- Measure of local subsidence
- Potential fisheries impacts
- Measure of flood and infrastructure protection provided by site
- Proximity of pipeline right-of-ways and access for construction
- Overlap with LCA/CWPPRA projects

Ultimately, prioritization was made primarily on the contribution of the measures to sustaining the integrity of the most critical estuarine regions in each hydrologic basin. Highest priority was given to measures that would restore and/or maintain critically important landscape features or marsh areas. Because construction of the most critically important measures would require more sediment than was readily available in many

cases, the HET subdivided many of the marsh polygons from the State Master Plan into smaller units that could be prioritized separately. Additional marsh creation areas or erosion reducing measures not identified in the State Master Plan were also developed and applied to coastal restoration alternatives R1, R2, and R4, which are described below. Those marsh creation measures assigned the lowest priority were excluded from further analysis.

Five primary alternatives were identified for further analysis following screening of the first tier. See **Table 2** below:

Alternative Rationale	PU 1	PU2	PU3a	PU3b	PU4
Alternative relies on small to medium diversions off the Mississippi River. In PU 1 and 2, the diversions are steady state; PU3a diversions could be either steady state or "pulsed".	R1	R1	R1	NA	NA
Alternative relies on medium to large diversion "pulsed" flows off the Mississippi River.	R2	R2	NA	NA	NA
Alternative relies on diversions or water management off the GIWW	NA	NA	R2	NA	NA
Bank-line stabilization combined with dedicated marsh creation.	NA	NA	NA	R1	R1
Dedicated marsh creation without bank-line stabilization.	NA	NA	NA	R2	R2
State Master Plan	R3	R3	R3	R3	R3
Other coastal restoration measures not identified in the State Master Plan or modifications to the State Master Plan (R3).	R4	R4	R4	R4	R4
Louisiana Coastal Area (LCA) *Plan that Best Meets the Objectives.*	R5	R5	R5	R5	R5

NA – Not Applicable

Table 2. Coastal restoration alternatives developed for initial screening.

Each of the alternatives developed focus on the use of measures that contribute to estuarine maintenance at a basin scale, namely freshwater diversions, marsh creation using dredged material, ridge/Chenier restoration, and barrier island restoration.

Tier 2: Screening of Alternatives and Selection of a Representative Alternative

In the second tier of screening, each alternative as shown in **Table 2** above was subjected to a performance analysis over a 100 year period. The value generated was a simple gross maximum acreage of wetlands restored and/or sustained for each alternative by planning unit over 100 years. The acreages calculated from the analysis at various points in time were used to develop a performance trend for each alternative. The alternatives that resulted in negative acreages, indicating an inability to achieve coastal restoration goals, were dropped from further consideration. These were alternatives R4 and R5 for Planning Units 1 and 2 and alternatives R2, R3, R4 and R5 for Planning Units 3a, 3b and

4. The alternatives remaining for further consideration included R1, R2, and R3 in Planning Units 1 and 2 and R1 in Planning Units 3a, 3b, and 4. From the remaining alternatives in Planning Units 1 and 2, one alternative was chosen as a representative landscape coastal restoration alternative to be carried forward into the analysis in order to reduce the number of alternative combinations. Both alternatives achieve restoration of coastal features the difference between them being the design and operation of the diversion structures.. **Table 3** provides a summary of the coastal restoration alternatives carrier forward for further consideration.

PU	Alternatives Meeting Restoration Goals	Representative Alternatives	Representative Alternatives
1	R1, R2, R3	R2	Combination of medium to large river diversions operated with periodic large pulses and prioritized marsh creation measures to achieve sustainability.
2	R1, R2, R3	R2	Combination of medium to large river diversions operated with periodic large pulses and prioritized marsh creation measures to achieve sustainability.
3a	R1	R1	Variously sized Mississippi River diversions with prioritized MC measures to achieve sustainability.
3b	R1	R1	Alternative relies heavily on dedicated dredging to create a significant amount of wetlands in addition to shoreline protection to minimize wave/wake induced erosion.
4	R1	R1	Alternative relies heavily on dedicated dredging to create a significant amount of wetlands in addition to shoreline protection to minimize wave/wake induced erosion.

Table 3. Summary of coastal restoration alternatives.

The representative alternatives described above were combined with alternatives for structural and nonstructural storm damage reduction for analysis using a multi-criteria risk-informed decision framework, wherein stakeholders had the opportunity to weigh the importance of plan components. Uncertainty is explicitly included in the analysis through scenario analysis and the use of uncertainty estimates for the plan metrics. The principal factors around which scenarios were developed for the LACPR include:

a) Relative sea level rise, and
b) Redevelopment patterns within local communities in South Louisiana.

Two relative sea level rise rates were determined by combining the IPCC "medium" sea level rise projection and the NRC sea level rise rates with local subsidence rates. The two relative sea level rise rates are then combined with two levels of regional redevelopment (societal and economic recovery from Hurricanes Katrina and Rita) to form the four LACPR scenarios.

Alternative Formulation Process Overview

In developing alternatives, the HET considered numerous coastal restoration features that were developed in several collaborative venues, including the State Master Planning

Process and LCA. These features represented the initial array of management measures considered for inclusion in the LACPR, and they were augmented with features that have been proposed under other programs or separately identified by the HET. The HET utilized the factors identified below in the Tier 1 screening process to assess and prioritize each feature, and generated information regarding sediment availability to assess the feasibility of implementation of various alternatives.

Sediment availability from dredging operations (including routine O&M and possible additional borrow sources) and potential production rates from dredging for each planning unit were considered constraints in formulating alternatives involving beneficial uses of dredged material. A flow rate of 525,000 cfs between the months of December and May (normal peak flow periods) was assumed as an upper limit for Mississippi River Diversions to be used in planning until more detailed assessments can be completed to assess the diversion capacity with regard to associated flooding, navigation and environmental impacts. This flow rate was utilized in the LCA report and PEIS. The maximum flow rate for the Mississippi River below New Orleans is 1,250,000 cfs. The limit established in the LCA report was 45%, 525,000 cfs is approximately 42% of the maximum flow rate.

Given the above information and the objectives and principles previously discussed, the HET assessed each potential diversion site to determine the discharge magnitude and operations necessary to support the marsh community in the area influenced by the diversion such that maximum sustainability of wetlands was achieved. The deficit between the diversion benefits and overall wetland losses in each basin were then offset using dredged material beneficially to construct new wetlands, and other restoration measures. Where a marsh creation area would be located within a diversion influence area, that diversion was sized to sustain both the restored marsh and the marsh existing at baseline (year 2010).

Constraints

The development and evaluation of restoration alternatives within coastal Louisiana was constrained by several factors. Foremost among these factors was the fundamental premise that restoration of deltaic processes would be accomplished, in part, through reintroductions of riverine flows, but that natural and historical deltaic processes associated with the Mississippi River would not be fully realized. The availability of freshwater, primarily water transported down the Mississippi River, was considered a planning constraint because minimum levels or water flows are required to maintain navigation and flood control, and limit saltwater intrusion. The availability of sediment for restoration efforts was also considered a planning constraint for this study because there is not an unlimited, easily accessible, and low-cost source for restoration efforts.

Given the Congressionally-mandated time frame, hydrologic modeling and other intensive evaluations of measures and alternatives was not possible. Instead, relatively simple and rapid assessment methods were required. Consequently, the evaluation represents a limited programmatic assessment of the benefits and impacts of alternatives.

Time constraints also limited the ability to obtain and incorporate extensive external input and data into the assessment of measures and evaluation of restoration alternatives.

Another significant constraint is the scientific and technological uncertainties inherent in large-scale aquatic ecosystem restoration projects. The HET maintains that implementation of the LACPR must be accompanied by a concerted research and technology development program to address these uncertainties, and that this is consistent with our recommendations for an adaptive management program for LACPR. These needs are discussed in later sections of this report.

Measures

Among the many measures considered in the development of the State Master Plan, the HET considered those measures that would significantly contribute to estuarine maintenance processes at a basin scale to be of greatest importance. Given the effects of subsidence and RSLR, sediment inputs and restoration of natural wetland maintenance processes were considered to be essential for achieving the highest degree of ecosystem sustainability possible. Restoration of natural deltaic processes through diversions of Mississippi River freshwater, nutrients, and sediment were considered essential for the restoration of self-sustaining coastal wetlands. Marsh creation measures strategically located to provide basin or subbasin-level benefits were also considered. Similarly, natural landscape features such as ridges, cheniers, and barrier islands were considered, provided those landscape features contributed substantially to the maintenance of desirable system hydrology.

After assessing shoreline erosion rates and the impacts associated with 100 years of continued erosion, some proposed bank stabilization measures were dropped from further consideration if deemed to be of little system-level benefit. Some water control structures and other measures were dropped from further consideration for similar reasons if not located in a rapidly deteriorating area or if not of a scale to provide significant benefits to a rapidly deteriorating area.

Sediment Demanding Measures

The HET considered implementation of marsh creation measures identified during the development of the State Master Plan. Measures that would restore and/or maintain critically important landscape features or marsh areas were given highest priority. Because construction of the most critically important measures would require more sediment than was readily available in many cases, the HET subdivided many of the marsh polygons from the State Master Plan into smaller units that could be separately prioritized, permitting inclusion of as many of those critically important measures as possible in any given year.

Principles:

- Create-recreate strategic marsh and/or landscape features to achieve synergies with diversions and other measures to maximize natural wetland sustainability and reduce costly long-term artificial maintenance.

- Use of external sediments is preferred rather than sediment taken from within the basin to avoid adverse indirect impacts, to avoid tidal prism increases, and to improve opportunities for natural marsh sustainability through the resuspension of sediments from open water areas. Use of in-basin borrow would not be precluded, but should be planned in a manner that avoids or minimizes adverse impacts to the greatest degree possible after external available sediments have been exhausted.

- When hydraulically dredged, sediments from saline sources should be used on barrier islands or in saline marshes to reduce salinity related impacts to wetland vegetation.

- To maximize the value provided by the use of the existing limited sediment supply, restoration and maintenance of rapidly subsiding marshes or coastal landscape features may be given lower priority compared to areas/features subsiding less rapidly, unless those features provided necessary ecosystem or hurricane protection functions.

- Determine annual sediment quantities available to coastal hydrologic basins in order to develop the most effective and strategic use of that material within each basin.

- Because of sediment availability constraints, and the cost for replacing eroded sediments, erosion protection measures may be required to help maintain marshes or recreated natural landscape features that are subject to erosional losses.

The following table (table 4) presents the HET-prioritized list for marsh and landscape feature creation using dredged material. The table presents the features sorted in priority order by planning unit, with a simple sorting algorithm using structural importance first, lifespan second, and synergy with diversions as the third criterion. Criteria scoring range from 0 – 3, with a value of 3 reflecting the highest degree of importance, longest life, or greatest synergy.

Table 4. Marsh Creation Priorities		**Sorting Criteria**			
		Structural	Function	Syn w	
PU	**Creation & Protection Features**	Import.	Lifespan	Divs	acres
1	East Orleans landbridge MC & SP	3	1	1	**7,996**
1	Breton Sound strategic MC	2	3	1	**10,365**
1	Biloxi Marshes (north + south) MC	2	2	0	**33,553**
1	Breton Sound MC	1	2	1	**52,099**
1	Bayou Terre Boeuf MC	1	2	0	**4,214**
1	Bayou LaLoutre Ridge	1	1	1	-----

1	Central Wetlands MC	0	3	1	4,467
1	Labranche Marshes MC	0	3	0	3,298
1	Chanduleur Islands	0	3	0	
1	Golden Triangle MC	0	2	0.5	2,614
2	Barataria Bay Rim MC red (segs # 1,2,7,8,9)	3	3	1	1,317
2	Bar. MC: Red polys - SE Little Lake (8,19,11-17)	3	3	1	22,573
2	E.Grand Terre to Shell Is. Restoration	3	3	0.5	-----
2	Shell Is to Sandy Point restoration	3	3	0.5	-----
2	Barataria Landbridge MC	3	2	1	29,031
2	Grand Isle + W.Grand Terre restoration	3	2	0	-----
2	Cheniere Caminada Beach restoration	3	1	0	-----
2	Bar. MC: Orange polys - nr Little Lake (7,9)	2	2	1	9,468
2	Barataria Bay Rim MC orange (segs 4-6, 10-15)	2	2	0.5	2,221
2	Bayou L'Ours Ridge	2	2	0	-----
2	Cheniere Caminada Ridges Restoration	2	1	0	-----
2	Bayou Dupont Ridge	1	3	1	-----
2	Bayou Grande Cheniere Ridge	1	2	1	-----
2	Barataria Bay Rim MC blue (segs 3, 16-23)	1	2	0.5	2,536
2	Bar. MC: Blue polys - lower Laforuche (1-6)	1	2	0.5	27,687
2	Lower Bayou Lafourche Ridge	1	2	0	-----
2	Bar. MC: Grn polys - E of BWW (18-30)& L.Salvdr.	0	3	1	32,466
2	Bayou Long Fontanelle Ridge	0	3	0.5	-----
2	Bayou Barataria Ridge	0	2	0	-----
3a	3DR-east red polys (9,10,11,16,19,21,22,28)	3	3	1	31,006
3a	Terr Bay N. Rim (JeanCh. To B.Terr)	3	3	1	1,042
3a	South Caillou Lake Landbridge MC (polys 20-22)	3	3	0.5	6,237
3a	Timbalier Islands Restoration	3	3	0	-----
3a	Isle Derniers Restoration	3	2	0	-----
3a	DuLarge-Grand Caillou Landbridge MC	2	3	1	1,170
3a	Small Bayou la Pointe Ridge	2	3	1	-----
3a	3DR-east orange polys (S1,13,17,20,29,30)	2	3	0.5	22,521
3a	Bayou DuLarge Ridge	2	2	1	-----
3a	3DR-west green polys (1,2,3,4,8)	2	2	0.5	5,678
3a	South Caillou Lake Landbridge MC (polys 19,23,24)	2	2	0	13,727
3a	Bayou Pointe au Chene Ridge	2	2	0	-----
3a	3DR -east blue polys (8)	1	3	1	2,563
3a	3DR-west blue polys (5,6,7)	1	3	0	4,212
3a	Terr Bay N. Rim (Pt.Chen to JeanCh.)	1	2	1	524
3a	Margaret's Bayou Ridge	1	2	1	-----
3a	Terr Bay N. Rim (Lafch to Pt.Chene)	1	1	1	525
3a	Terr Bay N. Rim (B.Terr to west end)	1	1	0	1,067
3a	Bayou Terrebonne Ridge	0	3	0	-----
3a	3DR-east green N polys (2,7,12,14)	0	2	1	8,741
3a	3DR-east green S polys (N1,3,4,5,6,15,16,18,23-27)	0	2	0	19,634
3b	Penchant Basin Tidal MC	3	3	1	8,207
3b	Mauvois Bois - Marmande Ridges	3	2	0	-----
3b	Barrier Reef (Pt au Fer to Eugene Island)	2	3	1	**

3b	Pointe au Fer Island MC	2	2	0	1,462
3b	Marsh Island MC	2	2	0	7,883
3b	Avoca Island MC	0	1	0	1,445
3b	Lower Atch. River MC	0	1	0	1,526
3b	Lower DuLarge Ridge MC (PU3b only)	0	1	0	35
4	South Pecan Island MC	1	3	1	6,851
4	South Grand Chenier MC	1	3	1	5,575
4	Northwest Calcasieu MC	1	3	1	23,187
4	East Calcasieu Lake MC	1	3	0	11,141
4	Chenier Reforestation/Restoration	0	1	0	161

Freshwater Diversions

Note: See Attachment E for additional information on diversions in PUs 1 & 2

The HET considered those diversions identified during the development of the State Master Plan, plus additional diversions identified during other recent restoration planning efforts. Existing diversions (Davis Pond and Caernarvon) and siphons were considered to be part of the overall diversion plan and were assumed to operate at their maximum discharge potential. In addition to constant (non-pulsed) operation, the HET also evaluated one pulsed operation alternative where one high discharge year was followed by 4 or 5 consecutive low-discharge years. This alternative was evaluated as a means of providing for both estuarine-dependent fisheries and periodic introductions of large quantities of suspended sediment into the receiving area marshes.

Principles:

- Baseline wetland loss between 1978 and 2006 (data provided by the USGS through satellite imagery) were determined via a linear trendline through the 1978 to 2006 data in order to avoid bias due to excessive hurricane-related 2005 wetland losses and to compensate for water level effects during satellite overflights.

- Based on preliminary estimations, the maximum diversion discharge from the Mississippi River is approximately 525,650 cfs. The HET developed a low-flow diversion alternative which would discharge a total of 153,000 cfs (alternative R4). The State's Preliminary Draft Master Plan consists of a medium discharge alternative with a maximum total Mississippi River discharge of 251,000 cfs. The LCA Plan 10130 (PBMO) represent medium high maximum diversion amounts of 438,000 cfs and the R1 Plan (steady flow diversions only from December through May) represent medium high maximum diversion amounts at 331,000 cfs.

- Within each basin, the HET determined how much discharge would be needed to achieve maximum sustainability to ascertain whether that alternative would exceed the allowable diversion total (525,650 cfs). Consequently, the total

diversion discharge amounts of alternative plans R1 and R2 can be compared to the 525,650 cfs limit to evaluate the practicality of those alternative plans.

- determined which diversion would maintain the most critical marsh area within that basin. The second most critical marsh area was identified and a second priority diversion site identified to benefit it. Any remaining discharge to be allocated would be diverted at that location in amounts that would maintain that marsh area. This process was repeated again if unallocated basin flows are available.

Priorities are based on the potential for diversions to provide long-term maintenance of marshes that are of critical importance for basin hydrology. Unless otherwise specified, this prioritization does not consider diversion size/discharge, but it is assumed that the diversion should be sized to effectively maintain those critically important marsh and/or landscape features. The diversions listed below are in descending priority (table 5).

Table 5. Diversion priorities by basin.

Basin/Priority	PU	Diversion
Pontchartrain		
1	1	Violet*[5]
2	1	Maurepas swamp diversions (Hope Canal & Blind River)
3	1	LaBranche
4	1	Bonnet Carret
Bret[6]on Sound		
1	1	Caernarvon and/or White's Ditch[7]
2	1	American Bay
3	1	Bayou Lamoque
4	1	other lower river diversions
Barataria		
1	2	Myrtle Grove
2	2	Port Sulphur
3	2	upper basin swamp diversions
4	2	Davis Pond reauthorization
5	2	Buras
6	2	Fort Jackson
7	2	Bayou Lafourche 1,000 cfs siphon/pump

* *Recent WRDA 2007 legislation passed by Congress, authorized the construction of a diversion at or near Violet, Louisiana. All future alternative investigations and analysis will need to include the Violet Diversion as part of the FWOP condition*

Stabilization and Water Control Measures

[5] Violet or more efficient violet alternatives would be ranked highest, but because of the inefficiencies restored by discharge into the MRGO and Lake Borgne, Violet and/or the alternatives should not be sized to sustain the east Orleans landbridge.

[6] Proposed under Coast 2050. The HET believed a diversion American Bay to relatively inefficient for land building and marsh maintenance. Higher ranked diversions would provide more wetland benefits nd more storm protection benefits.

[7] Increased discharge at Caernarvon and/or a new diversion at Whites Ditch would provide maximum benefits to the Breton Sound estuary.

Stabilization Measures

In all of the planning units, but not all alternatives, stabilization measures were included in order to decrease erosion rates of existing wetlands. Combined with other measures, stabilization measures could reduce wetland loss rates significantly. The amount of wetlands potentially sustained is no more evident than in PU4[8], where shoreline erosion plays a large role in wetland loss rates. Stabilization measures typically include, but are not limited to, stone rip-rap along or in front of a shoreline or the use of oyster shell or reefs in front of critical areas as a means to reduce wave energy before reaching a wetland.

PU1 - Shoreline stabilization features could be placed on the perimeter of wetland areas that front the high energy open water of the Gulf of Mexico. Interior wetlands are sustained through diversions or dedicated dredging for marsh creation.

PU2 – Shoreline stabilization features might include fronting existing barrier islands with some type of rip-rap, but perhaps more importantly, critical marsh areas exposed to the high energy fetch of Barataria Bay. The goal is to prevent the inward degradation of wetlands, in order to reduce loss rates and enhance the sustainability success of diversions and mechanical wetland restoration.

PU3a - Shoreline stabilization features could include fronting existing barrier islands with some sort of rip-rap, but perhaps more importantly, critical marsh areas exposed to the high energy fetch of Terrebonne Bay. The goal is to prevent the inward degradation of wetlands, in order to reduce loss rates and enhance the sustainability success of diversions and mechanical wetland restoration.

PU3b – Shoreline stabilization features could include lining the perimeter of wetland areas that are exposed to the high energy open waters of the Gulf of Mexico and the interior high energy fetch of Vermilion Bay. A fair amount of this planning unit is experiencing growth through prograding deltas off of the Atchafalaya River and the Wax Lake Outlet.

PU4 – Shoreline stabilization features could include extensive shoreline protection measures along the Gulf coast shoreline of the planning unit, inland waterways, and large inland lakes/bays. Without significant shoreline protection measures in place, the ability to achieve coastal restoration goals in this planning unit are greatly diminished. Other measures that are available for other planning units are not necessarily available in PU4 because of the great distance from a major riverine input source or through current basin management practices for agricultural purposes.

Water Control Measures

[8] In PU4 the difference with and without shoreline stabilization measures, a amount of approximately 30,000 acres would be lost over the next 100 years.

This can be briefly described as implementing measures that re-distribute or restore hydrologic conditions to move freshwater (and associated nutrients/sediments) back into a particular system. This option is limited to the availability of freshwater sources (i.e., PU3a) and existing infrastructure obstacles that would have to be addressed and overcome (major highways, interior drainage, waterways, etc.).

Scenario Development and Application

The principal factors around which scenarios are being developed for the LACPR are: sea level rise, subsidence, population growth rates, and redevelopment patterns within local communities in south Louisiana. The scenarios under development combine two levels of relative sea level rise with two levels of regional redevelopment (societal and economic recovery from Hurricanes Katrina and Rita).

The HET determined that regional redevelopment patterns were unlikely to influence restoration outcomes, so the only scenario driver assessed by the HET was RSLR. The future acreage of wetlands and the spatial integrity index are both influenced by RSLR, so alternate outcomes were assessed for each condition. Ecosystem restoration measures are not located in areas where regional redevelopment (and new regional development) is anticipated to occur.

Alternative Descriptions

The measures used for the LACPR coastal restoration alternatives are summarized below. Figures illustrating coastal restoration alternatives are included in Attachment A.

LACPR Coastal Restoration Plan Alternative Measures for Planning Unit 1

PU1 R1 - December through May "Steady" Diversion Alternative (Attachment A – Figure A-1 PU1 R1)

- 1-1 Blind River Diversion - flows for sustaining entire south Maurepas swamp split between Blind River and Hope Canal
- 1-2 Hope Canal Diversion - flows for sustaining entire south Maurepas swamp split between Blind River and Hope Canal
- 1-3 LaBranche Diversion – diversion directly into LaBranche wetlands to sustain those wetlands
- 1-4 Bayou Bienvenu Diversion – to reduce East New Orleans landbridge loss rates by 50%
- 1-5 East New Orleans land bridge Marsh Creation – 7,996 acres @ 900 acres/year
- 1-6 Bayou LaLoutre Diversion – (In lieu of Violet) sized to sustain the Biloxi Marshes
- 1-7 Biloxi Marshes Shore Protection – 254,500 linear feet of protection around outer perimeter
- 1-8 Biloxi Marshes Marsh Creation – 33,553 acres of marsh creation with armored containment dikes where not already provided by Biloxi Marshes Shore Protection measure
- 1-9 Bayou Terre aux Boeufs Diversion - flows to sustain marshes between MRGO and Bayou Terre aux Boeufs
- 1-10 Bayou Terre aux Boeufs Marsh Creation – 2,591 acres in upper basin
- 1-11 Breton Sound Strategic Land Bridge – a band of marsh from MRGO to Miss. River (14,579 acres) plus marsh creation along either side of Bayou LaLoutre
- 1-12 Caernarvon Diversion – sized to sustain all marshes between Bayou Terre aux Boeufs and the Miss. River
- 1-13 Caernarvon Area Marsh Creation – Marsh creation along protection levee from Big Mar south to Pheonix (4,936 acres)
- 1-14 Bayou Lamoque Diversion – to sustain receiving area marshes
- 1-15 Grand Bay Diversion – sized to sustain receiving area marshes

PU1 R2 – Pulsed Diversion (one heavy flow year out of 5) Alternative (Attachment A – Figure A-2 PU1 R2)

- 2-1 Blind River Diversion - flows for sustaining entire south Maurepas swamp split between Blind River and Hope Canal
- 2-2 Hope Canal Diversion - flows for sustaining entire south Maurepas swamp split between Blind River and Hope Canal
- 2-3 LaBranche Diversion – diversion directly into LaBranche wetlands to sustain those wetlands
- 2-4 Bayou Bienvenu Diversion – to reduce East New Orleans landbridge loss rates by 50%
- 2-5 East New Orleans land bridge Marsh Creation – 7,996 acres @ 900 acres/year
- 2-6 Bayou LaLoutre Diversion – (In lieu of Violet) sized to sustain the Biloxi Marshes
- 2-7 Biloxi Marshes Shore Protection – 254,500 linear feet of protection around outer perimeter
- 2-8 Biloxi Marshes Marsh Creation – 33,553 acres of marsh creation with armored containment dikes where not already provided by Biloxi Marshes Shore Protection measure
- 2-9 Bayou Terre aux Boeufs Diversion - flows to sustain marshes between MRGO and Bayou Terre aux Boeufs
- 2-10 Bayou Terre aux Boeufs Marsh Creation – 2,591 acres in upper basin
- 2-11 Breton Sound Strategic Land Bridge – a band of marsh from MRGO to Miss. River (14,579 acres) plus marsh creation along either side of Bayou LaLoutre
- 2-12 Caernarvon Diversion – sized to sustain all marshes between Bayou Terre aux Boeufs and the Miss. River
- 2-13 Caernarvon Area Marsh Creation – Marsh creation along protection levee from Big Mar south to Pheonix (4,936 acres)
- 2-14 Bayou Lamoque Diversion – to sustain receiving area marshes
- 2-15 Grand Bay Diversion – sized to sustain receiving area marshes

PU1 R3 – State Master Plan Alternative (Attachment A – Figure A-3 PU1 R3)

- 3-1 Maurepas Shoreline Protection
- 3-2 Blind River Diversion @ 5,000 cfs[2]
- 3-3 Hope Canal Diversion @ 5,000 cfs[2]
- 3-4 Jefferson Parish Marsh Creation – 3,226 ac
- 3-5 St. Tammany Marsh Creation – 325 ac
- 3-6 East New Orleans Landbridge Marsh Creation – 7,996 ac
- 3-7 Central Wetlands Marsh Creation - 3,298 ac
- 3-8 Lake Borgne Marsh Creation – 4,357 ac
- 3-9 Biloxi Marsh Creation – 52,000 ac
- 3-10 Mississippi River Gulf Outlet Shoreline Protection
- 3-11 Golden Triangle Marsh Creation
- 3-12 Violet Diversion @ 50,000 cfs[2]
- 3-13 Caernarvon Freshwater/Sediment Introduction @ 8,500 cfs[2]
- 3-14 Breton Marsh Creation – 38,000 ac
- 3-15 White's Ditch Diversion @ 15,000 cfs[2]
- 3-16 Bayou LaLoutre Ridge Restoration
- 3-17 Bayou Lamoque Diversion @ 15,000 cfs[2]

[2] Maximum diversion discharge

PU1 R4 - HET Alternative (Attachment A – Figure A-4 PU1 R4)

- 4-1 Blind River Diversion @ 1,000 cfs[2]
- 4-2 Hope Canal Diversion @ 1,000 cfs[2]
- 4-3 Bonnet Carre Freshwater/Sediment Introduction @ 13,000 cfs[2]
- 4-4 St. Tammany Parish Marsh Creation – 325 ac
- 4-5 New Orleans East land bridge Marsh Creation – 7,996 ac
- 4-6 Central Wetlands Marsh Creation – 4,467 ac
- 4-7 South Lake Borgne Marsh Creation – 4,357 ac
- 4-8 Biloxi Marsh Creation - 33,561 ac
- 4-9 Golden Triangle Marsh Creation – 2,614
- 4-10 Violet Diversion @ 15,000 cfs[2]
- 4-11 Breton Landbridge Marsh Creation – 3,671 ac
- 4-12 Caernarvon Freshwater Divesion @ 8,000 cfs[2]
- 4-13 Bayou Lamoque Diversion @ 12,800 cfs[2]

- 4-14 Benny 's Bay Diversion @ 20,000 cfs[2]
- 4-15 Ridge Restoration

[2] Maximum diversion discharge

PU1 R5 –LCA PBMO Alternative (Attachment A – Figure A-5 PU1 R5)

- 5-1 Increase Amite River influence by gapping spoil banks on diversion canals
- 5-2 Convent/Blind River Diversion @ 5,000 cfs[1]
- 5-3 Hope Canal Diversion @ 1,000 cfs[1]
- 5-4 Authorized opportunistic use of the Bonnet Carre Spillway
- 5-5 Sediment Delivery via pipeline at LaBranche Marsh Creation – 2,434 ac
- 5-6 Marsh nourishment/creation on the New Orleans East land bridge – 1,080 ac
- 5-7 Post authorization change for diversion of water through Inner Harbor Navigation Canal
- 5-8 Rehabilitate Violet Siphon for enhanced influence into Central Wetlands
- 5-9 Mississippi River Gulf Outlet (MRGO) Environmental Features and Salinity Control Study
- 5-10 Reauthorization of the Caernarvon Freshwater Diversion (optimize for marsh creation)
- 5-11 White's Ditch Diversion @ 10,000 cfs[1]
- 5-12 American/California Bay Diversion @ 110,000 cfs[1]
- 5-13 Bayou Lamoque Diversion @ 12,000 cfs[1]

[1] 50% duration discharge

LACPR Coastal Restoration Plan Alternative Measures for Planning Unit 2

PU2 R1 - December through May "Steady" Diversion Alternative (Attachment A – Figure A-6 PU2 R1)

- 1-1 Lagan Diversion – sized to sustain a portion of upper basin swamps
- 1-2 Edgard Diversion - sized to sustain remaining Lac des Allemands portion of upper basin wetlands
- 1-3 Davis Pond Freshwater Diversion reauthorization - run full discharge only Dec-May
- 1-4 Naomi Diversion – sized to sustain receiving area
- 1-5 Myrtle Grove Diversion – sized to sustain receiving area
- 1-6 Strategic Marsh Creation in lower basin – 22,573 acres @ 900 ac per year
- 1-7 North Bay Rim Marsh Creation/Protection – 3538 acres along northern border of Barataria Bay @ 900 ac per year
- 1-8 West Point a la Hache Diversion – sized to sustain receiving area
- 1-9 Port Sulphur Diversion – sized to sustain receiving area
- 1-10 Buras Diversion – sized to sustain receiving area
- 1-11 Fort Jackson Diversion – sized to sustain receiving area
- 1-12 Barrier Islands Restoration – 15,029 acres @ 900 acres/year

PU2 R2 – Pulsed Diversion (one heavy flow year out of 5) Alternative (Attachment A – Figure A-7 PU2 R2)

- 2-1 Lagan Diversion – sized to sustain a portion of upper basin swamps
- 2-2 Edgard Diversion - sized to sustain remaining Lac des Allemands portion of upper basin wetlands
- 2-3 Davis Pond Freshwater Diversion reauthorization - run full discharge one year out of 5 years
- 2-4 Naomi Diversion – sized to sustain receiving area
- 2-5 Myrtle Grove Diversion – sized to sustain receiving area
- 2-6 Strategic Marsh Creation in lower basin – 22,573 acres @ 900 ac per year
- 2-7 North Bay Rim Marsh Creation/Protection – 3538 acres along northern border of Barataria Bay @ 900 ac per year
- 2-8 West Point a la Hache Diversion – sized to sustain receiving area
- 2-9 Port Sulphur Diversion – sized to sustain receiving area
- 2-10 Buras Diversion – sized to sustain receiving area
- 2-11 Fort Jackson Diversion – sized to sustain receiving area
- 2-12 Barrier Islands Restoration – 15,029 acres @ 900 acres/year

PU2 R3 – State Master Plan Alternative (Attachment A – Figure A-8 PU2 R3)

- 3-1 Two upper basin swamp diversions each @ 5,000 cfs[2]
- 3-2 Pipeline Conveyance Marsh Creation (90,070 acres total)
- 3-3 Gulf Intracoastal Waterway (GIWW) Shoreline Protection
- 3-4 Davis Pond Freshwater Diversion Reauthorization
- 3-5 Myrtle Grove diversion @ 15,000 cfs[2] w/marsh creation
- 3-6 West Point a la Hache Freshwater/Sediment Introduction @ 15,0000 cfs[2]
- 3-7 Bayou Lafourche Freshwater/Sediment Introduction @ 1,000 cfs[2]
- 3-8 Bayou Lafourche Ridge Restoration
- 3-9 Bayou L'Ours Ridge Restoration
- 3-10 Bayou Grand Chenier Ridge Restoration
- 3-11 Caminada Cheniers Ridge Restoration
- 3-12 Bayou Dupont Ridge Restoration
- 3-13 Bayou Barataria Ridge Restoration
- 3-14 Caminada-Shell Islands Barrier Island Restoration – 3,438 ac
- 3-15 West Bay Freshwater/Sediment Introduction @ 50,0000 cfs[2]
- 3-16 Barrier Island Restoration – 4,414 ac

[2] Maximum diversion discharge

PU2 R4 - HET Alternative (Attachment A – Figure A-9 PU2 R4)

- 4-1 Landbridge Marsh Creation – 60,106 ac
- 4-2 Bay-rim Marsh Creation – 6,074 ac
- 4-3 Reauthorize Davis Pond Freshwater Diversion
- 4-4 Myrtle Grove Diversion @ 2,000 cfs[2]
- 4-5 Bayou Dupont Ridge Restoration
- 4-6 Bayou Barataria Ridge Restoration
- 4-7 Bayou Long Fontanelle Ridge Restoration
- 4-8 Bayou Lafourche Ridge Restoration
- 4-9 Bayou L'Ours Ridge Restoration
- 4-10 Bayou Grand Chenier Ridge Restoration
- 4-11 Caminada Cheniers Ridge Restoration
- 4-12 Fort Jackson Freshwater/Sediment Introduction @ 15,000 cfs[2]
- 4-13 West Bay Freshwater/Sediment Introduction @ 50,000 cfs[2]
- 4-14 Bayou Grand Liard Ridge Restoration
- 4-15 Caminada-Shell Islands Barrier Island Restoration – 3,438 ac
- 4-16 Barrier Island Restoration – 6,142 ac

[2] Maximum diversion discharge

PU2 R5 –LCA PBMO Alternative (Attachment A – Figure A-10 PU2 R5)

- 5-1 Edgard Freshwater/Sediment Introduction @ 1,500 cfs[1]
- 5-2 Donaldsonville Freshwater/Sediment Introduction @ 1,000 cfs[1]
- 5-3 Reauthorize Davis Pond Freshwater Diversion
- 5-4 Wetland creation and restoration feasibility sites Marsh Creation – 26,562 ac
- 5-5 Pikes Peak/Lagan Freshwater/Sediment Introduction @ 1,500 cfs[1]
- 5-6 Myrtle Grove @ 5,000 cfs Marsh Creation[1]
- 5-7 Ft. Jackons/Boothville Freshwater/Sediment Introduction @ 60,000 cfs[1]
- 5-8 Miss. R. Delta Management Study Freshwater/Sediment Introduction
- 5-9 Third Delta Freshwater/Sediment Introduction
- 5-10 Barrier Shoreline Restoration feasibility study – 10,396 ac
- 5-11 Lac Des Allemands Diversion

[1] 50% duration discharge

LACPR Coastal Restoration Plan Alternative Measures for Planning Unit 3a

PU3a R1 – Mississippi River Diversions Alternative (Attachment A – Figure A-11 PU3a R1)

- 1-1 HNC Lock Multi-purpose Operation
- 1-2 Convey Atchafalaya River water via GIWW
- 1-3 Lapeyrouse Canal diversion
- 1-4 Blue Hammock diversion
- 1-5 Upper Lake Boudreaux Basin Mississippi River Diversion
- 1-6 East Terrebonne Mississippi River Diversion
- 1-7 Grand Bayou & Jean LaCroix Basins Mississippi River Diversions
- 1-8 Pipeline Conveyance Marsh Creation (92,174 acres)
- 1-9 North Terrebonne Bay Rim Marsh Creation (3,158 acres)
- 1-10 DuLarge to Grand Caillou Landbridge Marsh Creation (1,170 acres)
- 1-11 South Caillou Lake Landbridge Marsh Creation (19,964 acres)
- 1-12 Isles Dernieres Restoration
- 1-13 Timbalier Islands Restoration

PU3a R2 – GIWW Diversions Alternative (Attachment A – Figure A-12 PU3a R2)

- 2-1 HNC Lock Multi-purpose Operation
- 2-2 Convey Atchafalaya River water via GIWW
- 2-3 GIWW By-Pass Channel
- 2-4 Lapeyrouse Canal diversion
- 2-5 Blue Hammock diversion
- 2-6 Pipeline Conveyance Marsh Creation
- 2-7 North Terrebonne Bay Rim Marsh Creation
- 2-8 DuLarge to Grand Caillou Landbridge Marsh Creation
- 2-9 South Caillou Lake Landbridge Marsh Creation
- 2-10 Isles Dernieres Restoration
- 2-11 Timbalier Islands Restoration

PU3a R3 – State Master Plan Alternative (Attachment A – Figure A-13 PU3a R3)

- 3-1 Caillou Lake Landbridge Marsh Creation – restore 19,964 acres @ 1,800 acres/yr
- 3-2 Pipeline Conveyance Marsh Creation – restore 77,828 acres @ 1,800 acres/yr
- 3-3 HNC Bankline Protection
- 3-4 GIWW Bankline Protection
- 3-5 Restore the Bayou DuLarge Ridge
- 3-6 Restore the Small Bayou LaPointe Ridge
- 3-7 Restore the Mauvois Bois Ridge
- 3-8 Restore the Bayou Terrebonne Ridge
- 3-9 Restore the Bayou Pointe au Chene Ridge
- 3-10 HNC Lock Multi-purpose Operation
- 3-11 Convey Atchafalaya River water via GIWW
- 3-12 Blue Hammock Bayou Freshwater Introduction (features in PU3b, benefits in PU3a)
- 3-13 Freshwater Introduction from Barataria via GIWW
- 3-14 Chacahoula Basin Plan
- 3-15 Water Management Plan for Upper Terrebonne Basin
- 3-16 Isles Dernieres and Timbalier Islands Restoration

PU3a R4 - HET Alternative (Attachment A – Figure A-14 PU3a R4)

- 4-1 Isles Dernieres and Timbalier Islands Restoration
- 4-2 Caillou Lake Landbridge Marsh Creation – restore 19,964 acres @ 1,800 acres/yr
- 4-3 Bayou DuLarge to Grand Caillou Landbridge Marsh Creation -
- 4-4 Pipeline Conveyance Marsh Creation – restore 90,127 acres @ 1,800 acres/yr
- 4-5 Maximize Beneficial Use

- 4-6 Terrebonne and Timbalier North Bay Rim Bank Protection
- 4-7 HNC Critical Areas Bank Protection
- 4-8 GIWW Critical Areas Bank Protection
- 4-9 South Lake Decade Bank Protection
- 4-10 Restore the Bayou DuLarge Ridge
- 4-11 Restore the Small Bayou LaPointe Ridge
- 4-12 Restore the Bayou Terrebonne Ridge
- 4-13 Restore the Bayou Pointe au Chene Ridge
- 4-14 HNC Lock Multi-purpose Operation
- 4-15 Convey Atchafalaya River water via GIWW
- 4-16 Blue Hammock Bayou Freshwater Introduction (features in PU3b, benefits in PU3a)
- 4-17 Houma By-Pass Channel to Improve and Increase Freshwater Introduction
- 4-18 South Lake Decade Freshwater Introduction
- 4-19 Penchant Plan
- 4-20 Chacahoula Basin Plan

PU3a R5 –LCA PBMO Alternative (Attachment A – Figure A-15 PU3a R5)

- 5-1 Bayou DuLarge-Bayou Grand Caillou Landbridge Marsh Creation – restore 1,170 acres
- 5-2 Caillou Lake Landbridge Gulf Shoreline Protection (33,137 linear feet)
- 5-3 HNC Lock Multi-purpose Operation
- 5-4 Bayou Lafourche 1,000 cfs Pump/Siphon (Benefits in PU2)
- 5-5 Convey Atchafalaya River water via GIWW
- 5-6 Blue Hammock Bayou Freshwater Introduction (Benefits in PU3a)
- 5-7 Penchant Basin Plan (Benefits in PU3b)
- 5-8 Isles Dernieres and Timbalier Islands Restoration

LACPR Coastal Restoration Plan Alternative Measures for Planning Unit 3b

PU3b R1 – Marsh Creation with Shoreline Protection (Attachment A – Figure A-16 PU3b R1)

- 1-1 Penchant Basin Plan
- 1-2 Convey Atchafalaya River water via GIWW
- 1-3 Relocate the Navigation Channel through Lower Atchafalaya River Delta
- 1-4 Increase Sediment Transport down the Wax Lake Outlet
- 1-5 Barrier Reef from Eugene Island to Pointe au Fer Island
- 1-6 Blue Hammock Bayou Freshwater Introduction (benefits in PU3a)
- 1-7 Gulfshore Protection at Pointe au Fer Island
- 1-8 Freshwater Bayou Bank Protection, Belle Isle to Lock
- 1-9 Southwest Pass Bank Protection
- 1-10 Marsh Island Shoreline Protection
- 1-11 Gulfshore Protection from Freshwater Bayou to Southwest Pass
- 1-12 Shoreline Protection at Vermilion Bay & West Cote Blanche Bay
- 1-13 East Cote Blanche Bay Shore Protection
- 1-14 Bayou Decade Area Marsh Creation (5,870 acres)
- 1-15 Brady Canal Area Marsh Creation (2,731 acres)
- 1-16 Pointe au Fer Island Marsh Creation (1,462 acres)
- 1-17 Marsh Island Marsh Creation (7,883 acres)
- 1-18 Wax Lake Outlet Delta Marsh Creation (4,736 acres)
- 1-19 Bayou Penchant Area Marsh Creation (6,554 acres)
- 1-20 Terrebonne GIWW Area Marsh Creation (3,977 acres)

PU3b R2 – Marsh Creation without Shoreline Protection (Attachment A – Figure A-17 PU3b R2)

- 2-1 Penchant Basin Plan
- 2-2 Convey Atchafalaya River water via GIWW
- 2-3 Relocate the Navigation Channel through Lower Atchafalaya River Delta
- 2-4 Increase Sediment Transport down the Wax Lake Outlet

- 2-5 Barrier Reef from Eugene Island to Pointe au Fer Island
- 2-6 Blue Hammock Bayou Freshwater Introduction (benefits in PU3a)
- 2-7 Bayou Decade Area Marsh Creation (5,870 acres)
- 2-8 Brady Canal Area Marsh Creation (2,731 acres)
- 2-9 Pointe au Fer Island Marsh Creation (1,462 acres)
- 2-10 Marsh Island Marsh Creation (7,883 acres)
- 2-11 Wax Lake Outlet Delta Marsh Creation (10,536 acres)
- 2-12 Bayou Penchant Area Marsh Creation (12,954 acres)
- 2-13 Terrebonne GIWW Area Marsh Creation (11,055 acres)
- 2-14 Avoca Island Marsh Creation (1,445 acres)
- 2-15 Lower Atchafalaya River Marsh Creation (1,526 acres)

PU3b R3 – State Master Plan Alternative (Attachment A – Figure A-18 PU3b R3)

- 3-1 Barrier Shoreline Restoration: Point Au Fer Island
- 3-2 Convey Atchafalaya River Water Eastward via GIWW to Benefit Eastern and Lower Terrebonne Marshes
- 3-3 Bankline Stabilization of Freshwater Bayou from Belle Isle Bayou to Freshwater Bayou Canal Lock
- 3-4 Increase Sediment Transport Down Wax Lake Outlet
- 3-5 Southwest Pass Shoreline Stabilization
- 3-6 Barrier Shoreline Restoration: Freshwater Bayou to South Point/Marsh Island
- 3-7 Bankline Protection for Gulf Intracoastal Waterway (GIWW)
- 3-8 Raynie Marsh Restoration
- 3-9 Convey Atchafalaya River Water Westward via GIWW
- 3-10 Marsh Restoration Using Dredged Material at Weeks Bay
- 3-11 Marsh Restoration Using Dredged Material at Marsh Island
- 3-12 Marsh Restoration Using Dredged Material at Point Au Fer
- 3-13 Stabilize Shoreline of Vermilion, East and West Cote Blanche Bays
- 3-14 Freshwater Introduction into Central and Lower Terrebonne Marshes
- 3-15 Fortify Spoil Banks of GIWW and Freshwater Bayou
- 3-16 Marsh Creation near Lower Atchafalaya River

PU3b R4 - HET Alternative (Attachment A – Figure A-19 PU3b R4)

- 4-1 Marsh Creation via Beneficial Use near the Lower Atchafalaya River (2,970 acres)
- 4-2 Marsh Creation via Beneficial Use on Pointe au Fer Island (4,763 acres)
- 4-3 Gulfshore Protection at Pointe au Fer Island
- 4-4 Marsh Island Shoreline Protection
- 4-5 Restore the Mauvois Bois Ridge
- 4-6 Increase Sediment Transport down the Wax Lake Outlet
- 4-7 Convey Atchafalaya River water via GIWW (Bayou Shaffer Diversion)
- 4-8 Penchant Basin Plan
- 4-9 Barrier Reef from Eugene Island to Pointe au Fer Island
- 4-10Blue Hammock Bayou Freshwater Introduction (benefits in PU3a)

PU3b R5 –LCA PBMO Alternative (Attachment A – Figure A-20 PU3b R5)

- 5-1 Shoreline Protection along East Cote Blanche Bay
- 5-2 Pointe au Fer Island Shore Protection
- 5-3 Point Chevreuil Jetty-Reef
- 5-4 Relocate the Navigation Channel through Lower Atchafalaya River Delta
- 5-5 Increase Sediment Transport down the Wax Lake Outlet
- 5-6 Modification of Old River Control Structure Operation Study (not shown on map)
- 5-7 Penchant Plan
- 5-8 Blue Hammock Bayou Freshwater Introduction (benefits in PU3a)
- 5-9 Convey Atchafalaya River water via GIWW (Bayou Shaffer Diversion)

LACPR Coastal Restoration Plan Alternative Measures for Planning Unit 4

PU4 R1 – Marsh Creation with Shoreline Protection (Attachment A – Figure A-21 PU4 R1)

- 1-1 Marsh Creation at Mud Lake (5,669 acres)
- 1-2 Marsh Creation at South Grand Chenier (8,575 acres)
- 1-3 Marsh Creation at South Pecan Island (9,851 acres)
- 1-4 Marsh Creation at East Pecan Island (7,184 acres)
- 1-5 Marsh Creation at No-Name Bayou (2,151 acres)
- 1-6 Marsh Creation at NW Calcasieu Lake (23,187 acres)
- 1-7 Marsh Creation at East Calcasieu Lake (14,141 acres)
- 1-8 Marsh Creation at Black Bayou (4,769 acres)
- 1-9 Marsh Creation at Gum Cove (3,261 aces)
- 1-10 Marsh Creation at Cameron Meadows (1,293 acres)
- 1-11 Marsh Creation at Central Canal (120 acres)
- 1-12 GIWW bank stabilization
- 1-13 Grand Lake bank stabilization
- 1-14 White Lake bank stabilization
- 1-15 Gulf Shoreline Stabilization (Sabine River to Calcasieu River
- 1-16 Gulf Shoreline Stabilization (Calcasieu River to Freshwater Bayou

PU4 R2 – Marsh Creation without Shoreline Protection (Attachment A – Figure A-22 PU4 R2)

- 2-1 Marsh Creation at Mud Lake (5,669 acres)
- 2-2 Marsh Creation at South Grand Chenier (8,575 acres)
- 2-3 Marsh Creation at South Pecan Island (9851 acres)
- 2-4 Marsh Creation at East Pecan Island (7,184 acres)
- 2-5 Marsh Creation at No-Name Bayou (3,151 acres)
- 2-6 Marsh Creation at NW Calcasieu Lake (29,187 acres)
- 2-7 Marsh Creation at East Calcasieu Lake (14,141 acres)
- 2-8 Marsh Creation at Black Bayou (4,769 acres)
- 2-9 Marsh Creation at Gum Cove (3,261 aces)
- 2-10 Marsh Creation at Cameron Meadows (1,293 acres)
- 2-11 Marsh Creation at Central Canal (18,216 acres)
- 2-12 Marsh Creation at Sweet Lake (3,527 acres)

PU4 R3 – State Master Plan Alternative (Attachment A – Figure A-23 PU4 R3)

- 3-1 GIWW bank stabilization
- 3-2 Restore the Mermentau Lakes Basin Integrity
- 3-3 Grand Lake bank stabilization
- 3-4 White Lake bank stabilization
- 3-5 Freshwater Bayou bank stabilization
- 3-6 Calcasieu Pass Salinity Control Structure
- 3-7 Gulf Shoreline Stabilization (Sabine River to Calcasieu River)
- 3-8 Gulf Shoreline Stabilization (Calcasieu River to Freshwater Bayou)
- 3-9 Marsh Creation (12,427 acres)
- 3-10 Beneficial Use of Calcasieu Ship Channel Dredged Material (34,908 acres)
- 3-11 Sabine Pass Salinity Control Structure
- 3-12 Fortify Spoil Banks of GIWW & Freshwater Bayou
- 3-13 Stabilize Calcasieu Lake Shoreline
- 3-14 Stabilize Sabine Lake Shoreline
- 3-15 Mermentau Basin Watershed Management Plan
- 3-16 Sabine Basin Watershed Management
- 3-17 Strategic Water Control Structures along Highways 82 and 27

PU4 R4 - HET Alternative (Attachment A – Figure A-24 PU4 R4)

- 4-1 Marsh Creation & Terracing northwest of Calcasieu Lake (22,262 acres) and East Calcasieu Marsh Creation (10,848 acres)
- 4-2 Gulf Shoreline Protection – Sabine River to Calcasieu River – critical areas only

- 4-3 Gulf Shoreline Protection – Calcasieu R. to Freshwater Bayou – critical areas only
- 4-4 Grand Lake Bank Protection – critical areas only
- 4-5 White Lake Bank Protection – critical areas only
- 4-6 GIWW Bank Stabilization – critical areas only
- 4-7 Use old Calcasieu Lock for Evacuation of Excess Water
- 4-8 Restore-Reforest Chenier Ridges

PU4 R5 –LCA PBMO Alternative (Attachment A – Figure A-25 PU4 R5)

- 5-1 Salinity Control Structure at Oyster Bayou
- 5-2 Salinity Control Structure at Long Point Bayou
- 5-3 Salinity Control Structure at Black Lake Bayou
- 5-4 Salinity Control Structure at Alkali Ditch
- 5-5 Modify existing Cameron-Creole Watershed Control Structures
- 5-6 East Sabine Hydrologic Restoration
- 5-7 Salinity Control Structure at Black Bayou
- 5-8 Sabine Pass Salinity Control Structure
- 5-9 Freshwater Introduction at Pecan Island
- 5-10 Freshwater Introduction at Rollover Bayou
- 5-11 Freshwater Introduction at Highway 82
- 5-12 Freshwater Introduction at Little Pecan Bayou
- 5-13 Freshwater Introduction at South Grand Chenier
- 5-14 Black Bayou Bypass Culverts
- 5-15 Gulf Shoreline Stabilization – protect 12,865 acres of land
- 5-16 Calcasieu Ship Channel Beneficial Use – restore 17,620 acres
- 5-17 Chenier Plain Freshwater Management and Allocation Reassessment (not shown on map)

The State of Louisiana's Preliminary Draft State Master Plan changed during its review and approval process. The need to develop information regarding proposed coastal restoration measures and conduct the appropriate evaluations, precluded the HET from waiting until all revisions were completed before beginning to evaluate the State Master Plan. Alternative 4 was developed by the HET concurrently with the development of the draft State Master Plan. Alternative 4 was developed to identify and evaluate measures that differed from measures previously considered during that Master Plan development effort. Given the extensive amount of work conducted to develop LCA alternative comprehensive plans, the HET felt that the State's most preferred comprehensive alternative (Plan 10130 or the Plan that Best Meeting the Objectives) should be evaluated even though the LCA study did not explicitly include the hurricane protection goals that are part of the LACPR effort.

Additional Alternatives

The HET felt that a sustainable coastal ecosystem is essential to achieving sustainable hurricane protection and therefore decided that the two new alternative plans would generally represent alternative ways of achieving coastal wetland sustainability on a basin level basis (excluding the present Mississippi River Delta wetlands). Consequently, development of plans that would only reduce wetland losses were precluded from consideration. Where possible, restoration of natural land-building and wetland maintenance processes were considered by the HET as essential for achieving a sustainable coastal wetland ecosystem. Where diversions were not possible, marsh creation could potentially offset ongoing wetland losses and thereby achieve maximum sustainability. Because potential impacts to some commercially and recreationally important estuarine-dependent fish and shellfish resources resulting from large-scale diversions might be the greatest impediment to achieving restoration of ecosystem

sustainability, the HET decided that the two additional restoration plans should investigate alternative diversion operation schemes to reduce those impacts, while still seeking to achieve no-net coastal wetland loss.

PUs 1, 2, & 3a (the "Deltaic Plain Provinces") – Additional Alternatives

One of those new alternative plans would limit diversion discharges to December through May of every year. Such operations were anticipated to improve recruitment of post-larval and juvenile white shrimp, compared to continuing diversion discharges through June or July, the period of maximum recruitment into coastal estuaries. The concept for the other alternative diversion operation plan was modeled after fisheries responses to flood water discharges through the Bonnet Carre Floodway. Although fisheries are severely impacted during the discharge year, the following years have often exhibited exceptionally high fisheries production, due in part to the nutrient inputs and resulting increased productivity levels throughout the ecosystem. To periodically simulate this effect, and to introduce needed sediments into the coastal ecosystem, the HET considered conducting a year of high-flow diversions once in 4 years and once in every 5 years. To avoid and/or minimize fisheries impacts during the low-flow years, and to allow sufficient time for oyster production and to rebound after high-flow year impacts, the HET decided that this alternative would incorporate one high flow year in every 5 years. To determine discharges during high and low flow years, the HET evaluated the relative sizes of high-flow year diversions when high flow diversion levels were 2 times and 3 times that of the annual Dec-May diversion alternative. Based on that assessment, the HET decided that the "3 times" alternative would reduce low-flow year diversion quantities more than would the "2 times" alternative, and thereby would minimize fisheries impacts during the low-flow years. Compensation for fisheries impacts during the high-flow years would, therefore, be more effectively achieved during the low-flow years under the "3 times" alternative than under the "2 times" alternative.

Dec-May Diversion Alternative (PUs 1 & 2 - R1). This plan was developed to achieve coastal ecosystem sustainability on a planning unit basis in a manner that reduces some impacts to estuarine-dependent fish and shellfish resources. It employs use of multiple, various-sized, strategically located diversions that incorporate sufficient operational flexibility so that operation can be adapted to changing environmental conditions. Those diversions would be operated at maximum discharge, every year only during the December through May period. Sufficient marsh creation measures have been proposed to achieve basin-level wetland sustainability. Where marsh creation areas are located within diversion influence areas, those diversions have been sized to sustain both the restored and existing marsh areas.

Pulsed Diversion Alternative (PUs 1 & 2 - R2). This plan was developed to achieve coastal ecosystem sustainability on a planning unit basis under medium future sea-level rise conditions, in a manner that reduces some impacts to estuarine-dependent fish and shellfish resources. It employs use of multiple, various-sized, strategically located diversions that incorporate sufficient operational flexibility so that operation can be adapted to changing environmental conditions. Those diversions would be operated year-round at maximum discharge, one year out of 5. During the four low-flow years, discharge levels would be restricted to minimize adverse impacts to estuarine-dependent fisheries.

Mississippi River Diversions (PU3a R1) As in PUs 1 & 2, this plan was developed to achieve coastal ecosystem sustainability on a planning unit basis in a manner that reduces some impacts to estuarine-dependent fish and shellfish resources. It employs use of multiple, various-sized, strategically located diversions that incorporate sufficient

operational flexibility(operated December through May) so that operation can be adapted to changing environmental conditions. Sufficient marsh creation measures have been proposed to achieve basin-level wetland sustainability. Where marsh creation areas are located within diversion influence areas, those diversions have been sized to sustain both the restored and existing marsh areas.

GIWW Diversions (PU3a R2) Although the largest practical GIWW diversions were included, those diversions provided minimal benefits due to their relatively small size and lack of suspended sediment carried by the GIWW. However, while the title suggests the utilization of diversions, it actually employs the use of multiple, various-sized, strategically located water management structures or the re-routing of channels to re-distribute water through the planning unit in an effort to restore historic hydrologic flows through the ecosystem. This alternative would also incorporate sufficient operational flexibility so that operation can be adapted to changing environmental conditions. Because an unrealistically large amount of marsh creation would be needed to achieve basin-level maximum sustainability, the HET decided to limit marsh creation to the acreage proposed under the R1 alternative. Consequently, this altenrnative fails to achieve no-net loss.

PUs 3b & 4 (the "Chenier Plain") – Additional Alternatives

Transitioning from the Deltaic Plain to the Chenier Plain presented a difficult challenge in identifying restoration measures for PUs 3b, & 4. PU3b & 4 is an area of transition between the two coastal geographic regions. It is close enough to the Mississippi River to still use it as a resource, but far enough away to make implementation of the same diversion concepts as in PUs 1& 2 (steady or pulsed flow) extremely difficult. The concept for all planning units in the Chenier Plain can best be described as focusing on restoration of disrupted water flows through water management and dedicated dredging for marsh restoration.

Marsh Creation in PUs 3b & 4 (R1) with shoreline protection These plans were also developed to achieve coastal ecosystem sustainability on a planning unit basis in a manner that reduces some impacts to estuarine-dependent fish and shellfish resources. Unlike all of the other planning units, these plans relied entirely upon dedicated dredging with shoreline protection, to reduce erosion, to reach sustainability. Sufficient marsh creation measures have been proposed to achieve basin-level wetland sustainability.

Marsh Creation in PUs 3b & 4 (R2) without shoreline protection These plans were also developed to achieve coastal ecosystem sustainability on a planning unit basis in a manner that reduces some impacts to estuarine-dependent fish and shellfish resources. Unlike all of the other planning units, these plans relied entirely upon dedicated dredging without shoreline protection, to reduce erosion, to attempt to reach sustainability. The net result is that sustainability is not reached due to the limited availability of additional resources, such as the ability to divert water from an outside source (i.e., PUs 1, 2, & 3a). While the amount marsh creation proposed was an attempt at reaching basin-level sustainability, the rate of land loss overcomes most large scale marsh creation efforts.

Identification/location of measures for additional alternatives

Figures for planning units described in this section can be found in Attachment A to this Appendix

In PU1 and PU2, diversion locations identified during the State's Master Plan development work, the Coast 2050 Report, the Coastal Wetlands Planning, Protection and Restoration Act were considered as candidate diversion locations. Based on previous

existing evaluations and HET opinions, maximum influence area polygons were determined for each diversion in a manner that generally avoided overlapping polygons (Figure 3). For those few areas not sustained by diversions, marsh creation measures were proposed to offset wetland losses in those areas.

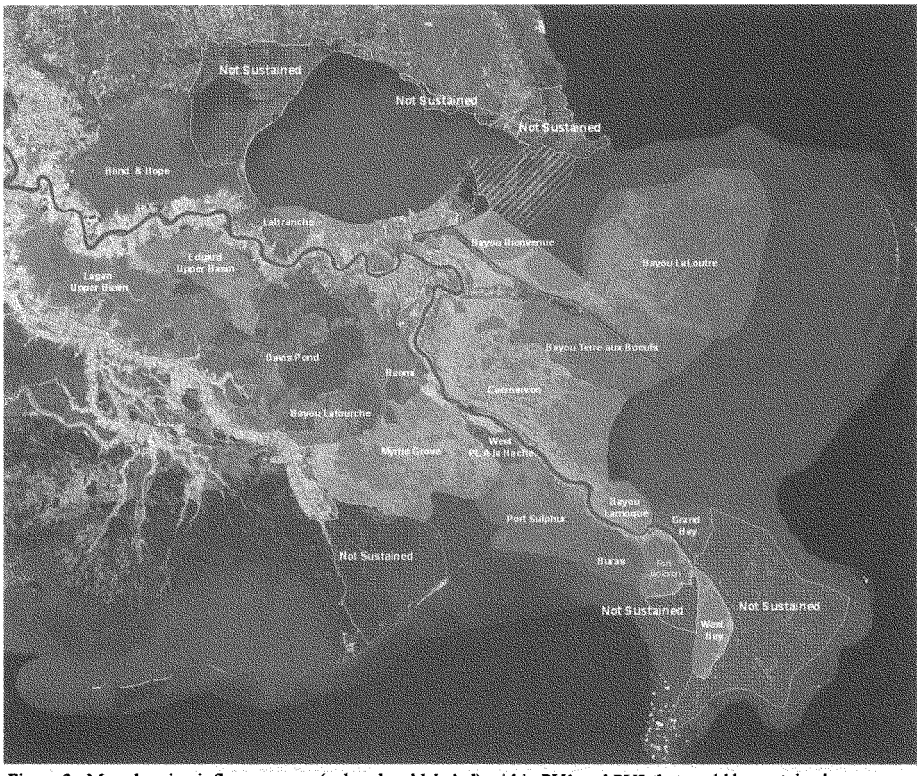


Figure 3. Map showing influence areas (colored and labeled) within PU1 and PU2 that could be sustained by diversions planned as part of alternatives R1 and R2. Hatched areas depict loss rates reduced by half and not totally sustained by a diversion

In each of the additional restoration alternatives, no new measures were proposed within the active Mississippi River Delta. Given the very high subsidence rates there and the continually decreasing suspended sediment loads in the Mississippi River, the HET assumed that the delta would be an inefficient location for use of the limited and continually decreasing suspended sediment resource. The HET, therefore, gave higher priority to restoration of Pontchartrain, Breton Sound, and Barataria Basin wetlands. As a general principle, the HET preferred upper basin introduction locations where introduced water, sediments, and nutrient could benefit as much of the wetland watershed as possible and where retention rates of sediment and nutrient resources would be maximized.

More details regarding measures are provided below. For alternatives R1 and R2 in PUs 1 and 2, the diversion measures differ only in diversion operation as described above. Otherwise, the measures contained in the additional diversion alternatives are identical.

Details regarding PU1 Measures within additional Alternatives

Additional alternatives rely upon eight freshwater/sediment diversions with additional marsh creation by other means (i.e., dedicated dredging, beneficial use of dredged material, etc), although the operations of the diversions differ. An overview of the diversions and marsh creation features follows.

Diversions:
Blind River/Hope Canal Diversions - To determine the sizes of these diversions, the flow from a single diversion needed to sustain the entire south Maurepas swamps (Amite/Blind Coast 2050 mapping unit) was allocated 50% to the Blind River Diversion location and 50% to the Hope Canal location.

Labranche Wetlands Diversion - Compared to the diversion of water through the Bonnet Carre Spillway and into Lake Pontchartrain, the HET decided instead to propose a small diversion or siphon directly into the deteriorating Labranche Wetlands. Such a diversion directly into the Labranche Wetlands would be much more effective in restoring/sustaining that area than would a diversion into the Lake where the Labranche Wetlands would receive only an indirect effect via tidal exchange with Lake Pontchartrain through Bayou Labranche.

Bayou Bienvenue Diversion - This diversion was developed to target marshes on the east New Orleans landbridge, a critical outer line of defense for New Orleans. Because of the inefficiencies associated with diverted sediments being lost to the MRGO and Lake Borgne, the flows needed to sustain the landbridge were deemed to be excessive. The HET, therefore, concluded that the goal of this diversion should be to reduce landbridge losses by half, and that marsh creation would offset the remaining losses. Because the Central Wetlands and the Golden Triangle marshes are closer to Bayou Bienvenue than the east New Orleans landbridge, they would receive a proportionally greater benefit. Not only would losses be prevented in those areas, but those areas would experience net wetland acreage increases. Because Bayou Bienvenue is closer to the Golden Triangle marshes and the east New Orleans landbridge marshes, the HET felt that it would be a more effective location than the often proposed Violet Canal location.

Bayou LaLoutre Diversion - This diversion targets the Biloxi Marshes and was developed to provide a more effective alternative to the Violet Canal diversion where a substantial amount of the diverted sediment would be lost to the MRGO and Lake Borgne. The Bayou LaLoutre Diversion would have to include a leveed conveyance channel from the Mississippi River across the MRGO, and directly into Bayou LaLoutre. It is sized to sustain the Biloxi Marshes, which together with the east New Orleans landbridge, provide an important outer line of defense for New Orleans and surrounding communities. Inclusion of a shore protection measure along the outer perimeter of the Biloxi Marshes reduces wetland losses that must the addressed by this diversion, thereby reducing the proposed diversion discharge.

Bayou Terre aux Boeufs Diversion – Because Bayou Terre aux Boeufs ridge prevents the Caernarvon Diversion from benefiting the marshes located between the MRGO and Bayou Terre aux Boeufs, the HET proposed a new diversion to achieve the sustainability of this isolated wetland subbasin area. Delivery of riverine freshwater, nutrients, and sediments to this location would require construction of a leveed conveyance channel and could be constructed in combination with the above-mentioned Bayou LaLoutre Diversion

Caernarvon Diversion Diversion – This diversion was sized to sustain all marshes between Bayou Terre aux Boeufs and Mississippi River. This flow could be distributed between the existing Caernarvon and other upper basin locations including Whites Ditch.

Bayou Lamoque Diversion - This diversion was sized to sustain the wetland area extending downriver from Bayou Lamoque. This diversion would be better located downriver in the center of the receiving area where it would discharge into protected bays rather than at Bayou Lamoque where diverted water would be discharged directly into unsheltered open water.

Grand Bay Diversion - This diversion was sized to sustain the area downriver of the Bayou Lamoque benefited area. The diversion should be located at a site to maximize distribution of benefits throughout the designated benefited area.

Marsh creation:

Five areas of marsh creation are proposed for PU 1[9]:

East NO Landbridge	- restore 7,996 acres @ 900 ac/year
Biloxi Marshes	- restore 33,553 acres @ 900 ac/year
Bayou Terre aux Boeufs	- restore 2,591 acres @ 900 ac/year
Breton Sound Strategic Landbridge	- restore 14,579 acres @ 900 ac/year
Caernarvon Area	- restore 4,936 acres @ 900 ac/year

Biloxi Marshes Shore Protection - To reduce wave-related erosion of the outer Biloxi Marshes, a 254,000 linear feet of shoreline protection is proposed along the outer perimeter of the Biloxi Marshes. Additionally, the containment dikes associated with the proposed marsh creation areas would also include shore protection, where not provided by the above-mentioned perimeter shore protection measures.

Details regarding PU2 Measures within additional alternatives

Additional alternatives rely upon nine freshwater/sediment diversions augmented by marsh creation, although the operations of the diversions differ. An overview of the diversions and marsh creation features follows.

Diversions:
Lagan Diversion – This diversion was sized to sustain a portion of the upper-most portion of the basin's swamps

[9] The number, 900 ac/yr is an assumed average productivity rate of a mechanical dredge. This table is intended to show an estimated scale at which desired marsh creation acreages would be restored assuming a particular production rate.

Edgard Diversion – This diversion was sized to sustain wetlands within the Lac des Allemands area.

Davis Pond Freshwater Diversion - This diversion was assumed to consist of the existing diversion operating at full discharge capacity, except that the in the Dec-May Diversion Alternative, it would only flow during that period, and during the Pulsed Diversion Alternative, it was assumed to flow year-round at full capacity during the one high-flow year. Otherwise, during the low-flow years, it was assumed to have a maximum discharge of 500 cubic feet per second (cfs).

Naomi Diversion – The HET assumed that the operation of this existing siphon has been of sufficient duration for the wetland benefits to be incorporated into the wetland loss rates derived from the 1978-2006 wetland acreage data. Consequently, the flows identified in this evaluation would be discharges needed to achieve sustainability of the benefited area in addition to that of its historic operation.

Myrtle Grove Diversion – This diversion was sized to sustain the benefited area.

West Pointe a la Hache Diversion - The HET assumed that the operation of this existing siphon has been of sufficient duration for the wetland benefits to be incorporated into the wetland loss rates derived from the 1978-2006 wetland acreage data. Consequently, the flows identified in this evaluation would be discharges needed to achieve sustainability of the benefited area in addition to that of its historic operation.

Port Sulphur Diversion - This diversion was sized to sustain the benefited area.

Buras - This diversion was sized to sustain the benefited area.

Fort Jackson - This diversion was sized to sustain the benefited area.

Marsh creation measures:

Three areas of marsh creation are proposed for PU 2:

North Bay Rim marsh creation	- restore 3,538 acres @ 900 ac/year
Barataria Landbridge marsh creation	- restore 22,573 acres @ 900ac/year
Barrier Island Restoration	- restore 15,029 acres @ 900ac/year

Details regarding PU3a Measures within the new Alternatives

Additional alternatives rely upon freshwater diversions augmented by marsh creation, although the operations of the diversions differ. An overview of the diversions and marsh creation features follows.

Diversions:
The obstacle presented for this planning unit is the lack of resources to carry out effective restoration measures. It is far from any direct source of renewable sediment resources as compared to PUs 1 & 2 or 3b of which all are directly connected to or within a distance to resources that can contribute to sustainability goals.

Mississippi River Diversions – This diversion was sized to influence the areas of Grand Bayou/Jean LaCroix, east of Bayou Terrebonne, and upper Lake Boudreaux. Although the size of the diversion was determined, the locations of the diversion at the river and the diversion channel have not been determined.

GIWW diversions - While the title suggests the utilization of diversions, it actually employs the use of multiple, various-sized, strategically located water management structures or the re-routing of channels to re-distribute water through the planning unit in an effort to restore historic hydrologic flows through the ecosystem. This alternative would also incorporate sufficient operational flexibility so that operation can be adapted to changing environmental conditions. Sufficient marsh creation measures have been proposed to achieve basin-level wetland sustainability.

Multi-purpose HNC Lock Operation – This measure would employ utilization of the proposed Houma Navigation Channel lock to redirect freshwater into areas of marsh in the vicinity. Minor flows would be directed into Lower Bayou Grand Caillou, Bayou Dulac to Lake Quitman, and Falgout Canal to Lake Decade. This would be a water management operation similar to methods employed under the GIWW diversion alternative.

Houma By-Pass Channel – Because the existing GIWW is very constricted in downtown Houma, a new unconstricted channel would be constructed east of Houma off of the GIWW that would run westward and south of Houma and then connecting back into the GIWW west of the Houma Navigation Channel. The resulting increased GIWW flows would be re-directed through Grand Bayou, St. Louis Canal, Humble Canal, and Bayou Chauvin. Infrastructure obstacles and land rights acquisition present a challenge for the constructability of this measure.

Marsh creation and other measures:

Four areas of marsh creation are proposed for PU 3a:

Pipeline Conveyance	- 92,174 acres
North Terrebonne Bay Rim	- 3,158 acres
DuLarge to Grand Caillou Landbridge	- 1,170 acres
South Caillou Lake Landbridge	- 19,964 acres

Details regarding PU3b and 4 Measures within additional alternatives

Unlike other planning units, PU 3b and PU 4 rely heavily on shoreline stabilization and dedicated marsh creation to maximize sustainability.

Shoreline Stabilization:

Sites for strategic shoreline stabilization have been identified throughout each of the alternatives. The intent is combining shoreline stabilization dedicated dredging

Marsh creation:

Nine areas of marsh creation are proposed for PU 3b:

Bayou Decade Area	- 5,870 acres
Brady Canal Area	- 2,731 acres
Pointe au Fer Island	- 1,462 acres
Marsh Island	- 7,883 acres
Wax Lake Outlet Delta	- 10,536 acres
Bayou Penchant Area	- 12,954 acres
Terrebonne GIWW Area	- 11,055 acres
Avoca Island Marsh Creation	- 1,445 acres
Lower Atchafalaya River Marsh Creation	- 1,526 acres

Eleven areas of marsh creation are proposed for PU 4:

Mud Lake	- 5,669 acres
South Grand Chenier	- 8,575 acres
South Pecan Island	- 9851 acres
East Pecan Island	- 7,184 acres
No-Name Bayou	- 3,151 acres
NW Calcasieu Lake	- 29,187 acres
East Calcasieu Lake	- 14,141 acres
Black Bayou	- 4,769 acres
Gum Cove	- 3,261 aces
Cameron Meadows	- 1,293 acres
Central Canal	- 18,216 acres
Sweet Lake	- 3,527 acres

Diversion Modeling, Assumptions and Inputs

The NRCS-Boustany model (2007) presented a screening level model for assessing both the nutrient and sediment benefits of flow diversions over long time scales. ERDC adapted the Boustany (2007) model to include daily variation in sediment processes in order to optimize diversion structure design and operation. The adapted Boustany model[10] was used to provide rough estimates of receiving area benefits for each year of the 100-year timeframe during past sea level rise conditions and future medium-increase RSLR conditions. An overview of the model is provided in Attachment C. Model benefits are based in part on Mississippi River discharge and the corresponding suspended sediment concentration which vary with discharge. The riverine hydrograph, in combination with diversion operation assumptions, are the key factors determining how much flow and sediment enters the diversion receiving area. Details regarding model inputs are discussed below.

A. Mississippi River Hydrograph
Excluding diversion structure operations, diversion discharges are determined primarily by the riverine hydrograph. To reduce the time required for assessing diversion benefits, it was decided to select a single annual hydrograph to assess all proposed diversion measures. To avoid intentionally biasing diversion discharges, an average hydrograph was selected from Tarbert Landing annual hydrographs 1980-2005. This was done averaging 26 years of daily discharges to obtain an index of the average annual discharge.

[10] Quantifying Benefits of Freshwater Flow diversion to Coastal Marshes: Theory and Applications, S. Kyle McKay, J. Crag Fischenich, S. Jarrell Smith, and Ronald Paille (2008)

Among the years where the annual average discharge index was within 5% of the 26-year average, the 1994 Tarbert Landing hydrograph (figure 4) was selected as its hydrograph shape most closely resembled the shape of the average hydrograph.

B. Diversion Discharges

Total diversion discharges presented in this section represent a "what-if" scenario for sensitivity analysis and plan formulation and are not necessarily indicative of a realistic end-state. Diversion discharge is determined by Mississippi River stage at the diversion structure. Because continuous stage and/or flow data from each proposed diversion location was not available, diversion discharges were related to river discharge at Tarbert Landing. According to operation records of the Caernarvon Freshwater Diversion structure (Nov. 1992 through 2006), that diversion has operated an average of 246 days a year. Lacking data to make similar determinations for many of the proposed diversion locations, all evaluated diversions were assumed to operate only during the 246 days of highest river discharges.

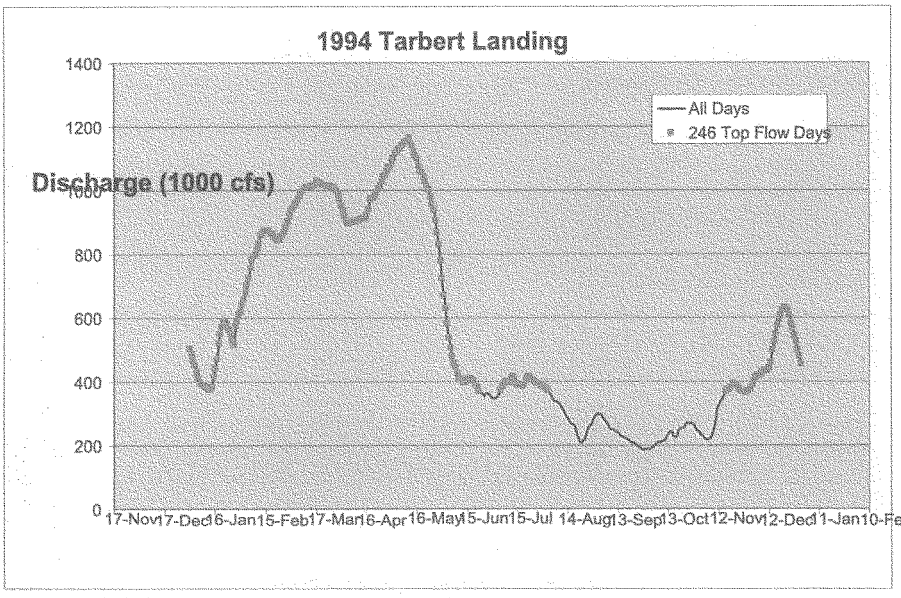


Figure 4. Mississippi River discharge at Tarbert Landing (1994).

Tarbert Landing 1994 daily discharge values were then sorted. The highest 246 discharge values were assumed to be sufficiently high to allow discharges through all evaluated diversion structures and the lower 119 values assumed to be too low to allow diversion discharges. To determine actual discharge through each proposed diversion structure, the data set of daily operation records (Nov. 1992 through 2006) for the Caernarvon Freshwater Diversion Structure was examined. A subset of Caernarvon dates and discharges was restored for only those days when all gates were fully open. Those discharges were assumed to represent the maximum discharge potential of the Caernarvon structure.

Those records reveal that discharges much higher than the structure's 8,000 cfs design discharge, which is both the 50% duration discharge and its maximum design flow capacity, could be obtained during medium to high Mississippi River stages (one daily discharge in excess of 10,000 cfs is present in the records). Because suspended sediment concentrations are greatest during high river discharge periods, the HET decided that restoration would be more effectively achieved if the design of new diversion structures did not cap diversion discharges at their 50% duration discharge. Therefore, the Caernarvon full-flow discharges were converted into percentages relative to its 50% duration flow design capacity of 8,000 cfs. Viewed in this manner, actual Caernarvon discharges have reached 126% of its design flow. A first degree polynomial equation was developed using Tarbert Landing discharge to predict percent of design discharge at Caernarvon (see equation 1). Because discharges at 126% of the design discharge occurred at a modest river discharge of <400,000 cfs, it was assumed that the Equation 1 could be used to predict diversion flows in excess of 126%.

Equation 1. *Caernarvon Design Discharge = 0.0019 (Tarbert Landing Discharge) – 0.226*

Using the 1994 Tarbert Landing data as input into Equation 1, Caernarvon discharges would reach 199% of the design discharge. A frequency analysis was conducted to lump Caernarvon discharges in 5 sub-groupings or bins according to the average percent discharge per bin. See Table 6.

Table 6. Discretization of Caernarvon discharges

Percent Discharge	Count
0.61931	97
0.92293	32
1.22655	12
1.53017	58
1.83379	47

According to Equation 1 presented above, the river discharge was used to determine percent of diversion design discharge according to the percent discharge values listed in Table 6. As a result, diversion discharges ranged from zero (actually 0.0001% was used) up to 183% of design discharge. Discharge at 183%[11] of design was used to describe the maximum discharge and the 100% design discharge was used to describe the average diversion discharge.

Equation 1 was used to predict discharge for all proposed diversions, and allowed those diversions to reach 183% of their design discharge. For the existing Davis Pond and Caernarvon structures, however, discharges were capped at their 50% duration design flows (10,650 cfs and 8,000 cfs, respectively).

For the Caernarvon Diversion, Naomi Siphon, and West Pointe a la Hache Siphon, it was assumed that benefits of their past discharges were reflected in the wetland loss rates determined for their respective influence areas. Consequently, estimates at Naomi and West Pointe a la Hache represent discharges in addition to past discharges. Unless

[11] Calculations conclude that the discharge rate can be significantly increased through an existing structure; in actuality, structural modifications would be necessary for safe operation and to reduce the risk of structural failure.

otherwise noted, the benefits associated with reauthorization of the Caernarvon Diversion to full-flow capacity was represented by maximum discharges of 6,163 cfs – the difference between its design capacity and its 1,837 cfs average annual maximum discharge. Similarly, for reauthorization of the existing Davis Pond Diversion, past average annual maximum discharges were estimated as 1,727 cfs such that reauthorization would only provide an additional maximum discharge of 8,923 cfs.

C. Mississippi River Suspended Sediment Concentration
Because sediment availability has been continually decreasing over the last 50 years, current data was needed to reflect those changes. Although good continuous total suspended solids (TSS) data exists for Tarbert Landing, the TSS concentrations are much reduced at locations below New Orleans. A sediment rating curve for Belle Chase (1991-2004) was used to determine quantities of sediment in the river at varying discharges (Snedden et al. 2006).

D. Mississippi River Nutrient Concentrations
The model applies a mean annual concentration for total nitrogen and phosphorus. Based on available historic records for the Mississippi River, the mean value was determined to be 1.7 mg/l and was used for all diversion analyses. The value assumed to range from 0.8 to 2.6 mg/l in the uncertainty analyses.

E. Diverted Suspended Sediment Characteristics
Monitoring data, obtained from the Caernarvon Diversion Structure's outfall channel, was used to characterize sediments being discharged via all evaluated diversions (Snedden et al. 2006).

F. Determining Wetland Loss Rates
Under the LCA project, the coastal wetland ecosystem was divided into approximately 160 units or polygons. Wetland acreage data for each polygon was obtained from the USGS. Assuming that the higher loss rates during the 1950s and 1960s would not be representative of future loss rates, wetland acreage data from 1978 through 2006 were used to develop loss rates for projecting throughout the future 100-year timeframe. Examination of those data reveal that although in some areas losses appeared to have either increased or decreased, the majority of polygons exhibited constant (linear) loss rates throughout the 1978 to 2006 period. Therefore a linear equation was developed for each polygon to estimate polygon acreages throughout the 100-year timeframe.

G. Determining Wetland Loss Rates with Future Increased RSLR
The HET determined it would be necessary to make preliminary projections regarding the implications of RSLR to land loss rates in order to assist in alternative formulation, and to determine how those impacts will be quantified. The methodology employed to make those projections is addressed in Attachment 2. Restoration alternatives R1 and R2 were designed to achieve sustainability under the increased RSLR scenario. Consequently, under the lower wetland loss rates of the existing RSLR scenario, those alternatives achieve net land gains.

H. Diversion Benefited Areas
Based on personal experience and involvement with previous diversion evaluation efforts, HET members made subjective determinations regarding potential maximum wetland areas that might be benefited by specific proposed diversions.

I. Receiving Area Depth
Based on personal experience and available data, HET members estimated average depths within diversion influence polygons.

J. Receiving Area Nutrient Retention
Using previously determined estimates of nutrient retention, diversion discharge, and receiving area characteristics, the HET made estimates of anticipated average nutrient retention.

K. Receiving Area Sediment Retention
A module of the diversion benefits model calculates sediment retention within the project area based on settling velocities, sediment particle size, receiving area water volume and depth. This module was used to estimate sediment retention rates for all diversions. However, for the Bayou Bienvenue diversion, the retention module was used to calculate sediment retention in a step-wise manner. Sediments not retained in the Central Wetlands were then assumed to be available to the MRGO. Sediments not retained in those areas were then assumed to be available to Lake Borgne. Remaining sediments were then assumed to be available to the Lake Borgne & Golden Triangle area marshes. Remaining sediments were then assumed to be available to the east New Orleans landbridge marshes.

For the LCA Plan measure known as "Opportunistic Use of the Bonnet Carre Spillway," the benefits assessment made through the Coastal Wetland Protection and Restoration Act Program was used. That methodology did not include use of the above-mentioned sediment retention module.

L. Bulk Density of New Marshes
The diversion benefits model allows the user to select bulk density typical of fresh or brackish marshes. To be conservative, the higher brackish marsh bulk density value was used for all evaluated diversions.

M. Receiving Area Maximum Tidal Velocity
Lacking velocity data for all evaluated diversion receiving areas, velocities were estimated to be 1.2 to 1.4 feet per second in receiving areas close to the Gulf. Velocities in middle basin areas were estimated to range from 0.5 to 1.0 feet per second, and upper basin velocities were estimated to be less than 0.5 feet per second.

N. Flocculent Percent Deposition
Since deposition of flocculants occurs where suspended sediments encounter saltwater, percent flocculent deposition was assumed to be roughly proportional to salinity. Given that salinity data was not available for all diversion receiving areas, habitat type maps were used as a guide to average salinities, such that flocculent deposition was typically estimated to be approximately 70% in saline marshes, 30-50% in brackish marshes, and 10-20% in upper basin fresh marshes.

Sediment Availability

The HET ascertained that sediment availability is a key limiting factor in any coastal restoration effort, however given the time constraints for the LACPR analysis; a significant effort such as developing a comprehensive sediment budget could not be completed. However, a study conducted by Thorne, et al entitled *Current and Historical Sediment Loads in the Lower Mississippi* is currently underway. A regional sediment budget study has been proposed that would be applicable to all regional projects such as the ongoing levee work, CWPPRA, LCDA and LACPR. This study is anticipated to take

a couple years to complete. The NRC Report (May 2008) and Day et al. (2007) estimate that the volume of sediment necessary to counter the effects of relative sea level (RSL) rise is 24,000 km^2 times a 10 cm rise in RSL. **Preliminary results of the Thorne et al. study conclude that there is more than ample sediment available in the Mississippi to sustain existing wetland acreages.**

It was not possible for the HET to duplicate the current sediment budget efforts in time to inform planning decisions for the LaCPR report due in December, 2008. None the less, the HET was able to make reasonable assumptions regarding sediment needs and availability without knowledge of the full sediment budget.

The HET established an objective to achieve "maximum sustainability" to the greatest degree possible. To accomplish this they determined that the sediment need is equivalent to what is required to replace lost resources (marsh, barrier island, and coastal ridges). The HET then applied the land loss rates from USGS data (Barras 2006)[12] to the land features in the project GIS. Losses were computed on an annual basis using a linear loss rate function for a period of 100 years to establish the future without project condition. The acreage of marsh loss computed above was multiplied by the depth to determine a volume of loss. To determine the quantity of sediment lost in tons, the volume was multiplied by the sediment bulk density, which varies depending upon the salinity. Thus, the amount of sediment needed to offset a $1km^2$ marsh is simply a function of the marsh height and the sediment bulk density.

Table 7 provides example quantities for three depths and two salinity conditions. The figures in the table reflect the quantity of sediment within a mature marsh. The actual amount of material required to restore the marsh may be considerably greater than this value because sediment retention is not 100 percent. Retention rates vary depending upon site conditions as well as the method used to construct the marsh.

Depth	Weight (tons) of Sediment	
(ft)	Intermediate	Brackish
0.5	50400	100800
3.0	215000	349400
6.0	917300	1152500

Table 7. Sediment quantities (by weight) in $1km^2$ of coastal marsh.

Losses in each planning unit were offset using a combination of freshwater diversions and mechanical placement of dredged material. The approaches for accomplishing this were detailed in the previous section and attachments C, E, and F.

[12] Barras, John A. 2006. Land area change in coastal Louisiana after the 2005 Hurricanes: A Series of Three Maps. U.S. Geological Survey Open-File Report 06-1274.

The sediment requirements for marsh creation/protection can be demonstrated to be less than the availability based upon the relatively conservative assumptions applied in the analyses. The HET formulated alternatives to meet the objective to achieve "maximum sustainability" by a stepped approach wherein the use of diversions at select sites were first evaluated and optimized, and additional losses beyond those compensated by diversions and/or shoreline protection measures, were offset using mechanical sediment placement.

To assess the potential for marsh creation using freshwater diversions, a desktop model (modified Boustany model, 2008) that accounts for both the creation of new marsh and the reduction in losses to existing marsh as a function of the sediments and nutrients delivered by the diversion was developed and applied. Several assumptions were made in the model analyses, and these are detailed in Attachment C. The USACE identified 525,000 cfs as an upper limit for Mississippi River Diversions to be used in planning until more detailed assessments can be completed to assess the diversion capacity with regard to associated flooding, navigation and environmental impacts. For alternative R1, PU1 and PU2 maximum Mississippi River discharge would equal approximately 331,000 cfs. The PU3a Mississippi River diversions would total 76,000 cfs. Therefore, the total Mississippi River maximum discharge in alternative R1 = 407,000 cfs.

The sediment volumes associated with those discharges were determined by applying sediment rating curves developed from measured data at the gaging stations on the Mississippi, Atchafalaya, and Calcasieu Rivers to the volume of diverted water. Table 8 shows the corresponding sediment volumes for the most sediment-demanding alternatives (R1 and R2).

Table 8. Mean annual diverted sediment volumes (CY) by Planning Unit for alternatives R1 and R2.

Planning Unit	**Alternative R1**	**Alternative R2**
PU1	28,650,000	27,012,000
PU2	11,895,000	11,243,000
PU3a	12,413,000	1,937,000
PU3b	677,000	677,000
PU4	0	0
Total	53,635,000	40,869,000

Sediment availability from dredging is unknown. Estimates of annual dredging volumes for the lower Mississippi River obtained by the HET range from 40 to 140 MCY in the period since 1970. The average for this time period is about 79 MCY. According to LCA (2004), 44 MCY of an annual 70 MCY of dredging is suitable for beneficial use. The HET determined that no more than 30 MCY of dredged material could be relied upon as an annual average, although a higher yield may occur in some years. For this effort, the HET worked with Corps staff to determine supplemental sediment quantities available by dredging water bottoms within the estuaries and from nearshore waters for situations where in-shore dredge material was not readily available.

In addition to material availability, the total number of dredges available and the production rate for any single dredge were considered limiting factors. Because of Jones

Act restrictions, it was assumed that the number of available dredges would be limited to nine. Dredge production for offshore and back-bay work assumed = 20K cyds/day x 365 days = 7.3M cyds/yr. It was assumed that 1.0 M cyds = 124 acres x 5 feet of fill (placed in 3 feet of water). Therefore, 7.3M cyds/yr x 124 ac/M cyds = 900 ac/yr production for one dredge (in shallow water locations).

Table 9 shows the average annual dredging volumes needed to offset losses not addressed by the diversions. In all cases, annual dredging is highly variable, but the number of required dredges is never greater than six, and the maximum volume dredged in any single year is less than 44 MCY.

Table 9. Average annual dredging quantities by planning unit for alternatives R1 and R2.

Planning Unit	Alternative R1	Alternative R2
PU1	3,423,000	3,423,000
PU2	2,616,000	3,043,000
PU3a	9,084,000	9,084,000
PU3b	2,678,000	4,473,000
PU4	6,468,000	8,776,000
Total	24,269,000	28,789,000

Table 10 is a summary of estimated dredging volumes necessary to offset projected barrier island and shoreline losses over 50 and 100 year planning horizons. Total acreages for barrier island restoration over the 100-yr project life are the same for Alternatives R1 and R2. Estimated sediment volumes for those island/headland measures are based on applying different fill density classifications (land, fractured, open water) developed according to design templates for 20- and 50-year project lives given the TY 0 condition of the various islands/headlands. The land change analysis that was conducted on a polygon level does not allow differentiation on a island level within polygons. Therefore, average cy/ac/polygon and average cy/ac/PU were calculated if there were multiple islands/headlands within a polygon. The existing conditions were assumed to degrade to a point and then restoration of those lost acres would occur. Lost acres were summed over the 50 and 100 year intervals as reported in Table 10. However, fill volume estimates were derived by back calculating the fill density in cubic yards per acre from a fill density based on a planform that initially would be restored to an optimal level (i.e., up front) then be allowed to degrade.

Site	50-yr Creation (ac)	100-yr Creation (ac)	Applied Fill Density (cy/ac)	50-yr Volume.	100-yr Volume.
PlaqBarS	2,700	5,400	4,566	12,328,200	24,656,400
GrandTIs	900	1,800	856	770,400	1,540,800
ChenCam	2,700	7,829	1,227	3,312,900	9,606,183
PU2 Subtotal	6,300	10,169		16,411,500	35,803,383
Timbaliers	1,800	5,400	4,478	8,060,400	24,181,200

Dernieres	1,800	4,700	2,220	3,996,000	10,434,000
PU3a Subtotal	3,600	10,100		12,056,400	34,615,200
Total				28,467,900	70,418,583

Table 10. Summary estimates for barrier island and shoreline fill volumes to restore acreages that would be lost over 50 and 100 year planning horizons in order to maintain baseline conditions.

METRICS

Performance metrics were developed within the risk informed decision framework that were used to evaluate plans to establish the degree to which they satisfy the planning objectives. The performance metrics are considered indicators of the state of complex systems. They are indicative – but not definitive – gauges, and consequently must be interpreted with their limitations in mind. The list of environmental metrics being developed to conduct plan evaluations are presented in Table 13.

Four environmental metrics were developed early in the process; however, two were dropped from the multi-criteria decision analysis because they had no affect on the outcome of the rankings (i.e. results were the same with or without the metric). The two metrics dropped were wetlands sustained/restored and spatial integrity. These two environmental metrics[13] were used to prioritize and identify restoration plans. The two metrics that were utilized in the MCDA to evaluate the LACPR alternatives were: (1) direct wetland loss impacts and (2) indirect impacts from structural measures. Table 11 below lists the metrics, and the following sections describe each metric as well as the data sources, uncertainty, and scale of application.

[13] The indirect impacts and direct wetland impact metrics are applicable to structural alternatives (proposed levees), whereas the remaining metrics are applied to the coastal restoration features.

Table 11 - Environmental Metrics

Planning Account	Planning Objective	Metrics	Units	Description	Data Source
Environmental Quality	Promote sustainable coastal ecosystem	Spatial Integrity (area, edge, shape, connectivity and interspersion	Unitless (scaled 0-1)	The size, shape, density, configuration and structure of patches across a landscape affect fundamental ecosystem processes, which determine the trajectories of ecological condition. Spatial integrity refers to undivided, contiguous space. A fragmented landscape (one containing several discrete patches of land or many inclusions of water) has less spatial integrity than a landscape containing fewer patches or inclusions. Land loss rates have been observed to vary substantially with spatial integrity. Typically, more aggregated landscapes display a higher probability of retaining land as compared to the more disaggregated landscapes. These trends were utilized to form a Landscape Stability Index which ranges from 0 to1, with probability of land retention increasing as the index approaches 1. The Landscape Stability Index places emphasis not only on the amount of land built, but the spatial configuration of that land.	Models, empirical data, maps and expert opinion
	Restore and sustain diverse fish and wildlife habitats	Direct Wetland Impacts	Acres	Many of the proposed levee alignments cross wetlands and result in the direct loss of those wetlands occupied by the footprint of the levee and adjacent borrow areas. The magnitude of the impact is a function of the levee alignment and the level of risk reduction, which influences levee base width. The potential direct wetland losses are calculated by simply overlaying the footprint of a given levee and associated borrow areas on the existing coastal landscape, assuming that all construction impacts occur simultaneously. These simplifying assumptions produce acreages of potential adverse direct wetland impacts. A high weighting penalizes plans that have significant wetland loss associated with levee construction.	Models, empirical data, maps and expert opinion
		Wetlands Created and/or protected	Acres	This metric is the direct measure of gain of wetlands restored and those existing wetlands protected form further degradation. A high weighting rewards plans that have significant wetland creation and/or protection compared to the anticipated loss of wetlands projected over the period of analysis in the no action scenario.	Models, empirical data, maps and expert opinion
	Reduce Impacts	Indirect Impacts	Unitless	This metric compares levee alignments and their potential indirect impacts (both positive and negative) to wetlands and other aquatic resources. Indirect impacts considered include (1) hydrologic changes, (2) effects on fisheries, (3) potential to induce development in wetlands, and (4) consistency with coastal restoration. Rankings range from +8 to -8, with a positive ranking meaning that there is the potential for beneficial effects to wetlands. Other factors being equal, it is assumed that the greater the acreage of wetlands that would be enclosed within a proposed levee system, the greater the potential for adverse indirect impacts. If, for example, a levee were to be built on an existing barrier (such as a levee, road, or distributary ridge), the risk for further hydrologic alteration is, in general, minimal. If a levee were built through a wetland area with limited or no existing barrier, the risk of hydrologic disruption would be far greater. A moderate adverse ranking for hydrologic impacts, for example, does not necessarily mean that a particular alignment does not have the potential for significant adverse hydrologic impacts. It simply means that the potential adverse hydrologic impacts of that alignment are substantially below what might be expected for other potential alignments in that planning unit. Fishery impacts refers to potential increases/reductions in fish access and in fish habitat. Induced development refers to the potential increase or decrease in wetland areas with significantly improved hurricane risk reduction and which are susceptible to residential, recreational and/or commercial development. Ecological sustainability/consistency (with coastal restoration) refers to the extent to which the proposed levee is or is not likely to be consistent with existing and future coastal restoration projects, particularly river reintroduction projects (a.k.a. diversions).	Expert opinion and pertinent scientific literature
	Sustain the unique heritage of coastal Louisiana by protecting cultural resources	Archaeological sites protected	Number of sites	The number of archaeological sites protected. Archaeological sites include locations with artifacts and other materials from people and cultures from the prehistoric and historic past. Archaeological sites may include the remains of buildings, trash pits, hearths, pottery, and tools (stone, metal, and other materials). A higher weighting for this metric indicates a preference for minimizing disturbance.	Survey and register
		Historic Properties Protected	Number of Properties	The number of historic properties include properties eligible or listed on the National Register and National Historic Landmarks. While archaeological sites may fall into any of these categories, structures form an overwhelming majority. In general, cultural resources in these categories must meet criteria defined at a local or national level to be included. Examples of historic resources in this category include Fort Jackson, Oaklawn Manor, Jackson Square, and the Garden District. A higher weighting for this metric indicates a preference for minimizing disturbance.	Survey and register

Restoration Metric: Wetland Acreage

Several wetland functions that produce benefits to coastal populations can be directly related to the total acreage of wetlands, including storm impact buffering, floodwater storage, nutrient, sediment and contaminant absorption, provision of wildlife habitat, and biological productivity and diversity. Given Louisiana's coastal wetland loss crisis, we propose to use the total wetland acreage over time as a primary metric for alternative comparison. In a self-sustaining coastal ecosystem, wetland acreage would remain roughly constant and the corresponding storm surge threat would also remain relatively constant, all other factors being equal. The accounting includes benefits due to mechanical marsh creation and diversion of sediments and nutrients.

The following figures (Figures 5 - 12) show the computed total wetland acreages for each of the alternatives evaluated, as well as the FWOP in all planning units. For each alternative, two projections are presented, representing the two SLR projections assessed by the HET.

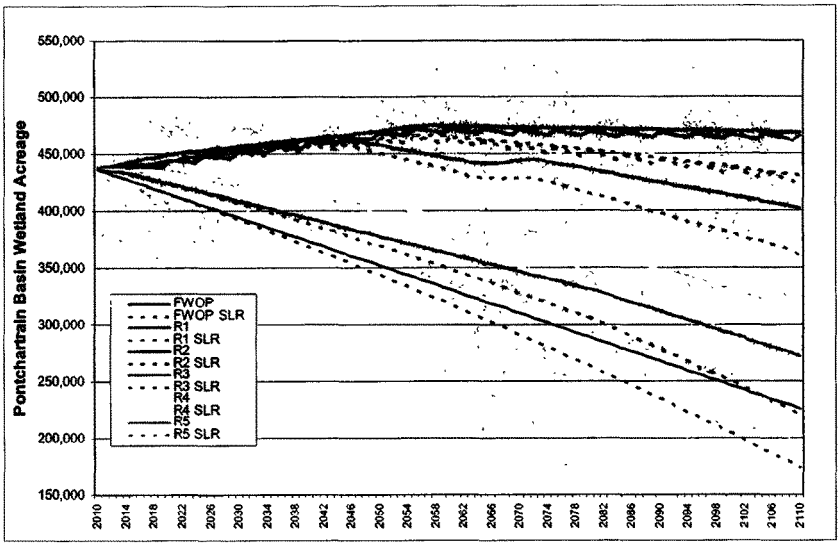
Ideally, future wetland acreage would be determined by wetland type (which could be summed) to provide additional insight into potential impacts or benefits of the proposed restoration measures. Unfortunately, the time constraints preclude use of sophisticated modeling techniques to predict acreages of future habitat types at the end of the 50-year planning horizon or a 100-year timeframe.

Adjustments to the baseline wetland acreages to account for levee impacts will be made on the basis of the direct footprint of the levee and any needed borrow area. These estimates were generated by the USACE for the HET. Adjustments are also made to account for mechanical marsh creation on the basis of the prioritizations discussed earlier in the document, and available sediment within each planning unit. Adjustments in annual acreages are also made on the basis of freshwater diversion benefits, as computed by a modified NRCS model that is discussed in Attachment C.

Future with Project (FWP) – Coastal Wetland Restoration Results for PU1

In PU1, Alternatives R1 and R2 sustain the Breton Sound and Pontchartrain Basin wetlands (Figures 5 & 6), but not that of the PU1 portion of the Mississippi River Delta. Because of the high subsidence rates in the Delta, the HET decided not to include any new restoration measures there and instead focused restoration measures in lower subsidence rate areas where benefits would be provided over a longer period of times. Consequently over the entire planning unit, R1 and R2 achieve sustainability only under the existing RSLR scenario but not under the medium RSLR increase scenario (Figure 5).

Figure 7. Predicted Pontchartrain Basin wetland restoration plan results.



Extensive future wetland losses in the Pontchartrain Basin make sustainability difficult to achieve. Possibly contributing to those high wetland losses is the uncertainty associated with the Maurepas Swamps wetland loss rate. The loss rate used was derived through the LCA Study and was not determined through satellite imagery since such rates are not well suited to forested wetland areas such as this. Better wetland loss rates in forested wetlands are needed to reduce uncertainty and improve restoration planning.

The existing I-10 earthen embankment through the Maurepas Swamp may preclude Mississippi River diversions of the magnitude needed to achieve sustainability of those swamps as proposed in Alternatives R1 and R2. More investigations are therefore needed to determine the extent of diversion that I-10 would allow and if insufficient, then solutions to this problem would be needed to achieve sustainability of those swamps.

Because the Biloxi Marshes and on the East Orleans Landbridge are somewhat distant from the Mississippi River and are bordered by lakes and bays which tend to capture diverted sediments, a Violet diversion over 100,000 cfs would be needed to achieve sustainability of those areas via Mississippi River diversions. This was considered to be impractical, hence, extensive use of shoreline protection and marsh creation measures was proposed in R1 and R2 to reduce and offset the high loss rates in those areas. However, if substantial synergistic effects of the proposed wetland restoration measures occur, then a reduction in scale or scope of those measures may be possible. Re-establishment of ideal conditions for oyster production to facilitate creation of oyster reef wave breaks may provide a less costly alternative means of achieving shoreline protection for the Biloxi Marshes.

The proposed 110,000 cfs diversion with sediment enrichment at American Bay provides substantial land-building benefits and is responsible for the superior performance of the R5 Alternative (Figure 4). However, American Bay is an inefficient location for landbuilding, the land created would provide little hurricane protection for New Orleans and adjoining

communities, and dedicating such a large volume of river water at that location may preclude opportunities to sustain other more critically important marshes.

Figure 6. Predicted Breton Sound Basin wetland restoration plan results.

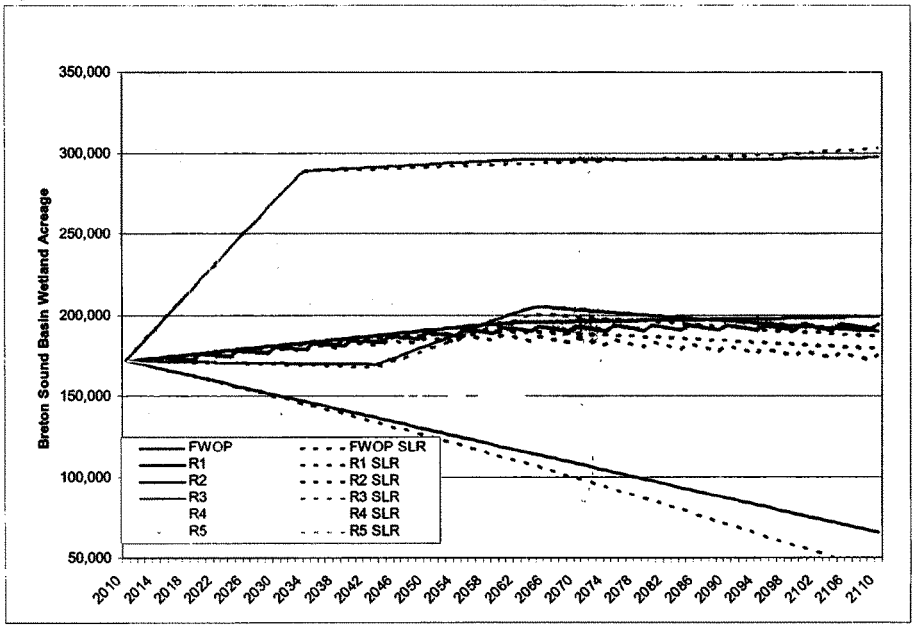
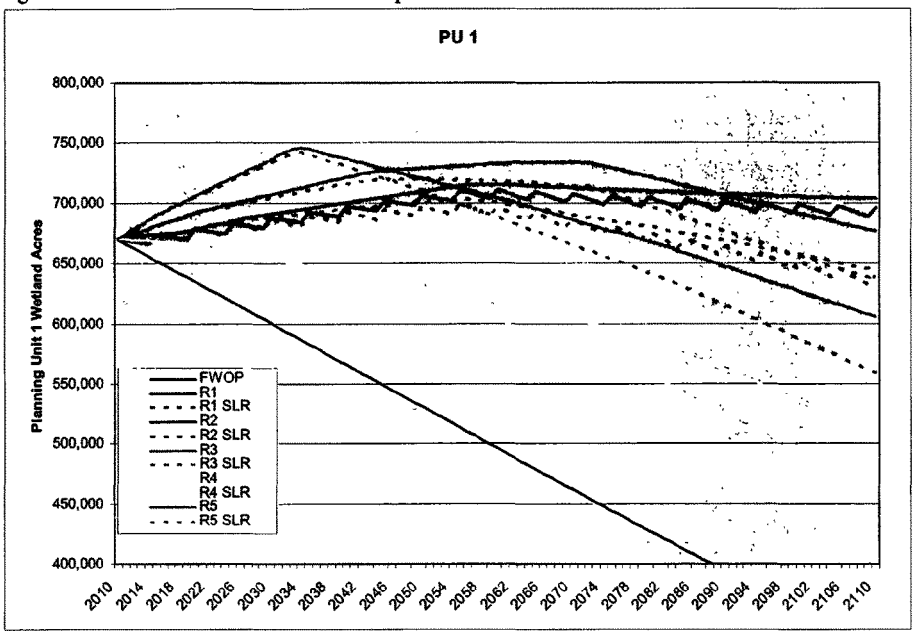


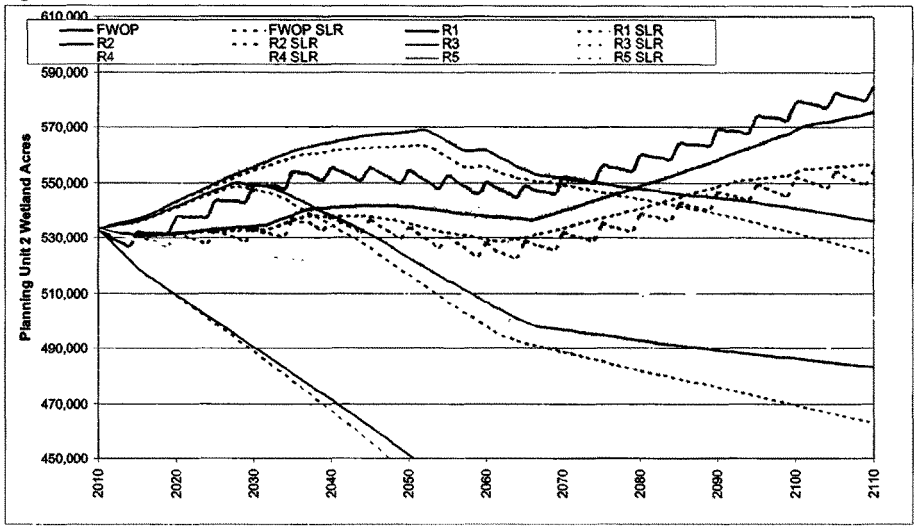
Figure 7. Predicted PU1 wetland restoration plan results.



FWP – Coastal Wetland Restoration Results for PU2

Ongoing wetland gains in the Mississippi River Delta portion of PU2 result in net wetland gains when included with restoration measures in the Barataria Basin portion of the planning unit (Figure 6). However, when sustainability is considered for the Barataria Basin alone (Figure 7), only R1 and R2 are able to achieve sustainability under the medium RSLR increase scenario.

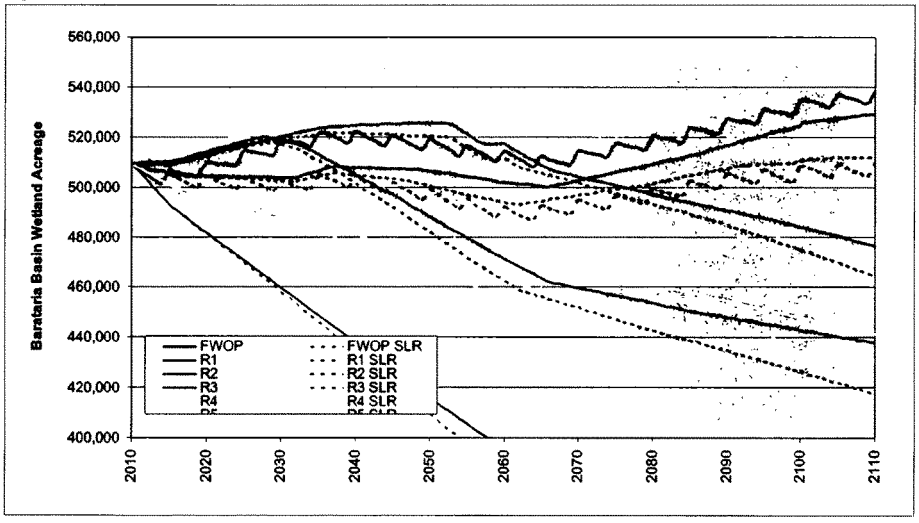
Figure 8. Predicted PU2 wetland restoration results.



In Alternatives R1 and R2, it was assumed that the extreme southwestern portion of the basin could not be sustained via diversions (area southwest of the Bayou L'Ours Ridge). However, the evaluation of those alternatives did not capture the likely reduction of loss rates in that area due to indirect diversion effects. Hence, the need to incorporate marsh creation to offset wetland losses not eliminated by diversions might be reduced. Also, the synergistic effects of the diversions into that basin may provide additional benefits that the analyses could not capture.

The Kraemer Ridge located in the upper basin swamps may isolate the swamps south of that ridge from benefits associated with the proposed upper basin diversions at Lagan and Edgard. In Alternatives R1 and R2, it was assumed that measures would be undertaken to ensure that those isolated swamps received sufficient benefits to eliminate wetland losses. As in PU1, a more accurate assessment of forested wetland loss rates is needed to appropriately plan and design diversions to sustain those upper basin swamps.

Figure 9. Predicted Barataria Basin wetland restoration results.



The ability to sustain the upper basin swamps may also be impacted by the combined effects of the existing hydrologic constriction at Bayou Des Allemand, the Highway 90 embankment across the basin, and potential diversion-related flooding of developed areas not currently protected by forced drainage systems.

Maintenance of the marshes along the northern edge of Bartaria Bay was considered to be a critical restoration need for the entire basin. Loss of those marshes might allow saltwater impacts to cause wetland losses in currently stable fresh marsh areas. Maintenance and restoration of those bay-edge marshes would likely require erosion prevention measures as well as marsh creation as proposed in Alternatives R1, R2, and R4.

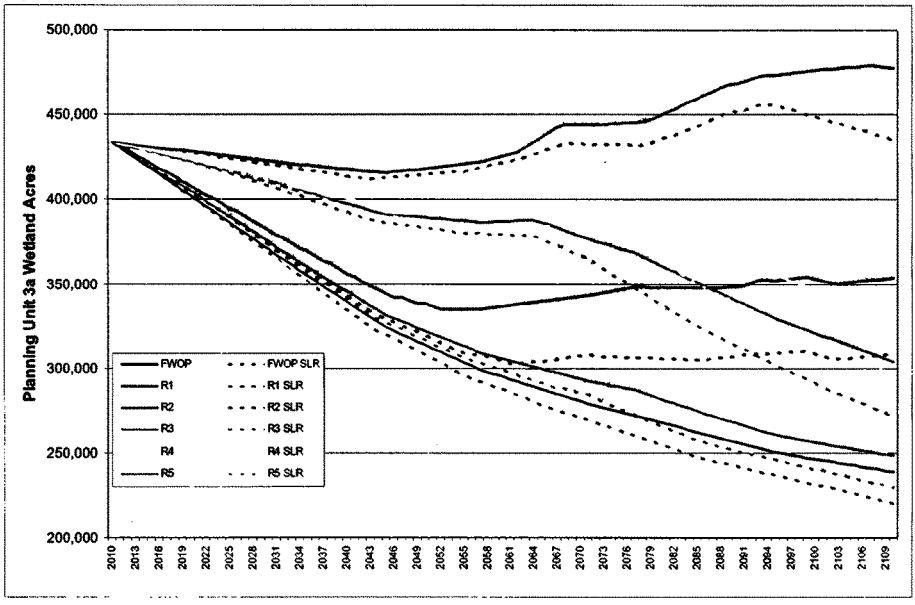
Restoration and maintenance of the barrier islands were also considered to be a critical need for the entire basin. That work could be achieved through deposition of hydraulically dredged sediments. A sediment diversion at Buras or Fort Jackson, to introduce sand into the litteral drift ecosystem may provide an alternative to mechanical barrier island maintenance as proposed via the R4 Alternative's 60,000 cfs diversion at Fort Jackson.

FWP – Coastal Wetland Restoration Results for PU3a

In Planning Unit 3a, sustainability was achieved only with the more effective Mississippi River Diversion Alternative (R1). Nevertheless, over 120,000 acres of marsh creation was needed to offset wetland losses in portions of the area not benefited by those diversions. The combined benefits of the many smaller GIWW diversions in Alternative R2 were much less effective in reducing wetland loss (Figure 8). Rather than propose an excessive and unrealistic amount of marsh creation to offset the remaining wetland losses, it was decided to include only the R1 marsh creation measures. In PU3a therefore, the R2 Alternative does not achieve sustainability. These evaluations illustrate the difficulties associated with achieving effective coastal wetland

restoration in PU3a. More work, specifically hydrologic modeling, is needed to assess the feasibility and extent of benefits of some of the larger measures and the combined benefits of all measures in PU3a.

Figure 10. Predicted PU3a wetland restoration results.



Although introduction of Mississippi River to portions of eastern Terrebonne could sustain that most rapidly deteriorating part of PU3a, construction of such a feature would be very difficult and costly. If that were not feasible or affordable, increasing Atchafalaya River freshwater inputs would be next best alternative, although unlikely to achieve sustainability. The more effective Atchafalaya River introduction options, however, may aggravate existing backwater flooding problems in the vicinity of Amelia and in Lake Verret Basin. Hence, that flooding problem would likely have to be resolved before those aggressive Atchafalaya introduction alternatives could be implemented.

Those more aggressive Atchafalaya River introduction options, in combination with a GIWW conveyance channel south of Houma and other distribution channels, offer possibilities for substantially reducing wetland losses. The amount of water that could be introduced by such a combination of measures cannot be accurately determined at this time. Hydrologic modeling of such an alternative is needed to better assess the potential effectiveness of those options.

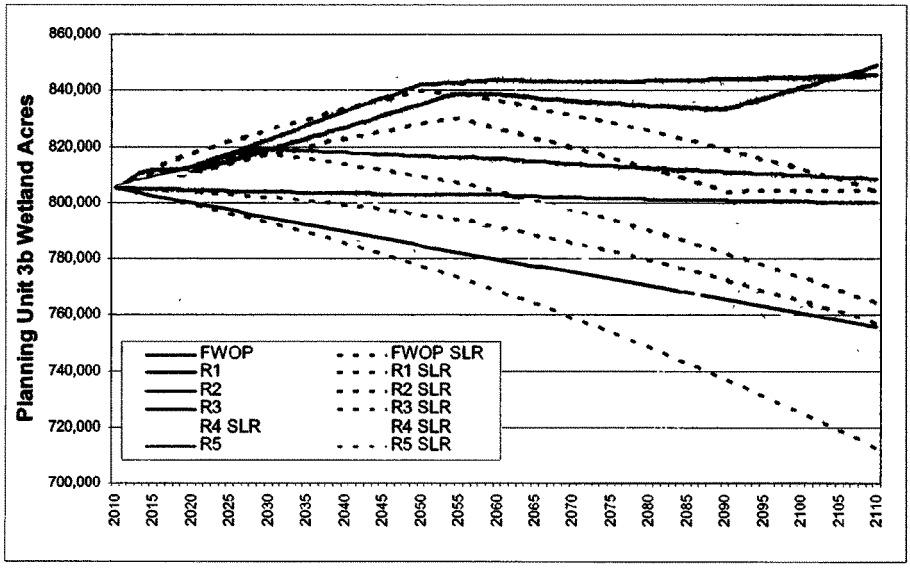
FWP – Coastal Wetland Restoration Results for PU3b & 4

Restoration plans in Planning Unit 3b included a number of small diversions from the GIWW, Bayou Penchant, and other local water bodies, in combination with shore protection and marsh creation measures (Figure 9). Hydrologic modeling of those larger measures is needed to better

assess freshwater introduction opportunities for moving Atchafalaya River water and sediments to the critically important tidal marshes protecting the flotant marshes of the Penchant Basin.

Some plans also included several large-scale water/sediment management measures in Atchafalaya Bay. Benefits for those measures were obtained through evaluations made via the Coastal Wetlands Planning, Protection and Restoration Act program. A further assessment of benefits that might be obtained by such measures is needed, especially when combined with measures to provide synergistic opportunities. Those measures, such as the proposed reconstruction of the barrier reef from Pointe au Fer Island to Eugene Island, might have much greater benefits than anticipated as well as sizeable indirect benefits to western Terrebonne and other marshes.

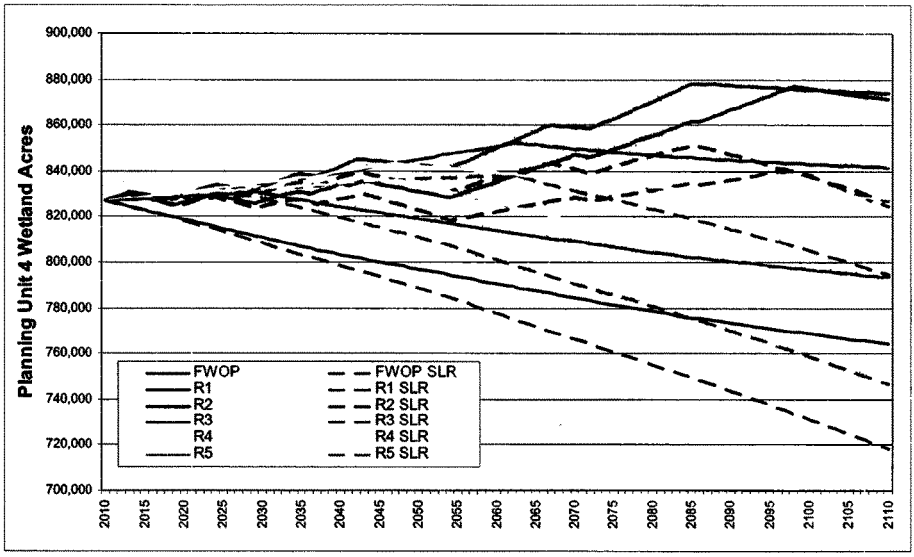
Figure 11. Predicted PU3b wetland restoration results.



In PU4, few details were available regarding aspects of proposed water management and salinity control measures. Lacking those details and suitable methods for assessing their benefits, the evaluation of alternative restoration plans in those areas was limited to the benefits achieved through shore protection and marsh creation measures (Figure 10). More detailed information, together with a method for assessing the effects of water and salinity management measures, would facilitate restoration planning and may reduce the need to rely strictly on shore protection and marsh creation measures.

The beneficial use of all maintenance dredged material is an obvious restoration measure in PU4. The mining of dredged material located in upland disposal sites may also offer an opportunity to restore marsh without the impacts associated with mining of lake bottoms. In PU4 and coastwide, an assessment of the relative cost-efficiency of shore protection to prevent wetlands losses versus marsh creation to replace lost marshes would facilitate restoration planning.

Figure 12. Predicted PU4 wetland restoration results.



Wetland Loss Rate Determination Methods.
To provide estimates of future wetland sustainability, loss rates were applied to existing and new wetland areas. Wetland acreage data (1956 to 2006) were obtained from the USGS, for a number of polygons across the coast. The 1956 and 1978 acreage data were obtained via map digitization and not from satellite imagery as were the data from later years. Because the 1978 to 2005 period did not include the rapid losses during the 1960s and 1970s, it was believed to better represent anticipated future losses. Therefore wetland acreage during the 100-year timeframe (2010-2110), was determined by extrapolation of the 1978-2006 loss rate. Although projecting acreage over the 100-year timeframe introduces enormous uncertainty, doing so is very valuable to illustrate where the current wetland loss trends are leading and to compare results among the various plans.

When extrapolating a loss rate over such a long period of time, the end result may vary significantly depending on how that rate is applied. The compounding rate (typical of the current CWPPRA program), may result in a reduction of losses over 100 years. However, plots of actual wetland acreage over the past 50 years reveals that losses have been quite linear and have not exhibited a decreasing trend. In fact, some areas exhibit a slight increasing loss trend (Figure 11).

For many of the polygons, the 50 years of wetland acreages were slightly better represented by a polynomial curve than by a linear line (Figure 12 & 13). However, when the polynomial curve was extended over the 100-year timeframe, it occasionally resulted in very unlikely scenarios. Hence, the polynomial equations were deemed to be not suitable for making 100-year projections. Given the uncertainties in future wetland loss rate changes, and the observed linear loss trends over the last 50 years, the HET decided to apply the 78-06 loss rate as a linear rate based on 1978 acreages.

Figure 13. Compounded Wetland Loss Rate

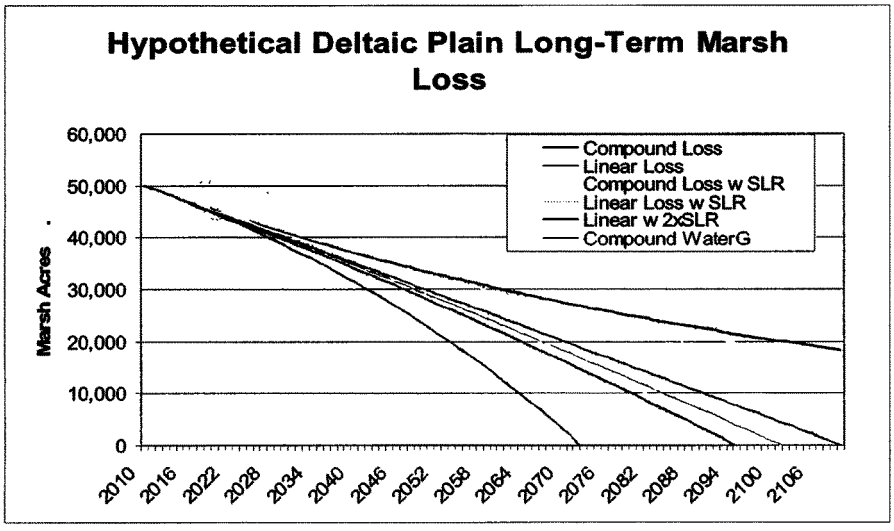


Figure 14. Example uncertainty in loss rate functions.

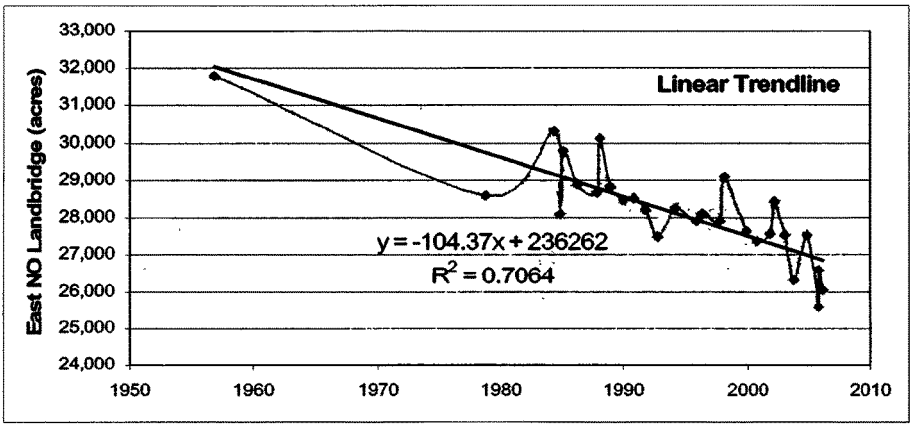
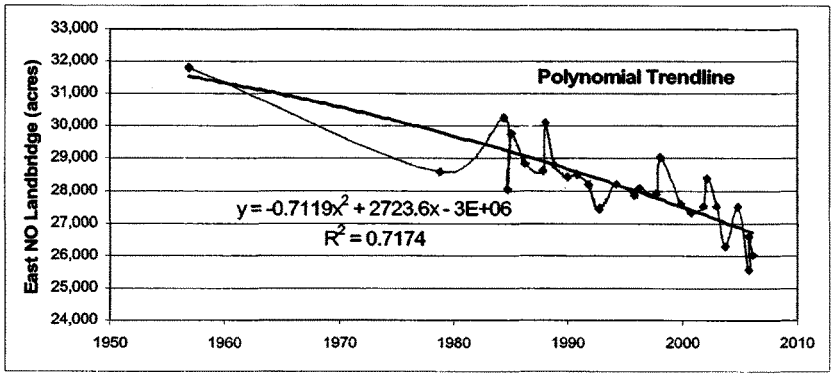


Figure 15. Trendline fits to measured wetland acreages.



Wetland acreage measurements from satellite imagery exhibit variations depending on water levels when sampled. To reduce this error, 1978 to 2006 loss rates were obtained from a linear regression over that period rather than from the actual data. This was especially useful in the Breton Sound Basin, which suffered extensive hurricane-related wetland losses during the later part of 2005 (see Figure 14). Use of the regression line to calculate wetland loss rates minimizes the substantial effect those hurricane impacts would otherwise have had on the loss rate.

Figure 16. Adjusted regression fit to Breton Sound.

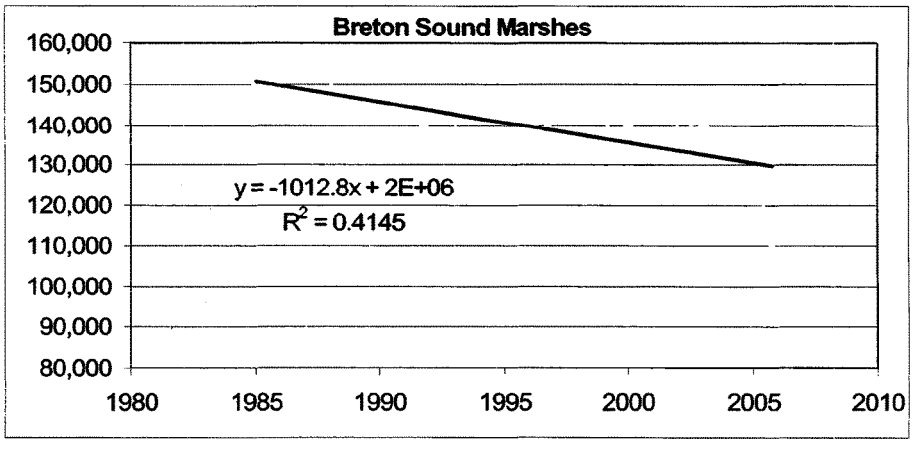


Table 12. Partial List of Uncertainties Affecting Wetland Acreage Projections.

Wetland Loss Rate Uncertainties
Subsidence rate changes
Sea level rise rate changes
Future hurricane effects
Satellite imagery-methodology issues
Loss rate extrapolation methodology
Synergistic and complimentary wetland restoration benefits
Diversion Benefits Assessment Uncertainities
Future Mississippi River suspended sediment quantity and quality
Location-related effects on duration of diversion discharges
Location-related effects on duration of diversion discharges
Sediment introduction characteristics of individual diversions
Diversion discharge estimates
Riverine nutrient flux
Suspended sediment deposition within diversion receiving areas
Nutrient retention with diversion receiving areas
Resuspension and removal of deposited subaqueous sediments
Anthromorphic-related inefficiencies in deltaic landbuilding
Nutrient-related benefits to emergent marshes
Sediment distribution throughout receiving area

Restoration Metric: Spatial Integrity Index

(Note: All Figures and Tables referred to in this section are presented in Attachment D)

Introduction

Principles of landscape ecology assert that landscapes are a mosaic of patches that can be defined by their structure, their function and change (Forman 1995). Our conceptual approach defines the landscapes in each of the principal hydrologic basins of the Louisiana coast by their structure (meaning the spatial relationship among distinct wetland patches or their elements and other key physical features such as barrier islands, ridges, and tributaries), their function (meaning the flow of mineral nutrients, water, energy, or species among component patches or between landscapes), and change (meaning the temporal alterations in the structure and function of landscapes or their components).

Our premise is that the structure, function and change of patches across landscape mosaics affect fundamental ecosystem processes, which determine the trajectories of ecological condition. Therefore, the quantification of landscape structure and measurements of change to that structure are important precursors to understanding functional effects of change (Tischendorf 2001). At the site scale, the structure of a wetland patch can be related to topography and other spatial attributes such as channel density and pattern and heterogeneity of vegetation types. At the

landscape scale, the spatial configuration of wetland patches—e.g., their size, shape and connectivity—and the composition and connectivity of surrounding open water areas are the key components of structure.

One method to quantify structure employs the use of spatial "metrics" (Wu et al. 2000). Spatial structure metrics can be linked to function through a variety of analyses including regression-based and other types of statistical models and sensitivity analyses (Tischendorf 2001). For example, a tidal marsh-dependent vertebrate species might require connectivity with other wetland patches for dispersal and recruitment purposes, or may experience higher rates of predation in marshes with a high ratio of edge to interior habitat. Measurement of landscape context metrics may reveal adjacent land uses as potential stressors, or hint at exchange rates across ecotones.

For the LACPR, spatial characteristics will be calculated for important wetland features at the site and landscape scales and tied to ecological functions through hypotheses supported by conventional landscape ecology theory. It is anticipated that studies will be conducted to better link the spatial metrics and key functions, and that future revisions to the spatial model may be required. Remotely sensed satellite and low-altitude aerial photographic data combined with spatial data analysis tools in ARCGIS will be used for the assessment. This approach has proven successful in measuring broad scale landscape patterns and correlating such patterns with ecological functional changes (Kelly 2001).

Numerous spatial metrics have been used to characterize various landscape attributes and, by inference, important ecological processes. They can be categorized as follows:
(a) area metrics, (b) core area metrics, (c) patch density and size metrics, (d) edge metrics, (e) shape metrics, (f) diversity metrics, and (g) connectivity/interspersion metrics. Since many spatial metrics are highly correlated, an appropriate number of metrics each representing area, edge/shape, and connectivity/interspersion will be used in discriminating alternative plans. It will be necessary to relate the metrics to important processes or characteristics so that they can be interpreted for weighting the alternative plans. The table below establishes some of the potential inferences from each metric.

Metric	What is Measured	Related Processes/Conditions
Area	Composition	Stability/resiliency; Geomorphic process (if temporal assessment applied); Productivity
Edge/Shape	Configuration	Primary productivity; Hydropattern (applied to open water pathways); Stability/resiliency
Connectivity/ Interspersion	Configuration	Local spatial variability (diversity)

Table 13. Spatial Integrity Metrics and Related Processes/Conditions.

These metrics, and particularly interspersion, are highly scalable and determining the appropriate scale of application will be necessary. The large ecological gradients in the eastern basins may

require division into smaller units (e.g. fresh/intermediate vs. brackish/saline) for landscape metric characterization.

Several trade-offs may be embedded within individual metrics. For example, edge and interspersion could both be used to assess wetland fragmentation. While this may result in higher primary productivity, it may also eventually lead to more rapid wetland losses. This suggests a careful evaluation of the metric sets and, where possible, identification of important thresholds or trade-offs.

Although the intent of the spatial integrity metric is to compare alternative plans, it may be possible to also refine the models so that they provide some predictive capability. Valid comparison to reference wetlands is difficult, but correlations between spatial metrics and ecosystem services may be developed over time, provided the appropriate data collection and analyses are conducted.

This study proposes to identify and test a variety of spatial metrics and incorporate them in a spatially-explicit model to assess historic trends. The historic trend output would then be used by the LACPR HET team to (1) support projections of "future without" and "future with" alternative landscape configuration patterns and (2) determine which restoration alternatives promote the greatest ecological sustainability.

Approach

Study Area

This study utilized the LACPR planning unit boundaries minus fastlands as the overall spatial extent (Figure 1). The spatial boundaries upon which the metrics were run are 4km^2 grids. The boundaries of these 2km x 2km tiles are consistent with the original Louisiana Coastal Area (LCA) grid. Based on these spatial designations, a total of 8,437 tiles were evaluated in the study area using both grid-based and landscape-scale fragmentation analyses. The landscape-level metrics and analyses were used to assess more general trends in landscape configuration by planning unit.

Landscape Metrics

FRAGSTATS (McGarigal and Marks, 1995) is a software program designed to compute a wide variety of landscape metrics for categorical map patterns. This program was utilized because of its well tested utility as a packaged management tool and because it provides the greatest likelihood of product reproducibility. FRAGSTATS uses a grid-based approach, which is commonly not suitable for class scale determinations on entire landscapes; however it can provide class-level metrics, classification and assessments through individual non-related grid tiles. Historically, FRAGSTATS has been used for habitat suitability, change, and connectivity dynamics for forested ecosystems. Although there is very limited scientific literature on the study of marsh fragmentation and classification using FRAGSTATS, the authors have tested the use of this program to evaluate marsh breakup patterns in Terrebonne Parish, Louisiana under a saltwater intrusion scenario (Steyer et al., in prep), and feel it is appropriate for this study.

Landscape Classification

The Spatial Integrity Index (SII) developed as part of this study utilized a land-water classified image and a two-part classification system to support projections of landscape change as influenced by restoration alternatives. The two levels used in this system to denote landscape structure are: (1) *category*: ratio of water to land, and (2) *configuration*: marsh water area, shape and connectivity. This classification system (modified from Dozier, 1983) assigns values 1-10 to represent percentages of water. In this study, we represent the 10 classes of water as follows:

- Category 1, 0% to <5% water within marsh,
- Category 2, 5% to <15% water,
- Category 3, 15% to <25% water,
- Category 4, 25% to <35% water,
- Category 5, 35 to <45% water,
- Category 6, 45 to <55% water,
- Category 7, 55 to <65% water,
- Category 8, 65 to <75% water,
- Category 9, 75 to <85% water, and
- Category 10, >85% water.

The system subclasses utilized are identical to Dozier (1983) and are designated by the configuration of water bodies in the marsh. Class "A", are configurations that are typically large water, (in relation to percent water class) and have connected water patches with linear edge. Class "B", are configurations that are typically small (as related to associated percent water class) disconnected patches with a more random distribution, and fewer instances of connection. Class "C", are configurations that are a combination of both class "A" and class "B" (with discernible regions of both). Figure 2 illustrates the SII class system. The numerical precursor denotes the amount of each tile occupied by water (increasing toward class 10) and the spatial configuration of water and land patches in each tile represented by A, B and C.

Due to considerations of data availability and time periods of interests, four dates of classified TM Landsat Thematic Mapper satellite imagery were selected for this examination. The classified land:water images utilized in this methodology were taken from existing data analyses described in Morton et al. (2005), Barras (2006), and Barras et al. (in-prep) using the same standardized methodology. The imagery and data utilized, from 1985, 1990, 2001 and 2006, were collected under similar water level and seasonal conditions.

To determine the appropriate grid scale required for maximizing the accuracy of SII classification, 4 km^2 and 16 km^2 raster grids were evaluated. These grid scales were identified because they were coarse enough to permit the extensive computer processing, and fine enough to not bias the classification. To standardize the tiling origin, and alleviate potential shift error, the project vector grid origin was based on an established grid system developed by Twilley and Barras (2003) for the Louisiana Coastal Area Ecosystem Restoration Study. Each land-water image was tiled using a geoprocessing routine to expedite the preparation and extraction of all raster grids or "tiles". Each tile was then processed using FRAGSTATS and analyzed at the class metric level (i.e., statistics computed for every patch type or class in the landscape), and at

each designated grid scale. Tiles were sorted by adjusted water percentages (recalculated category class, excluding "other" class), and by preliminary configuration thresholds (established to assess suitable metrics and metric combinations). Countless arrangements of metrics and metric combinations were selected and tested against configuration definitions. Category and configuration class output were assessed for accuracy of the computer generated classification. This method was used to evaluate all potential metrics, fit value thresholds to visually derived SII, and select adequate scale of tile. It was determined that the classifications based on the 4 km x 4 km extracted tile were often overwhelmed by large open water bodies, contained multiple SII classes, and were therefore too large to accurately classify the landscape. Conversely, the 2 km x 2 km tile system consistently classified the landscape correctly and thus was selected for this study.

The following landscape metrics which represent area, edge/shape, and connectivity/interspersion were selected after careful consideration of previous landscape fragmentation and configuration study metrics and evaluation of selected metrics toward meeting study goals.

Percentage of landscape occupied by water (PLDW) quantifies the proportional abundance of water within each patch type in the landscape. It is measured as the percentage of the landscape comprised of the corresponding class.

Number of patches of water (NPW) of a particular patch type is a simple measure of the extent of subdivision or fragmentation of the patch type. It is measured as the number of patches of the corresponding class.

Patch density (PDW) of water has the same basic utility as number of patches as an index, except that it expresses number of patches on a per unit area basis that facilitates comparisons among landscapes of varying size. It is measured as the number of patches of the corresponding class divided by total landscape area.

Largest patch index (LPIW) of water at the class level quantifies the percentage of total landscape area comprised by the largest patch. As such, it is a simple measure of dominance. It is measured as the percentage of total landscape area comprised by the largest class.

Edge density of land (EDL) equals the sum of the lengths (m) of all edge segments involving the corresponding patch type, divided by the total landscape area (m^2). Edge density reports edge length on a per unit area basis that facilitates comparison among landscapes of varying size.

Normalized Landscape shape index (NLSI) provides a simple measure of class aggregation or clumpiness. It is measured as the class perimeter length divided by the minimum perimeter needed for maximum aggregation.

Patch cohesion index of water (COHW) measures the physical connectedness of the corresponding patch type. Patch cohesion increases as the patch type becomes more clumped or aggregated in its distribution; hence, more physically connected.

Aggregation index of water (AIW) is calculated from an adjacency matrix, which shows the frequency with which different pairs of patch types (including like adjacencies between the same patch type) appear side-by-side on the map.

Modified Simpson's diversity index (MSIDI) belongs to a general class of diversity indices to which Shannon's diversity index belongs. The Modified Simpson's diversity index evaluates whether any 2 classes selected at random would be different patch types.

Landscape Evaluation

The SII was used to examine multiple restoration alternatives, and project future landscape pattern under those scenarios. The restoration alternatives that were presented for evaluation are as follows:

- R1, (Figures 3a - 3e);
- R2, (Figures 4a - 4e);
- R3, (State Master Plan, Figures 5a - 5e);
- R4, (Figures 6a - 6e); and
- R5, (LCA Plan Best Meeting Objectives, Figures 7a - 7e).

Each of these alternatives was based on a low sea-level rise scenario. The diversion, marsh creation and barrier island measures of these plans were the primary features modeled in this application based on the initiation data provided by the HET team. Features such as shoreline stabilization, ridge restoration and gapping banks were assumed to have little effect on land change and configuration.

In order to provide a baseline of comparison, a "future without project (FWOP)" predictive scenario was created. While multiple "future without" scenarios have been developed in recent years, most project land loss or gain with little or no attention to the spatial pattern of that land. The LCA land loss polygons described in Barras et al. (2003) were updated for the current trend of land loss generated from 13 dates over the timeperiod 1978 – 2006. Polygons not evaluated for land loss trends under Barras et al (2003) were incorporated under the current analysis using the 1985-2006 data. The LCA polygon trend data set was rasterized at a 25x25 meter cell size to create a raster index file containing each loss polygon identified using a unique integer id (Figure 8). The Leica Imagine "Summary" function was then used to compare the raster index LCA loss unit file to each Landsat Thematic Mapper satellite classified land-water coastal mosaic and simplified historical habitat land-water coastal dataset to identify land-water acreage for each dataset by LCA trend polygon. To establish the FWOP scenario at year 50, a linear regression fit was applied to the data (Paille et al., in-prep). This FWOP scenario defined the total remaining acres in each of 183 polygons across the study area annually through year 2060 (50 year projection). The acreage by polygon was then merged with the tile grid in order to determine future acreage by tile. The composition of tiles in 2006, as well as trajectory of change over the 1985-2006 time period, was utilized to drive assumptions as to the spatial configuration of future acreage. All 8 metrics were run and evaluated by planning unit for years 2006, 2010, 2020, 2030, 2040, 2050, and 2060 to remain consistent with the LACPR land change evaluations.

Upon completion of the FWOP scenario, the restoration alternatives were evaluated. For each alternative, shape boundaries of all restoration measures were overlaid on the 2 km x 2 km grid. Tiles that were influenced by restoration measures were assigned new spatial configurations estimated based on land:water acreage provided by Paille et al., in-prep). Tiles affected by a restoration measure were compared to the same tile under the base year 2010 of the FWOP scenario for examination of effects. Details of the modeling approach are provided later in this document.

Determining future spatial configurations of restored landscapes with any degree of certainty is impossible at this time. The science has not evolved enough to support strong linkages between pattern and process that this level of assessment needs. A multiple lines of evidence approach was utilized that includes identifying historic patterns as a predictor of future change, identifying natural analogs that represent the types of restoration proposed, and using rules to drive configuration changes based on hypotheses of how spatial metrics and SII classes are linked to key functions provided by different categories of restoration measures.

In order to conduct the multiple lines of evidence approach, we identified eight categories of restoration measures that were common to the three restoration alternatives and considered them based on their location within the coastal landscape (high energy versus low energy). The categories are (1) freshwater diversions, (2) freshwater diversions coupled with marsh creation, (3) sediment diversions, (4) marsh creation coupled with shoreline stabilization, (5) marsh creation, (6) shoreline stabilization, (7) ridge restoration, and (8) barrier island restoration. Rules or hypotheses were then established that define how these restoration measures influence spatial configurations based on conventional landscape ecology theory and existing scientific literature or best professional scientific judgment. The existing scientific knowledge that helped frame our hypotheses are identified below.

Existing Scientific Knowledge:

- Suspended sediments increase and organic content decreases with increasing connectivity to riverine sources.
- Sedimentation rates in salt marshes vary as a function of either the distance from tidal channels or with flow distance between marsh and larger bodies of water.
- Sedimentation rates are inversely related to distance from marsh edge when sediment supplies are available to marsh.
- Sedimentation rates are positively related to hydro period (inundation duration) when sediment supplies are available to marsh.
- There are tradeoffs between hydro period and sedimentation. Increasing hydro period (to support sedimentation) beyond plant community thresholds will decrease productivity.
- Dissolved nutrient availability to marshes generally increases with greater connectivity to riverine sources and greater residence time of water.
- Sedimentation rates are positively related to plant stem density under normal conditions. Sedimentation by large storms may impact this relationship.

- Connectivity is a function of habitat type, drainage density, waterway orientation and levee height.
- Marshes tend to aggrade where fluvial flow becomes unconfined and degrade away from such sources.
- The flux of energy and nutrients across an ecotone depends on the surface area of the wetland contact zone.
- High river discharge coupled with southerly wind conditions can lead to sheet flow and sedimentation on the marsh.
- Storm surge breaks in barrier islands occur where the island width is least; so increasing island width not only minimizes the effects of storm surge, but also traps the sand as it rolls over the island.

Hypotheses

- Freshwater Diversions into existing patchy marsh will favor deposition of both organic and fine inorganic material and slowly increase sediment platform elevation. Large diversion flows or pulses into upper basins may result in transition to less fragmented classes due to the development of flotant. RULE: Existing marsh patches (B and C classes) will expand along their edges (stay within class or B go to C class) and small marsh patches will not coalesce unless large pulses or high diversion flows are employed (C class can go to A class, but is dependent on distance from source).
- Freshwater Diversions into large contiguous marsh creation patches will maintain contiguous marsh integrity by providing necessary sediment and nutrients to sustain the marsh. RULE: A class remains A class if sustained by diversion.
- Sediment Diversions into existing patchy marsh with low land:water ratios and slow currents will facilitate coarse and fine sediment deposition onto subaqueous habitats (e.g. bay bottoms), increasing their elevation and ultimately transforming them to subaerial marsh platforms (near field effect – extent dependent on diversion size/sediment content). RULE: Existing marsh patches will expand along their edges as adjacent ponds are infilled with sediment, and marsh patches will coalesce nearest the diversion. This effect might be greatest in class B and C. Increased channelization in near field will route flows and decrease sediment retention.
- Marsh creation will form contiguous marsh, and therefore increase the flow resistance on the marsh platform and thus concentrate flow in developed channels while maintaining large marsh patches. RULE: Marsh creation projects produce class A patterns immediately, with immediate formation of marsh channels, which are then subjected to change to class B or C based on trajectory of change from 1985-2006 by planning unit by marsh type.
- Marsh creation will form contiguous marsh, and coupling with shoreline stabilization will only change land:water acreage and not configuration (except immediately adjacent to shoreline stabilization). Therefore, increase in the flow resistance on the marsh platform will concentrate flow in developed channels while maintaining large marsh patches. RULE: Marsh creation projects produce class A patterns immediately, which are then subjected to change to class B or C based on trajectory of change from 1985-2006 by planning unit by marsh type.

- Shoreline stabilization will only change land:water acreage (from reduced shoreline erosion) and not change configuration. RULE: Trajectory of change from 1985-2006 by planning unit by marsh type will be applied to future condition.
- Ridge restoration will enhance skeletal network for water distribution within planning units, but no effect on pattern can be predicted. RULE: Trajectory of change from 1985-2006 by planning unit by marsh type will be applied to future condition.
- Barrier Island restoration will form contiguous back barrier marsh that may be enhanced by island rollover, but also susceptible to significant erosion during storm events. RULE: Marsh creation projects produce class A patterns immediately, which are then subjected to change to class B or C based on trajectory of change from 1985-2006 by planning unit by marsh type.
- Ecosystem performance and species survival are enhanced when external (storms) and internal (water flow) pulses are coupled.

Some of the assumptions made in applying the hypotheses in this application are:

- The effects of protection structures (levees) on water transport and flow, and how that process influences spatial configuration of the landscape was not addressed. It is anticipated that there will be non-linear responses in the landscape to these engineering features.
- Freshwater diversions will be operated in a manner that will not cause persistent flooding and impacts to the marsh landscape.
- No rapid subsidence collapse of the marsh landscape as described by Morton et al (2005) will occur again.
- Patchiness of vegetation is strongly dependent on propagation patterns (local reproduction strategies) of individual plant species within a marsh community type, but this will not be addressed.
- Build up of new land or the development of open water is a balance between net inputs of suspended sediments and organic production and outputs due to subsidence and export of eroded sediments.
- Primary productivity and, hence, stem density is enhanced with increased dissolved nutrient availability when nutrients are limited. This assumption does not take into account some evidence that belowground productivity will be reduced with increased nutrients nor that nutria may prefer higher nutrient plants.
- The remaining coastal landscape is more resilient to wetland loss (harder to lose) than the marsh that has been already lost, however it will be treated the same.
- Internal and external pulses were not coupled, therefore the effects of levees and shoreline stabilization on back marsh spatial integrity was not captured by spatial integrity metrics.
- Channel infilling will continue only until an equilibrium condition is reached based on the flow rates (tidal or diversion velocities) and the stability of the vegetation/soil matrix of the marsh.
- High discharge freshwater diversions or pulsed diversions will provide sedimentation on the marsh surface, but will also experience erosion in areas closest to the diversion.
- Barrier Island widths when restored will be maintained to eliminate island breaching during large storms.

These hypotheses need to be tested in order to better link the spatial metrics to key functions. As an initial test of the hypotheses, SII classes should be calculated for natural analogs representing some of the categories of restoration measures. In coastal Louisiana, there are few restoration projects that have been constructed and in place for a sufficient period of time to assess spatial change. The projects suggested for this evaluation are Sabine Refuge 1993, 1996, 1999 and Bayou Labranche 1994 representing marsh creation; Naomi 1993, West Pt ala Hache 1993, and Caernarvon 1991 representing freshwater diversion in broken marsh; West Bay 2003 representing sediment diversion into open water; and Wax Lake Outlet 1973 representing natural delta development.

Modeling Approach

FWOP

The foremost premise upon which the model operates is an assumption that different SII classes change in variable patterns. Observation of historic trends (1985 to 2006) will be used to determine how resistant A, B and C classes are to change, and how they vary by water class as well as across planning units. These spatial and categorical delineations will be utilized to drive future projections.

The mean change over time for each of the 8 spatial configuration metrics were calculated for every possible combination of planning unit (PU) and SII class. Any PU_SII class combination which did not occur during the observation period was assigned the average of a similar PU_SII class combination; however, this occurred infrequently. An assumption of linearity of change was then utilized (due to time constraints) and mean metric change was converted to a change rate on an annual basis. These change rates then formed "lookup tables" upon which the model draws (Appendix A of Attachment D).

Future projections (2010 – 2060) are based on land area change provided by Paille et al. (in prep), where the model attempts to reflect the land change data, driving the classification into the numeric portion of the SII class (1, 2, 3, 4, 5, 6, 7, 8, 9, 10). Land change projections were conducted on larger polygons than the 4 km^2 tiles used in this analysis. Therefore, tiles were assigned to polygons based on a majority rule. For FWOP projections, land gain or loss rates (in each 10-yr period) were then assigned to each tile in a polygon and projected future land area was calculated.

The spatial configuration portion of the SII class was calculated for each of the 8 metrics based on the lookup table value of the starting time period PU_SII class. Those tiles which experienced land gain utilize gain rates and loss tiles utilize loss rates. The annualized rate was first calculated for 4 years to achieve a 2010 projection. The 2010 SII class was then assigned based on the newly calculated spatial configuration metrics.
The process then iterates for the next 10-yr period based on the new SII class lookup value. The year 2010 served as our base year for the projection of future change.

Alternatives Assessment
The presence of hypothetical diversions and marsh creation measures in the alternatives required additional approaches for creating projections. As with the FWOP scenario, net benefit acreage

for each of the measures that comprise the restoration alternatives was provided by Paille et al. (in-prep), and the model seeks to reflect those data. Net benefit acreage was again assigned to larger polygons, so tiles were assigned to polygons based on a majority rule. The model seeks to first distribute that benefit acreage appropriately throughout the tiles based on the type of restoration measures; however each type was modified differently based on the rules that were previously described.

Benefit area assignments were defined for marsh creation measures, marsh creation measures sustained by diversion measures, and diversion measures. The approach for each is defined as follows:

Marsh Creation Benefit Area Assignment

- Total available water area was assessed for all tiles in a given polygon.
- This figure was then multiplied by 0.7 as a result of the desire to implement marsh creation projects in a 70/30 land/water ratio.
- The resulting acreage was the maximum available area to be built, which was then compared to the Paille et al. (in-prep) benefit acreage for that 10-yr period.
- All cells were brought to the highest land acreage possible and assigned a spatial configuration class of "A". The mean metrics for the class were assigned.
- If the maximum available area was less than that of the benefit acres provided, that benefit could not be reflected.
- If the marsh creation project was not sustained by a diversion, it was subjected to 10-yrs of loss spatial configuration change rates and the process repeated for the next 10-yr period.

Marsh Creation (sustained by diversion) Benefit Area Assignment

- The benefit area was assigned in the same manner as other marsh creation projects, however the sustaining effect of the diversion was assumed to keep the spatial configuration as an "A" class.

Diversion Benefit Area Assignment

- Diversion land building was excluded in SII classes 1 and 10.
  - The assumptions here being that a diversion will not build a tile to any more than 95% land, and open water is very difficult to alter and build land.
- Diversion benefits were commonly assigned to large polygons, requiring a means of further discriminating where benefits occurred.
- Diversion "Zones of Influence" polygons were often found to not contain enough available water area to reflect the land benefit acreages provided.
- A shortest distance to diversion methodology was utilized where:
  - The cell which was closest to a diversion would first be subjected to gain rates as assigned by PU_SII class for a ten year period;
  - The model would then check that increase in acreage against the total benefit provided. If more benefit needed to be assigned, the next closest cell would receive benefits;
  - Once all benefits were assigned, the model would exit the loop and move on to the next diversion.

- A 20km threshold was also utilized as the maximum distance a diversion could assign benefits to avoid situations in which the benefit acreage criteria was not met, and consequently land building occurs at distances it logically could not benefit.
- If the benefit acreage can not be completely assigned within those restrictions (available tiles SII classes 2-9, within 20km) those benefits could not be reflected.

The LACPR HET will ultimately be responsible for placing value judgments on what type of spatial pattern is more beneficial from an overall ecosystem sustainability perspective. A reproducible numeric approach was developed for each selected metric (percentage of landscape occupied by water, edge density of land, and patch cohesion), where the average values calculated from each of the four dates of imagery (1985, 1990, 2001 and 2006) were averaged across all dates to determine rankings by SII. The SII rankings were then assigned an index value from 0 – 1 based on equal distribution across the 24 SII classes. These values were then used to calculate average values for each metric by PU. This type of ranking system may prove valuable to facilitate the comparison and interpretation of results; otherwise evaluation of positive or negative effect for particular processes as represented by a specific SII (i.e., fisheries utilization vs. land stability) will be a subjective determination by the LACPR HET.

Results & Discussion

The results and discussion presented in this draft report are going to concentrate on change assessments for PU's 1, 2, 3a, 3b, and 4 between two historic time periods (1985 and 2006) and two future dates (2010 and 2060) even though multiple dates were assessed. Additionally, results will focus on the metrics "Percentage of Landscape Occupied by Water", "Edge Density of Land", and "Patch Cohesion" as metrics that best represent the functions land stability, fisheries utilization, and hydrologic connectivity, respectively.

Classification Change

Historic Evaluation

The SII was calculated for 8,437 tiles coastwide for 1985, 1990, 2001 and 2006, and the spatial representation of the data from 1985 and 2006 are shown in Figures 9 and 10, respectively. The darker saturations/intensities (within a particular color) represent A classes, which denote large, contiguous patches of land and at least one large, contiguous patch of water. The intermediate saturations/intensities (within a particular color) represent C classes, which denote some fragmented patches of land and at least one large, contiguous patch of water. The light saturations/intensities (within a particular color) represent B classes, which denote a disaggregated configuration of land and water patches occurring throughout the tile.

Preliminary observations of these data suggest that the classification system accurately classified the amount of each tile represented by water. Overlays of these results with the original land:water classification by Barras (2006) showed a significant match. The SII also appear to match up fairly well with long term personal observations. As an initial sensitivity analysis, an evaluation of PU's 1 and 2 (Figures 11 – 12) and PU's 3a, 3b, and 4 (Figures 13 - 14) was conducted to corroborate results from this study with detailed pre and post-hurricane observations and data collection that was conducted in 2004, 2005 and 2006 throughout coastal

Louisiana. The lighter saturation/intensities in upper Breton Sound in PU1 and in Cameron Creole Watershed in PU4 in 2006 are confirmed B classes. Preliminary data comparisons of configuration classes in PU's 2, 3a and 3b were inconclusive. A more detailed sensitivity analysis needs to be conducted in the future.

The coastwide evaluation of SII changes from 1985 to 2006 is presented in Table 1. This matrix shows that over 58% of the coastwide tiles classified remained unchanged over this 21 year period. More importantly, it shows that tiles that started out as either class 1 (solid land) or class 10 (solid water) remained stable and didn't change class over the timeperiod. The data also show that generally A classes are most stable over time, followed by C classes and B classes. The percent of the A classes that remained unchanged, regardless of the water class in the tiles, always exceeded that of the B and C classes. Additionally, as water classes increase, the B classes that remain unchanged decrease. These findings suggest that the general trend of most stable to least stable is class A to C to B. When this evaluation was conducted at the planning unit (PU) scale, all planning units followed this general trend. Results from PU's 1, 2, 3a, 3b and 4 are included in Tables 2 - 6. It is interesting to note that PU1 had the greater amount of percent unchanged tiles (70.8%) whereas PU4 had the least (41.67). The result in PU4 may be reflecting the change in solid land (class 1) to water classes that is associated with impacts from Hurricane Rita. Further investigation into why there are large differences in the amount of percent unchanged tiles between PU's is needed.

FWOP

The FWOP SII was projected for 2010 and 2060 and is shown for PU's 1-2 in Figures 15 and 16. The greatest change over this time period is reflected in the increase in open water (higher SII classes), that visually match the land loss estimates provided by Paille et al. (in-prep). The large open water projected by 2060 is primarily in the marshes adjacent to the Gulf of Mexico in PU's 1 and 2, adjacent to large existing water bodies in PU1, and in interior marshes in central Barataria Basin in PU2. Figure 17 illustrates this point by showing that the middle and lower portions of PU's 1 and 2 are completely dominated by water. The SII change matrices also reflect the increase in water from 2010 to 2060. Planning unit 1 (Table 7) is dominated by a 1 category increase in water and a large shift in A classes to C classes. The matrix for PU2 (Table 8) illustrates 1-3 category increases in water (primarily 2 category), reflective of the higher landloss rates in PU2. The configuration of the remaining landscape is dominated by larger water patches in Barataria and Breton Sound and a greater disaggregation of land in lower Pontchartrain Basin (Figure 18). Planning units 1 and 2 have a slightly greater connectivity between water patches in the lower basin and a greater connectivity in the upper basin, as reflected in the patch cohesion metric in Figure 19.

The FWOP SII projections for 2010 and 2060 for PU's 3a, 3b and 4 are shown in Figures 20 and 21. The areas showing the highest SII classes reflecting increases in open water visually match those estimates provided by Paille et al. (in-prep) and Barras et al. (2003). The areas projected to continue to fragment and/or convert to open water include, but are not limited to, the landscape between Lake Boudreaux and Bayou LaFourche in PU 3a, North of Lake Mechant in PU 3b, and Grand Chenier and south White Lake in PU 4. The landscape west of Calcasieu Lake does not reflect well the losses projected from Barras et al. (2003). This area (other than the southwest region) shows higher percentages of water in 2010 than in 2060 (Figure 22), which suggests

either an error in the model or that the polygon size and associated land loss rate applied from Paille et al. (in-prep) needs to be adjusted. The matrix for PU3a (Table 9) illustrates 1-3 category increases in water, consistent with the highest landloss rates found in this PU (Figure 22 and 23). Planning unit 3b, which includes a land building area in the Atchafalaya delta, and PU4 have slightly greater connectivity between water patches, as reflected in the patch cohesion metric in Figure 24, but also a smaller change in water category classes as compared to the higher loss areas in PU's 2 and 3a (Tables 10 & 11). A limitation of the projections is they assume that trajectories of land change and land configuration in the past (1985 – 2006) will be the same in the future. Refinements to address this assumption and a more detailed sensitivity analysis will be conducted in the future.

Alternatives Assessment

The alternatives assessment focused on evaluations of each of the alternatives at 2060 as compared to the FWOP condition. In PU's 1 and 2, all of the alternatives had greater spatial integrity than the FWOP condition (Figure 16). Most restoration measures within all of the plans are clearly identifiable. The R1 and R2 diversion and marsh creation measures increased the spatial integrity significantly in upper Breton Sound, the east flank of the Barataria Basin and the Barrier Islands (Figure 26). The R3 diversion and marsh creation measures increased the spatial integrity significantly in the Biloxi marshes, the east and west flanks of the Barataria Basin, the upper birdsfoot delta, and the Barrier Islands (Figure 27). The R4 diversion and marsh creation measures increased the spatial integrity similarly to R3 except had less spatial integrity in the upper Breton Sound and upper birdsfoot delta (Figure 28). The heavy influence of diversions and limited marsh creation is evident in the spatial integrity patterns of alternative R5 (Figure 29).

Planning units 3a, 3b and 4 also had greater spatial integrity than the FWOP condition for all alternatives (Figure 21). The influence of marsh creation features on the landscape, especially in PU3a - upper Terrebonne Basin are obvious (Figures 30 – 33), and when combined with freshwater influence from the GIWW, show the greatest spatial integrity (Figure 31). The R5 alternative in PU3a limited the use of marsh creation and showed the greatest water classes in 2060 (Figure 34). The differences in spatial integrity among alternatives in PU3b and PU4 were barely recognizable, primarily due to the use of protection features, which are not captured by the model, and small benefit areas associated with marsh creation and freshwater introduction features.

The individual SII change matrices between 2010 and 2060 for each of the alternatives can be found in Appendix B. A summary of those matrices are provided by category (water class; Figures 35 and 36) and by configuration class (Figures 37 and 38). Though categories 1 and 10 are end members which signify extremes in the category class spectrum and are therefore important to the overall average change in classification, their frequency and resistance to change, both require and enable their exclusion from select summary statistics and figures. In PU1, the alternative that maintained a majority of land (classes 2 – 5) at year 2060 was R3 followed by R1 and R2 then R4 > R5 > FWOP (Figure 35). There was little difference in the occurrence of A classes at year 2060 between all alternatives except R5 (Figure 37). In PU2, the alternative that maintained a majority of land (classes 2 – 5) at year 2060 was R1, followed closely by R2 and R3 with the least land classes in R5 > R4 > FWOP, however the increase in

water classes 6 – 9 do not show FWOP as the greatest. This decline in FWOP classes 6 – 9 was expected since a higher percentage of tiles converted to class 10 in FWOP than in any other plan. The greatest number of A classes and fewest number of B and C classes are found in R3.

In PU3a, the alternative that maintained a majority of land (classes 2 – 5) at year 2060 was R3 followed closely by R1, R2 and R4 then R5 > FWOP (Figure 36). There was little difference in the occurrence of A classes at year 2060 between all alternatives except R5 (Figure 38). In PU3b and PU4, a trend of declining frequency in water classes as you gain more water was distinct (Figure 36). This is evident of natural land building that occurs in the Atchafalaya delta in PU3b and lower land loss rates in PU4. The results across all PU's illustrate that you lose a higher percentage of B classes in FWOP and that a large number of C classes are converted to A classes by marsh creation and diversion measures.

The ability to discern the influences of restoration measures on specific functions, and therefore compare each alternative was captured through a change analysis by metric between FWOP and each alternative. This approach shows only the influences of the restoration measures that comprise each of the alternatives, with no change represented outside of these areas. The change in percentage of landscape occupied by water metric for Alternatives R1 – R5 are shown for PU's 1 and 2 in Figures 39 – 43 and in PU's 3a, 3b and 4 in Figures 44 - 48. The change in the edge density of land metric for Alternatives R1 – R5 are shown for PU's 1 and 2 in Figures 49 – 53 and in PU's 3a, 3b and 4 in Figures 54 - 58. The change in the patch cohesion of water metric for Alternatives R1 – R5 are shown for PU's 1 and 2 in Figures 59 – 63 and in PU's 3a, 3b and 4 in Figures 64 - 68. These figures provide a visualization of how particular functions as represented by the metrics are maintained in 2060 by the different alternatives. The details of how individual metrics change among alternatives and FWOP between 2010 and 2060 are included in Figures 69 - 74 and Tables 12 - 14. In PU's 1 and 2, the general pattern in 2060 is that R3 has the smallest percentage of landscape occupied by water, followed by R1 and R2, then the most water in R4 < R5 < FWOP. In PU3a, R4 has the smallest percentage of landscape occupied by water. The patterns in PU3b and PU4 are similar with R3 having the smallest percentage of landscape occupied by water, followed by R1 < R2 < R4 < R5 < FWOP. Alternative R5 had the greatest amount of water at year 2060 across all PU's. The amount of edge metric represented in Figures 71 & 72 must be interpreted carefully because edge density increases when SII classes 1 – 5 degrade and then edge density declines when you increase the amount of SII classes 6 – 9. All PU's show declines in edge density over time except in PU3b, where active land building (Atchafalaya delta) and large marsh creations into previous large open water areas increase edge. Cohesion values represent in part how water bodies coalesce over time as land is lost. Across all PU's, R3 generally had the lowest cohesion of water values whereas R5 and FWOP had the highest values.

Index values were created for each metric to calculate an average value for each metric by PU to support a further evaluation of alternatives. It is important to note with regard to interpretation of R1 and R2, that the model is incapable of appropriately projecting the differential effects of the operation schemes which distinguish these alternatives from each other. As the locations of diversions and marsh creation features are held constant, leaving only the net land area benefits to vary among the plans, we expected and indeed saw nearly identical results for these plans.

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A land stability index was generated from the percentage of landscape occupied by water and the number of unchanged tiles (Figures 75 and 76, Table 15). Though it may be intuitive to believe this occurs as a result of these plans building the most land, it is not necessarily the case. The land stability index places emphasis not only on the amount of land built, but the spatial configuration of that land. Also, the results of the spatial integrity model utilized in this analysis are highly dependent upon the spatial distribution of restoration features throughout a landscape. The greatest land stability was found in R3 for alternatives PU1 and PU2; R4 in PU3a; R1 in PU3b; and R1 and R3 in PU4. In general, it appears that R1, R2 and R3 seem to have employed a greater number of small to medium diversions, spaced strategically throughout the PU with significant marsh creation. A diversion strategically placed to influence large areas of degraded, fragmented marsh will often have more beneficial results than a diversion placed in close proximity to large amounts of open water. This occurs as a result of multiple assumptions built into the spatial integrity model. First, diversion benefits are only allowed within a 20km distance of the diversion. Second, benefits are not allowed to be assigned to "open water" (Class 10) or tiles containing more than 95% land (Class 1). The combination of these assumptions can lead to situations where the model is incapable of assigning land building benefits. Placement is also of the utmost importance with regard to marsh creation projects. Marsh creation projects are assumed to be installed as "A" configuration classes (typically containing large amounts of aggregated land). Therefore, a marsh creation project which falls on top of areas which are already highly aggregated will have less beneficial influence than one placed in highly disaggregated areas. This is reflected in PU2 where R3 employed the greatest amount of marsh creation and had the greatest land stability at 2060. The R5 alternative in PU4 shows a significant increase in land stability from 2010 to 2040. This finding is contrary to what we would expect and may be reflective of how benefits (land loss rate reductions) were assigned associated with salinity control features in this alternative and the large polygon size that represents this area.

The edge utilization index was calculated from the edge density of land metric (Figures 77 and 78, Table 16). The results from PU's 1, 2 and 3a reflect the large contiguous marsh patches created initially followed by there disaggregation over time and creation of more edge. Alternative R5 which employed the least amount of marsh creation across PU's, showed high edge utilization values. This is suggestive of fewer A classes and a greater amount of B and C classes. The highest wetland loss areas are found in PU's 2 and 3b and this is reflected in very low values of edge utilization in 2060, apparently from small water patches coalescing into large water patches. There is an increasing trend in edge utilization in PU's 3b and 4 over time. This may be reflective of a less patchy landscape and more stable landscape in 2010 that then degrades over time. The low initial edge utilization index value of R5 in PU4 is consistent with the problem findings addressed in the land stability index.

The cohesion of water patch metric was used to generate the hydrologic connectivity index (Figures 79 and 80, Table 17). The FWOP reflects that as you lose land, there is a greater connectivity between water patches, and therefore high index values. The R4, R5 and FWOP alternatives had the highest values in PU's 1, 2, 3b and 4. This may be indicative of PU1 and PU2 starting out in a more deteriorated condition, such that new land building contributes to the large increase in cohesion of water patches. In PU3b and PU4, all alternatives decrease over

time. The cohesion of water patch trend most commonly reflects that C classes are higher than A classes which are higher than B classes

The results from all of the metrics suggest that the geographic location of features is highly influential on model output. In many ways, placement of restoration features has a larger influence on the values of spatial integrity metrics than does cfs load or net acres of benefit. It may be important to place larger emphasis on feature location in future plan development efforts.

Future Plans

The conception, creation, and implementation of this model took place in a very short timeframe. Minimal time was afforded for further investigations of historical trends and in depth assessments of the validity of model's assumptions and/or methodologies. Easy approaches were, at times, selected over more rigorous approaches due to time constraints and the lack of the scientific backing to draw on. Therefore, future study of the assumptions and methodologies is encouraged to increase the validity and value of the results.

One such assumption warranting further investigation are the rates of change projected for various restoration features. The model currently utilizes rates of change based on tiles experiencing land gain from a variety of sources during the 1990-2001 period. This approach excludes an ability to incorporate variable patterns of change which may result from features with variable design and operation schemes. For example, rates of spatial pattern change are exactly the same for a 1,000 cfs diversion as that of an 80,000 cfs diversion (until land gain projections are met). Similarly, the model currently assumes a steady and pulsed diversion operation scheme will affect spatial pattern in the same manner. Realistically, benefits and change in spatial pattern will probably vary with operation scheme, cfs load and other factors. Therefore, further investigation into these variables is considered vital to the utility of projections of spatial pattern under different restoration strategies.

Another issue in need of future study would be incorporation of bathymetric depth as a variable affecting the likelihood and magnitude of change, not only in terms of land gain, but the spatial pattern of that gain. One assumption that affects model output routinely is the restriction of diversion land building benefits in open water tiles (Class 10). This assumption is logical in most cases, in that a $4km^2$ area of open water is unlikely to experience land gain. These tiles are usually deep and subjected to sufficient energy to maintain them as open water. There are a few cases however, where shallow open water, protected from wave energy, should be considered viable candidates to receive land building benefits from diversions. Therefore, incorporation of depth dependency may also improve the value of results.

A constant threshold distance of 20km is currently utilized to prevent diversion benefits beyond a reasonable distance. This distance was commonly utilized in LCA and was agreed upon as a maximum distance at which you could expect benefits by a panel of experts. This assumption needs to be tested. Although one would expect a majority of the benefits to occur closest to the diversions, there is uncertainty regarding the distance from source that freshwater, sediment, and nutrient benefits are provided.

Investigation of boundary condition effects on the spatial integrity model also warrants further investigation. Boundary conditions may affect specific metrics primarily due to the Euclidean geometry of square tiles. This study utilized 4km^2 tiles in an attempt to alleviate boundary conditions as much as possible. Boundary condition effects could be reduced further by using a moving window analysis to assess patterns; however it is computationally intensive. Removing the potential influence of boundary condition effects may enable assessment of finer scale patterns, and thereby provide more accurate projections at finer scales.

Structural Metric: Direct Wetland Impacts

A direct wetland impact is the acreage directly lost or impacted by construction of structural alternatives (i.e., levees). It is a straightforward number that could eventually be used to determine the amount and, depending on habitat impacted, quality of habitat that needs to be replaced or restored through mitigation. This is not a measure of direct impacts due to non-structural or coastal restoration alternatives.

Methodology

To understand the full range of potential environmental effects from structural hurricane risk reduction measures (e.g., levees) both direct and indirect environmental effects must be assessed. For LACPR, the potential direct impacts to wetlands from the footprint of levees and associated borrow sites have been estimated using what is being called a "max-gross" approach. With the max-gross approach there is no consideration of temporal aspects such as background wetland loss rates and phased levee construction. The potential direct wetland losses (and associated mitigation needs) are calculated by simply overlaying the footprint of a given levee and associated borrow areas on the existing coastal landscape, assuming that all construction impacts occur simultaneously. The max-gross approach uses these simplifying assumptions to produce acreages of potential adverse direct wetland impacts.

Table 14 Direct Wetland Impacts for Structural Alternatives (acres)

	PU1
Structural Alternatives	Direct Impacts
LP-a-100-1	4,200
LP-b-400-1	3,600
LP-a-100-3	6,000
HL-a-100-3	5,500
LP-a-100-2	1,000
HL-a-100-2	4,100
LP-b-1000-1	3,700
HL-b-400-2	4,200
LP-b-400-3	7,500
HL-b-400-3	5,100
LP-b-1000-2	9,100

PU2	
Structural Alternatives	Direct Wetland Impacts
WBI-100-1	0
G-100-1	1,000
R-100-2	700
R-100-3	1,000
WBI-400-1	3,700
R-100-4	1,600
R-400-2	4,400
G-100-4	2,200
R-400-3	4,700
R-400-4	5,300
R-1000-4	6,800
G-400-4	7,400
PU3a	
Structural Alternatives	Direct Wetland Impacts
M-100-1	4,900
M-100-2	4,200
G-400-2	5,300
G-1000-2	6,600
PU 3b	
Structural Alternatives	Direct Wetland Impacts
G-100-1	2,300
F-100-1	2,500
F-400-1	3,900
F-1000-1	5,200
RL-100-1	900
RL-400-1	1,700
PU4	
Structural Alternatives	Direct Wetland Impacts
G-100-1	2,200
G-100-2	1,800
G-400-3	2,500
G-1000-3	2,500
RL-100-1	100
RL-400-1	100

Structural Metric: Indirect Impacts to Wetlands

(Note: Tables are presented in Attachment C)

Methodology

Given constraints in time and resources, the LACPR Habitat Evaluation Team (HET) did not think it possible to accurately quantify potential indirect impacts to wetlands and other aquatic resources from the structural hurricane risk reduction measures under consideration. Instead, the HET decided to qualitatively describe and compare the potential indirect impacts (both positive and negative) of the various proposed structural measures. The HET developed an indirect impacts ranking matrix which covers four categories of potential indirect impacts: Hydrologic Impacts, Fishery Impacts, Induced Development, and Ecological Sustainability/Consistency with coastal restoration. Using best professional judgment based on field experience and knowledge of pertinent scientific literature, the HET rated the various structural measures according to the following key:

- **"+2" indicates a relatively high potential for *positive* indirect impacts.**
- **"+1" indicates a relatively moderate potential for *positive* indirect impacts.**
- **"0" indicates relatively low to no potential for indirect impacts.**
- **"-1" indicates a relatively moderate potential for *adverse* indirect impacts.**
- **"-2" indicates a relatively high potential for *adverse* environmental impacts.**

Unlike the max-gross assessment of direct wetland impacts, the indirect impacts matrix does not provide an absolute measurement; rather, it describes how a particular alignment is expected to perform relative to other alignments and existing conditions in the same planning unit. Thus, the matrix is a tool for comparing levee alignments in terms of potential indirect impacts, as opposed to assessing mitigation needs. A moderate adverse ranking for hydrologic impacts, for example, does not necessarily mean that a particular alignment does not have the potential for significant adverse hydrologic impacts. It simply means that when comparing one alignment to another, the potential adverse hydrologic impacts of that alignment are substantially below what might be expected for other potential alignments in that planning unit.

Assumptions Regarding "Leaky Levees":
Both the State of Louisiana and the USACE are considering levee alignments that would enclose large wetland areas (e.g., alignments that parallel the Gulf Intracoastal Waterway [GIWW] in the Barataria Basin). Proponents believe that such levees can be built to minimize adverse impacts to the coastal ecosystem by incorporating gates and other structures to maintain or even restore natural hydrologic processes. Such levees are commonly referred to as "leaky levees"; as they would remain open to tidal flow at certain locations until a storm approaches.

In assessing the potential indirect effects of alignments that would enclose wetlands, the HET had to decide whether to assume that proposed leaky levees can and would be built to substantially minimize indirect impacts to the coastal ecosystem or whether in some cases such alignments pose a serious threat to the aquatic environment. There is much scientific information regarding the potential for levees and other unnatural linear barriers (such as spoil banks) to adversely affect coastal wetlands. However, there is little to no scientific information to substantiate the theory that leaky levees can actually accomplish the goal of minimizing

adverse indirect impacts to wetlands, particularly in the complex and dynamic hydrologic settings in which such levees would be built. *Given what is known about the potential negative effects of building barriers through aquatic ecosystems and the lack of understanding of how to minimize such impacts, the HET assumed that certain leaky levees may pose a serious risk of indirect adverse impacts to wetlands and other aquatic resources.*

In applying this assumption, the HET considered the amount of wetlands that would be enclosed by the proposed levee. Other factors being equal, the HET assumed that the greater the acreage of wetlands that would be enclosed within a proposed levee system, the greater the risk (or potential) for adverse indirect impacts. All other factors are not, however, equal. The analysis of the potential effects of leaky levees is complicated by the fact that the corridors upon which such levees would be built range in the extent of existing hydrologic obstruction. If, for example, a levee were to be built on an existing barrier (such as a levee, road, or distributary ridge), the risk for further hydrologic alteration is, in general, minimal. (In such cases, there may even be an opportunity to restore natural hydrology, with limited risk of further hydrologic disruption.) On the other hand, if a levee were built through a wetland area with limited or no existing barrier, the risk of hydrologic disruption would be far greater.

Thus, in addition to the extent of wetlands that would be enclosed, the HET also considered the extent of existing hydrologic obstruction in the corridor through which the levee would be built. The HET assumed, for example, that a levee alignment along Highway 90 in Barataria Basin would not have the greatest potential for hydrologic and fishery impacts (despite enclosing a large acreage of wetlands), because the existing highway and adjacent railroad already substantially block flow across the area (with the exception of Bayou Des Allemands). By comparison, the GIWW does not appear to obstruct hydrology to the same extent. (There are numerous cuts in the GIWW spoil bank, in addition to the passes at Bayou Perot and leading into Bayou Barataria.) Accordingly, a levee along Highway 90 would have substantially less potential for adverse indirect hydrologic impacts than would an alignment along the GIWW in Barataria Basin. (This risk is compounded by the fact that a GIWW alignment would enclose a far larger area of wetlands and open water.)

Critics of these assumptions might argue that leaky levees could theoretically be designed to mimic or even restore natural hydrology. In this sense, leaky levees could present an opportunity to both build structural hurricane protection and address coastal restoration needs. The HET does not necessarily challenge the conceptual basis for such a position. (Indeed, the HET acknowledges such potential in cases such as a Highway 90 alignment in Barataria Basin.) Rather, the HET questions whether there is sufficient knowledge to successfully design and build such levees in more complex situations. In the Barataria Basin, for example, we do not adequately understand the existing hydrology (basin-wide modeling for the Donaldsonville to the Gulf hurricane protection study is still being developed), nor do we know how much river water would ultimately need to be reintroduced for that basin to be sustainable. Future sea level rise, subsidence, storm intensity, and rainfall patters are also uncertain. Given these and other uncertainties, it would be premature to assume that certain leaky levee alignments could be built in a way that adequately minimizes the potential for adverse environmental impacts.

Categories of Potential Indirect Impacts

(1) Hydrologic Impacts

This refers to potential changes such as reduced or increased impoundment; reduced or increased sheet flow; and reduced or increased salinities. The following factors were considered in estimating the extent (positive or negative) of the potential hydrologic impacts:

- Extent to which the proposed levee alignment is located on an existing hydrologic barrier or disruption, and the extent to which that barrier would likely be maintained, increased, or reduced.

- Number of inlets/outlets through the area that would be traversed by the proposed levee alignment (includes major and minor channels and areas where sheet flow may occur), and the extent to which these inlets/outlets would likely be maintained, increased, or reduced.

- Amount of enclosed wetlands. (Indicates potential for impoundment/drainage problems, for example.)

(2) Fishery Impacts

This refers to potential reductions in fish access due to increased velocities and/or physical barriers; increases in fish access due to removal of obstructions; and/or reductions or increases in fish habitat. The following factors were considered in estimating the extent (positive or negative) of the potential impacts to fisheries:

- Extent to which area that would be enclosed currently supports fisheries or could support fisheries with improvements in access and/or habitat.

- Extent to which fish access would increase or decrease in area enclosed by the levee.

- Amount of fish habitat that would be enclosed or otherwise affected by the levee.

(3) Induced Development

This refers to the potential increase or decrease in wetland areas with significantly improved hurricane risk reduction and which are susceptible to residential, recreational and/or commercial development. Areas susceptible to residential development have or will have auto access and are near or adjacent to areas of current or likely foreseeable future residential growth. Areas susceptible to commercial development have or likely will have significant access to navigation, rail, and/or highway transportation and are in a position to support economic activities typical of the area (e.g., oil and gas support). Areas susceptible to recreational development are areas that are desirable given location and ease of access to popular recreational activities (such as fishing).

It is recognized that unlike traditional forced drainage systems, "leaky levees" would not be designed to drain wetland areas. Nevertheless, the presence of a "leaky levee" would

substantially reduce the risk of flooding from storm surges in enclosed areas. Such reduced risk could facilitate the development or expansion of local forced drainage systems and/or the filling of wetlands in the absence of forced drainage.

As with the other elements of the indirect impacts rankings, induced development rankings are relative to other levee alignments and existing conditions in the same planning unit. A negative score indicates that the given alignment has a relatively greater potential to encourage future development in wetlands (thereby leading to further wetland loss and increased assets at risk of flooding). A positive score indicates a potential to encourage or direct future development towards higher and safer ground.

(4) Ecological Sustainability/Consistency (with coastal restoration)

This refers to the extent to which the proposed levee is or is not likely to be consistent with existing and future coastal restoration projects, particularly river reintroduction projects (a.k.a. diversions). This also refers to the extent to which the proposed levee may or may not be located in a potentially sustainable environment. The following factors were considered in determining consistency with coastal restoration:

- Extent to which additional up-basin river re-introduction projects have been identified in coastal plans such as CWPPRA, Coast 2050, LCA, BTNEP CCMP, and/or LACPR itself, and the technical and budgetary challenges of designing the proposed levee and structures to accommodate such increased flows.

- Size of wetland area above the proposed levee alignment and hydrologic structures

Compensatory Wetlands Mitigation

Note: At a later date, a final determination will be made on the applicability of the following LACPR mitigation discussion, as it relates to current USACE policy, for projects that contain an ecosystem restoration component.

Introduction

The term *compensatory mitigation* generally refers to actions taken to offset environmental impacts by replacing or providing substitute resources or environments. National policy on compensatory mitigation for wetlands and other aquatic resources comes primarily from the Clean Water Act (CWA) Section 404 regulatory program. For the purposes of CWA Section 404, compensatory mitigation is the restoration, creation, enhancement, or in exceptional circumstances, preservation of wetlands and/or other aquatic resources for the purpose of compensating for unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved. In this context, compensatory mitigation is critical to National policy goal of achieving no net loss of wetlands and aquatic resources.

The various structural hurricane risk reduction measures under consideration in the LACPR study will inevitably result in unavoidable impacts to wetlands and other aquatic resources. In these cases, compensatory mitigation would be needed to ensure that such unavoidable impacts

are fully offset, consistent with the policy of no-net-loss. This section describes in general the policies and assumptions that should be used to identify and implement appropriate, practicable, and effective compensatory mitigation measures for such unavoidable impacts. This section is not an exhaustive list of all the specific actions necessary for successful compensatory mitigation. Rather, it is intended to highlight some of the key issues pertaining to compensatory mitigation in the context of LACPR and coastal Louisiana.

Assumptions

- Compensatory mitigation actions for LACPR will comply with the policies and standards used for the CWA Section 404 program. (Section 2036 of WRDA '07 mandates that mitigation plans for water resources projects comply with the mitigation standards and policies established pursuant to the regulatory programs administered by the Secretary.).

- Acres of mitigation required (ratio) will vary depending upon quality functions and values of acres impacted, quality of acres of mitigation area. Furthermore the quantity of acres required to meet mitigation requirements will fluctuate depending upon length of the project analysis period (i.e., 50 or 100 years).

- Sediment sources for mechanical marsh creation should come from the least environmentally damaging sites (i.e., place highest priority on mining sediment from outside the system such as the rivers or offshore)

- Compensatory mitigation for LACPR projects will be conducted in advance or concurrent with implementation of the structural hurricane risk reduction projects for which the mitigation is required.

- Notwithstanding the need for flexibility and a watershed approach to designing compensatory mitigation (see below), it is generally not appropriate to offset wetland impacts in one planning unit (or basin) through compensatory mitigation actions in another planning unit.

- Impacts to wetlands outside of existing levee systems will not be offset by compensatory mitigation projects within existing levee systems.

- No mitigation credit should be given for theoretical benefits to wetland areas enclosed within the levee system unless there is definitive, quantitative information to support such claims. For example, mitigation credit should not be given for assumed salinity reductions in wetlands enclosed within levee systems.

Site Selection (on-site)

In 2001, the National Research Council (NRC) recommended the use of a watershed approach for decisions regarding compensatory mitigation (www.nap.edu/books/0309074320/html/). This recommendation is based in part on the finding that there are circumstances in which on-site mitigation may not be either practicable or environmentally preferable. In coastal Louisiana, such flexibility and watershed-based planning may provide opportunities to complement existing

or planned coastal restoration projects. A watershed approach to compensatory mitigation site selection in coastal Louisiana would include consideration of:

- the environmental conditions and needs of the entire basin or planning unit, as well as restoration opportunities to meet such needs;
- trends in wetland loss by type;
- functional lifespan and potential sustainability of the mitigation area;
- structural importance of the mitigation area; and
- potential synergies with other coastal restoration projects.

Such a watershed approach does not in any way preclude mitigation at or near the site of the impact. Indeed, there may be cases where such traditional on-site mitigation is preferable. For example, it may in some instances be preferable to create a marsh buffer in front of a new or improved levee.

Mitigation Type

Generally in-kind compensatory mitigation is preferable to out-of-kind compensation because it is most likely to compensate for the specific functions, services, and values lost at the impact site. In-kind means a resource type that is structurally and/or functionally similar to the impacted resource type. The compensatory mitigation project site must be ecologically suitable for providing the desired aquatic resource functions. In striving for in-kind compensation within the planning unit approach, implementation of mitigation could be sequenced so mitigation is constructed by habitat as it is impacted annually by constructing structural storm protection.

Due to the uncertainties with salinity gradient changes and associated habitat switching with the 100 year planning horizon, some consideration may be given at this pre-feasibility level of allowing fresh marsh to be compensated for intermediate marsh or visa versa and brackish marsh compensated for saline marsh or visa versa. This potential assumption is based on the uncertainties in the potential spatial changes in the landscape and somewhat similar functions these marsh types provide.

Amount of Compensatory Mitigation

Federal policy on compensatory mitigation calls for a minimum of one for one functional replacement (i.e., no net loss of values), with an adequate margin of safety to reflect the expected degree of success associated with the mitigation plan.

The basis of this Federal mitigation policy is Federal Regulation Vo.73, No. 70, published Thursday April 10, 2008 and codified in 33 CFR Parts 325 and 332 and 40 CFR Part 230. The regulations state "(1) If the district engineer determines that compensatory mitigation is necessary to offset unavoidable impacts to aquatic resources, the amount of required compensatory mitigation must be, to the extent practicable, sufficient to replace lost aquatic resource functions. In cases where appropriate functional or condition assessment methods or other suitable metrics are

available, these methods should be used where practicable to determine how much compensatory mitigation is required. If a functional or condition assessment or other suitable metric is not used, a minimum one-to-one acreage or linear foot compensation ratio must be used.
(2) The district engineer must require a mitigation ratio greater than one-to-one where necessary to account for the method of compensatory mitigation (e.g., preservation), the likelihood of success, differences between the functions lost at the impact site and the functions expected to be produced by the compensatory mitigation project, temporal losses of aquatic resource functions, the difficulty of restoring or establishing the desired aquatic resource type and functions, and/or the distance between the affected aquatic resource and the compensation site. The rationale for the required replacement ratio must be documented in the administrative record for the permit action".

Since the earlier 1990 Memorandum of Agreement between the EPA and the Department of the Army, the Corps and various resource agencies involved in compensatory mitigation have often used acreage ratios of greater than 1:1, particularly in cases where there is a temporal lag in the development of wetland functions at the mitigation site and/or where there is uncertainty regarding the likelihood of the mitigation being fully successful.

Various national and local policy precedents exist for use of ratios and ratios higher than one to one. Local precedents include requests by commenting agencies on civil works projects (e.g., Morganza to the Gulf, proposed procedures for 3rd and 4th supplemental Acts), use under the CWA Section 404 Program. Analysis conducted thus far for Task Force Guardian and now being used for the 3rd and 4th Supplemental Appropriations work are using ratios both less than and greater than 1.5:1 which were approximated based on previous and generic functional based analyses to reserve sufficient mitigation funds.

Examination of the Corps national statistics for the CWA Section 404 program (from 1993 to 2000), indicates that the average mitigation ratio is closer to 2:1. Specifically, 42,000 areas of mitigation were required for 24,000 acres of impacts. Despite a nearly 2:1 ratio, the National Academy of Science still concluded that it is questionable whether the goal of no-net-loss is being reached.

EPA Region 4 has developed mitigation guidance, which provides recommended ratios including why these ratios are usually greater than 1:1.
http://www.epa.gov/region4/water/wetlands/technical/mitigation.html

In the case of LACPR, the level of data available and time allotted renders a functional based assessment impracticable at this point in the process, except of course for cases where such work has already been completed for previously authorized project components (e.g., MRGO closure). Additionally, the development of compensatory mitigation for LACPR can be expedited through up-front agreement on the amount and type of compensatory mitigation to be implemented to offset unavoidable adverse impacts to wetlands. Doing so would allow the Corps to more readily incorporate the potential costs of mitigation for various alternatives under consideration, and it could reduce the time needed to develop and implement final mitigation plans on a project-by-project basis.

Function-based ratio estimator example

In addition to adjust for temporal losses (time to implement) and limited success, some mitigation may be function inequivalent to the habitat it is compensating for. As an example, some studies have demonstrated constructed marsh is approximately half as productive as natural marsh for economically-important crustacean shellfish species (e.g., brown shrimp, white shrimp, and blue crab) for at least the first five to ten years after construction (Minello and Webb 1997, Rozas and Minello 2001). However, some of the same studies have documented that restored marsh is similar in productivity for finfish soon after construction (Minello 2000). To offset this loss of shellfish productivity, an increase of approximately 50 percent in terms of acreage would be appropriate based on the need to restore at least one acre of marsh for every acre impacted to compensate for finfish productivity and two acres of marsh for every one impacted to compensate for shellfish productivity.

Quality-based ratio estimator example

For the purposes preliminary cost estimating under the 3rd and 4th supplemental, a mitigation ratio was assigned to each area of wetland impact identified that corresponds to the estimated quality of habitat impacted. The ratios below are based on the professional judgment of New Orleans District Environmental staff, which relied on earlier examples of mitigation for estimating appropriate ratios.

Bottomland Hardwood Habitat Quality Ratios

- High Quality (upland) – 1 acre impacted: 4.5 acres mitigated
- High Quality (wet) - 1 acre impacted: 3 acres mitigated
- Medium Quality- 1 acre impacted: 2 acres mitigated
- Low quality- 1 acre impacted: 1 acre mitigated

Timing

Construction of mitigation should be in advance of or concurrent with the activity causing the authorized impacts to avoid temporal loss of aquatic resources. Authorizations of any measures to implement (i.e., feasibility, preliminary engineering and design, and construction) should include funds for the commensurate mitigation. Cost share agreements and programming of funds under the agreements should enable concurrent mitigation.

Cost

The full cost of compensatory mitigation must include not just project implementation, but also monitoring, long-term management, and contingency funds. For forested wetland mitigation projects, costs typically include land acquisition, hydrologic improvements (e.g., removing ditches, grading), planting, vegetative management (e.g., invasive control), monitoring, contingencies (such as replanting), and long-term stewardship. Marsh mitigation projects would typically entail marsh creation via mechanical placement with dredges or with river diversions. Marsh is restored in areas where it does not currently exist, often on state-owned water bottoms. Therefore, no real estate costs are usually associated with marsh mitigation. However, marsh creation via mechanical dedicated dredging is an intense construction process, usually involving the pumping or trucking and placing of fill material as well as planting of marsh vegetation; thus, the construction cost over the first ten years of the project is much higher for marsh than for

bottomland hardwood. Marsh creation with diversion also has a high initial cost for construction of the diversion structure, but takes many years to realize marsh creation.

The following is a copied break-down of the costs of mitigating one acre of wetland by wetland type as derived and used for Task Force Guardian and expected use for 3rd and 4th Supplemental Appropriations flood protection work (2007 MVN Environmental Whitepaper). "Estimated costs were derived from recently conducted mitigation activities. Real costs were based on the actual purchase price of bottomland hardwoods adjacent to the Bayou Sauvage National Wildlife Refuge as part of the mitigation associated with work completed by Task Force Guardian (TFG). The cost of marsh creation per acre and bottomland hardwood management were derived from figures provided by the US Fish and Wildlife Service planning-aid report, developed as part of an interagency team effort lead by Corps to assist MVN staff in determining impacts and mitigation needs associated with Task Force Guardian efforts.

Bottomland Hardwood forest
Costs per acre for mitigation: $37,000 per acre

- $35,000 Real Estate cost per acre. Based upon TFG cost estimates for Bottomland Hardwood impacts in Orleans Parish 2006 and includes fees typically associated with land acquisition such as title searches, closing costs, recording fees, etc.
- $1,200 construction costs per acre. Year 1 to 10 of project.
- $800.00 O&M and monitoring cost per acre for 50 year life of project.

Tidal Emergent Marsh, Fresh Water Marsh, Salt Water Marsh
Cost per acre for mitigation: $80,000

- $0 Real Estate cost per acre
    - This cost assumes mitigation on state water bottoms, which will not always be possible. CEMVN RE has estimated marsh real estate at $500 per acre historically in those cases where non-state water bottom is acquired.
- $79,000 construction cost per acre.
- $1,000 for O&M and monitoring cost per acre for 50 year life of project."

Financial Assurances, Long-Term Stewardship, and Adaptive Management

Sufficient financial assurances should be provided to ensure a high level of confidence that the compensatory mitigation will be successfully completed. Sediment availability and practicable construction schedules based on equipment availability will directly limit the amount and rate at which impacts occur and could be offset. Due to the large amount of impacts and complexity of mitigation needs, sufficient funds for all anticipated impacts should be set provided in legislative appropriations at the same time activities are authorized from which the impacts would occur. Project sponsors should set aside these funds upfront.

Estimates of mitigation funding needs should include resources for additional measures that may be needed to ensure success of the compensatory mitigation project. With forested wetland mitigation, for example, it is not unusual for replanting to be needed due to higher than expected planting mortality. Such contingency funds can and should be released as the mitigation project meets specified performance thresholds. For example, once an adequate amount and diversity of

trees become well established in a forested mitigation site, it is less likely that replanting will be needed.

Success Criteria, Monitoring, Reporting, and Adaptive Management

Compensatory mitigation plans should contain specific, measurable criteria for assessing whether mitigation is succeeding. Success criteria typically address hydrologic conditions (e.g., whether or not the mitigation area has self-sustaining wetland hydrology), vegetative success (considering both quantity and type), and in some cases factors pertaining to fish and wildlife usage.

Monitoring should be designed to provide both a general overview of how the mitigation project is or is not working, as well as measuring progress relative to the specific success criteria discussed above. Monitoring it typically more frequent in the first five years of the mitigation project, after which monitoring intervals can increase. For example, a typical forested wetland mitigation project might entail monitoring at years one, three, five, and ten, with reports every five years thereafter. Additional monitoring may be needed in cases where success criteria are not being met and remedial actions are needed. Monitoring reports should be made available to the resource agencies to help evaluate the effectiveness of the compensatory mitigation project, and to help determine whether corrective actions are needed.

Restoration and Structural Metric: Fisheries Impacts

The economic and ecologic value of Louisiana's coastal fisheries is nationally important and therefore it is desirable to have an assessment of fisheries impact to inform the plan formulation process for LaCPR. Specifically, an assessment method and resultant metric is desired to inform the Multi-Criteria Decision Analysis (MCDA) for both structural and restoration measures. Fundamental limitations exist both in terms of the specificity of measures and alternatives and the degree of understanding of relative effects on fisheries production. This is complicated in that migratory pathways within planning units, the limits of habitat support functions, and the effects of hurricane protection structures on fisheries are not fully understood. Further confounding and equally, if not most, challenging is the relative value of fisheries habitat varies spatially by species and life-stage of species.

With respect to restoration measures, various matrices could and should be developed because changes occurring under the no-action or various action alternatives create unique challenges for fisheries management. However, only qualitative data are available at this time. Thus, the limited information and time do not allow for quantitative analysis, although available information can inform the planning process, managers, and decision makers of what is needed. The following is a cursory list of suggestions and characterizations of details on fisheries impacts associated with restoration rather than measurable input metrics for MCDA. The development of those metrics is not possible at this time given the current project schedule and planning process.

No Action

The project area supports one of the most productive fisheries in the Nation. However, it is believed that with no action, sharp declines in fisheries productivity are likely (Minello et al. 1994; Rozas and Reed et al.1993). Impacts to fisheries resulting from the implementation of each plan will vary depending on the features included in the selected plan, species-specific habitat, prey, spawning requirements, and current conditions in the Deltaic and Chenier Plain estuaries." (LCA, FPEIS November 2004)

Louisiana is second only to Alaska in terms of commercial fisheries production and home to three of the top six commercial fishing ports in the country. Louisiana's recreational harvest is second only to Florida among the states surveyed by the NOAA Fisheries recreational survey. In recent years Louisiana landed significant portions of the total U.S. commercial harvest, including, 37% of the shrimp, 35% of oysters, 60% of Gulf menhaden and 27% of blue crab, 56% of black drum, 26% of mullet, 28% of all snapper species, and 31% of yellowfin tuna. Louisiana-based recreational anglers caught high proportions of the U.S. recreational harvest, including, 49% of black drum, 73% of red drum, 28% of sheepshead, 32% of southern flounder, and 71% of spotted seatrout from the states surveyed by the Marine Recreational Fishery Statistical Survey (MRFSS).

The relative production of deteriorating marsh in Louisiana is often very high, but this condition is not sustainable. Steep declines in fish production have been forecast for the next century (Thomas 1999). This is particularly important for the resource users who are satisfied with "current conditions" in terms of fish production. In order to maintain current conditions for fish production major habitat restoration actions are required.

"Indirect impacts to fisheries may result from the expected continuation of land loss and further loss of habitat supportive of estuarine and marine fishery species. In the short-term, land loss and predicted relative sea level changes are likely to increase open water habitats available to marine species, except in the active deltas of the Atchafalaya and Mississippi Rivers; and areas otherwise influenced by river flow, such as, the Caernarvon and Davis Pond Freshwater Diversions, and to a lesser extent, Pointe a la Hache and Naomi Siphons. In the long-term, as open water replaces wetland habitat and the extent of marsh to water interface begins to decrease, fishery productivity is likely to decline (Minello et al. 1994; Rozas and Reed 1993). This may already be happening in the Barataria and Terrebonne estuaries. Browder et al. (1989) predicted that brown shrimp catches in Barataria, Timbalier, and Terrebonne Basins would peak around the year 2000 and may fall to zero within 52 to 105 years." (LCA FPEIS, November 2004)

This goal of maintaining or restoring some desired ecological baseline and associated fish production is challenging due to the uncertainties in possible endpoint outcomes. As described by Cowan et al. 2006, two examples include regime shift (bottom-up process driven) and man-induced changes in ecosystem function (top-down effects). Although responses of Louisiana

coastal fisheries from regime shifts (e.g., climate variability) are unknown, restoration efforts may produce a nearly linear response in efforts to restore ecosystem function including fisheries productivity. A more challenging endpoint possibility is that a shift in the ecological baseline could result from top-down habitat modification effects through restoration. Mechanisms for this second scenario possibly include habitat reduction and change to reorganization of food webs, but regardless of the mechanisms, top-down forcing with ecosystem or landscape level attempts in restoration may be less likely to return to a state that resembles "pristine" that are similar to the level of fishery productivity provided by the pre-disturbed conditions. Despite these uncertainties there is reason to forge ahead with optimism if efforts include investigations on the potential effects on fisheries and means for adaptive management of both the process and potential structure operations.

Action Alternatives

General alignments and restoration
Leaky levee concept
Diversions- freshen

General characterizations of impacts by restoration method are listed in Table 15 & 16.

Coastal restoration projects attempting to address the loss of estuarine habitat with a number of techniques may produce localized to widespread changes in fisheries production and distribution (Thomas 1999).

Public perception difficulties with restoration efforts arise from misunderstandings of the nature of estuarine functions, particularly of the importance of nursery habitat and of the value of low-salinity marshes as nursery habitat (Thomas 1999).

Significant improvement in the outlook for estuarine fish habitat in Louisiana will require long-term and large-area vision from managers and the public (Thomas 1999).

Resource displacement can result in increased harvest costs, and basin-scale changes may be particularly hard for resource users who are satisfied with the current conditions
Harvesters have demonstrated reluctance, and may lack the financial flexibility, to forfeit expected current catches for predicted enhancement of long-term fisheries production (Thomas 1999).

Diversions
Degree of displacement depends on the species and life stage-specific variables, structure location, flow-rate, and env. conditions (Caffey and Schexnayder 2002)

Salinity reductions result in a seaward shift of the optimal harvest zones form brown shrimp. Some displacement of white shrimp and blue crab landings. Meanwhile, low salinity marsh restored by diversions may expand the nursery required for the development of brown and white shrimp (Caffey and Schexnayder 2002).

Large-scale diversions can cause a range of temporal and spatial impacts to various fisheries. The ultimate merit of diversions on fisheries should not be measured by short-run impacts alone (Caffey and Schexnayder 2002).

Mechanical vs. Diversions

Mechanical -- rapid marsh creation and relatively little fish production but

- High or low mechanical marsh creation – realize land gain rapidly, but spatial and landscape benefits are limited
- Dredge fleet limited
- Not sustainable; no net loss of wetlands and associated levels of fish production would have to be maintained via dedicated dredging unless creation sites are located to enable synergy with diversions
- Relatively no landscape displacement impacts to fish displacement or production and associated users

Diversion – slow marsh response, but

- High diversion = may displace valuable estuarine less valuable fisheries; however process will create sustainable low-salinity nursery grounds for valuable estuarine fisheries
- Low diversion =smaller displacement due to changes in salinity regimes, smaller increase in fuel, time, and refrigeration needs on fishing industry)

- Those techniques include the types of measures included in this plan: marsh creation and freshwater diversions. Changing the distribution and timing of freshwater inputs and the configuration of land and water will change the distribution of estuarine organisms and thus the economics of estuarine fisheries in coastal Louisiana.

Operation of structures may be the most critical component of any diversion plans; a closer adherence to natural cycles of high and low flow would lessen fisheries impact

What is Needed

Topics, associated data, and available resources to compile and evaluate the outcome and effects in alternatives analysis is needed to inform this process and to inform managers and decision makers. Establishment of an understanding, or a more complete understanding, of fundamental processes is needed for many habitat stability, resiliency, and shifting response effects on fisheries productivity.

Inventory of needs and resources

1. Project-specific inferences – e.g., make inferences from the Caernarvon type impacts; analyze the LDWF Caernarvon data
2. Empirical analysis with LDWF fisheries independent data is one analytical option among others

3. Evaluate perturbations (productivity and driver mechanisms) from existing restoration along a gradient.
4. Evaluation of protection structure designs on fisheries.
5. Evaluate habitat shifting and structural complexity effects.
6. Refinement of measures including optimizing operation plans for structures and the commitment to adaptively managed the structures
7. Assessment of cumulative impact of alternative features (e.g., multiple diversions, etc.)
8. Identify other existing data sets, staff, or researchers that can facilitate these evaluations in necessary timelines

Table 15. Comparison of diversion impacts on fisheries.

Coastal Restoration Alternatives	Diversion Impacts	Comments
Alts 3, 4, and LCA Plan PBMO (see assumptions below this table)	Displacement and habitat preservation	
Non Pulsed (Dec-May unrestricted flow) (see assumptions below this table)	Displacement and habitat preservation	Salinity reductions result in a seaward shift of the optimal harvest zones form brown shrimp. Some displacement of blue crab landings. Impacts to American Oyster (see caption below this table)
Pulsed (1 unrestricted flow year out of 5) (see assumptions below this table)	Displacement and habitat preservation	Limited adverse fisheries impacts to once in five years; however depending on whether it was a high or low flow year, year class strength of most economically important estuarine dependent fisheries species would be adversely impacted Impacts to American Oyster (see caption below this table)

American Oyster

The amount of discharge with relatively numerous and large scale freshwater diversions in all alternatives would adversely impact growing conditions within a large area of oyster grounds. The diversions would have the potential to reduce salinities within receiving areas to levels, which are lethal to oysters across large areas of water bottom. As previously stated, this is partly dependent upon natural variations within water bodies; the size, location, and operation of the diversion structures; and the proximity of oyster grounds to the diversions.

Louisiana has a far more extensive and productive oyster lease program than any other state in the United States. Providing more than 35 percent of the Nation's oysters, any project that adversely impacts oyster resources in Louisiana would impact nationwide oyster harvest, in addition to reducing the contribution of this industry to the local, state, and national economy. Although in the long-term, oyster populations are anticipated to benefit from large-scale coastal restoration, significant impacts could affect the industry for the foreseeable future.

Assumptions

For alternatives R3, R4, and R5, the HET assumed unrestricted flows whenever the diversion would flow, but, based on past Caernarvon records, the HET assumed that all diversions would only flow for 246 days per year.

For alternative R1, the non-pulsed Dec-May diversion, the HET assumed unrestricted flows only during those months. Otherwise no flows at all - this would be more restrictive than the limiting of flows to only 245 days per year.

For alternative R2, the Pulsed 1 high flow year out of 5, the HET assumed unrestricted flow during the high flow year - as all flows are based on the 1994 Tarbert Landing hydrograph in which there is a Dec rise, there would be good diversion discharges during that month. During the low-flow years, flows would be restricted to much lower levels, but those flows would also be year-round when the river allows. Those flows would vary according to river stage. Note that in this alternative, there is still the assumption of only 246 days of flow per year for both high flow and low flow years.

Table 16. Adapted from LCA, FPEIS.

Items of consideration in the impact analysis of restoration opportunities on fisheries resources.	
Freshwater Diversions	Direct impacts to fisheries resulting from freshwater diversions include mortality due to burial or sudden salinity changes; injury or mortality due to increased turbidity (e.g., gill abrasion, clogging of feeding apparatus); modified behavior, and short-term displacement. Indirectly, fisheries may be displaced to offshore areas. Displacement is related to the timing and volume of freshwater input proposed. These projects prevent the loss of marsh, and generally improve conditions for SAV and other highly productive forms of EFH. As a result, project areas can maintain most of their current ability to support Council-managed species (such as white shrimp, brown shrimp, and red drum), as well as the estuarine-dependent species (such as spotted seatrout, gulf menhaden, striped mullet, and blue crab) that are preyed upon by other Council-managed species (such as mackerels, red drum, snappers, and groupers) and highly migratory species (such as billfish and sharks). Potential increases in submerged aquatics will increase the habitat required for juveniles to escape predation and therefore increase quality and habitat.
Dredging	These projects, or project components, would negatively impact benthic organisms and benthic feeders in the borrow and disposal areas. Sessile and slow-moving aquatic invertebrates would be disturbed by the dredge or buried by the dredged material. Dredging and disposal activities and the resultant increased turbidity would temporarily displace other fisheries, but these species are expected to return after dredging and disposal activities are completed. Impacts include smothering of non-mobile benthic organisms in dredged material deposition sites and increased turbidity in waters near the construction sites.
Salinity/water control structures	If water control structures are designed and operated to maximize marine fishery migratory opportunities, while minimizing the worst salt water events, these projects can slow the loss of emergent marsh without severely impacting marine fishery productivity. However, care must be taken to ensure the structures do not create conditions that would adversely impact marsh habitats supportive of marine fishery resources. Additionally, operational plans should incorporate provisions to ensure the structures are open during appropriate times to allow drainage, facilitate freshwater inflow, and allow the maximum possible marine fishery ingress and egress. Without these provisions, these projects can significantly reduce the marine fishery productivity of the project area, even if the structures help maintain marsh habitats; the maintained habitats would not support production of marine fishery species, if the species do not have access to those critical nursery and foraging habitats.
Beneficial Use/ Sediment Delivery/Marsh Creation, Restoration, or Nourishment	The use of dredged sediment would convert open water habitat to wetlands providing a more diverse habitat. The conversion would increase foraging, breeding, spawning, and cover habitat for a greater variety of fisheries species than would occur with no action, and potentially increase the marsh/water interface. The increased marsh/water interface is a greater benefit than marsh acres alone (Rozas and Minello 2001). Measures should be taken (i.e., creating tidal creeks and ponds) to maximize the fisheries productivity of the restored marsh areas.

	Nutrients and detritus would be added to the food web, providing a benefit to local area fisheries. Fisheries access features and structure operation plans would be necessary to facilitate ingress and egress of various fisheries species to restored wetlands within the proposed disposal areas. Short-term adverse impacts to fish would occur during the construction phase of these projects as a result of dredging activities (see dredging impacts).
Shoreline Protection/ Stabilization	Shoreline protection projects are likely to prevent the loss of marsh for protected areas. This helps maintain valuable fisheries habitat. Design of shoreline protection should incorporate low-sill openings, gaps, and/or allow historical channels to remain open for aquatic organism ingress and egress, and the adequate discharge of surface flow drainage.
Barrier Island Restoration	Barrier islands protect coastal marshes from storm surges and provide unique back barrier and sand bottom habitats. Barrier island restoration that involves supratidal vegetative plantings and sand retention structures alone will not directly affect fisheries species. However, the long-term impact to fisheries would be beneficial by maintaining the valuable habitats that would otherwise convert to open water. Restoration on a larger scale involving dredging of sand resources for placement on and around existing islands would impact the benthic areas of both the borrow and disposal areas. Subsequent benefits would result from the increase in back barrier shallow water and sand bottoms, and the increased protection to coastal marshes.

SCIENTIFIC ISSUES AND TECHNICAL UNCERTAINTIES

Although numerous scientific studies have been conducted within the Louisiana coastal environments, considerable uncertainty remains regarding key ecological processes and the efficacy of some of the proposed restoration measures. Limitations in analytical tools to assess ecosystem responses also exist, and were compounded by the relatively short timeframe in which the LACPR was formulated. These limitations and uncertainties substantiate the value of a truly adaptive approach to the LACPR, and suggest that some plan components require further and more detailed study prior to implementation. Demonstration projects based on sound scientific and technological theory and practice should be implemented in order to test the uncertainty in a controlled manner.

To meet that challenge, (1) mechanisms to fund a coordinated program of coastal investigations to understand the longer term dynamics of the system must be developed, (2) research and demonstrations that specifically advance restoration technology must be conducted, (3) usable databases must be developed, and (4) mechanisms to integrate research results into the planning and design of restoration projects must be developed.

Research and Technology Development Needs

(Subject to continued revision)

Although many studies have been conducted in the Louisiana coastal area, most were limited in geographic extent or technical scope. Therefore, while much has been learned from previous efforts, many scientific and technical uncertainties remain. Some areas of high uncertainty include:

- availability of sediment (riverine and offshore)

- subsidence rates and sea level rise
- benefits and impacts of pulsed freshwater diversions
- channel evolution in freshened areas
- effect of diversions on Mississippi River sediment transport
- over freshening of estuaries
- fisheries impacts associated with river diversions
- pipeline conveyance technologies and costs
- thin-layer sediment placement techniques
- salt transport inland with sediments from offshore
- benthic habitat impacts

Appendix A of the LCA Report (LCA 2004) outlines the R&D needs for coastal Louisiana as well as a general strategy for achieving those goals. Rather than reiterate those needs and strategy, the HET advocates the adoption of the LCA S&T Program as a model for LACPR.

To effectively use existing knowledge and gain the increased understanding necessary to deal with the issues described above, it is essential that appropriate predictive tools are developed. The tools include numerical modeling approaches to predicting patterns of water level, salinity, and sediment distribution. Hydrologic models, which specifically encompass flows across marsh surfaces and through channels and structures, must be developed. Ecological models must address marsh accretion (mineral and organic), nutrient budgets, and soil biogeochemical processes.

To fully achieve the ecosystem goals set forth in this plan, a better understanding of ecological and biogeomorphic processes and functions is needed. Critical questions still need answers, such as "What is the effect on ecosystem sustainability of a seasonal river diversion that increases the annual range of salinities within the receiving basin? How important to coastal marshes is nutrient input alone vs. freshwater and sediment delivery from the river? How does this vary with marsh type?"

Although the intent of the spatial integrity metric is to compare alternative plans, it may be possible to also refine the models so that they provide some predictive capability. Valid comparison to reference wetlands is difficult, but correlations between spatial metrics and ecosystem services may be developed over time, provided the appropriate data collection and analyses are conducted.

Demonstration and Evaluation Needs

Demonstration projects may be necessary to address uncertainties that would be identified in the course of individual project implementation or during the course of studies of large-scale and long-term restoration concepts. Nominated demonstration projects would be subject to review and approval of individual project feasibility-level decision documents by the Secretary of the Army. In addition to standard feasibility-level decision document information, the demonstration project feasibility-level documents would address: 1) major scientific or technological uncertainties to be resolved; 2) a monitoring and assessment plan to ensure that the demonstration project would provide results, and that those results contribute to overall LACPR

effectiveness; 3) a lessons learned discussion and 4) transparent framework to distribute knowledge gained.

Clearly, there are still many restoration issues in coastal Louisiana that cannot be resolved without additional research. The research must then be integrated into the refinement of the strategies and the revision of the plan.

Monitoring and Adaptive Management Needs

In the long-term, success of the coastal restoration component of LACPR will be largely measured by the quantity, diversity, and quality of wetland acreage, and the resulting benefits from various services to Louisiana, the Gulf region, and the nation. These benefits include protection against storms and floods, production of fisheries and wildlife resources, protection of water supply and water quality, and support to regional economic activities such as oil and gas development, navigation, and recreation. Although the LACPR and other related efforts have attempted to quantify these potential benefits, considerable uncertainty remains. In addition, it is likely that new technologies, improved understanding of ecosystem processes, and other factors will lead to innovative approaches to coastal ecosystem restoration not contemplated in this study.

For these reasons, and to permit the assessment of the success of those plan components that are implemented, the LACPR must include a concerted monitoring and evaluation program that benefits from the monitoring efforts through adaptive management and improved techniques. The general restoration strategy identified by the HET is dependent on the overall input, movement, and circulation of water, sediment, and nutrients in each basin (although some measures can be implemented largely independently of these considerations), and early monitoring and evaluation efforts should focus on these processes.

Monitoring funds are routinely allocated for the life of constructed projects and monitoring plans for each project are developed to include statistical designs and the use of reference areas. Because of funding constraints, these monitoring efforts are limited to the environmental parameters expected to be affected by the projects and are confined to the area immediately affected by a project and an adjacent reference area if a suitable one can be located. As more projects are undertaken, monitoring databases for some essential variables such as water level and salinity data will cover extensive areas of the coast. These collective data will provide a good starting point to assess the cumulative spatial and temporal impacts of the numerous projects proposed as part of the LACPR.

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ATTACHMENTS

ATTACHMENT A – COASTAL RESTORATION MAPS
ATTACHMENT B – INDIRECT MATRIX TABLE
ATTACHMENT C – DIVERSION BUILDING MODEL
ATTACHMENT D - SPATIAL INTEGRITY FIGURES & TABLES
ATTACHMENT E – HET DIVERSION SUMMARY
ATTACHMENT F - WETLAND ACREAGE

ACRONYM LIST

BTNEP	Barataria-Terrebonne National Estuary Program
CEM	Conceptual Ecological Model
CWA	Clean Water Act
CWPPRA	Coastal Wetland Planning Protection and Restoration Act
EPA	Environmental Protection Agency
ERDC	Engineering Research Design Center
FPEIS	Final Programmatic Environmental Impact Statement
FTR	Final Technical Report
FWP	Future With Project
FWOP	Future Without Project
GIWW	Gulf Intracoastal Waterway
HET	Habitat Evaluation Team
LACPR	Louisiana Coastal Protection and Restoration
LCA	Louisiana Coastal Area
LDNR	Louisiana Department of Natural Resources
LDWF	Louisiana Department of Wildlife and Fisheries
MCDA	Multi-Criteria Decision Analysis
MOA	Memorandum of Agreement
MRFSS	Marine Recreational Fishery Statistical Survey
MRGO	Mississippi River-Gulf Outlet
MVN	Mississippi Valley Division, New Orleans District
NGO	Non-Governmental Organization
NMFS	National Marine Fisheries Service
NPS	National Parks Service
NRC	National Research Council
NRCS	Natural Resource Conservation Service
NTP	Near-Term Plan
PBMO	Plan that Best Meets the Objectives
ppt	parts per thousand
PU	Planning Unit
RSLR	Relative Sea Level Rise
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Service
WRDA	Water Resources Development Act

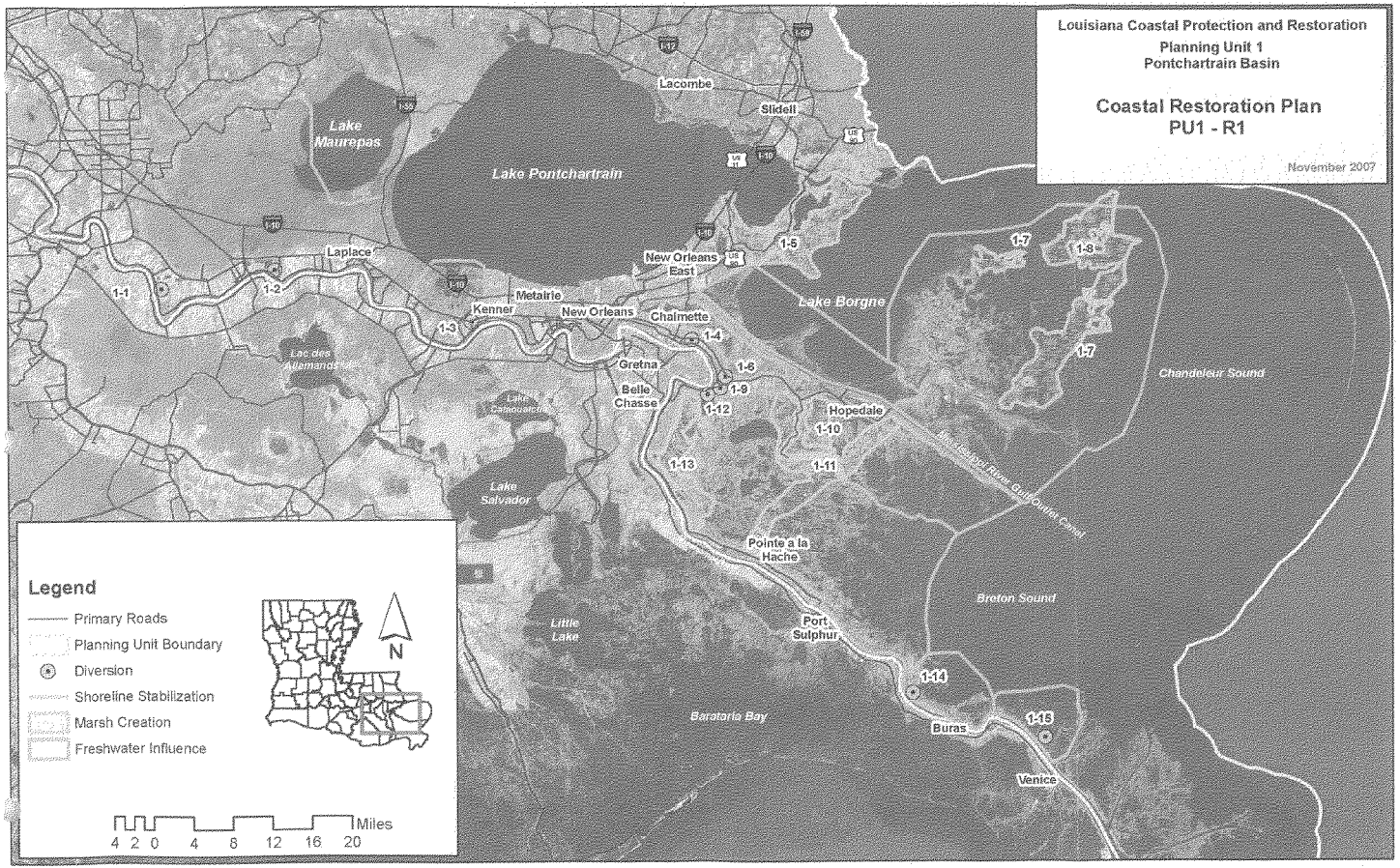
GLOSSARY

Brackish Marsh (BRM)	Intertidal plant community typically found in the area of the estuary where salinity ranges between 4-15 ppt.
Comprehensive	A combination of structural, non-structural and coastal restoration plans
Conceptual Ecological Model	non-quantitative planning tools that can be used to identify major stressors on a system, the effects of those stressors, and the best way to measure those effects (Ogden et al. 2005:795-809)
Deltaic Plain	The land formed and reworked as the Mississippi River switched channels in the eastern part of the Louisiana coastal area
Direct Impacts	Those effects that result from the initial construction of a measure (e.g., marsh destroyed during the dredging of a canal). Contrast with "Indirect Impacts."
Diversion	A turning aside or alteration of the natural course or flow of water. In coastal restoration this usually consists of such actions as channeling water through a canal, pipe, or conduit to introduce water and water-borne resources into a receiving area.
Ecosystem	An organic community of plants and animals viewed within its physical environment (habitat); the ecosystem results from the interaction between soil, climate, vegetation and animal life.
Ecosystem Restoration	activities that seek to return a organic community of plants and animals and their habitat to a previously existing or improved natural condition or function.
Estuary	A semi-enclosed body of water with freshwater input and a connection to the sea where fresh water and salt water mix.
Estuarine	Related to an estuary.
Feature	A constructible increment of an alternative plan.
Fresh Marsh	Intertidal herbaceous plant community typically found in that area of the estuary with salinity ranging from 0-3 ppt.
Future With	Projection of conditions within a study area over the project life if the proposed plan is implemented
Future Without	Projection of conditions within a study area over the project life if the proposed plan is not implemented
Indirect Impacts	Those effects that are not as a direct result of project construction, but occur as secondary impacts due to changes in the environment brought about by the construction. Contrast with "Direct Impacts."
Levee	A linear mound of earth or stone built to prevent a river from overflowing; a long, broad, low ridge built by a stream on its flood plain along one or both banks of its channel in time of flood.
Marsh Creation	To build wetland habitat by mechanical means
Maximum sustainability	greatest amount of measureable habitat that could be maintained
Pulsing	Letting a diversion flow periodically at a high rate for a short time, rather than continuously.
Relative Sea Level Change	The sum of the sinking of the land (subsidence) and eustatic sea level change; the change in average water level with respect to the surface.
Saline Marsh	Intertidal herbaceous plant community typically found in that area of the estuary with salinity ranging from 12-32 ppt.
Salt Marshes	See "Saline Marsh."
Storm Surge	An abnormal and sudden rise of the sea along a shore as a result of the winds of a storm.
Subsidence	The gradual downward settling or sinking of the Earth's surface with little or no horizontal motion.
Sustain	To support and provide with nourishment to keep in existence; maintain.

ATTACHMENT A

COASTAL RESTORATION MAPS

DECEMBER 2008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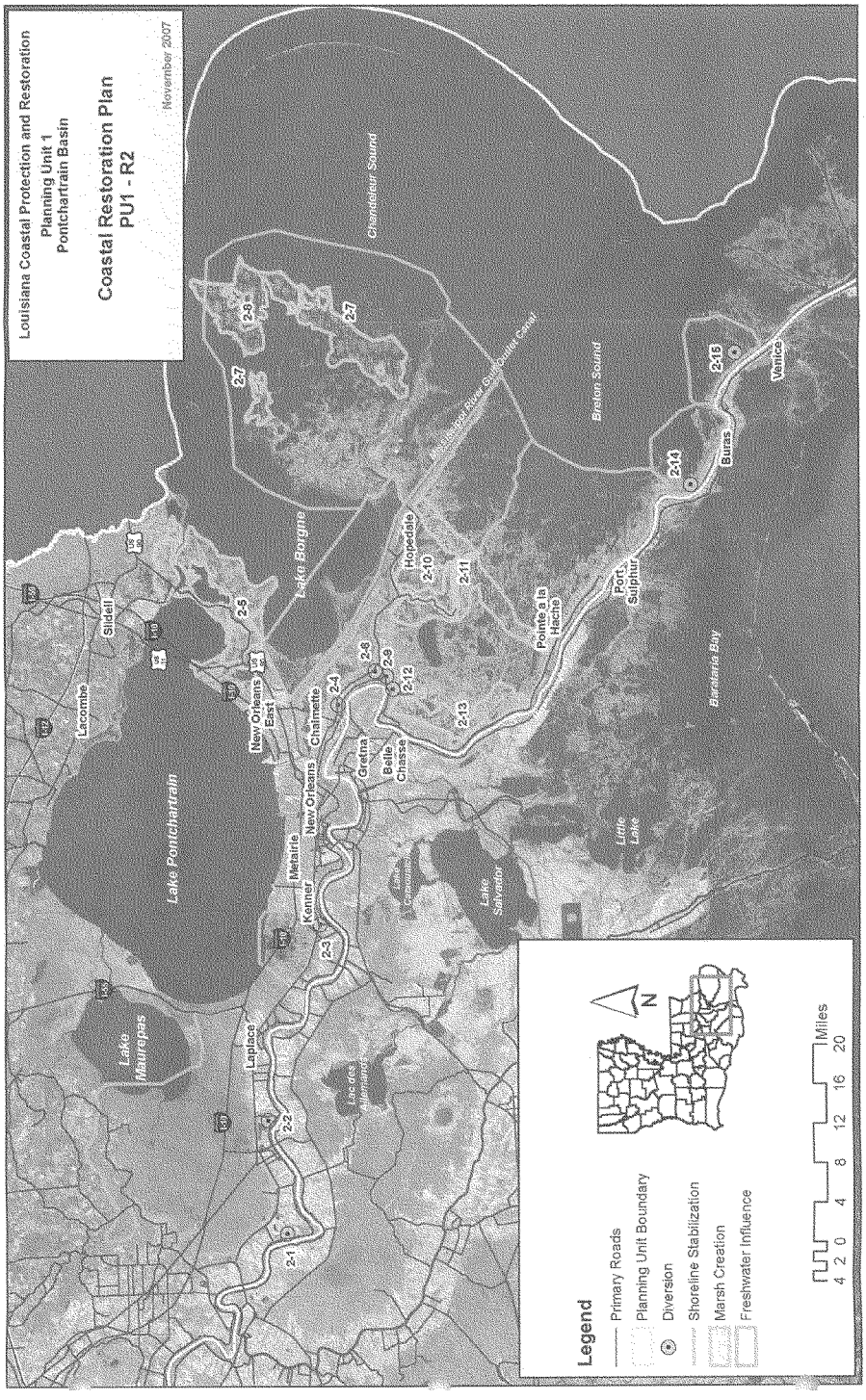
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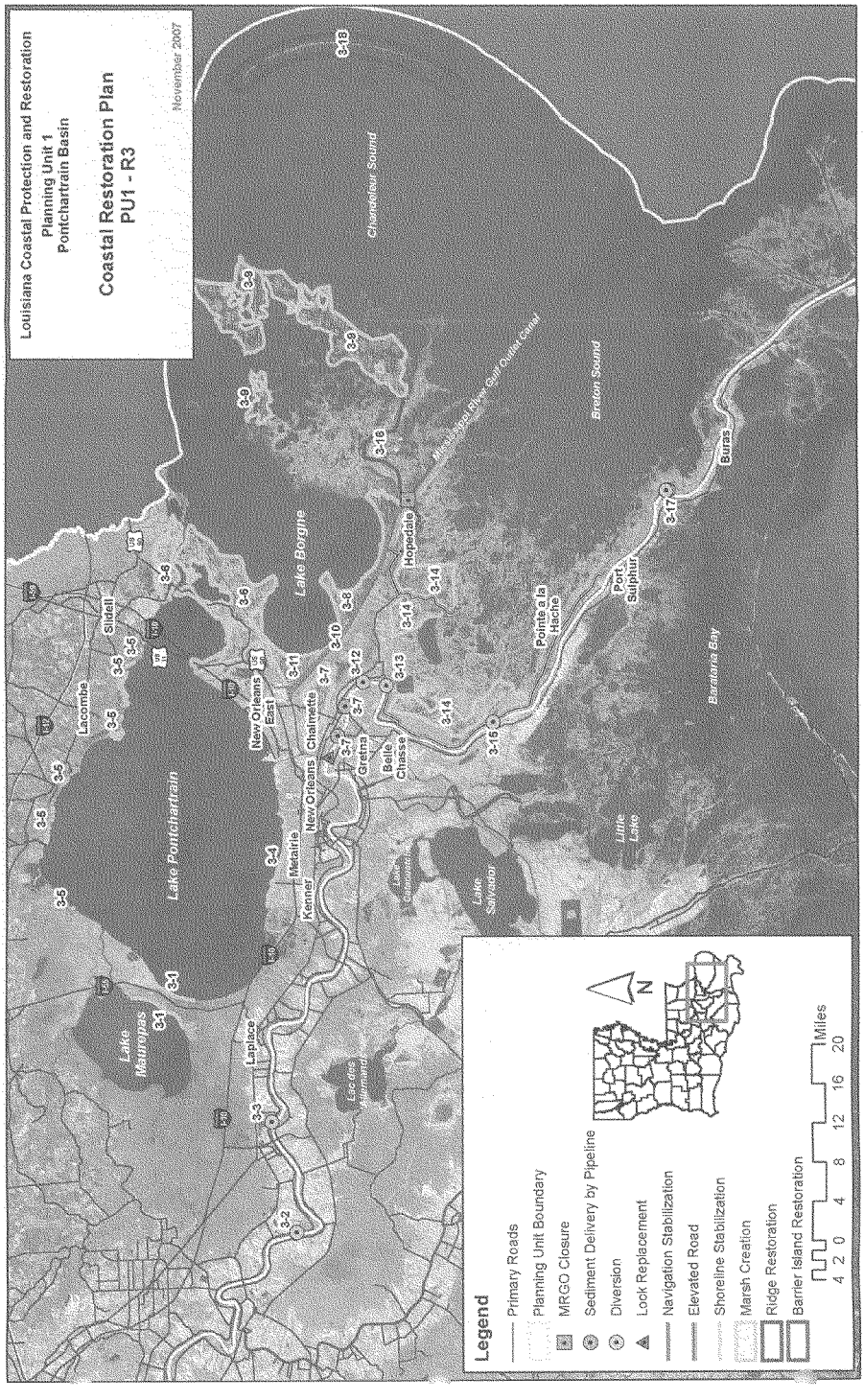
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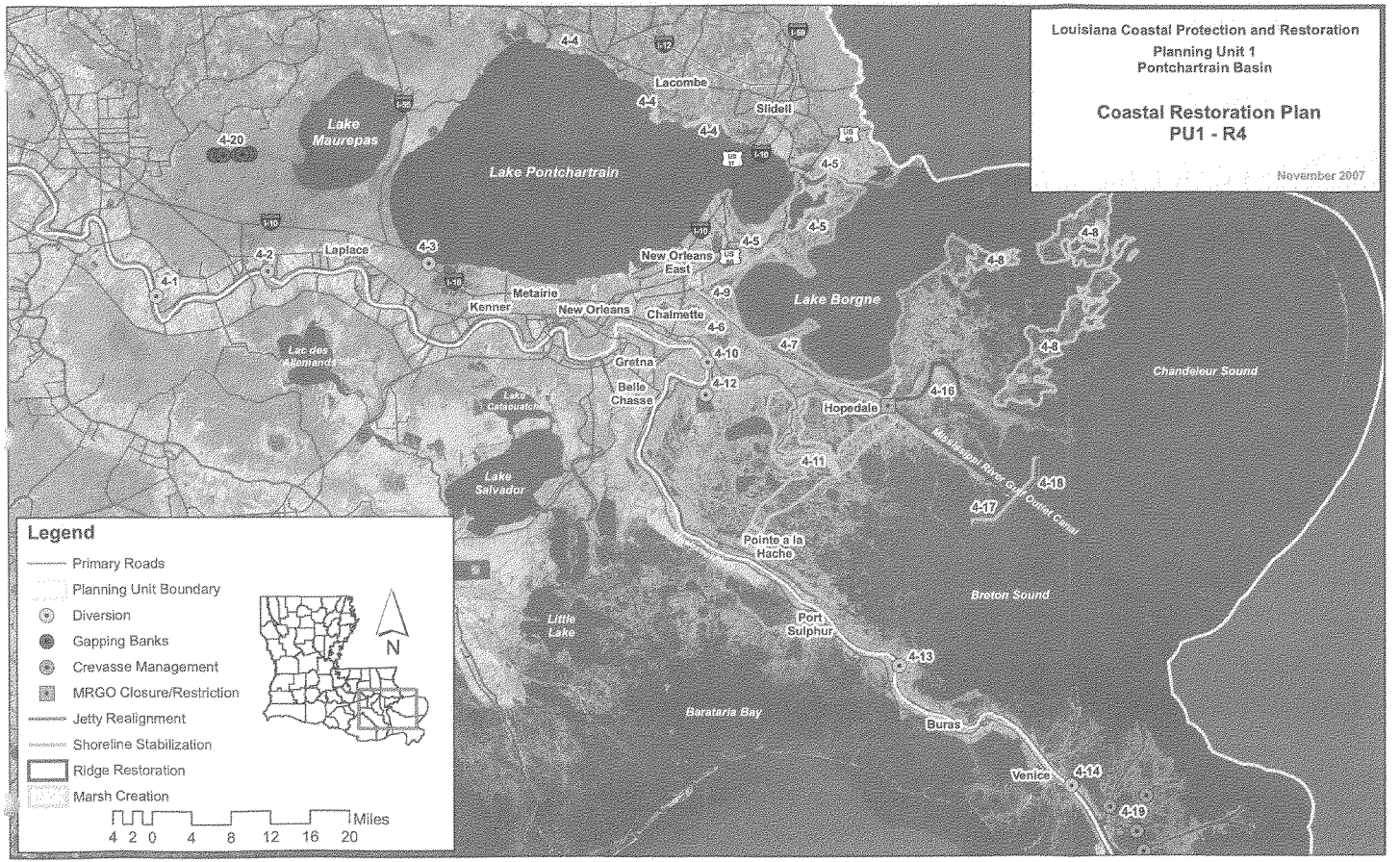
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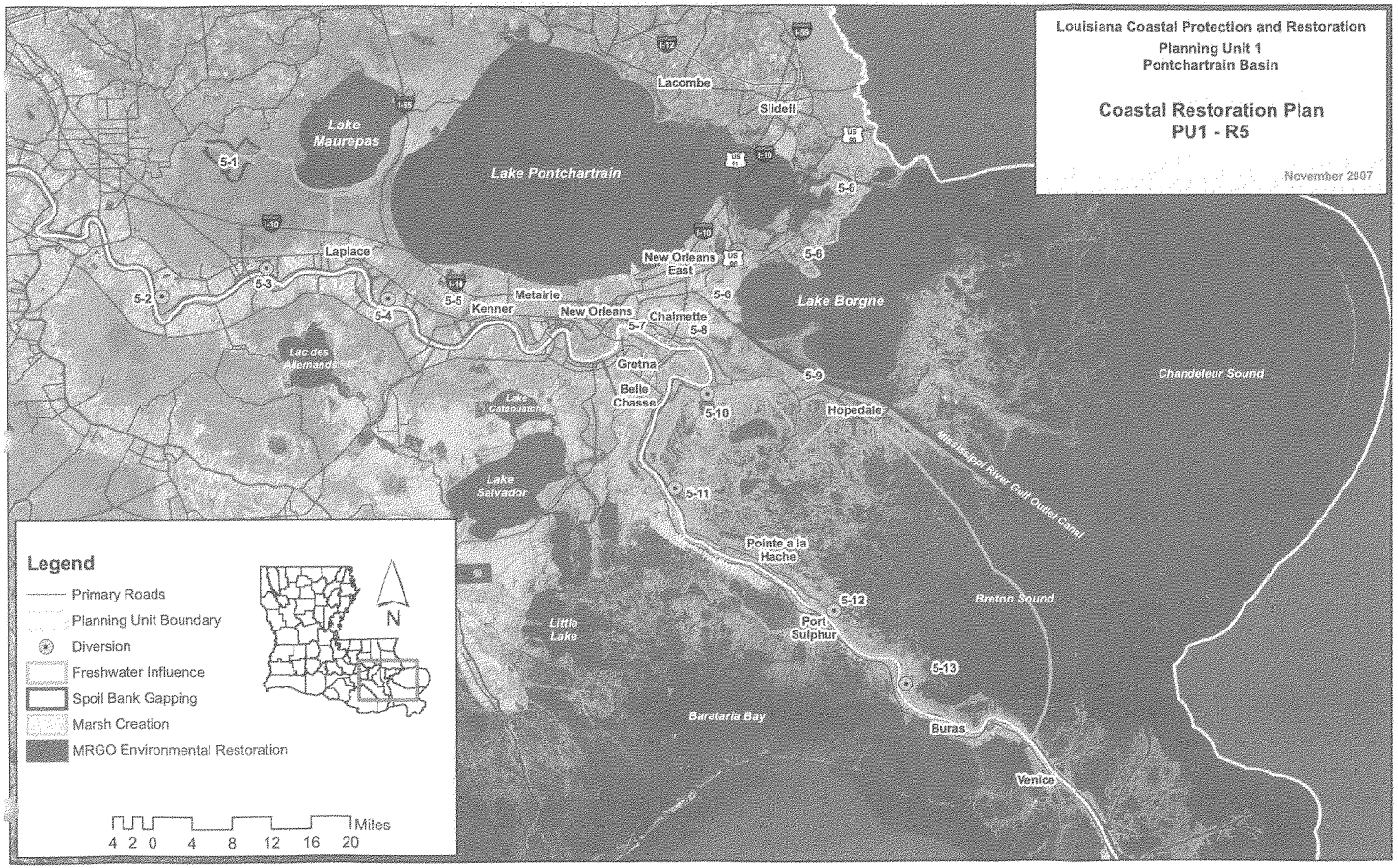
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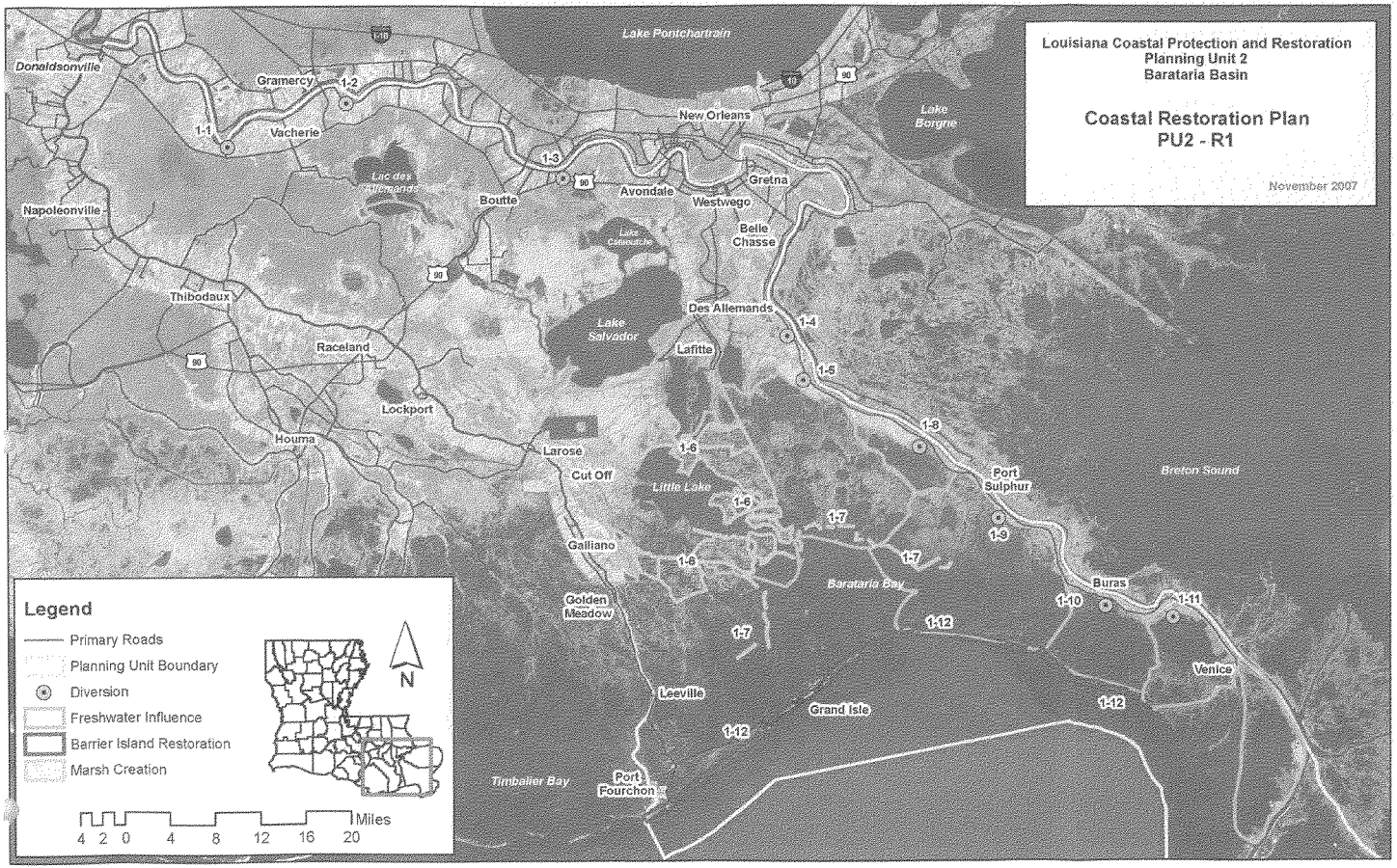
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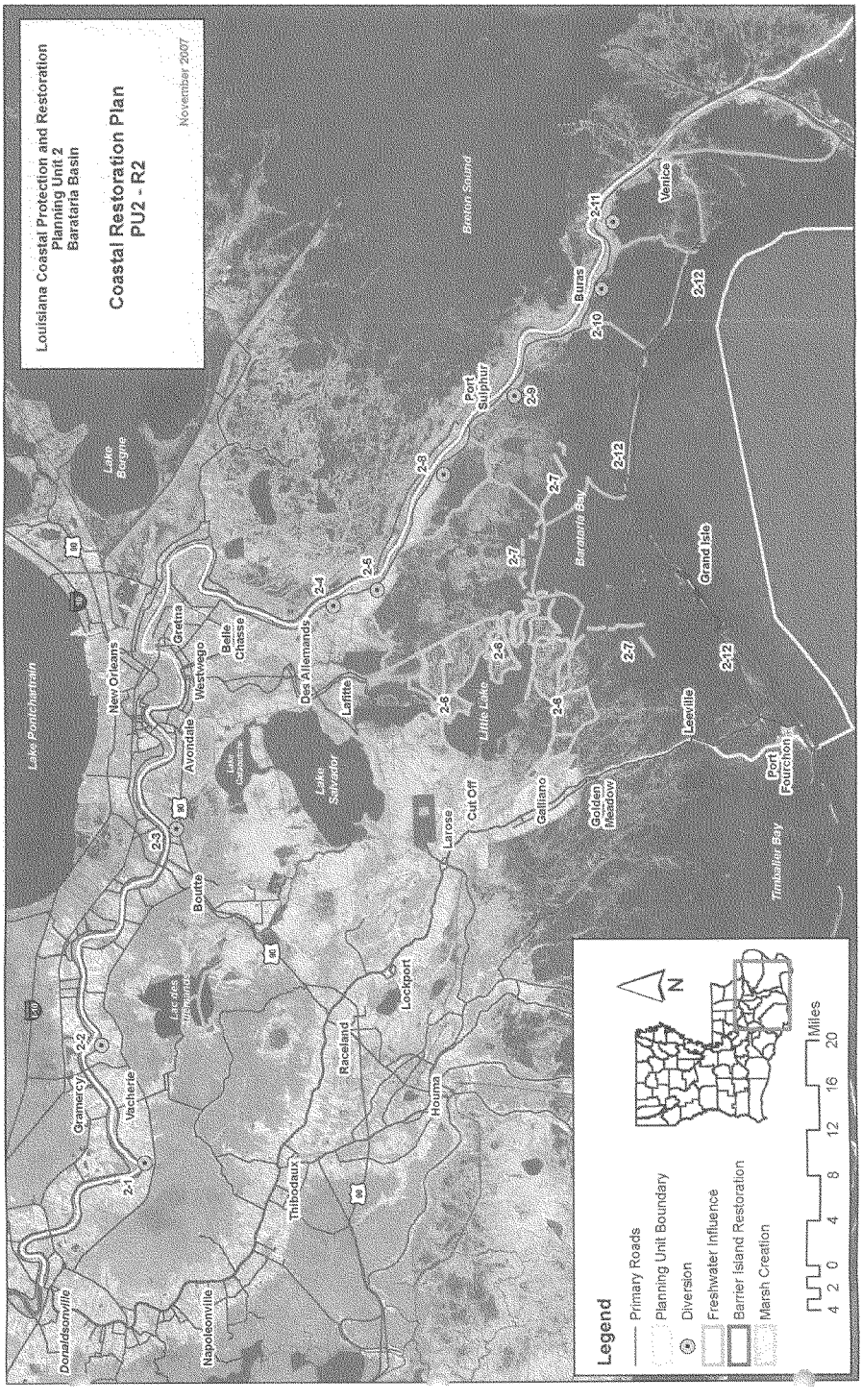
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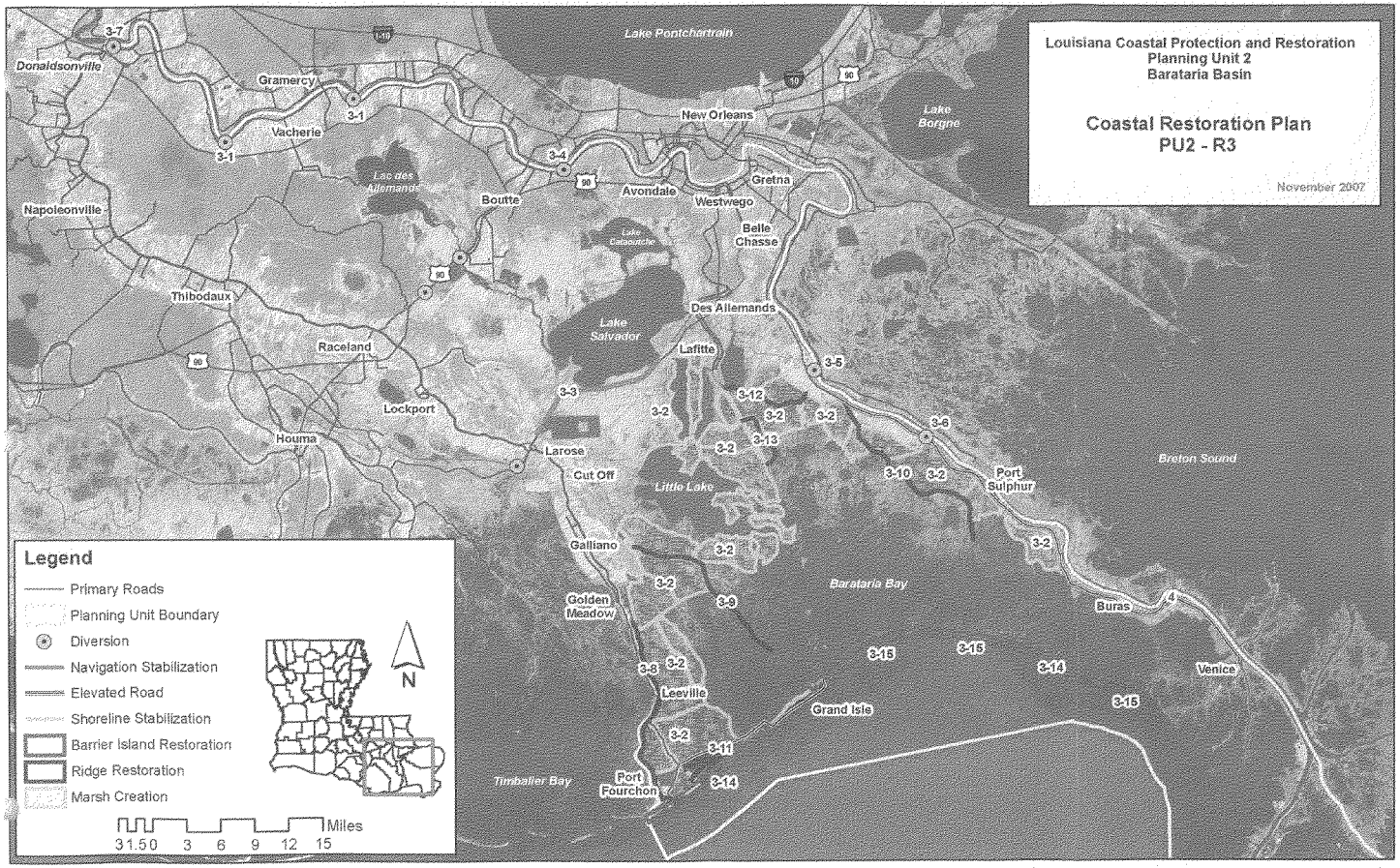
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Des Allemands
Thibodaux
Raceland
Lockport
Houma
Larose
Cut Off
Lafitte
Galliano
Golden Meadow
Leeville
Grand Isle
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Port Sulphur
Buras
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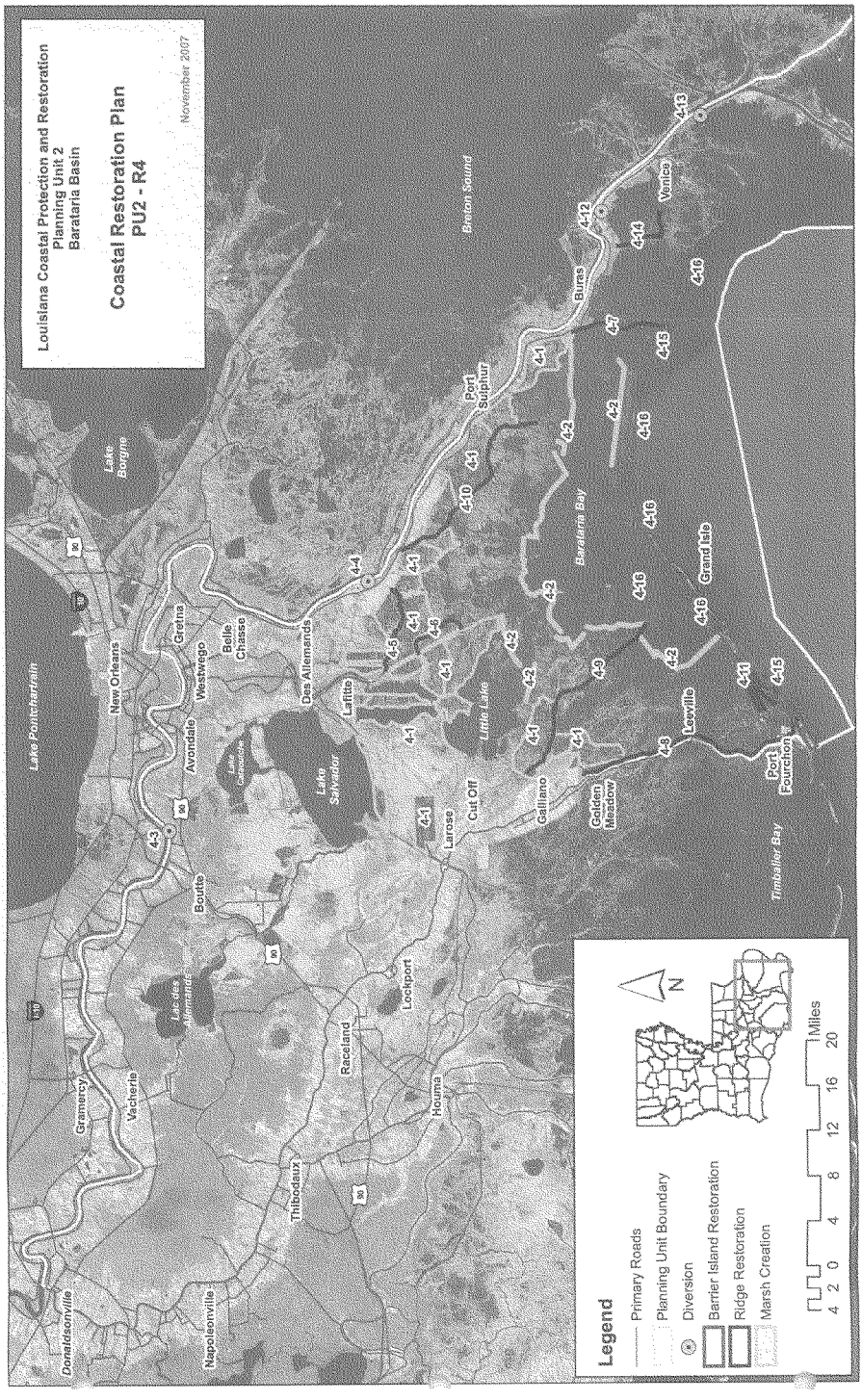
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Ridge Restoration
Marsh Creation
4 2 0 4 8 12 16 20
Miles
N
Lake Pontchartrain
Lake Borgne
Breton Sound
Barataria Bay
Timbalier Bay
Lake Salvador
Little Lake
Lac des Allemands
New Orleans
Gretna
Belle Chasse
Westwego
Avondale
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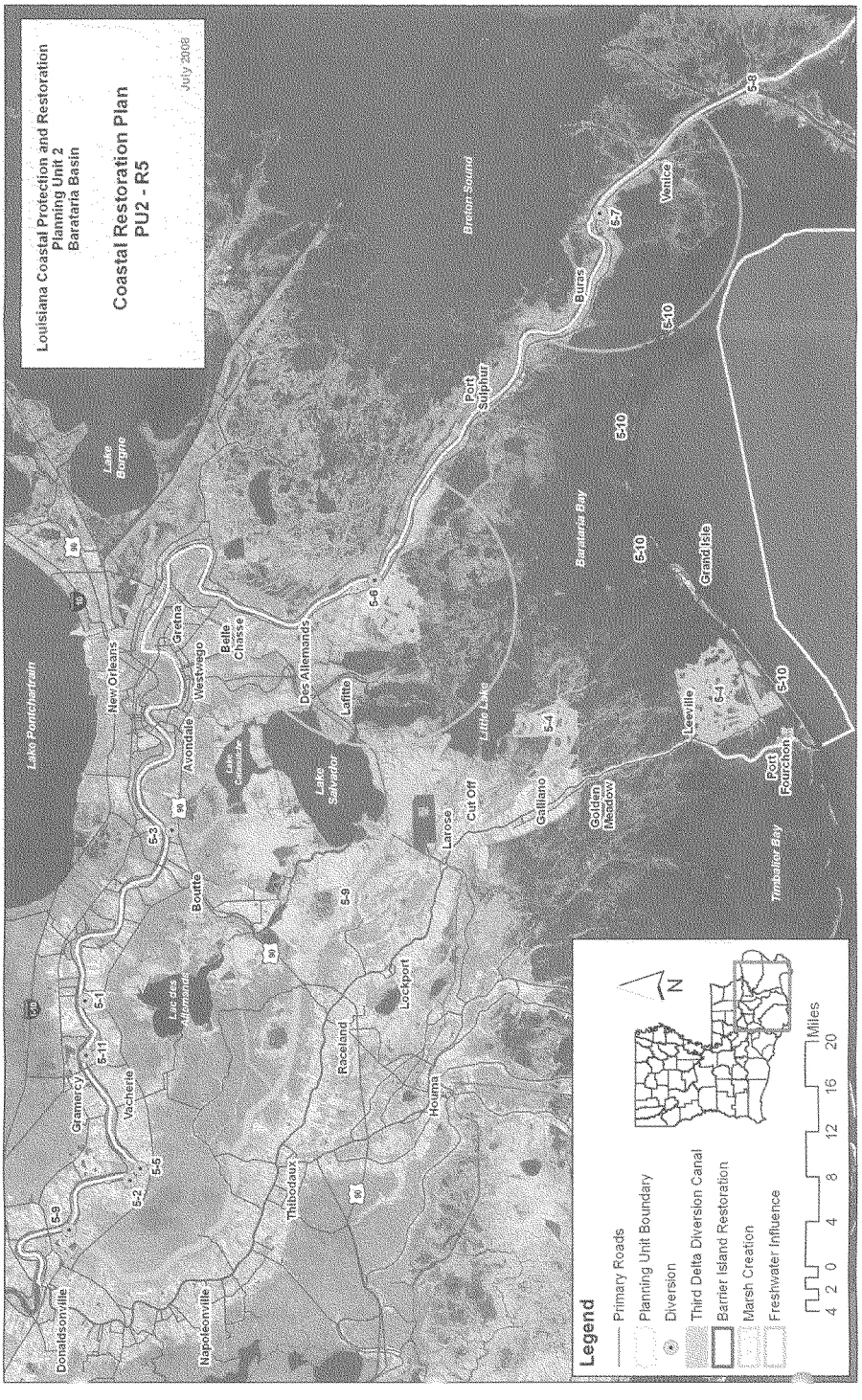
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Lake Borgne
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Barataria Bay
Timbalier Bay
New Orleans
Gretna
Westwego
Belle Chasse
Des Allemands
Lafitte
Avondale
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Larose
Cut Off
Lockport
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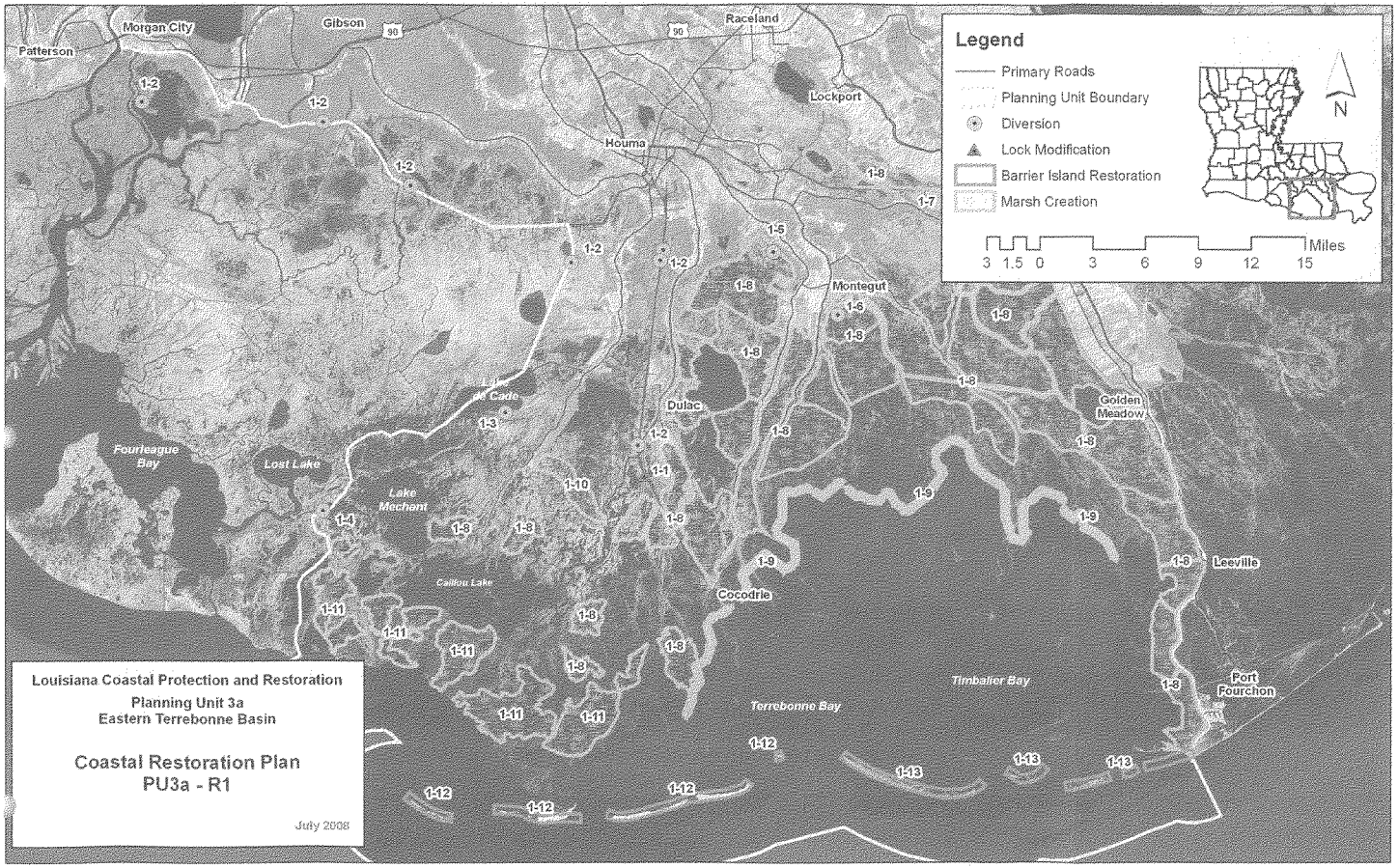
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Houma
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Dulac
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Leeville
Cocodrie
Port Fourchon
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Terrebonne Bay
Fourleague Bay
Lost Lake
Lake Mechant
Caillou Lake
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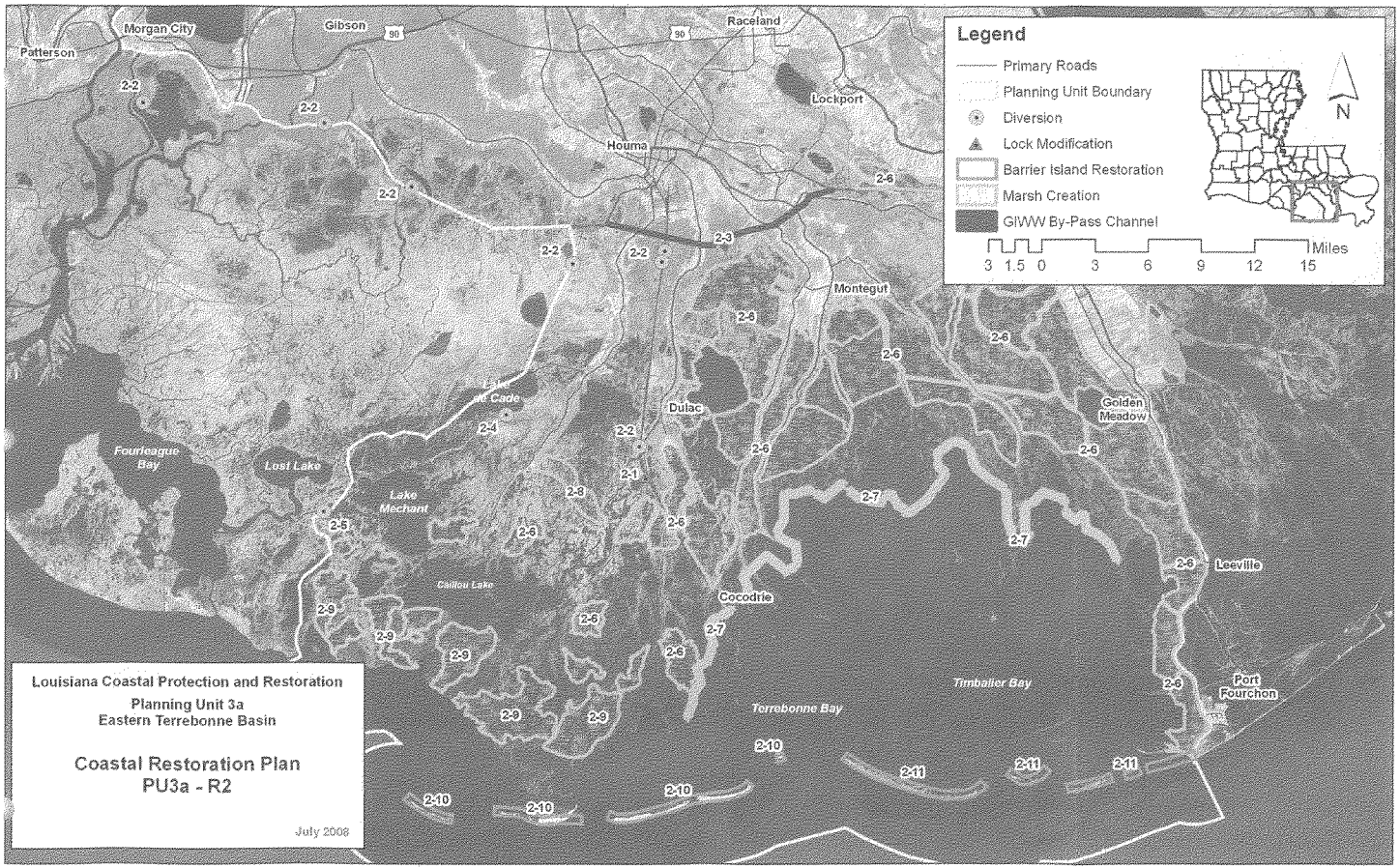
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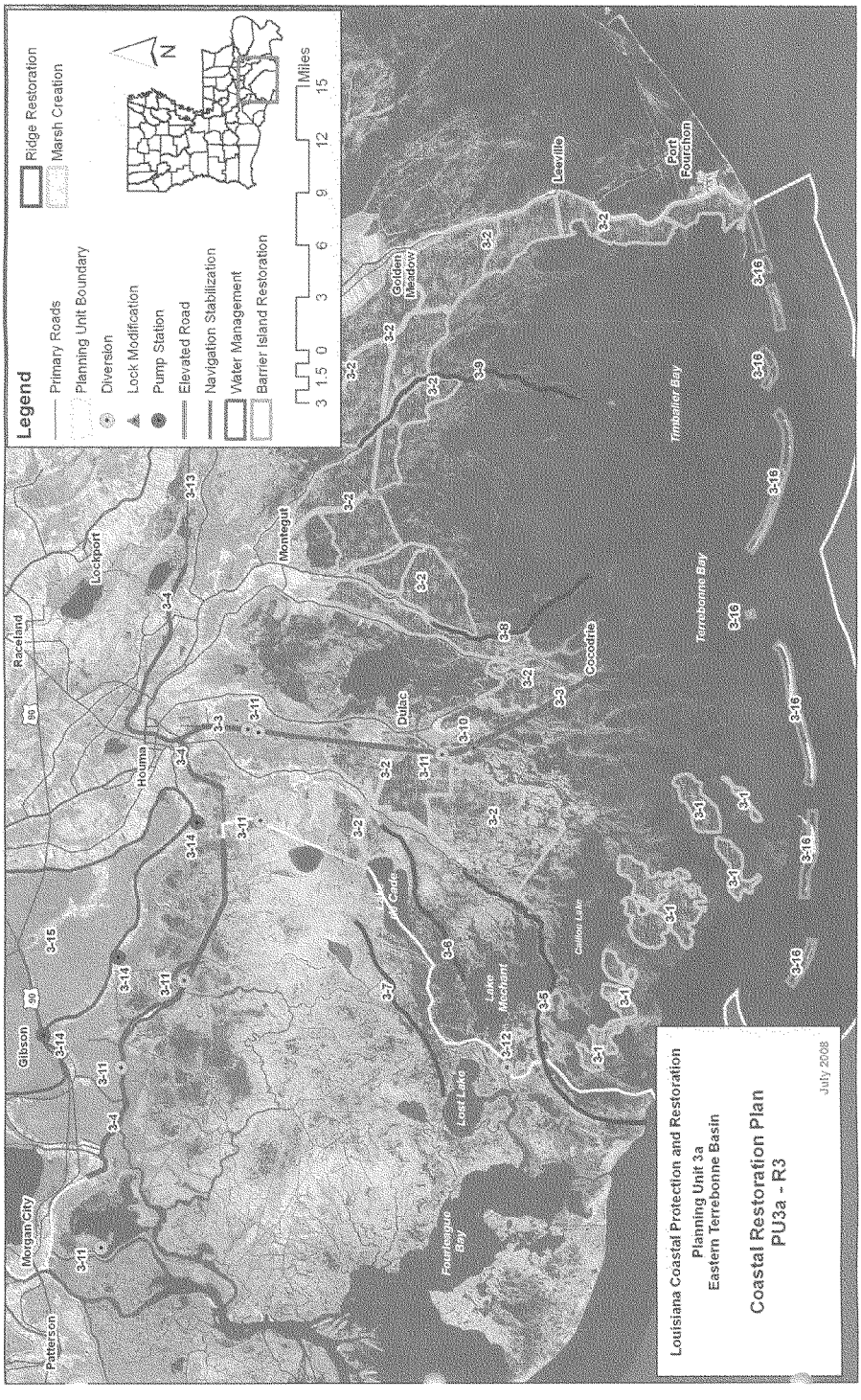
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Louisiana Coastal Protection and Restoration
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Lost Lake
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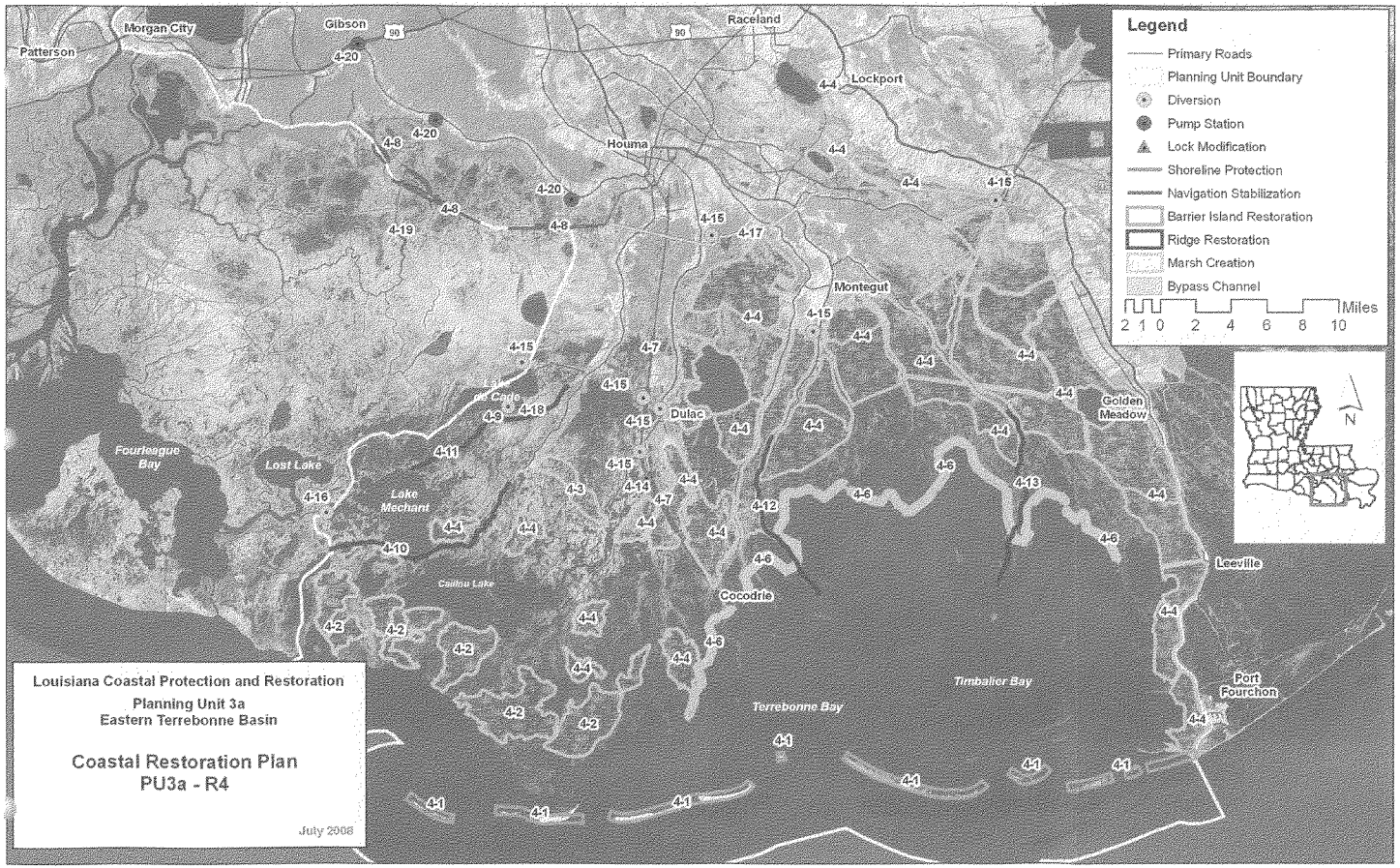
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Navigation Stabilization
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Marsh Creation
Bypass Channel
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2 1 0 2 4 6 8 10
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Louisiana Coastal Protection and Restoration
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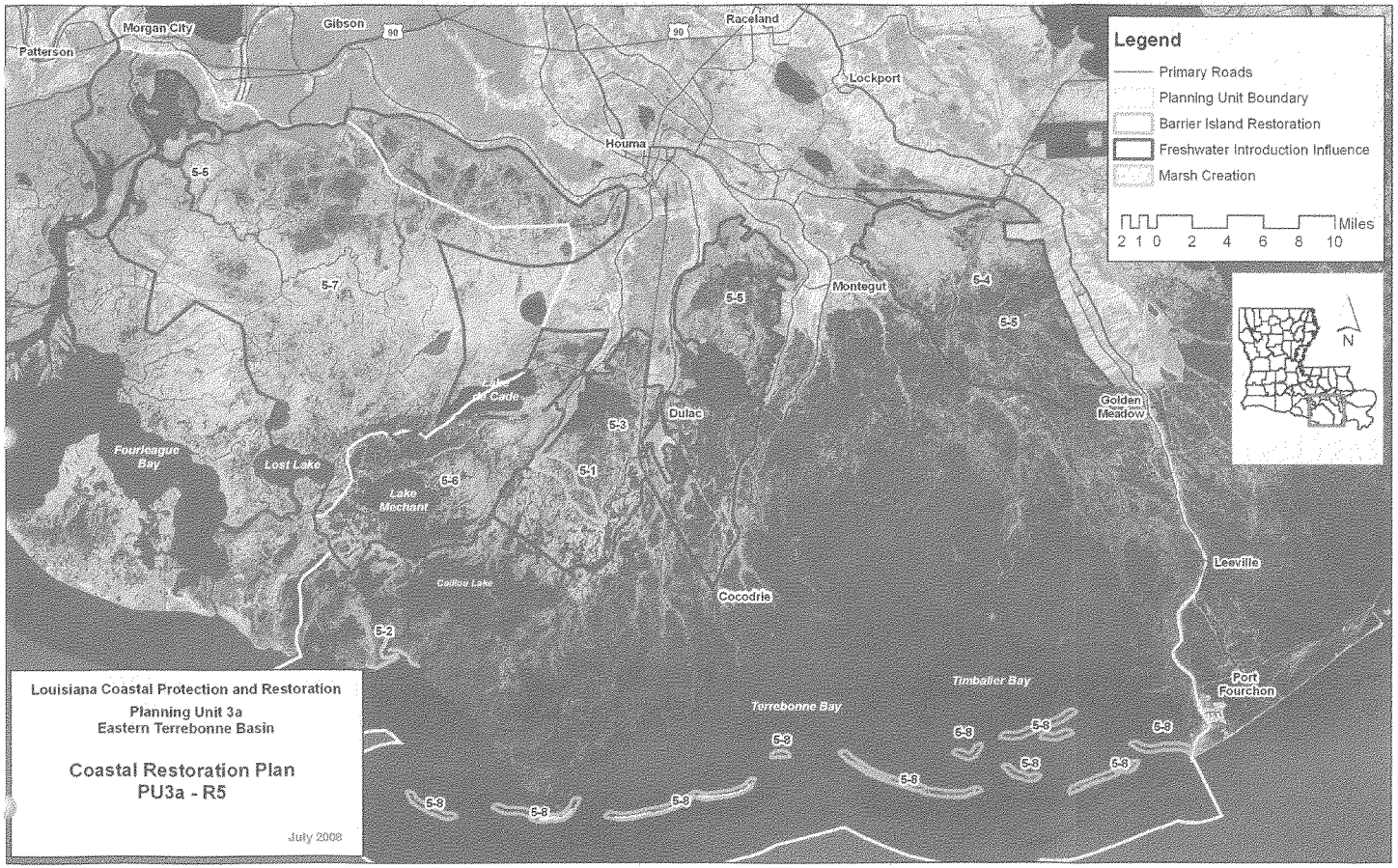
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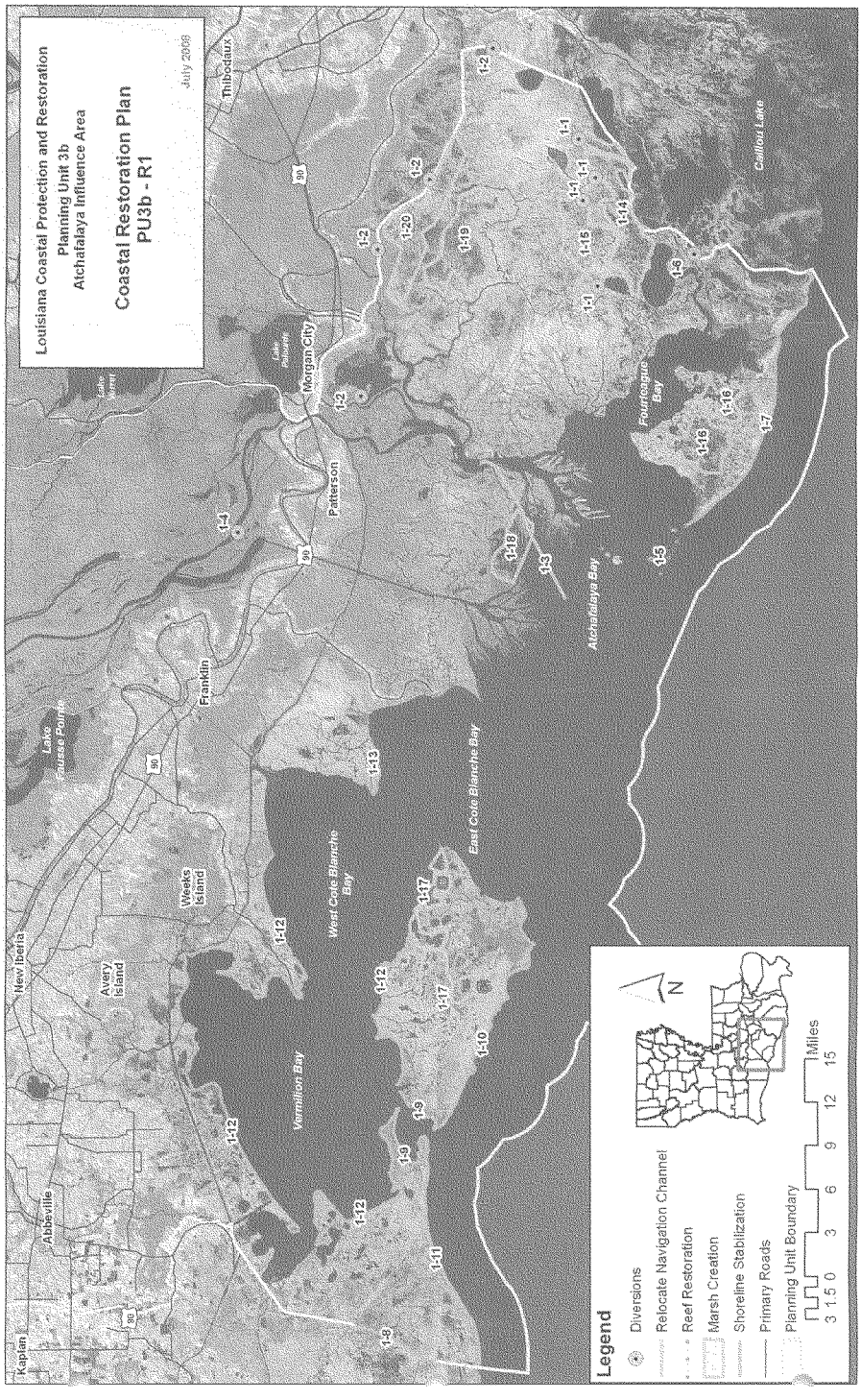
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Weeks Island
Avery Island
New Iberia
Abbeville
Kaplan
Vermilion Bay
West Cote Blanche Bay
East Cote Blanche Bay
Atchafalaya Bay
Fourleague Bay
Caillou Lake
Legend
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Marsh Creation
Shoreline Stabilization
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Miles
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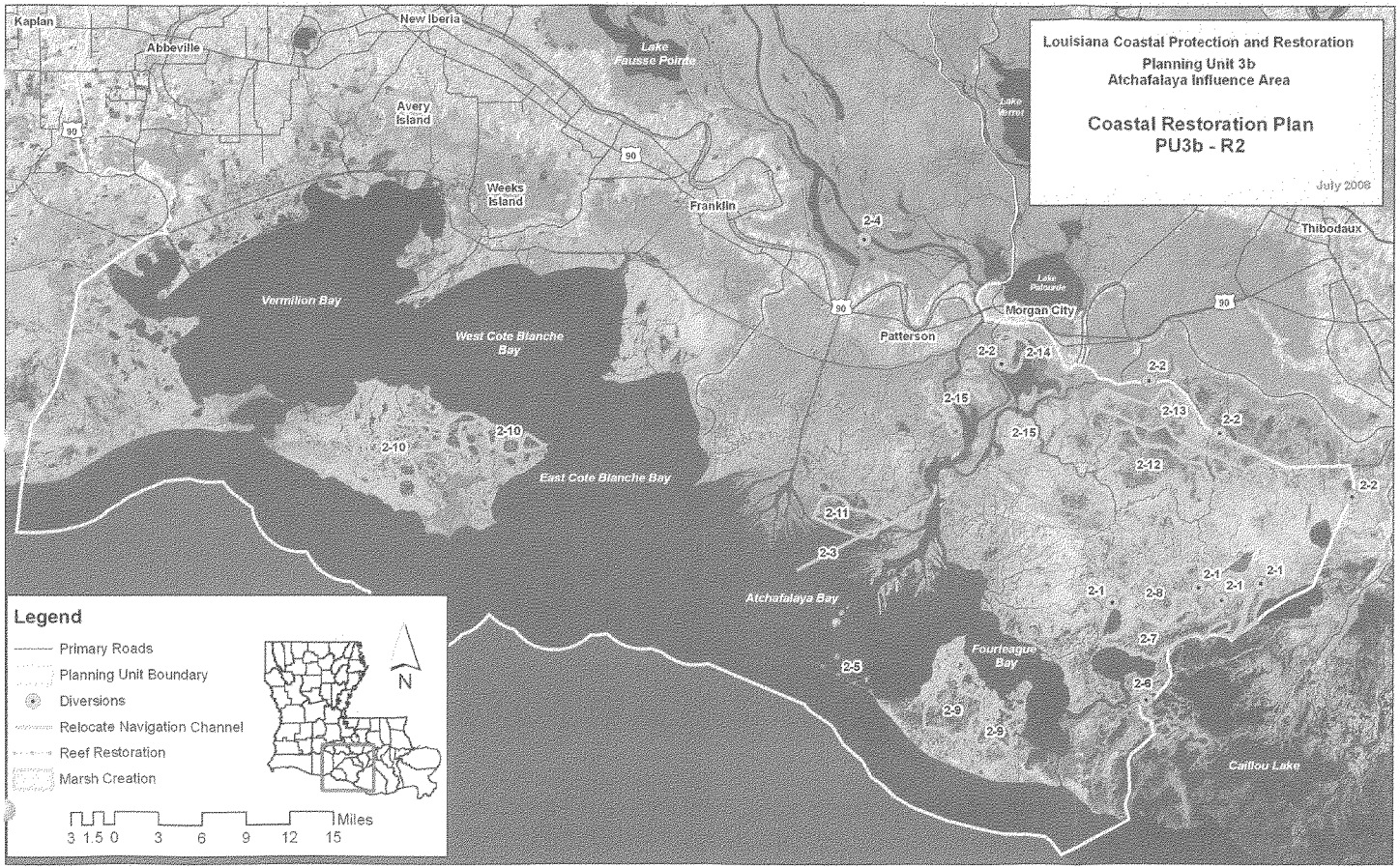
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Fourleague Bay
Lake Palourde
Morgan City
Patterson
Thibodaux
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Relocate Navigation Channel
Reef Restoration
Marsh Creation
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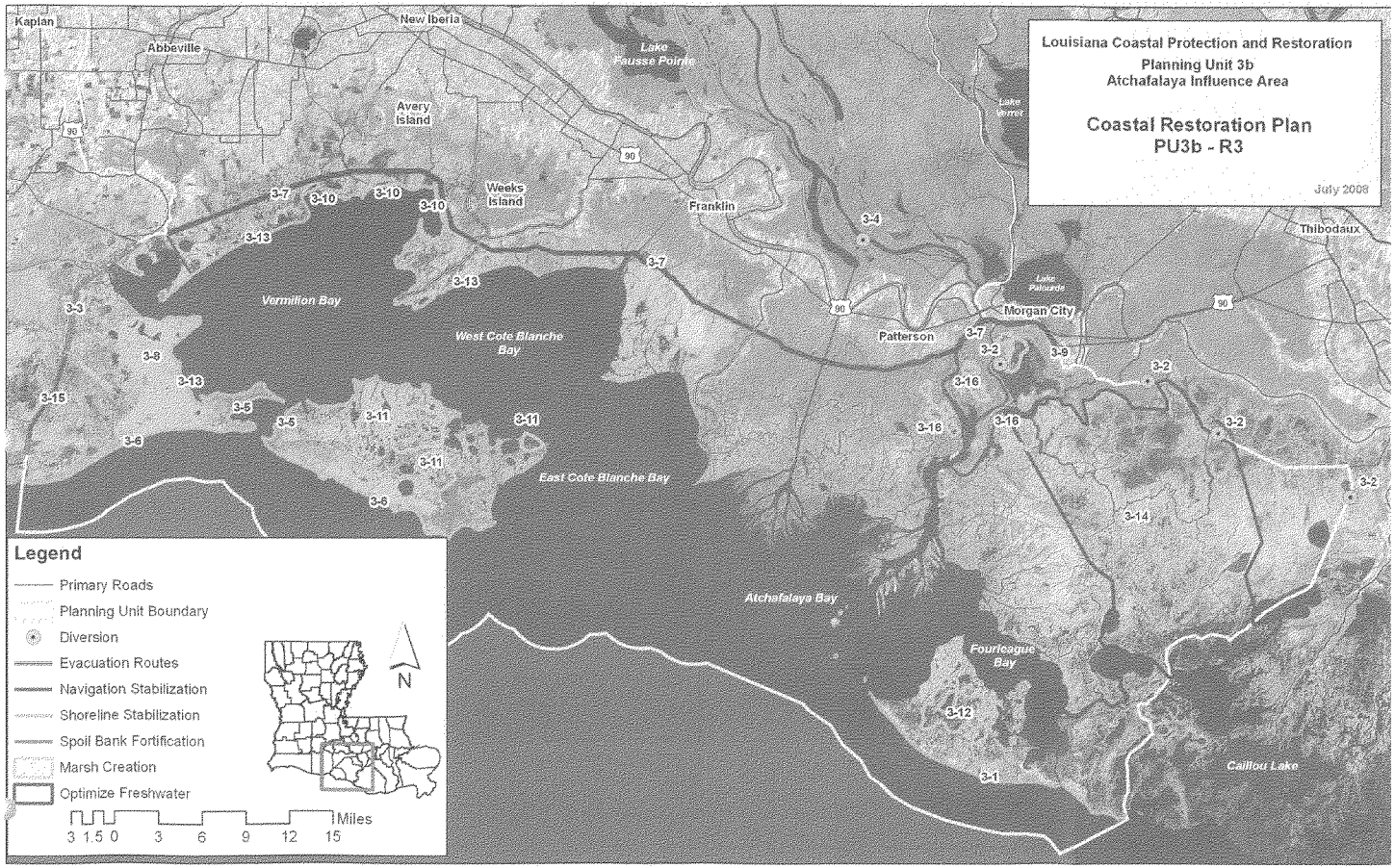
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Lake Palourde
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Atchafalaya Bay
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Marsh Creation
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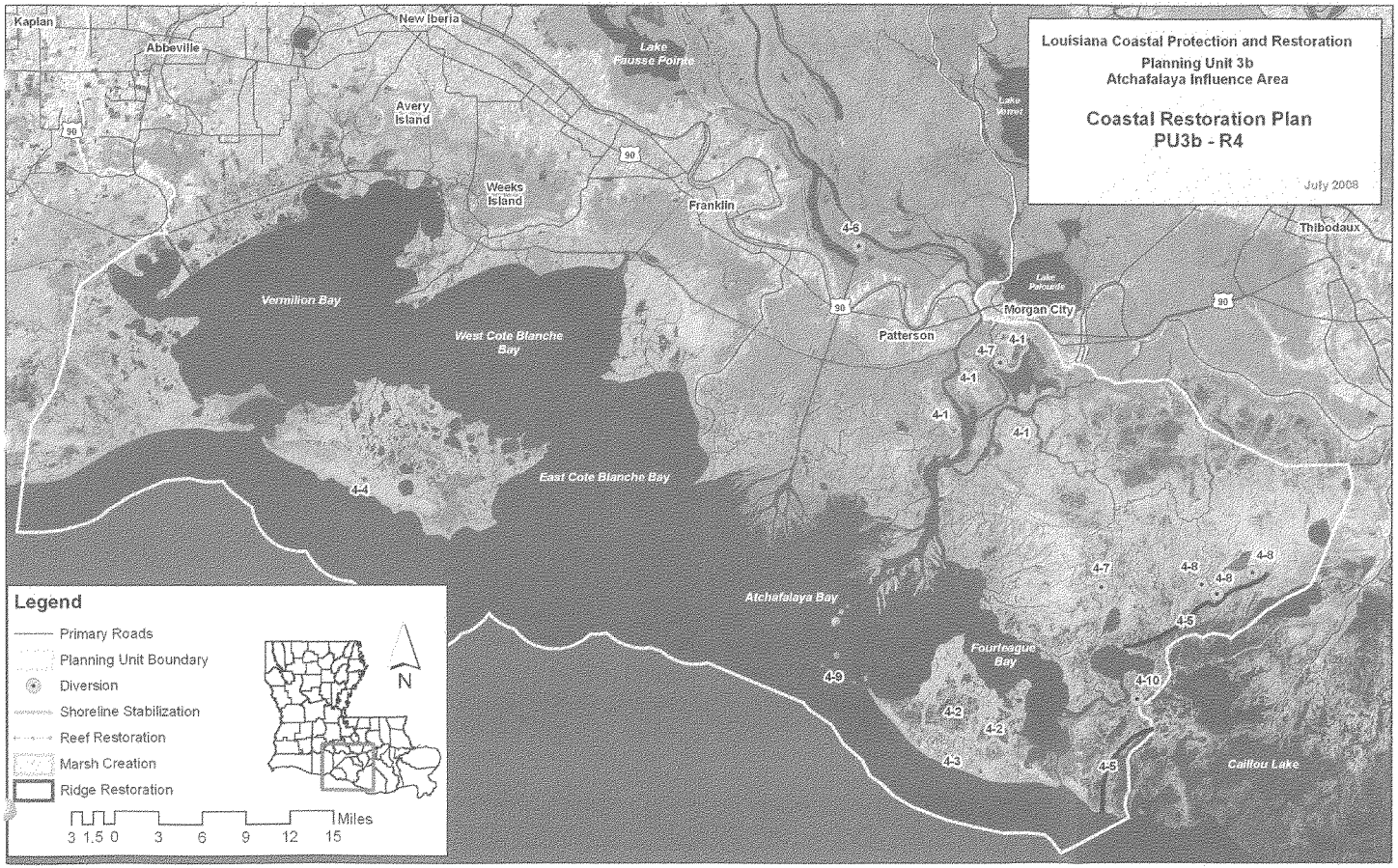
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Morgan City
Lake Palourde
Atchafalaya Bay
Fourleague Bay
Caillou Lake
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Legend
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Diversion
Shoreline Stabilization
Reef Restoration
Marsh Creation
Ridge Restoration
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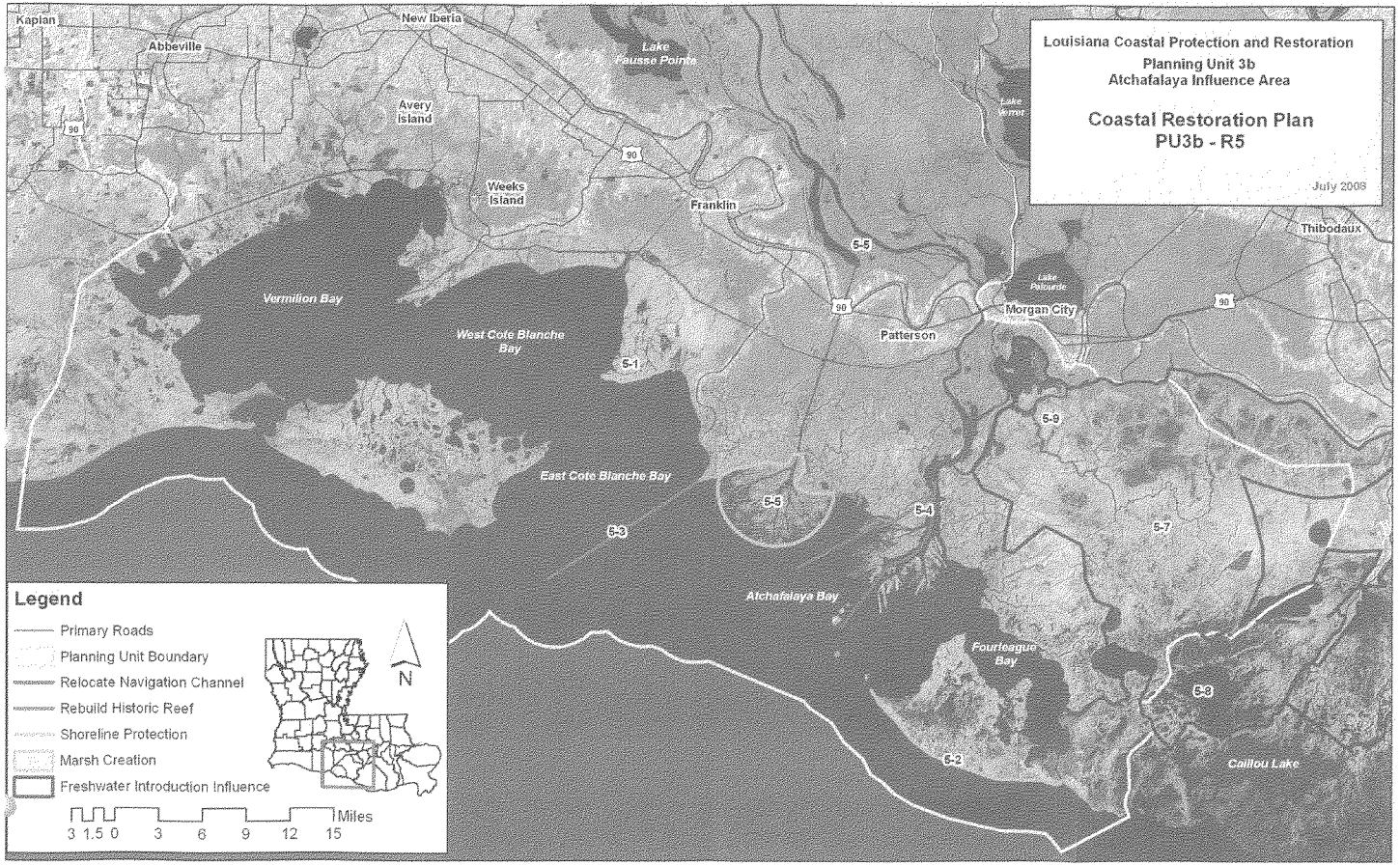
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Weeks Island
Franklin
Thibodaux
Vermilion Bay
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East Cote Blanche Bay
Lake Palourde
Morgan City
Patterson
Atchafalaya Bay
Fourleague Bay
Calliou Lake
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Legend
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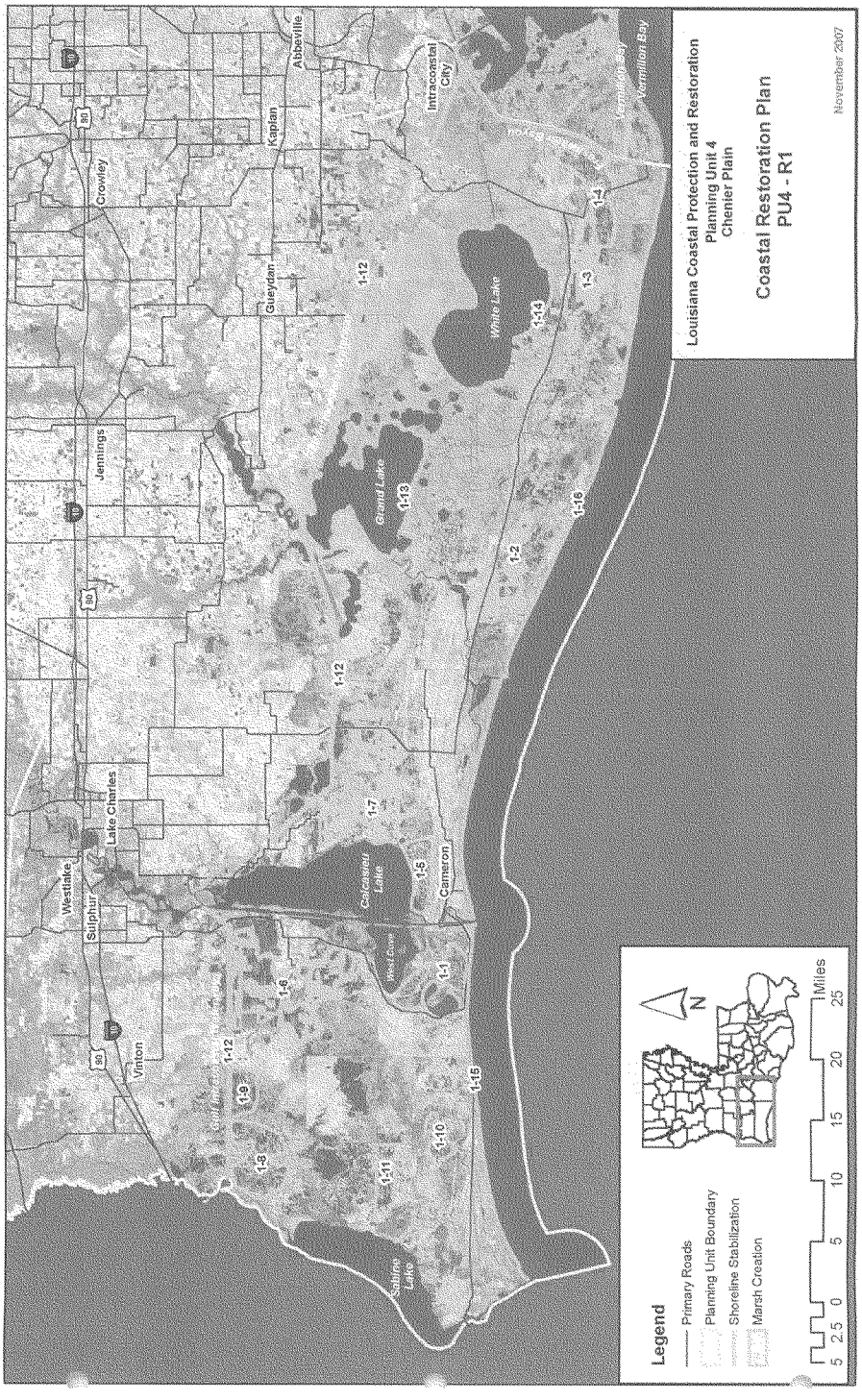
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PU4 - R1
November 2007
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Shoreline Stabilization
Marsh Creation
Miles
5 2.5 0 5 10 15 20 25
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Sabine Lake
Calcasieu Lake
West Cove
Grand Lake
White Lake
Intracoastal City
Abbeville
Kaplan
Gueydan
Crowley
Jennings
Lake Charles
Westlake
Sulphur
Vinton
Cameron
Intracoastal Waterway
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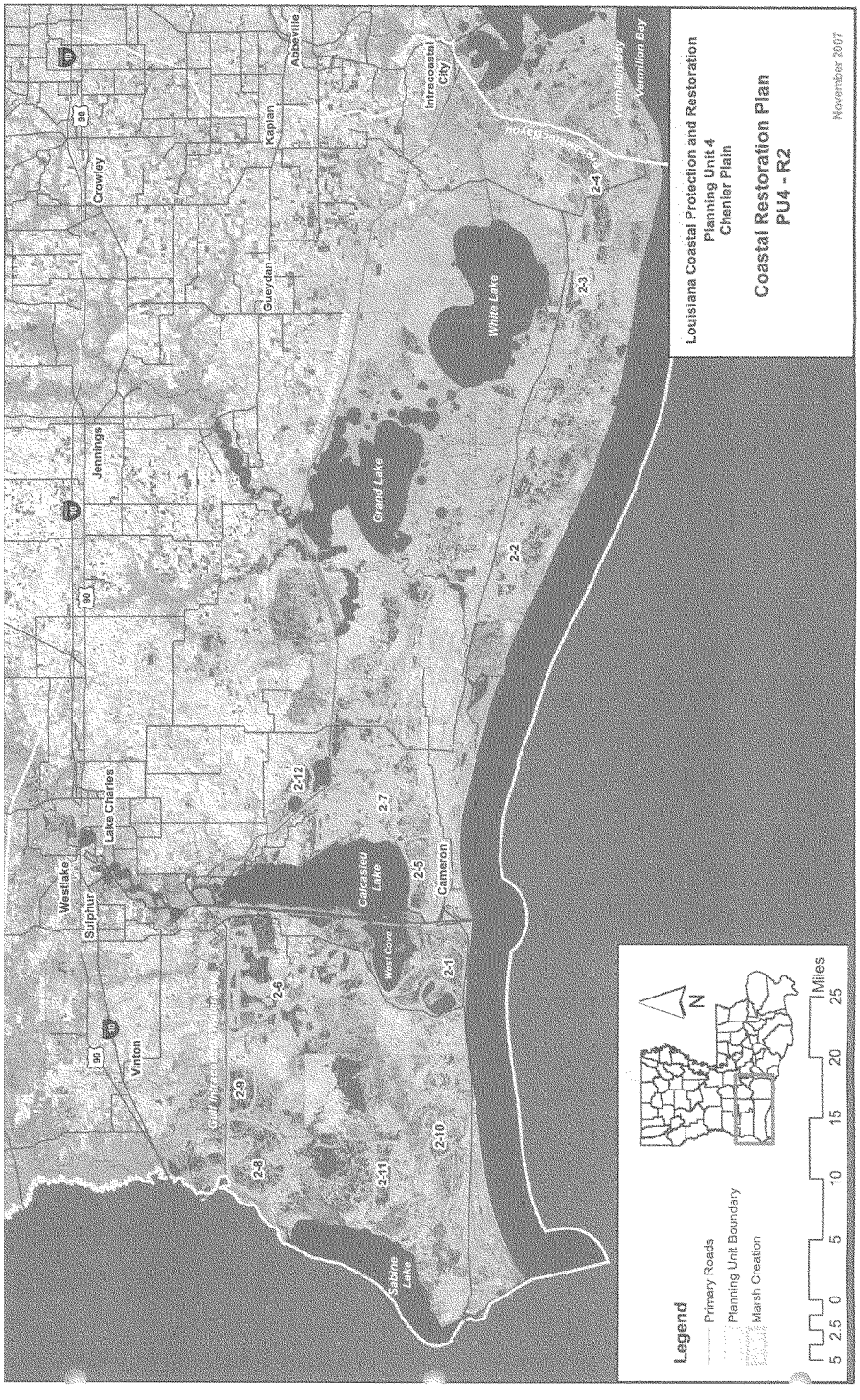
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PU4 - R2
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Marsh Creation
Miles
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Vinton
Jennings
Crowley
Kaplan
Abbeville
Gueydan
Intracoastal City
Grand Lake
White Lake
Calcasieu Lake
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Sabine Lake
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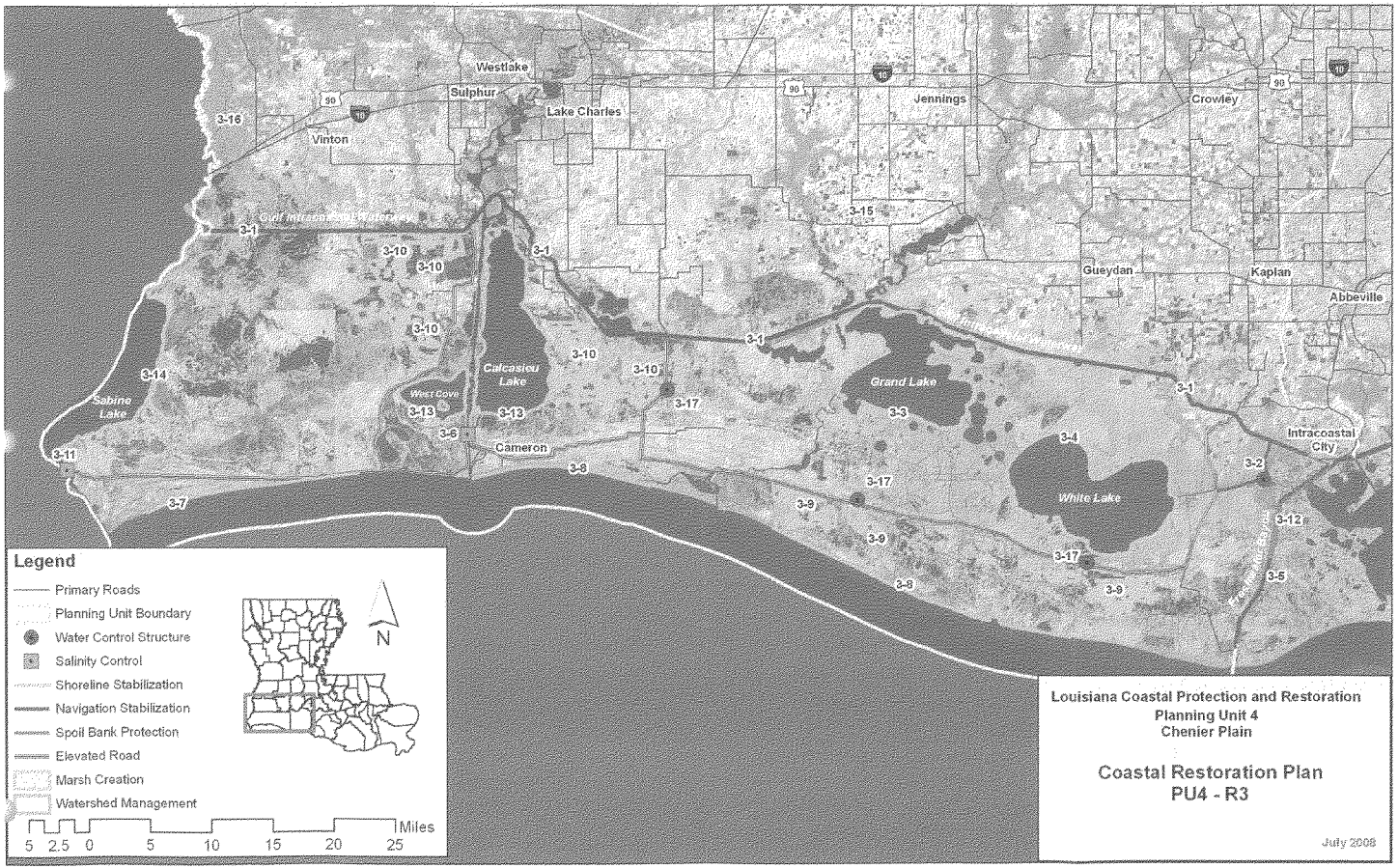
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Planning Unit Boundary
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Salinity Control
Shoreline Stabilization
Navigation Stabilization
Spoil Bank Protection
Elevated Road
Marsh Creation
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Louisiana Coastal Protection and Restoration
Planning Unit 4
Chenier Plain
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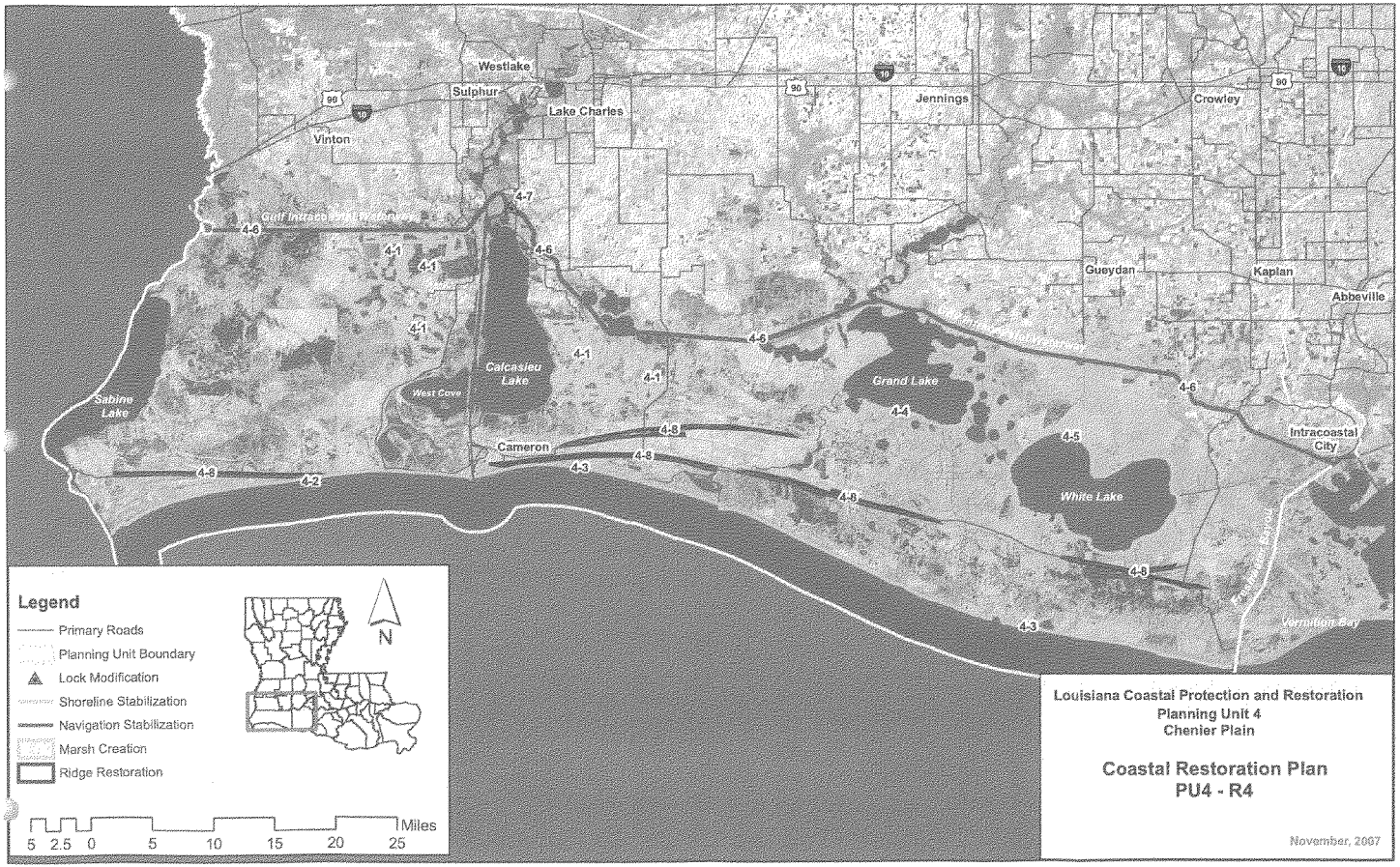
PU4 - R3
July 2008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White Lake
Intracoastal City
Vermilion Bay
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4-6
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Legend
Primary Roads
Planning Unit Boundary
Lock Modification
Shoreline Stabilization
Navigation Stabilization
Marsh Creation
Ridge Restoration
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Louisiana Coastal Protection and Restoration
Planning Unit 4
Chenier Plain
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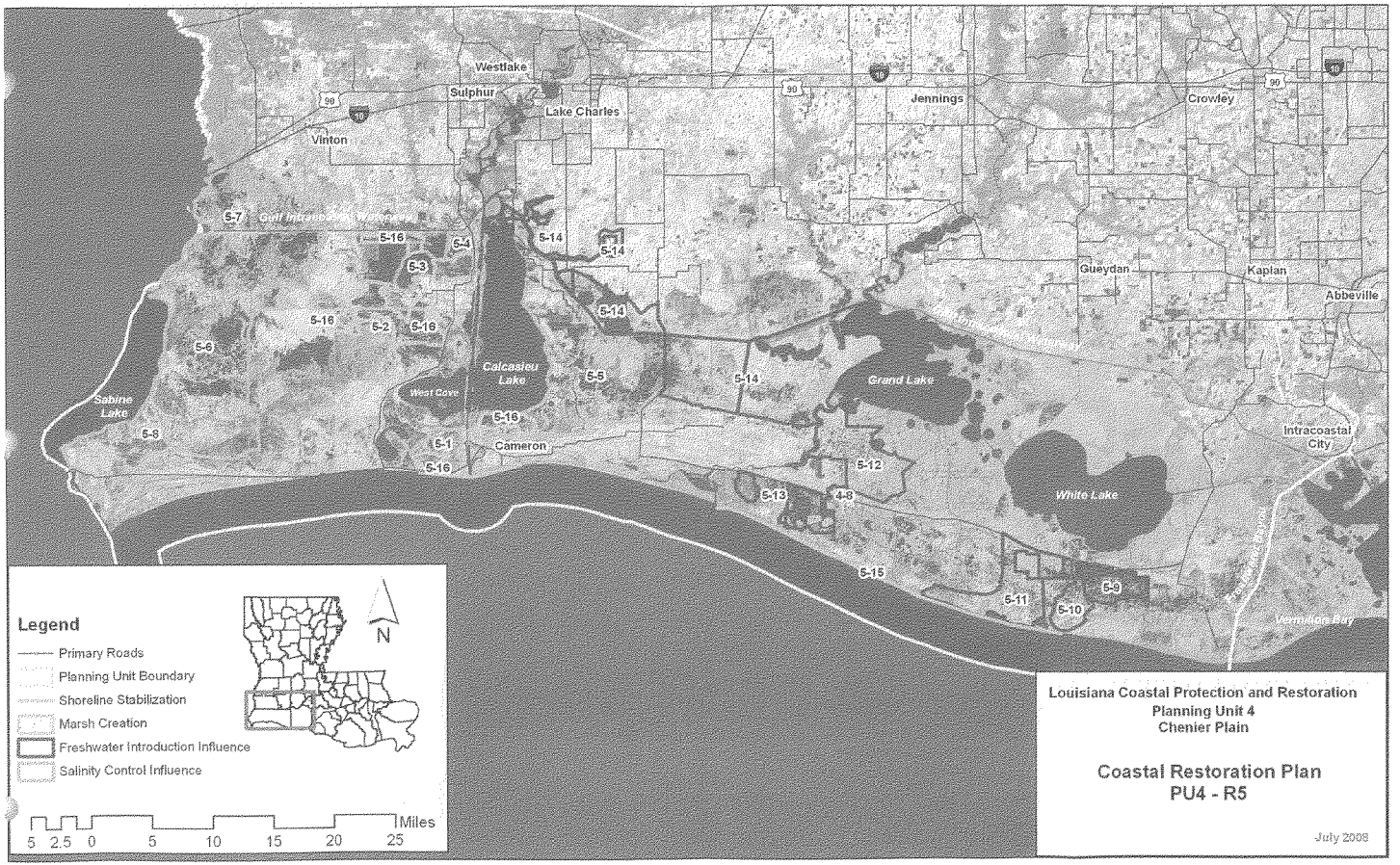
PU4 - R4
November, 2007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Legend
Primary Roads
Planning Unit Boundary
Shoreline Stabilization
Marsh Creation
Freshwater Introduction Influence
Salinity Control Influence
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Miles
5 2.5 0 5 10 15 20 25
Louisiana Coastal Protection and Restoration
Planning Unit 4
Chenier Plain
Coastal Restoration Plan
PU4 - R5
July 2008

ATTACHMENT B

Indirect Impacts Matrix

December 2008

Planning Unit 1

Levee Alignment	Hydrologic Impacts	Fishery Impacts	Induced Development	Ecological Sustainability/ Consistency	Total Score
LP-a-100-1	-2[1]	-2[2]	-2[3]	-2[4]	-8
LP-b-400-1	-2	-2	-2	-2	-8
LP-a-100-3	-2	-2	-2	-2	-8
HL-a-100-3	-1[5]	0[6]	-1[7]	+1[8]	-1
LP-a-100-2	-2	-2	-2	-2	-8
HL-a-100-2	-1[9]	-1[10]	-1[11]	+1	-2
LP-b-1000-1	-2	-2	-2	-2	-8
HL-b-400-2	-1[12]	-1[13]	-1[14]	+1	-2
LP-b-400-3	-2	-2	-2	-2	-8
HL-b-400-3	-1	-1	-1	+1	-2
LP-b-1000-2	-2	-2	-2	-2	-8

[1] High potential to alter tidal flow in and out of Lake Pontchartrain, as well as drainage rates. *Such impacts could potentially be mitigated by designing the barrier in a way that does not change the cross sections at the passes.*

[2] High potential to affect fish ingress and egress due to changes in velocities and other factors. *Such impacts could potentially be mitigated by designing the barrier in a way that does not change the cross sections at the passes.*

[3] Could facilitate various types of development in wetlands along north shore of Lake Pontchartrain and around Lake Maurepas.

[4] High potential for basin-wide enclosure impacts. Could conflict with future up-basin diversions.

[5] Potential for adverse hydrologic changes due to Slidell ring levee.

[6] Slidell ring levee could adversely affect fisheries, but such impacts would be relatively minor compared to other levee alignments in this planning unit.

[7] Slidell ring levee could induce development in wetlands.

[8] Could facilitate river reintroduction projects by minimizing potential concerns with flood risks to developed areas.

[9] North shore levees could affect tributary flow into Lake Pontchartrain and could enclose some wetlands. South shore would be built on existing alignments.

[10] North shore levees could have adverse impacts on fisheries.

[11] North Shore levees could facilitate recreational and residential development in enclosed wetlands.

[12] The enclosure of the Golden Triangle is likely to adversely impact wetland hydrology.

[13] The enclosure of the Golden Triangle is likely to adversely impact fisheries.

[14] Slidell and North Shore levees could induce development in wetlands.

Planning Unit 2

Levee Alignment	Hydrologic Impacts	Fishery Impacts	Induced Development	Ecological Sustainability/ Consistency	Total Score
WBI-100-1	0	0	+1[15]	+1[16]	+2
G-100-1	-2[17]	-2[18]	-2[19]	-2[20]	-8
R-100-2	0[21]	0	+2[22]	+2[23]	+4
R-100-3	0	0	+2	+2	+4
WBI-400-1	0	0	+1	+1	+2
R-100-4	0	0	+2	+2	+4
R-400-2	0	0	+2	+2	+4
G-100-4	-2	-2	-2	-2	-8
R-400-3	0	0	+2	+2	+4
R-400-4	0	0	+2	+2	+4
R-1000-4	0	0	+2	+2	+4
G-400-4	-2	-2	-2	-2	-8
G-1000-4	-2	-2	-2	-2	-8

[15] Would direct future development towards higher ground, but would not to the same extent as the "Ridge" alignment.

[16] Could facilitate diversions and hydrologic restoration, though not as much as "Ridge" alignment.

[17] Existing hydrologic disruption caused by GIWW would likely be worsened unless numerous gates were installed. Potential to further restore basin-wide hydrology in future would be greatly reduced. Encloses greatest area of wetlands.

[18] Would enclose large estuarine area. The ability to maintain or enhance existing fishery access is highly uncertain. Would likely cause significant direct, indirect, and secondary impacts to fish habitat.

[19] Could induce commercial and/or recreational development in wetlands along Highway 90/I49, GIWW, Lake Salvador and vicinity. Forested wetlands north of Highway 90/I49 would be more susceptible to residential, commercial and recreational development.

[20] High potential for conflict with future up-basin diversions.

[21] Assumes that levee is built on upland side of wetland-upland interface.

[22] Would direct future development away from wetlands towards higher ground along the Mississippi River and Bayou Lafourche.

[23] Could facilitate diversions and hydrologic restoration by minimizing flood risk to developed areas.

Planning Unit 3a

Levee Alignment	Hydrologic Impacts	Fishery Impacts	Induced Development	Ecological Sustainability/ Consistency	Total Score
M-100-1	-2[24]	-2[25]	-1[26]	-2[27]	-7
M-100-2	-1	-1	-1	-1	-4
G-400-2	-2	-1	-2[28]	-2	-7
G-1000-2	-2	-1	-2	-2	-7

[24] Potential for adverse impacts to wetlands enclosed within levee system due to altered hydrology. Such impacts could be further minimized by proper design, construction, and operation of water control features.

[25] This alignment would enclose large estuarine area. Could adversely affect fisheries ingress and egress into large estuarine area. Such impacts could be minimized by proper design, construction, and operation of water control features.

[26] This alignment could induce/facilitate commercial, residential, and recreational development in wetland areas behind levee.

[27] Potential for conflict with future diversions. (However, the Morganza to the Gulf alignment, the Bayou Black Ridge alignment, and the GIWW alignment could theoretically be designed, built, and operated in a way that could improve freshwater distribution.)

[28] Substantially reduced hurricane flooding risk could substantially induce development in wetlands in vicinity of Houma. Could be less negative or positive if the design is optimized.

Planning Unit 3b

Levee Alignment	Hydrologic Impacts	Fishery Impacts	Induced Development	Ecological Sustainability/ Consistency	Total Score
G-100-1	-2	-2	-2	-2[29]	-8
F-100-1	0	0	+1	+1	2
F-400-1	0	0	+1	+1	2
F-1000-1	0	0	+1	+1	2
RL-100-1	0	0	+1	+1	2
RL-400-1	0	0	+1	+1	2

[29] Levees would enclose marshes and may reduce freshwater flow and sediment input to enclosed and outside marshes via GIWW and other structures.

Planning Unit 4

Levee Alignment	Hydrologic Impacts	Fishery Impacts	Induced Development	Ecological Sustainability/ Consistency	Total Score
G-100-1	-2[30]	-1[31]	-1[32]	-1	-5
G-100-2	-2	-1	-1	-1	-5
G-400-3	-2	-1	-2	-1	-6
G-1000-3	-2	-1	-2	-1	-6
RL-100-1	0	0	0	0	0
RL-400-1	0	0	0	0	0
RL-1000-1	0	0	0	0	0

[30] Existing hydrologic disruptions caused by the GIWW would likely be worsened unless gates were installed. Potential to restore basin-wide hydrology in future would be reduced or eliminated.

[31] Could enclose estuarine habitat.

[32] Could induce commercial and/or recreational development in wetlands south of Highway 14.

ATTACHMENT C

Quantifying Benefits of Freshwater Flow Diversion to Coastal Marshes: Theory and Application

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Quantifying Benefits of Freshwater Flow Diversion to Coastal Marshes: Theory[a] and Applications[b]

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Abstract

The combination of relative sea level rise and river/marsh disconnection has created a deficit of available soil and accompanying land loss in a large portion of coastal Louisiana. The U.S. Congress recently charged the U.S. Army Corps of Engineers, State of Louisiana, and other federal and local agencies with restoring the coastal wetlands of Louisiana and Mississippi. Many alternative combinations of restoration measures have been proposed, and assessment of the advantages and disadvantages of these efforts must be made to determine the optimal design. One technique being applied for coastal restoration is the reconnection of rivers to coastal marshes through flow diversions.

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[a] Based on material from McKay, S.K., J.C. Fischenich, and S.J. Smith. (2008). "Quantifying Benefits of Flow Diversion to Coastal Marshes. I: Theory." In draft for submission to Ecological Engineering.
[b] Based on material from McKay, S.K., J.C. Fischenich, and R. Paille. (2008). "Quantifying Benefits of Flow Diversion to Coastal Marshes. II: Application to Louisiana Coastal Protection and Restoration." In draft for submission to Ecological Engineering.

Freshwater flow diversions offer significant nutrient and sediment inputs to marshes that induce both organic and inorganic accumulation of soil. Boustany (2007) presented a screening level model for assessing both the nutrient and sediment benefits of flow diversion over long time scales. This paper has presented the adaptation of Boustany's (2007) model to include daily variation in sediment processes in order to optimize diversion structure design and operation. The model was verified using an existing diversion to prove the ability of the model to track land evolution associated with flow diversion. This paper also demonstrates the application of the model to diversion operational and structural optimization.

Introduction

In the fall of 2005, Hurricanes Katrina and Rita awakened the United States public to the natural protection that coastal wetlands provide in reducing of the effects of hurricanes on coastal communities. In response to these catastrophic events, the U.S. Congress directed the U.S. Army Corps of Engineers (USACE) to "conduct a comprehensive hurricane protection analysis and design...to develop and present a full range of flood control, coastal restoration, and hurricane protection measures" (USACE, 2006). This paper focuses on interagency efforts to assess and weigh benefits of coastal restoration via freshwater flow diversion. The paper will focus on the development and adaptation of a screening level model to quantify the benefits of flow diversion to coastal marshes and will describe the assessment of various diversion operational and structural scenarios.

Coastal Marsh Accretion and Flow Diversion

The tidal marshes of coastal Louisiana are receding at alarming rates as high as 115 km^2/yr (Barras et al., 1994). Submergence of these valuable ecological assets (Figure 1) was once counteracted by vertical accretion due to the addition of freshwater, nutrient, and mineral inputs from riverine environments; however, eustatic sea level rise (ESLR) and basin subsidence now exceed the current rate of vertical accretion, and coastal marshes have been disconnected from their freshwater and sediment sources, distributary channels of the Mississippi and Atchafalya Rivers. ESLR has been attributed to global increase in ocean volume and has been estimated as 1.0-2.4 mm/yr (Church et al., 2001). Subsidence of the Mississippi delta has been attributed to multiple factors, namely: regional isostasy, faulting, sediment consolidation, and soil dewatering (Dokka et al., 2006). Previous researchers identified other potential sources of subsidence as groundwater and petroleum extraction (Morton et al., 2002); however, Dokka et al. (2006) renounce these hypotheses as unlikely due to the relative lack of groundwater extraction from the highly saltwater intruded groundwater table of most of southern Louisiana and the lack of coincidence between petroleum extraction and subsidence. The synergy of ESLR and basin subsidence has created an apparent local change in sea level known as Relative Sea Level Rise (RSLR) that has been measured in the Mississippi Delta at rates as high as 10 mm/yr (Snedden et al., 2007).

In addition to RSLR, the disconnection of coastal marshes from their sediment and nutrient source is equally disconcerting. Over geologic time scales, large-scale delta lobe switching has lead to alternating episodes of delta building and redistribution of sediment

and nutrients throughout the coastal plain (Coleman, 1988; Coleman et al., 1998); however, in the last two centuries, the Mississippi River has been controlled by levees and other structures in order to maintain a consistent navigation channel for commerce and protect infrastructure against floods (Coleman et al., 1998; Parker et al., 2006). Presently, much of the sediment and nutrient load of the Mississippi River is discharged directly into the northern Gulf of Mexico through the birdsfoot delta, providing little benefit to protective delta building and contributing to an increasing zone of hypoxia near the river mouth (Mitsch et al., 2001). In addition to problems associated with fate of river sediment and nutrients, this disconnection starves coastal wetlands of historic nutrient and sediment inputs necessary for marsh sustainment. Although the relative importance of this multitude of factors has yet to be rigorously quantified throughout the Louisiana coastal plain, the combination of RSLR and river/marsh disconnection has led to high land loss rates and conversion of many freshwater marshes to shallow saltwater bays.

In recent years, freshwater flow diversions from river sources to coastal marshes have been offered as a tool for combating RSLR and disconnection of rivers and wetlands. In these diversions, river water is released into marshes to simulate flooding of a river onto its floodplain and increase hydrologic connectivity. Potential benefits have been observed from pulsing diversion discharges to simulate natural flood regimes (Day et al., 2003; Reyes et al., 2003; Snedden et al., 2007). Many studies have also shown that flow diversion is a plausible remedy to reconnect rivers to tidal marshes and deltas and induce organic and inorganic deposition (Parker et al., 2006; Snedden et al., 2007). An ancillary benefit of these flow diversions is potentially reduction of the nutrient loading to the Gulf of Mexico with associated reduction in the hypoxic zone (Lane et al., 1999; Mitsch et al., 2001).

Vertical accretion of marshes has been identified as highly dependent upon both inorganic and organic accumulation (Figure 2; Delaune et al., 1981; Nyman et al., 1993; Day et al., 1995; Reed, 1995; Foote and Reynolds, 1997; Nyman et al., 2006; Morris, 2007). Often accretion is only accounted for through sedimentation (e.g. Parker et al., 2006); however locations have been identified that depend more upon organic inputs than sediment inputs (Nyman et al., 2006). The characteristics of the receiving marsh and associated hydrologic connectivity are likely to influence whether inorganic or organic inputs control (Boustany, 2007). For instance, if a region is initially unvegetated, sediment inputs will be necessary to establish a soil platform for dense vegetative growth; however, once vegetation is well established, the vegetative inputs are likely to dominate while at the same time inducing higher retention of sediment in the process. This complex feedback system necessitates the inclusion of both inorganic (sediment) and organic (vegetative) inputs to any calculation of vertical accretion (Reed, 1995).

Vegetative accumulation in coastal marshes involves a delicate balance of above and belowground plant productivity (Gosselink, 1984; Edwards and Mills, 2005), salinity (Visser et al., 2004), nutrient availability (Delaune et al., 2005), flood frequency (Nyman et al., 2006), vegetation type (Gosselink, 1984), and seasonality (Visser et al., 2004), among other factors. Freshwater reintroduction has been shown to increase nutrient

inputs to coastal marshes (Lane et al., 1999) and stimulate growth in these ecosystems (Cardoch et al., 2002), further causing vegetative inputs to contribute to accretion. In coastal Louisiana most marshes are nutrient limited (Nyman et al., 1990; Delaune et al., 2005), so the introduction of limiting nutrients such as nitrogen and phosphorous from flow diversion is a topic of great importance when considering flow diversion alternatives and benefits (Lane et al., 1999; Hyfield, 2004; Hyfield, 2008); however, excessive nutrient loading to coastal wetlands could potentially induce harmful water quality effects such as eutrophication (Delaune et al., 2005) or stimulation of invasive plant species (Carter and Bernard, 2007), so diversion of flow to coastal wetlands must be carefully balanced and planned.

The accretion of sediment on coastal marshes and deltas has also been studied extensively (Stumpf, 1983; Wang, 1997; Rybczyk and Cahoon, 2002; Reyes et al., 2003; Parker et al., 2006; Snedden et al., 2007). Relevant sedimentation processes have been identified as sediment loading from floods/diversions (Reed, 1995; Parker et al., 2006), sediment settling properties (Stumpf, 1983; Soulsby, 1997; Winterwerp and van Kesteren, 2004), tidal erosion (Stumpf, 1983; Wang et al., 1997), wind and storm induced erosion and deposition (Wang, 1997), sediment export through canals and bayous (Wang, 1997; Baustian and Turner, 2006), and vegetation induced settling (Gleason et al., 1979; Stumpf, 1983; Reed, 1995; Leonard and Luther, 1995).

Although flow diversions have proved useful for combating coastal land loss, the optimization of flow diversion locations and operation has been difficult due to the complexity in data needs of a coupled ecological and hydrodynamic model (Reyes et al., 2003; Delaune et al., 2003; Snedden et al., 2007). These complexities encourage the development of a simple, screening-level model that includes the effects of vegetation and sediment dynamics and allows for straightforward examination and optimization of flow diversion feasibility and operational benefits.

Boustany (2007) Landscape Evolution Model

Boustany (2007) developed a composite nutrient and sediment model to assess the feasibility of flow diversions and screen diversion alternatives under the Coastal Wetland Planning, Protection, and Restoration Act (CWPPRA; Boustany, Personal Communication). This model, herein referred to as the Boustany Model (BM), presents all benefits of flow diversion in terms of marsh area by assuming all nutrient and sediment benefits additive to the existing area and land change rate:

$$A_{i+1} = A_i + \delta_{nut} A_i + A_{sed}$$

Equation 1

Where A_i is the marsh area at time i, δ_{nut} is the fractional change in land area due to RSLR and river-marsh disconnection (value may be positive or negative) that has been adjusted to account for the benefits associated with nutrient addition, and A_{sed} is the area benefit of sediment addition.

The BM was developed to compare long term relative benefits of many flow diversion locations and was implemented with an annual time step to provide quick estimates of the potential benefits of diversions. The BM is sufficient for quick estimation of flow

diversion benefits and initial screening of alternatives, but the LACPR program required greater temporal resolution in order to assess not only the relative benefits of diversion locations, but also the effects of diversion structure type, diversion operational regimes, and hydrologic variability. Ideally a detailed two- or three-dimensional model coupling nutrient and sediment processes would be used to account for the complex mechanisms governing coastal marsh accretion (Reyes et al., 2000; Dortch et al., 2007); however, the vast number of alternatives and short time scale of the LACPR report to Congress precluded development of such models for every alternative and marsh. As such, the BM was adapted to include processes deemed most critical to LACPR alternatives analysis. The following sections provide further details of the nutrient and sediment models implemented in the landscape evolution calculations, but the two major adaptations of the BM were:

- High temporal variability in sediment processes encouraged the refinement of the temporal resolution of the sediment model to include daily impacts of the diversion on the marsh.
- In order to maintain model simplicity, the BM required estimation of a number of parameters to account for nutrient and sediment processes (e.g. sediment retention and average annual suspended sediment concentration). The adaptation of the model has also included the calculation of many of these inputs in order to account for temporal variance, reduce data requirements, and minimize potential input errors.

Nutrient Benefits

Nutrient addition to coastal marshes has proven to be a source of vegetation stimulation and strengthening and biomass creation (Deegan et al., 2007). Boustany (2007) proposes a model that accounts for the ability of nutrients to stimulate vegetation to better resist erosional processes. This model determines the percent of the vegetated area that is strengthened from nutrient addition. This parameter is found by examining the annual nutrient requirements of the marsh relative to the nutrients loaded to the marsh.

The nutrients required by the marsh for vegetative growth are assumed to be the mass of the nutrients held in plant biomass. This quantity may be assessed by examining the rate of biomass production (annual primary productivity, P_r) and the percent of biomass containing these nutrients (γ). Since most Louisiana coastal marshes are nitrogen or phosphorous limited, Boustany proposes that the total concentration of nitrogen and phosphorous (TNP) be used to account for nutrient benefits.

$$LR_{req} = P_r \gamma_{TNP}$$

Equation 2

Where LR_{req} is the marsh required nutrient loading rate [$ML^{-2}T^{-1}$], P_r is primary productivity [$ML^{-2}T^{-1}$], and γ_{TNP} is the percent of plant biomass containing nitrogen and phosphorous [1].

The nutrient loading rate of the diversion to plant biomass, LR_{div}, may be calculated from the volumetric discharge of water to the marsh from the diversion, Q_{div} [L^3T^{-1}], the

concentration of nutrients in the source water, C_{source} [ML^{-3}], the retention rate of nutrients in plant biomass, R_{nut} [1], and the vegetated marsh area, A_{veg} [L^2].

$$LR_{div} = \frac{Q_{div} C_{source}}{A_{veg}} R_{nut}$$

Equation 3

In addition to nutrient loading from the diversion, there is ambient nutrient loading to the marsh from other ongoing processes (e.g. atmospheric deposition, stormwater runoff, current plant decomposition, denitrification, etc.). These processes will be accounted for by a loading rate for background sources, $LR_{background}$. The net loading of nutrients to the marsh, LR_{net}, is therefore the sum of the background and diversion loading rates.

$$LR_{net} = LR_{div} + LR_{background}$$

Equation 4

From knowledge of the loading rates applied, LR_{net}, and required, LR_{req}, one may obtain the fraction of wetlands sustained by nutrient addition, E_s.

$$E_s = \frac{LR_{net}}{LR_{req}}$$

Equation 5

In this model, nutrients are assumed to be unable to freely construct land; however, they can reduce the loss rate by strengthening vegetated areas against erosion. This assumption produces conservative estimates of the organically-induced benefits of the diversion. For instance, in an environment with a low land loss rate, according to the model, the diversion could potentially reduce the land loss to zero; however, no land gain would be associated with organic inputs. The percentage of wetland sustained by nutrient addition serves as a reduction ratio to the land loss rate in the form of Equation 6.

$$\delta_{nut} = \begin{cases} \delta(1 - E_s) & For E_s < 1 \\ 0 & For E_s \geq 1 \end{cases}$$

Equation 6

Where δ is the land change rate prior to the diversion and δ_{nut} is the nutrient adjusted land change rate.

Sediment Benefits

The accumulation of diverted sediments is determined by a sediment budgeting model utilizing the input concentration of sediment from the source water and calculated hydrodynamics of the system to determine the quantity of diverted sediment retained in the marsh. As previously specified, the BM implemented sedimentation calculations on an annual timescale, and while this assumption is reasonable for preliminary screening of alternatives, further refinement is necessary for more detailed analyses of flow diversion benefits. The sediment model implemented herein relies on calculation of sediment inputs and sediment settling theory on a daily timescale over a single representative year and reapplies that year throughout the proposed project life cycle.

Sediment Input

In order to minimize costs and maximize benefits of flow diversion in coastal Louisiana, diversion structures often withdraw water from one of the region's major rivers (e.g.

Mississippi, Atchafalya, Calcasieu). These rivers are located throughout the coastal plain, carry large water and sediment loads, and serve as a virtually infinite source of diversion resources.

River discharge and suspended sediment concentration have often been shown to be positively correlated (Mossa, 1996; Snedden et al., 2007). The relationship between discharge and sediment load may be determined by analytical and partially analytical models (e.g. Meyer-Peter Muller, Einstein, Yang; Richardson et al., 2001) or by empirical models for a given set of observed discharge and sediment concentration values (Mossa, 1996; Snedden et al., 2007). In coastal Louisiana, there exists enough recorded sediment discharge data to generate empirical models of sediment concentration for some of the major rivers of the region. For this analysis, a power function was found to provide enough resolution in sediment concentration variation (Equation 7). Table 1 presents a number of sediment ratings of this form for coastal Louisiana.

$$Q_{s,river} = a_1 Q_{river}^{\ a_2}$$

Equation 7

Where $Q_{s,river}$ is sediment load (ton/da), Q_{river} is river discharge (cfs), a_1 is a dimensional coefficient, and a_2 is a dimensionless coefficient. From this sediment rating, flow-averaged suspended sediment concentration of the river, C_{river}, may be calculated $\left(C_{river} = {Q_{s,river}}/{Q_{river}} \right)$ and transformed to the desired units.

Regardless of the model defining this relationship, the sediment concentration has been shown to be highly dependent upon discharge; therefore, in order to capture the temporal variance in sediment discharge through a diversion, the sediment concentration must vary with river discharge at an appropriate time scale (Snedden et al., 2007). For the purposes of this analysis, daily variation in discharge provides sufficient temporal resolution for accurate calculation of sediment loading to marshes by diversions.

One of the purposes for adapting the BM is the desire to examine relative diversion structure operation. In order to do this, daily estimates of diversion discharge are also required. These daily diversion discharges, Q_{div}, are combined with the daily predictions of river suspended sediment concentration, C_{river}, to determine the mass loading rate of sediment to the marsh, $Q_{s,div}$ (Equation 8). This increase in temporal resolution allows for examination of diversion discharge operation such that sediment benefits may be maximized by coinciding diversion discharges with periods of high river suspended sediment concentration.

$$Q_{s,div} = Q_{div} C_{river}$$

Equation 8

Sediment Retention

After sediment laden water has been diverted to a coastal wetland, a portion of the sediment load is expected to settle from suspension and deposit. Sediment that remains in suspension is then subject to being transported outside the system boundaries. Sediment retention defines the fraction of diverted sediments retained within the coastal wetland.

Retention is dependent upon system properties such as: wetland geometry, diversion discharge, tidal velocities (Stumpf, 1983), wind and storm events (Wang, 1997), settling velocity of diverted sediments (Soulsby, 1997; Winterwerp and van Kesteren, 2004), vegetation coverage (Stumpf, 1983), and canal-induced sediment import/export (Wang, 1997). The approach taken by Boustany (2007) is to apply retention factors estimated for other sites (e.g. Wax Lake Outlet) or allow the analyst to choose a retention factor based on knowledge of the receiving area and best professional judgment. Building upon the suggestion of Stumpf (1983), an alternative to this approach is to use a simple calculation which includes effects of wetland geometry, sediment properties, and flow hydrodynamics at the site. The effects of vegetation and channels are ignored in this analysis in order to maintain model simplicity; however, vegetation would likely increase roughness, reduce turbulence, and induce greater sediment deposition leading to conservatively low estimates of sediment retention, while the influence of channels may serve as pathways to sediment export and thus produce non-conservatively high estimates of sediment retention.

Consider suspended sediments in a water body. The time required for a given particle to settle from the water surface to the bed is given as:

$$T = \frac{H}{W_{s,eff}}$$

Equation 9

Where T is the time required for sediment to completely settle, H is the local depth, and $W_{s,eff}$ is the effective settling velocity of a specific sediment class.

As the particle settles, it is also transported by tidal and diversion currents, so the distance traveled by the particle is:

$$X = U_{div} T = U_{div} \frac{H}{W_{s,eff}}$$

Equation 10

Where U is the diversion induced mean velocity. As the averaging timescale of the model is greater than the tidal period and net tidal flow is zero, Equation 10 neglects the influence of tidal velocities, and the net displacement of water within the marsh is described by the diversion flow.

For this analysis the wetland is assumed to have rectangular planform and cross-sectional geometries described by the average length (L), width (B), and depth (H). The fraction of sediment retained in the wetland then becomes a function of wetland length relative to transport distance prior to full deposition of the sediment fraction in question (Stumpf, 1983). If all diverted sediment is retained within the system, the retention factor is 1. Since this analysis takes a macroscopic view of the total sediment retained in the system and location of deposit is not considered, the retention factor becomes 1 if the length of the wetland is greater than the transport length, and the retention of a given sediment particle class, R_j, may be expressed as:

$$R_j = \min\left(\frac{L}{X}, 1\right)$$

Equation 11

Due to variation in fall velocity with sediment size, coarse particles may be retained while fines are flushed from the system; therefore, the combined retention of the entire grain size distribution must be made. Retention over all sediment classes may be expressed as:

$$R_T = \sum R_j f_j$$

Equation 12

Where R_T is the combined total retention factor and f_j is the mass fraction associated with each sediment class.

Fall Velocity

A key element of the sediment budgeting model presented is the calculation of the effective fall velocity of a given sediment size class, which is a function of the fall velocity of that sediment in a static body of water, W_s, and the turbulence of the flow. Fall velocity of sediment is dependent upon both sediment properties (shape, size, density, concentration, ability to flocculate) and fluid properties (viscosity, density, temperature, salinity). In the natural environment, turbulence is generated by flow over the sediment bed. The presence of turbulence acts to vertically mix suspended sediments, which reduces the effective settling velocity of suspended particles. The steady-state vertical flux balance at a point in the water column is given by:

$$W_s C + K_z \frac{dC}{dz} = 0$$

Equation 13

Where C is the suspended sediment concentration, K_z is the vertical diffusivity, and z is the vertical distance from the bed.

For the purposes of this tool to estimate retention, it is convenient to combine the terms in Equation 13 to define an effective settling velocity (Equation 14).

$$W_{s,eff} C = W_s C + K_z \frac{dC}{dz}$$

Equation 14

Vertical diffusivity varies with turbulent intensity and height above the bed. Rouse proposes that diffusivity varies parabolically with height above the bed in the form (Richardson et al., 2001):

$$K_z = \kappa u_* z \left(1 - \frac{z}{H}\right)$$

Equation 15

Where κ is the von Karman constant (~0.4) and u_* is the total friction velocity (a measure of turbulent intensity).

Given the sediment flux balance in Equation 13, the vertical concentration profile is:

$$C = C_a \left(\frac{z}{z_a} \frac{H - z_a}{H - z}\right)^{-b}$$

Equation 16

Where b is the Rouse parameter $\left(b = {}^{W_s}\!/_{\kappa u_*}\right)$ and z_a is a reference height above the bed with a known sediment condition, C_a.

The turbulent shear velocity is estimated from the depth-averaged velocity by the logarithmic boundary layer (law of the wall) (Kundu, 1990).

$$u_* = \frac{U\kappa}{\ln\left(\frac{H/3}{z_0}\right)}$$

Equation 17

Where U is the daily mean wetland velocity with both tidal and diversion related components and z_0 is the hydraulic roughness length.

For the diurnal tidal cycle of coastal Louisiana, the tide is assumed to have approximately sinusoidal periodicity. The mean instantaneous wetland velocity can then be determined by considering both tidal and diversion components (Figure 3).

$$U_i = U_{div} + U_{max,tide} \sin\omega = \frac{Q_{div}}{HB} + U_{max,tide} \sin\omega$$

Equation 18

Where U_i is the instantaneous mean velocity with tidal and diversion components and $U_{max,tide}$ is the maximum tidal velocity (or tidal amplitude), and ω is tide phase.

For the use in the flow diversion model, the velocity is integrated over the tidal cycle (0 to 2π) to obtain the daily mean velocity, U.

$$U = \frac{1}{2\pi}\left\{U_{div}(2\omega_1 - \omega_0 - \omega_2) + U_{max,tide}(\cos(\omega_2) - 2\cos(\omega_1) + \cos(\omega_0))\right\}$$

Equation 19

Where ω_0 is the tide phase at zero up-crossing $\left(\omega_0 = \sin^{-1}\left({}^{-U_{div}}\!/_{U_{max,tide}}\right)\right)$, ω_1 is the tide phase at zero down-crossing $(\omega_1 = \pi - \omega_0)$, and ω_2 is the completed tidal phase $(\omega_2 = \omega_0 + 2\pi)$ (Figure 3).

In order to estimate the shear velocity, the hydraulic roughness must also be estimated from local sediment grain size, form roughness, and vegetative coverage. In this analysis, a lumped parameter accounting for both grain size and form roughness is implemented based on marsh surface character (Table 2). Vegetative roughness is incredibly important in coastal marshes where emergent plants are encountered throughout the marsh, and although basing this parameter on bed material ignores the effects of vegetation, this will provide an estimate of sediment settling in open water and will therefore provide conservative estimates of settling in vegetated or partially vegetated marsh.

Combining Equation 13 – Equation 17, one may obtain an expression for the effective settling velocity of sediment in coastal marshes.

$$W_{s,eff} = W_s - bK_z\left(\frac{H - z_a}{z_a}\right)^{-b}\left(\frac{z}{H - z}\right)^{-b-1}\left(\frac{H}{(H - z)^2}\right)$$

Equation 20

For incorporation into the flow diversion model, vertical mixing has been computed at a height above the bed equal to 1/10 of water depth $\left(z = H/10\right)$ and z_a is approximated as 1/100 of the depth $\left(z_a = H/100\right)$. These values provide an estimate of the settling velocity of particles very near the bed that are assumed to settle. Insertion of these relations into Equation 20 yields:

$$W_{s,eff} = W_s - bK_z(99)^{-b}\left(\frac{1}{9}\right)^{-b-1}\left(\frac{0.81}{H}\right)$$

Equation 21

Where $K_z = 0.009\kappa u_* H$.

Net Sediment Benefit

By accounting for sediment loading to the marsh and sediment retention within the marsh, the mass loading rate of sediment retained in the marsh may be determined by:

$$Q_{s,net} = Q_{s,div} R_T$$

Equation 22

Where $Q_{s,net}$ is the net mass loading rate of sediment to the marsh.

This loading rate may then be used to calculate the net aerial sediment benefit due to flow diversion, A_{sed}, for a given time period.

$$A_{sed} = \frac{Q_{s,net} dt}{H\rho_{bd}}$$

Equation 23

Where dt is the time step (da) and ρ_{bd} is the average bulk density of the receiving area.

Bulk density in coastal marshes varies significantly with depth due to sediment consolidation. For our analysis, we assumed that the bulk density was a depth averaged value based on the depth of marsh being filled with sediment (i.e. flow depth, H). Bulk density profiles were obtained from literature (Nyman et al., 1990; Nyman et al., 1993; Delaune et al., 2003) and available data (Michael Channel, personal communication).

Application: Caernarvon Diversion and Breton Sound Estuary

In order to verify the ability of the model to account for landscape evolution due to flow diversion, the model was applied to an existing diversion structure and marsh, the Caernarvon Diversion to Upper Breton Sound Estuary (Figure 4). The Caernarvon Diversion is located on the east bank of the Mississippi River at river mile 81.5 (131.2 km) (approximately 12.5 river miles (20.1 km) downstream of New Orleans) and

discharges Mississippi River water into Breton Sound through five 15-ft (4.57-m) box culverts with vertical lift gates (Lane et al., 1999; Snedden et al., 2007). The diversion was constructed between 1988 and 1991 and opened for operation in August of 1991 with goals of reducing the salinity in Breton Sound for commercial shell fisheries. An ancillary benefit of the diversion has been sediment and nutrient loading to the marsh and corresponding reduction in land loss (Snedden et al., 2007).

Upper Breton Sound is approximately 231 mi^2 (599 km^2) in area with a length of 18.8 mi (30.2 km) and a width of 12.3 mi (19.8 km). This estuary was historically an intermediate marsh, but due to RSLR and river/marsh disconnection, marsh salinity elevated to brackish conditions before the diversion became operational (Carter and Bernard, 2007). The current marsh is dominated by brackish species (e.g. *S. patens*) near the diversion and saline marsh species (e.g. *S. alterniflora*) far from the diversion (Snedden et al., 2007).

Breton Sound is hydrologically isolated from surrounding marshes by levees on both the eastern and western borders; therefore accounting for inflows and outflows to the marsh is relatively straightforward with water budgets for Upper Breton Sound revealing major hydrologic processes to be precipitation, evaporation, and freshwater diversion. Groundwater and stormwater inflows have been shown to be relatively small compared to precipitation and diversion (Hyfield, 2004).

In order to maximize the retention time of diverted water and induce desirable sediment settling and nutrient uptake, the State of Louisiana has initiated outfall management for the Caernarvon Diversion. Management actions have included restoration and backfilling of man-made canals, installation of control structures throughout the marsh (Carter and Bernard, 2007), and operational adjustment to test theories of marsh sedimentation processes (Snedden et al., 2007).

Snedden et al. (2007) have shown that a large majority (nearly 99%) of Caernarvon's discharge flows downmarsh through two major flow routes for low discharges. These authors indicate that below 3500 cfs, the diverted waters remain almost entirely in these canals. When diversion discharge exceeds this threshold value, diverted waters appear to exceed canal banks and flow over the marsh as sheet flow (Snedden et al., 2007). This indicates that large pulses of discharge may be more effective in distributing sediments throughout the estuary. These authors also applied a local river sediment rating based on near-surface suspended sediment concentrations of the Mississippi River approximately 5 mi (8 km) downstream of the Caernarvon structure at Belle Chase, Louisiana. By examining sediment loading rates through the diversion, these authors concluded that pulsing of discharges in phase with high river sediment concentrations not only induces sheet flow over the marsh, but also has the ability to load much greater quantities of sediment to the marsh (Snedden et al., 2007).

The Caernarvon Diversion provides an excellent test case for the model developed herein due to the variable discharge inputs and extensive knowledge of current system processes. Table 3 presents the inputs to the model for the Caernarvon Diversion and

Breton Sound. Many of these inputs have a significant amount of variability and have been presented with standard deviations in order to provide the reader with a scale of parameter uncertainty. When data was not available, parameters and ranges were estimated by best professional judgment. Since many of the input parameters contain a significant amount of uncertainty and forecasting land evolution in such a complex system is difficult, model uncertainty has been characterized by a Monte Carlo risk analysis. In this analysis, parameter uncertainty was estimated and assumed normal about the mean. Random errors were then introduced in each parameter for 10,000 calculations. Model results were computed with each set of randomly induced errors, and the range of area predictions was analyzed to determine 90% confidence intervals.

In order to apply the model to Breton Sound, the diversion and river hydrographs must be estimated to indicate marsh nutrient and sediment availability. The river hydrograph may be estimated by using a representative water year or by averaging flows for many years and determining mean daily discharges over a period of record. The diversion hydrograph may be estimated by applying historic operational records, assuming an input hydrograph, testing various operational theories (e.g. pulses timed with river discharge), or linking the discharge to the diversion structure type (e.g. diversion discharge dependence upon river stage using a weir equation). A sample representative diversion and river hydrograph are displayed (Figure 5) for operation of the Caernarvon structure in 1994. Both the diversion and river hydrographs for this year output very near average annual discharge volumes and the peak magnitudes of the hydrographs were well represented; therefore, for this analysis, the diversion and river hydrographs were assumed to be that of the 1994 calendar year for each year of the simulation.

Figure 6 presents the evolution of land area within Upper Breton Sound from before the diversion was opened (1 November 1990) until the end of 2006 (31 December 2006). This figure shows the observed values of marsh area along with estimates by the current model with associated parameter uncertainty alongside the Boustany Model. The estimated future without project (FWOP) is presented to provide the reader with the magnitude of marsh area benefit the Caernarvon Diversion is providing Breton Sound. Vertical lines indicate the beginning of diversion operation and hurricanes making landfall in Louisiana. It is clear that hurricanes create significant perturbations to the system; however, hurricanes may provide both import and export to a given marsh depending upon the location of landfall and are, for the purpose of this screening level model, assumed to create no net import or export of sediment over a long planning horizon.

In addition to model verification at Caernarvon, readers may be interested in the benefits provided by nutrient and sediment components separately; therefore Figure 7 presents the model predictions with nutrient only and sediment only scenarios for the Caernarvon Diversion application.

Optimization of Implemented Diversion

The focus of LACPR has been the analysis of alternatives and the decision support framework associated with choosing diversion sites and quantities. The land evolution

model has been applied as tool for assisting in this framework and has provided relative benefits of various flow diversion sites and scenarios. The utility of the tool, however, has not yet been fully exploited. Following the narrowing of alternatives, the land evolution model may then be used in the initial optimization of the selected diversions by examining different operational and structural scenarios. This type of analysis has not yet been conducted for each of the alternatives of the LACPR, but this section provides a sample of how these analyses might be conducted for a given diversion site. The model will be applied to an existing diversion (Caernarvon) to assess the land gain benefits of six operational and five structural scenarios with near equal annual discharge volumes.

As previously stated, the Caernarvon Diversion discharges Mississippi River water to Upper Breton Sound through five 15 ft box culverts with vertical lift gates which can be used to control diversion discharges to the marsh. For this analysis the diversion is merely used to demonstrate the ability of the land evolution model to provide relative benefits of different operational and structural conditions. Table 3 provides the model inputs used for these optimization exercises. For these analyses, the 1994 Mississippi River hydrograph was found to be representative of the average annual discharge volume, peak magnitude, and seasonality of flow in the river and has been used throughout the duration of the model simulations in these exercises.

Operational Optimization of Gate Structures

The continuous hydrographic inputs of the model provide a tool for optimizing gate-type diversion operation to obtain the greatest land evolution benefits. In this section, the model will be applied to demonstrate the operational benefits for the six approximately equal-volume discharge scenarios that follow (Figure 8). These annual hydrographs were chosen based on previous research indicating that pulsing and timing of diversions may be critical to land evolution (Day et al., 2003; Snedden et al., 2007).

1. Historic operation based on 2003 operational conditions (a "pulsed" diversion year with a large portion of the annual sediment load derived from two two-week pulses)
2. Simulated operation with a large pulse of one-month duration timed *in phase* with high river sediment discharges
3. Simulated operation with a large pulse of one-month duration timed *out of phase* with high river sediment discharges
4. Simulated operation with a small pulse of six-month duration timed *in phase* with high river sediment discharges
5. Simulated operation with a small pulse of six-month duration timed *out of phase* with high river sediment discharges
6. Constant diversion discharge

Each of the annual hydrographs was input to the model, and land evolution estimates were made for a 50 year time period starting at the arbitrary starting date of January 1, 2001 (Figure 9). These results indicate that, for the inputs considered, the magnitude and timing of the diversion discharges is critical to suppression of the land loss rate. Therefore, for this hypothetical diversion scenario at Caernarvon, the diversion of flows

could be altered to be in phase with high river sediment discharges and should occur from later winter to early summer (February – June). These periods of high sediment discharge may not, however, align with other project goals of a given diversion (e.g. reduction of salinity for maintenance of commercial fisheries). This analysis indicates a time period over which the greatest land evolution benefits may be obtained, and diversion operation may be optimized within that timeframe to include multiple project goals.

Structure Selection

Not only will operational considerations impact diversion benefits, but structure type will also have a drastic impact on the selection and operation of a given diversion. For instance, a gate-type structure (such as the one at Caernarvon) may be controlled to achieve the desired water and sediment discharges, but the cost and maintenance may be high. Whereas a broad-crested weir may have low cost, but control of diversion discharges is relatively minimal. A siphon is a third common diversion structure that may require significant maintenance and operational effort, but the suspended sediment concentration of the diverted water may be higher and the size gradation of the sediment diverted may be significantly larger inducing more land gain on both accounts. This section will demonstrate the ability of the model to assess land evolution by applying the model to the Caernarvon Diversion for the following five hypothetical structural scenarios:

1. Gate structure with pulsed operation based on the 2003 hydrograph
2. 100-ft wide broad-crested weir
3. 200-ft wide broad-crested weir structure
4. 1 – 15 ft siphon with a single short duration (113 day) discharge event
5. 1 – 6 ft siphon with continuous operation throughout the year

The weir structures have been assumed to behave as theoretical broad-crested weirs (Equation 24) and the discharge was determined based on the Mississippi River stage for the representative hydrograph (1994). The weir elevations were adjusted to produce annual discharge volumes approximately equal to the average annual diversion discharge volume from 1991-2006.

$$Q_{div} = C_{weir} B_{weir} \left(z_{river} - z_{weir}\right)^{3/2}$$

Equation 24

Where C_{weir} is a weir coefficient (~4.37 $ft^{0.5}/s$), B_{weir} is the width of the weir (ft), z_{river} is the elevation of the river for a given flow rate (ft), z_{weir} is the elevation of the weir (ft) (White, 2003).

In order to calculate the discharge of the diversion by siphoning, Bernoulli's equation was implemented (Equation 25). Frictional losses in the pipe were assumed negligible due to the qualitative nature of this analysis. As with the weir, the marsh elevation was optimized to produce annual discharge volumes approximately equal to the average annual diversion discharge volume from 1991-2006. Figure 10 presents diversion discharge hydrographs for the five scenarios considered.

$$Q_{div} = V_{siphon} A_{siphon} = \sqrt{2g(z_{river} - z_{marsh})} \left(\frac{\pi d^2}{4} \right)$$

Equation 25

Where z_{marsh} is the elevation of the marsh and d is the pipe diameter.

The land evolution model was applied using these annual diversion hydrographs and the parameters from the Caernarvon Diversion (Table 3). The only alteration of the Caernarvon model inputs was the sediment rating curve and size fraction applied to the siphon calculations. A weir or gate structure diverts surface waters of the Mississippi River to the marsh, and the Belle Chase surface sediment rating presented in Table 1 was determined as such (Snedden et al., 2007), but a siphon could draw water from lower in the water column, producing a larger sediment concentration and a more coarse sediment size fraction. As such, the total sediment rating at Belle Chase was applied with an assumed size fraction distribution based on the observed fraction of silt and clay ($f_{sand} = 0.12, f_{silt} = 0.44, f_{clay} = 0.44, f_{floc} = 0.3$).

As evident by the land evolution calculations (Figure 11), the benefits of flow diversion are extremely sensitive to the size fraction and concentration of the river water diverted. Therefore, the choice of structure type from a land evolution perspective is overwhelmingly in favor of siphons which divert higher concentrations of coarser sediment. However, logistical difficulties associated with operation and maintenance of a siphon (e.g. maintaining head differential, priming the siphon, air intrusion) may eliminate this structure type from consideration in many instances. It is also important to note that the results presented herein likely offer overly optimistic benefits of siphon structures due to the exclusion of friction in the siphon and the use of the total suspended sediment rating at Belle Chase. Although the siphon will be able to draw water from lower in the Mississippi River water column than a gate or weir, in order to maintain appropriate pressure differential for flow to the marsh, the siphon inlet will likely be required to draw in the upper half of the water column where suspended sediment concentrations are lower. The land evolution benefits of a siphon may also be overshadowed by other project objectives which may be detrimentally impacted by high turbidity or suspended sediment concentrations, such as fisheries production and marsh vegetation stimulation.

Summary of Diversion Optimization

The purpose of this exercise was not to identify an operational condition or structural alternative that is ideal for all flow diversions in coastal Louisiana, but was instead to demonstrate the land evolution model's ability to maximize land gain benefits for various operational and structural alternatives. Land gain (or suppression of land loss) is often not the only objective in the large-scale, long-term projects of the LACPR, and many other factors may be included in the selection of a diversion operational or structural scheme, some of which include:

- Cost of diversion with both structural and operation/maintenance components
- Desire to control diversion releases
- Commercial fisheries impacts
- Public recreational land use patterns

Conclusions

This paper has presented the adaptation of a model for quantifying flow diversion benefits and demonstrated the model's ability to estimate the relative benefits of various flow diversion locations, structures, and operational regimes; however, the model results are limited due to the exclusion of a variety of important system processes. Some of the major assumptions and limitations of the model were:

- Benefits of flow diversion are independent (in reality the benefits are likely non-linearly coupled due to vegetation inducing sediment deposition and sedimentation increasing suitable habitat for vegetation)
- Nutrients serve as a reduction in land loss, not a source of land gain benefits (Deposition of particulate organic matter neglected)
- Spatial uniformity - vegetation, roughness, bulk density, and other parameters are highly heterogeneous in coastal marshes
- Temporal resolution is only represented intra-annually, not contiuously
- Rectangular wetland geometry
- No vegetative component to settling/roughness
- Organic accumulation is not considered as a function of time even through biomass production is highly seasonal
- No habitat switching with time
- Canals are not accounted for as a sediment loss mechanism
- Sheetflow was assumed for all diversion flow rates
- No sediment resuspension due to rainfall, tidal flows, waves, or hurricanes
- Uniform distribution of sedimentation.
- Nutrient recycling neglected

Although these assumptions significantly limit the model's ability to quantify the benefits of flow diversion, approximations had to be made due to the time and resource constraints under which the model was developed. Further refinement of model processes and algorithms are recommended and should address the above limitations specifically focusing on the following:

- Temporal distribution of nutrient benefits to account for seasonality and storage
- Nutrients as a source of benefit, not just a source of loss reduction. Refer to the organic accumulation models of Blum et al. (1978), Mitsch and Reeder (1991), and Reyes et al. (2000) for examples of organic benefit frameworks
- Nutrient retention calculations inclusive of marsh nutrient cycling processes (e.g. denitrification, burial)
- Division of nutrients – nutrients should be divided into individual components (e.g. nitrogen and phosphorous) due to marsh limitation to a single nutrient
- Salinity is roughly covered in the model by the adjustment of bulk density and primary productivity, but the parameter is not explicitly covered and habitat switching is not tracked
- Spatial complexity/geometry improvements
- Inclusion of coastal currents and erosion, major storm events, and wind erosion
- Better methods of accounting for hydraulic resistance

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Figures

Figure 1. Typical coastal Louisiana marsh community with a patchwork of dense vegetation and open water

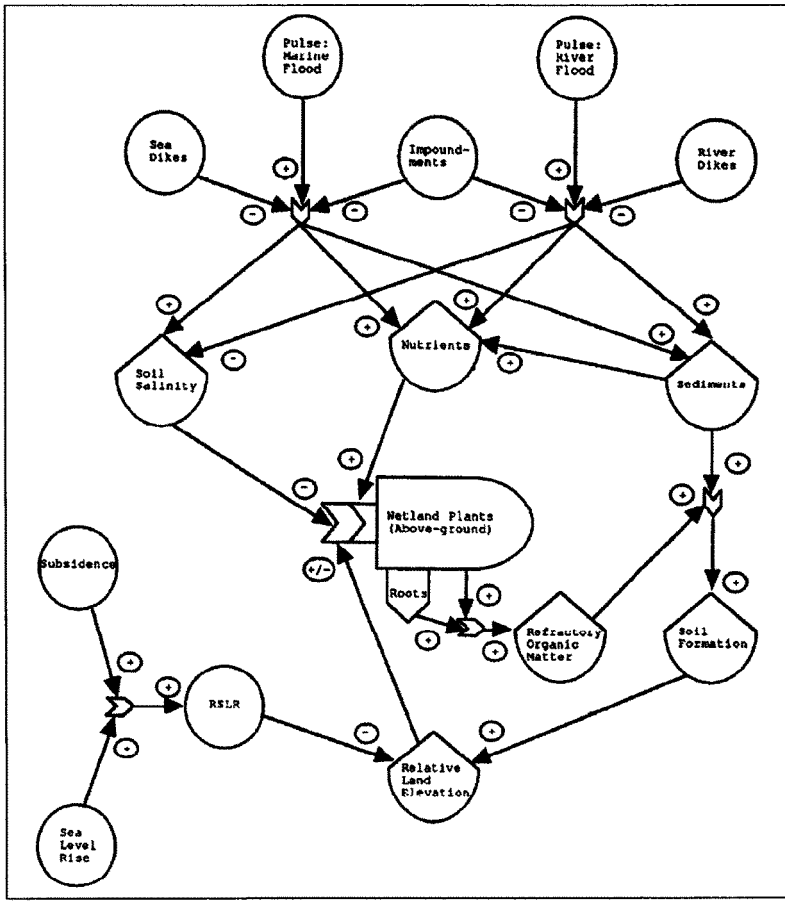

Figure 2. Conceptual model of coastal Louisiana marsh accretionary processes (from Day et al., 1995)

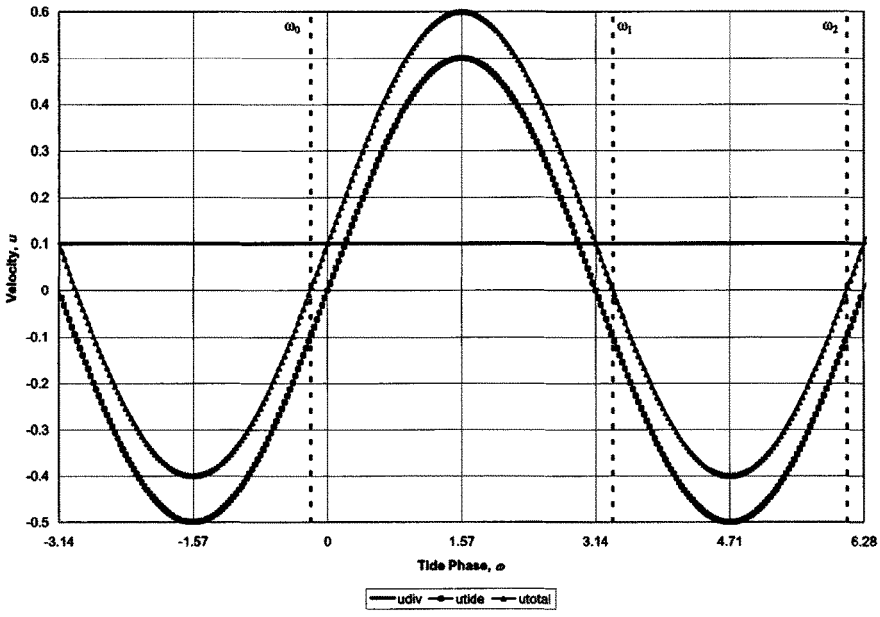

Figure 3. Wetland velocity with diversion and tidal components

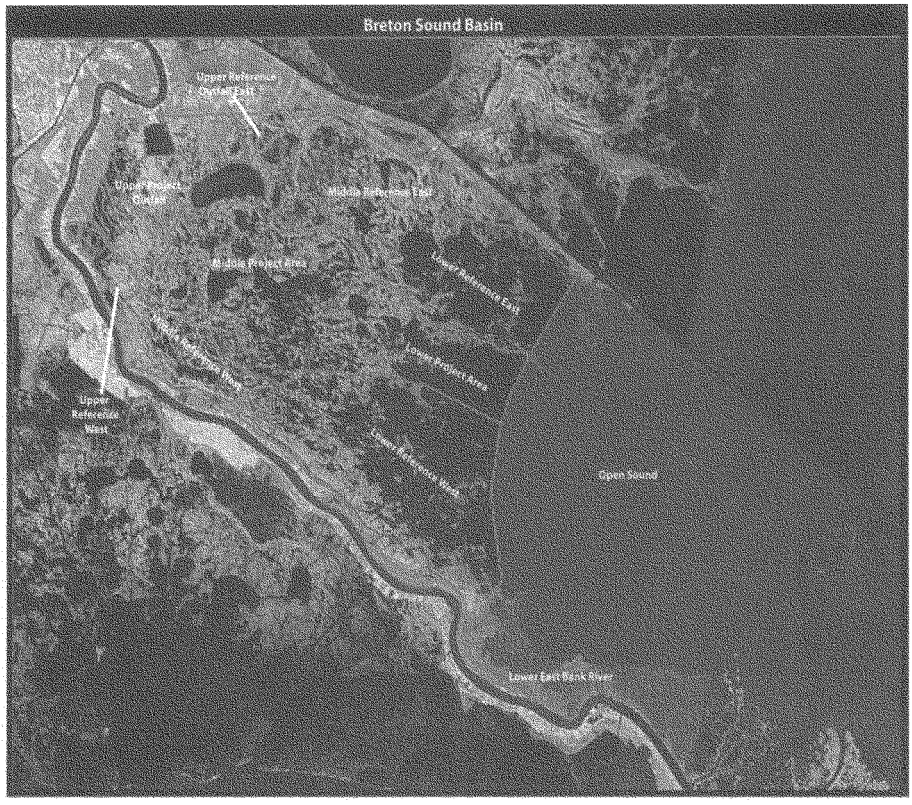

Figure 4. Aerial view of Breton Sound displaying Caernarvon Diversion and project division areas for tracking land evolution. In this analysis only the following areas were considered to be directly influenced by the Caernarvon Diversion in order to maintain relative uniformity in conditions: Upper Reference Outfall East, Upper Project Outfall, Upper Reference West, Middle Reference West, and Middle Project Area.

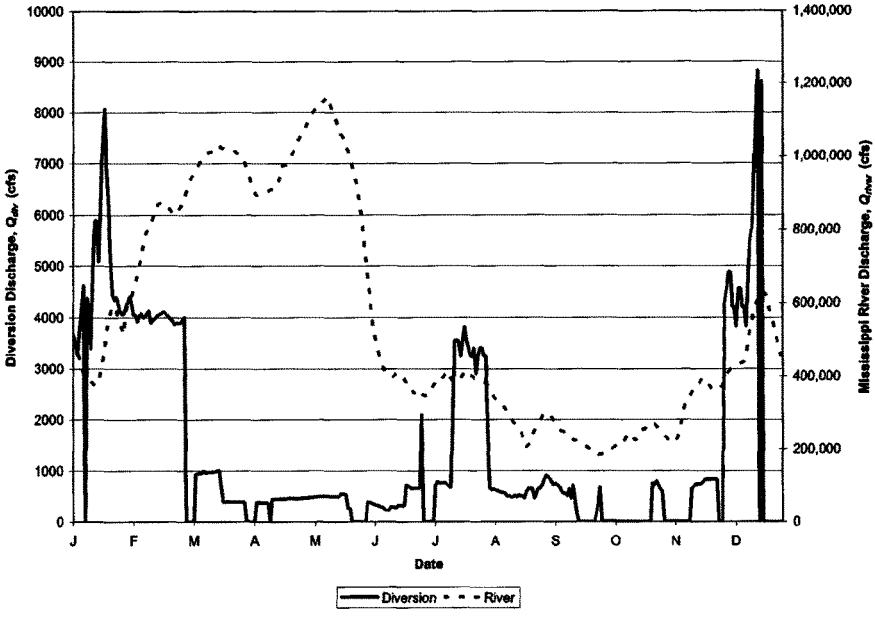

Figure 5. Representative diversion and river hydrographs for land evolution forecasting associated with the Caernarvon Diversion (1994 hydrographs)

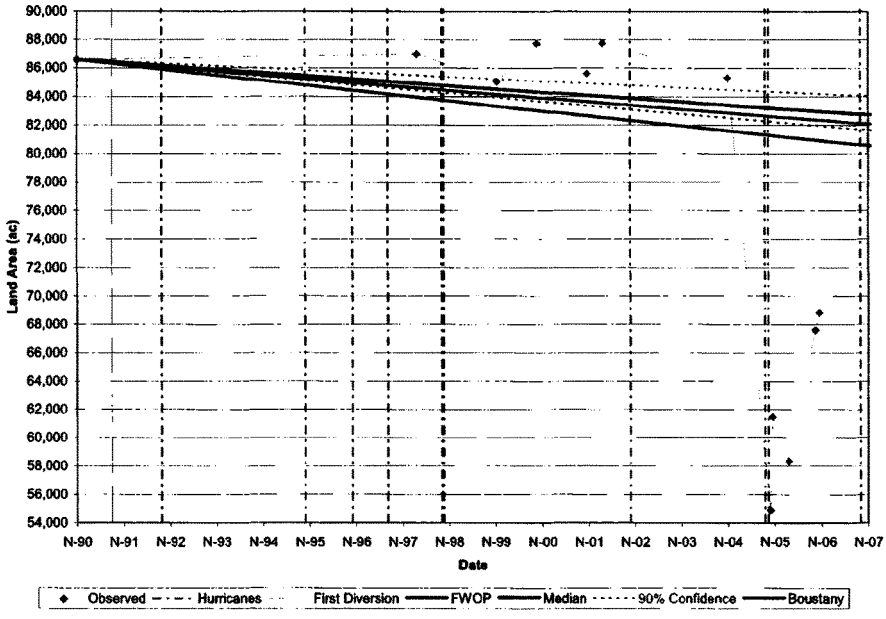

Figure 6. Marsh area prediction for the Caernarvon Diversion from 1990-2006 with observed acreages, model predictions with parameter uncertainty bounds, as well as the Boustany Model predictions

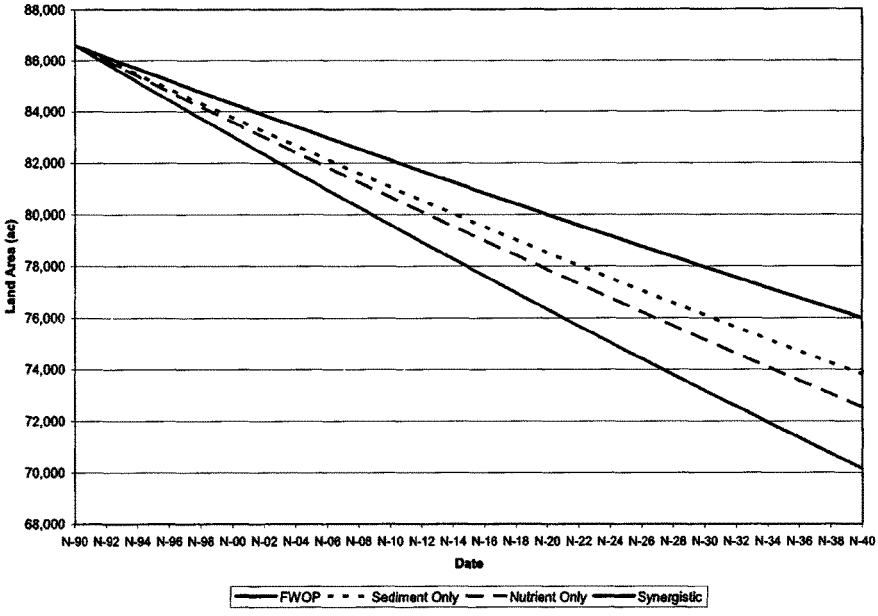

Figure 7. Marsh area prediction for the Caernarvon Diversion from 1990-2040 with isolated nutrient and sediment benefits

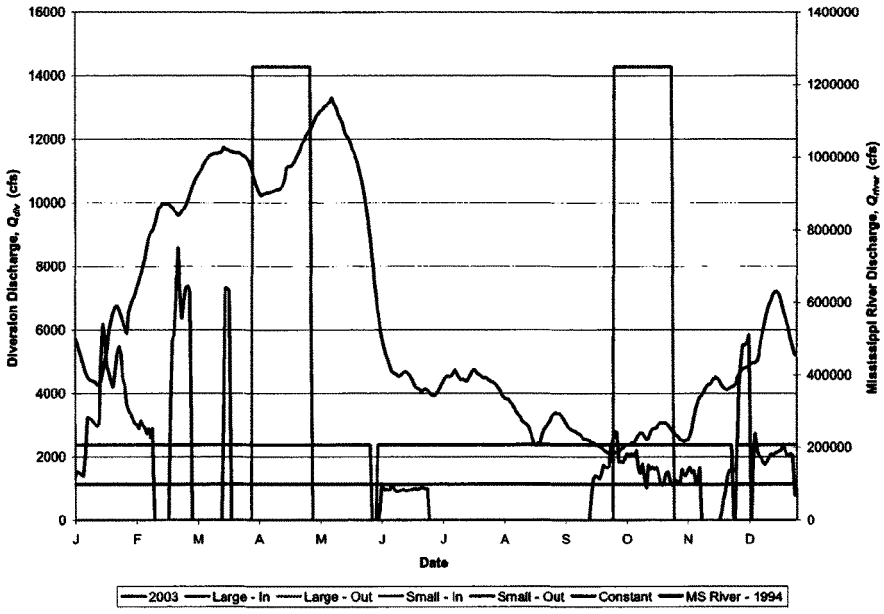

Figure 8. Hydrographs considered in Caernarvon Diversion operational optimization

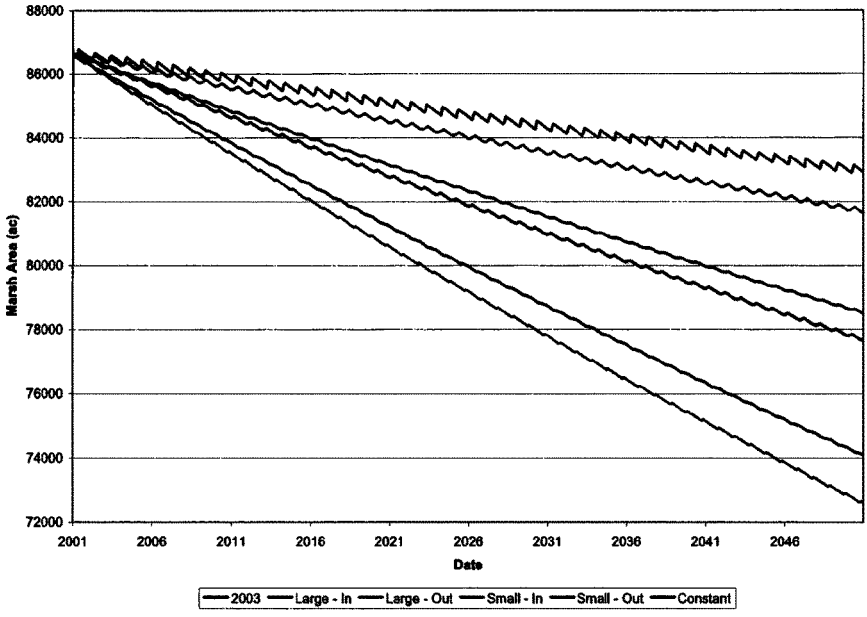

Figure 9. Land evolution predictions for multiple operational scenarios at the Caernarvon Diversion

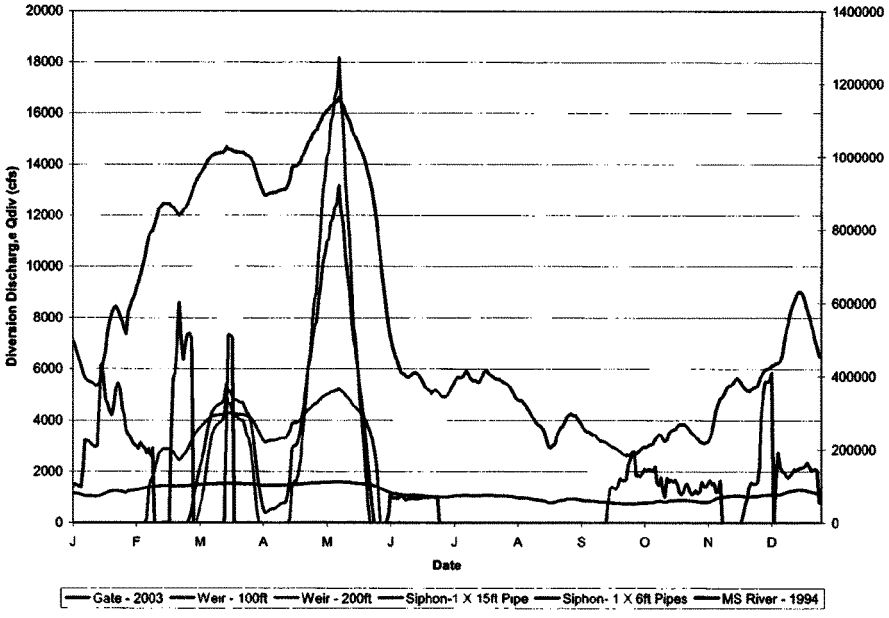

Figure 10. Calculated hydrographs for various structure types at the Caernarvon Diversion

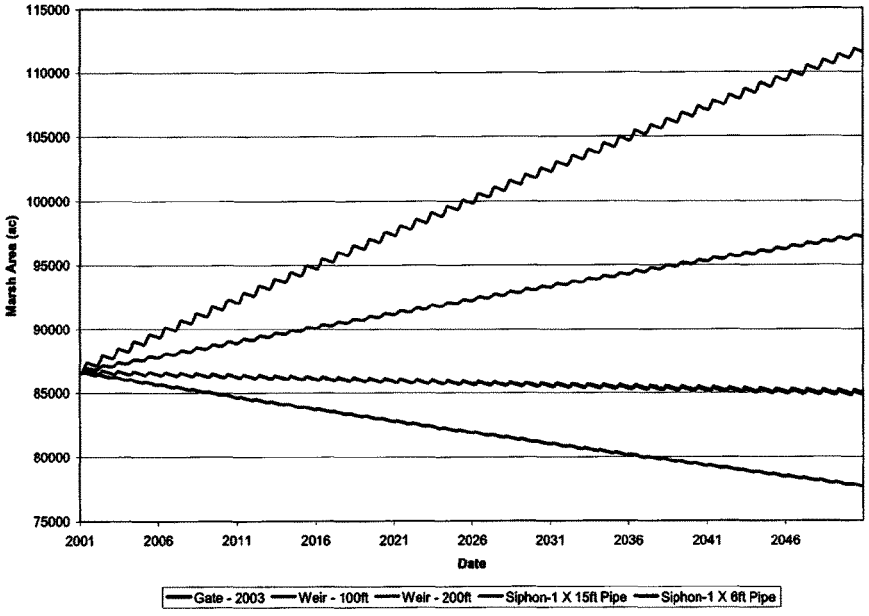

Figure 11. Land evolution predictions for various structure types at the Caernarvon Diversion

Tables

Table 1. Sediment Ratings for Rivers on the Louisiana Coastal Plain

River	Gauge Location	a_1	a_2	R^2
Mississippi	Belle Chase Surface*	3.205E-07	2.000	0.6648
	Belle Chase	1.237E-08	2.320	0.7302
	Tarbert - 1949-1975	1.192E-04	1.702	0.7945
	Tarbert - 1975-2007	7.096E-03	1.342	0.7689
	St. Francisville	6.501E-04	1.507	0.7357
Atchafalaya	Melville	4.941E-06	1.937	0.7764
	Simmesport	8.286E-04	1.563	0.8138

All ratings developed from suspended sediment concentrations and water discharges from USGS Website except "Belle Chase Surface"

*Surface concentrations of suspended sediment at Belle Chase and Tarbert's Landing Discharges (Snedden et al., 2007)

Table 2. Hydraulic roughness height as a function of bed material grain size

Channel Boundary	Roughness Height, z_0[1]		
	ft	mm	m
Mud	6.6E-04	0.2	2.0E-04
Mud/Sand	2.3E-03	0.7	7.0E-04
Silt/Sand	1.6E-04	0.05	5.0E-05
Sand (unrippled)	1.3E-03	0.4	4.0E-04
Sand (rippled)	2.0E-02	6	6.0E-03
Sand/Shell	9.8E-04	0.3	3.0E-04
Sand/Gravel	9.8E-04	0.3	3.0E-04
Mud/Sand/Gravel	9.8E-04	0.3	3.0E-04
Gravel	9.8E-03	3	3.0E-03

[1]Adapted from Soulsby (1983, Table 5.4)

Table 3. System properties and land evolution model parameters for the Caernarvon Diversion to Breton Sound Estuary

Parameter	Best Estimate	Approximate Standard Deviation
General System Properties		
Initial Land Area (ac)[#]	86,591	-
Project Area (ac)[#]	148,018	-
Average Water Depth, H (ft)[*]	3	0.5
Average Water Width, B (ft)	65,000[#]	1,000[*]
Maximum Tidal Velocity, $U_{tide,max}$ (ft/s)[*]	0.6	0.1
Roughness Height, z_o (ft)[*]	0.005	0.0005
Land Loss Rate (%/y)[1]	-0.42	0.042
Bulk Density, ρ_{bd} (g/cm^3)	0.26	-
Sediment Rating of Surface Concentrations of the Mississippi River at Belle Chase[2]		
Coefficient	3.205E-07	3.21E-08
Exponent	2.000	-
Size Fraction of Belle Chase Rating[2]		
Sand	0.01	0.0017
Silt	0.63	0.1050
Clay	0.36	-
Floc Fraction[*]	0.3	0.0667

Parameter	Best Estimate	Approximate Standard Deviation
Approximate Fall Velocity[3] (m/s)		
Sand	1.00E-02	8.33E-04
Silt	3.00E-04	2.50E-05
Clay	7.00E-06	5.83E-07
Floc Fraction	2.00E-04	4.00E-05
Marsh Nutrient Requirements		
Plant Productivity Rate, P_r (g/m^2yr)*	4,150	415
Percent of N and P in Plant Biomass, γ_{TNP}(%)[4]	0.72	0.072*
Nutrient Loading to Marsh		
Background Concentration of N and P, $C_{background}$ (mg/L)[5]	0.34	0.034*
Sourcewater Concentration of N and P, C_{source} (mg/L)#	2.28	0.5*
Nutrient Retention, R_{nut} (%)*	50	10

[1]Land loss rate calculated from observed marsh acreage from 1978-1990

[2]Data for rating and size fraction from Snedden et al. (2007)

[3]Calculated from method of Soulsby (1997)

[4]Foote and Reynolds (1997)

[5]Hyfield (2004)

#Available data

*Best professional judgment

Symbols

b = Rouse parameter
d = Diameter of siphon
f_i = Sediment size fraction i
g = Acceleration due to gravity
u_* = Shear velocity
x = Longitudinal or down-marsh coordinate
y = Horizontal or cross-marsh coordinate
z = Vertical coordinate
z_0 = Hydraulic roughness length
z_a = Reference depth
z_{river} = River stage
z_{marsh} = Marsh Elevation
z_{weir} = Weir Elevation
A = Marsh area
A_{veg} = Vegetated area of receiving area
A_{nut} = Total aerial nutrient benefit from flow diversion
A_{sed} = Total aerial sediment benefit from flow diversion
A_{siphon} = Cross-sectional area of siphon
B = Average marsh width
B_{weir} = Weir width
C = Suspended sediment concentration
C_a = Suspended sediment concentration at reference elevation z_a
C_{river} = Suspended sediment concentration of river
C_{source} = Nutrient concentration of source water
C_{weir} = Theoretical weir coefficient
E_{sus} = Percent of wetland sustained by nutrient loading
H = Average marsh depth
K_z = Vertical diffusivity
L = Average marsh length
LR_{req} = Marsh required nutrient loading rate
LR_{div} = Loading rate of nutrients from the flow diversion
$LR_{background}$ = Background loading rate of nutrients from preexisting marsh sources
LR_{net} = Net loading rate of nutrients from diversion and background sources (=LR_{div} - $LR_{background}$)
P_r = Primary Production
Q_{div} = Volumetric water discharge through diversion
$Q_{s,river}$ = Sediment discharge of river
$Q_{s,div}$ = Sediment discharge of diversion
$Q_{s,net}$ = Rate of sediment discharged to and retained in marsh
R_i = Sediment retention of size fraction i
R_T = Total sediment retention factor
T = Time required for particle settling
U = Daily mean velocity with tidal and diversion related components
U_i = Instantaneous mean velocity with tidal and diversion related components

U_{div} = Diversion induced velocity (= Q_{div} / HB)
$U_{max,tide}$ = Maximum tidal velocity (tidal velocity amplitude)
V_{siphon} = Velocity of flow in siphon
W_s = Natural settling velocity
$W_{s,eff}$ = Effective settling velocity due to natural settling and turbulence
X = Transport distance of suspended sediment
δ = Land change rate (% / time)
δ_{nut} = Nutrient suppressed land change rate (% / time)
γ_{nut} = Percent of plant biomass made up of nutrients
κ = von Karman's constant (0.4)
ω = Tide phase
ω_0 = Tide phase of the up-crossing zero velocity
ω_1 = Tide phase of the down-crossing zero velocity (=$\omega_0 + \pi$)
$\omega_2 = \omega_0 + 2\pi$

ATTACHMENT D

Spatial Integrity
Figures and Tables

December 2008

Spatial Integrity Index
December 21, 2007

INTRODUCTION

Principles of landscape ecology assert that landscapes are a mosaic of patches that can be defined by their structure, their function and change (Forman 1995). Our conceptual approach defines the landscapes in each of the principal hydrologic basins of the Louisiana coast by their structure (meaning the spatial relationship among distinct wetland patches or their elements and other key physical features such as barrier islands, ridges, and tributaries), their function (meaning the flow of mineral nutrients, water, energy, or species among component patches or between landscapes), and change (meaning the temporal alterations in the structure and function of landscapes or their components).

Our premise is that the structure, function and change of patches across landscape mosaics affect fundamental ecosystem processes, which determine the trajectories of ecological condition. Therefore, the quantification of landscape structure and measurements of change to that structure are important precursors to understanding functional effects of change (Tischendorf 2001). At the site scale, the structure of a wetland patch can be related to topography and other spatial attributes such as channel density and pattern and heterogeneity of vegetation types. At the landscape scale, the spatial configuration of wetland patches—e.g., their size, shape and connectivity—and the composition and connectivity of surrounding open water areas are the key components of structure.

One method to quantify structure employs the use of spatial "metrics" (Wu et al. 2000). Spatial structure metrics can be linked to function through a variety of analyses including regression-based and other types of statistical models and sensitivity analyses (Tischendorf 2001). For example, a tidal marsh-dependent vertebrate species might require connectivity with other wetland patches for dispersal and recruitment purposes, or may experience higher rates of predation in marshes with a high ratio of edge to interior habitat. Measurement of landscape context metrics may reveal adjacent land uses as potential stressors, or hint at exchange rates across ecotones.

For the LACPR, spatial characteristics will be calculated for important wetland features at the site and landscape scales and tied to ecological functions through hypotheses supported by conventional landscape ecology theory. It is anticipated that studies will be conducted to better link the spatial metrics and key functions, and that future revisions to the spatial model may be required. Remotely sensed satellite and low-altitude aerial photographic data combined with spatial data analysis tools in ARCGIS will be used for the assessment. This approach has proven successful in measuring broad scale landscape patterns and correlating such patterns with ecological functional changes (Kelly 2001).

Numerous spatial metrics have been used to characterize various landscape attributes and, by inference, important ecological processes. They can be categorized as follows:

(a) area metrics, (b) core area metrics, (c) patch density and size metrics, (d) edge metrics, (e) shape metrics, (f) diversity metrics, and (g) connectivity/interspersion metrics. Since many spatial metrics are highly correlated, an appropriate number of metrics each representing area, edge/shape, and connectivity/interspersion will be used in discriminating alternative plans. It will be necessary to relate the metrics to important processes or characteristics so that they can be interpreted for weighting the alternative plans. The table below establishes some of the potential inferences from each metric.

Metric	What is Measured	Related Processes/Conditions
Area	Composition	Stability/resiliency; Geomorphic process (if temporal assessment applied); Productivity
Edge/Shape	Configuration	Primary productivity; Hydropattern (applied to open water pathways); Stability/resiliency
Connectivity/ Interspersion	Configuration	Local spatial variability (diversity)

These metrics, and particularly interspersion, are highly scalable and determining the appropriate scale of application will be necessary. The large ecological gradients in the eastern basins may require division into smaller units (e.g. fresh/intermediate vs. brackish/saline) for landscape metric characterization.

Several trade-offs may be embedded within individual metrics. For example, edge and interspersion could both be used to assess wetland fragmentation. While this may result in higher primary productivity, it may also eventually lead to more rapid wetland losses. This suggests a careful evaluation of the metric sets and, where possible, identification of important thresholds or trade-offs.

Although the intent of the spatial integrity metric is to compare alternative plans, it may be possible to also refine the models so that they provide some predictive capability. Valid comparison to reference wetlands is difficult, but correlations between spatial metrics and ecosystem services may be developed over time, provided the appropriate data collection and analyses are conducted.

This study proposes to identify and test a variety of spatial metrics and incorporate them in a spatially-explicit model to assess historic trends. The historic trend output would then be used by the LACPR HET team to (1) support projections of "future without" and "future with" alternative landscape configuration patterns and (2) determine which restoration alternatives promote the greatest ecological sustainability.

APPROACH

Study Area

This study utilized the LACPR planning unit boundaries minus fastlands as the overall spatial extent (Figure 1). The spatial boundaries upon which the metrics were run are

$4km^2$ grids. The boundaries of these 2km x 2km tiles are consistent with the original Louisiana Coastal Area (LCA) grid. Based on these spatial designations, a total of 8,437 tiles were evaluated in the study area using both grid-based and landscape-scale fragmentation analyses. The landscape-level metrics and analyses were used to assess more general trends in landscape configuration by planning unit.

Landscape Metrics

FRAGSTATS (McGarigal and Marks, 1995) is a software program designed to compute a wide variety of landscape metrics for categorical map patterns. This program was utilized because of its well tested utility as a packaged management tool and because it provides the greatest likelihood of product reproducibility. FRAGSTATS uses a grid-based approach, which is commonly not suitable for class scale determinations on entire landscapes; however it can provide class-level metrics, classification and assessments through individual non-related grid tiles. Historically, FRAGSTATS has been used for habitat suitability, change, and connectivity dynamics for forested ecosystems. Although there is very limited scientific literature on the study of marsh fragmentation and classification using FRAGSTATS, the authors have tested the use of this program to evaluate marsh breakup patterns in Terrebonne Parish, Louisiana under a saltwater intrusion scenario (Steyer et al., in prep), and feel it is appropriate for this study.

Landscape Classification

The Spatial Integrity Index (SII) developed as part of this study utilized a land-water classified image and a two-part classification system to support projections of landscape change as influenced by restoration alternatives. The two levels used in this system to denote landscape structure are: (1) *category*: ratio of water to land, and (2) *configuration*: marsh water area, shape and connectivity. This classification system (modified from Dozier, 1983) assigns values 1-10 to represent percentages of water. In this study, we represent the 10 classes of water as follows: Category 1, 0% – <5% water within marsh, Category 2, 5% – <15% water, Category 3, 15% – <25% water, Category 4, 25% – <35% water, Category 5, 35 – <45% water, Category 6, 45 – <55% water, Category 7, 55 – <65% water, Category 8, 65 – <75% water, Category 9, 75 – <85% water, and Category 10, >85% water. The system subclasses utilized are identical to Dozier (1983) and are designated by the configuration of water bodies in the marsh. Class "A", are configurations that are typically large water, (in relation to percent water class) and have connected water patches with linear edge. Class "B", are configurations that are typically small (as related to associated percent water class) disconnected patches with a more random distribution, and fewer instances of connection. Class "C", are configurations that are a combination of both class "A" and class "B" (with discernible regions of both). Figure 2 illustrates the SII class system. The numerical precursor denotes the amount of each tile occupied by water (increasing toward class 10) and the spatial configuration of water and land patches in each tile represented by A, B and C.

Due to considerations of data availability and time periods of interests, four dates of classified TM Landsat Thematic Mapper satellite imagery were selected for this

examination. The classified land:water images utilized in this methodology were taken from existing data analyses described in Morton et al. (2005), Barras (2006), and Barras et al. (in-prep) using the same standardized methodology. The imagery and data utilized, from 1985, 1990, 2001 and 2006, were collected under similar water level and seasonal conditions.

To determine the appropriate grid scale required for maximizing the accuracy of SII classification, 4 km^2 and 16 km^2 raster grids were evaluated. These grid scales were identified because they were coarse enough to permit the extensive computer processing, and fine enough to not bias the classification. To standardize the tiling origin, and alleviate potential shift error, the project vector grid origin was based on an established grid system developed by Twilley and Barras (2003) for the Louisiana Coastal Area Ecosystem Restoration Study. Each land-water image was tiled using a geoprocessing routine to expedite the preparation and extraction of all raster grids or "tiles". Each tile was then processed using FRAGSTATS and analyzed at the class metric level (i.e., statistics computed for every patch type or class in the landscape), and at each designated grid scale. Tiles were sorted by adjusted water percentages (recalculated category class, excluding "other" class), and by preliminary configuration thresholds (established to assess suitable metrics and metric combinations). Countless arrangements of metrics and metric combinations were selected and tested against configuration definitions. Category and configuration class output were assessed for accuracy of the computer generated classification. This method was used to evaluate all potential metrics, fit value thresholds to visually derived SII, and select adequate scale of tile. It was determined that the classifications based on the 4 km x 4 km extracted tile were often overwhelmed by large open water bodies, contained multiple SII classes, and were therefore too large to accurately classify the landscape. Conversely, the 2 km x 2 km tile system consistently classified the landscape correctly and thus was selected for this study.

The following landscape metrics which represent area, edge/shape, and connectivity/interspersion were selected after careful consideration of previous landscape fragmentation and configuration study metrics and evaluation of selected metrics toward meeting study goals.

Percentage of landscape occupied by water (PLDW) quantifies the proportional abundance of water within each patch type in the landscape. It is measured as the percentage of the landscape comprised of the corresponding class.

Number of patches of water (NPW) of a particular patch type is a simple measure of the extent of subdivision or fragmentation of the patch type. It is measured as the number of patches of the corresponding class.

Patch density (PDW) of water has the same basic utility as number of patches as an index, except that it expresses number of patches on a per unit area basis that facilitates comparisons among landscapes of varying size. It is measured as the number of patches of the corresponding class divided by total landscape area.

Largest patch index (LPIW) of water at the class level quantifies the percentage of total landscape area comprised by the largest patch. As such, it is a simple measure of dominance. It is measured as the percentage of total landscape area comprised by the largest class.

Edge density of land (EDL) equals the sum of the lengths (m) of all edge segments involving the corresponding patch type, divided by the total landscape area (m^2). Edge density reports edge length on a per unit area basis that facilitates comparison among landscapes of varying size.

Normalized Landscape shape index (NLSI) provides a simple measure of class aggregation or clumpiness. It is measured as the class perimeter length divided by the minimum perimeter needed for maximum aggregation.

Patch cohesion index of water (COHW) measures the physical connectedness of the corresponding patch type. Patch cohesion increases as the patch type becomes more clumped or aggregated in its distribution; hence, more physically connected.

Aggregation index of water (AIW) is calculated from an adjacency matrix, which shows the frequency with which different pairs of patch types (including like adjacencies between the same patch type) appear side-by-side on the map.

Modified Simpson's diversity index (MSIDI) belongs to a general class of diversity indices to which Shannon's diversity index belongs. The Modified Simpson's diversity index evaluates whether any 2 classes selected at random would be different patch types.

Landscape Evaluation

The SII was used to examine multiple restoration alternatives, and project future landscape pattern under those scenarios. The restoration alternatives that were presented for evaluation are (1) R1, (Figures 3a - 3e); (2) R2, (Figures 4a - 4e); (3) R3, (State Master Plan, Figures 5a - 5e); R4, (Figures 6a - 6e); and R5, (LCA Plan Best Meeting Objectives, Figures 7a - 7e). Each of these alternatives was based on a low sea-level rise scenario. The diversion, marsh creation and barrier island measures of these plans were the primary features modeled in this application based on the initiation data provided by the HET team. Features such as shoreline stabilization, ridge restoration and gapping banks were assumed to have little effect on land change and configuration.

In order to provide a baseline of comparison, a "future without project (FWOP)" predictive scenario was created. While multiple "future without" scenarios have been developed in recent years, most project land loss or gain with little or no attention to the spatial pattern of that land. The LCA land loss polygons described in Barras et al. (2003) were updated for the current trend of land loss generated from 13 dates over the timeperiod 1978 – 2006. Polygons not evaluated for land loss trends under Barras et al (2003) were incorporated under the current analysis using the 1985-2006 data. The LCA polygon trend data set was rasterized at a 25x25 meter cell size to create a raster index

file containing each loss polygon identified using a unique integer id (Figure 8). The Leica Imagine "Summary" function was then used to compare the raster index LCA loss unit file to each Landsat Thematic Mapper satellite classified land-water coastal mosaic and simplified historical habitat land-water coastal dataset to identify land-water acreage for each dataset by LCA trend polygon. To establish the FWOP scenario at year 50, a linear regression fit was applied to the data (Paille et al., in-prep). This FWOP scenario defined the total remaining acres in each of 183 polygons across the study area annually through year 2060 (50 year projection). The acreage by polygon was then merged with the tile grid in order to determine future acreage by tile. The composition of tiles in 2006, as well as trajectory of change over the 1985-2006 time period, was utilized to drive assumptions as to the spatial configuration of future acreage. All 8 metrics were run and evaluated by planning unit for years 2006, 2010, 2020, 2030, 2040, 2050, and 2060 to remain consistent with the LACPR land change evaluations.

Upon completion of the FWOP scenario, the restoration alternatives were evaluated. For each alternative, shape boundaries of all restoration measures were overlaid on the 2 km x 2 km grid. Tiles that were influenced by restoration measures were assigned new spatial configurations estimated based on land:water acreage provided by Paille et al., in-prep). Tiles affected by a restoration measure were compared to the same tile under the base year 2010 of the FWOP scenario for examination of effects. Details of the modeling approach are provided later in this document.

Determining future spatial configurations of restored landscapes with any degree of certainty is impossible at this time. The science has not evolved enough to support strong linkages between pattern and process that this level of assessment needs. A multiple lines of evidence approach was utilized that includes identifying historic patterns as a predictor of future change, identifying natural analogs that represent the types of restoration proposed, and using rules to drive configuration changes based on hypotheses of how spatial metrics and SII classes are linked to key functions provided by different categories of restoration measures.

In order to conduct the multiple lines of evidence approach, we identified eight categories of restoration measures that were common to the three restoration alternatives and considered them based on their location within the coastal landscape (high energy versus low energy). The categories are (1) freshwater diversions, (2) freshwater diversions coupled with marsh creation, (3) sediment diversions, (4) marsh creation coupled with shoreline stabilization, (5) marsh creation, (6) shoreline stabilization, (7) ridge restoration, and (8) barrier island restoration. Rules or hypotheses were then established that define how these restoration measures influence spatial configurations based on conventional landscape ecology theory and existing scientific literature or best professional scientific judgment. The existing scientific knowledge that helped frame our hypotheses are identified below.

Existing Scientific Knowledge:

- Suspended sediments increase and organic content decreases with increasing connectivity to riverine sources.

- Sedimentation rates in salt marshes vary as a function of either the distance from tidal channels or with flow distance between marsh and larger bodies of water.
- Sedimentation rates are inversely related to distance from marsh edge when sediment supplies are available to marsh.
- Sedimentation rates are positively related to hydroperiod (inundation duration) when sediment supplies are available to marsh.
- There are tradeoffs between hydroperiod and sedimentation. Increasing hydroperiod (to support sedimentation) beyond plant community thresholds will decrease productivity.
- Dissolved nutrient availability to marshes generally increases with greater connectivity to riverine sources and greater residence time of water.
- Sedimentation rates are positively related to plant stem density under normal conditions. Sedimentation by large storms may impact this relationship.
- Connectivity is a function of habitat type, drainage density, waterway orientation and levee height.
- Marshes tend to aggrade where fluvial flow becomes unconfined and degrade away from such sources.
- The flux of energy and nutrients across an ecotone depends on the surface area of the wetland contact zone.
- High river discharge coupled with southerly wind conditions can lead to sheet flow and sedimentation on the marsh.
- Storm surge breaks in barrier islands occur where the island width is least; so increasing island width not only minimizes the effects of storm surge, but also traps the sand as it rolls over the island.

Hypotheses:

- Freshwater Diversions into existing patchy marsh will favor deposition of both organic and fine inorganic material and slowly increase sediment platform elevation. Large diversion flows or pulses into upper basins may result in transition to less fragmented classes due to the development of flotant. RULE: Existing marsh patches (B and C classes) will expand along their edges (stay within class or B go to C class) and small marsh patches will not coalesce unless large pulses or high diversion flows are employed (C class can go to A class, but is dependent on distance from source).
- Freshwater Diversions into large contiguous marsh creation patches will maintain contiguous marsh integrity by providing necessary sediment and nutrients to sustain the marsh. RULE: A class remains A class if sustained by diversion.
- Sediment Diversions into existing patchy marsh with low land:water ratios and slow currents will facilitate coarse and fine sediment deposition onto subaqueous habitats (e.g. bay bottoms), increasing their elevation and ultimately transforming them to subaerial marsh platforms (near field effect – extent dependent on diversion size/sediment content). RULE: Existing marsh patches will expand along their edges as adjacent ponds are infilled with sediment, and marsh patches will coalesce nearest the diversion. This effect might be greatest in class B and C.

Increased channelization in near field will route flows and decrease sediment retention.

- Marsh creation will form contiguous marsh, and therefore increase the flow resistance on the marsh platform and thus concentrate flow in developed channels while maintaining large marsh patches. RULE: Marsh creation projects produce class A patterns immediately, with immediate formation of marsh channels, which are then subjected to change to class B or C based on trajectory of change from 1985-2006 by planning unit by marsh type.
- Marsh creation will form contiguous marsh, and coupling with shoreline stabilization will only change land:water acreage and not configuration (except immediately adjacent to shoreline stabilization). Therefore, increase in the flow resistance on the marsh platform will concentrate flow in developed channels while maintaining large marsh patches. RULE: Marsh creation projects produce class A patterns immediately, which are then subjected to change to class B or C based on trajectory of change from 1985-2006 by planning unit by marsh type.
- Shoreline stabilization will only change land:water acreage (from reduced shoreline erosion) and not change configuration. RULE: Trajectory of change from 1985-2006 by planning unit by marsh type will be applied to future condition.
- Ridge restoration will enhance skeletal network for water distribution within planning units, but no effect on pattern can be predicted. RULE: Trajectory of change from 1985-2006 by planning unit by marsh type will be applied to future condition.
- Barrier Island restoration will form contiguous back barrier marsh that may be enhanced by island rollover, but also susceptible to significant erosion during storm events. RULE: Marsh creation projects produce class A patterns immediately, which are then subjected to change to class B or C based on trajectory of change from 1985-2006 by planning unit by marsh type.
- Ecosystem performance and species survival are enhanced when external (storms) and internal (water flow) pulses are coupled.

Some of the assumptions made in applying the hypotheses in this application are:

- The effects of protection structures (levees) on water transport and flow, and how that process influences spatial configuration of the landscape was not addressed. It is anticipated that there will be non-linear responses in the landscape to these engineering features.
- Freshwater diversions will be operated in a manner that will not cause persistent flooding and impacts to the marsh landscape.
- No rapid subsidence collapse of the marsh landscape as described by Morton et al (2005) will occur again.
- Patchiness of vegetation is strongly dependent on propagation patterns (local reproduction strategies) of individual plant species within a marsh community type, but this will not be addressed.
- Build up of new land or the development of open water is a balance between net inputs of suspended sediments and organic production and outputs due to subsidence and export of eroded sediments.

- Primary productivity and, hence, stem density is enhanced with increased dissolved nutrient availability when nutrients are limited. This assumption does not take into account some evidence that belowground productivity will be reduced with increased nutrients nor that nutria may prefer higher nutrient plants.
- The remaining coastal landscape is more resilient to wetland loss (harder to lose) than the marsh that has been already lost, however it will be treated the same.
- Internal and external pulses were not coupled, therefore the effects of levees and shoreline stabilization on back marsh spatial integrity was not captured by spatial integrity metrics.
- Channel infilling will continue only until an equilibrium condition is reached based on the flow rates (tidal or diversion velocities) and the stability of the vegetation/soil matrix of the marsh.
- High discharge freshwater diversions or pulsed diversions will provide sedimentation on the marsh surface, but will also experience erosion in areas closest to the diversion.
- Barrier Island widths when restored will be maintained to eliminate island breaching during large storms.

These hypotheses need to be tested in order to better link the spatial metrics to key functions. As an initial test of the hypotheses, SII classes should be calculated for natural analogs representing some of the categories of restoration measures. In coastal Louisiana, there are few restoration projects that have been constructed and in place for a sufficient period of time to assess spatial change. The projects suggested for this evaluation are Sabine Refuge 1993, 1996, 1999 and Bayou Labranche 1994 representing marsh creation; Naomi 1993, West Pt ala Hache 1993, and Caernarvon 1991 representing freshwater diversion in broken marsh; West Bay 2003 representing sediment diversion into open water; and Wax Lake Outlet 1973 representing natural delta development.

Modeling Approach

Future Without Project (FWOP)
The foremost premise upon which the model operates is an assumption that different SII classes change in variable patterns. Observation of historic trends (1985 to 2006) will be used to determine how resistant A, B and C classes are to change, and how they vary by water class as well as across planning units. These spatial and categorical delineations will be utilized to drive future projections.

The mean change over time for each of the 8 spatial configuration metrics were calculated for every possible combination of planning unit (PU) and SII class. Any PU_SII class combination which did not occur during the observation period was assigned the average of a similar PU_SII class combination; however, this occurred infrequently. An assumption of linearity of change was then utilized (due to time constraints) and mean metric change was converted to a change rate on an annual basis. These change rates then formed "lookup tables" upon which the model draws (Appendix A).

Future projections (2010 – 2060) are based on land area change provided by Paille et al. (in prep), where the model attempts to reflect the land change data, driving the classification into the numeric portion of the SII class (1, 2, 3, 4, 5, 6, 7, 8, 9, 10). Land change projections were conducted on larger polygons than the 4 km^2 tiles used in this analysis. Therefore, tiles were assigned to polygons based on a majority rule. For FWOP projections, land gain or loss rates (in each 10-yr period) were then assigned to each tile in a polygon and projected future land area was calculated.

The spatial configuration portion of the SII class was calculated for each of the 8 metrics based on the lookup table value of the starting time period PU_SII class. Those tiles which experienced land gain utilize gain rates and loss tiles utilize loss rates. The annualized rate was first calculated for 4 years to achieve a 2010 projection. The 2010 SII class was then assigned based on the newly calculated spatial configuration metrics. The process then iterates for the next 10-yr period based on the new SII class lookup value. The year 2010 served as our base year for the projection of future change.

Alternatives Assessment

The presence of hypothetical diversions and marsh creation measures in the alternatives required additional approaches for creating projections. As with the FWOP scenario, net benefit acreage for each of the measures that comprise the restoration alternatives was provided by Paille et al. (in-prep), and the model seeks to reflect those data. Net benefit acreage was again assigned to larger polygons, so tiles were assigned to polygons based on a majority rule. The model seeks to first distribute that benefit acreage appropriately throughout the tiles based on the type of restoration measures; however each type was modified differently based on the rules that were previously described.

Benefit area assignments were defined for marsh creation measures, marsh creation measures sustained by diversion measures, and diversion measures. The approach for each is defined as follows:

Marsh Creation Benefit Area Assignment

- Total available water area was assessed for all tiles in a given polygon.
- This figure was then multiplied by 0.7 as a result of the desire to implement marsh creation projects in a 70/30 land/water ratio.
- The resulting acreage was the maximum available area to be built, which was then compared to the Paille et al. (in-prep) benefit acreage for that 10-yr period.
- All cells were brought to the highest land acreage possible and assigned a spatial configuration class of "A". The mean metrics for the class were assigned.
- If the maximum available area was less than that of the benefit acres provided, that benefit could not be reflected.
- If the marsh creation project was not sustained by a diversion, it was subjected to 10-yrs of loss spatial configuration change rates and the process repeated for the next 10-yr period.

Marsh Creation (sustained by diversion) Benefit Area Assignment

- The benefit area was assigned in the same manner as other marsh creation projects, however the sustaining effect of the diversion was assumed to keep the spatial configuration as an "A" class.

Diversion Benefit Area Assignment

- Diversion land building was excluded in SII classes 1 and 10.
  - The assumptions here being that a diversion will not build a tile to any more than 95% land, and open water is very difficult to alter and build land.
- Diversion benefits were commonly assigned to large polygons, requiring a means of further discriminating where benefits occurred.
- Diversion "Zones of Influence" polygons were often found to not contain enough available water area to reflect the land benefit acreages provided.
- A shortest distance to diversion methodology was utilized where:
  - The cell which was closest to a diversion would first be subjected to gain rates as assigned by PU_SII class for a ten year period;
  - The model would then check that increase in acreage against the total benefit provided. If more benefit needed to be assigned, the next closest cell would receive benefits;
  - Once all benefits were assigned, the model would exit the loop and move on to the next diversion.
  - A 20km threshold was also utilized as the maximum distance a diversion could assign benefits to avoid situations in which the benefit acreage criteria was not met, and consequently land building occurs at distances it logically could not benefit.
  - If the benefit acreage can not be completely assigned within those restrictions (available tiles SII classes 2-9, within 20km) those benefits could not be reflected.

The LACPR HET will ultimately be responsible for placing value judgments on what type of spatial pattern is more beneficial from an overall ecosystem sustainability perspective. A reproducible numeric approach was developed for each selected metric (percentage of landscape occupied by water, edge density of land, and patch cohesion), where the average values calculated from each of the four dates of imagery (1985, 1990, 2001 and 2006) were averaged across all dates to determine rankings by SII. The SII rankings were then assigned an index value from 0 – 1 based on equal distribution across the 24 SII classes. These values were then used to calculate average values for each metric by PU. This type of ranking system may prove valuable to facilitate the comparison and interpretation of results; otherwise evaluation of positive or negative effect for particular processes as represented by a specific SII (i.e., fisheries utilization vs. land stability) will be a subjective determination by the LACPR HET.

RESULTS & DISCUSSION

The results and discussion presented in this draft report are going to concentrate on change assessments for PU's 1, 2, 3a, 3b, and 4 between two historic time periods (1985 and 2006) and two future dates (2010 and 2060) even though multiple dates were assessed. Additionally, results will focus on the metrics "Percentage of Landscape Occupied by Water", "Edge Density of Land", and "Patch Cohesion" as metrics that best represent the functions land stability, fisheries utilization, and hydrologic connectivity, respectively.

Classification Change

Historic Evaluation

The SII was calculated for 8,437 tiles coastwide for 1985, 1990, 2001 and 2006, and the spatial representation of the data from 1985 and 2006 are shown in Figures 9 and 10, respectively. The darker saturations/intensities (within a particular color) represent A classes, which denote large, contiguous patches of land and at least one large, contiguous patch of water. The intermediate saturations/intensities (within a particular color) represent C classes, which denote some fragmented patches of land and at least one large, contiguous patch of water. The light saturations/intensities (within a particular color) represent B classes, which denote a disaggregated configuration of land and water patches occurring throughout the tile.

Preliminary observations of these data suggest that the classification system accurately classified the amount of each tile represented by water. Overlays of these results with the original land:water classification by Barras (2006) showed a significant match. The SII also appear to match up fairly well with long term personal observations. As an initial sensitivity analysis, an evaluation of PU's 1 and 2 (Figures 11 – 12) and PU's 3a, 3b, and 4 (Figures 13 - 14) was conducted to corroborate results from this study with detailed pre and post-hurricane observations and data collection that was conducted in 2004, 2005 and 2006 throughout coastal Louisiana. The lighter saturation/intensities in upper Breton Sound in PU1 and in Cameron Creole Watershed in PU4 in 2006 are confirmed B classes. Preliminary data comparisons of configuration classes in PU's 2, 3a and 3b were inconclusive. A more detailed sensitivity analysis needs to be conducted in the future.

The coastwide evaluation of SII changes from 1985 to 2006 is presented in Table 1. This matrix shows that over 58% of the coastwide tiles classified remained unchanged over this 21 year period. More importantly, it shows that tiles that started out as either class 1 (solid land) or class 10 (solid water) remained stable and didn't change class over the timeperiod. The data also show that generally A classes are most stable over time, followed by C classes and B classes. The percent of the A classes that remained unchanged, regardless of the water class in the tiles, always exceeded that of the B and C classes. Additionally, as water classes increase, the B classes that remain unchanged decrease. These findings suggest that the general trend of most stable to least stable is class A to C to B. When this evaluation was conducted at the planning unit (PU) scale, all planning units followed this general trend. Results from PU's 1, 2, 3a, 3b and 4 are

included in Tables 2 - 6. It is interesting to note that PU1 had the greater amount of percent unchanged tiles (70.8%) whereas PU4 had the least (41.67). The result in PU4 may be reflecting the change in solid land (class 1) to water classes that is associated with impacts from Hurricane Rita. Further investigation into why there are large differences in the amount of percent unchanged tiles between PU's is needed.

Future Without Project (FWOP)

The FWOP SII was projected for 2010 and 2060 and is shown for PU's 1-2 in Figures 15 and 16. The greatest change over this time period is reflected in the increase in open water (higher SII classes), that visually match the land loss estimates provided by Paille et al. (in-prep). The large open water projected by 2060 is primarily in the marshes adjacent to the Gulf of Mexico in PU's 1 and 2, adjacent to large existing water bodies in PU1, and in interior marshes in central Barataria Basin in PU2. Figure 17 illustrates this point by showing that the middle and lower portions of PU's 1 and 2 are completely dominated by water. The SII change matrices also reflect the increase in water from 2010 to 2060. Planning unit 1 (Table 7) is dominated by a 1 category increase in water and a large shift in A classes to C classes. The matrix for PU2 (Table 8) illustrates 1-3 category increases in water (primarily 2 category), reflective of the higher landloss rates in PU2. The configuration of the remaining landscape is dominated by larger water patches in Barataria and Breton Sound and a greater disaggregation of land in lower Pontchartrain Basin (Figure 18). Planning units 1 and 2 have a slightly greater connectivity between water patches in the lower basin and a greater connectivity in the upper basin, as reflected in the patch cohesion metric in Figure 19.

The FWOP SII projections for 2010 and 2060 for PU's 3a, 3b and 4 are shown in Figures 20 and 21. The areas showing the highest SII classes reflecting increases in open water visually match those estimates provided by Paille et al. (in-prep) and Barras et al. (2003). The areas projected to continue to fragment and/or convert to open water include, but are not limited to, the landscape between Lake Boudreaux and Bayou LaFourche in PU 3a, North of Lake Mechant in PU 3b, and Grand Chenier and south White Lake in PU 4. The landscape west of Calcasieu Lake does not reflect well the losses projected from Barras et al. (2003). This area (other than the southwest region) shows higher percentages of water in 2010 than in 2060 (Figure 22), which suggests either an error in the model or that the polygon size and associated land loss rate applied from Paille et al. (in-prep) needs to be adjusted. The matrix for PU3a (Table 9) illustrates 1-3 category increases in water, consistent with the highest landloss rates found in this PU (Figure 22 and 23). Planning unit 3b, which includes a land building area in the Atchafalaya delta, and PU4 have slightly greater connectivity between water patches, as reflected in the patch cohesion metric in Figure 24, but also a smaller change in water category classes as compared to the higher loss areas in PU's 2 and 3a (Tables 10 & 11). A limitation of the projections is they assume that trajectories of land change and land configuration in the past (1985 – 2006) will be the same in the future. Refinements to address this assumption and a more detailed sensitivity analysis will be conducted in the future.

Alternatives Assessment

The alternatives assessment focused on evaluations of each of the alternatives at 2060 as compared to the FWOP condition. In PU's 1 and 2, all of the alternatives had greater spatial integrity than the FWOP condition (Figure 16). Most restoration measures within all of the plans are clearly identifiable. The R1 and R2 diversion and marsh creation measures increased the spatial integrity significantly in upper Breton Sound, the east flank of the Barataria Basin and the Barrier Islands (Figure 26). The R3 diversion and marsh creation measures increased the spatial integrity significantly in the Biloxi marshes, the east and west flanks of the Barataria Basin, the upper birdsfoot delta, and the Barrier Islands (Figure 27). The R4 diversion and marsh creation measures increased the spatial integrity similarly to R3 except had less spatial integrity in the upper Breton Sound and upper birdsfoot delta (Figure 28). The heavy influence of diversions and limited marsh creation is evident in the spatial integrity patterns of alternative R5 (Figure 29).

Planning units 3a, 3b and 4 also had greater spatial integrity than the FWOP condition for all alternatives (Figure 21). The influence of marsh creation features on the landscape, especially in PU3a - upper Terrebonne Basin are obvious (Figures 30 – 33), and when combined with freshwater influence from the GIWW, show the greatest spatial integrity (Figure 31). The R5 alternative in PU3a limited the use of marsh creation and showed the greatest water classes in 2060 (Figure 34). The differences in spatial integrity among alternatives in PU3b and PU4 were barely recognizable, primarily due to the use of protection features, which are not captured by the model, and small benefit areas associated with marsh creation and freshwater introduction features.

The individual SII change matrices between 2010 and 2060 for each of the alternatives can be found in Appendix B. A summary of those matrices are provided by category (water class; Figures 35 and 36) and by configuration class (Figures 37 and 38). Though categories 1 and 10 are end members which signify extremes in the category class spectrum and are therefore important to the overall average change in classification, their frequency and resistance to change, both require and enable their exclusion from select summary statistics and figures. In PU1, the alternative that maintained a majority of land (classes 2 – 5) at year 2060 was R3 followed by R1 and R2 then R4 > R5 > FWOP (Figure 35). There was little difference in the occurrence of A classes at year 2060 between all alternatives except R5 (Figure 37). In PU2, the alternative that maintained a majority of land (classes 2 – 5) at year 2060 was R1, followed closely by R2 and R3 with the least land classes in R5 > R4 > FWOP, however the increase in water classes 6 – 9 do not show FWOP as the greatest. This decline in FWOP classes 6 – 9 was expected since a higher percentage of tiles converted to class 10 in FWOP than in any other plan. The greatest number of A classes and fewest number of B and C classes are found in R3.

In PU3a, the alternative that maintained a majority of land (classes 2 – 5) at year 2060 was R3 followed closely by R1, R2 and R4 then R5 > FWOP (Figure 36). There was little difference in the occurrence of A classes at year 2060 between all alternatives except R5 (Figure 38). In PU3b and PU4, a trend of declining frequency in water classes as you gain more water was distinct (Figure 36). This is evident of natural land building

that occurs in the Atchafalaya delta in PU3b and lower land loss rates in PU4. The results across all PU's illustrate that you lose a higher percentage of B classes in FWOP and that a large number of C classes are converted to A classes by marsh creation and diversion measures.

The ability to discern the influences of restoration measures on specific functions, and therefore compare each alternative was captured through a change analysis by metric between FWOP and each alternative. This approach shows only the influences of the restoration measures that comprise each of the alternatives, with no change represented outside of these areas. The change in percentage of landscape occupied by water metric for Alternatives R1 – R5 are shown for PU's 1 and 2 in Figures 39 – 43 and in PU's 3a, 3b and 4 in Figures 44 - 48. The change in the edge density of land metric for Alternatives R1 – R5 are shown for PU's 1 and 2 in Figures 49 – 53 and in PU's 3a, 3b and 4 in Figures 54 - 58. The change in the patch cohesion of water metric for Alternatives R1 – R5 are shown for PU's 1 and 2 in Figures 59 – 63 and in PU's 3a, 3b and 4 in Figures 64 - 68. These figures provide a visualization of how particular functions as represented by the metrics are maintained in 2060 by the different alternatives. The details of how individual metrics change among alternatives and FWOP between 2010 and 2060 are included in Figures 69 - 74 and Tables 12 - 14. In PU's 1 and 2, the general pattern in 2060 is that R3 has the smallest percentage of landscape occupied by water, followed by R1 and R2, then the most water in R4 < R5 < FWOP. In PU3a, R4 has the smallest percentage of landscape occupied by water. The patterns in PU3b and PU4 are similar with R3 having the smallest percentage of landscape occupied by water, followed by R1 < R2 < R4 < R5 < FWOP. Alternative R5 had the greatest amount of water at year 2060 across all PU's. The amount of edge metric represented in Figures 71 & 72 must be interpreted carefully because edge density increases when SII classes 1 – 5 degrade and then edge density declines when you increase the amount of SII classes 6 – 9. All PU's show declines in edge density over time except in PU3b, where active land building (Atchafalaya delta) and large marsh creations into previous large open water areas increase edge. Cohesion values represent in part how water bodies coalesce over time as land is lost. Across all PU's, R3 generally had the lowest cohesion of water values whereas R5 and FWOP had the highest values.

Index values were created for each metric to calculate an average value for each metric by PU to support a further evaluation of alternatives. It is important to note with regard to interpretation of R1 and R2, that the model is incapable of appropriately projecting the differential effects of the operation schemes which distinguish these alternatives from each other. As the locations of diversions and marsh creation features are held constant, leaving only the net land area benefits to vary among the plans, we expected and indeed saw nearly identical results for these plans.

A land stability index was generated from the percentage of landscape occupied by water and the number of unchanged tiles (Figures 75 and 76, Table 15). Though it may be intuitive to believe this occurs as a result of these plans building the most land, it is not necessarily the case. The land stability index places emphasis not only on the amount of land built, but the spatial configuration of that land. Also, the results of the spatial

integrity model utilized in this analysis are highly dependent upon the spatial distribution of restoration features throughout a landscape. The greatest land stability was found in R3 for alternatives PU1 and PU2; R4 in PU3a; R1 in PU3b; and R1 and R3 in PU4. In general, it appears that R1, R2 and R3 seem to have employed a greater number of small to medium diversions, spaced strategically throughout the PU with significant marsh creation. A diversion strategically placed to influence large areas of degraded, fragmented marsh will often have more beneficial results than a diversion placed in close proximity to large amounts of open water. This occurs as a result of multiple assumptions built into the spatial integrity model. First, diversion benefits are only allowed within a 20km distance of the diversion. Second, benefits are not allowed to be assigned to "open water" (Class 10) or tiles containing more than 95% land (Class 1). The combination of these assumptions can lead to situations where the model is incapable of assigning land building benefits. Placement is also of the utmost importance with regard to marsh creation projects. Marsh creation projects are assumed to be installed as "A" configuration classes (typically containing large amounts of aggregated land). Therefore, a marsh creation project which falls on top of areas which are already highly aggregated will have less beneficial influence than one placed in highly disaggregated areas. This is reflected in PU2 where R3 employed the greatest amount of marsh creation and had the greatest land stability at 2060. The R5 alternative in PU4 shows a significant increase in land stability from 2010 to 2040. This finding is contrary to what we would expect and may be reflective of how benefits (land loss rate reductions) were assigned associated with salinity control features in this alternative and the large polygon size that represents this area.

The edge utilization index was calculated from the edge density of land metric (Figures 77 and 78, Table 16). The results from PU's 1, 2 and 3a reflect the large contiguous marsh patches created initially followed by there disaggregation over time and creation of more edge. Alternative R5 which employed the least amount of marsh creation across PU's, showed high edge utilization values. This is suggestive of fewer A classes and a greater amount of B and C classes. The highest wetland loss areas are found in PU's 2 and 3b and this is reflected in very low values of edge utilization in 2060, apparently from small water patches coalescing into large water patches. There is an increasing trend in edge utilization in PU's 3b and 4 over time. This may be reflective of a less patchy landscape and more stable landscape in 2010 that then degrades over time. The low initial edge utilization index value of R5 in PU4 is consistent with the problem findings addressed in the land stability index.

The cohesion of water patch metric was used to generate the hydrologic connectivity index (Figures 79 and 80, Table 17). The FWOP reflects that as you lose land, there is a greater connectivity between water patches, and therefore high index values. The R4, R5 and FWOP alternatives had the highest values in PU's 1, 2, 3b and 4. This may be indicative of PU1 and PU2 starting out in a more deteriorated condition, such that new land building contributes to the large increase in cohesion of water patches. In PU3b and PU4, all alternatives decrease over time. The cohesion of water patch trend most commonly reflects that C classes are higher than A classes which are higher than B classes.

The results from all of the metrics suggest that the geographic location of features is highly influential on model output. In many ways, placement of restoration features has a larger influence on the values of spatial integrity metrics than does cfs load or net acres of benefit. It may be important to place larger emphasis on feature location in future plan development efforts.

Future Plans:

The conception, creation, and implementation of this model took place in a very short timeframe. Minimal time was afforded for further investigations of historical trends and in depth assessments of the validity of model's assumptions and/or methodologies. Easy approaches were, at times, selected over more rigorous approaches due to time constraints and the lack of the scientific backing to draw on. Therefore, future study of the assumptions and methodologies is encouraged to increase the validity and value of the results.

One such assumption warranting further investigation are the rates of change projected for various restoration features. The model currently utilizes rates of change based on tiles experiencing land gain from a variety of sources during the 1990-2001 period. This approach excludes an ability to incorporate variable patterns of change which may result from features with variable design and operation schemes. For example, rates of spatial pattern change are exactly the same for a 1,000 cfs diversion as that of an 80,000 cfs diversion (until land gain projections are met). Similarly, the model currently assumes a steady and pulsed diversion operation scheme will affect spatial pattern in the same manner. Realistically, benefits and change in spatial pattern will probably vary with operation scheme, cfs load and other factors. Therefore, further investigation into these variables is considered vital to the utility of projections of spatial pattern under different restoration strategies.

Another issue in need of future study would be incorporation of bathymetric depth as a variable affecting the likelihood and magnitude of change, not only in terms of land gain, but the spatial pattern of that gain. One assumption that affects model output routinely is the restriction of diversion land building benefits in open water tiles (Class 10). This assumption is logical in most cases, in that a $4km^2$ area of open water is unlikely to experience land gain. These tiles are usually deep and subjected to sufficient energy to maintain them as open water. There are a few cases however, where shallow open water, protected from wave energy, should be considered viable candidates to receive land building benefits from diversions. Therefore, incorporation of depth dependency may also improve the value of results.

A constant threshold distance of 20km is currently utilized to prevent diversion benefits beyond a reasonable distance. This distance was commonly utilized in LCA and was agreed upon as a maximum distance at which you could expect benefits by a panel of experts. This assumption needs to be tested. Although one would expect a majority of

the benefits to occur closest to the diversions, there is uncertainty regarding the distance from source that freshwater, sediment, and nutrient benefits are provided.

Investigation of boundary condition effects on the spatial integrity model also warrants further investigation. Boundary conditions may affect specific metrics primarily due to the Euclidean geometry of square tiles. This study utilized 4km^2 tiles in an attempt to alleviate boundary conditions as much as possible. Boundary condition effects could be reduced further by using a moving window analysis to assess patterns; however it is computationally intensive. Removing the potential influence of boundary condition effects may enable assessment of finer scale patterns, and thereby provide more accurate projections at finer scales.

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FIGURES

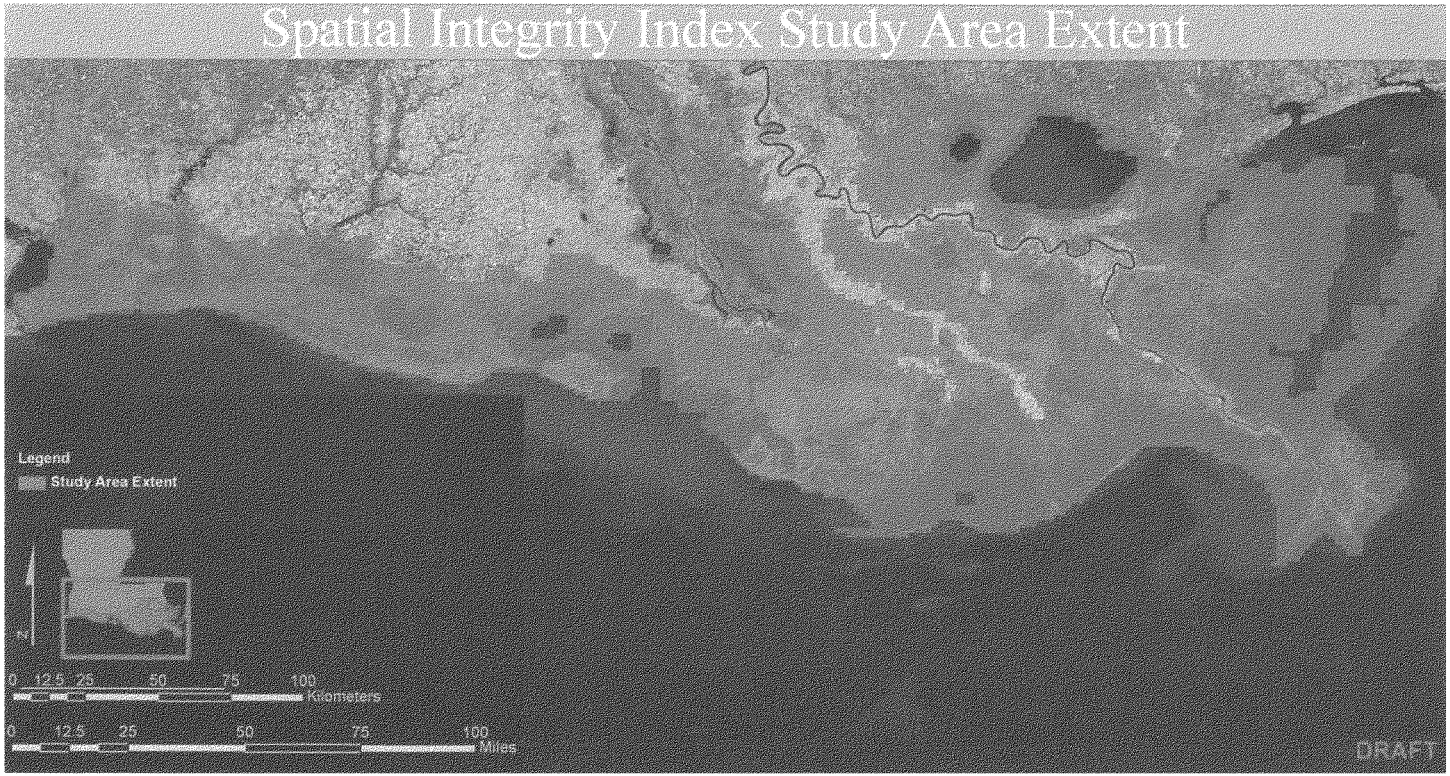


Figure 1. The overall spatial extent of the study area includes the LACPR planning unit boundaries minus fastlands.

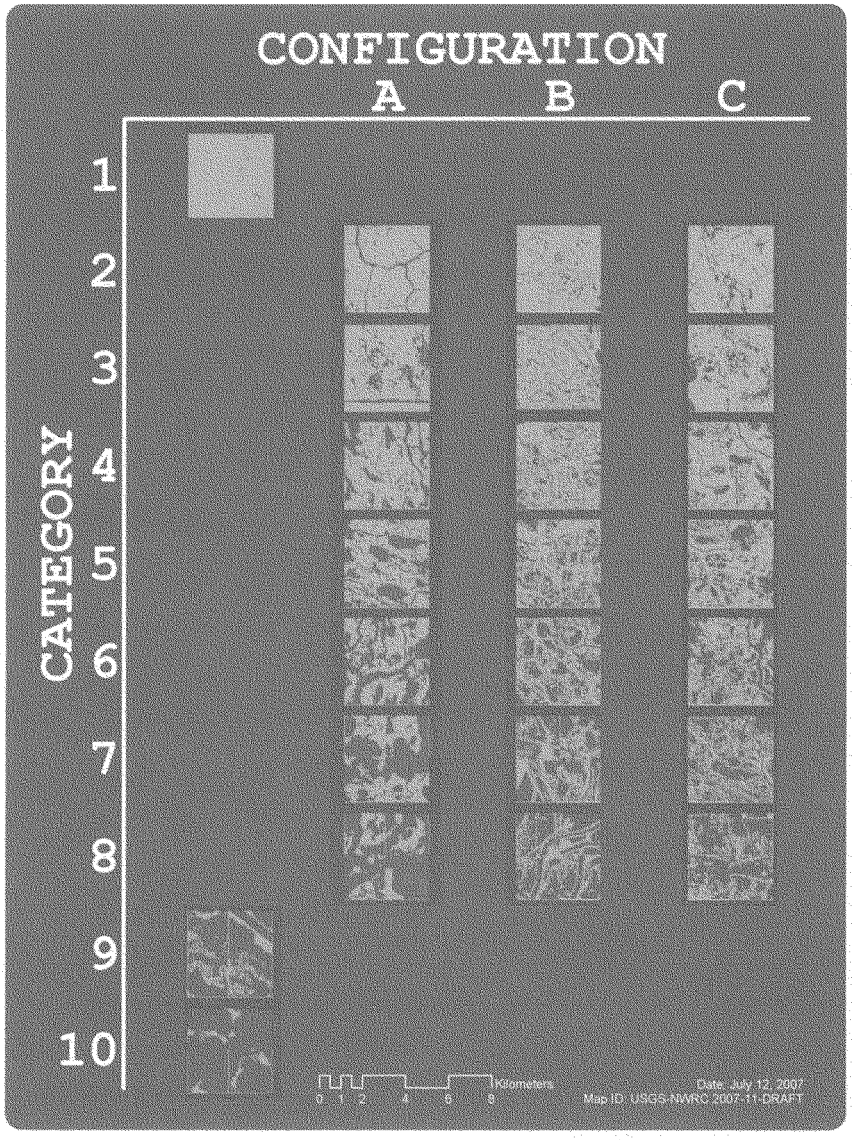


Figure 2. A representation of the spatial integrity index (SII) classification scheme modified from Dozier (1983) used for interpretation of classified TM landsat imagery. The numbers 1-10 represent percentages of water as: Class 1, 0%–<5% water within marsh, Class 2, 5%–<15% water, Class 3, 15%–<25% water, Class 4, 25%–<35% water, Class 5, 35–<45% water, Class 6, 45–<55% water, Class 7, 55–<65% water, Class 8, 65–<75% water, Class 9, 75–<85% water, and Class 10, ≥85% water. Letters A, B, and C are subclasses determined by configuration of water bodies in the marsh.

Figure 3a. Identified are the measures that comprise Alternative R1, May – December Medium Diversions – Planning Unit 1.

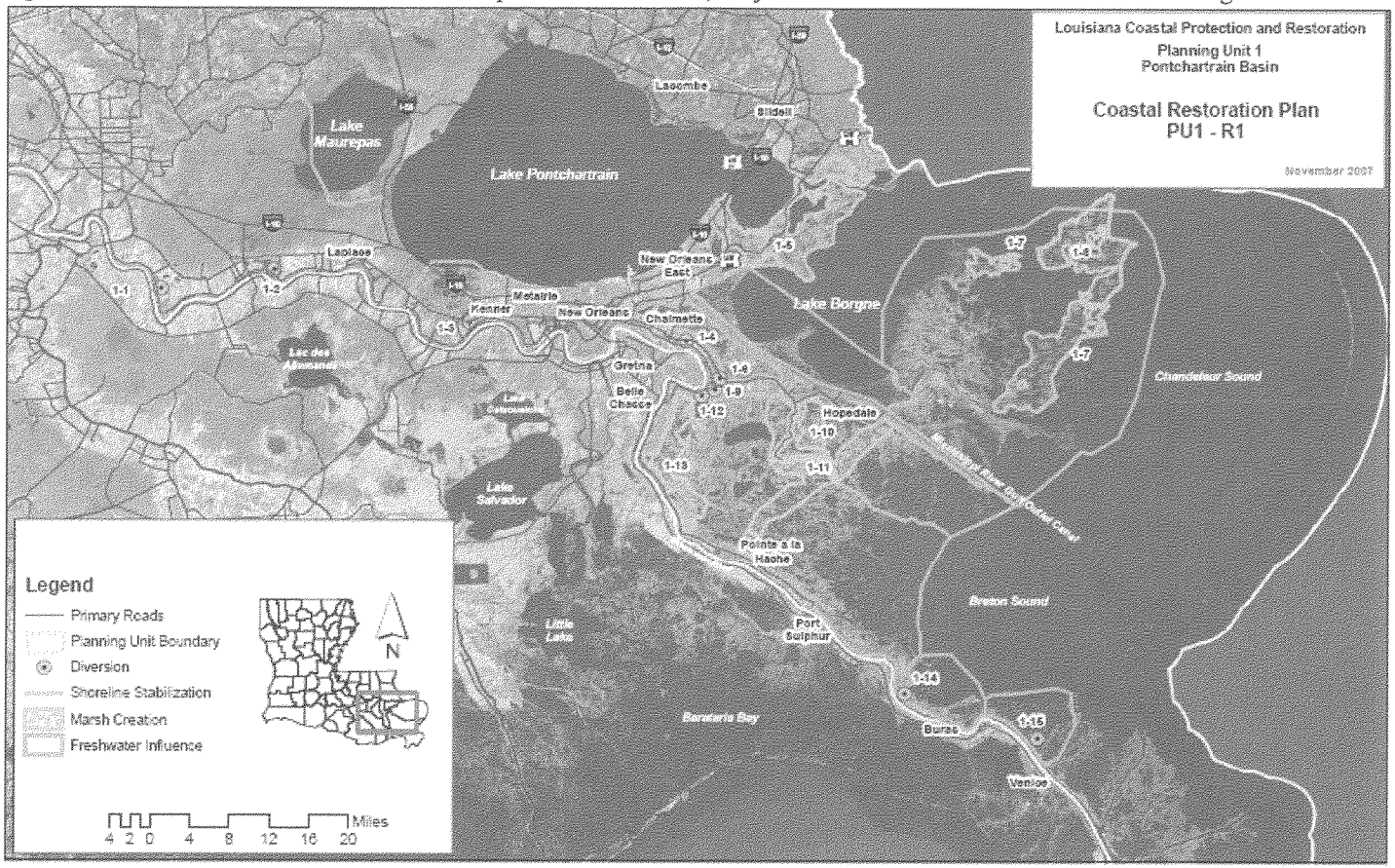


Figure 3b. Identified are the measures that comprise Alternative R1, May – December Medium Diversions – Planning Unit 2.

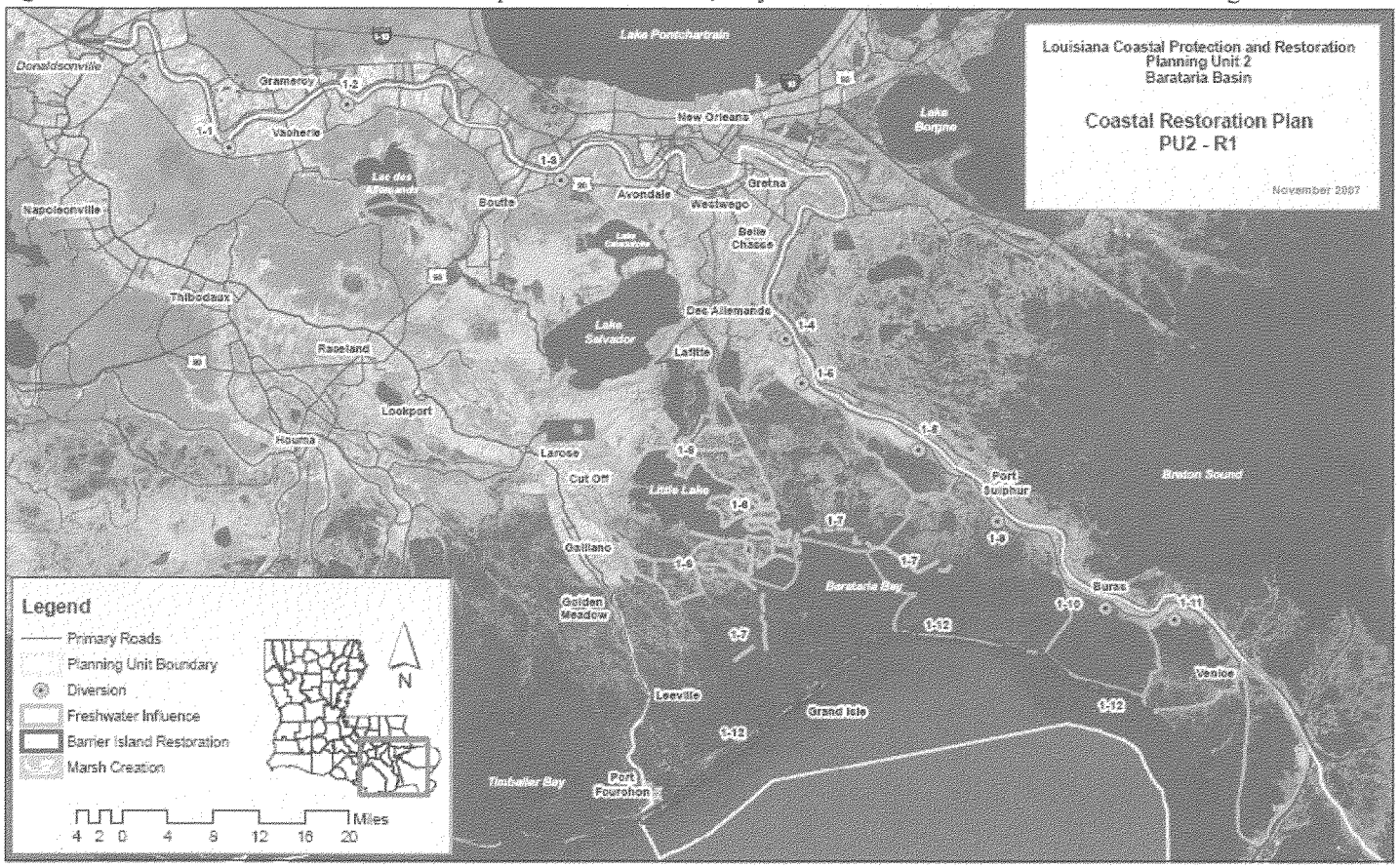


Figure 3c. Identified are the measures that comprise Alternative R1, Mississippi River Diversions – Planning Unit 3a.

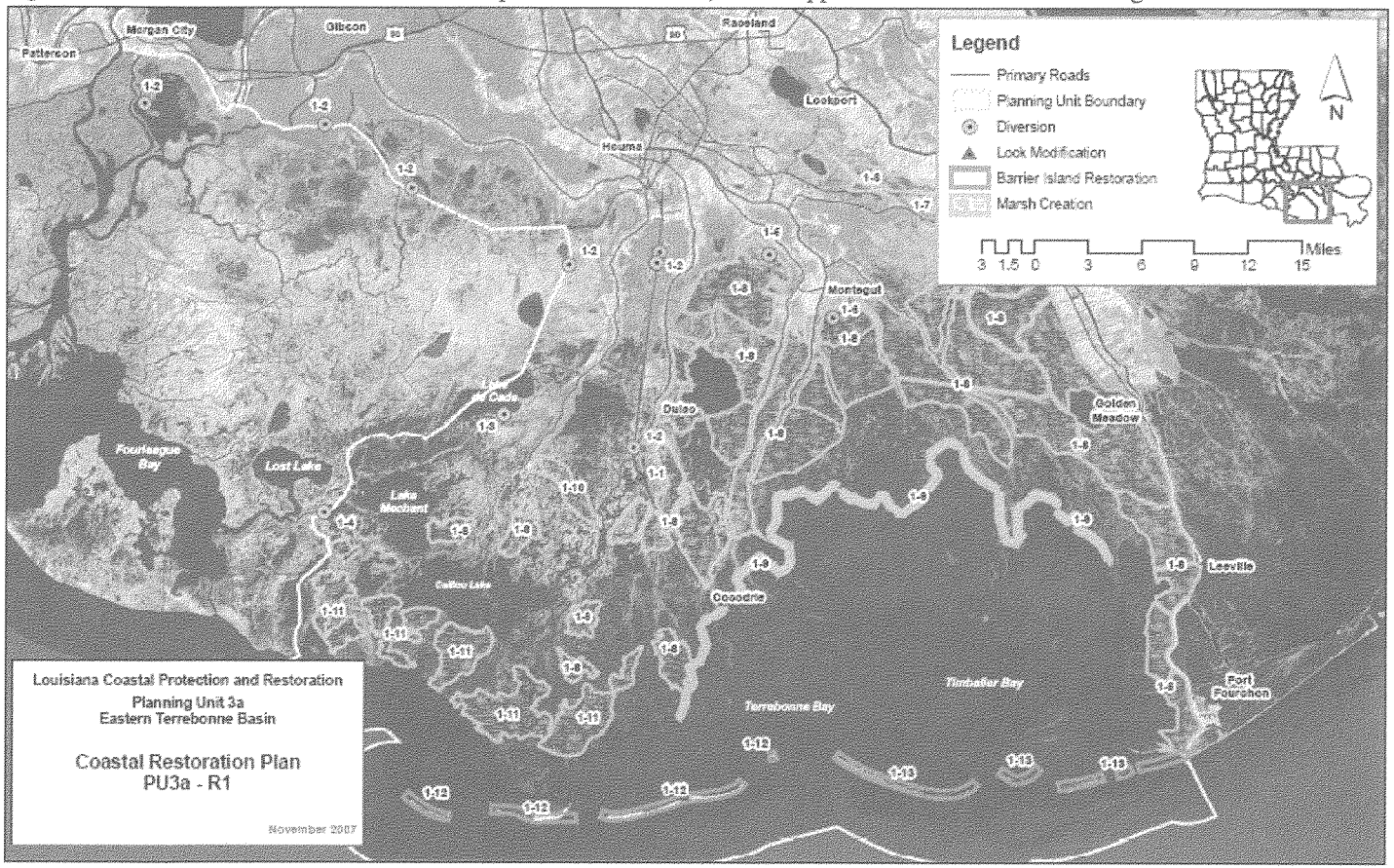


Figure 3d. Identified are the measures that comprise Alternative R1, GIWW Diversions With Shoreline Protection – Planning Unit 3b.

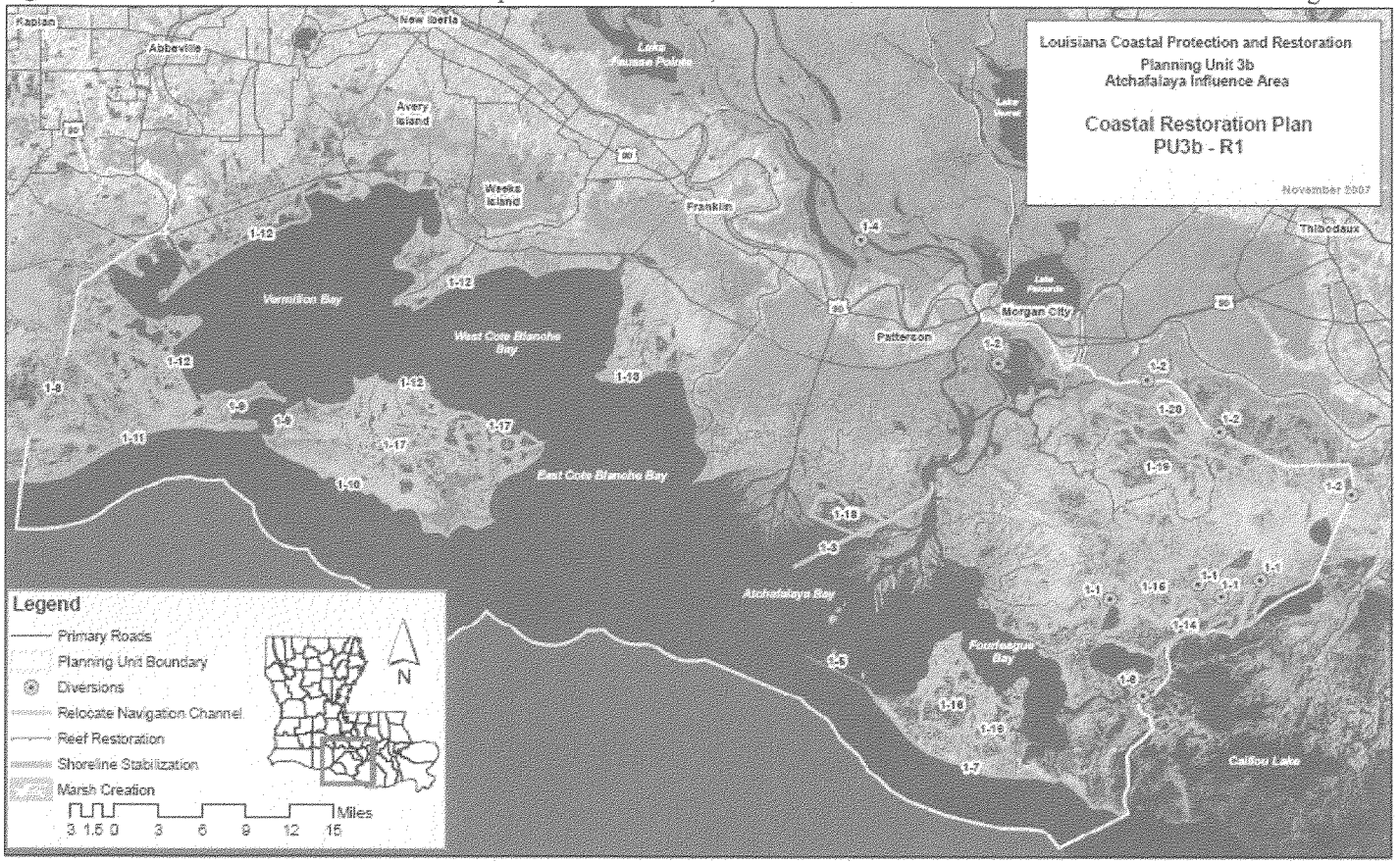
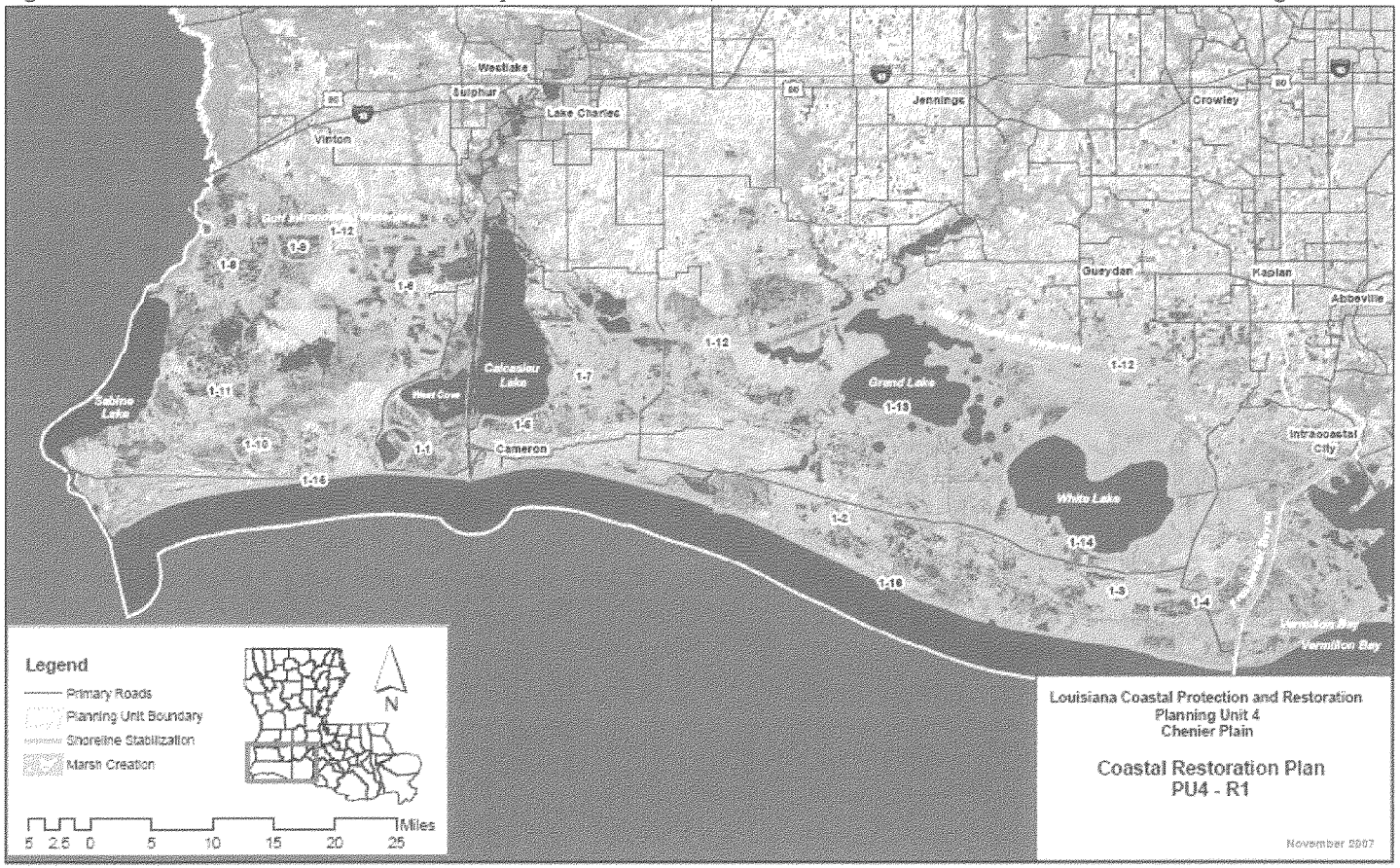


Figure 3e. Identified are the measures that comprise Alternative R1, Marsh Creation With Shoreline Protection – Planning Unit 4.



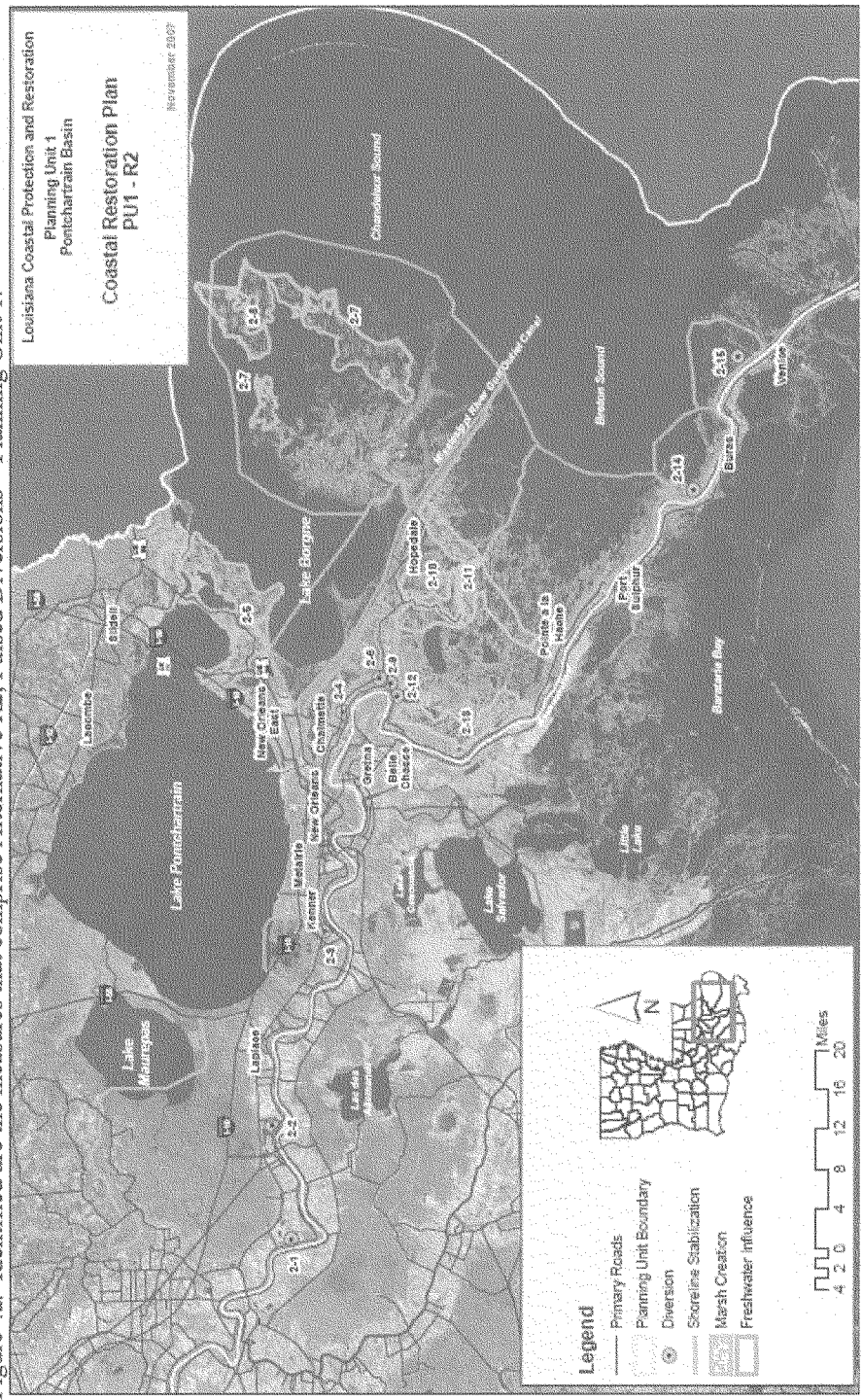


Figure 4a. Identified are the measures that comprise Alternative R2, Pulsed Diversions – Planning Unit 1.

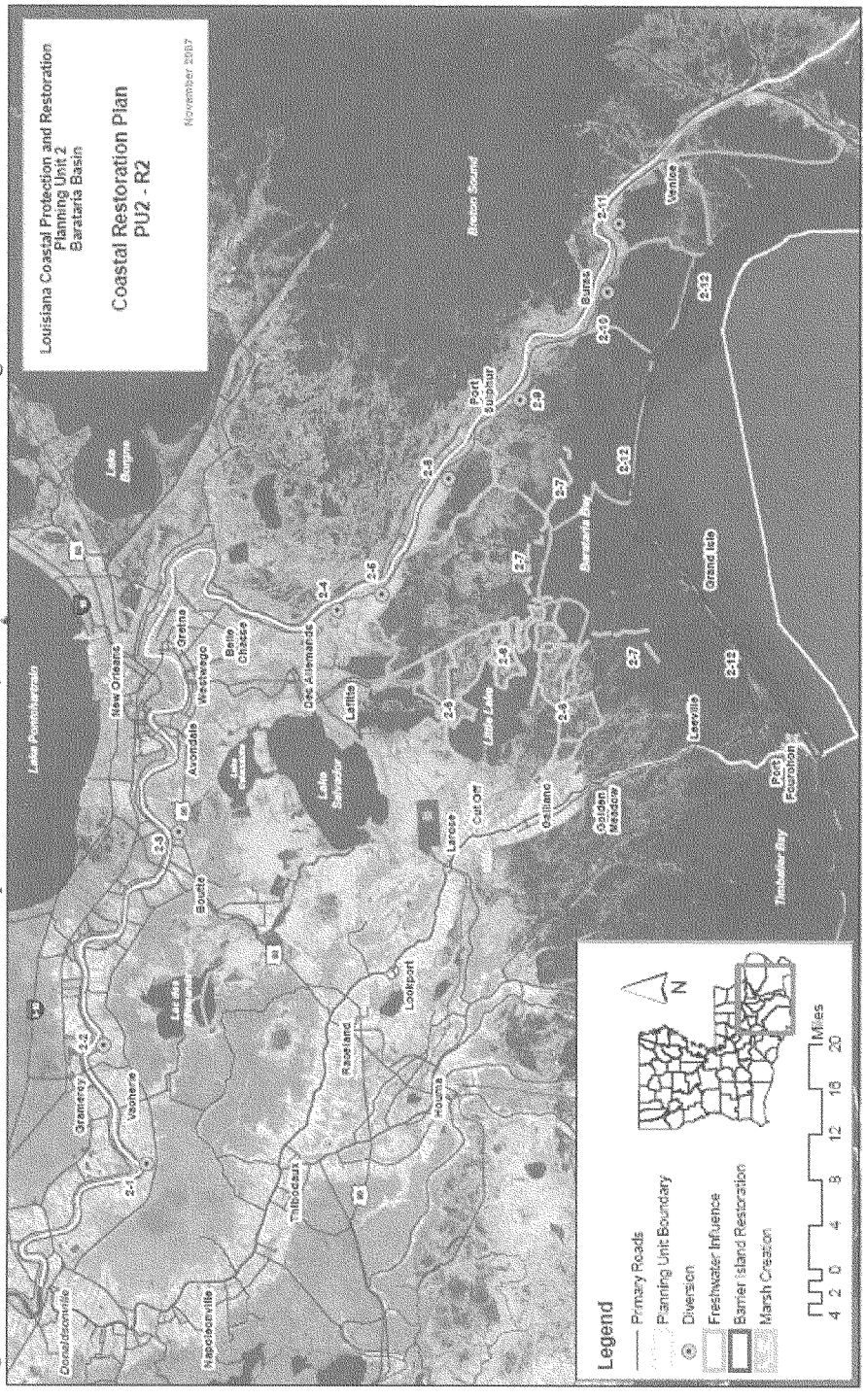


Figure 4b. Identified are the measures that comprise Alternative R2, Pulsed Diversions – Planning Unit 2.

Figure 4c. Identified are the measures that comprise Alternative R2, GIWW Diversions – Planning Unit 3a.

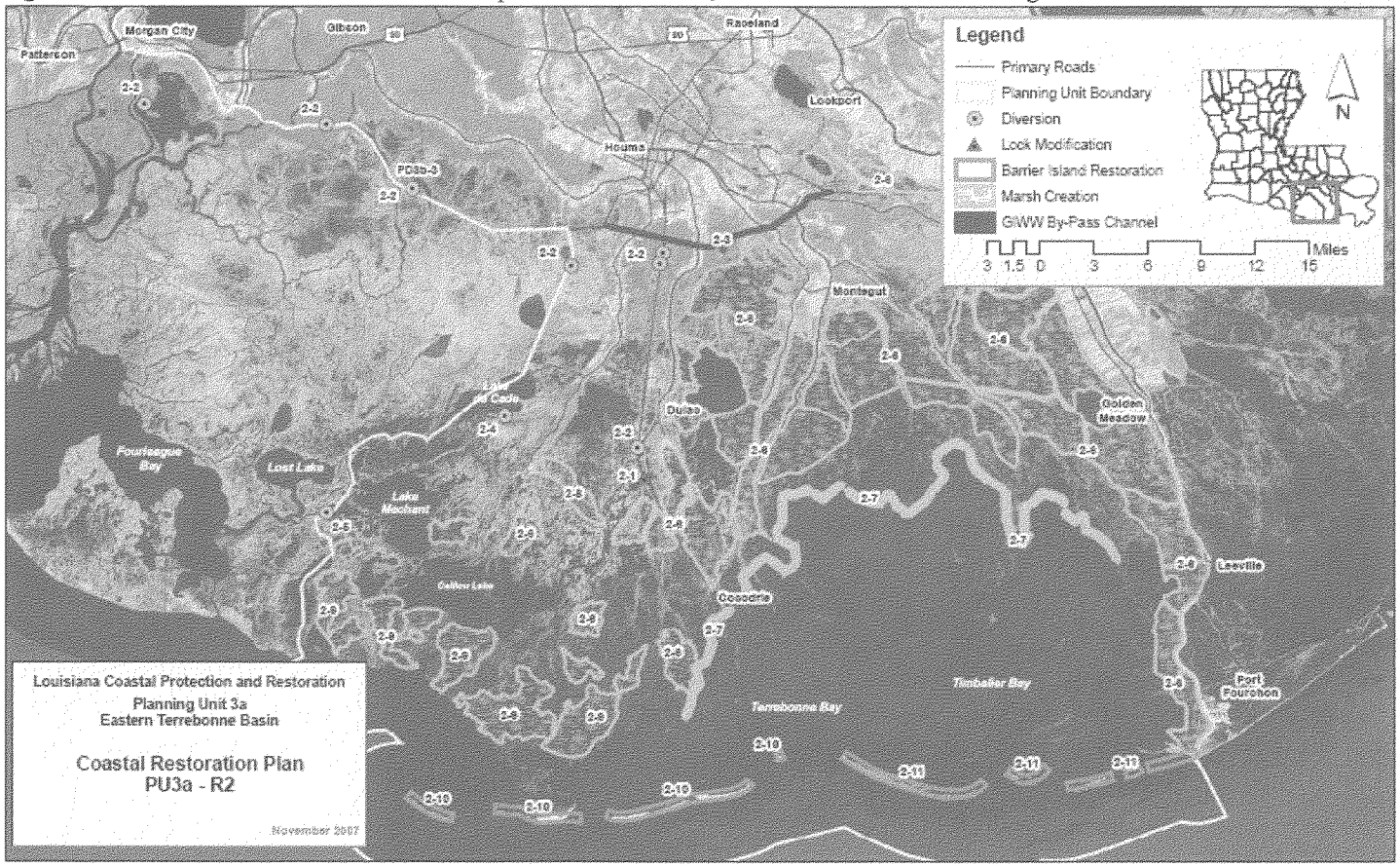


Figure 4d. Identified are the measures that comprise Alternative R2, GIWW Diversions With Marsh Creation – Planning Unit 3b.

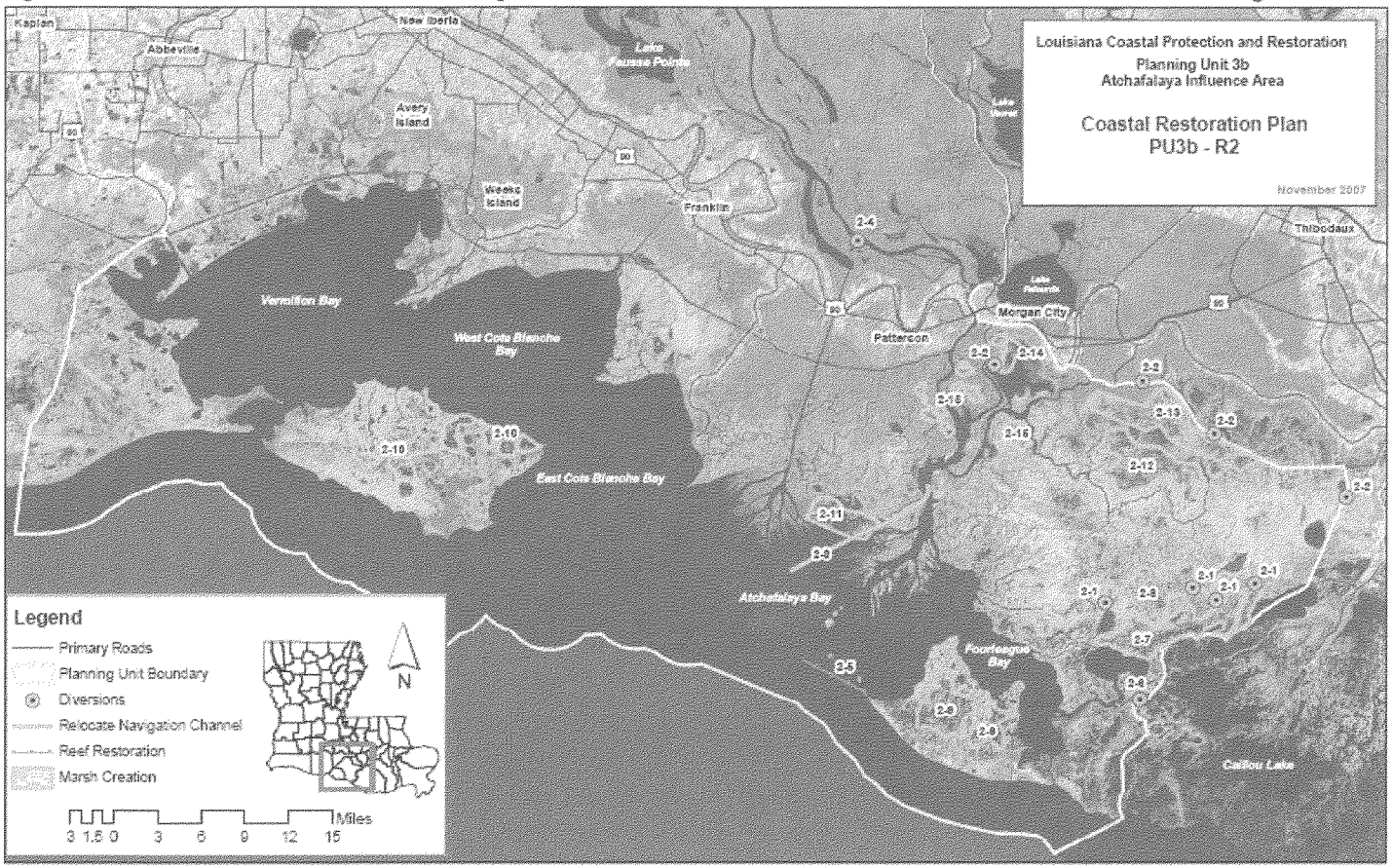
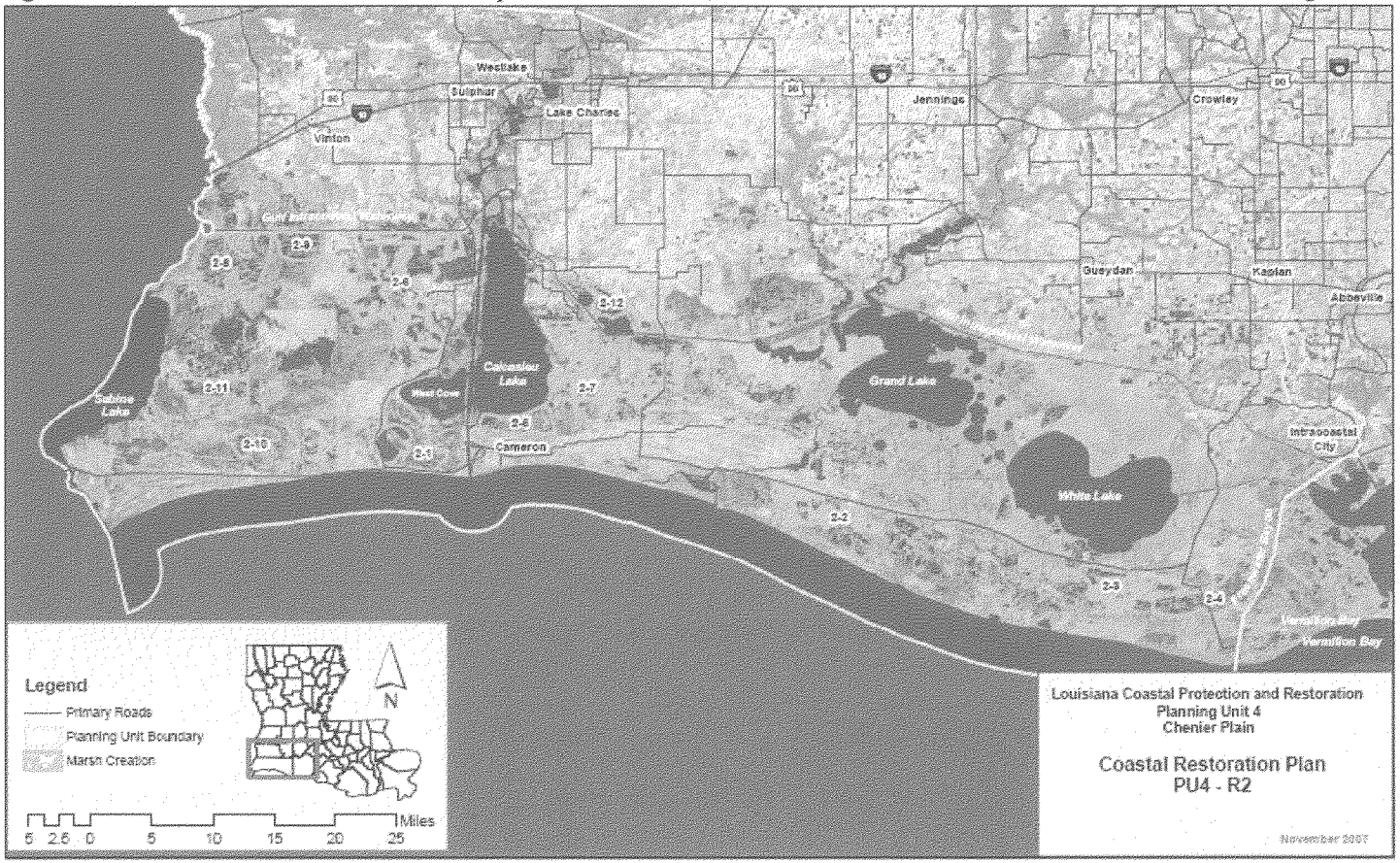


Figure 4e. Identified are the measures that comprise Alternative R2, Marsh Creation Without Shoreline Protection – Planning Unit 4.



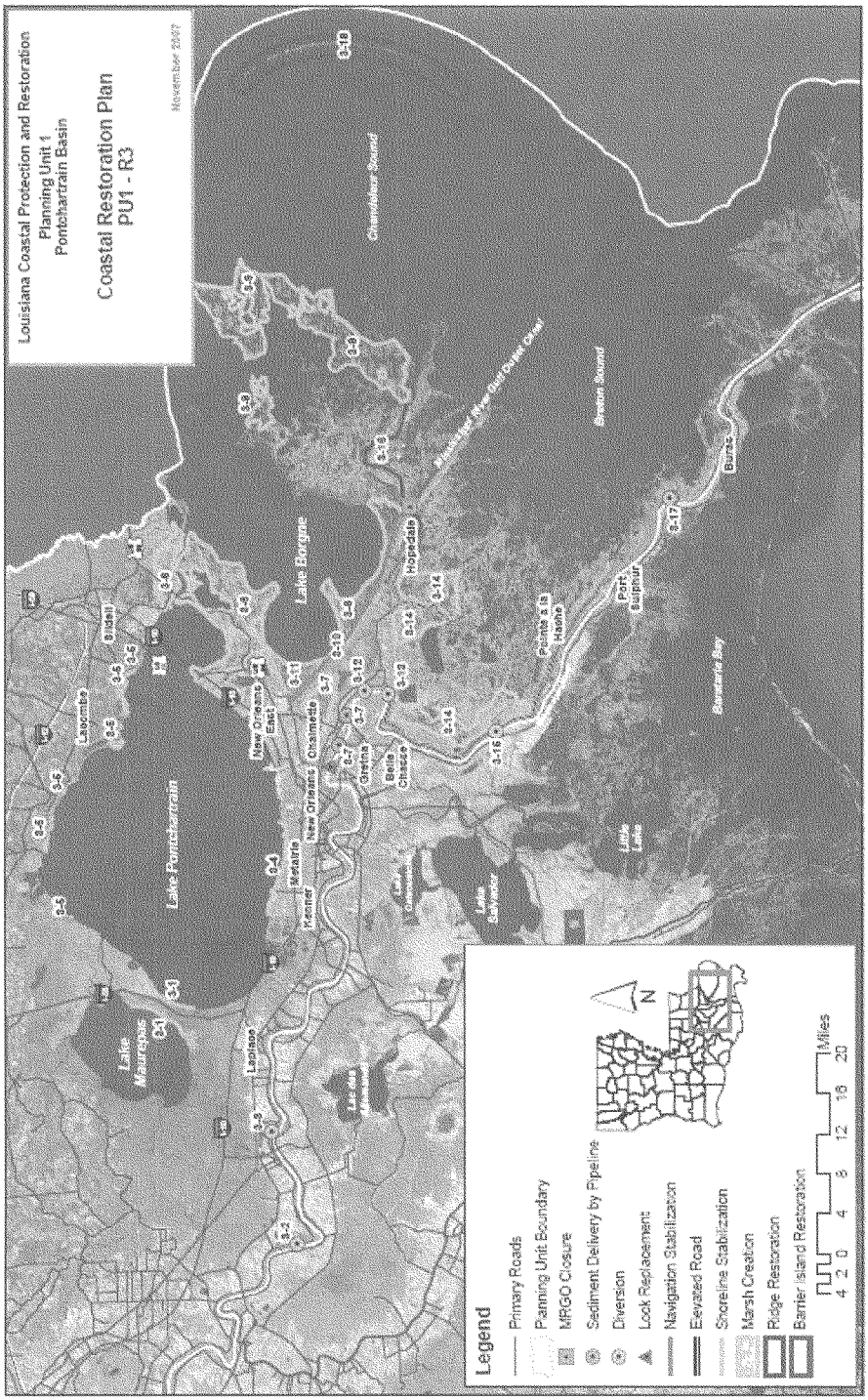


Figure 5a. Identified are the measures that comprise Alternative R3, State Master Plan – Planning Unit 1.

Figure 5b. Identified are the measures that comprise Alternative R3, State Master Plan – Planning Unit 2.

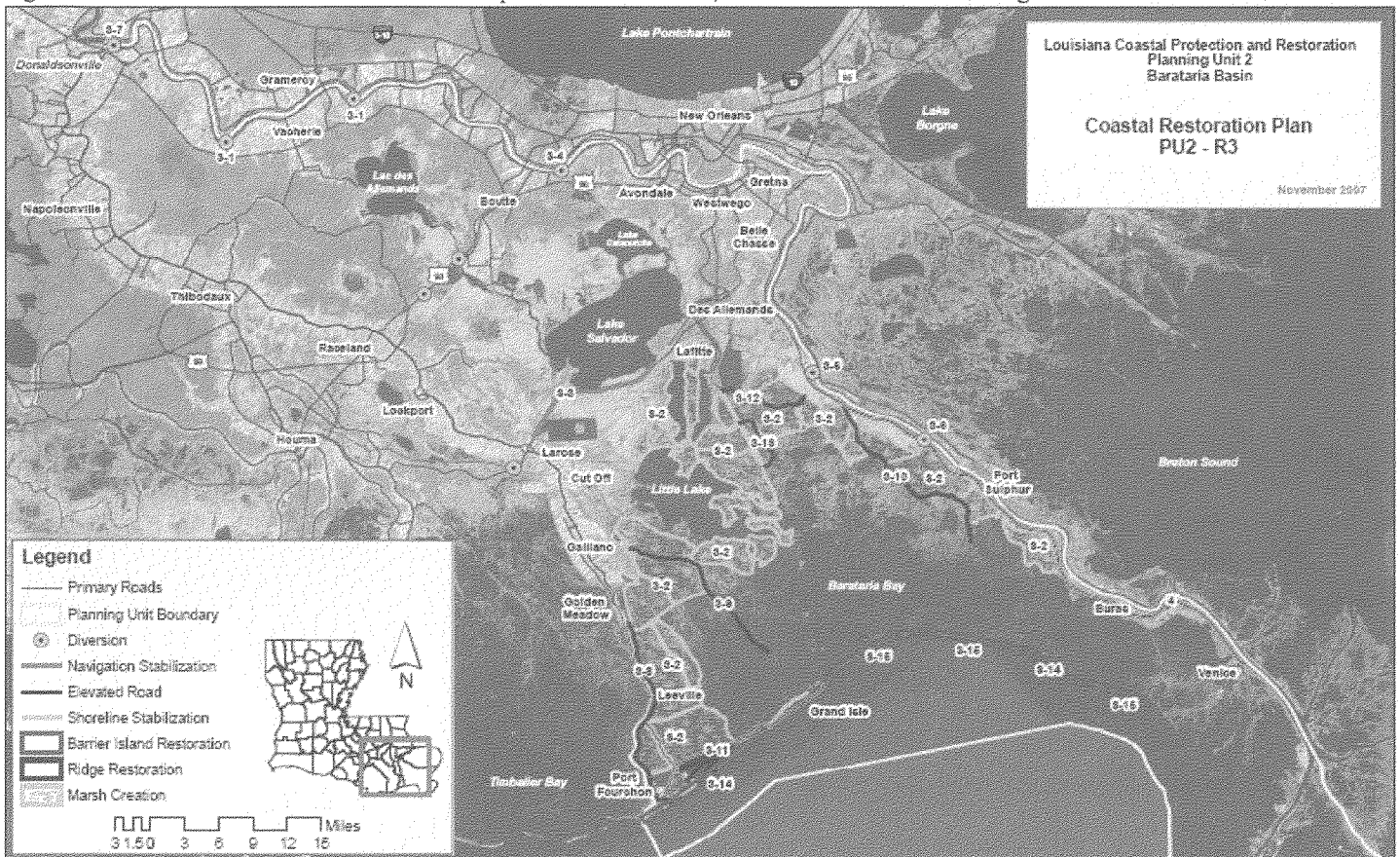


Figure 5c. Identified are the measures that comprise Alternative R3, State Master Plan – Planning Unit 3a.

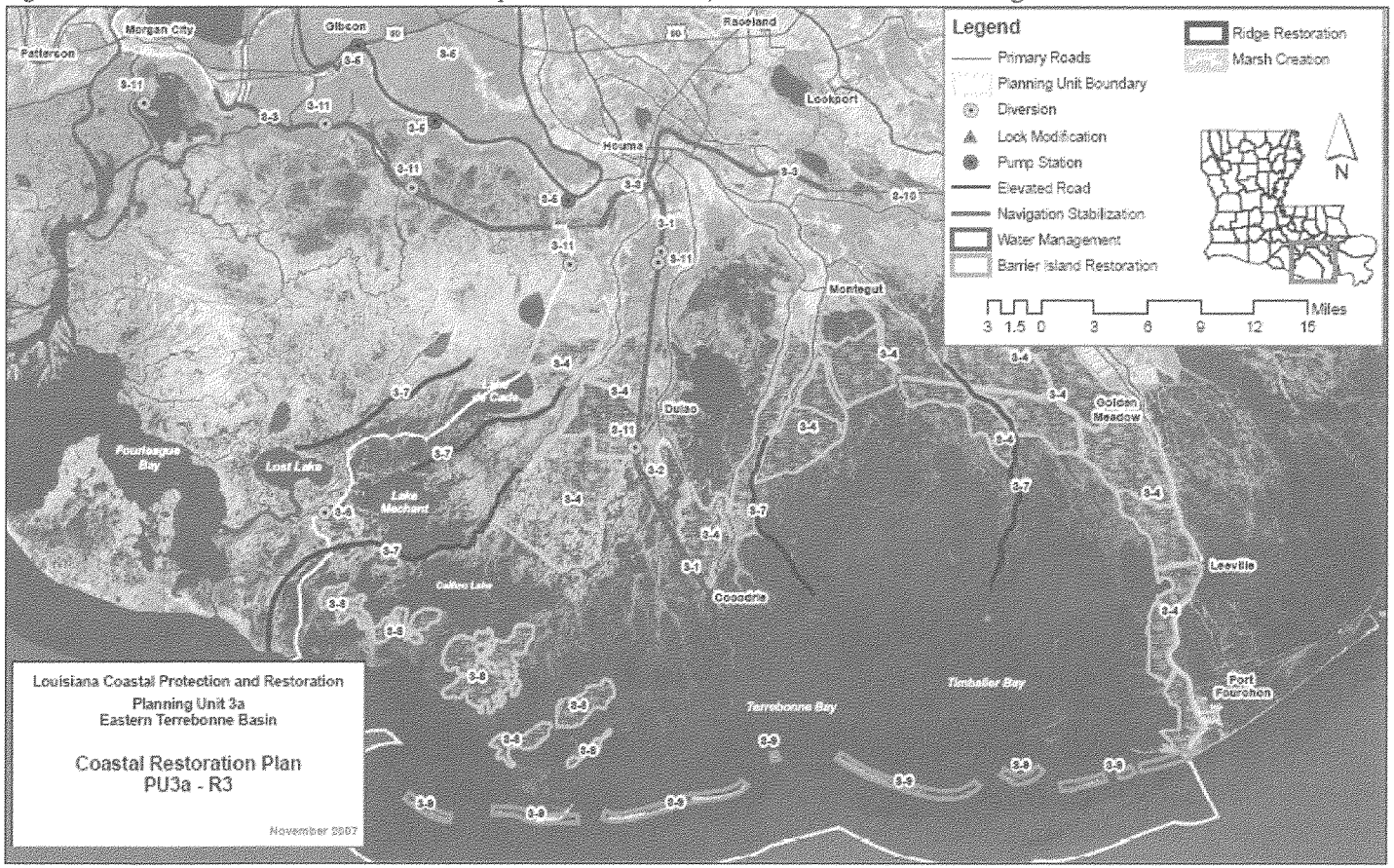


Figure 5d. Identified are the measures that comprise Alternative R3, State Master Plan – Planning Unit 3b.

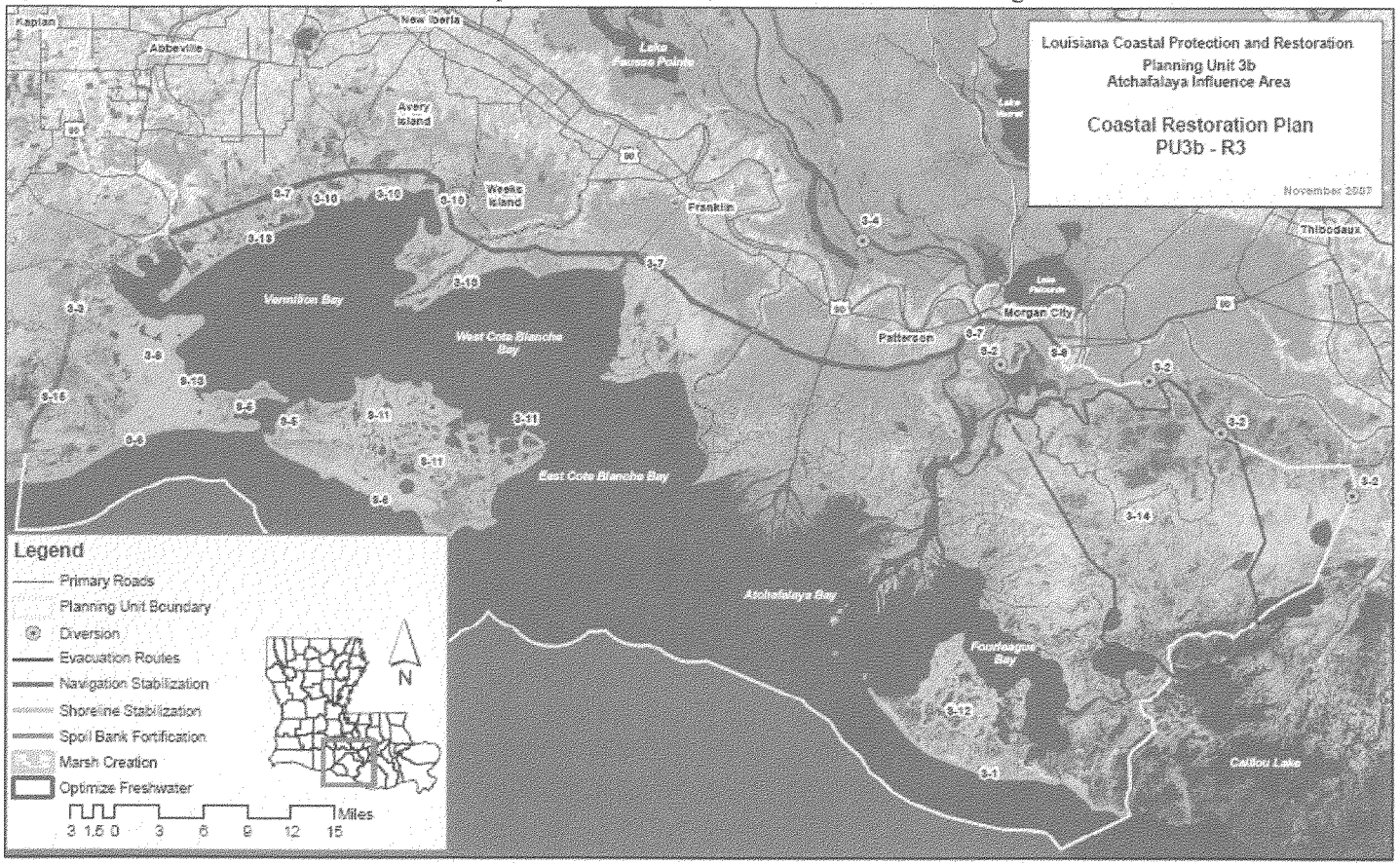


Figure 5e. Identified are the measures that comprise Alternative R3, State Master Plan – Planning Unit 4.

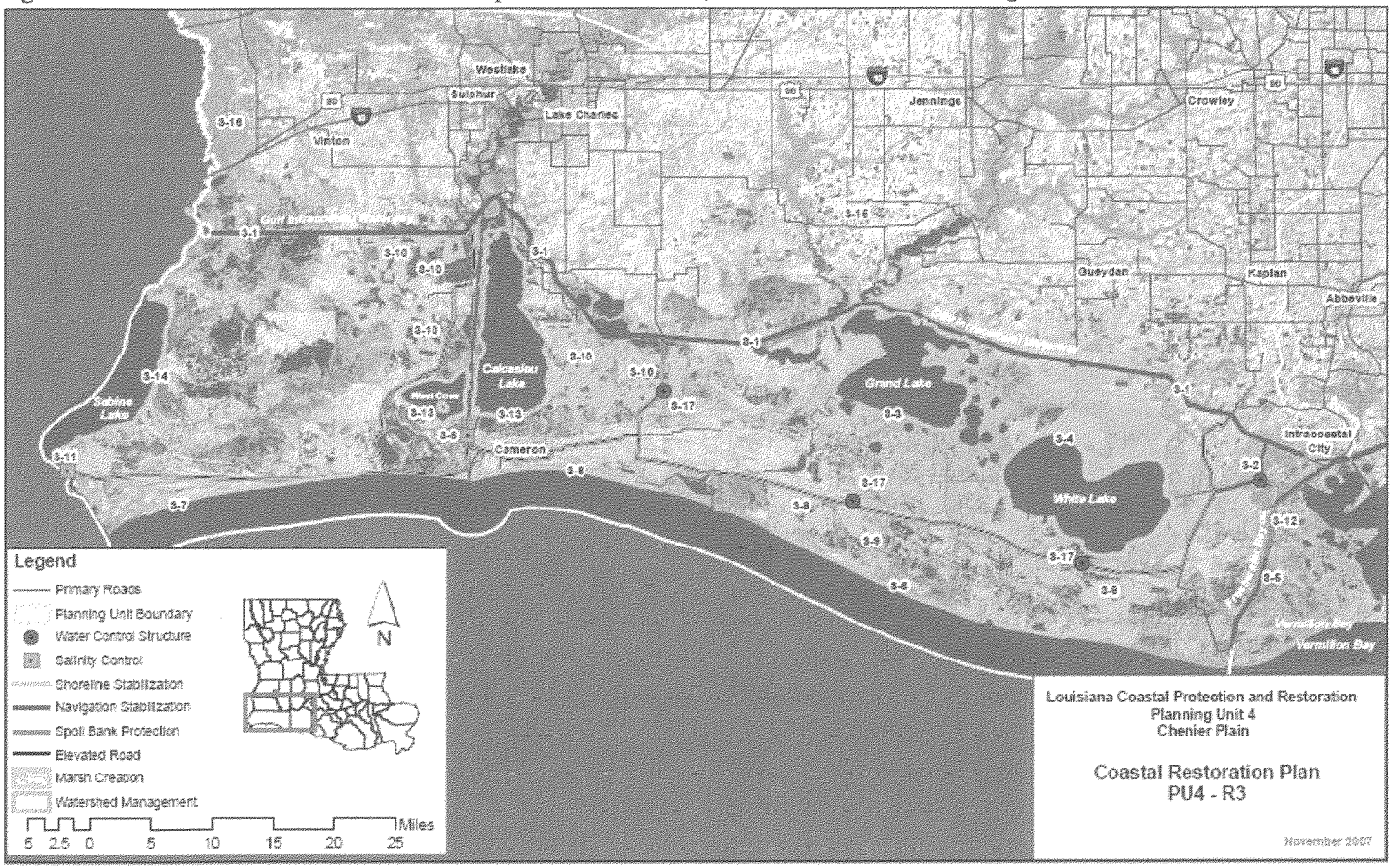


Figure 6a. Identified are the measures that comprise Alternative R4 – Planning Unit 1.

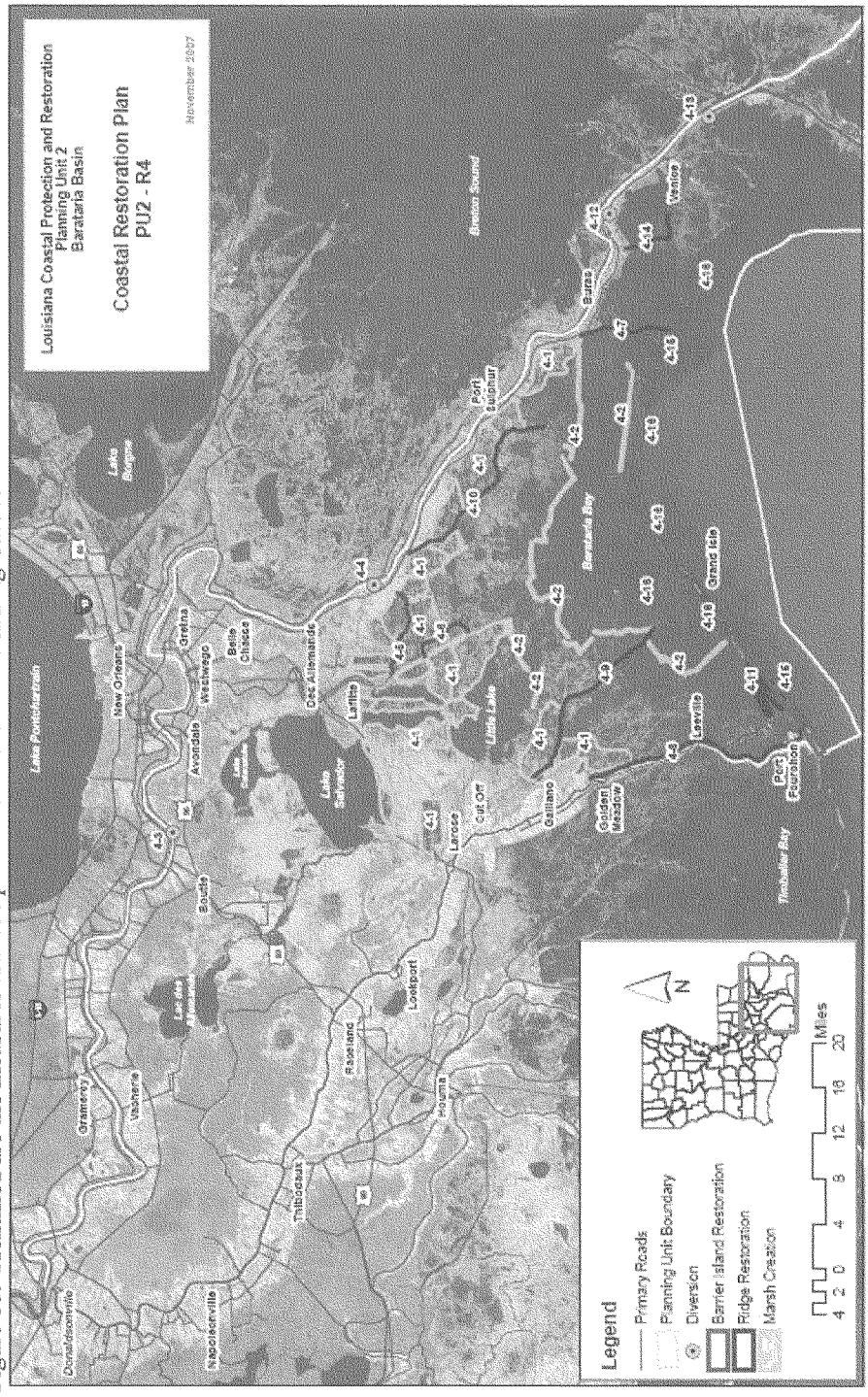


Figure 6b. Identified are the measures that comprise Alternative R4 – Planning Unit 2.

Figure 6c. Identified are the measures that comprise Alternative R4 – Planning Unit 3a.

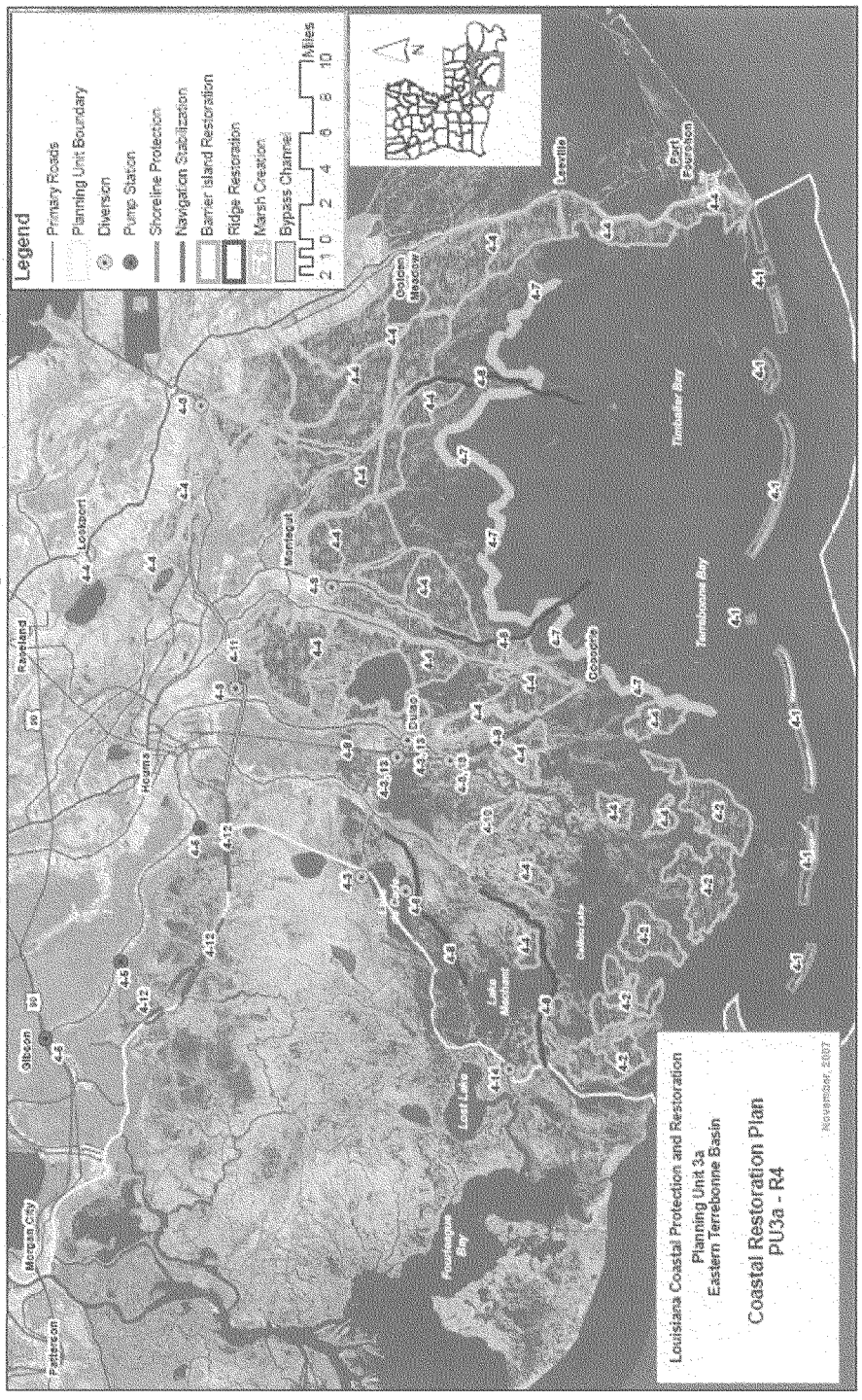
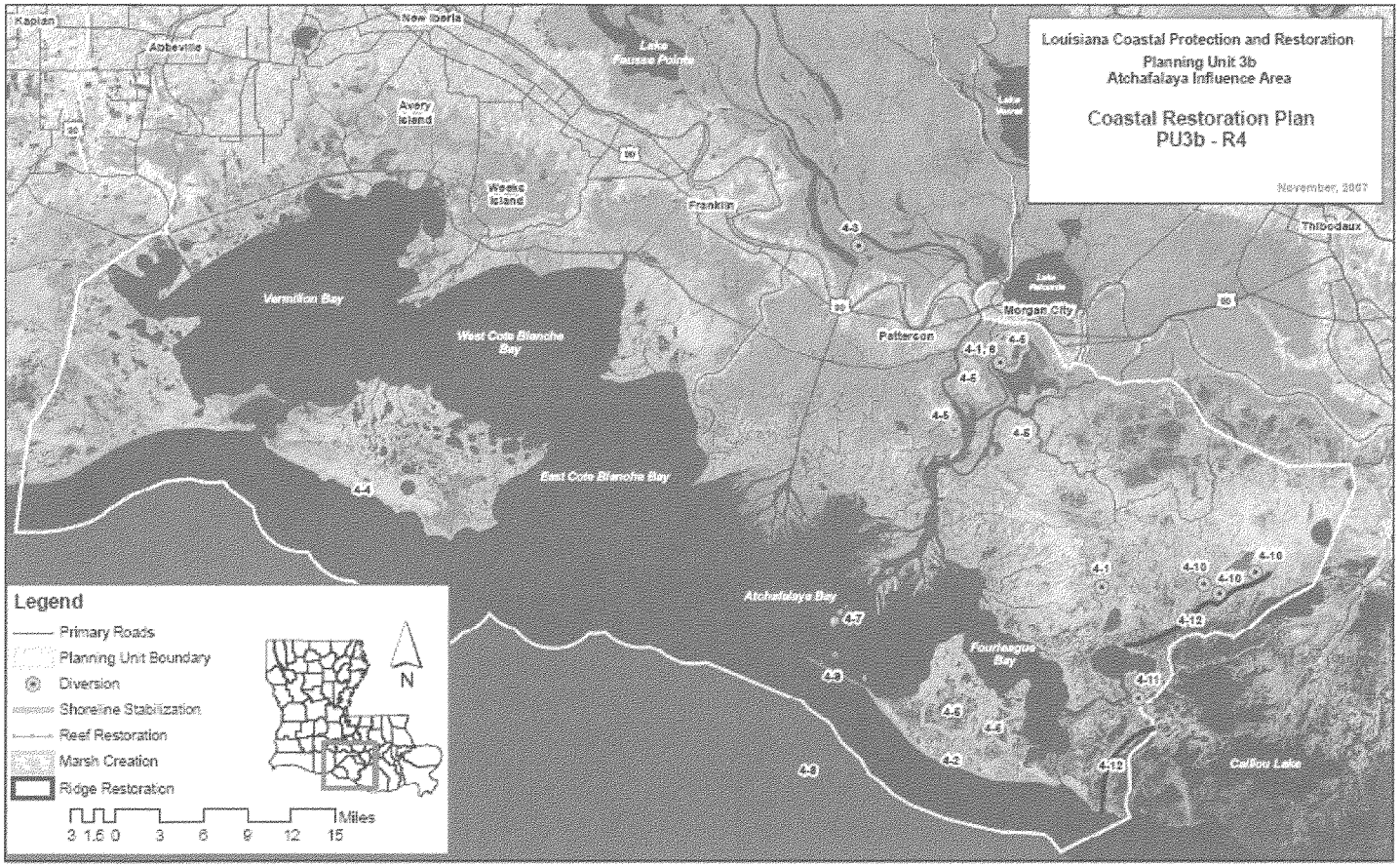


Figure 6d. Identified are the measures that comprise Alternative R4 – Planning Unit 3b.



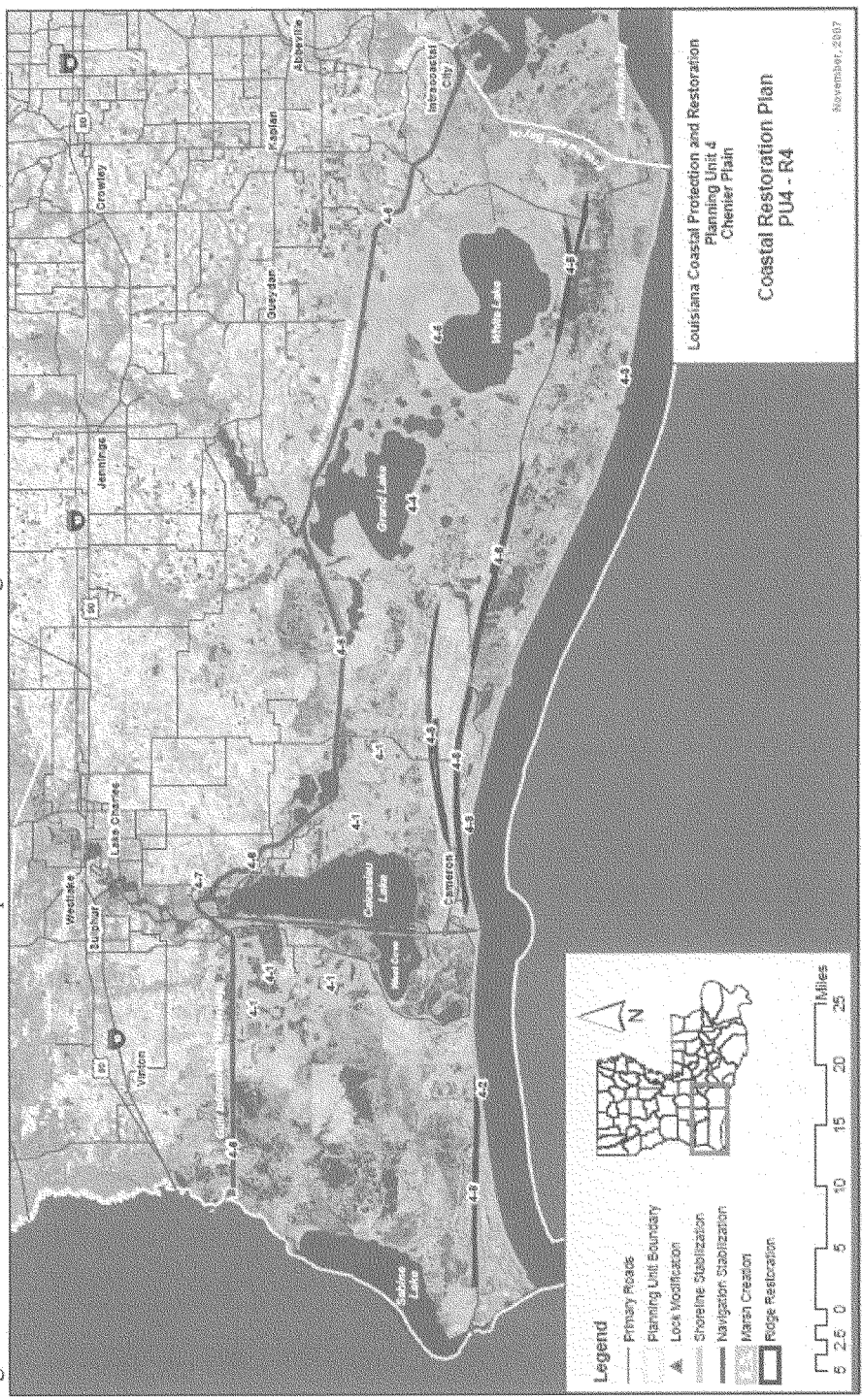


Figure 6e. Identified are the measures that comprise Alternative R4 – Planning Unit 4.

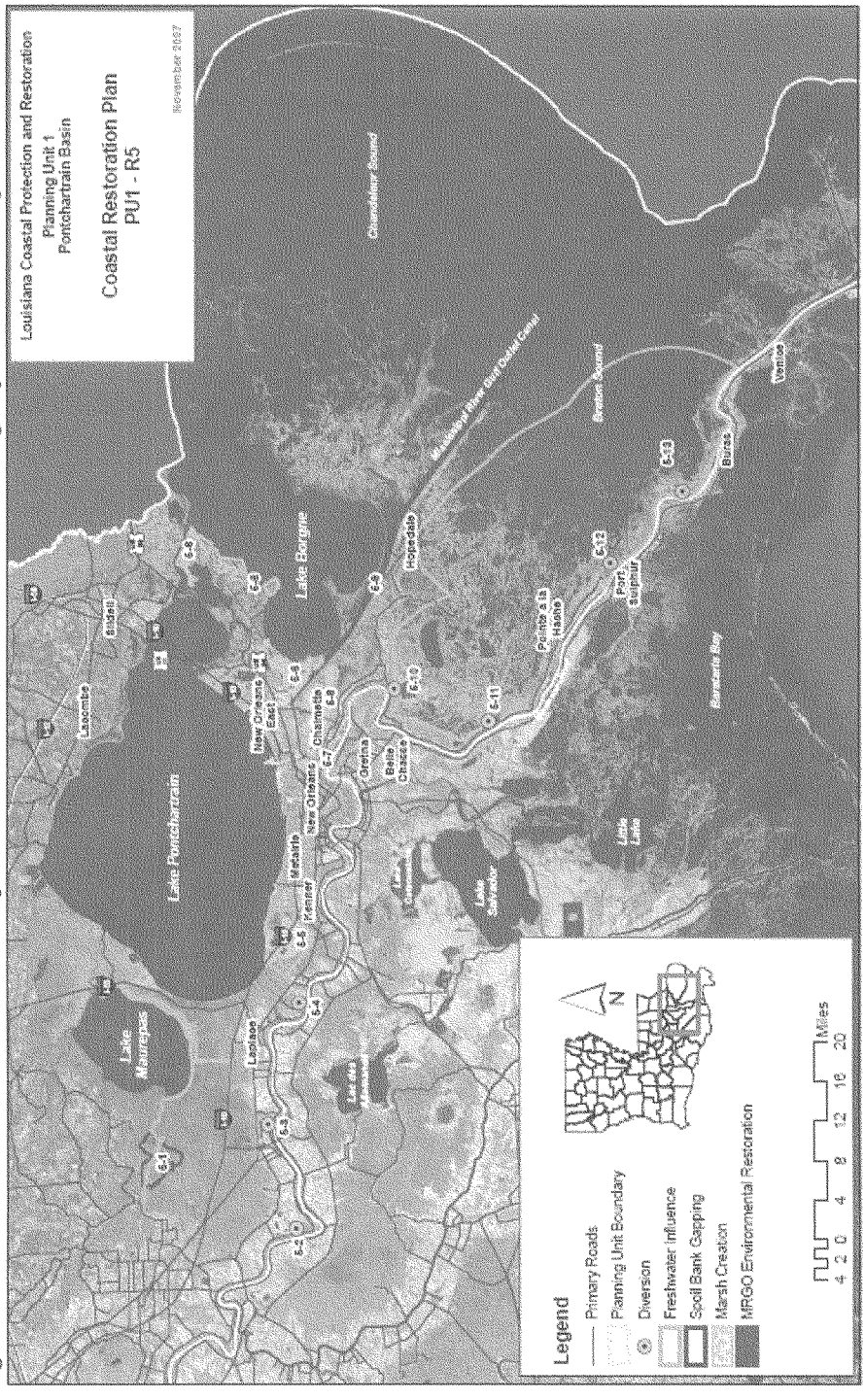


Figure 7a. Identified are the measures that comprise Alternative R5, LCA Plan Best Meeting Objectives – Planning Unit 1.

Figure 7b. Identified are the measures that comprise Alternative R5, LCA Plan Best Meeting Objectives – Planning Unit 2.

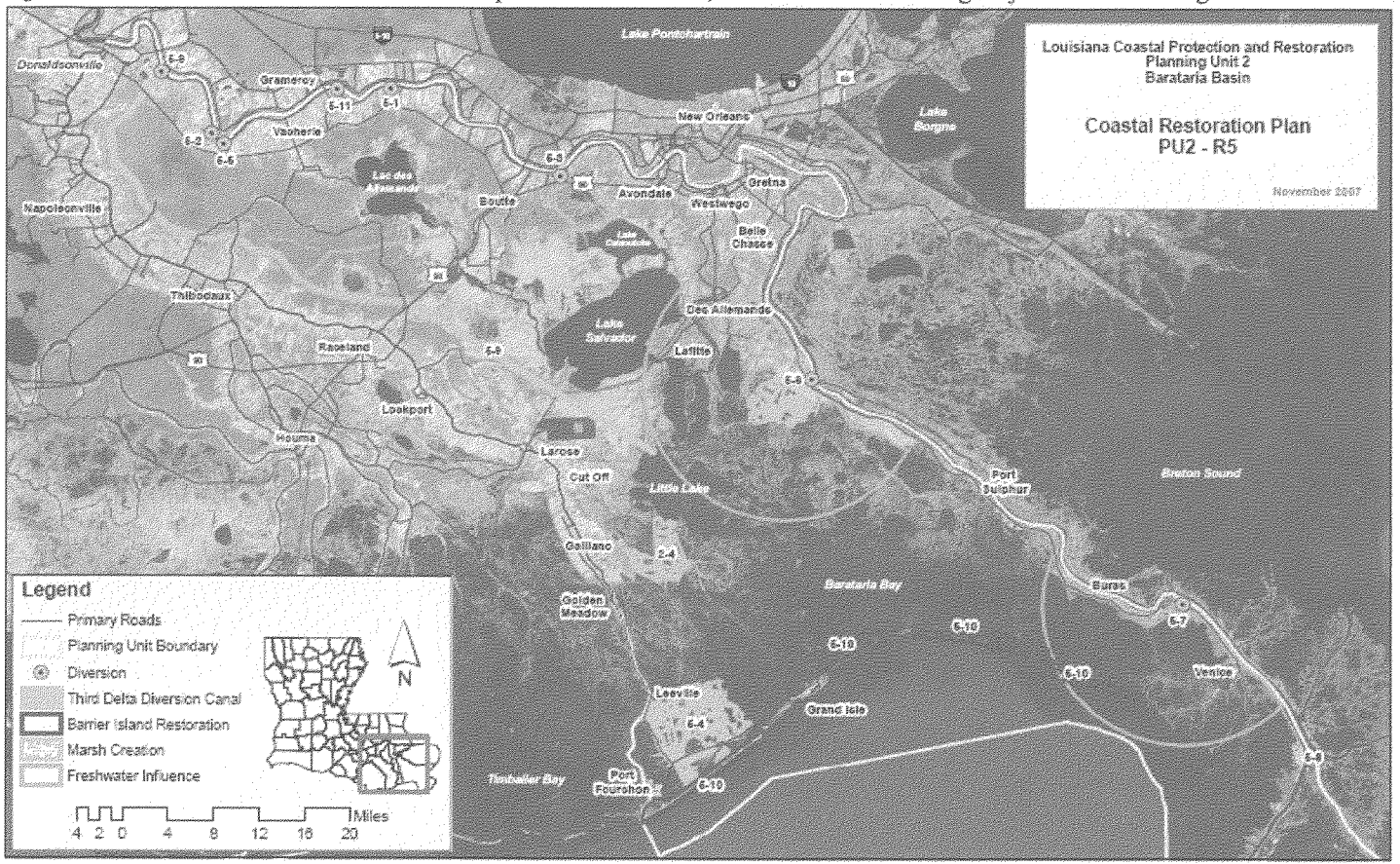


Figure 7c. Identified are the measures that comprise Alternative R5, LCA Plan Best Meeting Objectives – Planning Unit 3a.

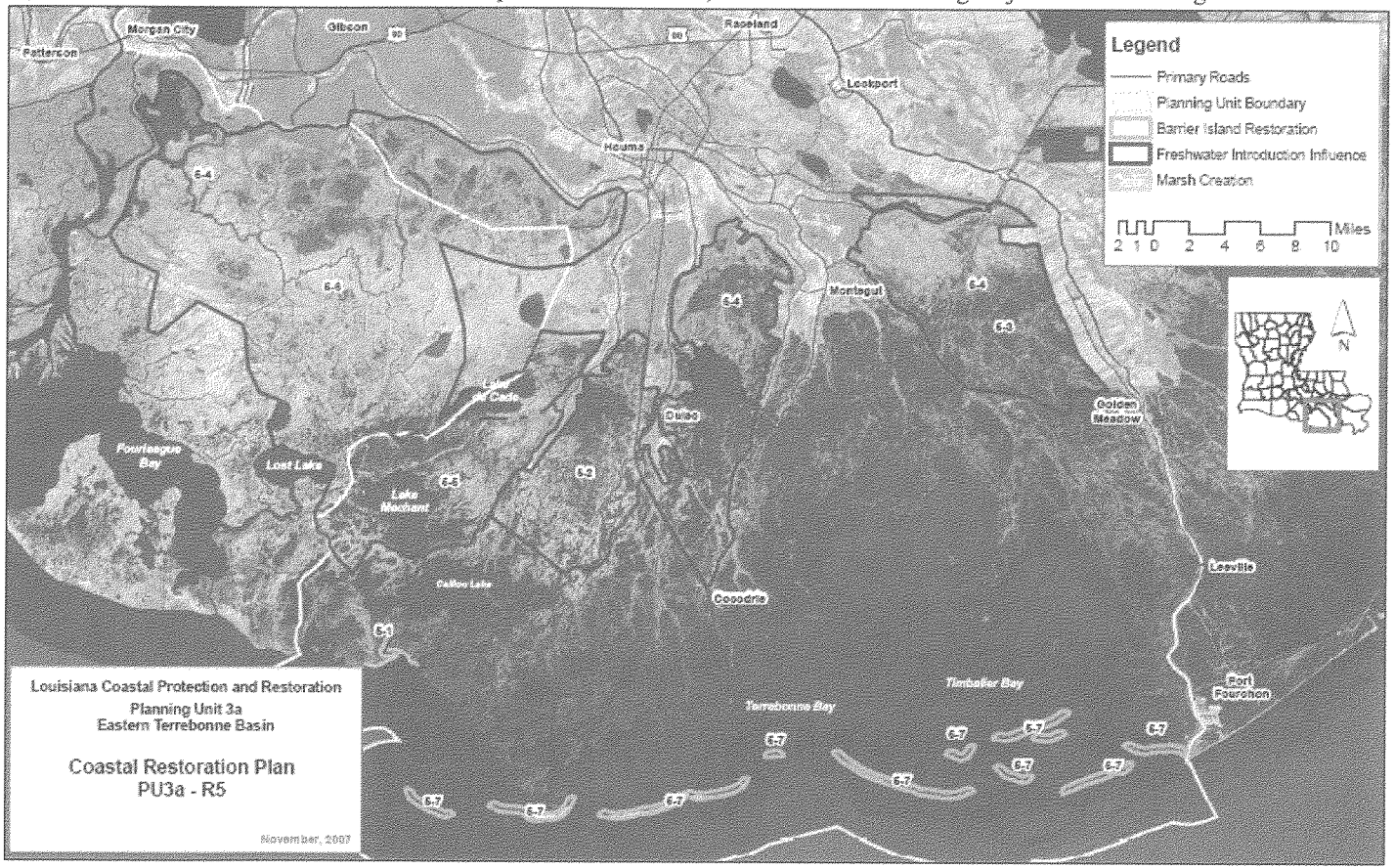


Figure 7d. Identified are the measures that comprise Alternative R5, LCA Plan Best Meeting Objectives – Planning Unit 3b.

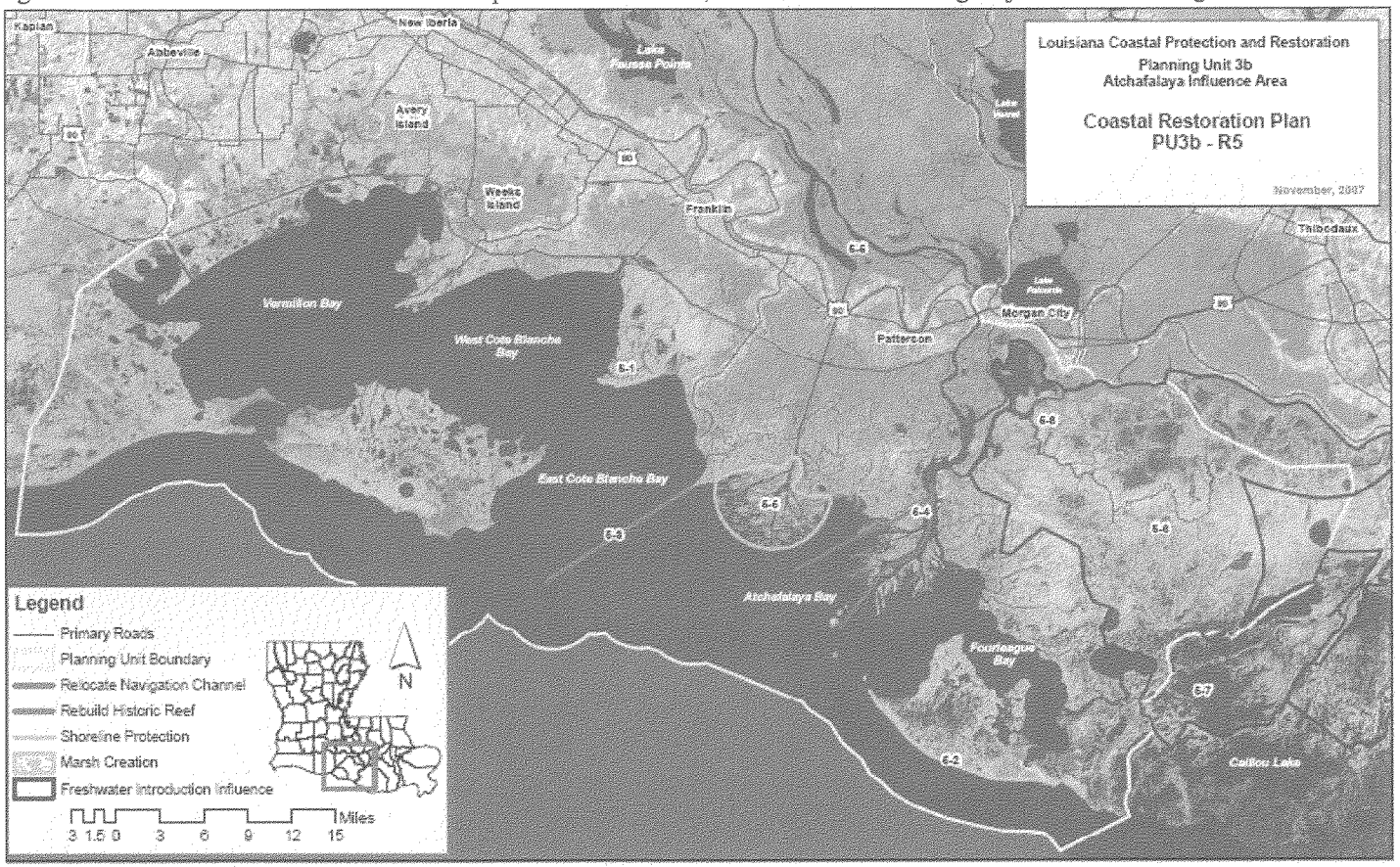


Figure 7e. Identified are the measures that comprise Alternative R5, LCA Plan Best Meeting Objectives – Planning Unit 4.

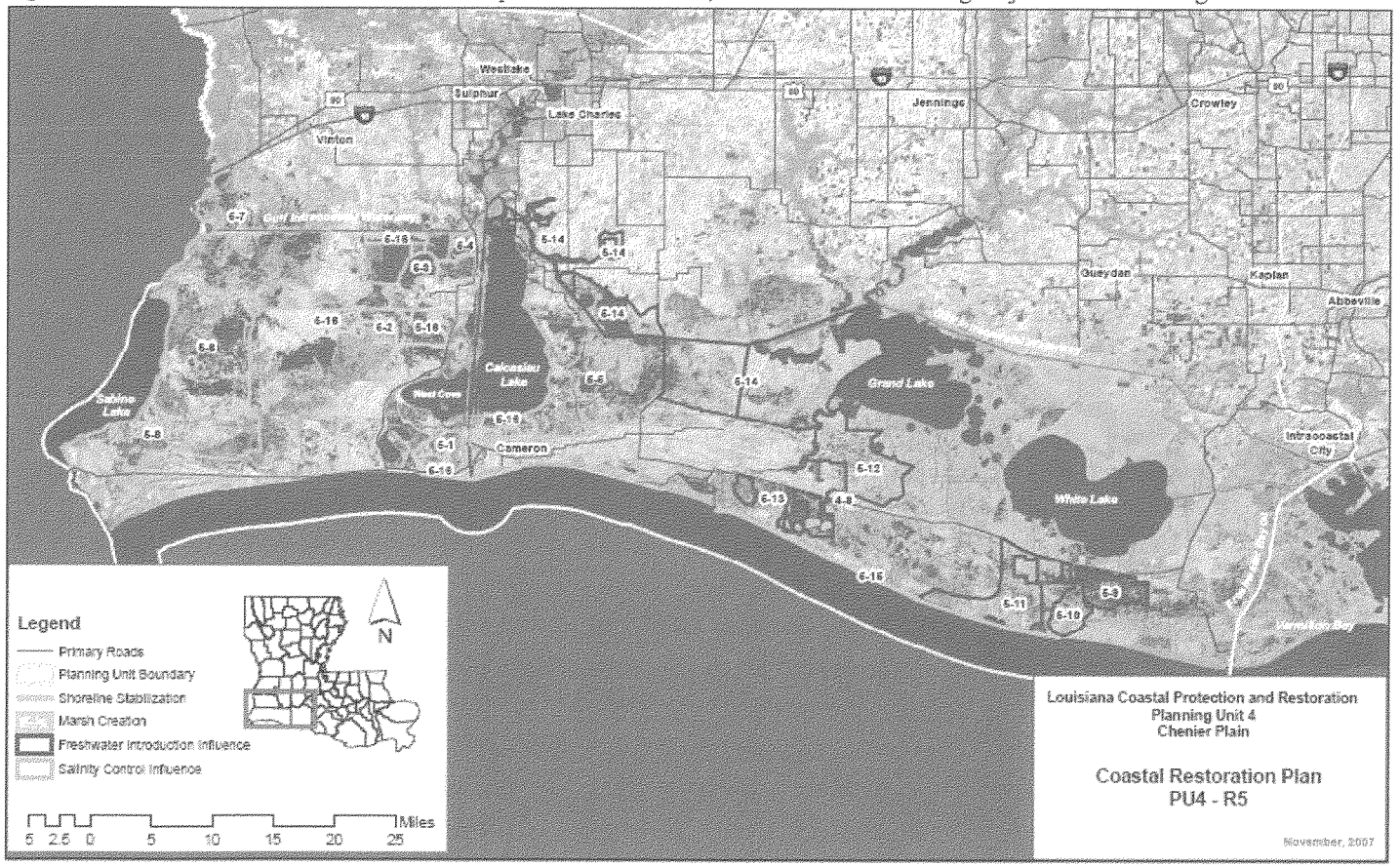
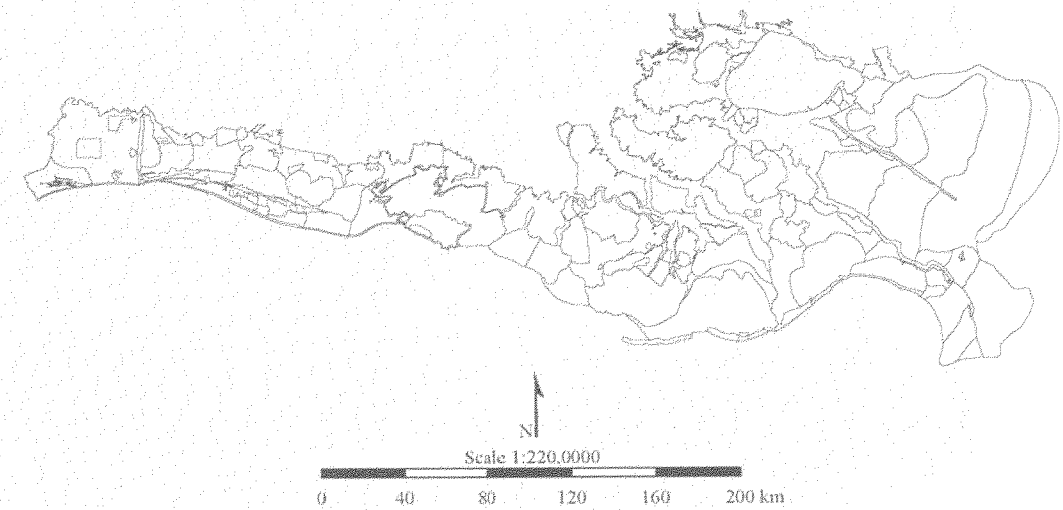


Figure 8. The LCA polygon trend data rasterized at a 25x25 meter cell size.



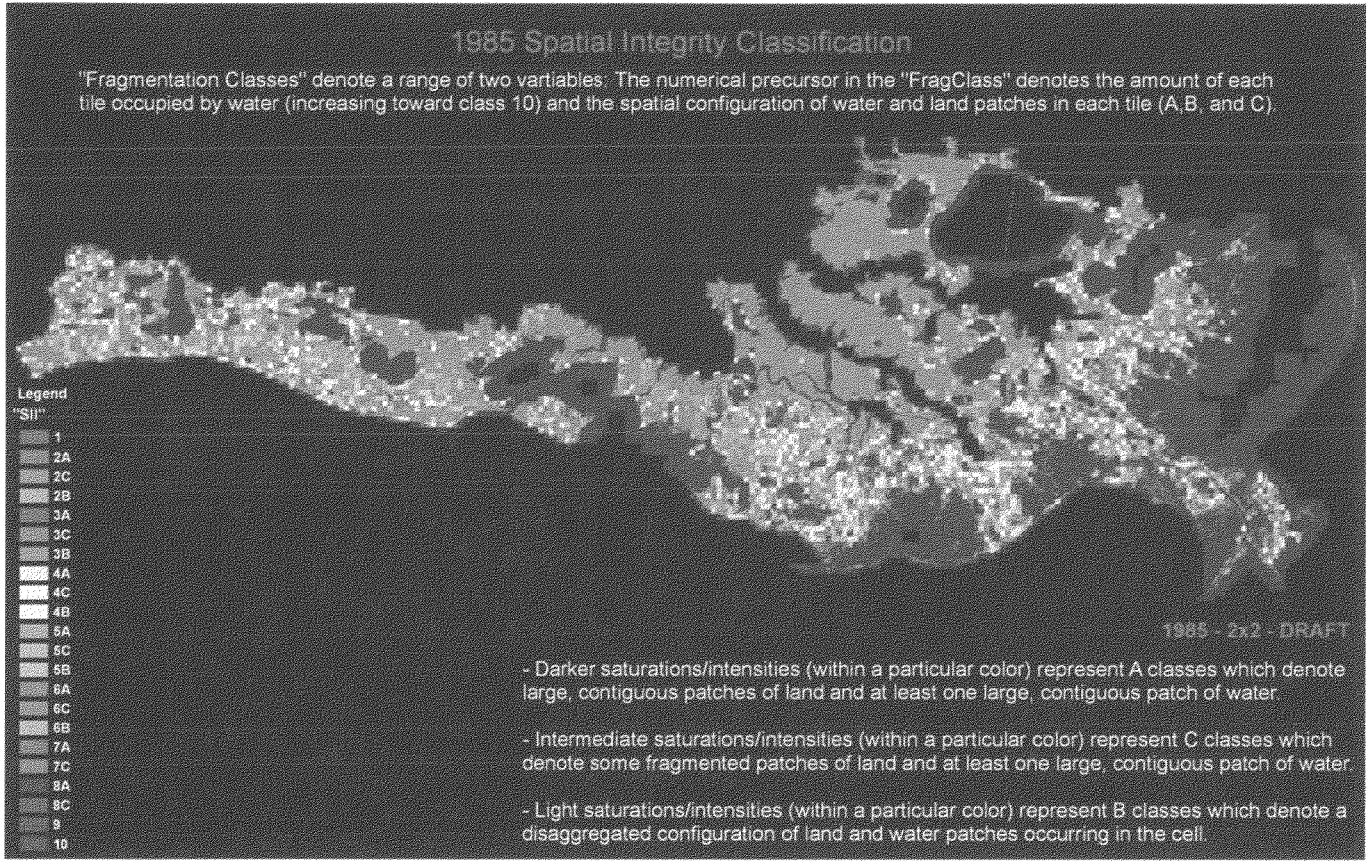


Figure 9. Coastwide spatial integrity index for 1985.

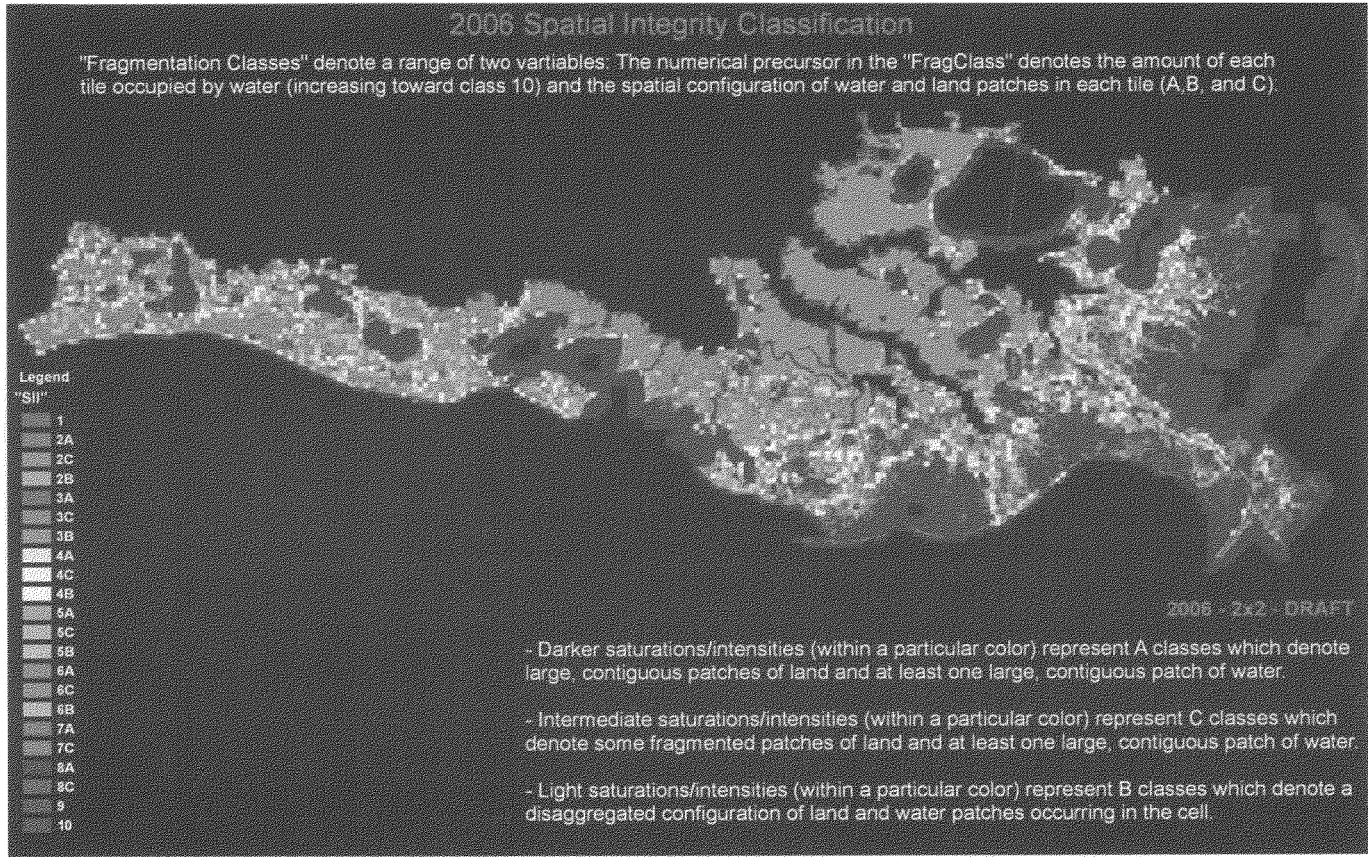


Figure 10. Coastwide spatial integrity index for 2006.

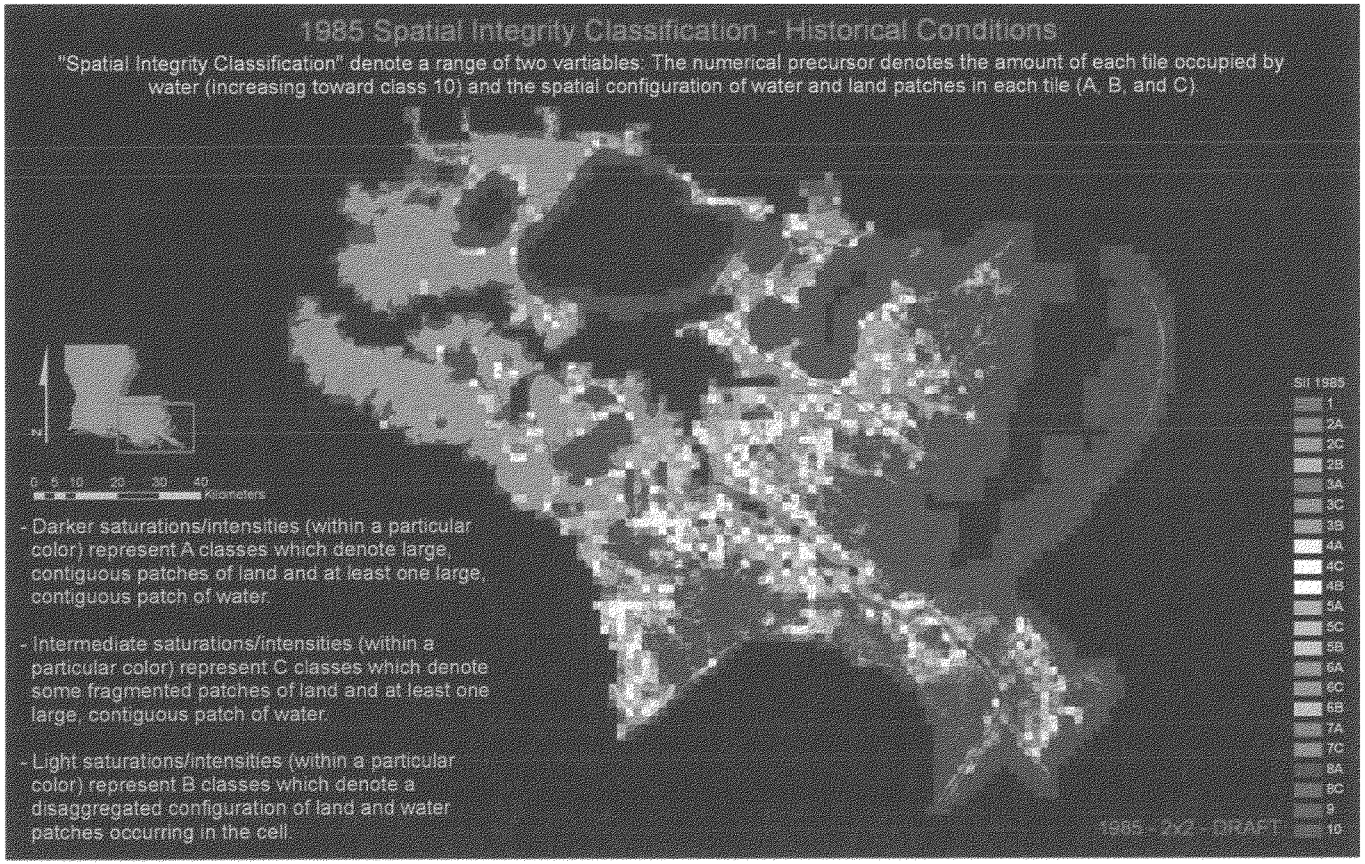


Figure 11. Spatial integrity index for 1985 for planning units 1 and 2.

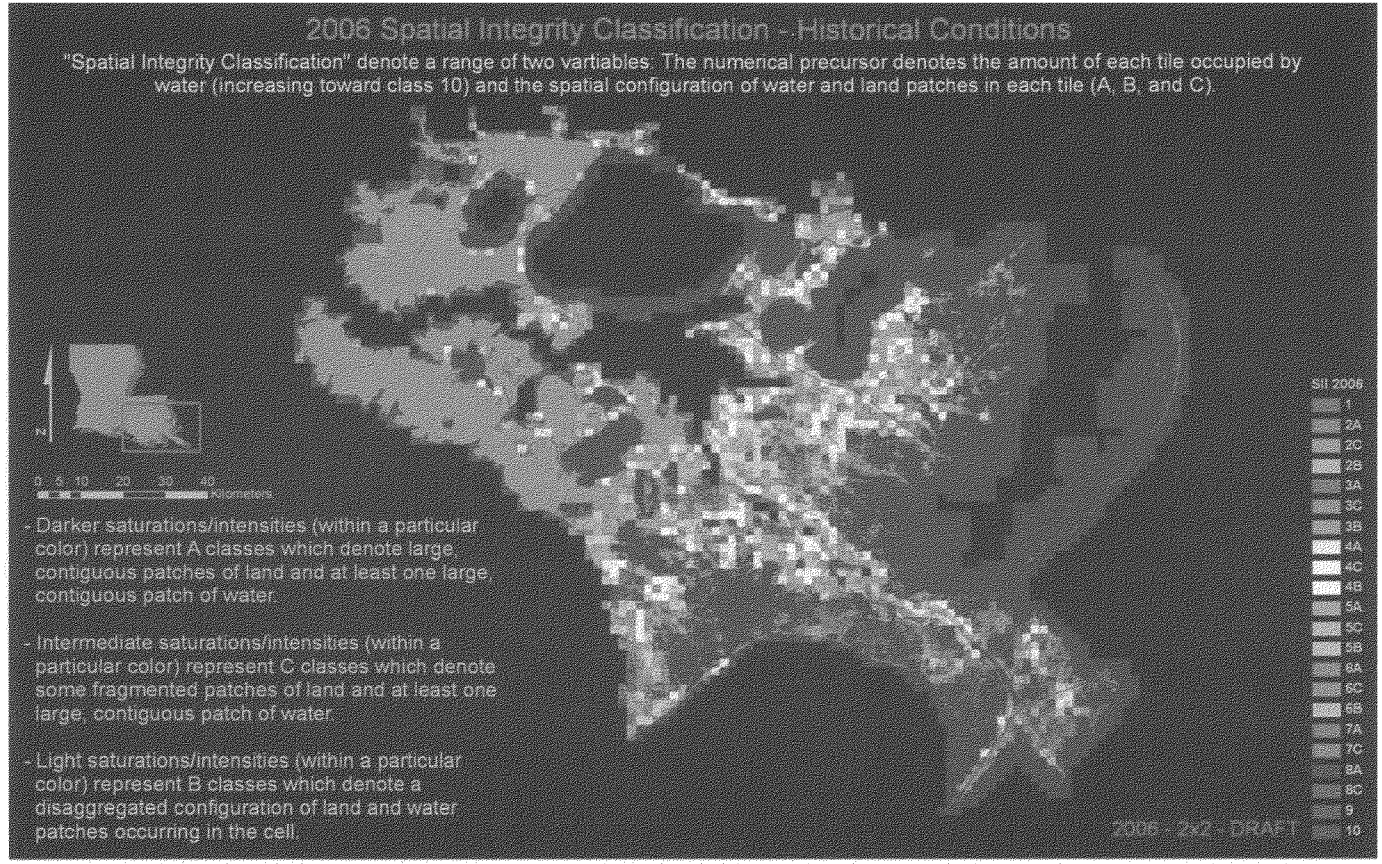


Figure 12. Spatial integrity index for 2006 for planning units 1 and 2.

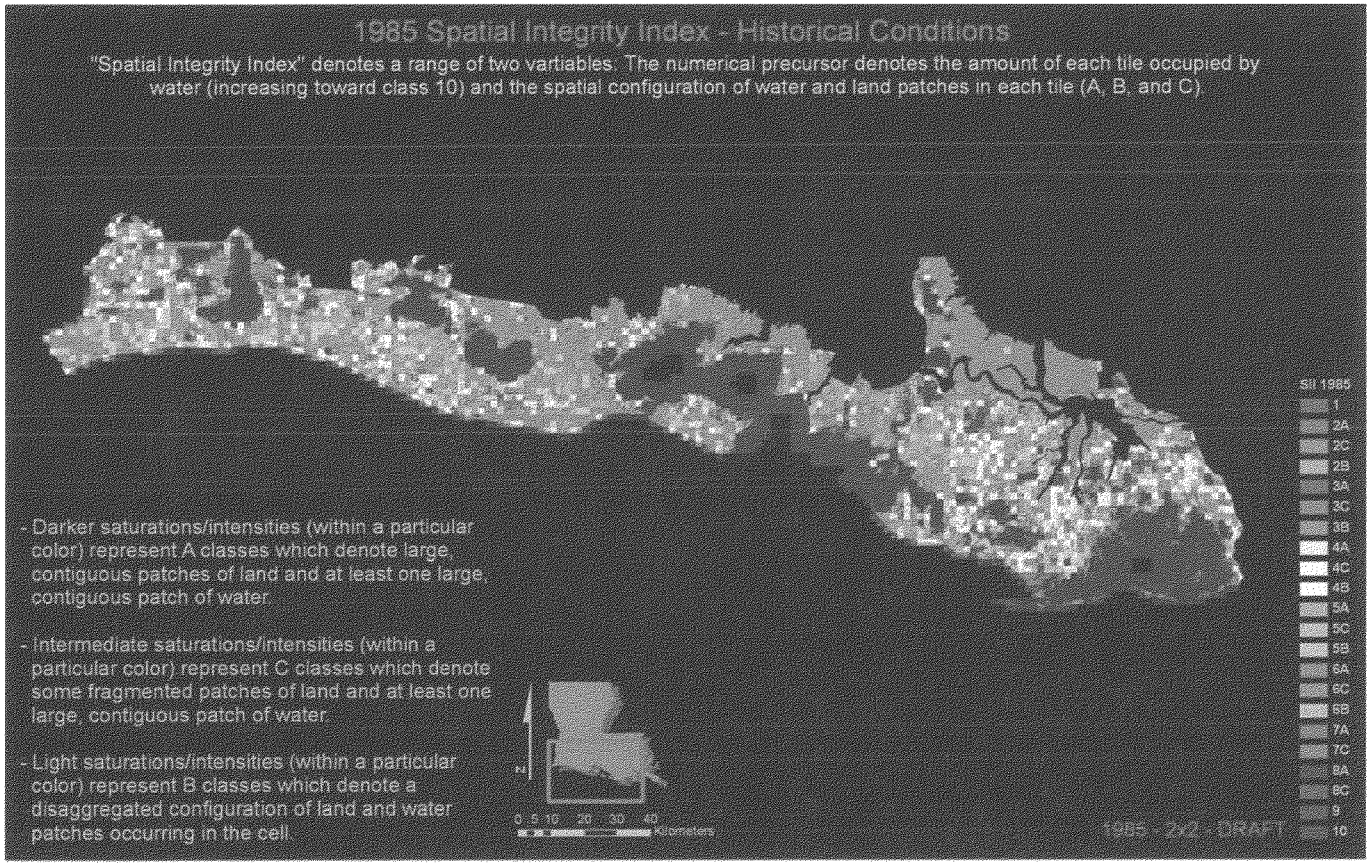


Figure 13. Spatial integrity index for 1985 for planning units 3a, 3b and 4.

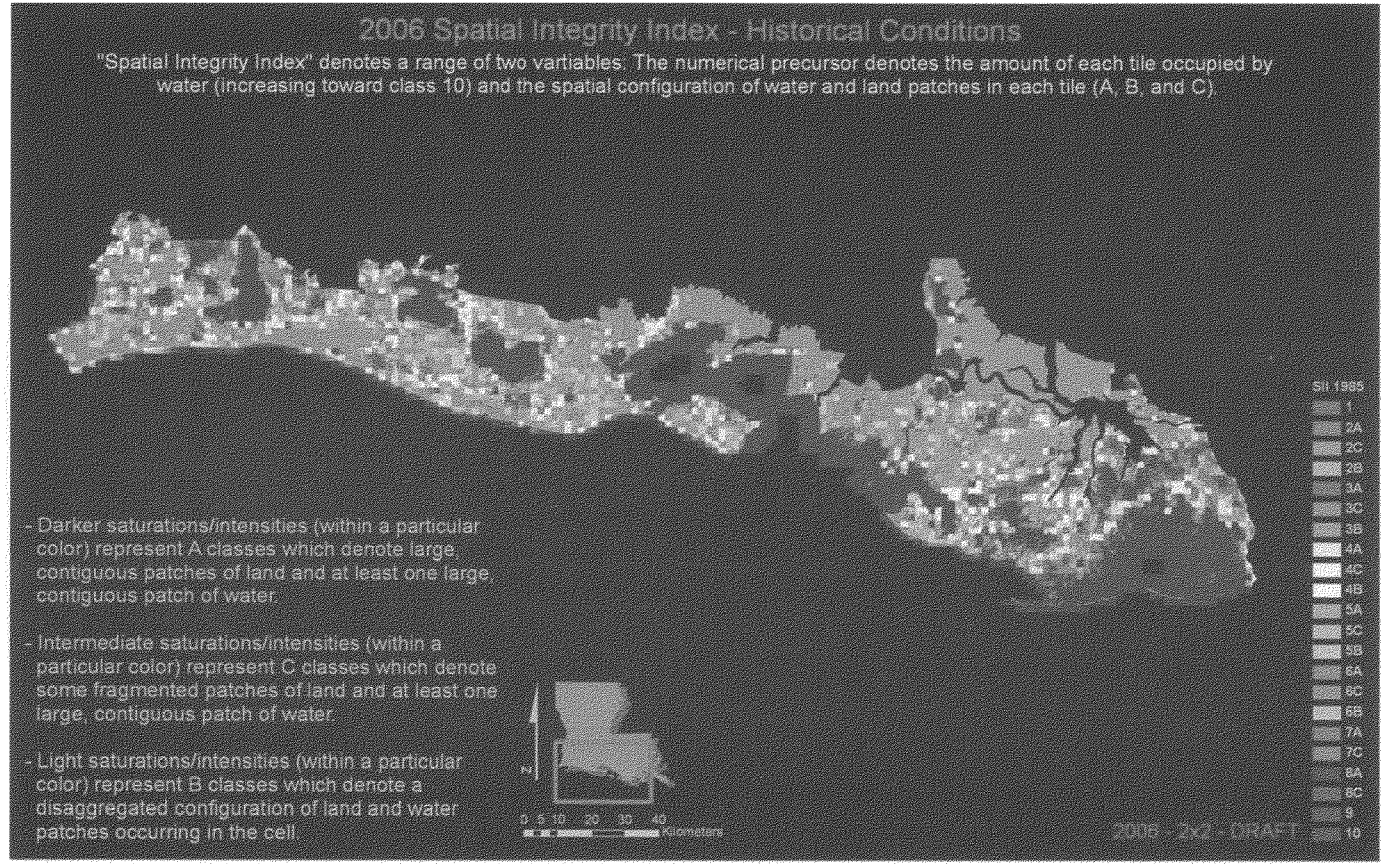


Figure 14. Spatial integrity index for 2006 for planning units 3a, 3b and 4.

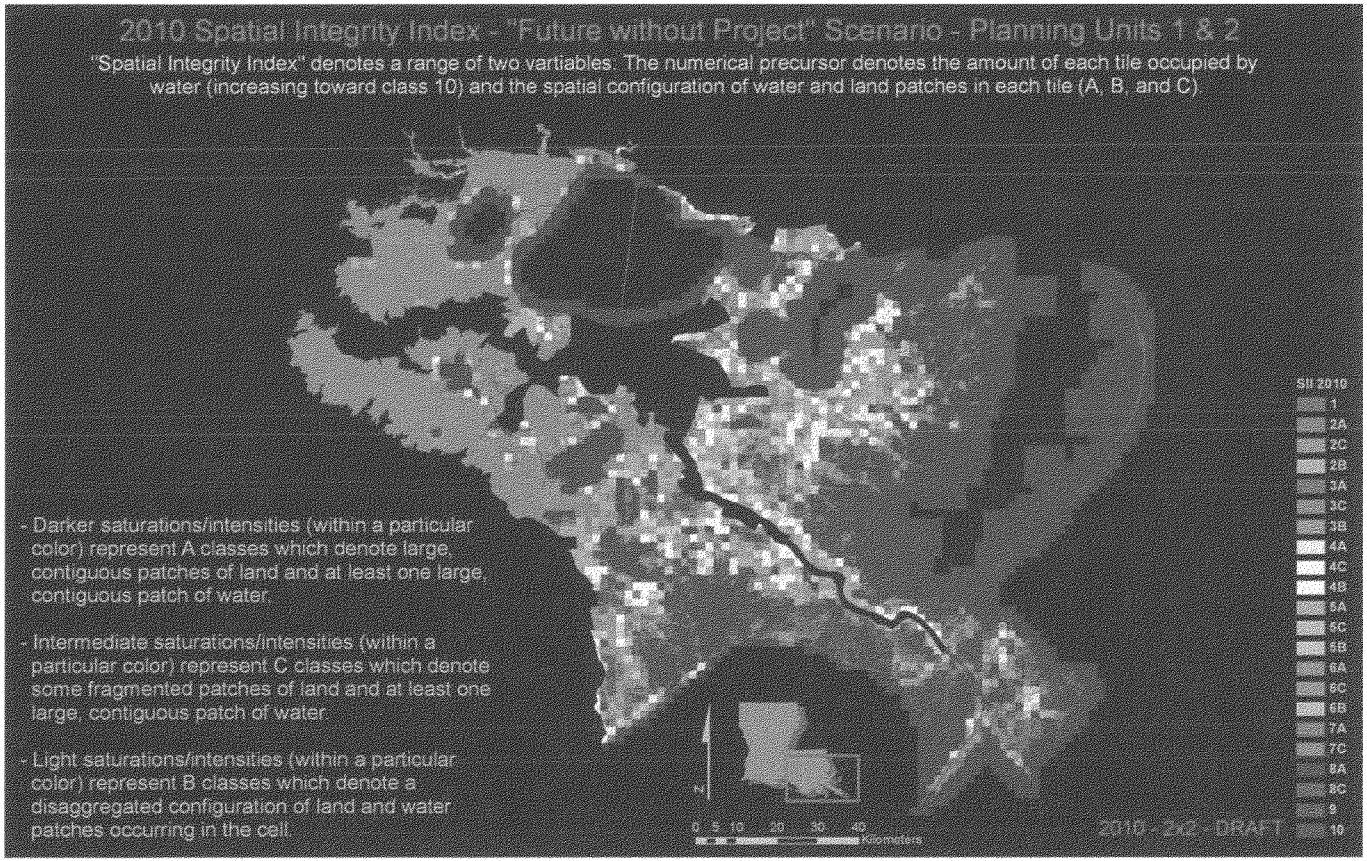


Figure 15. Spatial integrity index for 2010 for planning units 1 and 2.

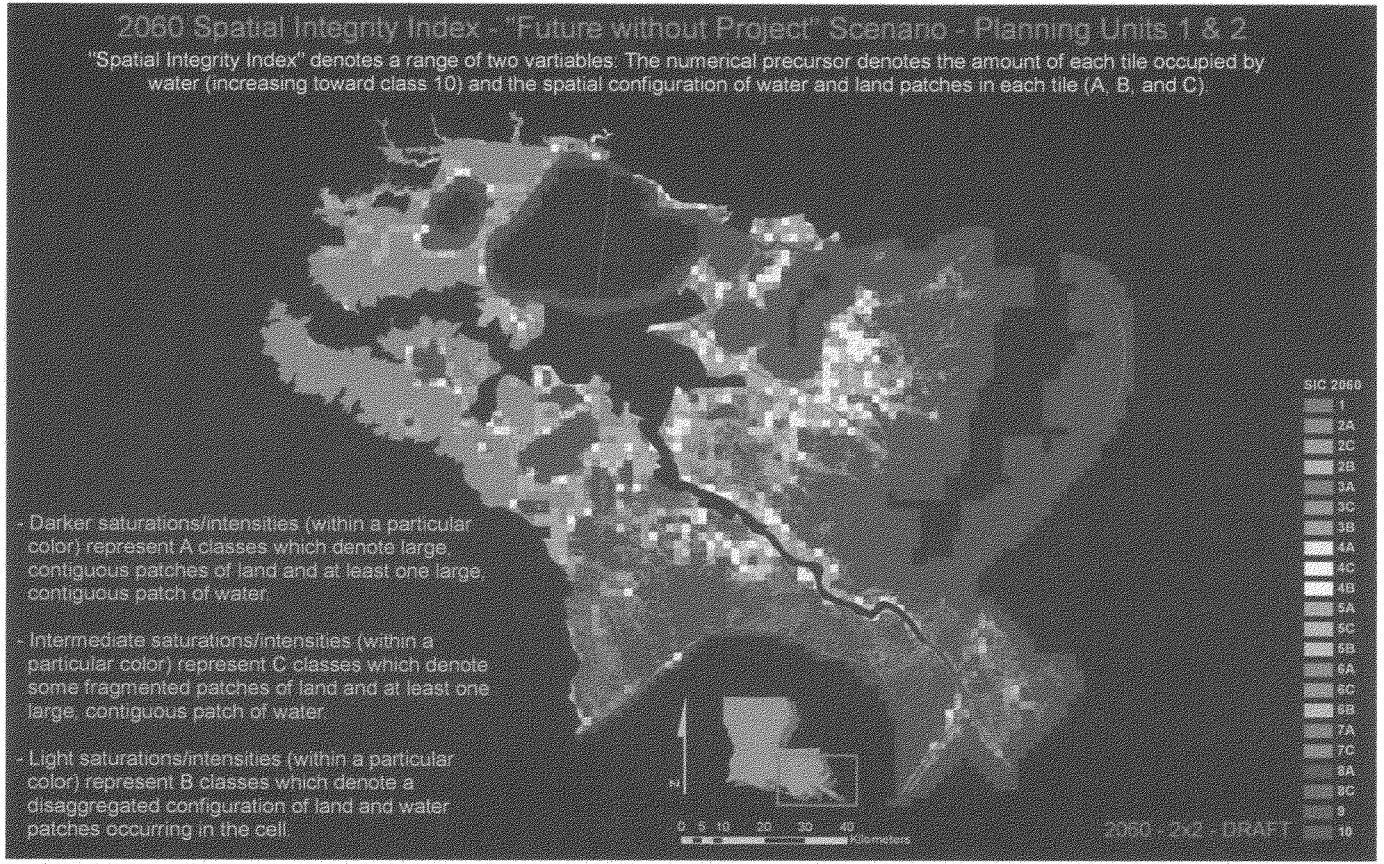


Figure 16. Spatial integrity index for future without project in 2060 for planning units 1 and 2.

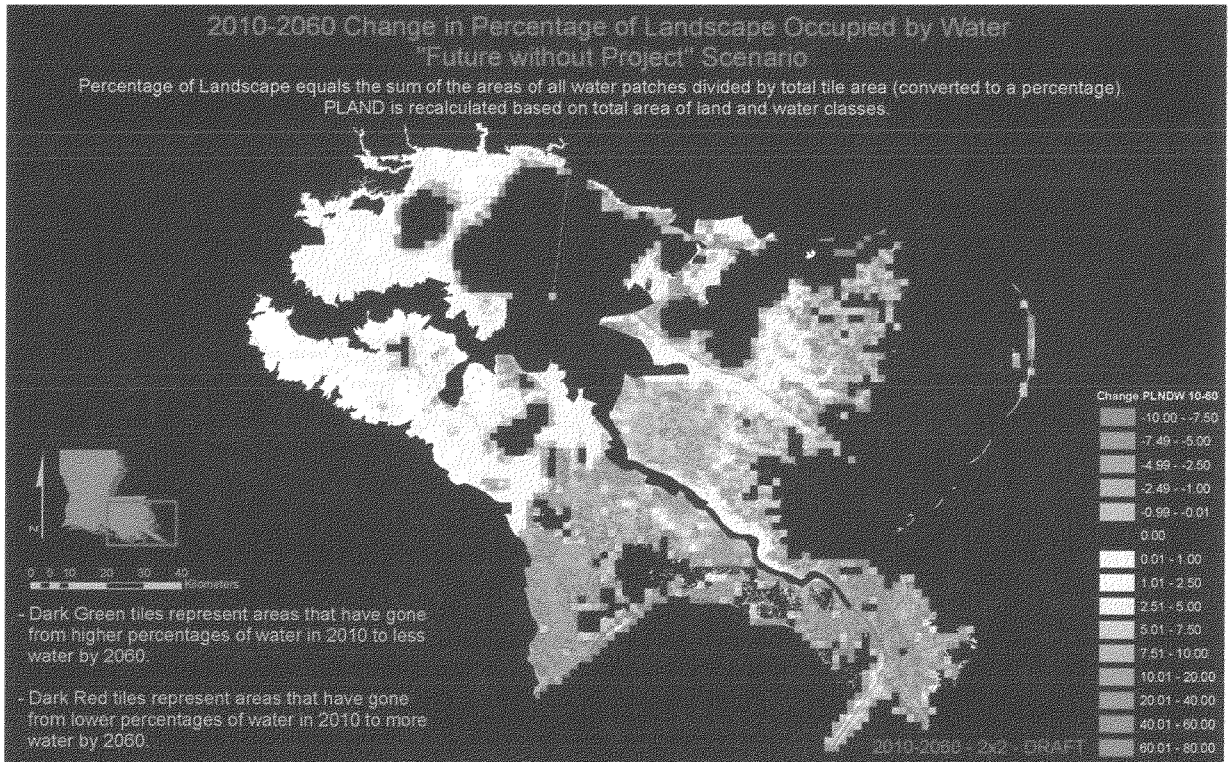


Figure 17. Percentage of landscape occupied by water metric for planning units 1 and 2 showing future without project changes projected between 2010 and 2060.

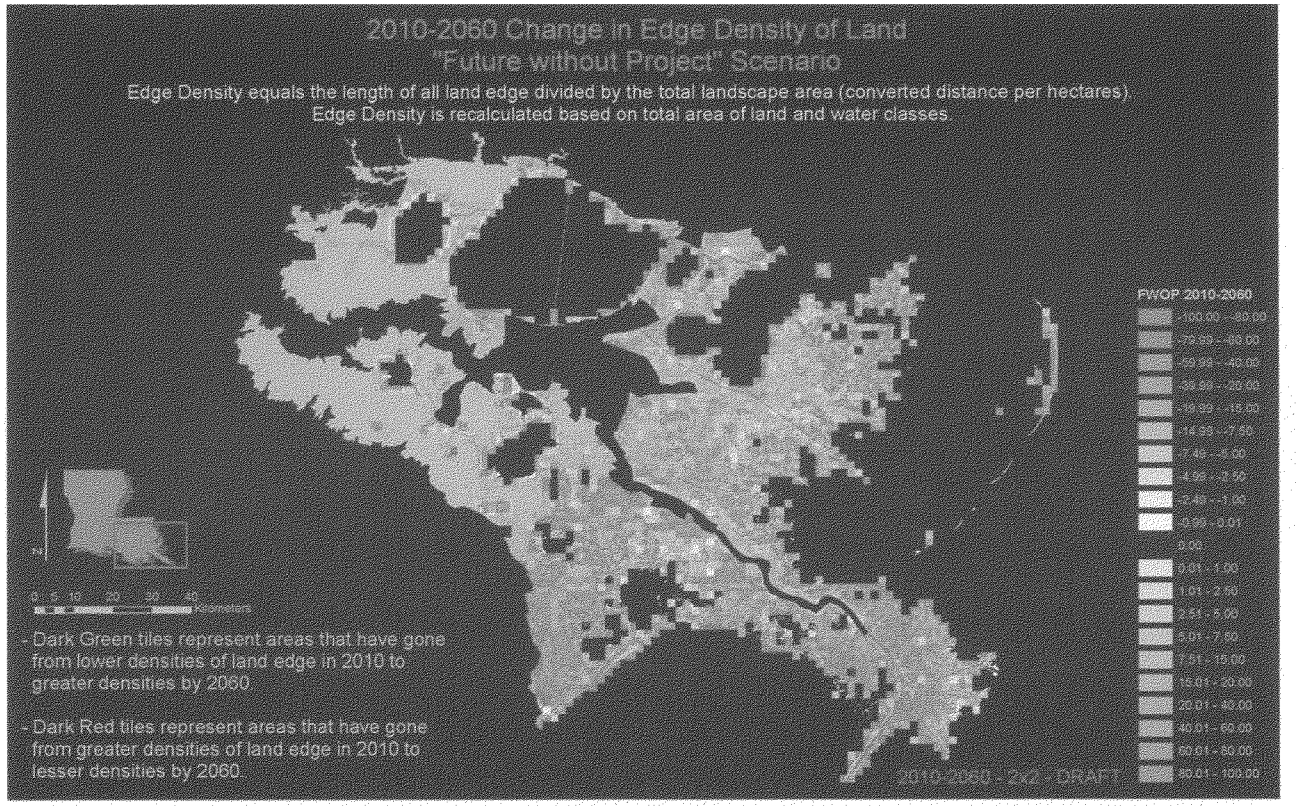


Figure 18. Edge density of land metric for planning units 1 and 2 showing future without project changes projected between 2010 and 2060.

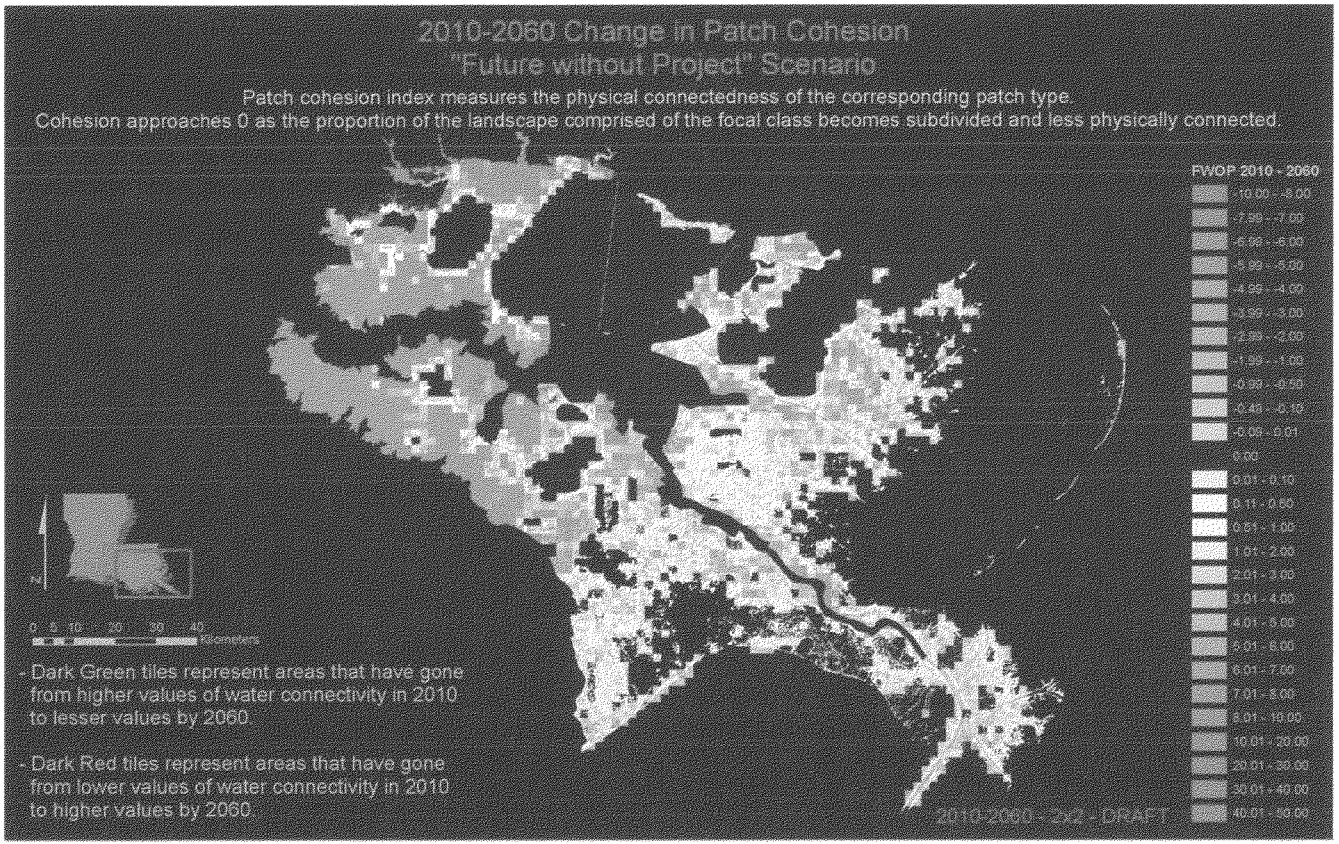


Figure 19. Patch cohesion metric for planning units 1 and 2 showing future without project changes projected between 2010 and 2060.

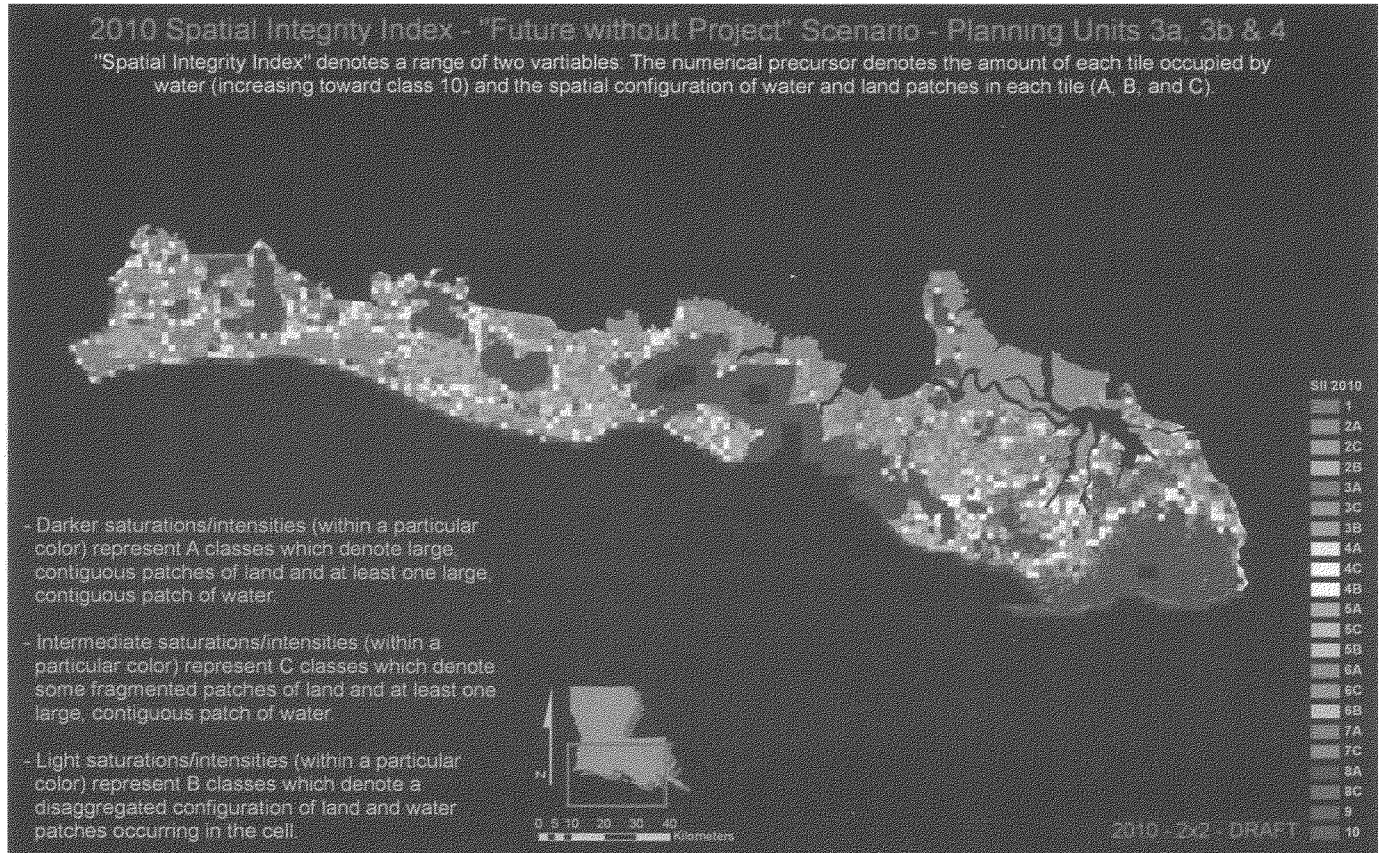


Figure 20. Spatial integrity index for 2010 for planning units 3a, 3b and 4.

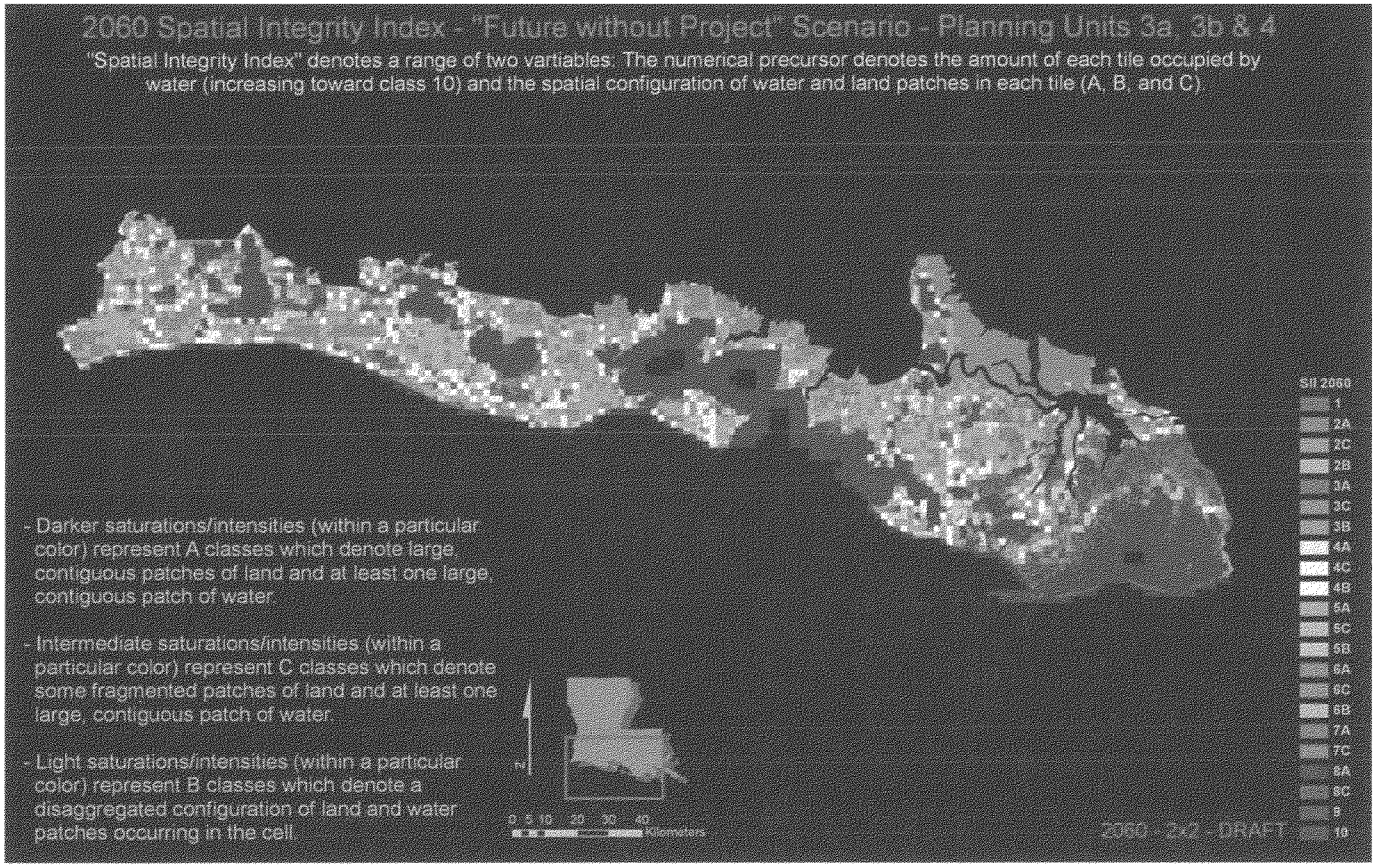


Figure 21. Spatial integrity index for future without project in 2060 for planning units 3a, 3b and 4.

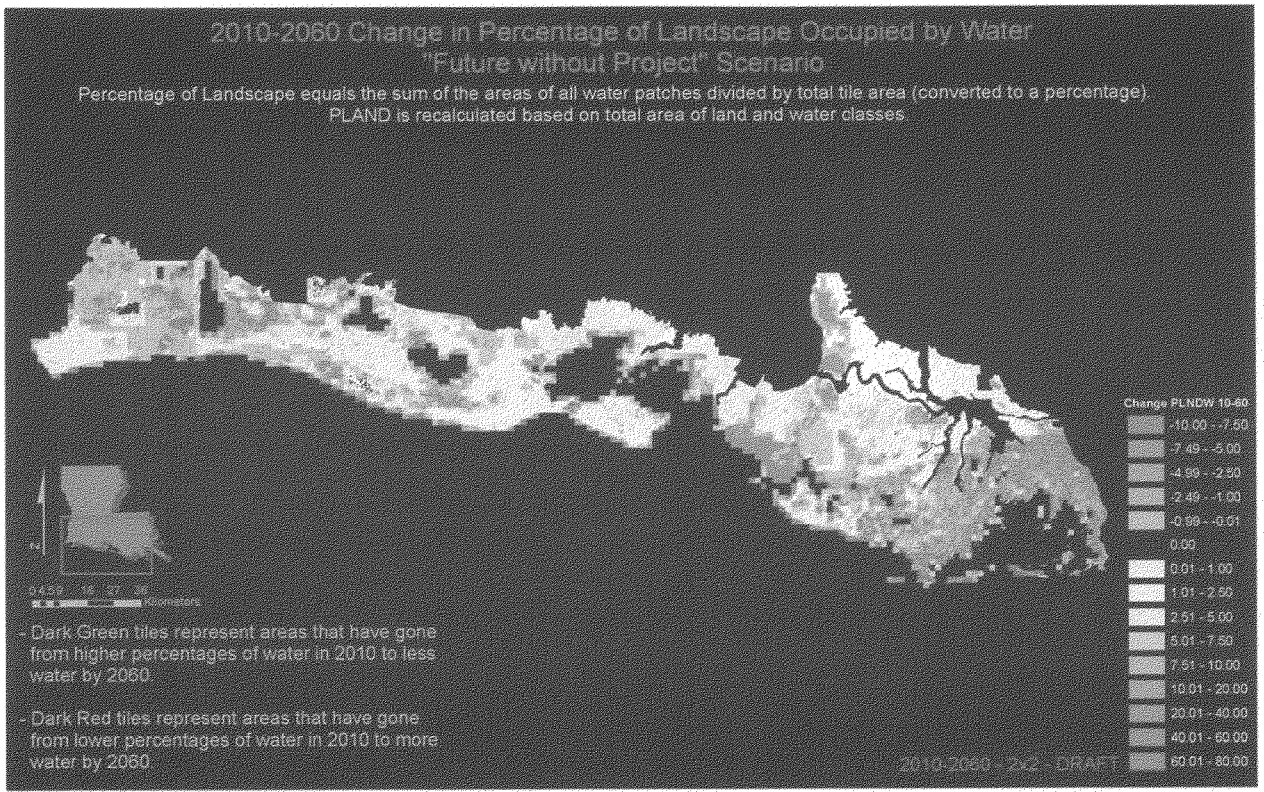


Figure 22. Percentage of landscape occupied by water metric for planning units 3a, 3b and 4 showing future without project changes projected between 2010 and 2060.

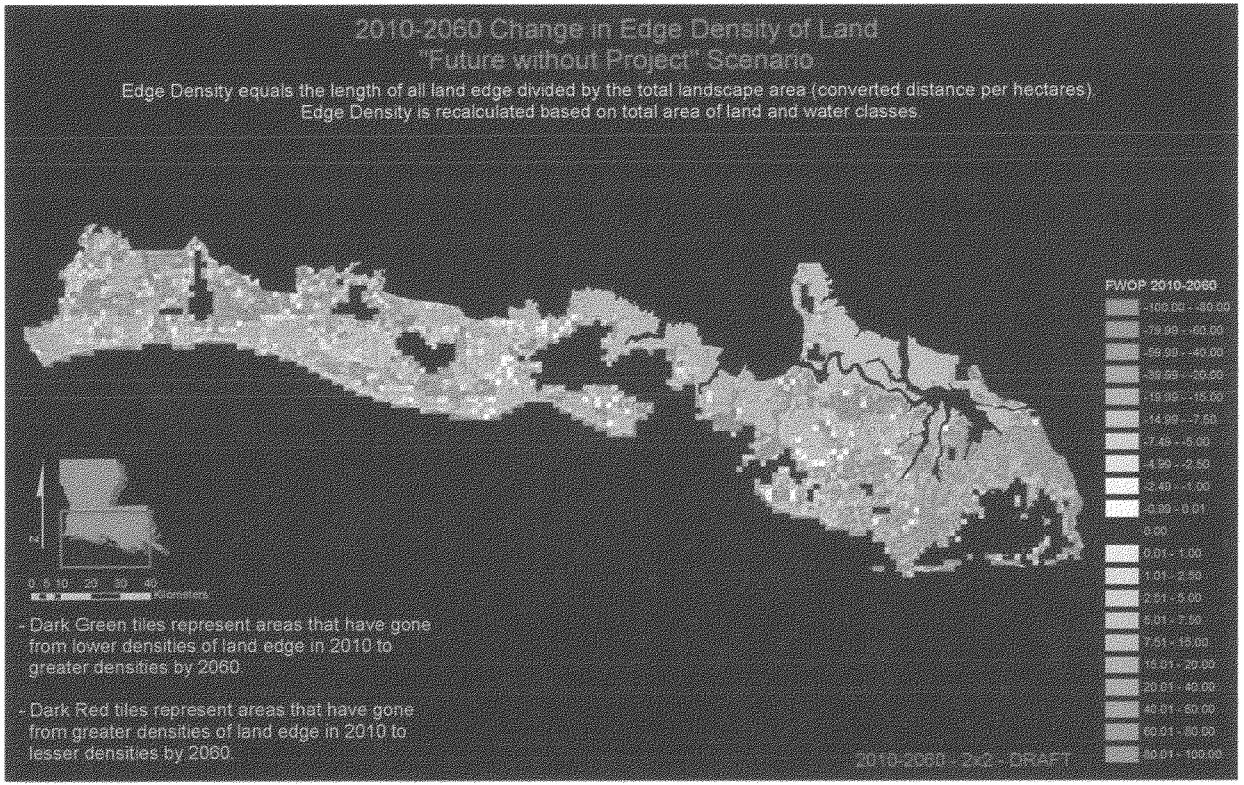


Figure 23. Edge density of land metric for planning units 3a, 3b and 4 showing future without project changes projected between 2010 and 2060.

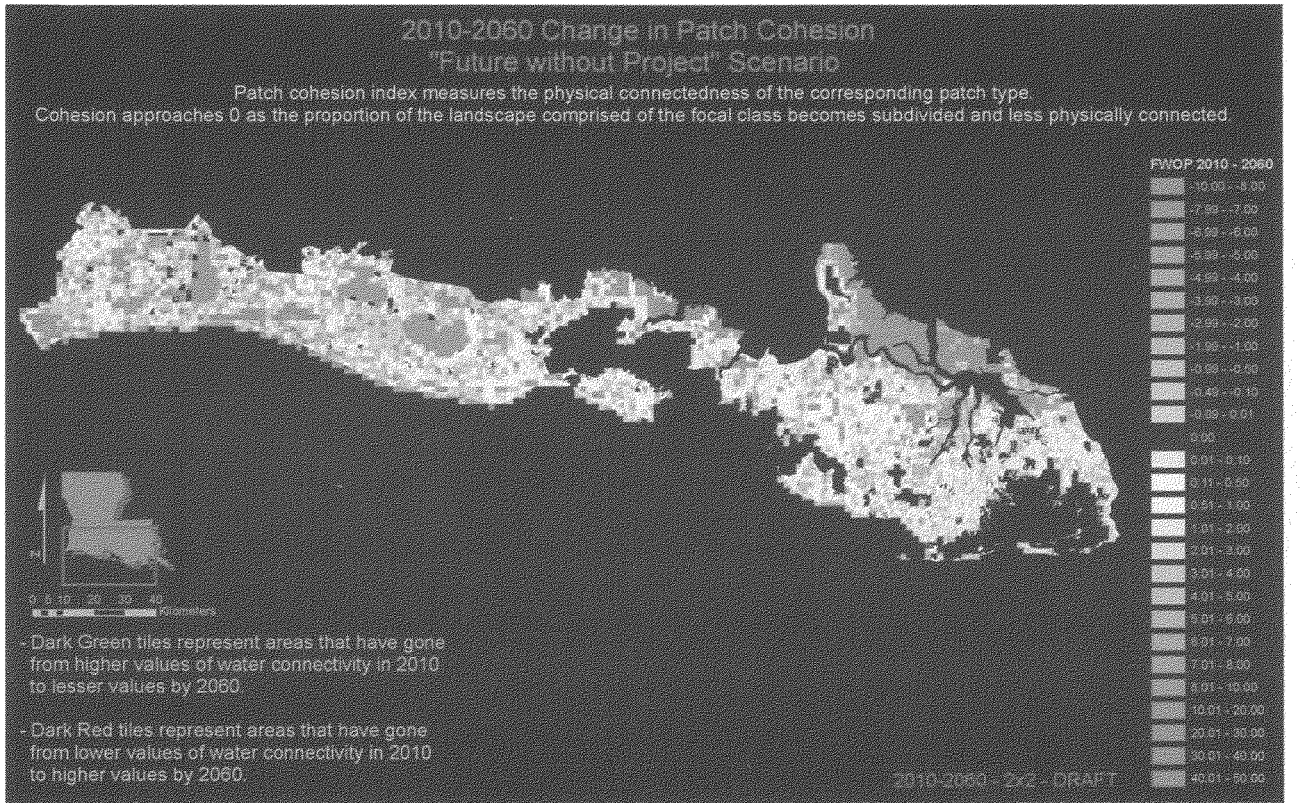


Figure 24. Patch cohesion metric for planning units 3a, 3b and 4 showing future without project changes projected between 2010 and 2060.

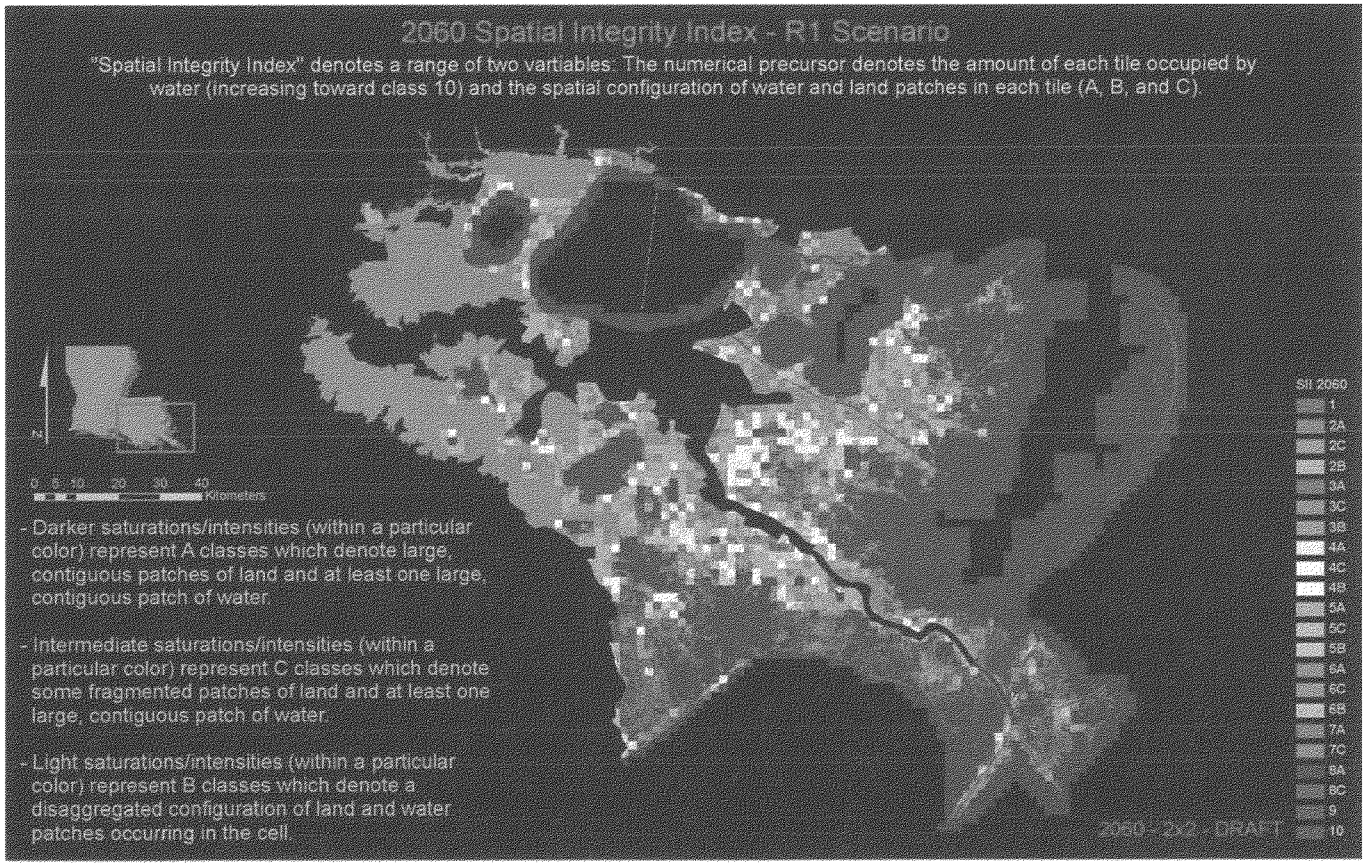


Figure 25. Spatial integrity index for Alternative R1 in 2060 for planning units 1 and 2.

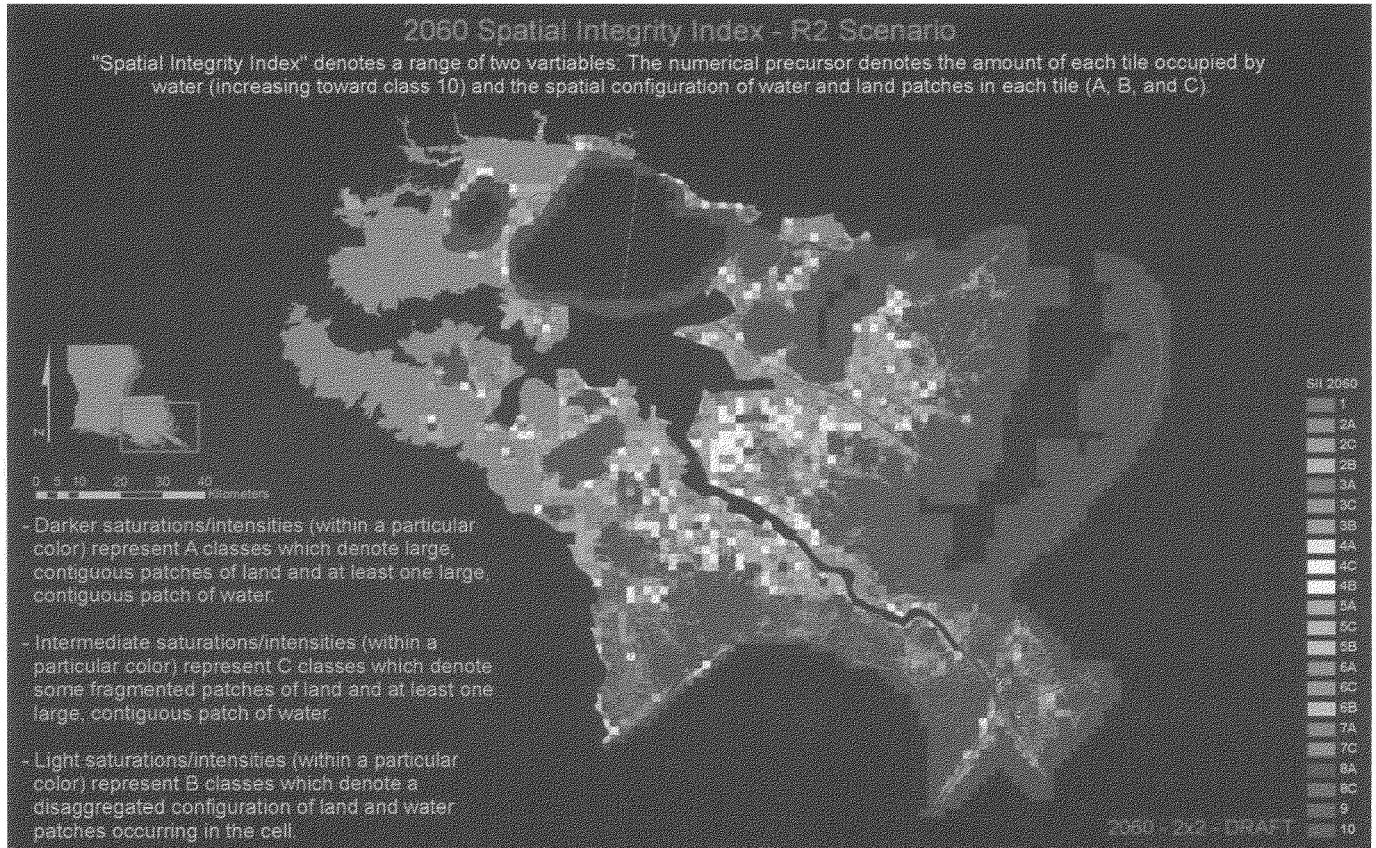


Figure 26. Spatial integrity index for Alternative R2 in 2060 for planning units 1 and 2.

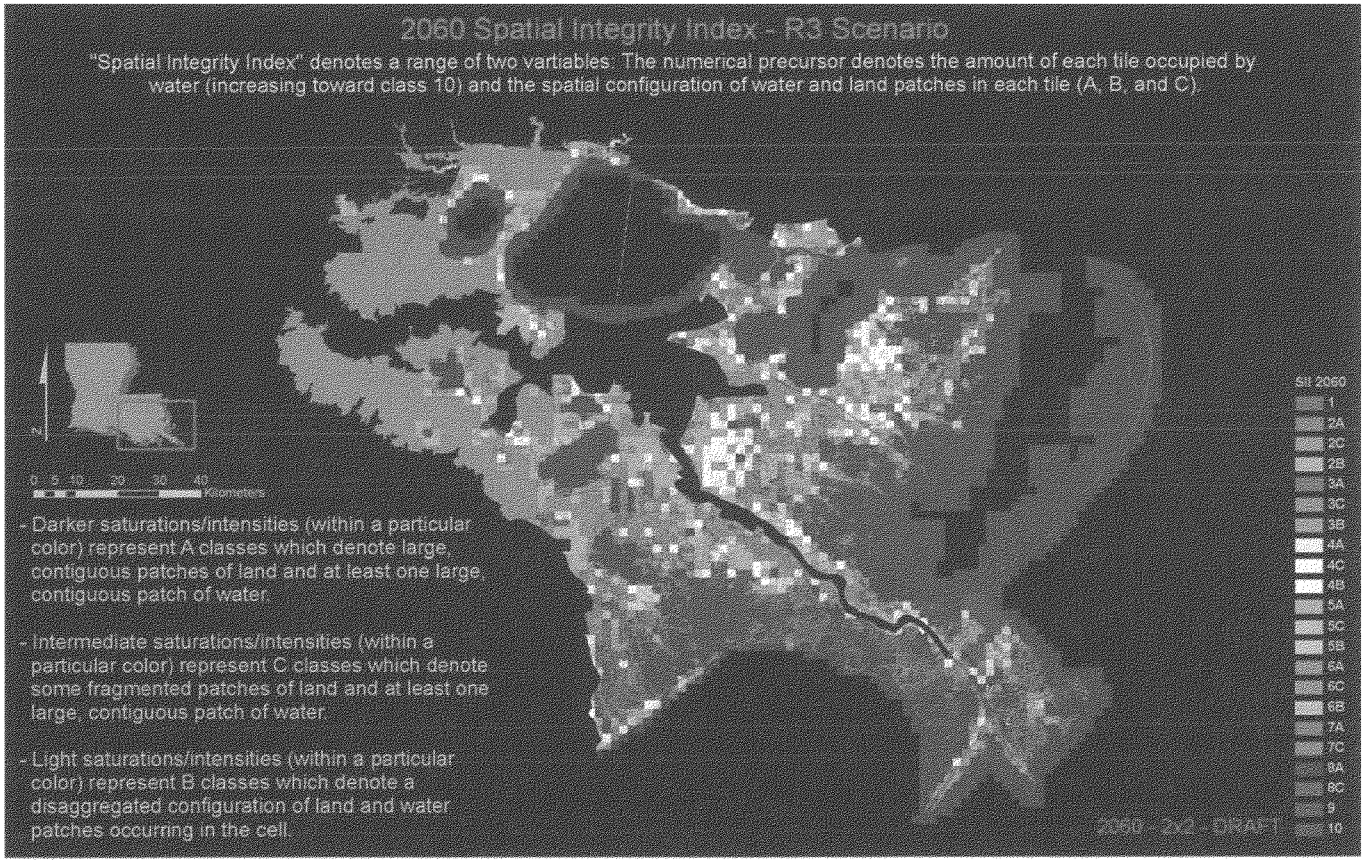


Figure 27. Spatial integrity index for Alternative R3 in 2060 for planning units 1 and 2.

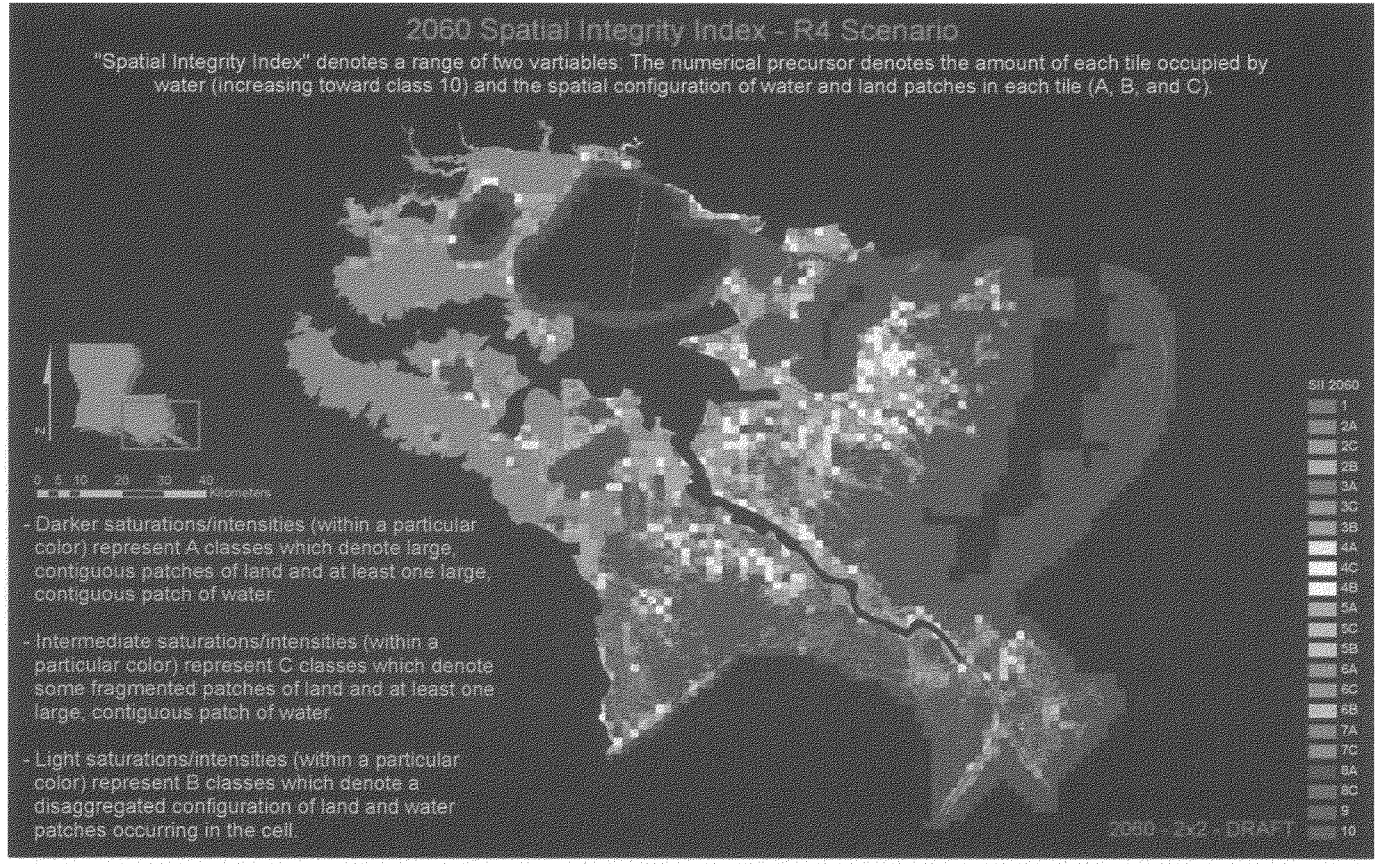


Figure 28. Spatial integrity index for Alternative R4 in 2060 for planning units 1 and 2.

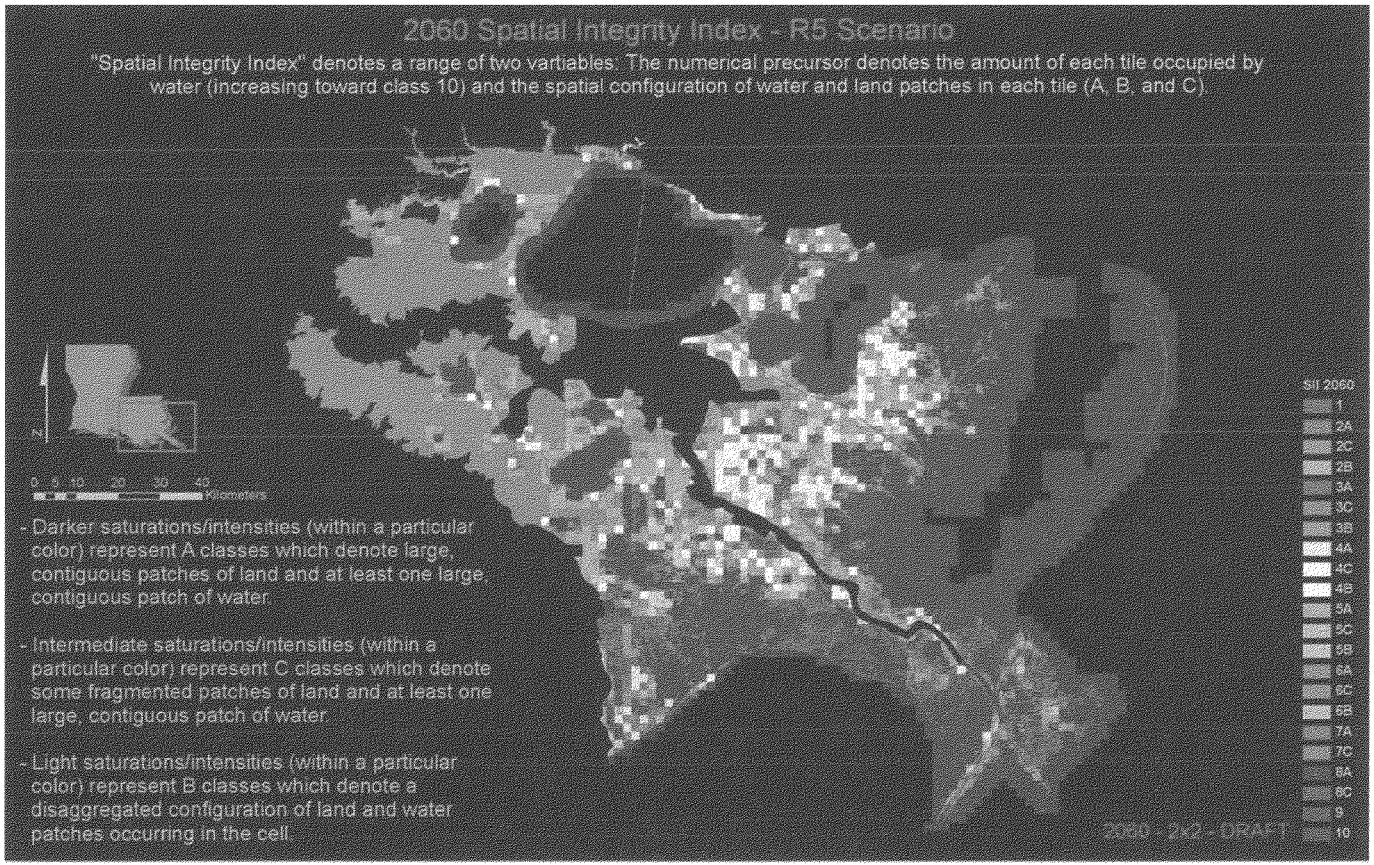


Figure 29. Spatial integrity index for Alternative R5 in 2060 for planning units 1 and 2.

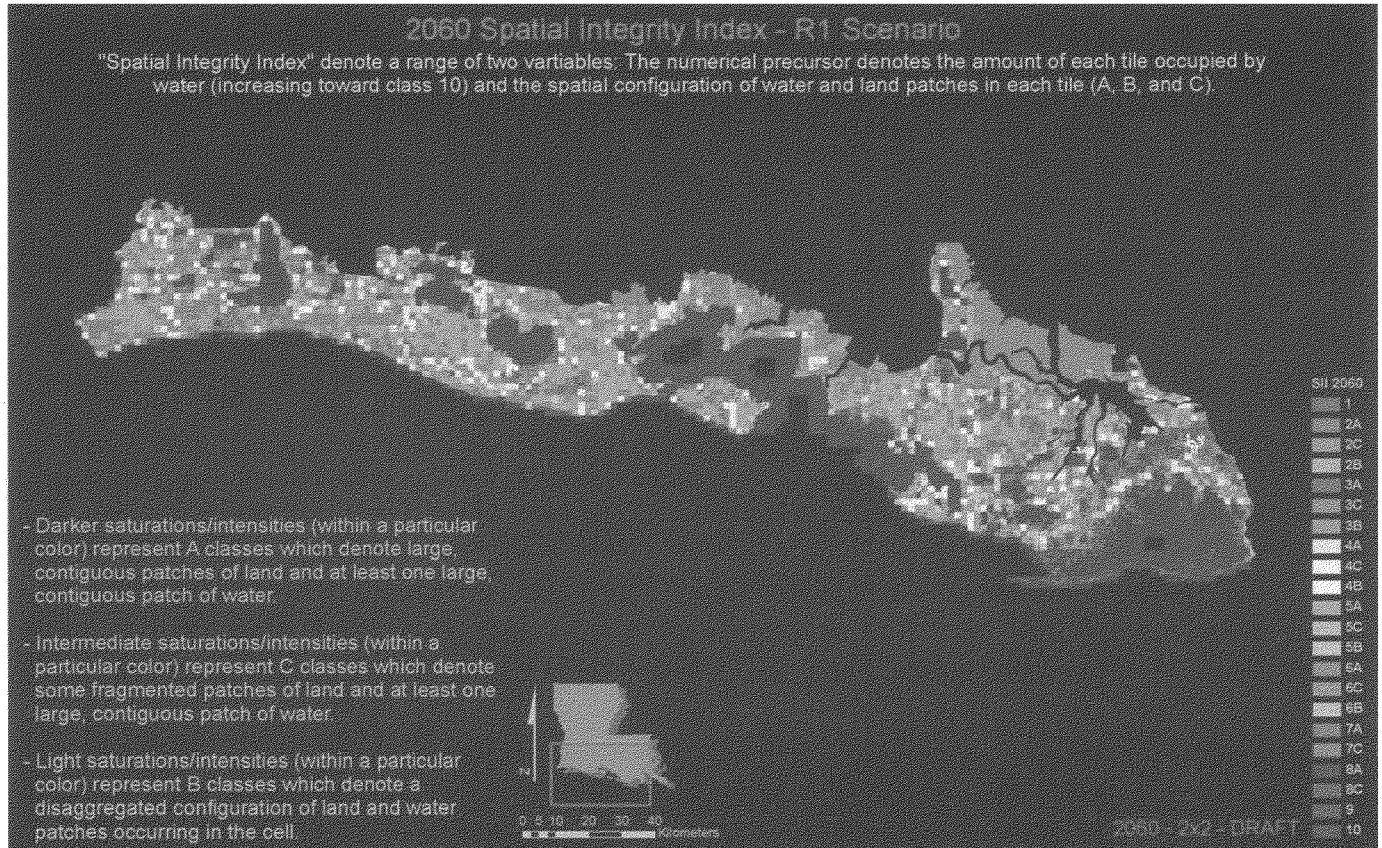


Figure 30. Spatial integrity index for Alternative R1 in 2060 for planning units 3a, 3b and 4.

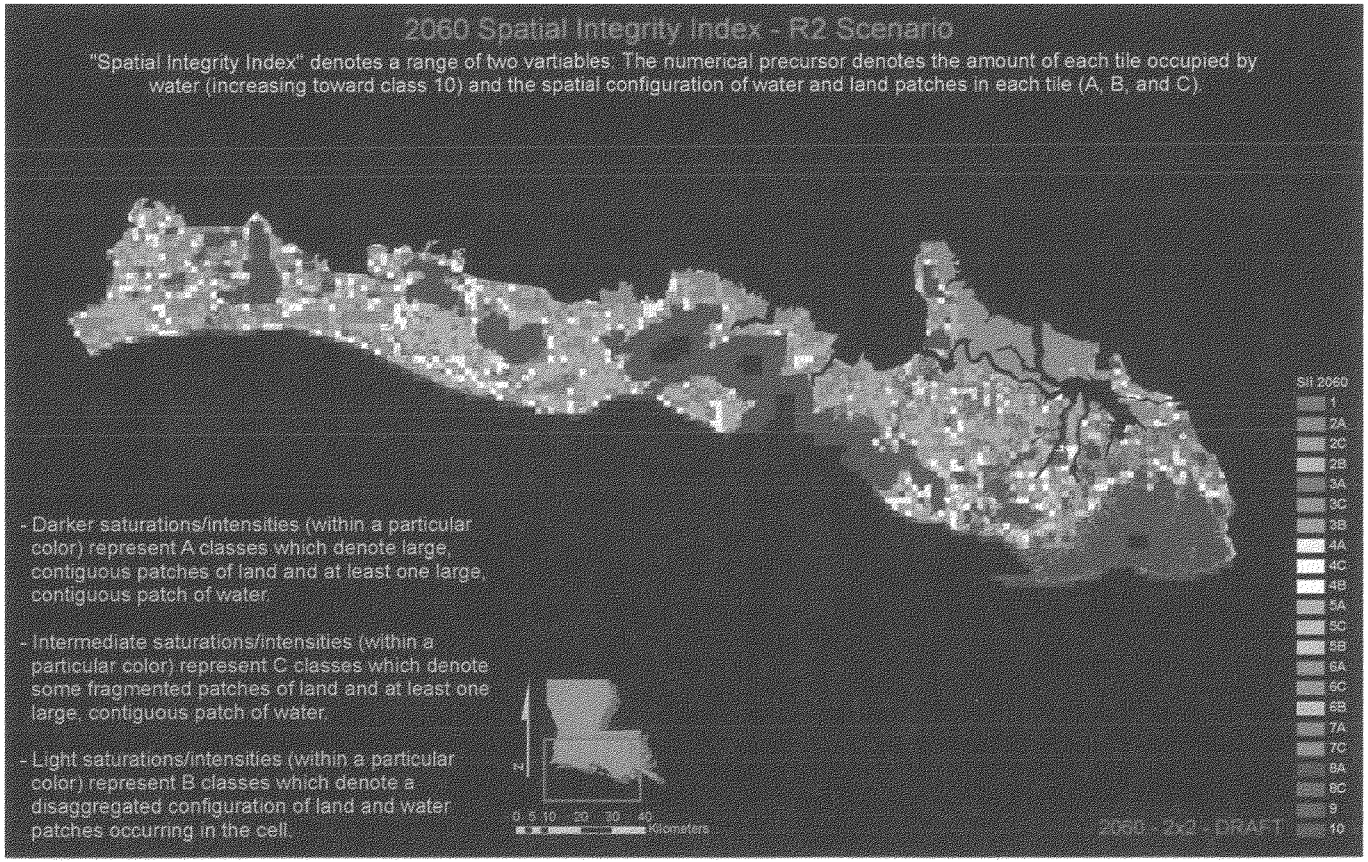


Figure 31. Spatial integrity index for Alternative R2 in 2060 for planning units 3a, 3b and 4.

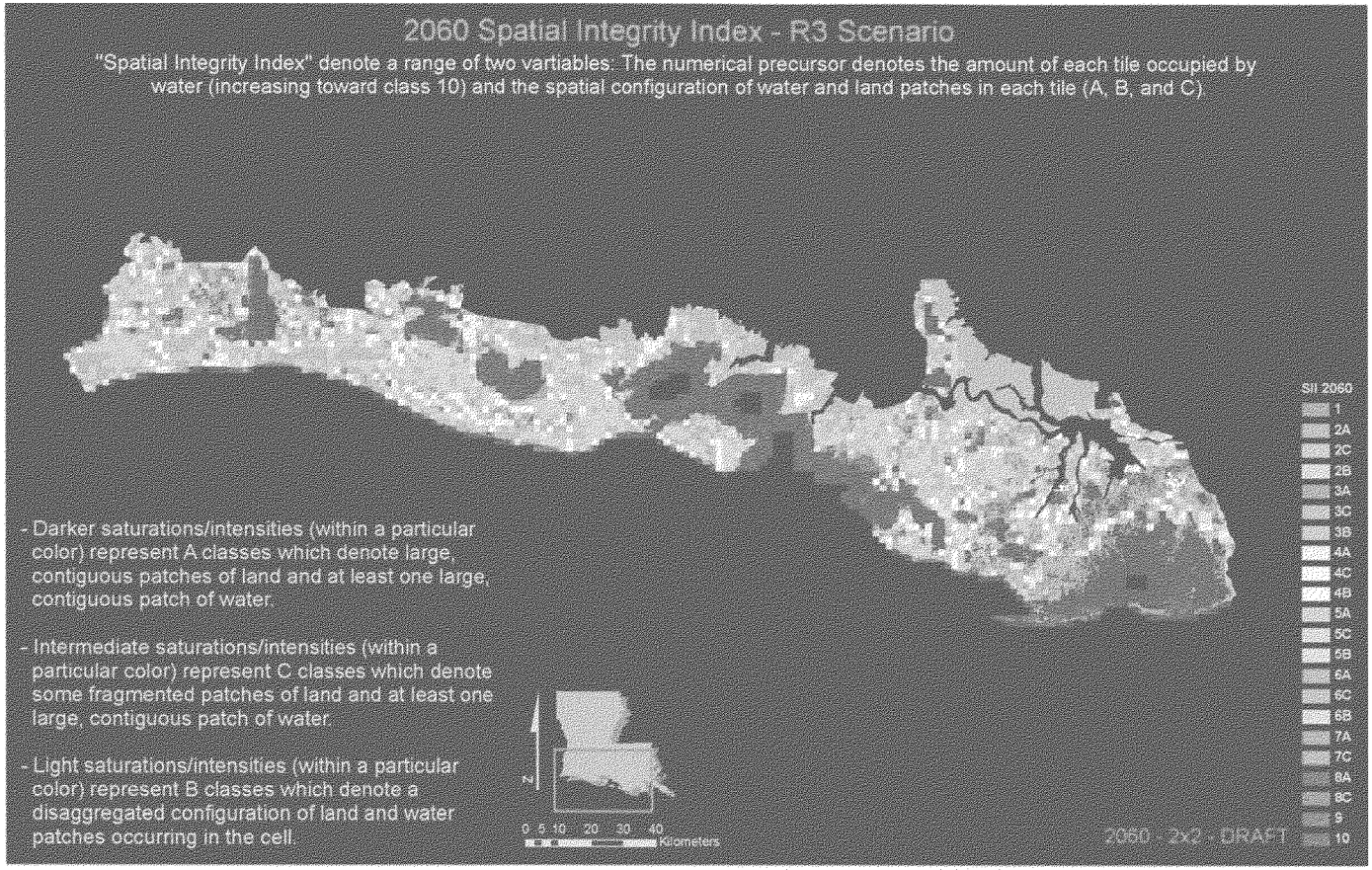


Figure 32. Spatial integrity index for Alternative R3 in 2060 for planning units 3a, 3b and 4.

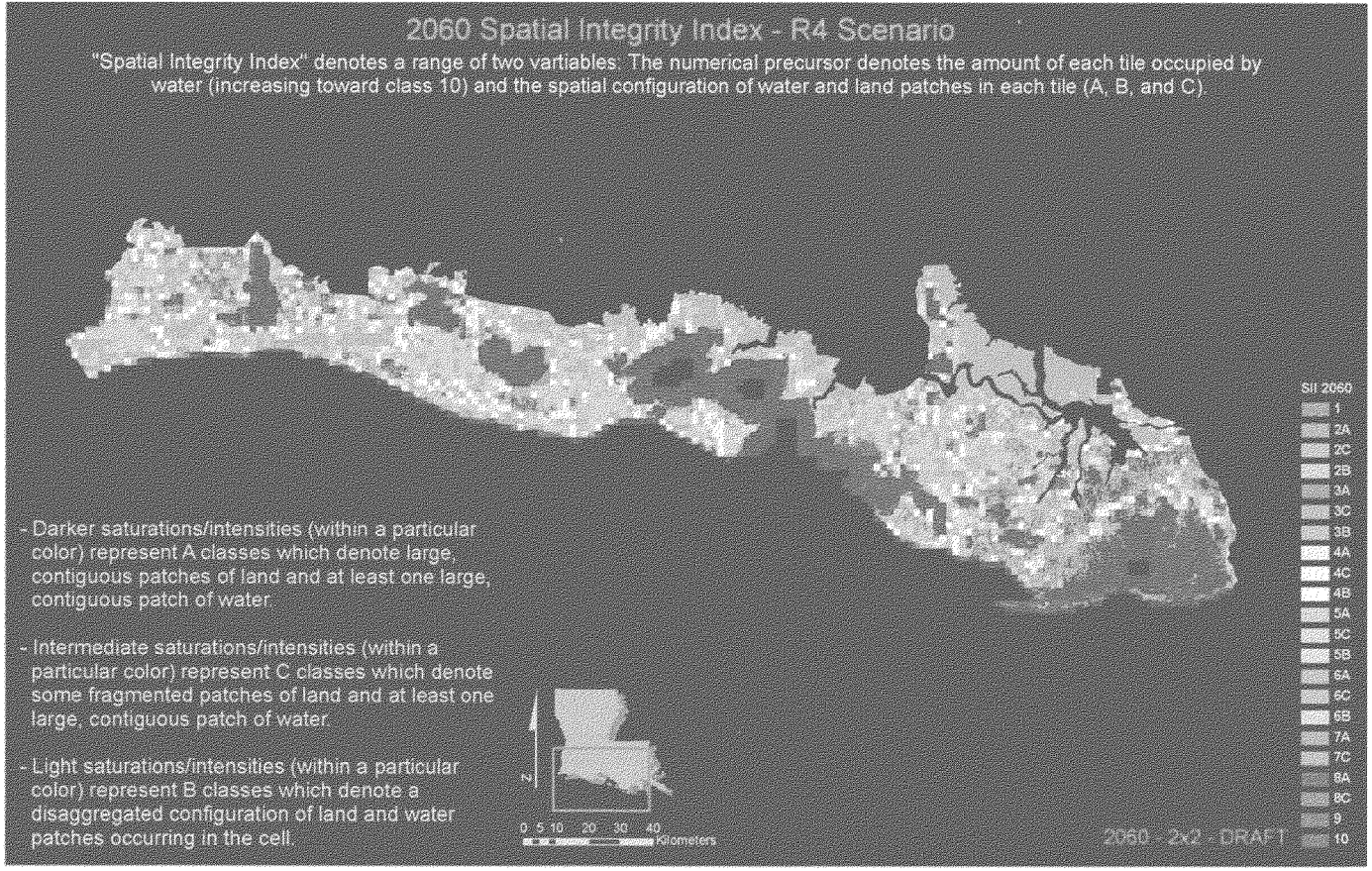


Figure 33. Spatial integrity index for Alternative R4 in 2060 for planning units 3a, 3b and 4.

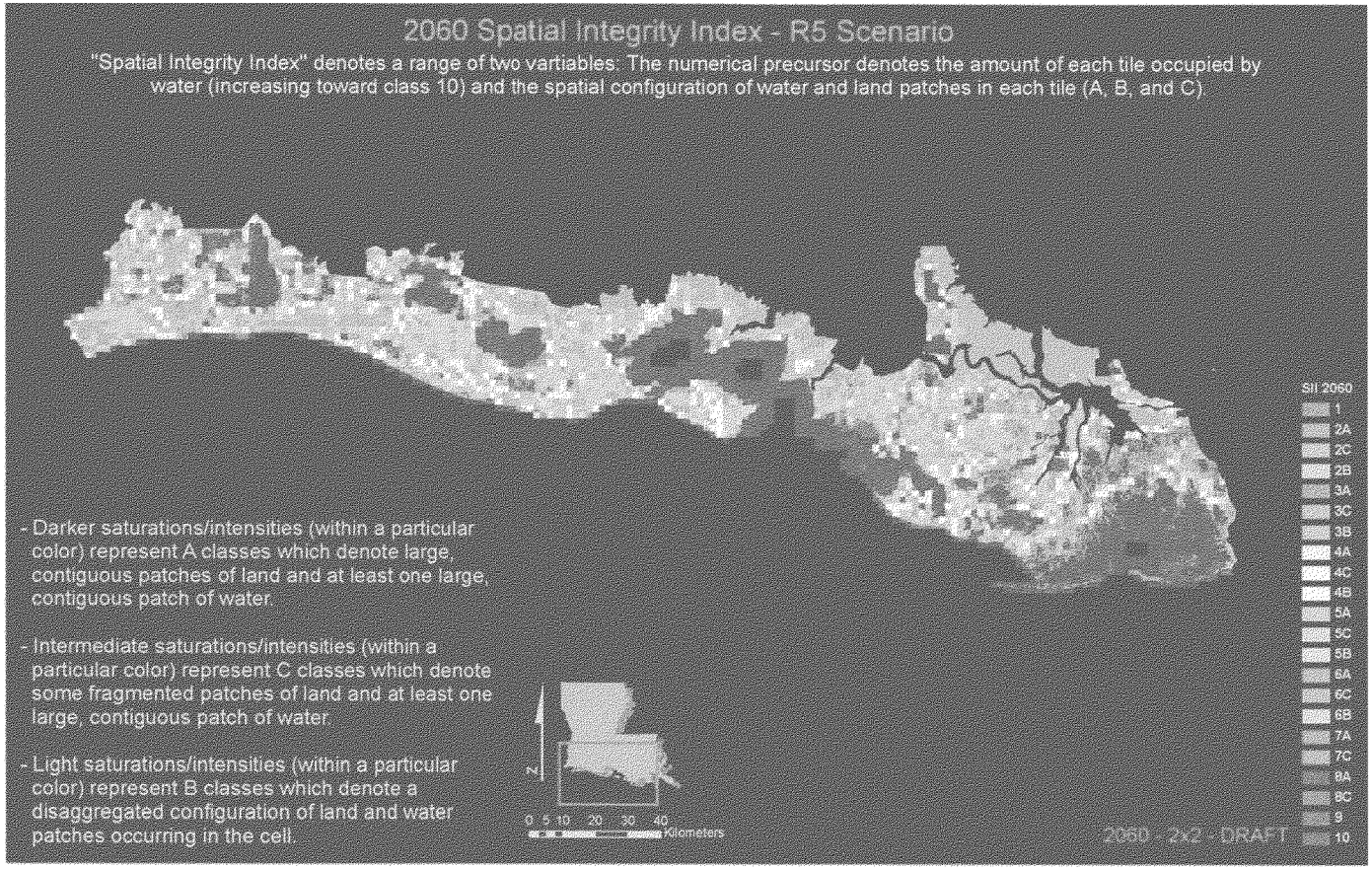


Figure 34. Spatial integrity index for Alternative R5 in 2060 for planning units 3a, 3b and 4.

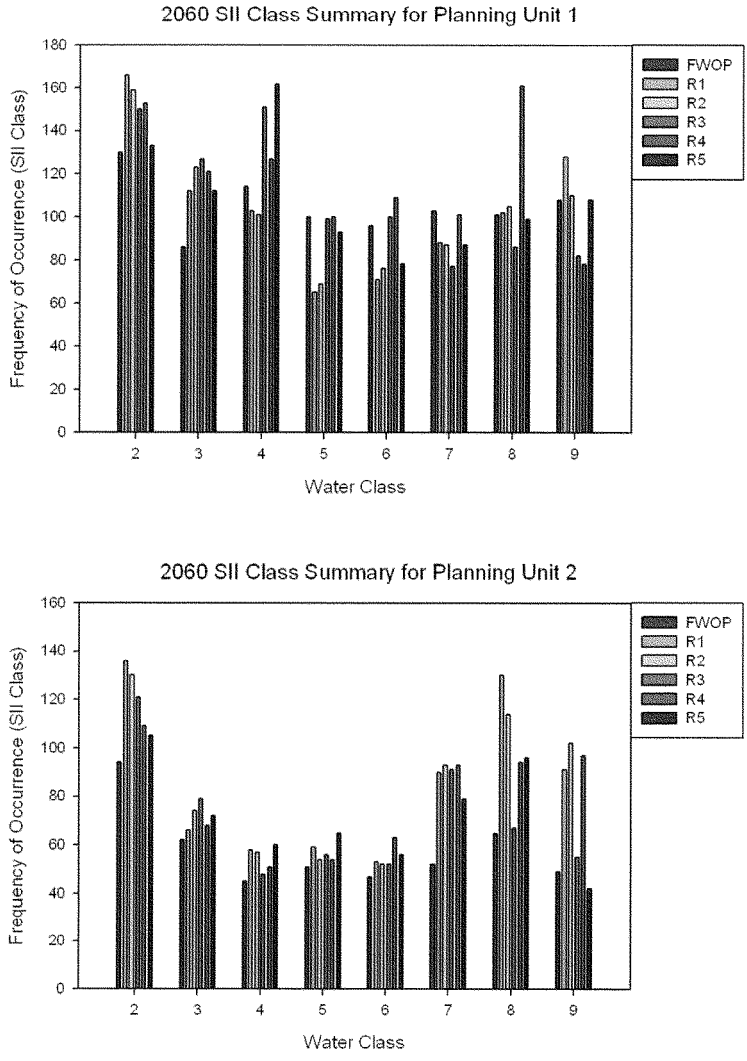


Figure 35. Spatial integrity index from 2060 summarized by individual water classes for planning units 1 and 2. Frequency represents counts of tiles in 2060 represented by the class.

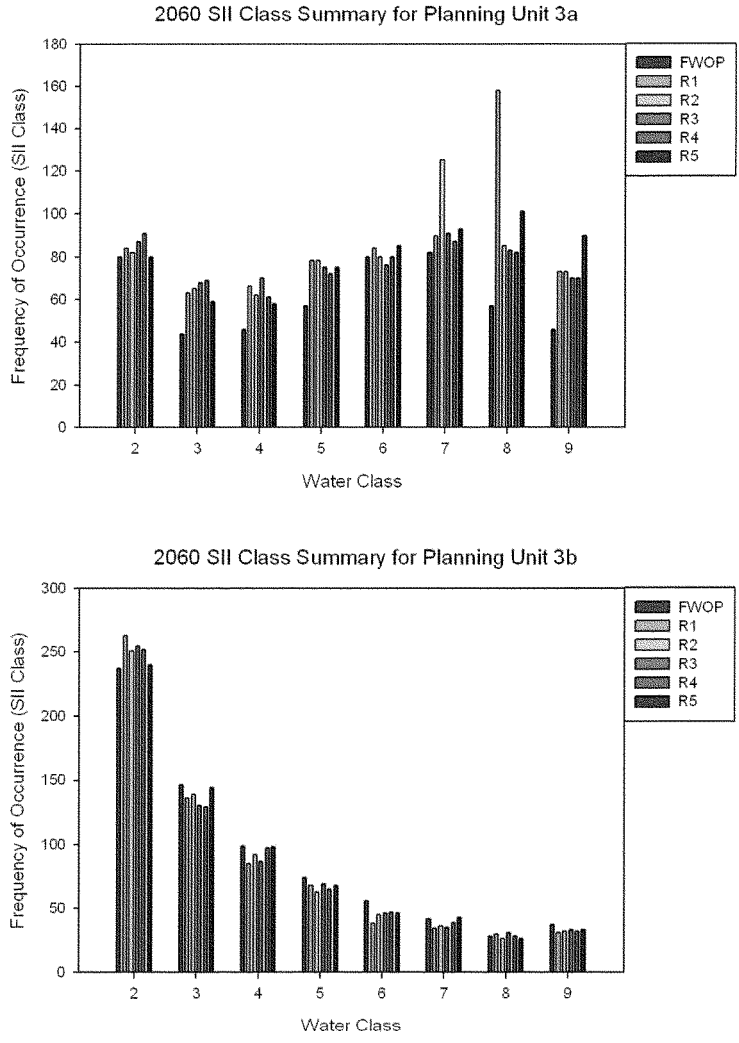


Figure 36a. Spatial integrity index from 2060 summarized by individual water classes for planning units 3a and 3b. Frequency represents counts of tiles in 2060 represented by the class.

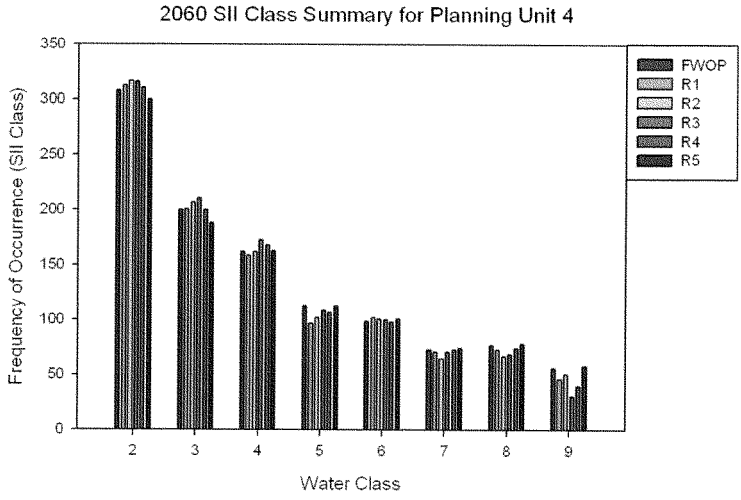


Figure 36b. Spatial integrity index from 2060 summarized by individual water classes for planning unit 4. Frequency represents counts of tiles in 2060 represented by the class.

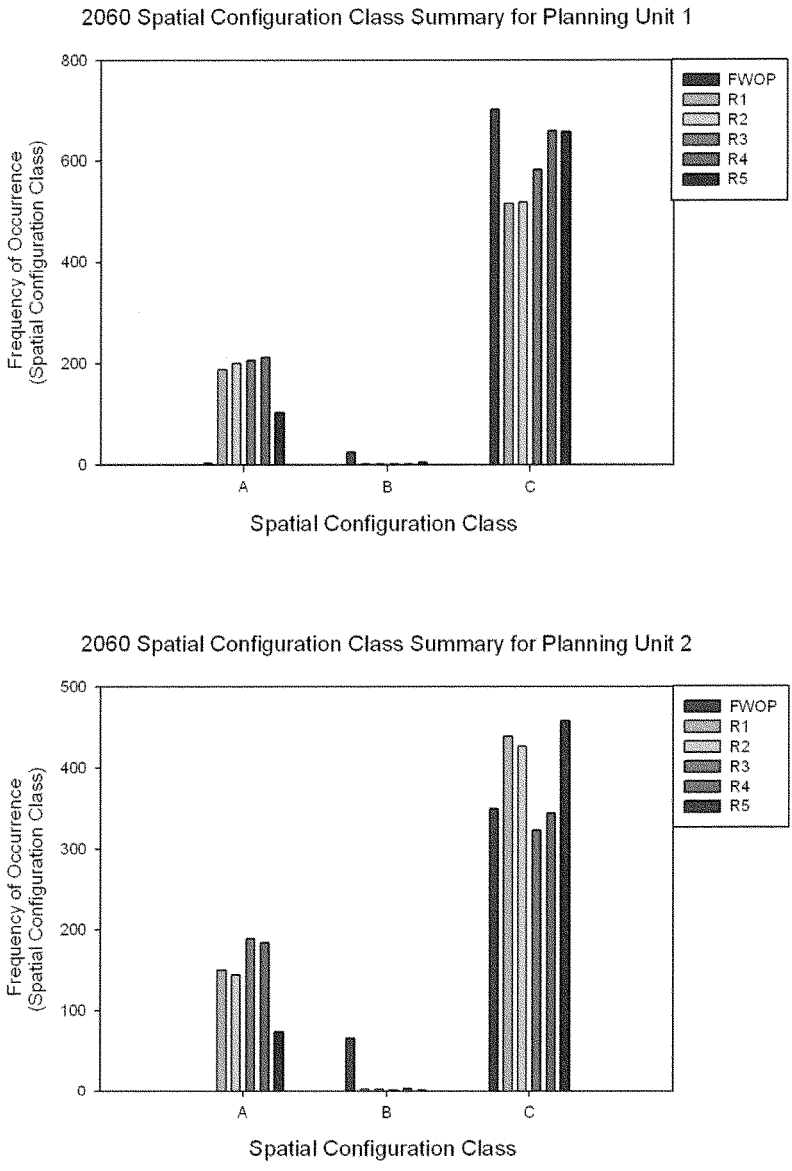


Figure 37. Spatial integrity index from 2060 summarized by individual configuration classes for planning units 1 and 2. Frequency represents counts of tiles in 2060 represented by the class.

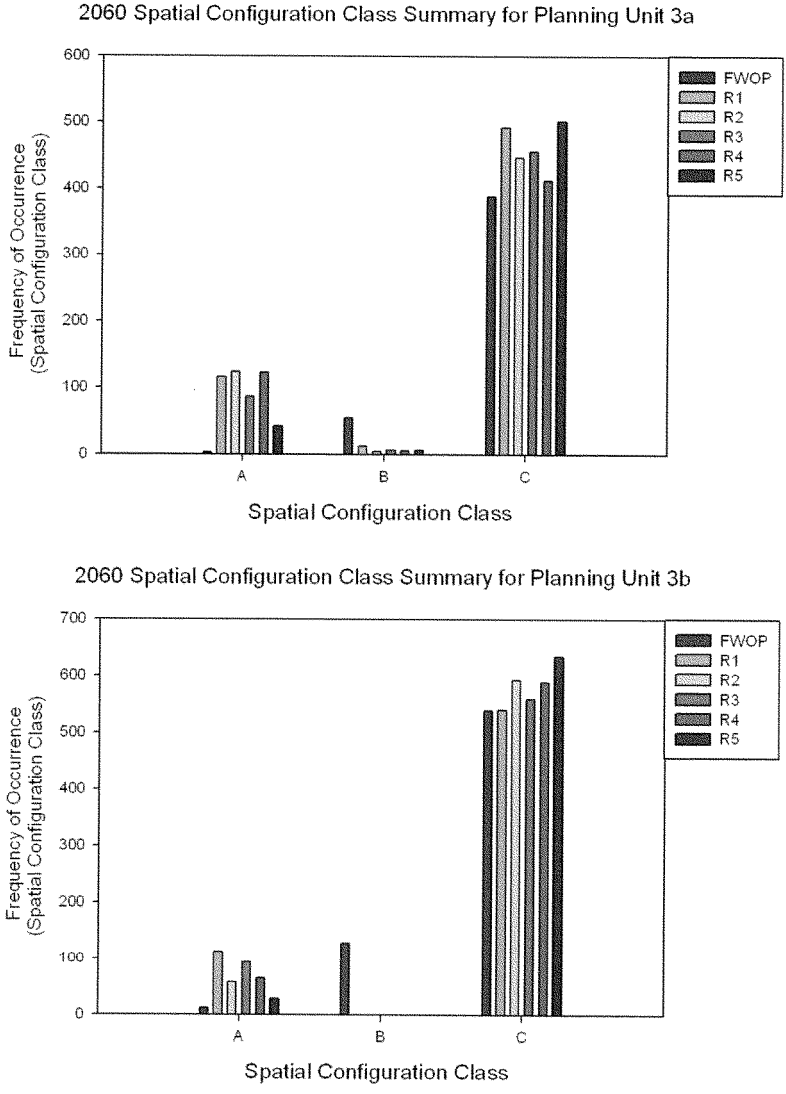


Figure 38a. Spatial integrity index from 2060 summarized by individual configuration classes for planning units 3a and 3b. Frequency represents counts of tiles in 2060 represented by the class.

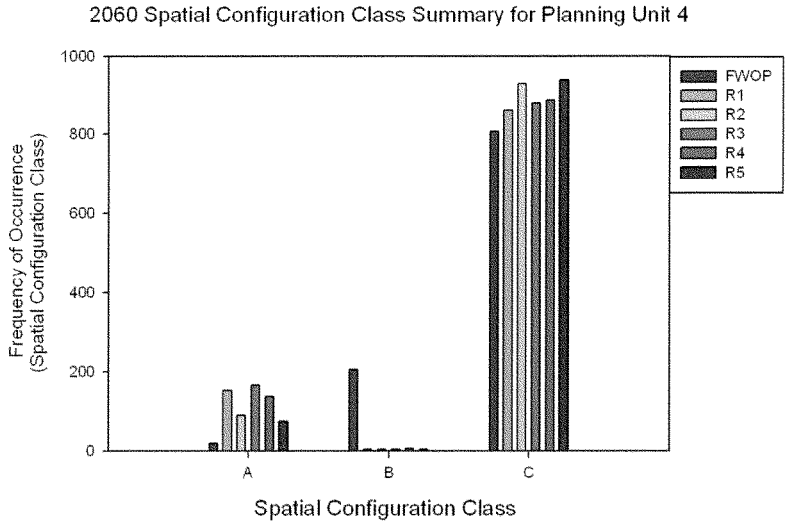


Figure 38b. Spatial integrity index from 2060 summarized by individual configuration classes for planning unit 4. Frequency represents counts of tiles in 2060 represented by the class.

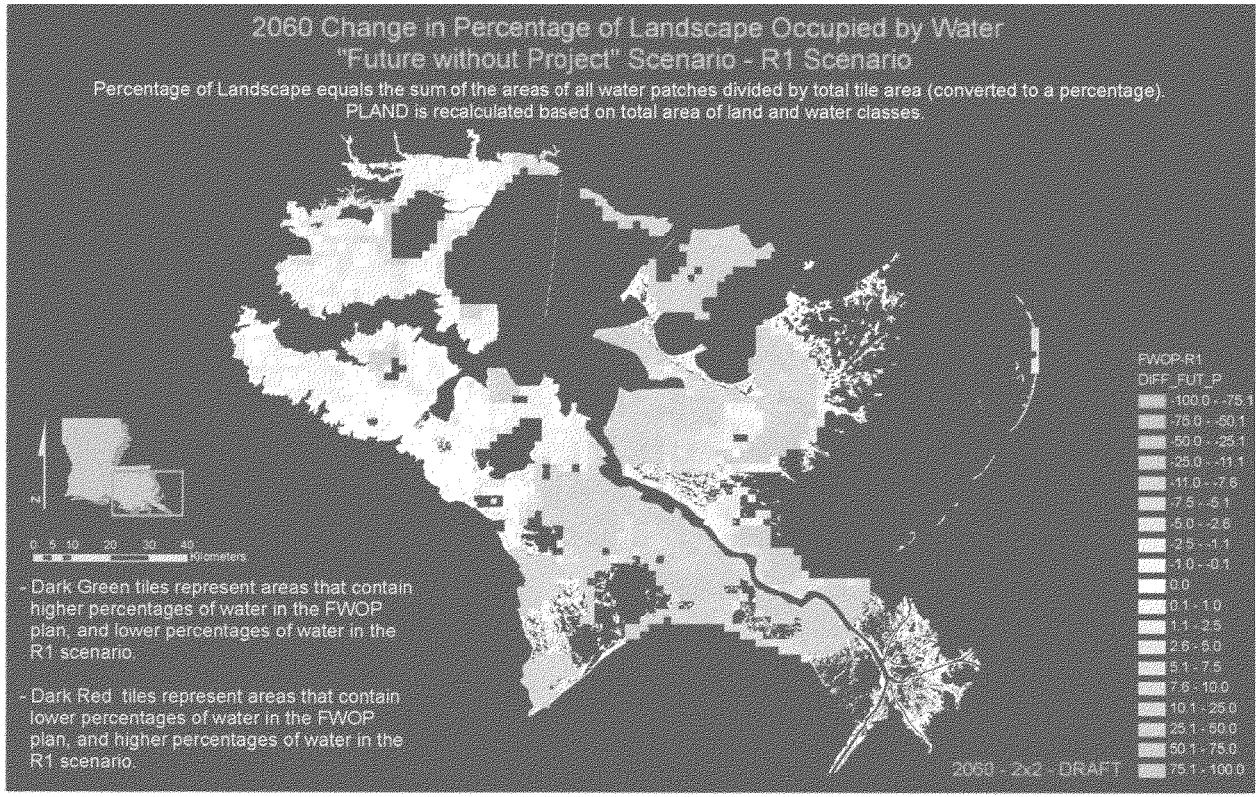


Figure 39. Percentage of landscape occupied by water metric for planning units 1 and 2 showing difference between future without project and Alternative R1 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

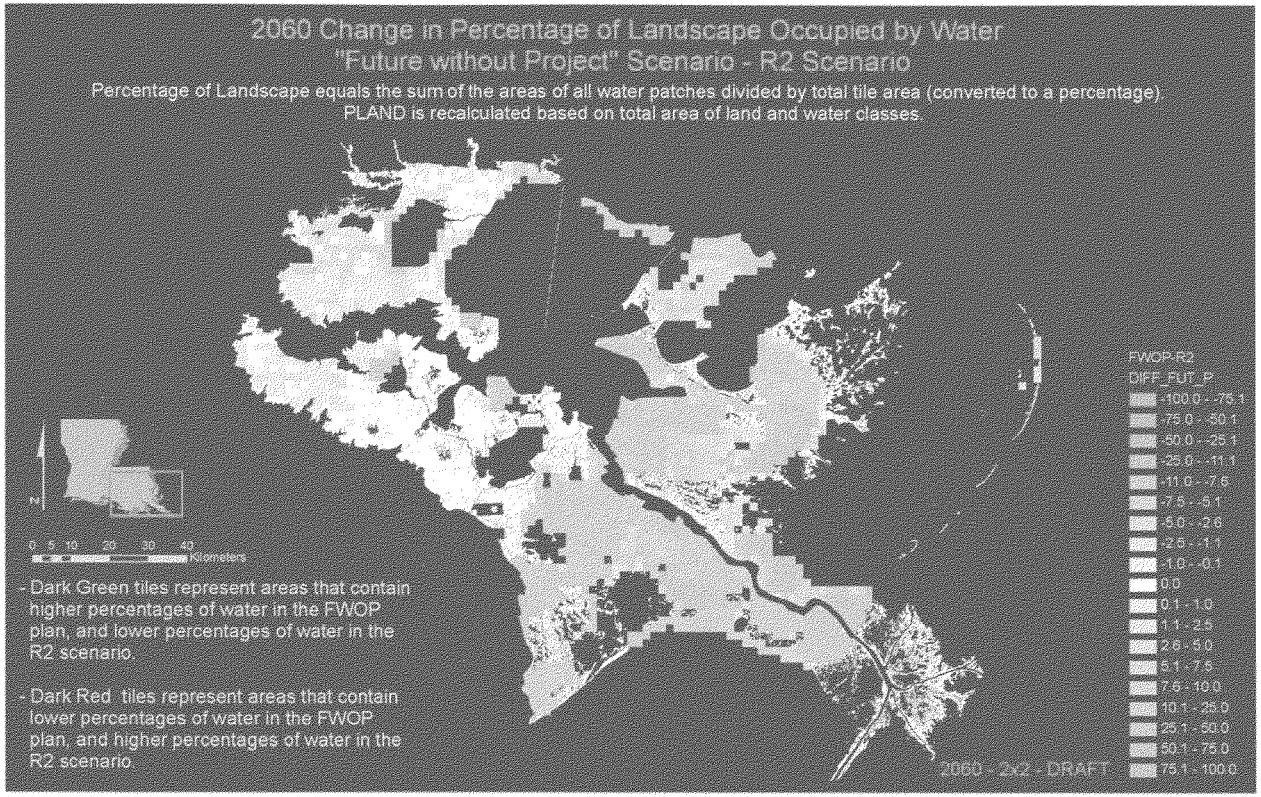


Figure 40. Percentage of landscape occupied by water metric for planning units 1 and 2 showing difference between future without project and Alternative R2 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

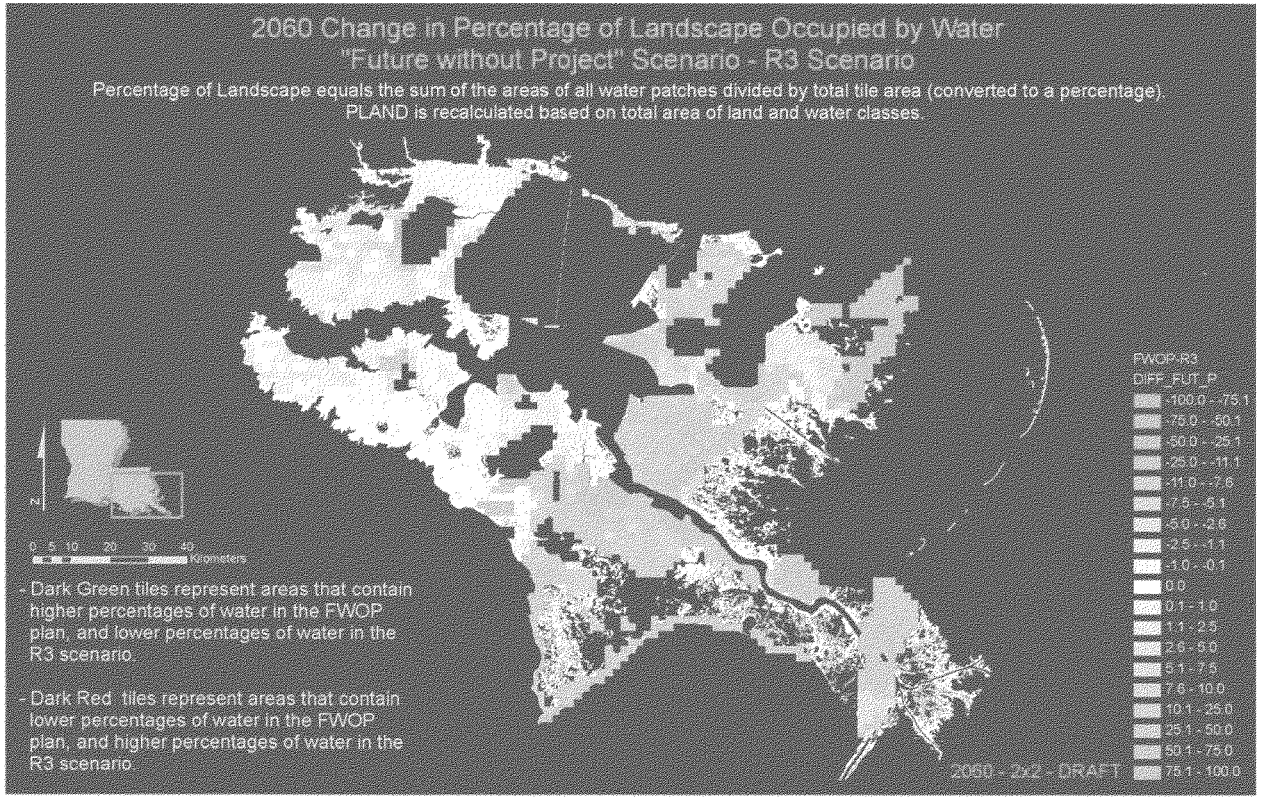


Figure 41. Percentage of landscape occupied by water metric for planning units 1 and 2 showing difference between future without project and Alternative R3 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

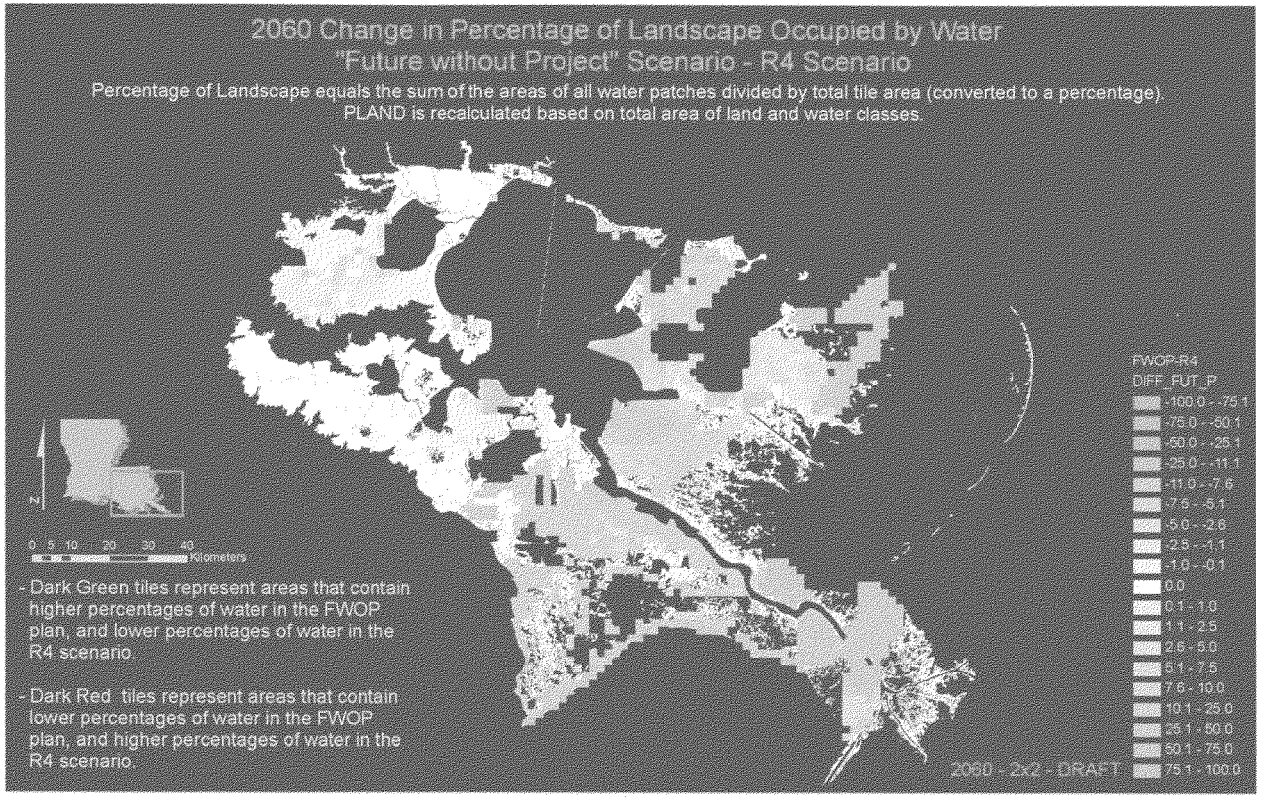


Figure 42. Percentage of landscape occupied by water metric for planning units 1 and 2 showing difference between future without project and Alternative R4 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

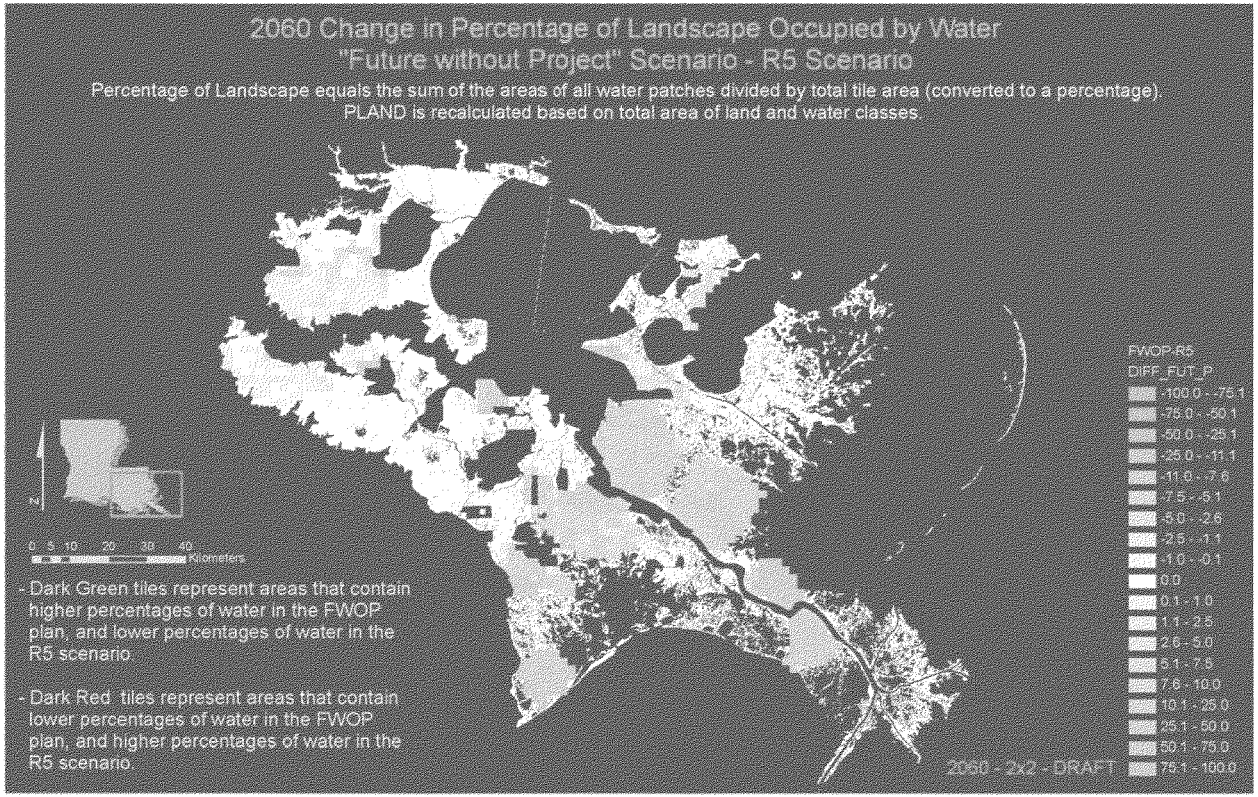


Figure 43. Percentage of landscape occupied by water metric for planning units 1 and 2 showing difference between future without project and Alternative R5 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

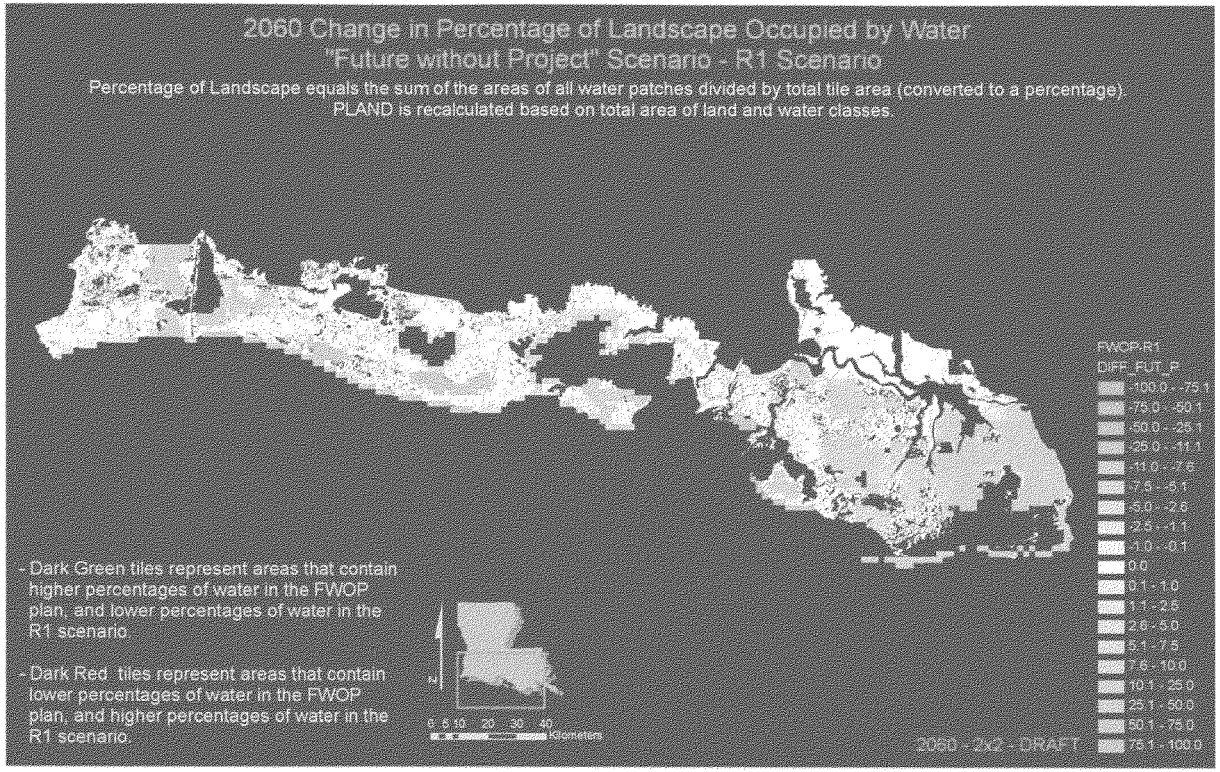


Figure 44. Percentage of landscape occupied by water metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R1 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

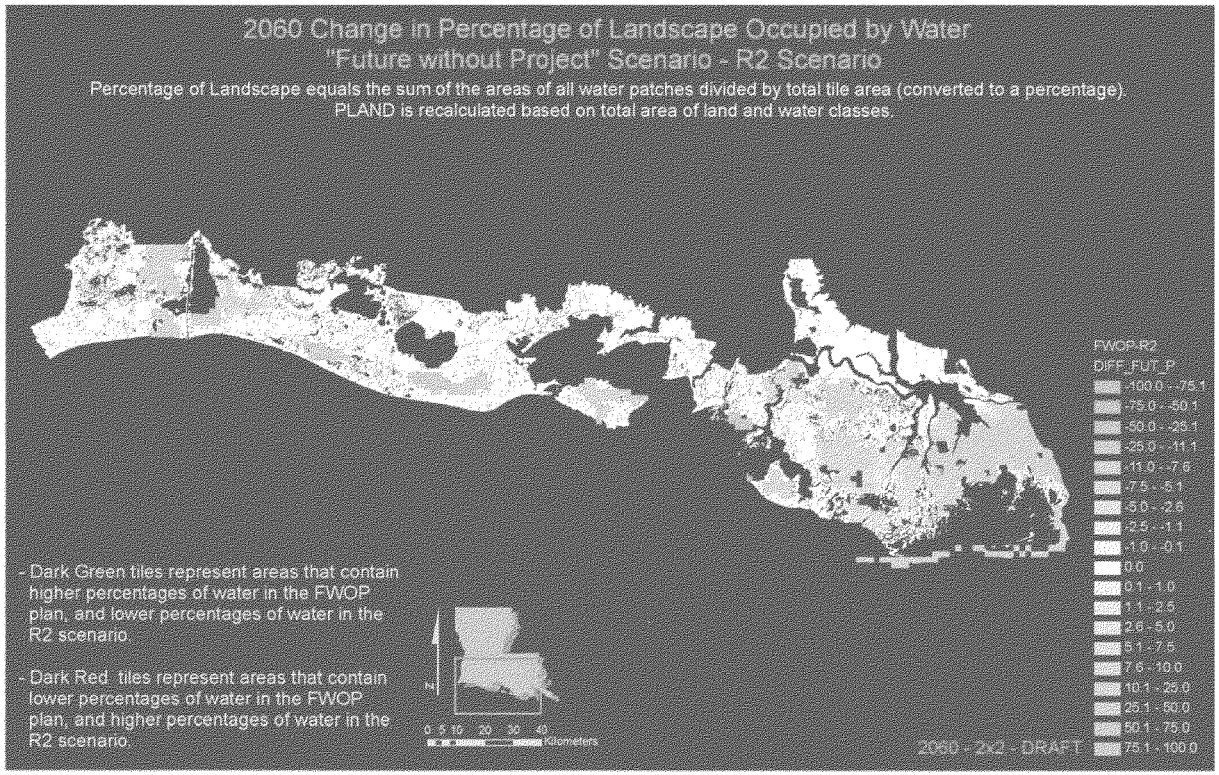


Figure 45. Percentage of landscape occupied by water metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R2 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

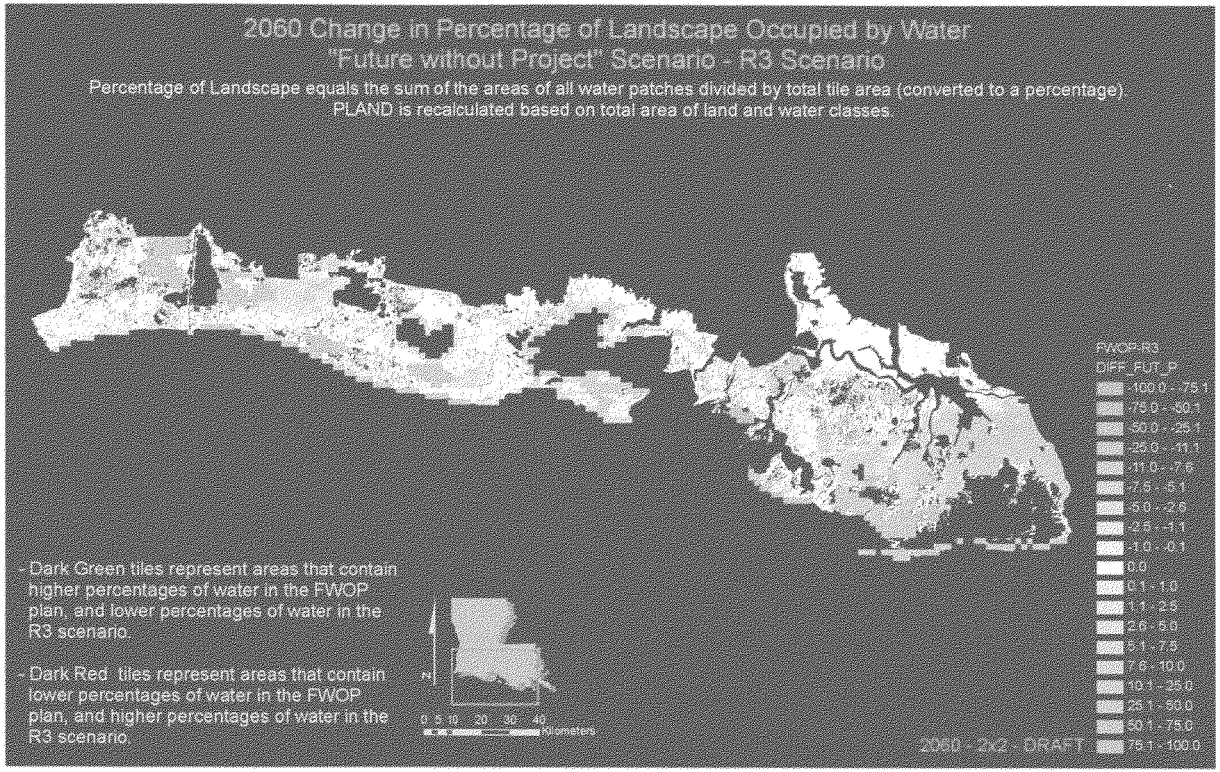


Figure 46. Percentage of landscape occupied by water metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R3 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

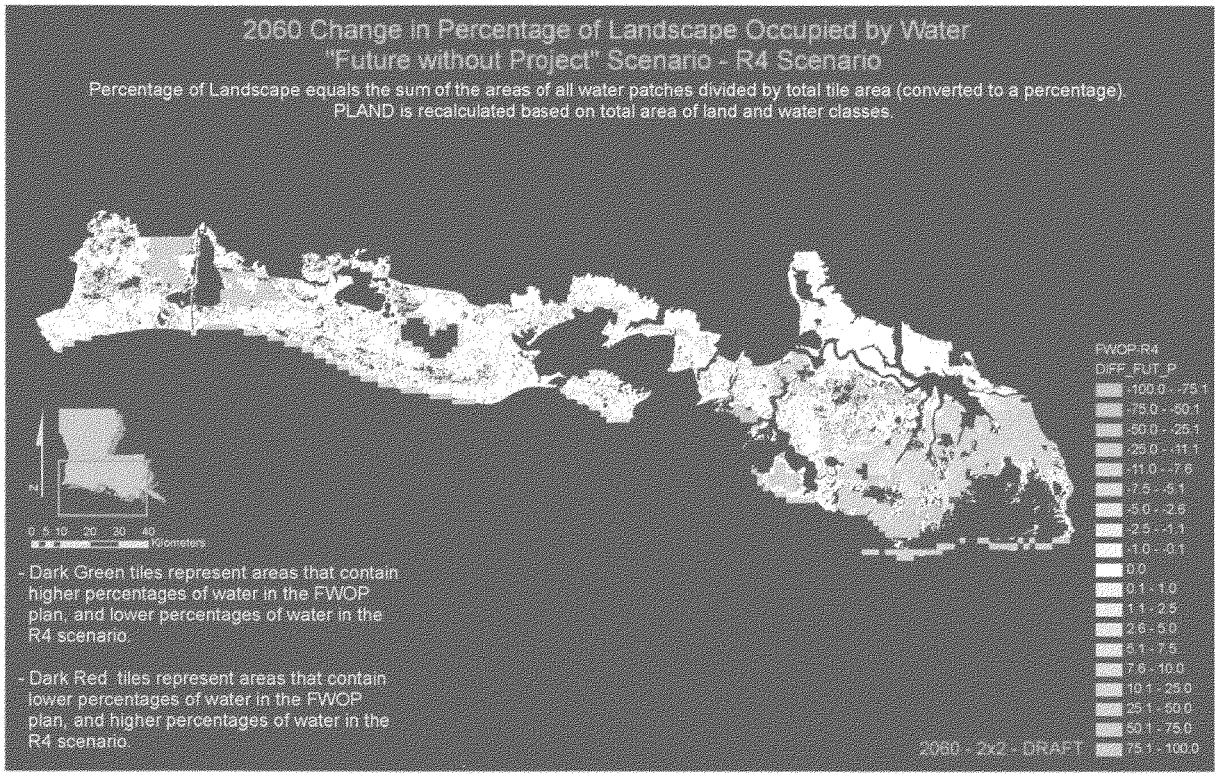


Figure 47. Percentage of landscape occupied by water metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R4 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

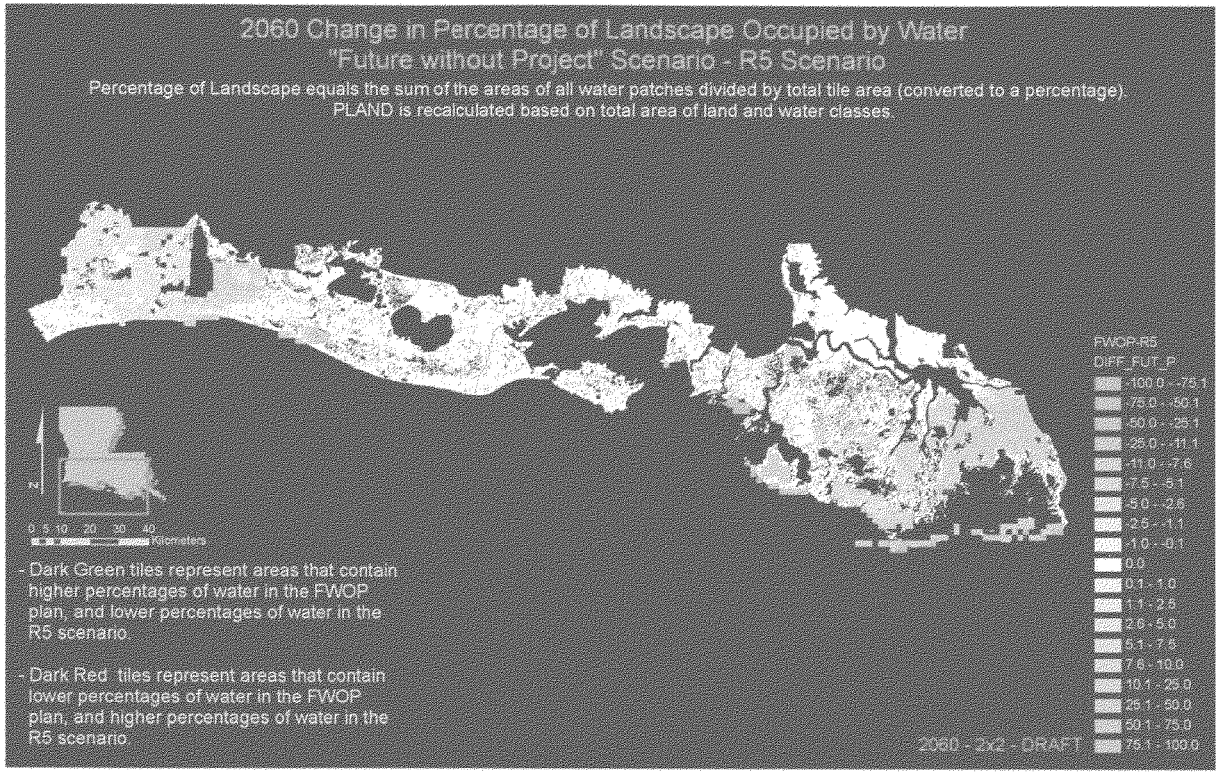


Figure 48. Percentage of landscape occupied by water metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R5 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

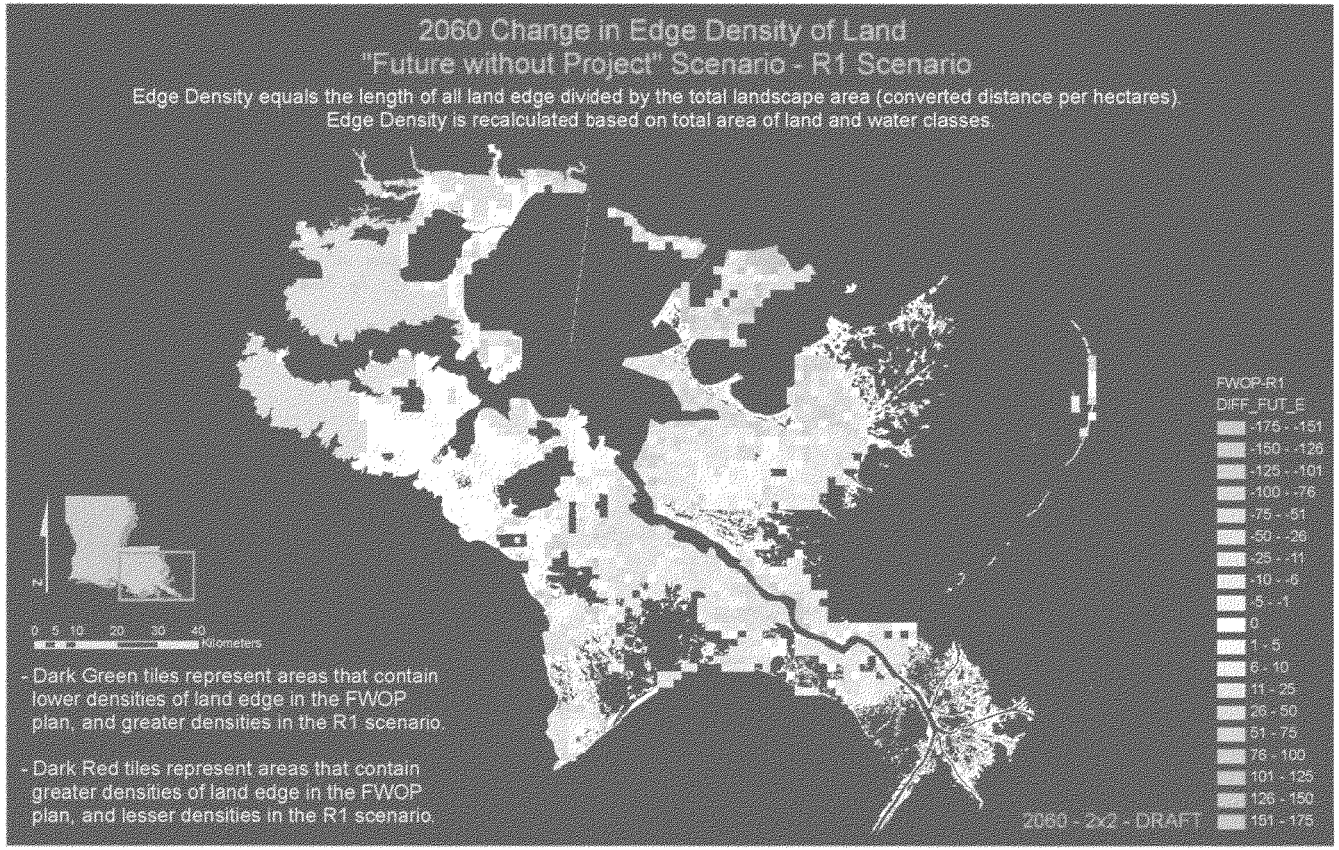


Figure 49. Edge density of land metric for planning units 1 and 2 showing difference between future without project and Alternative R1 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

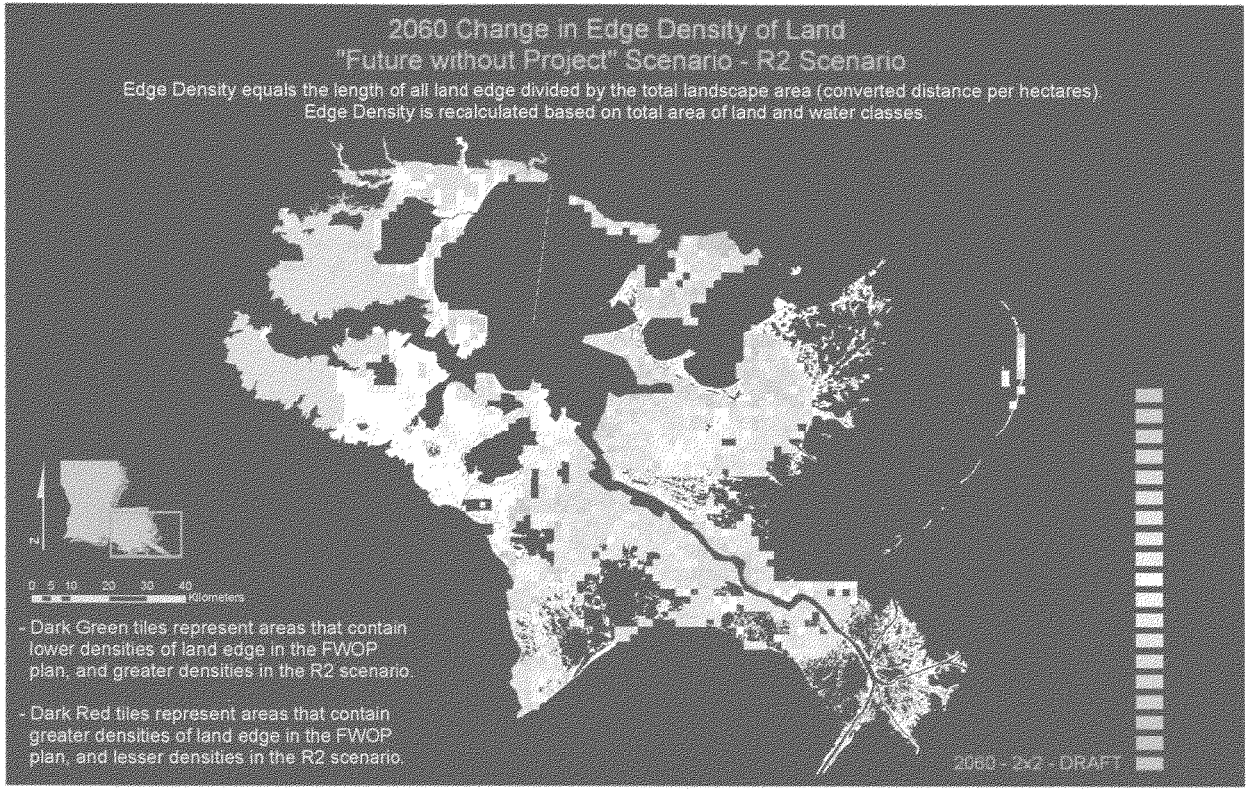


Figure 50. Edge density of land metric for planning units 1 and 2 showing difference between future without project and Alternative R2 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

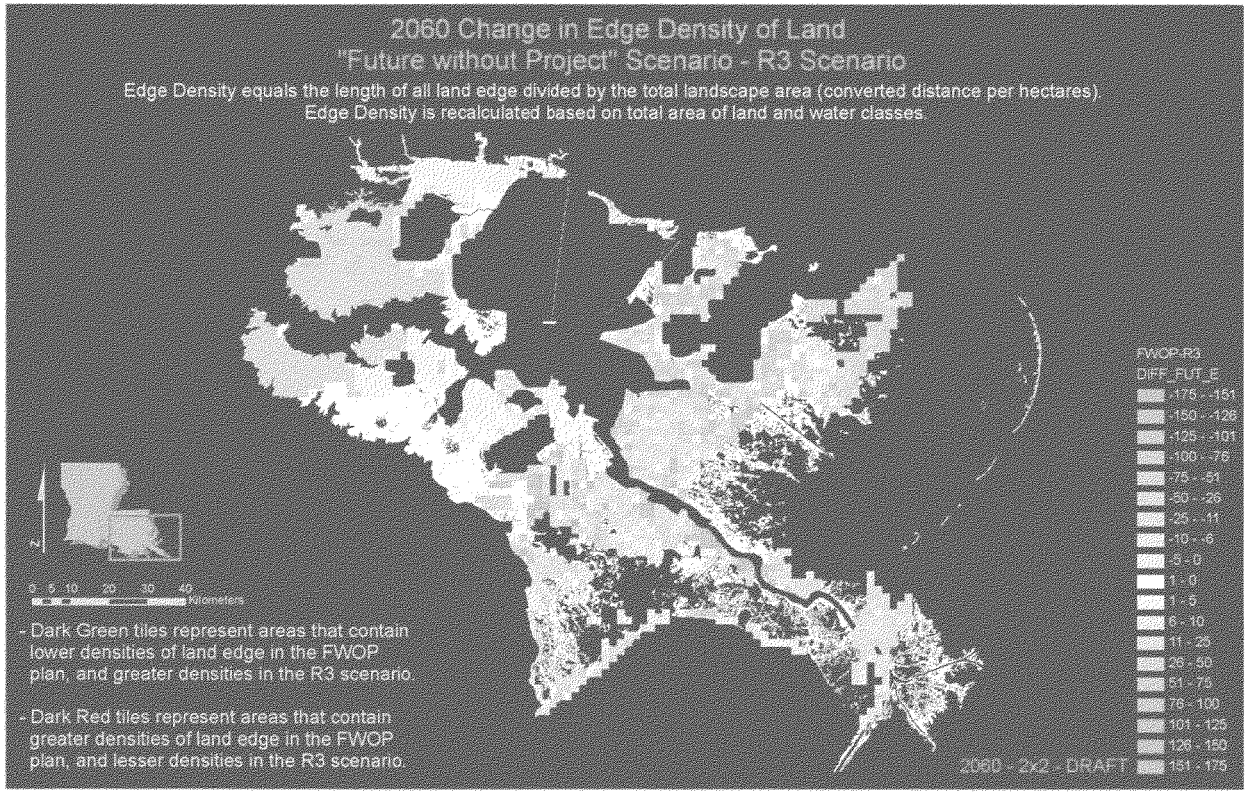


Figure 51. Edge density of land metric for planning units 1 and 2 showing difference between future without project and Alternative R3 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

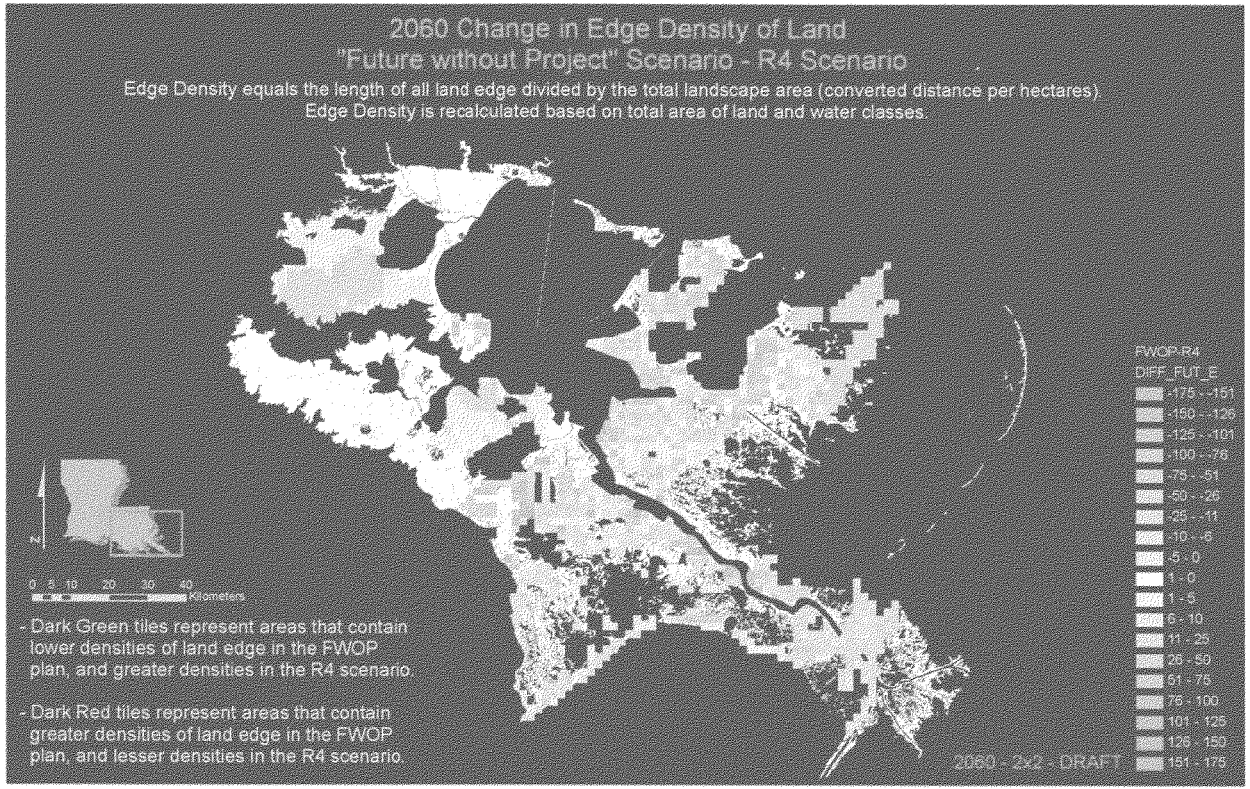


Figure 52. Edge density of land metric for planning units 1 and 2 showing difference between future without project and Alternative R4 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

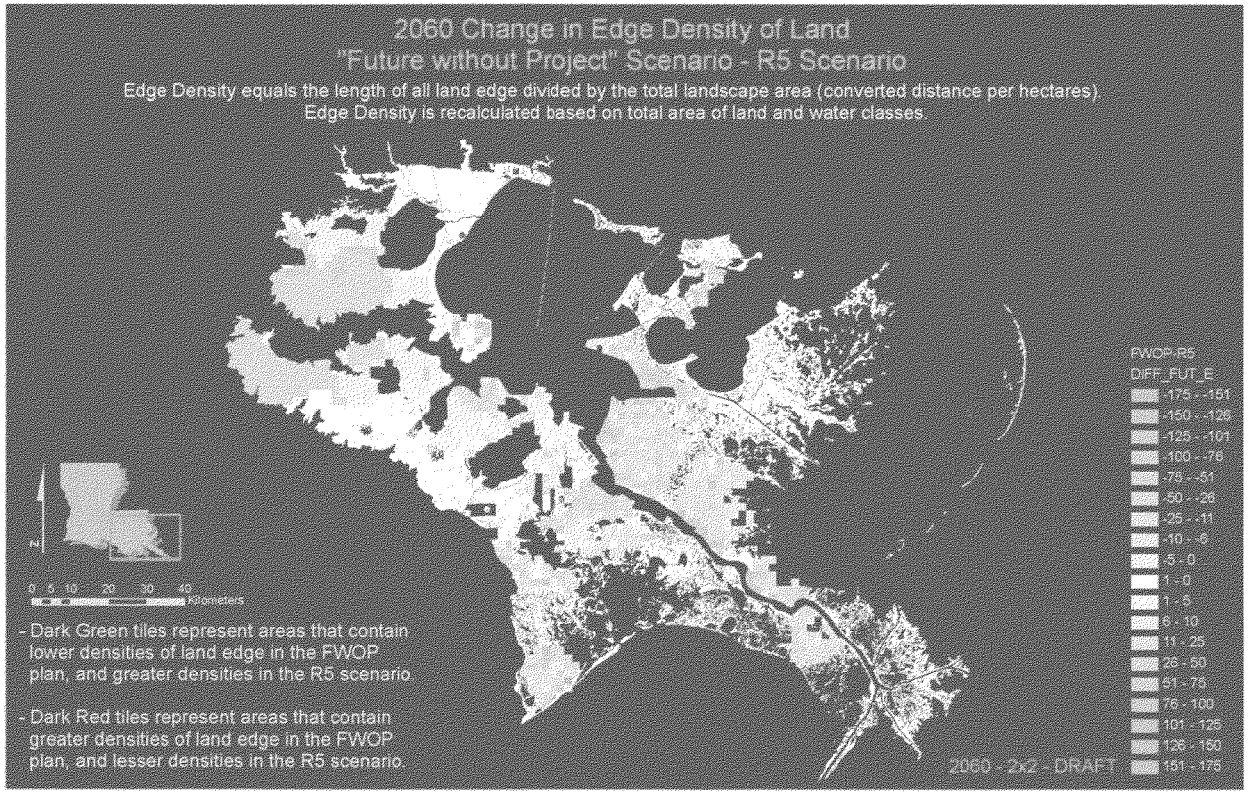


Figure 53. Edge density of land metric for planning units 1 and 2 showing difference between future without project and Alternative R5 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

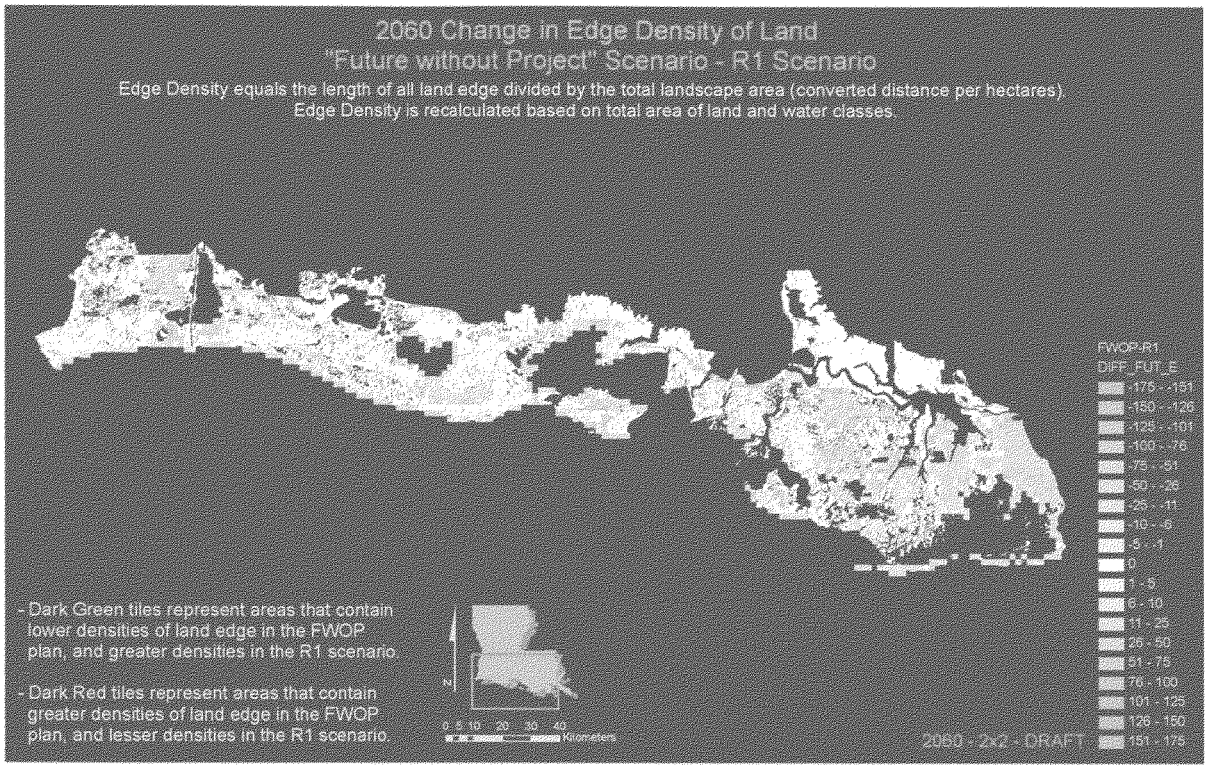


Figure 54. Edge density of land metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R1 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

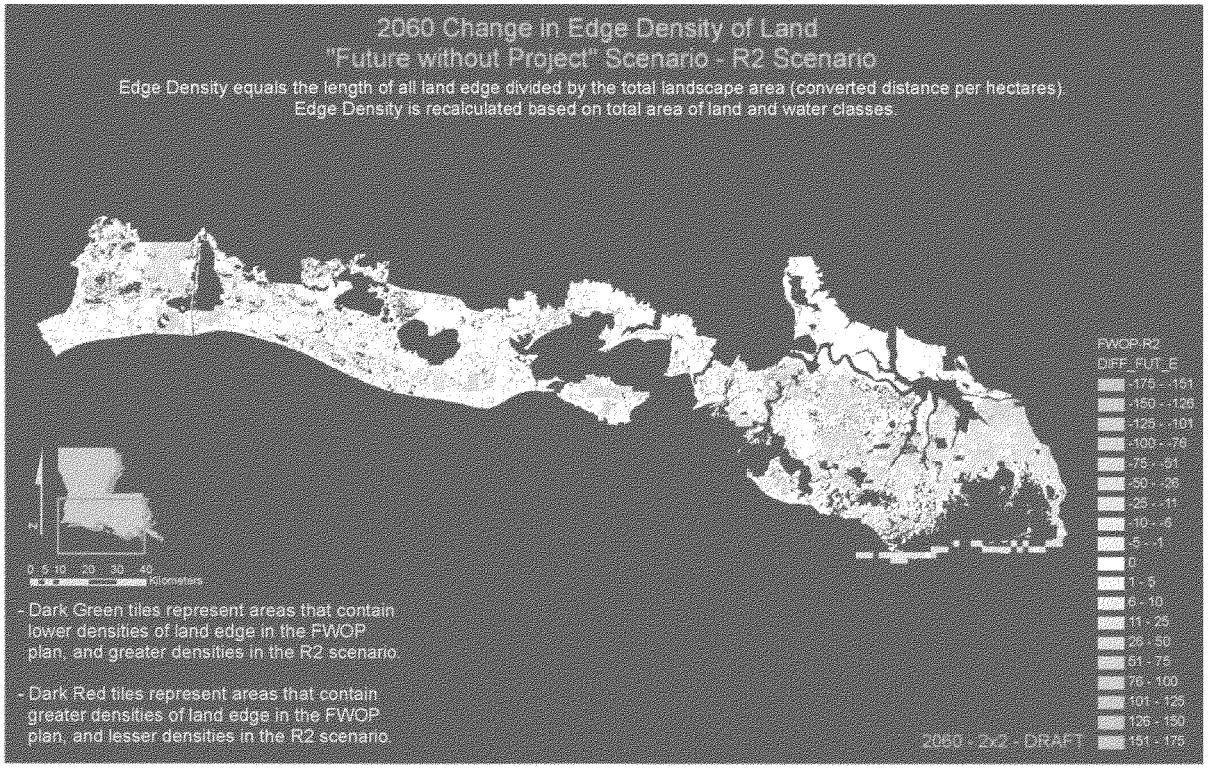


Figure 55. Edge density of land metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R2 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

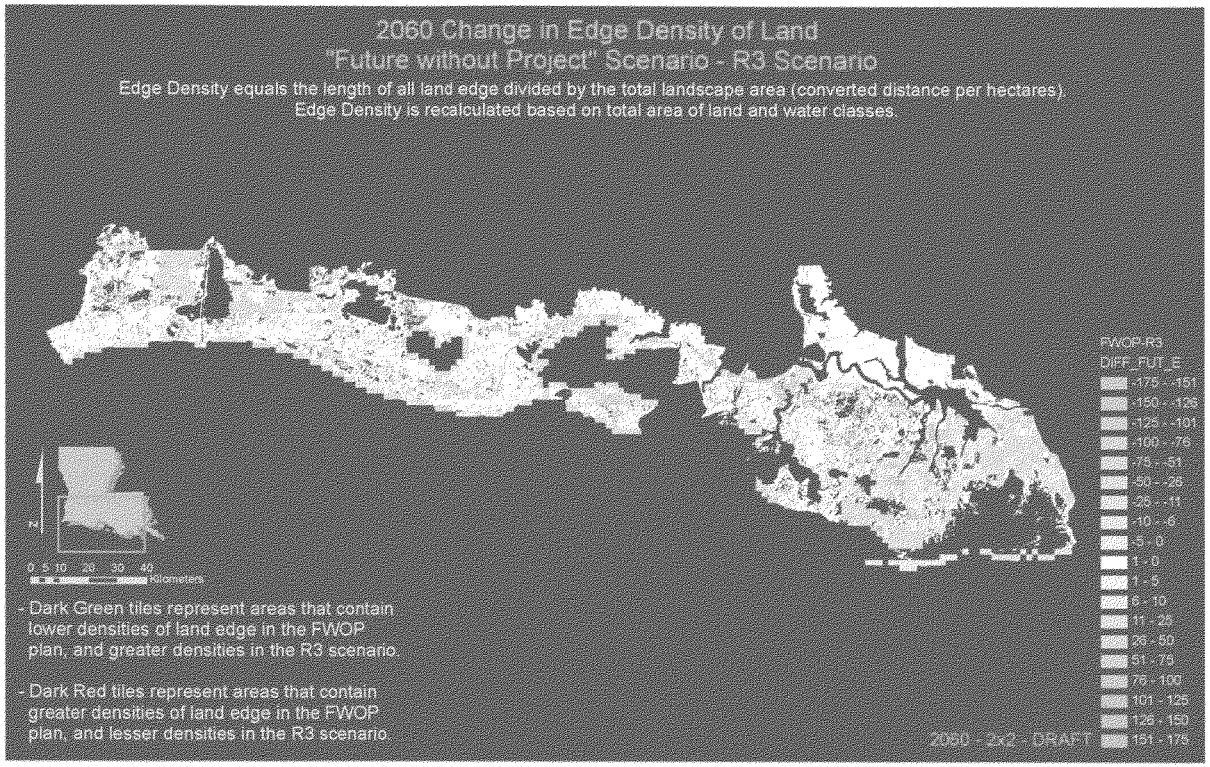


Figure 56. Edge density of land metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R3 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

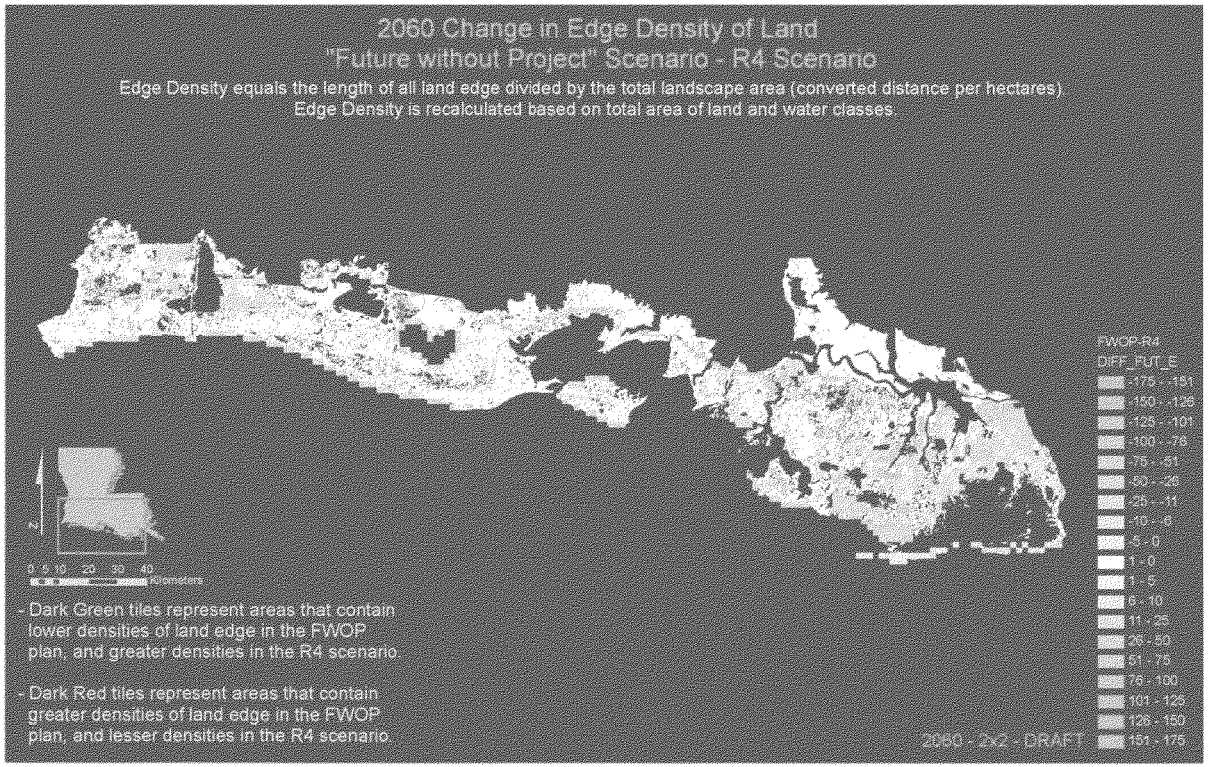


Figure 57. Edge density of land metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R4 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

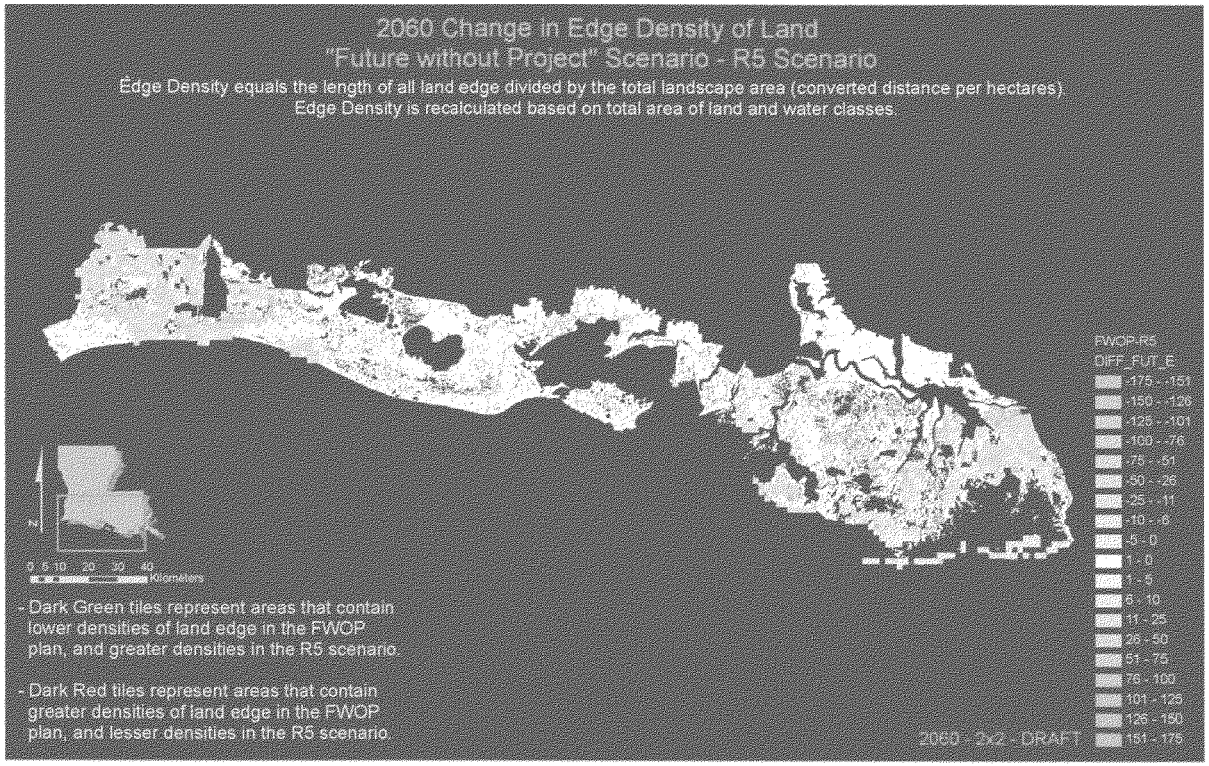


Figure 58. Edge density of land metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R5 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

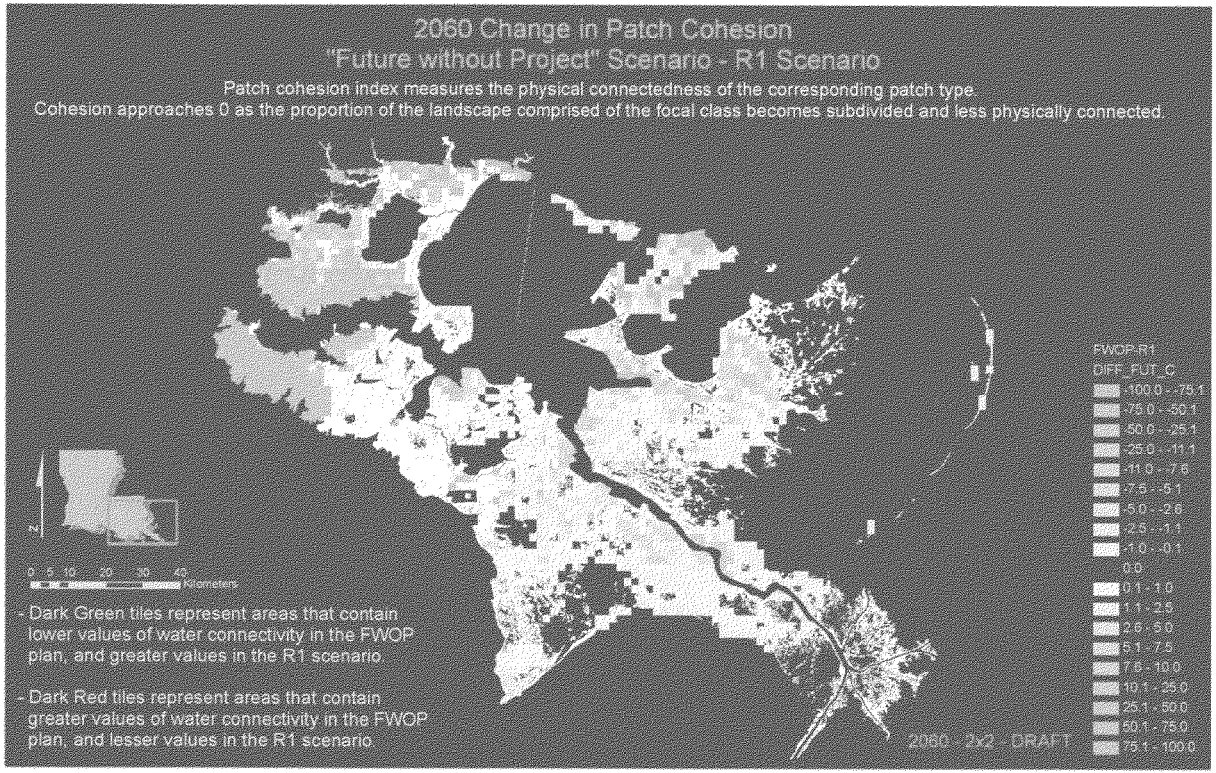


Figure 59. Patch cohesion metric for planning units 1 and 2 showing difference between future without project and Alternative R1 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

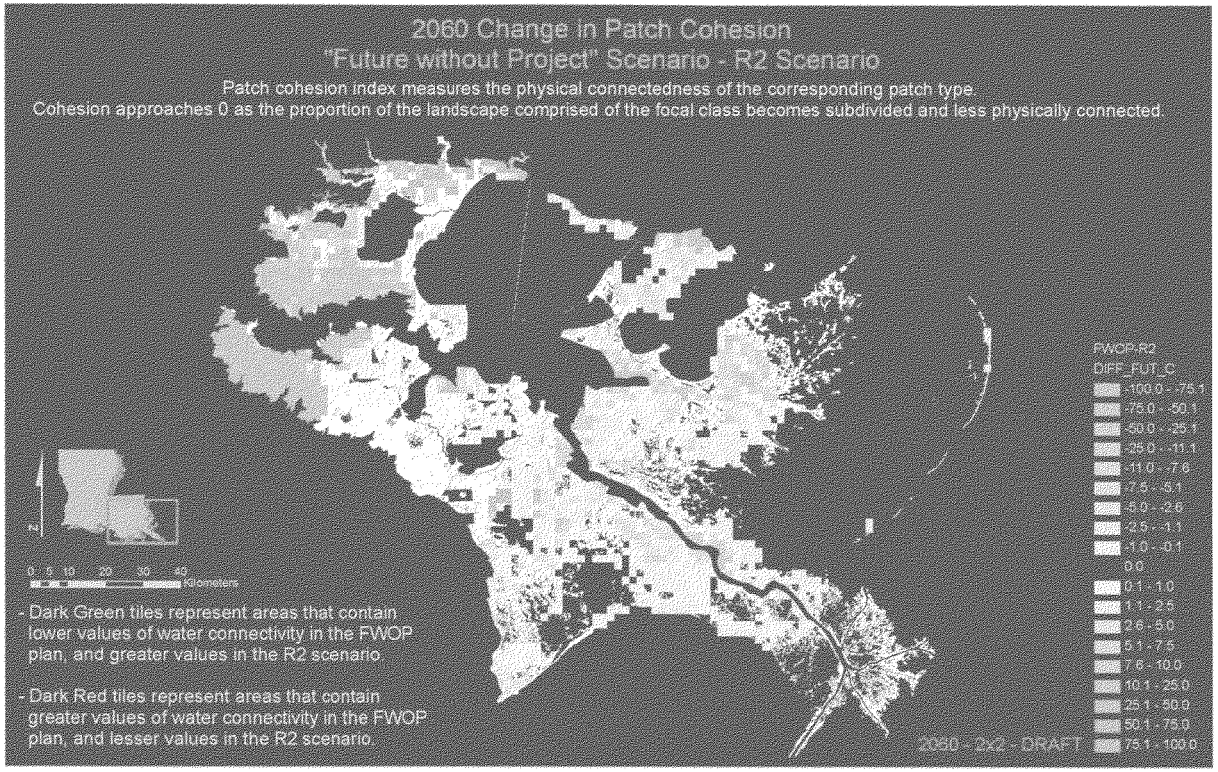


Figure 60. Patch cohesion metric for planning units 1 and 2 showing difference between future without project and Alternative R2 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

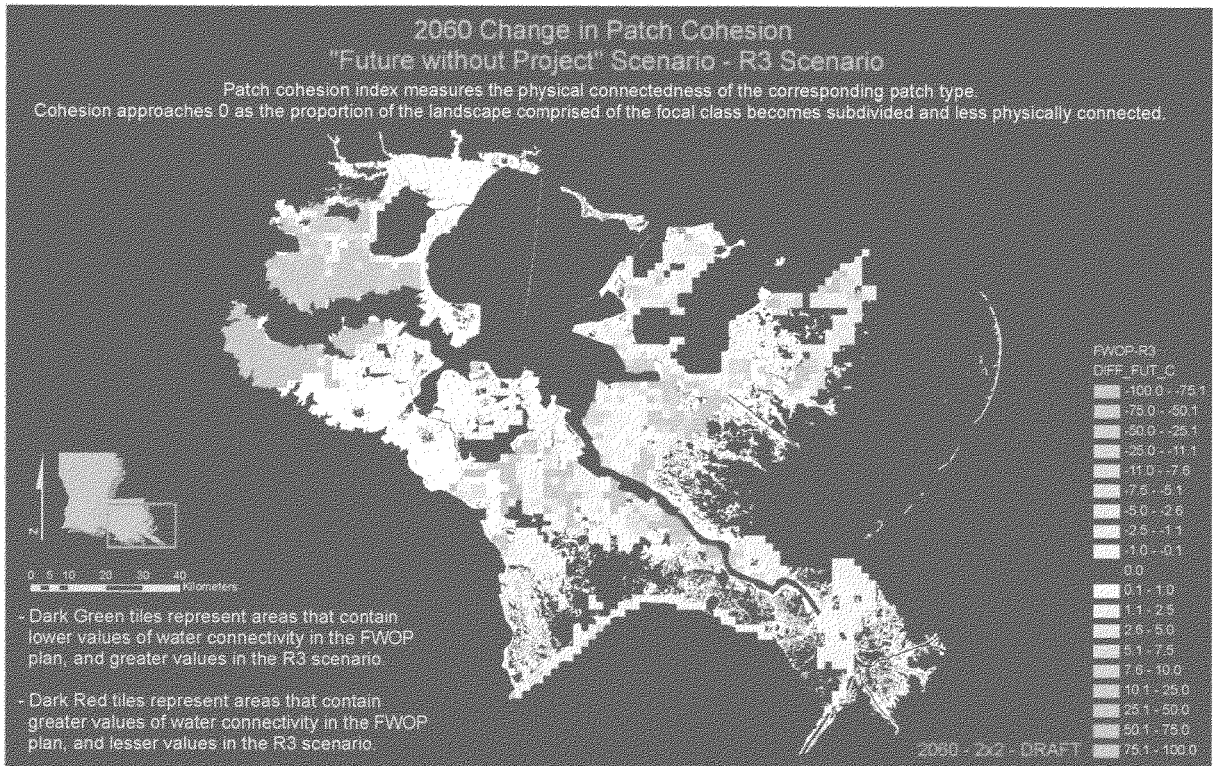


Figure 61. Patch cohesion metric for planning units 1 and 2 showing difference between future without project and Alternative R3 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

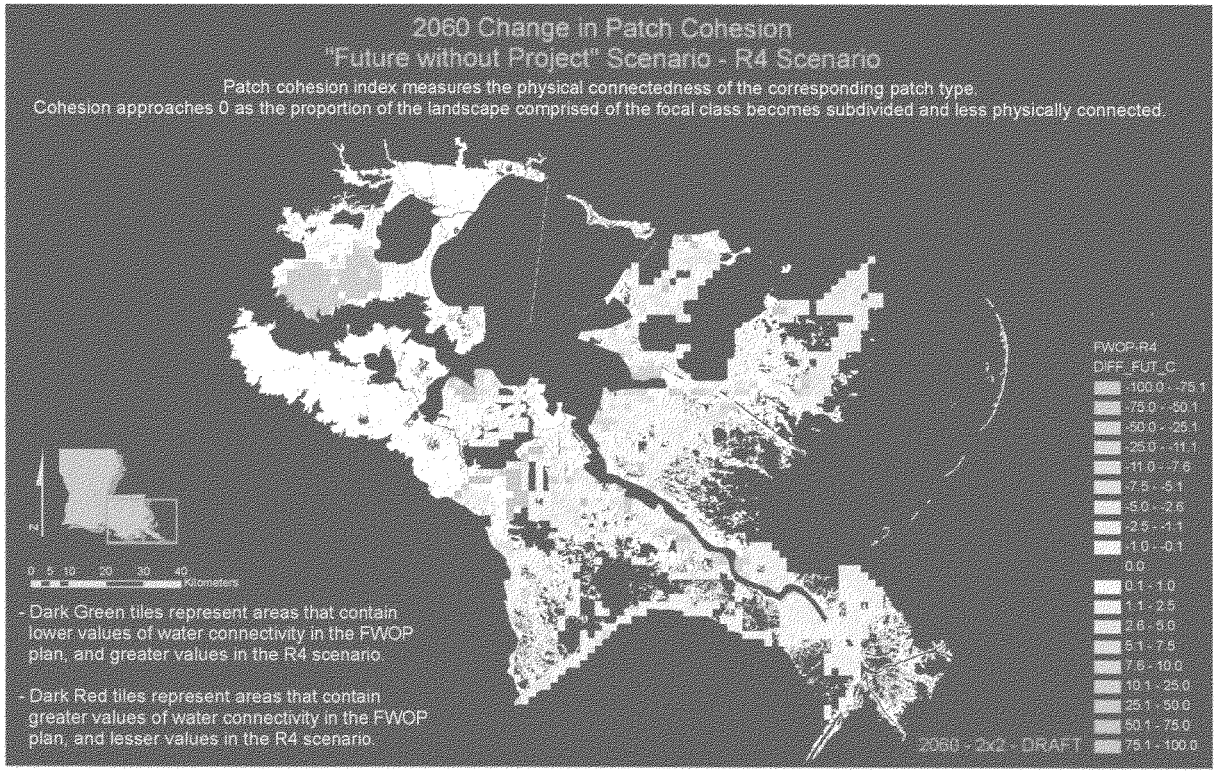


Figure 62. Patch cohesion metric for planning units 1 and 2 showing difference between future without project and Alternative R4 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

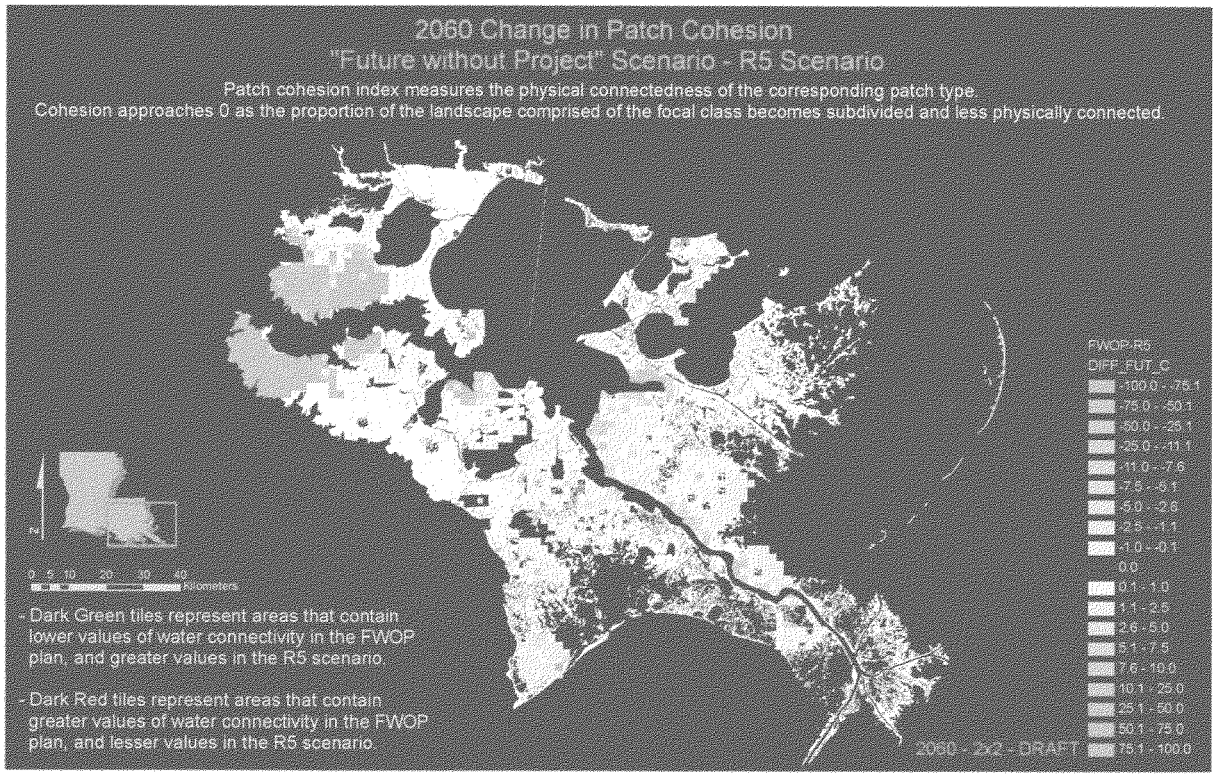


Figure 63. Patch cohesion metric for planning units 1 and 2 showing difference between future without project and Alternative R5 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

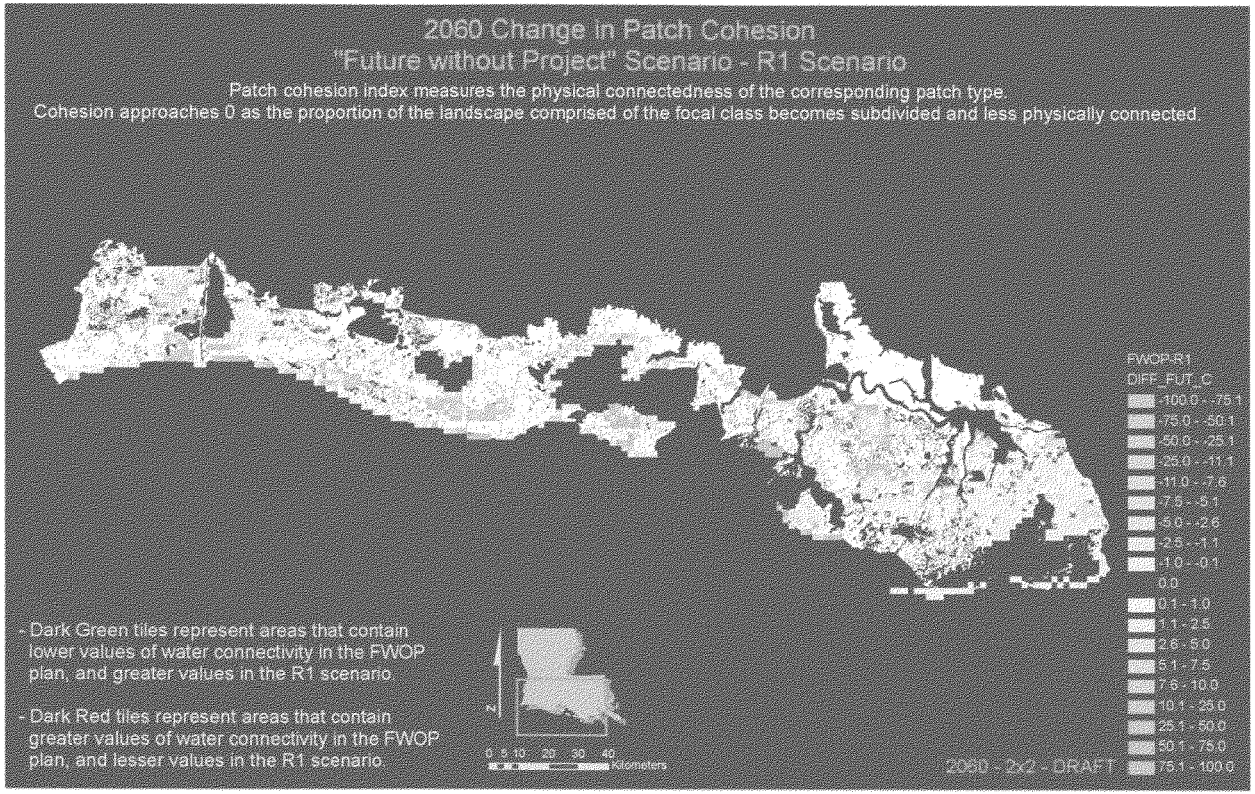


Figure 64. Patch cohesion metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R1 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

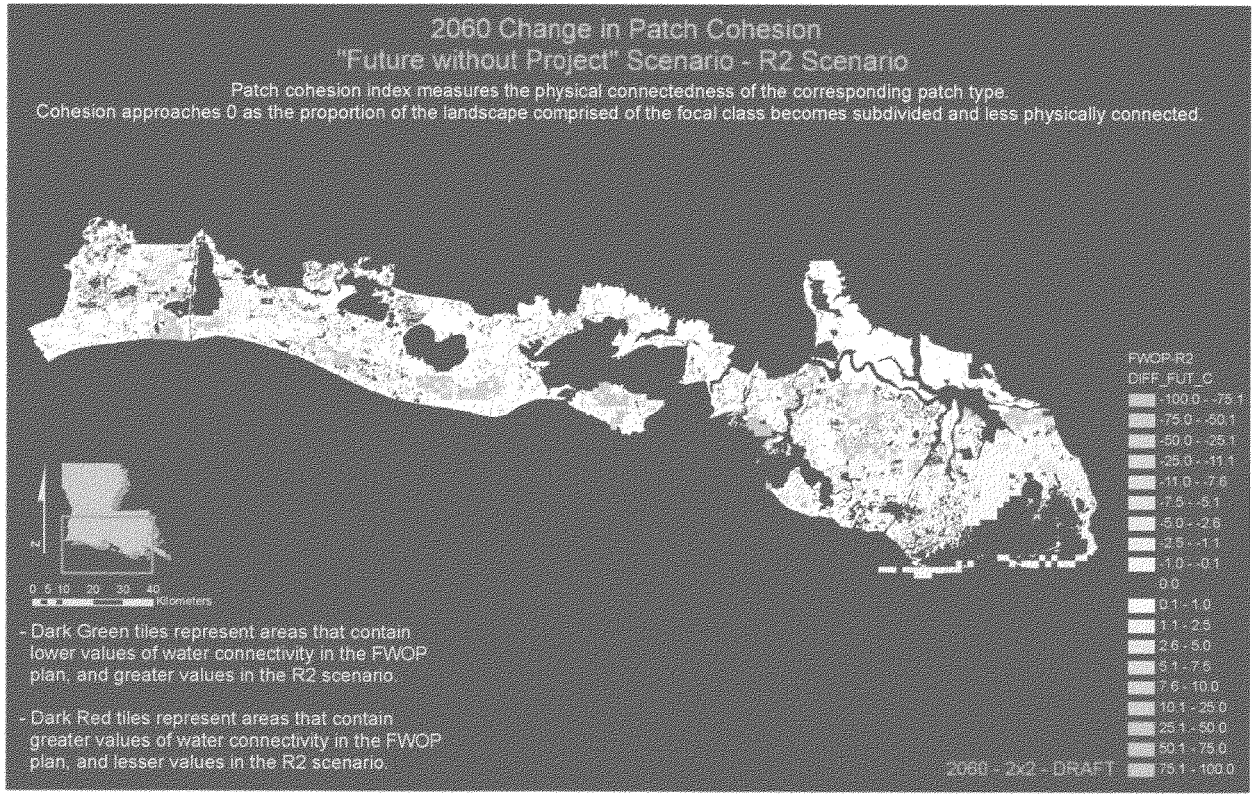


Figure 65. Patch cohesion metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R2 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

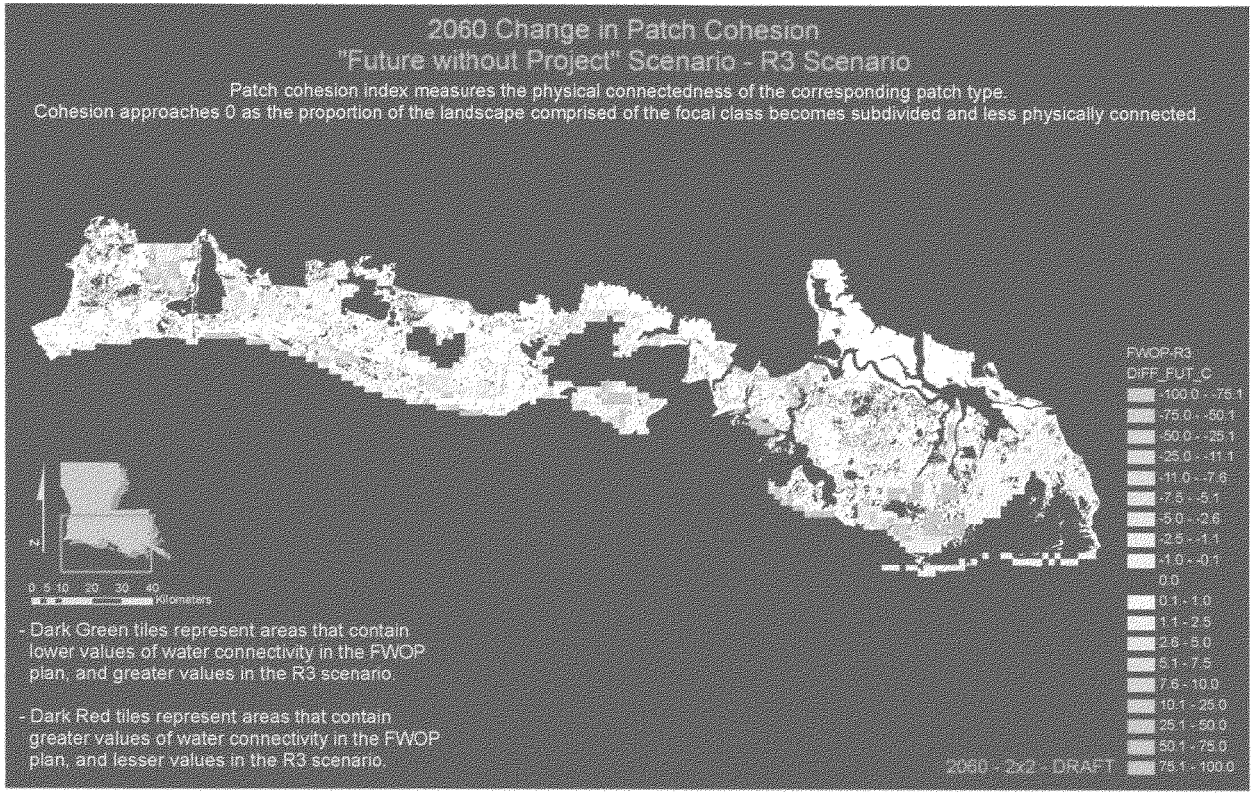


Figure 66. Patch cohesion metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R3 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

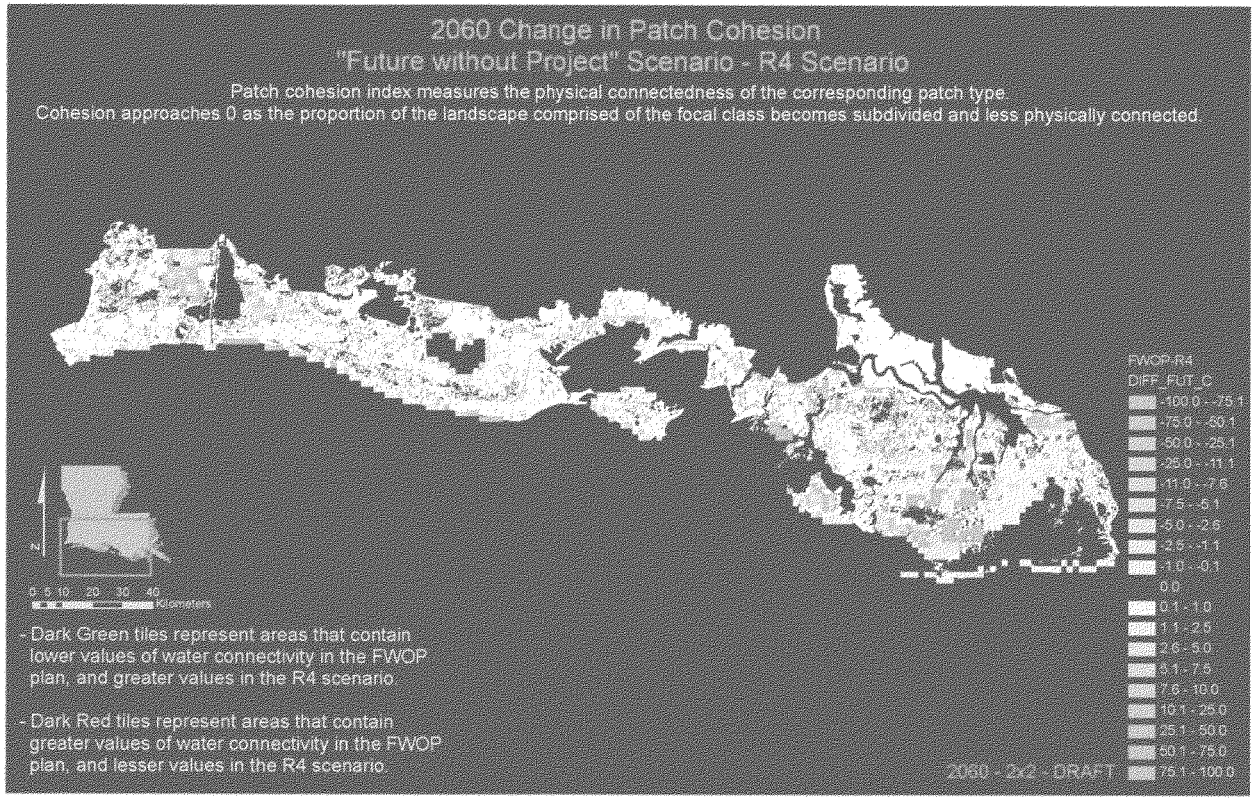


Figure 67. Patch cohesion metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R4 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

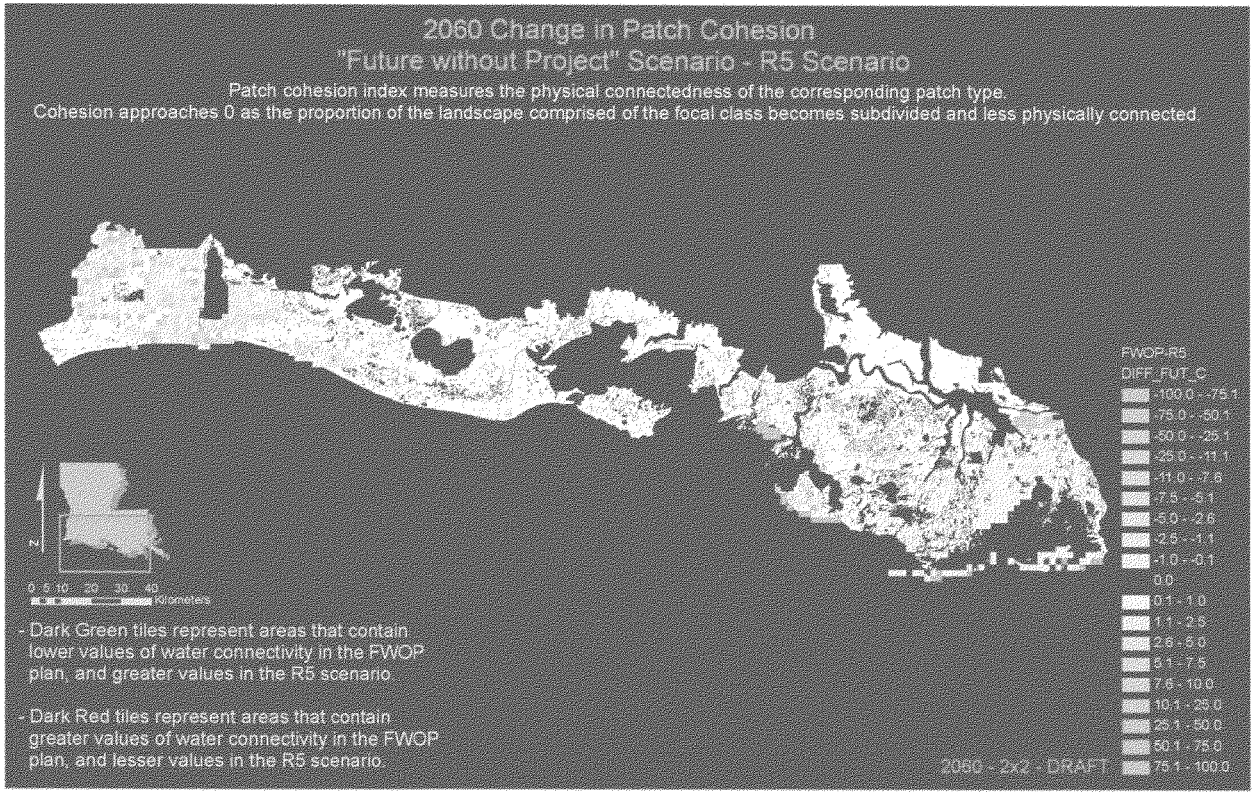


Figure 68. Patch cohesion metric for planning units 3a, 3b and 4 showing difference between future without project and Alternative R5 at 2060. Colored areas reflect influences of specific measures that comprise alternative.

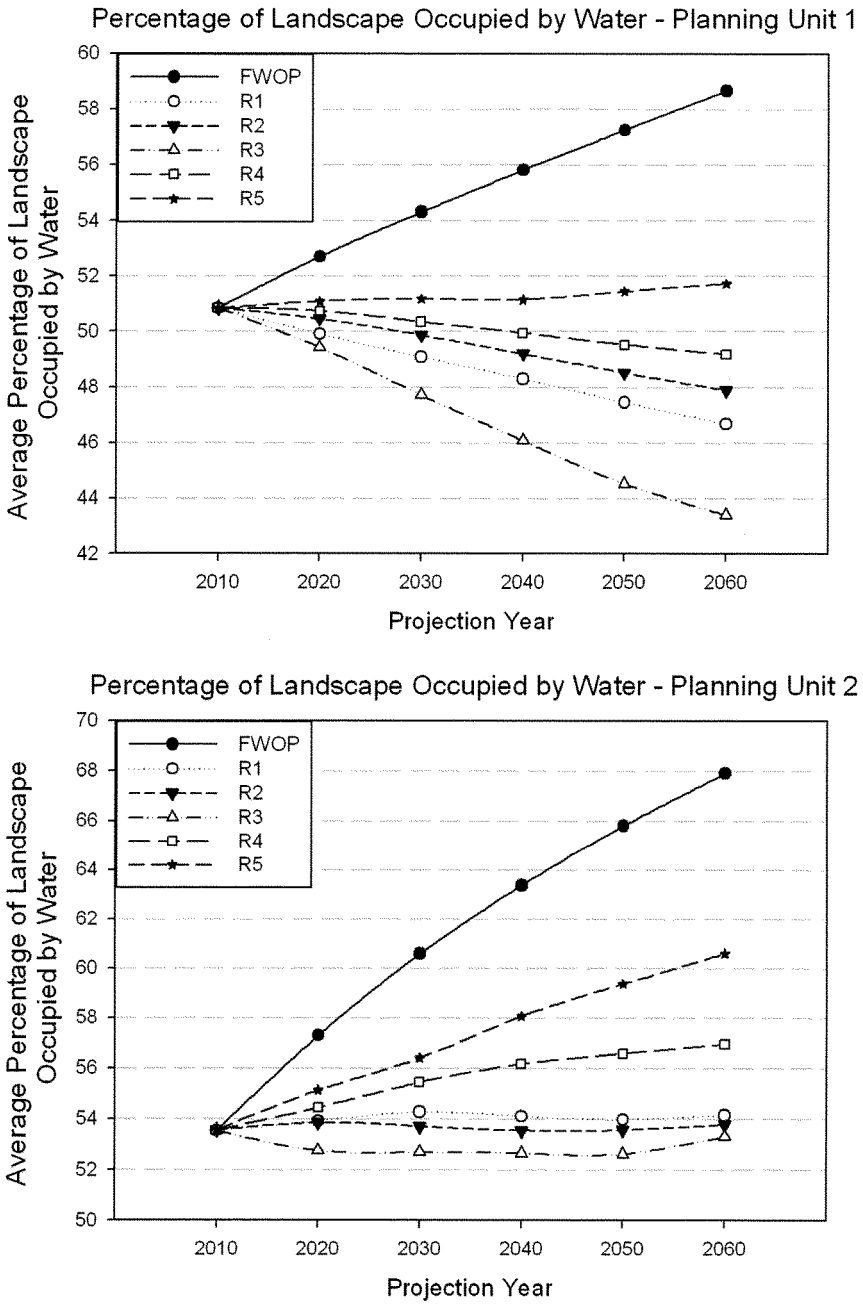


Figure 69. Projections of change in average percent of landscape occupied by water metric among alternatives from 2010 to 2060 in planning units 1 and 2.

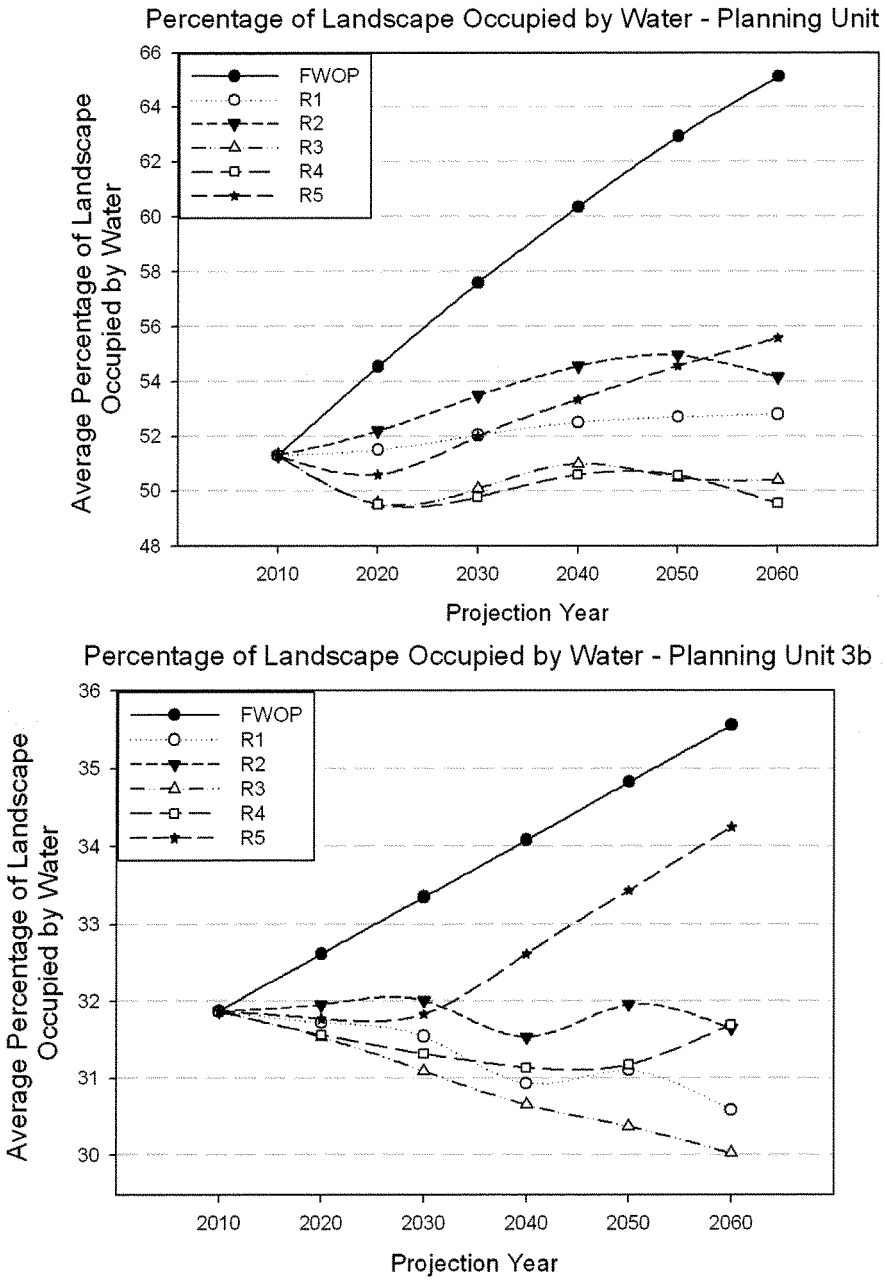


Figure 70a. Projections of change in average percent of landscape occupied by water metric among alternatives from 2010 to 2060 in planning units 3a and 3b.

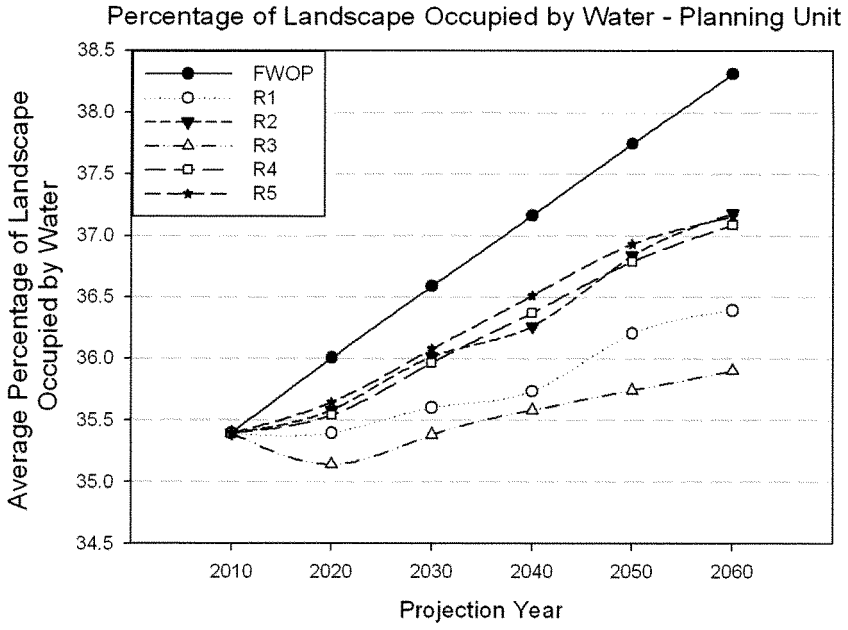


Figure 70b. Projections of change in average percent of landscape occupied by water metric among alternatives from 2010 to 2060 in planning unit 4.

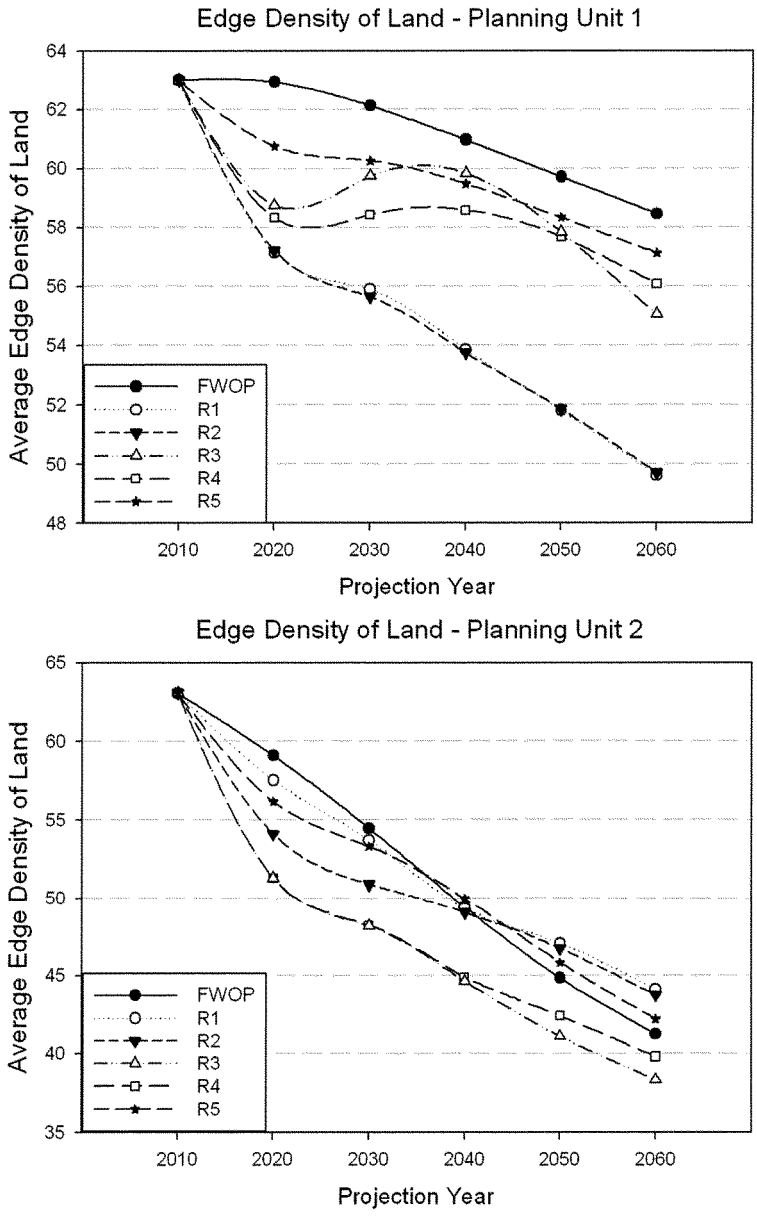


Figure 71. Projections of change in edge density of land metric among alternatives from 2010 to 2060 in planning units 1 and 2.

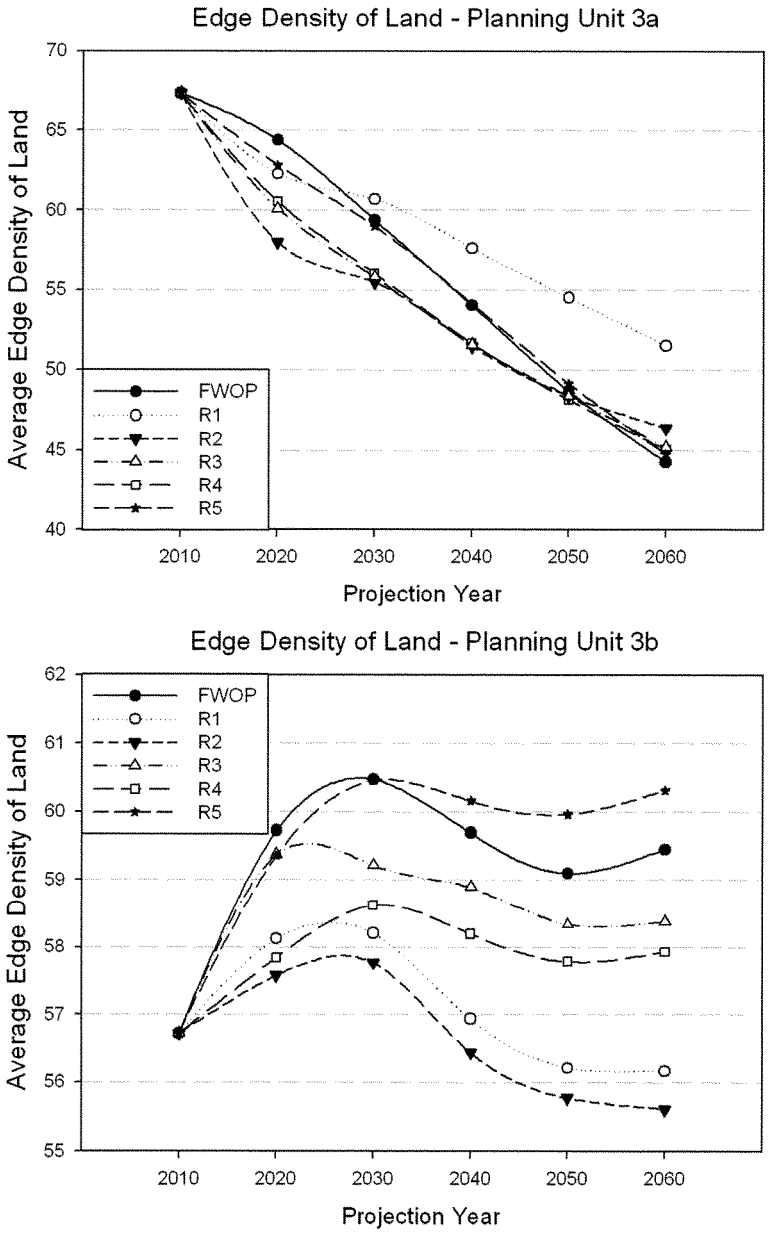


Figure 72a. Projections of change in edge density of land metric among alternatives from 2010 to 2060 in planning units 3a and 3b.

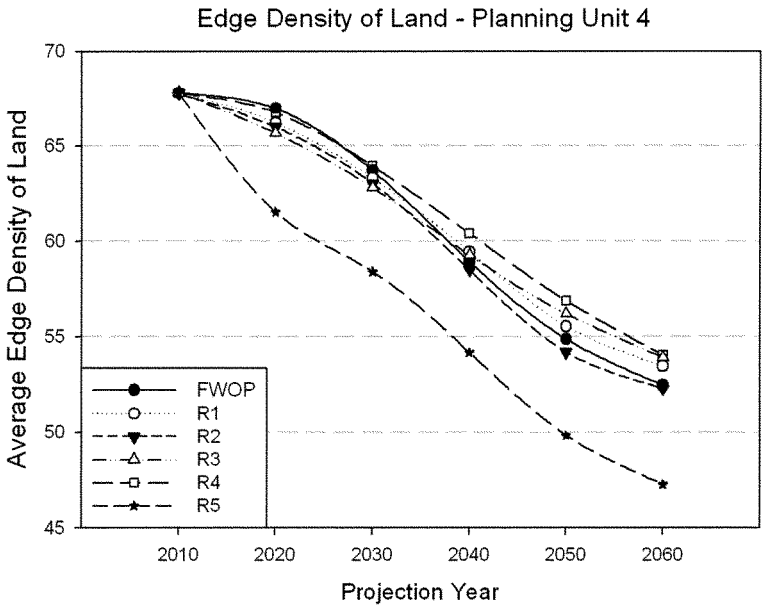


Figure 72b. Projections of change in edge density of land metric among alternatives from 2010 to 2060 in planning unit 4.

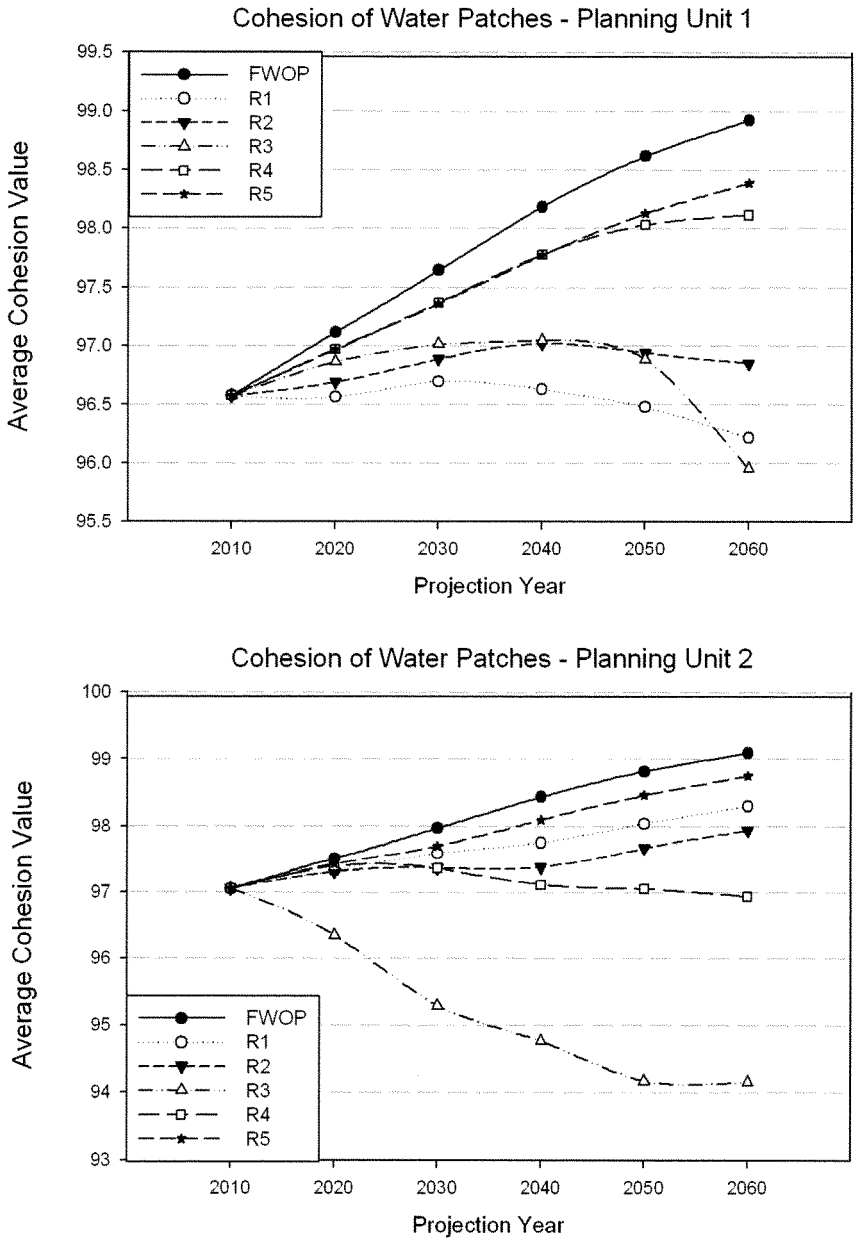


Figure 73. Projections of change in patch cohesion of water metric among alternatives from 2010 to 2060 in planning units 1 and 2.

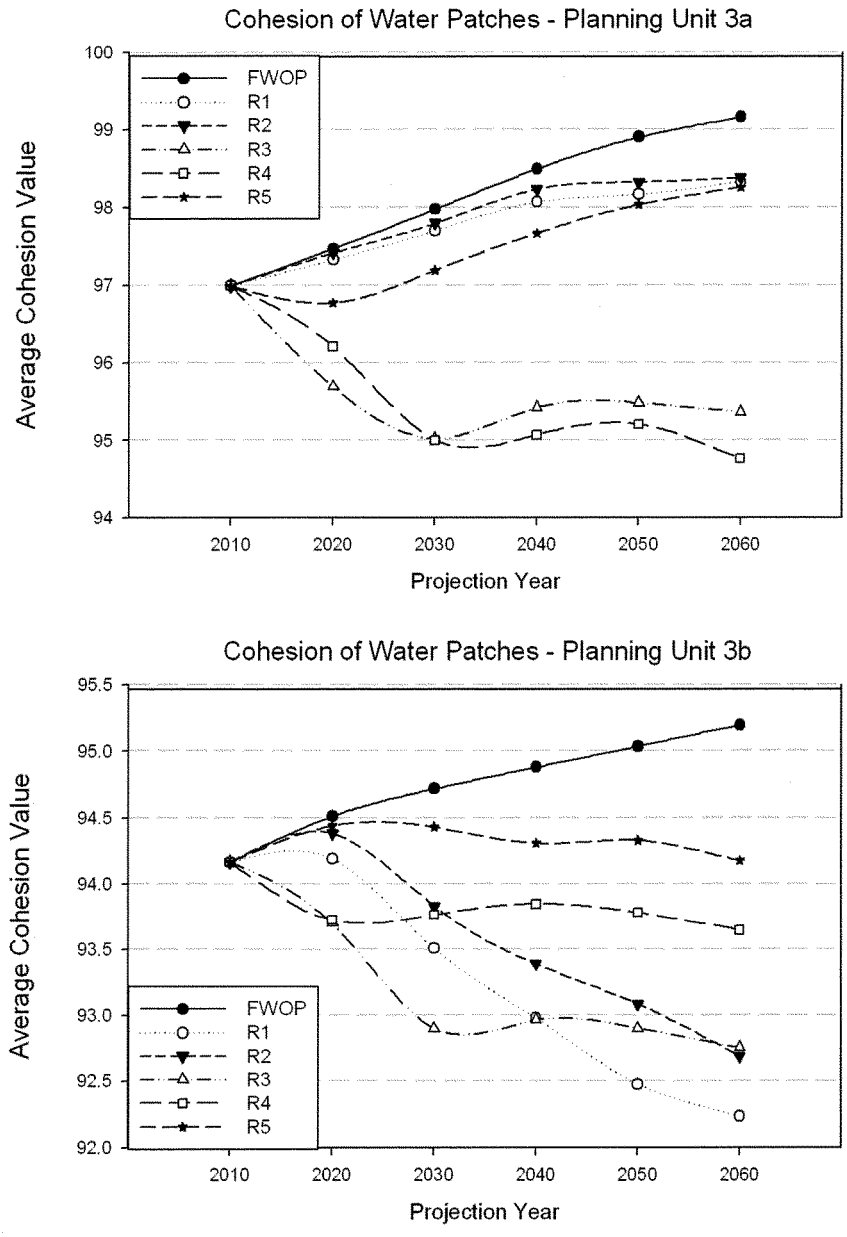


Figure 74a. Projections of change in patch cohesion of water metric among alternatives from 2010 to 2060 in planning units 3a and 3b.

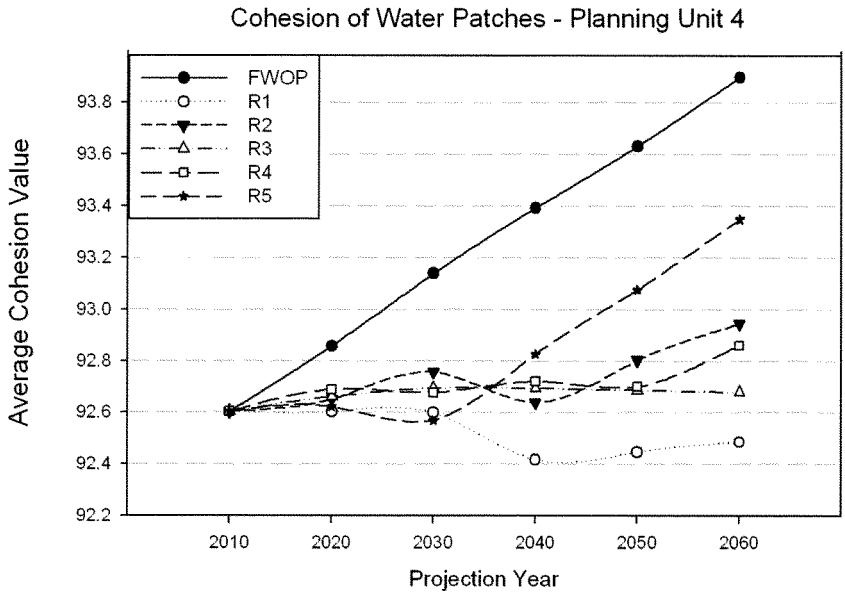


Figure 74b. Projections of change in patch cohesion of water metric among alternatives from 2010 to 2060 in planning unit 4.

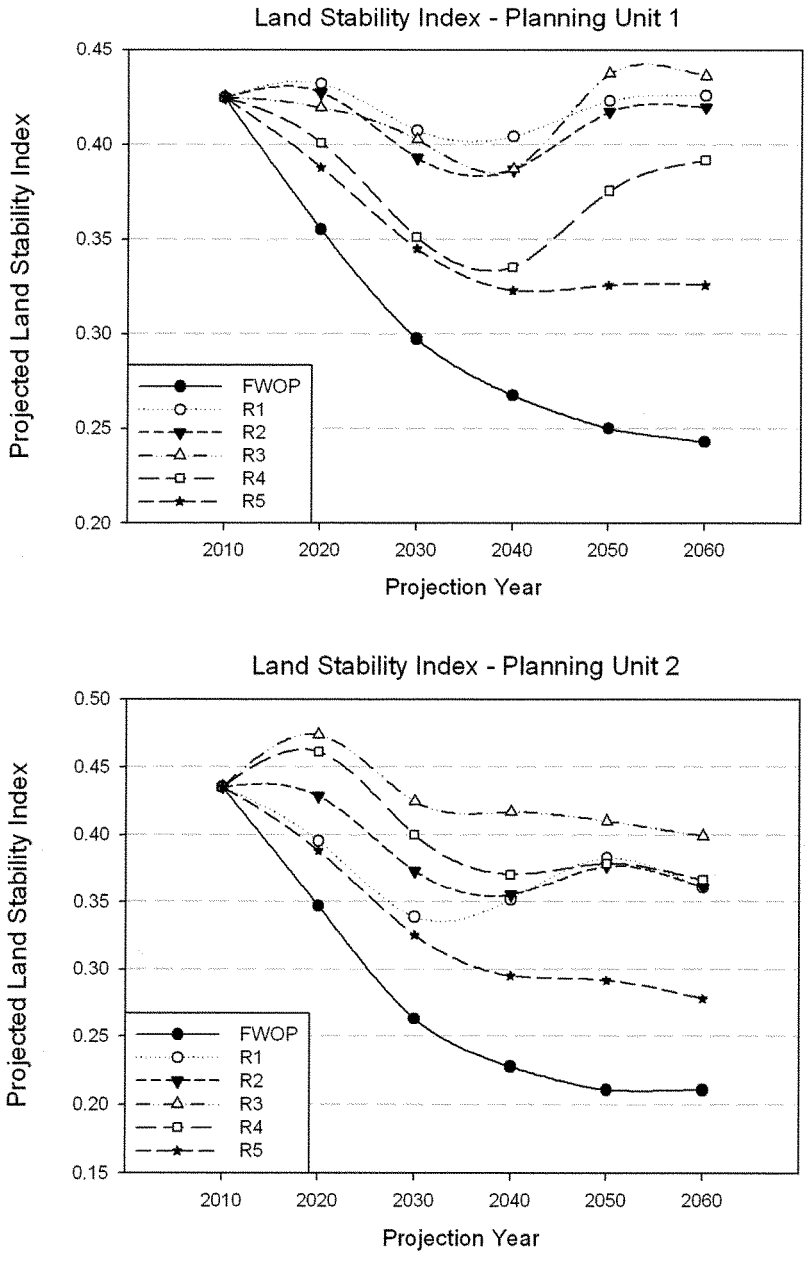


Figure 75. Projections of change in a land stability index among alternatives from 2010 to 2060 in planning units 1 and 2.

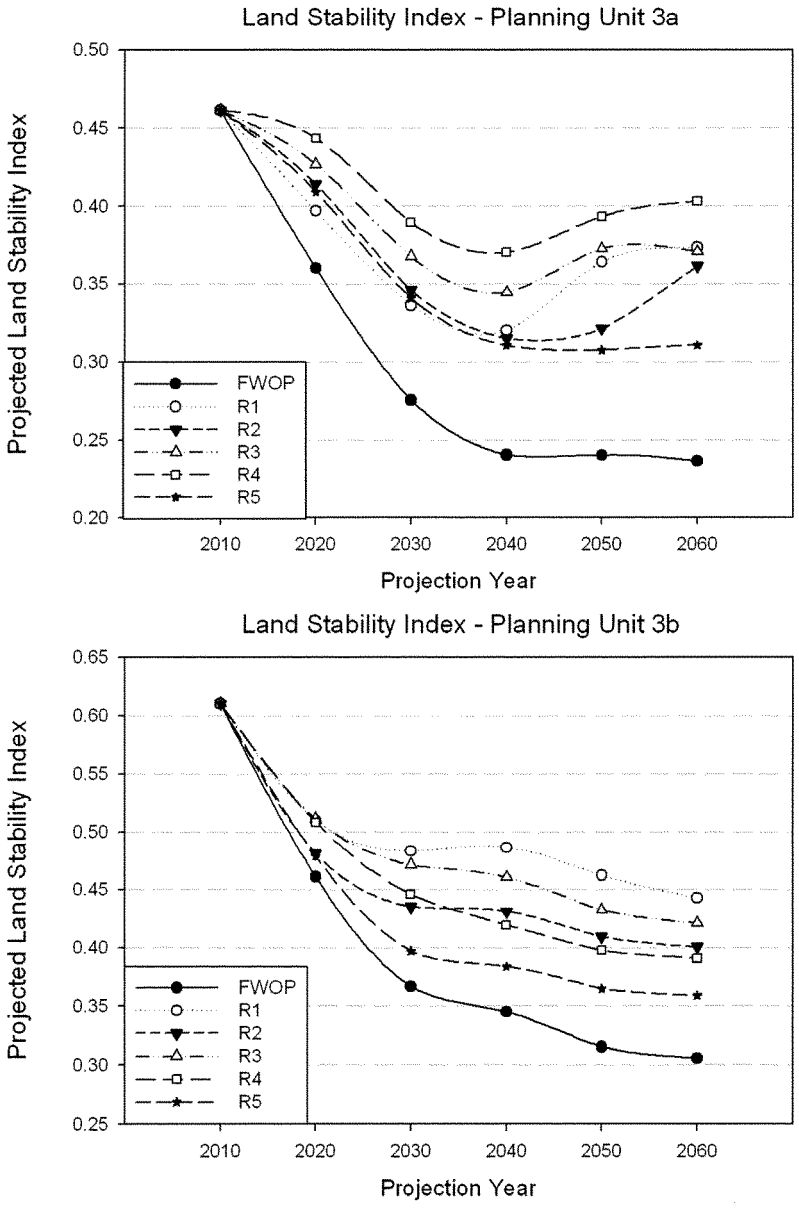


Figure 76a. Projections of change in a land stability index among alternatives from 2010 to 2060 in planning units 3a and 3b.

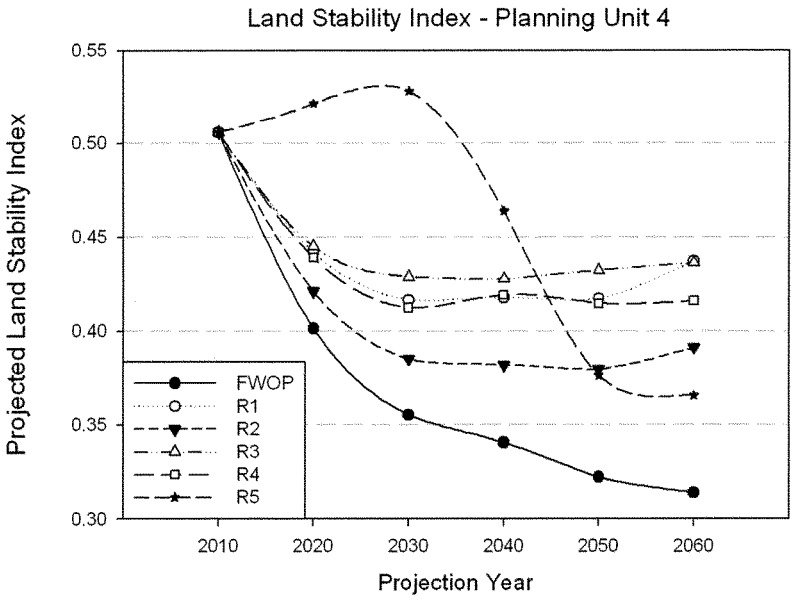


Figure 76b. Projections of change in a land stability index among alternatives from 2010 to 2060 in planning unit 4.

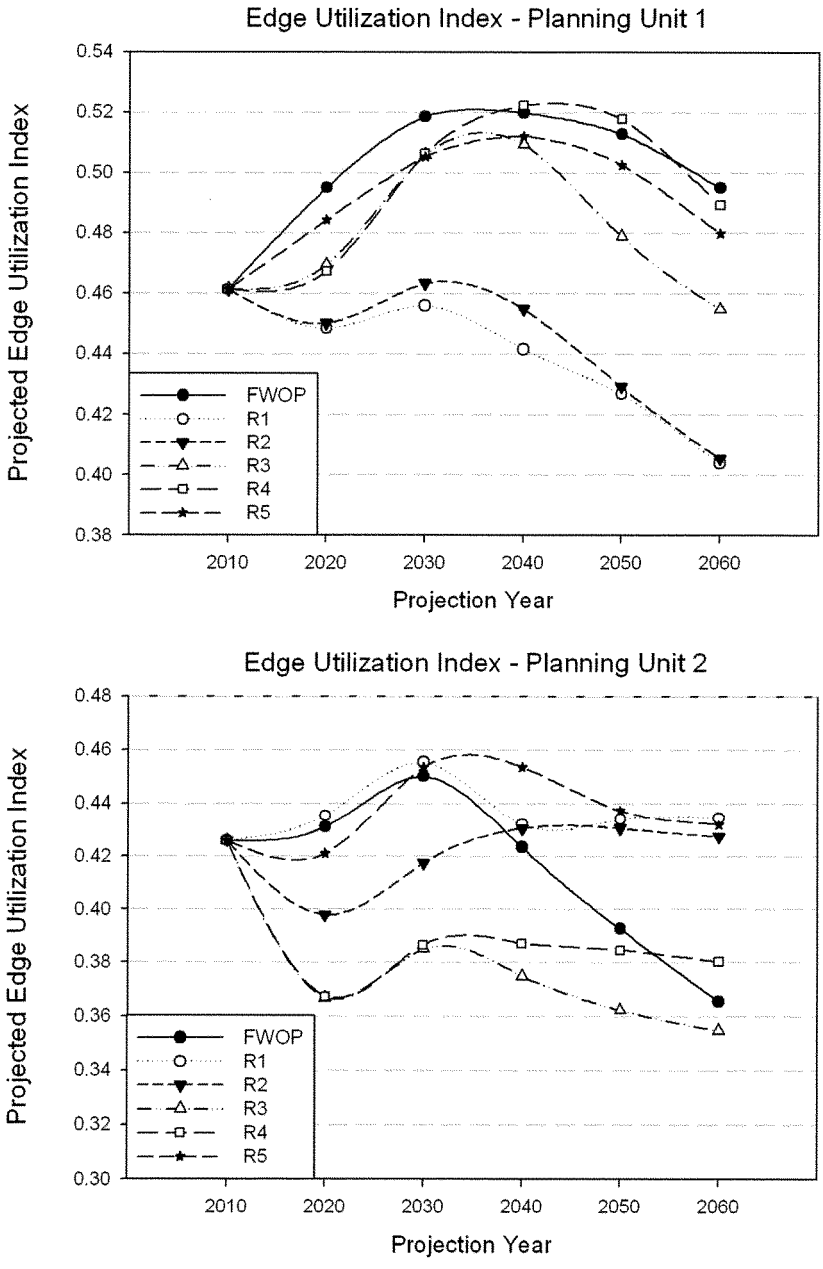


Figure 77. Projections of change in an edge utilization index among alternatives from 2010 to 2060 in planning units 1 and 2.

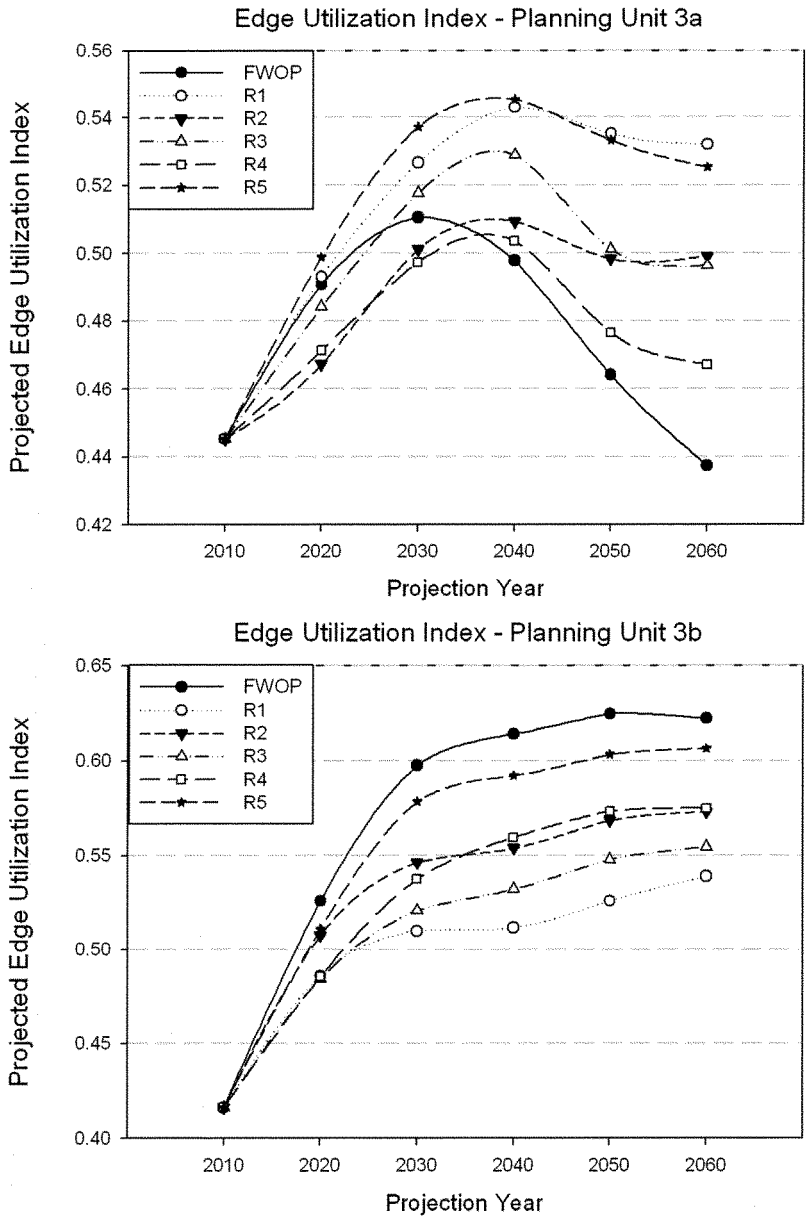


Figure 78a. Projections of change in an edge utilization index among alternatives from 2010 to 2060 in planning units 3a and 3b.

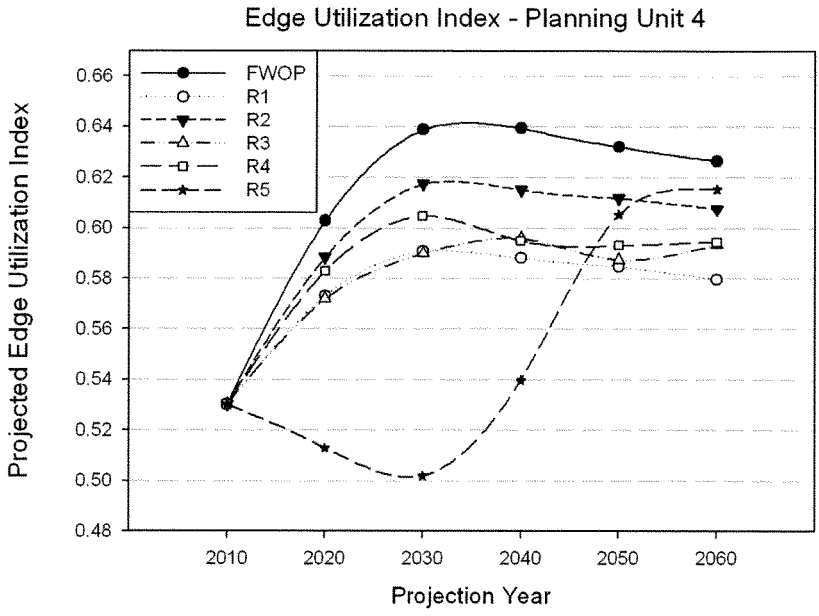


Figure 78b. Projections of change in an edge utilization index among alternatives from 2010 to 2060 in planning unit 4.

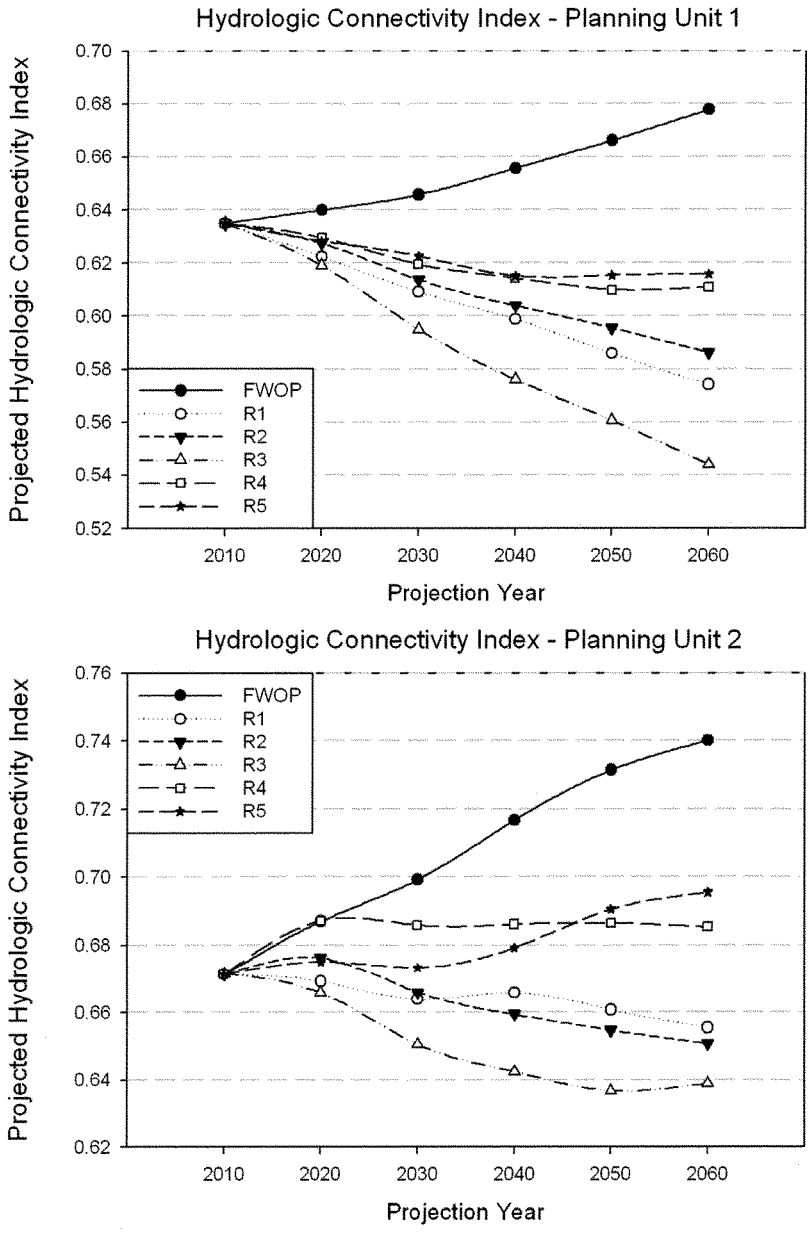


Figure 79. Projections of change in a hydrologic connectivity index among alternatives from 2010 to 2060 in planning units 1 and 2.

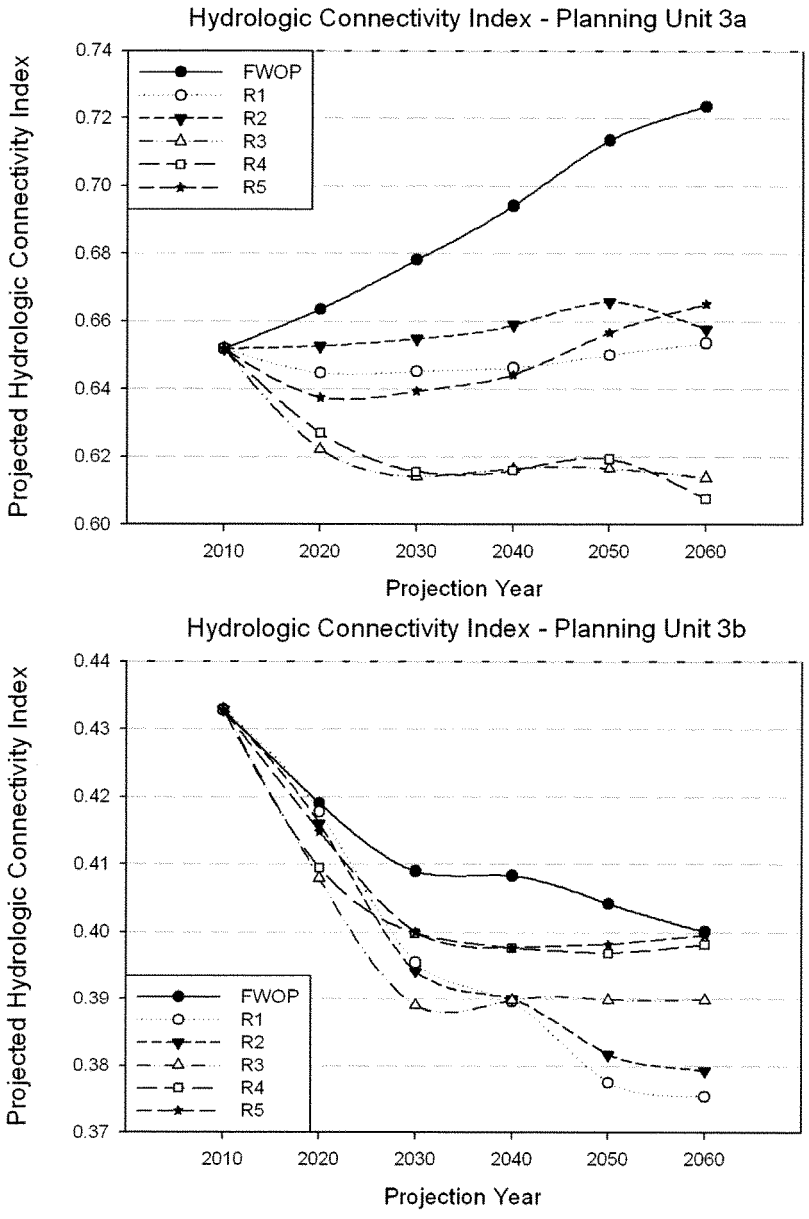


Figure 80a. Projections of change in a hydrologic connectivity index among alternatives from 2010 to 2060 in planning units 3a and 3b.

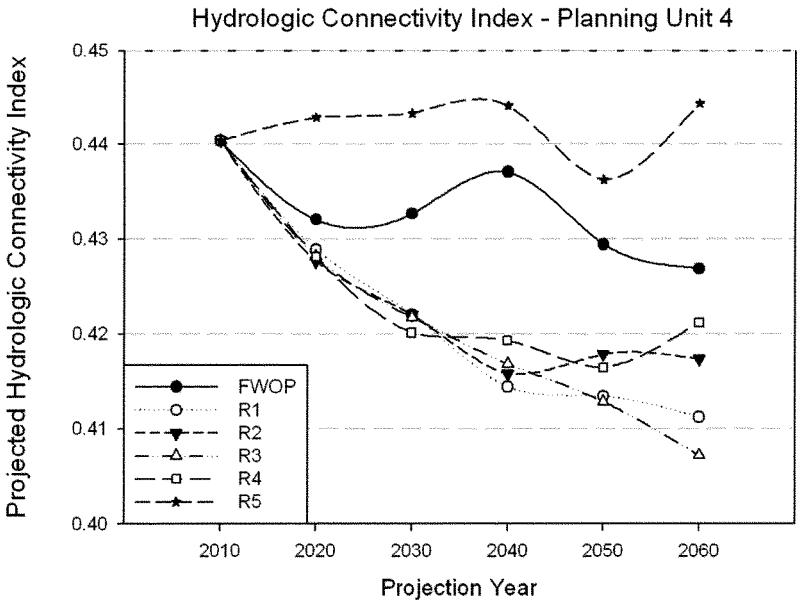


Figure 80b. Projections of change in a hydrologic connectivity index among alternatives from 2010 to 2060 in planning unit 4

TABLES

Table 1. Coastwide evaluation of spatial integrity index changes from 1985 to 2006.

Change Matrix (Historic): Spatial Integrity Index (SII) change count from 1985 to 2006 Coastwide

SII 1985 ↓ / SII 2006 →	1	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9	10	Total of 1985	% unchanged by SII
1	**1274**	42	44	34	12	1	17	0	0	5	3	0	3	0	0	2	0	1	4	0	0	3	0	0	1445	88.2
2A	71	**258**	10	35	56	2	20	6	2	5	2	2	2	2	0	1	0	0	1	0	0	0	0	0	475	54.3
2B	70	20	**39**	27	3	12	10	6	2	8	0	0	5	1	0	5	1	0	1	0	0	1	0	0	211	18.5
2C	68	77	33	**74**	19	21	32	2	2	11	3	2	5	1	1	3	0	0	1	0	1	2	0	0	358	20.7
3A	6	47	0	7	**162**	1	13	75	2	21	5	3	3	1	0	3	0	0	2	1	0	0	0	0	352	46.0
3B	6	7	9	11	1	**11**	12	2	10	9	1	4	10	1	0	6	0	0	3	0	0	2	1	0	106	10.4
3C	21	35	8	23	36	5	**56**	26	12	65	7	5	24	2	2	8	2	0	9	0	0	0	1	1	348	16.1
4A	3	8	0	1	23	2	1	**158**	0	21	82	5	33	14	1	15	4	0	3	2	0	2	0	3	381	41.5
4B	1	3	3	3	5	4	2	1	**6**	9	3	7	5	0	4	10	0	0	8	0	0	0	0	0	74	8.1
4C	2	14	3	7	14	0	12	5	3	**24**	9	4	50	1	2	38	5	1	13	4	0	3	1	1	216	11.1
5A	0	4	0	0	5	0	1	19	1	1	**109**	1	4	69	0	33	17	2	7	5	0	3	4	1	286	38.1
5B	0	2	0	1	0	1	4	3	4	3	1	**1**	2	1	2	12	1	1	11	2	0	5	4	0	61	1.6
5C	2	7	0	5	6	0	5	16	1	12	15	3	**21**	9	0	60	12	1	30	1	0	13	4	1	224	9.4
6A	0	0	0	0	2	0	0	3	0	0	16	1	0	**78**	0	5	75	0	14	12	0	3	11	2	222	35.1
6B	0	0	0	1	1	0	0	0	1	2	1	1	1	0	**1**	1	1	0	4	0	0	5	1	0	21	4.8
6C	1	1	0	1	2	2	0	4	2	7	11	2	12	14	1	**29**	15	0	37	5	0	30	16	7	199	14.6
7A	0	0	0	1	1	0	0	1	0	0	5	0	0	16	0	3	**72**	0	2	87	0	23	21	10	242	29.8
7B	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	**0**	2	0	0	2	0	0	7	0.0
7C	0	0	2	3	0	1	2	1	0	2	4	0	5	8	1	9	13	0	**28**	10	0	22	19	8	138	20.3
8A	0	0	0	0	1	0	0	1	0	0	2	0	1	7	0	0	9	1	2	**88**	0	0	83	30	225	39.1
8B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**0**	0	0	1	2	0.0
8C	0	0	0	0	0	0	1	0	0	0	3	0	0	2	0	0	5	1	14	12	0	**13**	40	29	120	10.8
9	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	1	7	0	2	20	0	3	**137**	179	354	38.7
10	0	0	0	0	1	0	0	1	0	0	0	0	0	2	0	0	3	0	0	6	0	3	28	**2331**	2375	98.1
Total of 2006	1525	525	151	234	350	63	189	330	48	205	282	41	186	234	16	244	244	8	198	255	1	138	371	2604	8442	

Overall percent unchanged = 58.87

Bold numbers in the diagonal represent number of unchanged SII.

Table 2. Evaluation of spatial integrity index changes from 1985 to 2006 in planning unit 1.

Change Matrix (Historic): Spatial Integrity Index (SII) change count from 1985 to 2006 PU-1

SII 1985 ↓ / SII 2006 →	1	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9	10	Total of 1985	% unchanged by SII
1	**362**	10	10	8	1	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	394	91.9
2A	7	**50**	1	13	16	1	8	2	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	102	49.0
2B	8	3	**7**	2	0	6	1	3	0	3	0	0	4	0	0	3	0	0	0	0	0	1	0	0	41	17.1
2C	9	5	3	**6**	5	9	13	1	1	3	1	2	2	0	0	2	0	0	0	0	0	0	0	0	62	9.7
3A	0	0	0	1	**37**	0	2	25	2	10	1	2	1	0	0	0	0	0	1	0	0	0	0	0	82	45.1
3B	0	0	0	2	0	**0**	3	0	2	1	0	1	2	1	0	4	0	0	0	0	0	2	0	0	18	0.0
3C	2	1	0	3	0	0	**7**	3	4	17	2	3	7	0	2	4	1	0	4	0	0	0	1	1	62	11.3
4A	0	1	0	0	0	0	0	**39**	0	4	31	3	12	3	1	8	1	0	1	1	0	2	0	2	109	35.8
4B	0	0	0	0	0	0	0	0	**0**	2	1	1	0	0	0	2	0	0	0	0	0	0	0	0	6	0.0
4C	0	0	0	0	0	0	2	1	0	**2**	2	2	11	0	0	8	3	0	0	1	0	1	1	1	35	5.7
5A	0	0	0	0	0	0	0	0	0	0	**27**	1	3	25	0	12	7	0	5	1	0	1	2	1	85	31.8
5B	0	0	0	0	0	0	0	0	0	1	0	**0**	1	0	0	0	0	0	0	2	0	0	1	0	5	0.0
5C	0	0	0	0	0	0	1	3	0	1	1	0	**3**	1	0	13	3	0	4	1	0	3	2	0	36	8.3
6A	0	0	0	0	0	0	0	0	0	0	1	0	0	**22**	0	3	28	0	9	5	0	0	2	1	71	31.0
6B	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	2	50.0
6C	0	0	0	0	0	1	0	0	0	2	0	0	2	0	0	**6**	3	0	8	2	0	5	2	1	32	18.8
7A	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	2	**16**	0	0	27	0	13	6	4	73	21.9
7B	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	**0**	1	0	0	0	0	0	4	0.0
7C	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	2	2	0	**4**	3	0	3	3	0	21	19.0
8A	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	1	**31**	0	0	33	12	80	38.8
8B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**0**	0	0	0	1	0.0
8C	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	3	3	0	**8**	7	4	28	28.6
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	4	0	0	**45**	58	109	41.3
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	1	5	**1248**	1257	99.3
Total of 2006	388	70	21	35	60	17	39	77	9	47	69	16	50	62	6	70	70	1	42	83	0	40	110	1333	2715	

Overall percent unchanged = **70.76**

Bold numbers in the diagonal represent number of unchanged SII.

Table 3. Evaluation of spatial integrity index changes from 1985 to 2006 in planning unit 2.

Change Matrix (Historic): Spatial Integrity Index (SII) change count from 1985 to 2006 PU-2

SII 1985 ↓ / SII 2006 →	1	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9	10	Total of 1985	% unchanged by SII
1	**368**	4	3	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	378	97.4
2A	10	**36**	0	0	5	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	54	66.7
2B	12	1	**5**	5	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	20.0
2C	11	15	2	**24**	2	4	7	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68	35.3
3A	1	3	0	1	**24**	0	1	9	0	3	0	0	0	1	0	0	0	0	0	1	0	0	0	0	44	54.5
3B	1	0	0	0	1	**2**	2	0	3	2	1	0	2	0	0	1	0	0	1	0	0	0	0	0	16	12.5
3C	5	2	0	2	3	1	**9**	7	0	14	1	0	8	1	0	0	1	0	0	0	0	0	0	0	54	16.7
4A	1	1	0	0	3	0	1	**24**	0	3	9	0	5	4	0	1	1	0	0	1	0	0	0	1	55	43.6
4B	1	0	0	0	0	0	1	1	**1**	1	0	2	1	0	2	4	0	0	3	0	0	0	0	0	17	5.9
4C	1	1	0	1	2	0	1	0	0	**3**	3	1	16	0	2	12	1	0	6	1	0	1	0	0	52	5.8
5A	0	0	0	0	0	0	1	1	0	0	**12**	0	0	5	0	9	4	0	1	0	0	0	1	0	34	35.3
5B	0	0	0	0	0	0	0	0	0	0	0	**0**	1	1	1	7	0	0	5	0	0	3	1	0	19	0.0
5C	0	1	0	0	0	0	0	0	1	1	3	0	**2**	2	0	24	4	0	14	0	0	5	1	1	59	3.4
6A	0	0	0	0	0	0	0	1	0	0	1	0	0	**19**	0	1	13	0	3	2	0	1	1	0	42	45.2
6B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	1	0	1	0	0	3	1	0	6	0.0
6C	0	0	0	0	0	0	0	0	0	0	1	0	0	4	0	**5**	5	0	11	1	0	14	9	2	52	9.6
7A	0	0	0	1	0	0	0	0	0	0	1	0	0	5	0	0	**13**	0	0	22	0	5	3	1	51	25.5
7B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	1	0	0	1	0.0
7C	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	1	3	0	**6**	3	0	9	8	6	39	15.4
8A	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	5	0	1	**18**	0	0	20	5	51	35.3
8B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	1	1	0.0
8C	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	5	0	**1**	21	21	51	2.0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	4	0	0	**31**	60	99	31.3
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	8	**314**	324	96.9
Total of 2006	411	64	10	37	40	7	28	43	6	31	33	3	35	46	5	65	56	0	52	60	0	43	105	412	1592	

Overall percent unchanged = 57.60

Bold numbers in the diagonal represent number of unchanged SII.

Table 4. Evaluation of spatial integrity index changes from 1985 to 2006 in planning unit 3a.

Change Matrix (Historic): Spatial Integrity Index (SII) change count from 1985 to 2006 PU-3A

SII 1985 ↓ / SII 2006 →	1	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9	10	Total of 1985	% unchanged by SII
1	**284**	7	6	2	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	302	94.0
2A	11	**35**	0	2	7	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58	60.3
2B	8	2	**1**	2	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	6.3
2C	6	5	3	**8**	2	3	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	33	24.2
3A	1	2	0	1	**23**	0	1	18	0	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	52	44.2
3B	0	1	0	0	0	**1**	0	1	0	3	0	0	3	0	0	1	0	0	2	0	0	0	1	0	13	7.7
3C	3	3	1	3	4	0	**7**	8	3	16	1	1	8	0	0	1	0	0	1	0	0	0	0	0	60	11.7
4A	0	0	0	0	2	0	0	**29**	0	6	21	1	4	4	0	3	0	0	0	0	0	0	0	0	70	41.4
4B	0	0	0	0	0	0	0	0	**0**	1	1	3	1	0	1	3	0	0	5	0	0	0	0	0	15	0.0
4C	0	0	0	0	0	0	0	1	0	**7**	4	0	16	1	0	11	1	1	6	1	0	0	0	0	49	14.3
5A	0	1	0	0	0	0	0	0	0	0	**22**	0	0	30	0	3	2	1	1	4	0	1	0	0	65	33.8
5B	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	1	3	1	0	5	0	0	2	0	0	12	0.0
5C	1	1	0	0	1	0	0	1	0	1	5	0	**4**	5	0	15	4	1	11	0	0	3	0	0	53	7.5
6A	0	0	0	0	1	0	0	0	0	0	1	0	0	**10**	0	0	23	0	0	1	0	1	5	0	42	23.8
6B	0	0	0	0	0	0	0	0	0	0	1	0	0	0	**0**	1	0	0	2	0	0	2	0	0	6	0.0
6C	0	0	0	0	0	1	0	0	1	1	0	1	0	2	0	**4**	3	0	9	2	0	9	5	2	40	10.0
7A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**12**	0	0	24	0	1	9	4	50	24.0
7B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	1	0	0	1	0.0
7C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	**4**	3	0	7	7	2	27	14.8
8A	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**7**	0	0	24	12	44	15.9
8B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	N/A
8C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	**1**	8	4	16	6.3
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	**21**	42	64	32.8
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	**276**	278	99.3
Total of 2006	314	57	11	18	41	7	17	58	5	39	57	7	39	52	2	47	48	3	47	45	0	28	82	342	1366	

Overall percent unchanged = **55.34**

Bold numbers in the diagonal represent number of unchanged SII.

Table 5. Evaluation of spatial integrity index changes from 1985 to 2006 in planning unit 3b.

Change Matrix (Historic): Spatial Integrity Index (SII) change count from 1985 to 2006 PU-3B

SII 1985 ↓ / SII 2006 →	1	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9	10	Total of 1985	% unchanged by SII
1	**153**	6	6	8	2	0	4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	180	85.0
2A	22	**66**	3	8	14	1	3	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	120	55.0
2B	14	0	**10**	6	0	1	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	27.8
2C	19	33	6	**19**	4	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85	22.4
3A	1	20	0	3	**36**	0	5	16	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	82	43.9
3B	4	2	2	2	0	**2**	1	1	2	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	19	10.5
3C	8	18	3	4	15	0	**11**	2	1	7	1	0	1	0	0	1	0	0	0	0	0	0	0	0	72	15.3
4A	1	2	0	0	6	0	0	**26**	0	4	13	1	4	0	0	1	0	0	0	0	0	0	0	0	58	44.8
4B	0	3	2	2	1	0	0	0	**2**	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	12	16.7
4C	1	9	1	2	4	0	2	2	1	**4**	0	0	2	0	0	3	0	0	0	0	0	0	0	0	31	12.9
5A	0	1	0	0	3	0	0	1	0	0	**26**	0	0	4	0	1	0	0	0	0	0	0	0	0	36	72.2
5B	0	2	0	1	0	0	2	0	0	0	1	**0**	0	0	0	0	0	0	0	0	0	0	0	0	6	0.0
5C	1	5	0	3	3	0	3	5	0	2	2	0	**4**	0	0	1	0	0	0	0	0	0	0	0	29	13.8
6A	0	0	0	0	0	0	0	2	0	0	6	0	0	**13**	0	0	5	0	0	0	0	0	0	0	26	50.0
6B	0	0	0	1	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	0	1	0.0
6C	1	1	0	1	1	0	0	2	0	0	4	0	2	4	0	**0**	2	0	4	0	0	0	0	0	22	0.0
7A	0	0	0	0	1	0	0	1	0	0	2	0	0	1	0	0	**18**	0	0	10	0	4	1	0	38	47.4
7B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	1	0	0	0	0	0	1	0.0
7C	0	0	0	1	0	0	2	1	0	1	2	0	2	2	0	2	0	0	**4**	1	0	0	0	0	18	22.2
8A	0	0	0	0	0	0	0	1	0	0	2	0	0	2	0	0	0	1	0	**14**	0	0	4	0	24	58.3
8B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	N/A
8C	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3	1	0	**0**	1	0	7	0.0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3	0	0	3	0	1	**19**	14	43	44.2
10	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	2	0	0	2	0	1	8	**336**	352	95.5
Total of 2006	225	168	33	61	90	7	37	63	7	22	62	2	16	31	0	10	30	1	13	31	0	6	33	350	1298	

Overall percent unchanged = 58.78

Bold numbers in the diagonal represent number of unchanged SII.

Table 6. Evaluation of spatial integrity index changes from 1985 to 2006 in planning unit 4.

Change Matrix (Historic): Spatial Integrity Index (SII) change count from 1985 to 2006 PU-4

SII 1985 ↓ / SII 2006 →	1	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9	10	Total of 1985	% unchanged by SII
1	**107**	15	19	14	8	1	9	0	0	5	2	0	3	0	0	1	0	1	3	0	0	3	0	0	191	56.0
2A	21	**71**	6	12	14	0	4	3	1	3	1	1	1	1	0	1	0	0	1	0	0	0	0	0	141	50.4
2B	28	14	**16**	12	3	3	4	2	1	4	0	0	1	1	0	2	1	0	1	0	0	0	0	0	93	17.2
2C	23	19	19	**17**	6	2	7	1	0	5	2	0	2	1	1	1	0	0	1	0	1	2	0	0	110	15.5
3A	3	22	0	1	**42**	1	4	7	0	4	3	0	1	0	0	3	0	0	1	0	0	0	0	0	92	45.7
3B	1	4	7	7	0	**6**	6	0	3	2	0	2	2	0	0	0	0	0	0	0	0	0	0	0	40	15.0
3C	3	11	4	11	14	4	**22**	6	4	11	2	1	0	1	0	2	0	0	4	0	0	0	0	0	100	22.0
4A	1	4	0	1	12	2	0	**40**	0	4	8	0	8	3	0	2	2	0	2	0	0	0	0	0	89	44.9
4B	0	0	1	1	4	4	1	0	**3**	4	1	1	3	0	1	0	0	0	0	0	0	0	0	0	24	12.5
4C	0	4	2	4	8	0	7	1	2	**8**	0	1	5	0	0	4	0	0	1	1	0	1	0	0	49	16.3
5A	0	2	0	0	2	0	0	17	1	1	**22**	0	1	5	0	8	4	1	0	0	0	1	1	0	66	33.3
5B	0	0	0	0	0	1	2	3	4	2	0	**1**	0	0	0	2	0	1	1	0	0	0	2	0	19	5.3
5C	0	0	0	2	2	0	1	7	0	7	4	3	**8**	1	0	7	1	0	1	0	0	2	1	0	47	17.0
6A	0	0	0	0	1	0	0	0	0	0	7	1	0	**14**	0	1	6	0	2	4	0	1	3	1	41	34.1
6B	0	0	0	0	0	0	0	0	1	2	0	1	1	0	**0**	0	0	0	1	0	0	0	0	0	6	0.0
6C	0	0	0	0	1	0	0	2	1	4	6	1	8	4	1	**14**	2	0	5	0	0	2	0	2	53	26.4
7A	0	0	0	0	0	0	0	0	0	0	2	0	0	5	0	1	**13**	0	2	4	0	0	2	1	30	43.3
7B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	N/A
7C	0	0	2	1	0	1	0	0	0	0	1	0	2	4	0	2	6	0	**10**	0	0	3	1	0	33	30.3
8A	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	2	0	0	**18**	0	0	2	1	26	69.2
8B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	N/A
8C	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	7	1	0	**3**	3	0	18	16.7
9	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	8	0	2	**21**	5	39	53.8
10	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	**157**	164	95.7
Total of 2006	187	166	76	83	119	25	68	89	21	66	61	13	46	43	3	52	40	3	44	36	1	21	41	167	1471	

Overall percent unchanged = 41.67

Bold numbers in the diagonal represent number of unchanged SII.

Table 7. Future without project evaluation of spatial integrity index changes from 2010 to 2060 in planning unit 1.

Change Matrix (FWOP): Spatial Integrity Index (SII) count from 2010 to 2060 for PU-1

SII 2010 ↓ / SII 2060 →	1	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9	10	Total of 2010	% unchanged by SII
1	**364**	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	386	94.3
2A	0	**0**	0	43	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45	0.0
2B	0	0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
2C	0	0	0	**65**	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	79	82.3
3A	0	0	0	0	**0**	0	22	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0.0
3B	0	0	0	0	0	**0**	5	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	7	0.0
3C	0	0	0	0	0	0	**44**	0	0	32	0	0	1	0	0	0	0	1	0	0	0	0	0	1	79	55.7
4A	0	0	0	0	0	0	0	**0**	0	24	0	0	9	0	0	0	0	0	0	0	0	0	0	0	33	0.0
4B	0	0	0	0	0	0	0	0	**0**	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4	0.0
4C	0	0	0	0	0	0	0	0	0	**46**	0	0	42	0	0	3	0	0	0	0	0	0	0	0	91	50.5
5A	0	0	0	0	0	0	0	0	0	0	**0**	0	14	0	0	19	0	0	0	0	0	1	0	0	34	0.0
5B	0	0	0	0	0	0	0	0	0	0	0	**0**	3	0	0	5	0	0	0	0	0	0	0	0	8	0.0
5C	0	0	0	0	0	0	0	0	0	0	0	0	**29**	0	0	52	0	0	8	0	0	0	0	2	91	31.9
6A	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	2	5	0	2	16	0	1	6	1	2	35	0.0
6B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	1	0	0	1	0	1	0	0	0	3	0.0
6C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**9**	0	2	55	0	1	21	1	5	94	9.6
7A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	2	9	0	4	35	16	1	67	0.0
7B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	1	0	1	0.0
7C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**6**	0	6	13	11	5	42	14.3
8A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**3**	0	8	46	20	77	3.9
8B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	N/A
8C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**0**	18	21	40	0.0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**13**	101	114	11.4
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1355**	1355	100.0
Total of 2060	364	0	0	130	0	0	86	0	0	114	0	1	99	0	2	94	0	8	95	3	14	84	108	1513	2715	

Overall percent unchanged = 71.23

Bold numbers in the diagonal represent number of unchanged SII.

Table 8. Future without project evaluation of spatial integrity index changes from 2010 to 2060 in planning unit 2.

Change Matrix (FWOP): Spatial Integrity Index (SII) count from 2010 to 2060 for PU-2

SII 2010 ↓ / SII 2060 →	1	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9	10	Total of 2010	% unchanged by SII
1	**409**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	409	100.0
2A	0	**0**	0	46	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0.0
2B	0	0	**0**	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
2C	0	0	0	**47**	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	62	75.8
3A	0	0	0	0	**0**	0	26	0	0	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	35	0.0
3B	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/A
3C	0	0	0	0	0	0	**17**	0	0	18	0	0	1	0	0	1	0	0	0	0	0	0	0	0	37	45.9
4A	0	0	0	0	0	0	0	**0**	0	11	0	0	13	0	0	3	0	0	0	0	1	0	0	0	28	0.0
4B	0	0	0	0	0	0	0	0	**0**	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	2	0.0
4C	0	0	0	0	0	0	0	0	0	**8**	0	0	22	0	0	13	0	1	3	0	0	0	0	0	47	17.0
5A	0	0	0	0	0	0	0	0	0	0	**0**	1	9	0	0	7	0	0	2	0	0	1	0	1	21	0.0
5B	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	1	1	0	0	0	0	0	2	0.0
5C	0	0	0	0	0	0	0	0	0	0	0	0	**3**	0	0	13	0	0	9	0	3	10	3	1	42	7.1
6A	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	5	3	0	11	4	0	6	3	3	3	38	0.0
6B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	1	0	1	0.0
6C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**	0	2	4	0	7	12	17	20	64	3.1
7A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	10	3	0	10	1	7	19	50	0.0
7B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	1	1	0.0
7C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	2	1	5	46	54	0.0
8A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	5	3	10	42	60	0.0
8B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	N/A
8C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	1	43	44	0.0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**	98	100	2.0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**444**	444	100.0
Total of 2060	409	0	0	94	0	0	62	0	0	45	0	1	50	0	5	42	0	26	26	0	34	31	49	718	1592	

Overall percent unchanged = 58.54

Bold numbers in the diagonal represent number of unchanged SII.

Table 9. Future without project evaluation of spatial integrity index changes from 2010 to 2060 in planning unit 3a.

Change Matrix (FWOP): Spatial Integrity Index (SII) count from 2010 to 2060 for PU-3A

SII 2010 ↓ / SII 2060 →	1	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9	10	Total of 2010	% unchanged by SII
1	**308**	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	314	98.1
2A	0	**0**	0	45	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52	0.0
2B	0	0	**0**	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.0
2C	0	0	0	**24**	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	85.7
3A	0	0	0	0	**0**	0	25	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	0.0
3B	0	0	0	0	0	**0**	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.0
3C	0	0	0	0	0	0	**8**	0	0	16	0	0	3	0	0	0	0	0	0	0	0	0	0	0	27	29.6
4A	0	0	0	0	0	0	0	**0**	0	15	0	0	8	0	0	5	0	0	0	0	0	0	0	0	28	0.0
4B	0	0	0	0	0	0	0	0	**0**	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	2	0.0
4C	0	0	0	0	0	0	0	0	0	**5**	0	0	32	0	0	27	0	1	0	0	0	0	0	0	65	7.7
5A	0	0	0	0	0	0	0	0	0	0	**0**	3	9	0	3	22	0	0	7	0	0	1	0	0	45	0.0
5B	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	3	0	2	0	0	0	5	0.0
5C	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	17	0	0	16	0	2	8	4	2	50	2.0
6A	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	2	1	0	11	12	0	4	4	9	3	46	0.0
6B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	1	0	0	0	0	0	0	0	0	1	0.0
6C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	8	12	0	5	9	8	11	54	1.9
7A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**0**	4	2	0	5	7	5	21	45	0.0
7B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	N/A
7C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**	0	2	2	8	30	47	10.6
8A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**3**	1	1	3	33	41	7.3
8B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	N/A
8C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**0**	5	25	31	0.0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**4**	79	83	4.8
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**362**	362	100.0
Total of 2060	308	0	0	80	0	0	44	0	0	46	0	3	54	0	5	75	0	25	57	3	22	32	46	566	1366	

Overall percent unchanged = 52.78

Bold numbers in the diagonal represent number of unchanged SII.

Table 10. Future without project evaluation of spatial integrity index changes from 2010 to 2060 in planning unit 3b.

Change Matrix (FWOP): Spatial Integrity Index (SII) count from 2010 to 2060 for PU-3B

SII 2010 ↓ / SII 2060 →	1	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9	10	Total of 2010	% unchanged by SII
1	**200**	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	223	89.7
2A	0	**0**	0	98	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	115	0.0
2B	0	0	**0**	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0.0
2C	0	0	0	**104**	0	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	130	80.0
3A	0	0	0	0	**0**	0	50	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64	0.0
3B	0	0	0	0	0	**0**	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.0
3C	0	0	0	0	0	0	**49**	0	0	21	0	0	2	0	0	0	0	0	0	0	0	0	0	0	72	68.1
4A	0	0	0	0	0	0	0	**0**	3	33	0	5	8	0	2	0	0	0	0	0	0	0	0	0	51	0.0
4B	0	0	0	0	0	0	0	0	**0**	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.0
4C	0	0	0	0	0	0	0	0	0	**23**	0	2	9	0	1	1	0	0	0	0	0	0	0	0	36	63.9
5A	0	0	0	0	0	0	0	0	0	1	**0**	25	5	0	19	4	0	1	1	0	0	0	0	0	56	0.0
5B	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	1	100.0
5C	0	0	0	0	0	0	0	0	0	0	0	11	**3**	0	5	1	0	1	1	0	0	0	0	0	22	13.6
6A	0	0	0	0	0	0	0	0	0	0	0	3	0	**0**	9	2	0	10	1	0	2	3	0	0	30	0.0
6B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	0	0	N/A
6C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	**3**	0	1	2	0	0	0	0	0	13	23.1
7A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	**0**	8	6	4	3	2	3	2	30	0.0
7B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	1	100.0
7C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	**6**	0	1	1	0	1	11	54.5
8A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**7**	1	0	18	7	33	21.2
8B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	N/A
8C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	**0**	0	1	5	0.0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	**14**	15	30	46.7
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	**353**	355	99.4
Total of 2060	200	0	0	237	0	0	146	0	3	96	0	47	27	0	45	11	0	25	17	12	10	6	37	379	1298	

Overall percent unchanged = 58.86

Bold numbers in the diagonal represent number of unchanged SII.

Table 11. Future without project evaluation of spatial integrity index changes from 2010 to 2060 in planning unit 4.

Change Matrix (FWOP): Spatial Integrity Index (SII) count from 2010 to 2060 for PU-4

SII 2010 ↓ / SII 2060 →	1	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C	7A	7B	7C	8A	8B	8C	9	10	Total of 2010	% unchanged by SII
1	**170**	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	187	90.9
2A	3	**0**	0	76	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83	0.0
2B	0	0	**0**	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.0
2C	1	0	0	**209**	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	235	88.9
3A	0	0	0	1	**0**	0	47	0	0	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	58	0.0
3B	0	0	0	0	0	**0**	10	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0.0
3C	0	0	0	1	0	0	**106**	0	0	31	0	0	3	0	0	0	0	0	0	0	0	0	0	0	141	75.2
4A	0	0	0	0	0	0	1	**0**	3	44	0	5	6	0	4	0	0	1	0	0	0	0	0	0	64	0.0
4B	0	0	0	0	0	0	2	0	**0**	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	11	0.0
4C	0	0	0	0	0	0	5	0	1	**62**	0	2	29	0	1	0	0	0	0	0	0	0	0	0	100	62.0
5A	0	0	0	0	0	0	0	0	1	1	**0**	20	11	0	7	4	0	5	0	0	0	0	0	0	49	0.0
5B	0	0	0	0	0	0	0	0	0	0	0	**3**	0	0	1	1	0	0	0	0	0	0	0	0	5	60.0
5C	0	0	0	0	0	0	0	0	0	0	0	19	**12**	0	20	5	0	4	3	0	1	0	0	1	65	18.5
6A	0	0	0	0	0	0	0	0	0	0	0	1	0	**0**	23	3	0	4	1	0	1	2	3	0	38	0.0
6B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	2	0	0	1	0	0	0	3	0.0
6C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	**4**	0	17	4	0	7	4	0	2	59	6.8
7A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	2	14	4	3	8	1	7	39	0.0
7B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	**0**	0	0	1	0	0	1	3	0.0
7C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	5	**7**	0	7	7	10	2	42	16.7
8A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	**12**	2	7	12	5	40	30.0
8B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	1	1	0.0
8C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	5	**1**	2	8	18	5.6
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	**25**	14	43	58.1
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	**168**	171	98.2
Total of 2060	174	0	0	308	0	0	200	0	5	157	0	50	63	0	81	18	1	42	30	19	28	30	56	209	1471	

Overall percent unchanged = 52.96

Bold numbers in the diagonal represent number of unchanged SII.

Table 12. Projections of change in percentage of landscape occupied by water metric among alternatives from 2010 to 2060 in planning units 1, 2, 3a, 3b and 4.

Average Percentage of Landscape Occupied by Water											
Yr	Alt	Mn_PU_1	Mn_PU_2	Mn_PU_3a	Mn_PU_3b	Mn_PU_4	St.Dev.PU_1	St.Dev.PU_2	St.Dev.PU_3a	St.Dev.PU_3b	St.Dev.PU_4
2010	FWOP	50.84	53.56	51.31	29.46	31.87	28.39	28.37	27.30	23.08	22.22
2020		52.70	57.29	54.55	30.13	32.62	29.27	30.26	28.83	23.43	22.92
2030		54.31	60.59	57.60	30.83	33.35	29.92	31.67	30.04	23.82	23.56
2040		55.81	63.37	60.36	31.56	34.08	30.46	32.56	30.90	24.25	24.19
2050		57.25	65.80	62.92	32.31	34.83	30.90	33.17	31.59	24.70	24.85
2060		58.67	67.90	65.13	33.09	35.56	31.31	33.59	31.94	25.18	25.47
2010	R1	50.84	53.56	51.31	29.46	31.87	28.39	28.37	27.30	23.08	22.22
2020		49.91	53.92	51.51	29.16	31.72	29.27	28.80	26.89	22.80	22.75
2030		49.09	54.28	52.05	28.07	31.54	30.17	29.34	26.87	22.83	23.04
2040		48.30	54.11	52.51	27.69	30.93	31.29	29.75	26.82	22.95	23.38
2050		47.45	53.99	52.71	27.09	31.10	32.48	30.31	27.00	22.96	23.80
2060		46.68	54.15	52.62	27.47	30.59	33.77	31.08	27.06	23.54	23.13
2010	R2	50.84	53.56	51.31	29.46	31.87	28.39	28.37	27.30	23.08	22.22
2020		50.45	53.86	52.20	29.47	31.96	29.33	29.00	27.63	22.96	22.85
2030		49.87	53.71	53.50	28.70	32.01	30.23	29.66	28.30	23.13	23.24
2040		49.21	53.55	54.56	28.62	31.54	31.36	30.13	28.68	23.39	23.75
2050		48.52	53.57	54.97	28.27	31.96	32.52	30.74	28.96	23.54	24.22
2060		47.90	53.79	54.17	28.44	31.65	33.80	31.50	28.95	24.10	23.70
2010	R3	50.84	53.56	51.31	29.46	31.87	28.39	28.37	27.30	23.08	22.22
2020		49.43	52.75	49.54	28.37	31.54	28.32	29.77	28.32	22.74	22.42
2030		47.71	52.69	50.09	27.80	31.09	28.26	31.54	29.43	22.91	22.07
2040		46.08	52.64	50.99	28.11	30.65	28.99	32.93	29.88	23.20	21.88
2050		44.53	52.63	50.49	28.50	30.37	29.97	34.22	30.23	23.64	22.08
2060		43.40	53.33	50.40	28.94	30.02	31.48	35.02	30.81	24.16	22.06
2010	R4	50.84	53.56	51.31	29.46	31.87	28.39	28.37	27.30	23.08	22.22
2020		50.74	54.46	49.52	28.76	31.56	28.88	28.87	28.07	23.06	21.97
2030		50.35	55.45	49.80	29.01	31.32	28.70	29.83	29.57	23.24	22.20
2040		49.95	56.17	50.59	29.35	31.14	28.79	30.60	30.17	23.64	22.53
2050		49.53	56.58	50.58	29.74	31.18	29.12	31.33	30.55	24.19	23.07
2060		49.18	56.96	49.56	30.19	31.70	29.72	31.98	31.40	24.83	23.59
2010	R5	50.84	53.56	51.31	29.46	31.87	28.39	28.37	27.30	23.08	22.22
2020		51.08	55.13	50.60	29.47	31.77	28.93	29.60	27.04	22.88	22.54
2030		51.17	56.41	52.01	29.58	31.83	29.55	30.82	27.70	23.08	23.24
2040		51.15	58.06	53.35	29.81	32.62	30.31	31.50	28.23	23.50	23.74
2050		51.45	59.38	54.57	30.15	33.44	31.15	32.21	28.68	24.06	24.27
2060		51.73	60.60	55.60	30.58	34.25	32.07	32.85	29.03	24.70	24.78

Table 13. Projections of change in edge density of land metric among alternatives from 2010 to 2060 in planning units 1, 2, 3a, 3b and 4.

Average Edge Density of Land											
Yr	Alt	Mn_PU_1	Mn_PU_2	Mn_PU_3a	Mn_PU_3b	Mn_PU_4	St.Dev.PU_1	St.Dev.PU_2	St.Dev.PU_3a	St.Dev.PU_3b	St.Dev.PU_4
2010	FWOP	62.99	63.06	67.31	56.72	67.78	39.00	41.09	39.89	29.70	30.86
2020		62.92	59.09	64.39	59.72	66.95	39.78	39.73	38.33	29.34	27.15
2030		62.13	54.48	59.37	60.47	63.71	41.54	39.25	37.75	31.25	27.23
2040		60.97	49.46	54.05	59.69	58.95	44.49	40.04	39.37	36.36	31.73
2050		59.72	44.84	48.67	59.09	54.89	48.35	41.89	43.29	42.42	37.11
2060		58.46	41.25	44.24	59.45	52.46	52.87	44.10	48.18	48.24	41.66
2010	R1	62.99	63.06	67.31	56.72	67.78	39.00	41.09	39.89	29.70	30.86
2020		57.15	57.54	62.29	58.12	66.22	34.85	36.07	34.55	26.61	25.98
2030		55.90	53.72	60.68	58.20	63.31	34.54	36.12	34.25	29.03	26.19
2040		53.86	49.36	57.59	56.93	59.47	35.58	35.53	36.11	34.22	29.63
2050		51.82	47.06	54.51	56.21	55.55	36.95	36.98	39.37	40.14	34.52
2060		49.63	44.12	51.50	56.17	53.47	38.67	39.11	43.84	46.29	38.50
2010	R2	62.99	63.06	67.31	56.72	67.78	39.00	41.09	39.89	29.70	30.86
2020		57.21	54.11	57.96	57.57	65.97	34.91	35.13	34.87	27.74	26.97
2030		55.65	50.91	55.47	57.76	63.03	35.23	34.97	34.86	30.47	27.00
2040		53.75	49.07	51.46	56.44	58.50	36.28	35.51	36.25	35.92	31.21
2050		51.86	46.73	48.37	55.77	54.20	37.23	36.93	38.59	41.89	36.56
2060		49.72	43.76	46.38	55.61	52.30	38.86	39.12	42.72	47.64	40.68
2010	R3	62.99	63.06	67.31	56.72	67.78	39.00	41.09	39.89	29.70	30.86
2020		58.76	51.30	60.09	59.37	65.65	34.49	32.93	34.08	27.51	25.25
2030		59.75	48.20	55.79	59.21	62.80	34.76	32.63	34.76	29.82	25.33
2040		59.83	44.62	51.56	58.89	59.28	36.52	33.25	35.95	34.39	28.94
2050		57.83	41.11	48.34	58.34	56.21	38.85	34.92	38.60	40.23	33.52
2060		55.07	38.30	45.18	58.38	53.92	42.45	37.10	42.81	46.02	38.09
2010	R4	62.99	63.06	67.31	56.72	67.78	39.00	41.09	39.89	29.70	30.86
2020		58.32	51.30	60.53	57.84	66.74	35.37	33.48	34.17	28.77	25.83
2030		58.43	48.25	56.01	58.62	63.94	35.82	33.69	34.92	30.84	25.97
2040		58.58	44.89	51.65	58.19	60.42	36.76	34.65	35.93	35.50	29.09
2050		57.68	42.42	48.12	57.78	56.88	39.43	35.94	38.43	41.12	34.05
2060		56.09	39.79	45.04	57.92	54.04	42.70	38.37	42.67	46.66	38.90
2010	R5	62.99	63.06	67.31	56.72	67.78	39.00	41.09	39.89	29.70	30.86
2020		60.75	56.16	62.82	59.35	61.53	37.17	36.33	33.97	28.44	26.39
2030		60.26	53.33	58.98	60.46	58.41	38.75	36.63	34.27	30.38	25.42
2040		59.49	49.98	54.14	60.16	54.19	41.25	37.74	36.03	35.35	29.21
2050		58.34	45.84	49.14	59.96	49.85	44.44	39.62	39.96	41.24	34.63
2060		57.14	42.21	44.77	60.31	47.27	48.03	41.99	44.95	47.10	39.32

Table 14. Projections of change in cohesion of water patches metric among alternatives from 2010 to 2060 in planning units 1, 2, 3a, 3b and 4.

Average Cohesion of Water Patches											
Yr	Alt	Mn_PU_1	Mn_PU_2	Mn_PU_3a	Mn_PU_3b	Mn_PU_4	St.Dev.PU_1	St.Dev.PU_2	St.Dev.PU_3a	St.Dev.PU_3b	St.Dev.PU_4
2010	FWOP	96.58	97.05	96.99	94.17	92.60	4.05	4.08	4.50	5.10	6.04
2020		97.11	97.51	97.47	94.51	92.86	3.52	3.69	3.92	4.89	5.66
2030		97.64	97.97	97.96	94.72	93.14	3.01	3.31	3.38	4.84	5.35
2040		98.18	98.44	98.50	94.88	93.39	2.53	2.91	2.85	4.82	5.09
2050		98.62	98.82	98.90	95.04	93.63	2.13	2.55	2.41	4.80	4.87
2060		98.92	99.09	99.16	95.20	93.90	1.80	2.23	2.06	4.78	4.70
2010	R1	96.58	97.05	96.99	94.17	92.60	4.05	4.08	4.50	5.10	6.04
2020		96.56	97.33	97.33	94.19	92.60	5.44	3.87	4.06	5.14	5.92
2030		96.70	97.59	97.70	93.51	92.60	5.63	3.68	3.65	7.16	5.90
2040		96.63	97.75	98.07	92.98	92.42	6.57	4.01	3.81	8.34	6.10
2050		96.48	98.04	98.17	92.47	92.45	7.63	3.83	4.98	9.24	6.24
2060		96.22	98.30	98.33	92.23	92.49	8.74	3.64	5.21	9.79	6.38
2010	R2	96.58	97.05	96.99	94.17	92.60	4.05	4.08	4.50	5.10	6.04
2020		96.69	97.31	97.41	94.38	92.65	5.13	4.30	4.12	5.16	5.96
2030		96.89	97.36	97.80	93.83	92.76	5.31	5.00	3.78	6.99	5.81
2040		97.02	97.36	98.24	93.39	92.64	5.64	6.23	3.46	8.14	5.97
2050		96.94	97.67	98.32	93.08	92.80	6.38	6.05	4.72	8.76	5.93
2060		96.85	97.94	98.38	92.69	92.94	7.17	5.87	5.03	9.64	5.90
2010	R3	96.58	97.05	96.99	94.17	92.60	4.05	4.08	4.50	5.10	6.04
2020		96.86	96.35	95.69	93.70	92.66	4.07	8.34	10.02	6.32	5.75
2030		97.01	95.29	95.02	92.90	92.69	4.34	11.99	12.57	8.44	5.67
2040		97.05	94.76	95.42	92.96	92.69	5.48	13.50	12.69	8.49	5.71
2050		96.89	94.16	95.47	92.90	92.68	6.59	15.08	13.08	8.78	5.95
2060		96.95	94.15	95.36	92.75	92.68	9.61	15.55	13.62	9.23	6.08
2010	R4	96.58	97.05	96.99	94.17	92.60	4.05	4.08	4.50	5.10	6.04
2020		96.97	97.39	96.21	93.73	92.69	4.04	4.16	8.14	6.54	5.69
2030		97.37	97.36	95.00	93.77	92.68	3.67	5.90	12.22	6.85	5.74
2040		97.78	97.11	95.07	93.85	92.72	3.34	8.20	12.90	6.94	5.72
2050		98.03	97.05	95.20	93.78	92.70	3.58	9.24	13.04	7.33	5.87
2060		98.11	96.94	94.76	93.65	92.86	4.10	10.18	13.87	7.92	5.94
2010	R5	96.58	97.05	96.99	94.17	92.60	4.05	4.08	4.50	5.10	6.04
2020		96.97	97.42	96.77	94.44	92.62	3.85	3.73	6.82	5.01	5.94
2030		97.36	97.70	97.19	94.43	92.57	3.53	3.95	6.63	5.57	6.14
2040		97.77	98.10	97.67	94.31	92.83	3.24	3.68	6.48	6.33	5.84
2050		98.13	98.47	98.04	94.33	93.08	3.01	3.44	6.37	6.56	5.58
2060		98.39	98.75	98.26	94.18	93.35	2.82	3.22	6.30	7.35	5.36

Table 15. Projections of change in a land stability index among alternatives from 2010 to 2060 in planning units 1, 2, 3a, 3b and 4.

Average Land Stability Index											
Yr.	Alt	Mn_PU_1	Mn_PU_2	Mn_PU_3a	Mn_PU_3b	Mn_PU_4	St.Dev.PU_1	St.Dev.PU_2	St.Dev.PU_3a	St.Dev.PU_3b	St.Dev.PU_4
2010	FWOP	0.42	0.44	0.46	0.61	0.51	0.31	0.32	0.32	0.30	0.28
2020		0.36	0.35	0.36	0.46	0.40	0.28	0.29	0.28	0.27	0.22
2030		0.30	0.26	0.28	0.37	0.36	0.23	0.22	0.22	0.21	0.18
2040		0.27	0.23	0.24	0.34	0.34	0.20	0.19	0.18	0.19	0.17
2050		0.25	0.21	0.24	0.32	0.32	0.18	0.19	0.20	0.16	0.17
2060		0.24	0.21	0.24	0.31	0.31	0.18	0.20	0.20	0.16	0.17
2010	R1	0.42	0.44	0.46	0.61	0.51	0.31	0.32	0.32	0.30	0.28
2020		0.43	0.40	0.40	0.51	0.44	0.32	0.31	0.29	0.29	0.25
2030		0.41	0.34	0.34	0.48	0.42	0.31	0.27	0.25	0.29	0.24
2040		0.40	0.35	0.32	0.49	0.42	0.32	0.28	0.23	0.29	0.25
2050		0.42	0.38	0.36	0.46	0.42	0.33	0.29	0.25	0.28	0.25
2060		0.43	0.36	0.37	0.44	0.44	0.34	0.28	0.25	0.28	0.26
2010	R2	0.42	0.44	0.46	0.61	0.51	0.31	0.32	0.32	0.30	0.28
2020		0.43	0.43	0.41	0.48	0.42	0.32	0.32	0.31	0.28	0.24
2030		0.39	0.37	0.35	0.44	0.39	0.30	0.30	0.27	0.26	0.21
2040		0.39	0.36	0.32	0.43	0.38	0.31	0.29	0.24	0.26	0.22
2050		0.42	0.38	0.32	0.41	0.38	0.33	0.29	0.25	0.25	0.22
2060		0.42	0.36	0.36	0.40	0.39	0.34	0.29	0.26	0.24	0.23
2010	R3	0.42	0.44	0.46	0.61	0.51	0.31	0.32	0.32	0.30	0.28
2020		0.42	0.47	0.43	0.51	0.45	0.31	0.34	0.31	0.30	0.25
2030		0.40	0.42	0.37	0.47	0.43	0.29	0.33	0.28	0.28	0.25
2040		0.39	0.42	0.34	0.46	0.43	0.29	0.33	0.26	0.28	0.24
2050		0.44	0.41	0.37	0.43	0.43	0.31	0.34	0.28	0.27	0.25
2060		0.44	0.40	0.37	0.42	0.44	0.32	0.34	0.28	0.26	0.25
2010	R4	0.42	0.44	0.46	0.61	0.51	0.31	0.32	0.32	0.30	0.28
2020		0.40	0.46	0.44	0.51	0.44	0.30	0.34	0.32	0.30	0.25
2030		0.35	0.40	0.39	0.45	0.41	0.27	0.32	0.30	0.27	0.23
2040		0.34	0.37	0.37	0.42	0.42	0.25	0.31	0.29	0.26	0.24
2050		0.38	0.38	0.39	0.40	0.41	0.27	0.31	0.30	0.24	0.24
2060		0.39	0.37	0.40	0.39	0.42	0.28	0.31	0.30	0.24	0.24
2010	R5	0.42	0.44	0.46	0.61	0.51	0.31	0.32	0.32	0.30	0.28
2020		0.39	0.39	0.41	0.48	0.52	0.29	0.31	0.30	0.28	0.29
2030		0.35	0.33	0.34	0.40	0.53	0.27	0.26	0.25	0.23	0.29
2040		0.32	0.30	0.31	0.38	0.46	0.26	0.24	0.23	0.22	0.27
2050		0.33	0.29	0.31	0.36	0.38	0.26	0.25	0.23	0.21	0.21
2060		0.33	0.28	0.31	0.36	0.37	0.27	0.24	0.23	0.20	0.21

Table 16. Projections of change in an edge utilization index among alternatives from 2010 to 2060 in planning units 1, 2, 3a, 3b and 4.

Average Edge Utilization Index											
Yr	Alt	Mn_PU_1	Mn_PU_2	Mn_PU_3a	Mn_PU_3b	Mn_PU_4	St.Dev.PU_1	St.Dev.PU_2	St.Dev.PU_3a	St.Dev.PU_3b	St.Dev.PU_4
2010	FWOP	0.46	0.43	0.45	0.42	0.53	0.32	0.30	0.31	0.25	0.26
2020		0.50	0.43	0.49	0.53	0.60	0.34	0.33	0.34	0.26	0.24
2030		0.52	0.45	0.51	0.60	0.64	0.34	0.34	0.35	0.25	0.24
2040		0.52	0.42	0.50	0.61	0.64	0.34	0.34	0.36	0.24	0.24
2050		0.51	0.39	0.46	0.62	0.63	0.34	0.34	0.36	0.24	0.23
2060		0.50	0.37	0.44	0.62	0.63	0.34	0.34	0.35	0.23	0.23
2010	R1	0.46	0.43	0.45	0.42	0.53	0.32	0.30	0.31	0.25	0.26
2020		0.45	0.44	0.49	0.49	0.57	0.33	0.32	0.33	0.26	0.25
2030		0.46	0.46	0.53	0.51	0.59	0.32	0.32	0.33	0.26	0.26
2040		0.44	0.43	0.54	0.51	0.59	0.31	0.29	0.31	0.26	0.26
2050		0.43	0.43	0.54	0.53	0.58	0.31	0.29	0.31	0.27	0.27
2060		0.40	0.43	0.53	0.54	0.58	0.31	0.30	0.31	0.27	0.26
2010	R2	0.46	0.43	0.45	0.42	0.53	0.32	0.30	0.31	0.25	0.26
2020		0.45	0.40	0.47	0.51	0.59	0.33	0.30	0.33	0.26	0.25
2030		0.46	0.42	0.50	0.55	0.62	0.32	0.30	0.33	0.25	0.25
2040		0.45	0.43	0.51	0.55	0.62	0.32	0.29	0.33	0.26	0.25
2050		0.43	0.43	0.50	0.57	0.61	0.31	0.29	0.32	0.26	0.25
2060		0.41	0.43	0.50	0.57	0.61	0.31	0.30	0.32	0.26	0.25
2010	R3	0.46	0.43	0.45	0.42	0.53	0.32	0.30	0.31	0.25	0.26
2020		0.47	0.37	0.48	0.48	0.57	0.33	0.28	0.33	0.26	0.25
2030		0.51	0.38	0.52	0.52	0.59	0.32	0.29	0.33	0.26	0.25
2040		0.51	0.37	0.53	0.53	0.60	0.32	0.29	0.33	0.27	0.25
2050		0.48	0.36	0.50	0.55	0.59	0.31	0.30	0.32	0.26	0.25
2060		0.45	0.35	0.50	0.55	0.59	0.32	0.30	0.32	0.27	0.25
2010	R4	0.46	0.43	0.45	0.42	0.53	0.32	0.30	0.31	0.25	0.26
2020		0.47	0.37	0.47	0.49	0.58	0.33	0.28	0.33	0.26	0.25
2030		0.51	0.39	0.50	0.54	0.60	0.33	0.29	0.34	0.26	0.25
2040		0.52	0.39	0.50	0.56	0.60	0.32	0.30	0.33	0.26	0.25
2050		0.52	0.38	0.48	0.57	0.59	0.32	0.30	0.32	0.26	0.25
2060		0.49	0.38	0.47	0.57	0.59	0.31	0.30	0.32	0.26	0.26
2010	R5	0.46	0.43	0.45	0.42	0.53	0.32	0.30	0.31	0.25	0.26
2020		0.48	0.42	0.50	0.51	0.51	0.33	0.31	0.32	0.25	0.26
2030		0.51	0.45	0.54	0.56	0.50	0.33	0.33	0.33	0.24	0.27
2040		0.51	0.45	0.55	0.59	0.54	0.33	0.33	0.32	0.25	0.25
2050		0.50	0.44	0.53	0.60	0.61	0.33	0.33	0.32	0.25	0.25
2060		0.48	0.43	0.53	0.61	0.62	0.33	0.34	0.32	0.25	0.26

Table 17. Projections of change in a hydrologic connectivity index among alternatives from 2010 to 2060 in planning units 1, 2, 3a, 3b and 4.

Average Hydrologic Connectivity Index											
Yr	Alt	Mn_PU_1	Mn_PU_2	Mn_PU_3a	Mn_PU_3b	Mn_PU_4	St.Dev.PU_1	St.Dev.PU_2	St.Dev.PU_3a	St.Dev.PU_3b	St.Dev.PU_4
2010	FWOP	0.63	0.67	0.65	0.43	0.44	0.30	0.29	0.27	0.27	0.26
2020		0.64	0.69	0.66	0.42	0.43	0.30	0.30	0.28	0.27	0.27
2030		0.65	0.70	0.68	0.41	0.43	0.31	0.31	0.29	0.28	0.27
2040		0.66	0.72	0.69	0.41	0.44	0.31	0.31	0.30	0.27	0.27
2050		0.67	0.73	0.71	0.40	0.43	0.31	0.31	0.30	0.27	0.27
2060		0.68	0.74	0.72	0.40	0.43	0.31	0.31	0.30	0.26	0.27
2010	R1	0.63	0.67	0.65	0.43	0.44	0.30	0.29	0.27	0.27	0.26
2020		0.62	0.67	0.64	0.42	0.43	0.31	0.30	0.28	0.27	0.27
2030		0.61	0.66	0.65	0.40	0.42	0.32	0.31	0.29	0.27	0.27
2040		0.60	0.67	0.65	0.39	0.41	0.32	0.31	0.29	0.27	0.27
2050		0.59	0.66	0.65	0.38	0.41	0.34	0.31	0.29	0.27	0.27
2060		0.57	0.66	0.65	0.38	0.41	0.35	0.32	0.29	0.27	0.27
2010	R2	0.63	0.67	0.65	0.43	0.44	0.30	0.29	0.27	0.27	0.26
2020		0.63	0.68	0.65	0.42	0.43	0.31	0.29	0.28	0.27	0.27
2030		0.61	0.67	0.65	0.39	0.42	0.32	0.31	0.29	0.27	0.27
2040		0.60	0.66	0.66	0.39	0.42	0.32	0.32	0.30	0.27	0.27
2050		0.60	0.65	0.67	0.38	0.42	0.33	0.32	0.30	0.27	0.27
2060		0.59	0.65	0.66	0.38	0.42	0.34	0.33	0.29	0.27	0.27
2010	R3	0.63	0.67	0.65	0.43	0.44	0.30	0.29	0.27	0.27	0.26
2020		0.62	0.67	0.62	0.41	0.43	0.30	0.30	0.29	0.27	0.26
2030		0.59	0.65	0.61	0.39	0.42	0.31	0.32	0.31	0.27	0.26
2040		0.58	0.64	0.62	0.39	0.42	0.31	0.33	0.31	0.27	0.26
2050		0.56	0.64	0.62	0.39	0.41	0.31	0.34	0.31	0.27	0.26
2060		0.54	0.64	0.61	0.39	0.41	0.33	0.35	0.32	0.27	0.26
2010	R4	0.63	0.67	0.65	0.43	0.44	0.30	0.29	0.27	0.27	0.26
2020		0.63	0.69	0.63	0.41	0.43	0.30	0.29	0.29	0.27	0.26
2030		0.62	0.69	0.62	0.40	0.42	0.31	0.30	0.31	0.27	0.26
2040		0.61	0.69	0.62	0.40	0.42	0.31	0.31	0.32	0.27	0.26
2050		0.61	0.69	0.62	0.40	0.42	0.31	0.31	0.32	0.27	0.27
2060		0.61	0.69	0.61	0.40	0.42	0.31	0.32	0.32	0.28	0.27
2010	R5	0.63	0.67	0.65	0.43	0.44	0.30	0.29	0.27	0.27	0.26
2020		0.63	0.68	0.64	0.41	0.44	0.30	0.30	0.28	0.27	0.27
2030		0.62	0.67	0.64	0.40	0.44	0.31	0.31	0.29	0.27	0.27
2040		0.62	0.68	0.64	0.40	0.44	0.31	0.31	0.30	0.27	0.28
2050		0.62	0.69	0.66	0.40	0.44	0.32	0.31	0.30	0.27	0.28
2060		0.62	0.70	0.67	0.40	0.44	0.33	0.31	0.30	0.27	0.28

ATTACHMENT E

HET Diversion Summary Tables

December 2008

PU1

	R1 (Dec-May)		R2 (Pulse Flow 5)				R3 (State Master Plan)		R4 (HET Alt)		R5 (LCA PBMO)	
			Low Flow Year		High Flow Year							
	Ave. Flow (cfs)	High Flow (cfs)	Ave. Flow (cfs)	High Flow (cfs)	Ave. Flow (cfs)	High Flow (cfs)	Ave. Flow (cfs)	High Flow (cfs)	Ave. Flow (cfs)	High Flow (cfs)	Ave. Flow (cfs)	High Flow (cfs)
Pontchartrain Basin												
Bonnet Carre									7,104	13,000	*opport. use*	
LaBranche	403	737	138	253	1,209	2,212						
Blind River	6,604	12,085	2,121	3,881	19,812	36,256	2,732	5,000	546	1,000	5,000	9,150
Hope Canal	6,604	12,085	2,121	3,881	19,812	36,256	2,732	5,000	546	1,000	1,000	1,830
Violet Canal							27,322	50,000	8,197	15,000	250	458
Bayou Bienvenue	32,000	58,560	5,000	9,150	96,000	175,680						
Bayou LaLoutre	21,000	38,430	5,224	9,560	63,000	115,290						
basin subtotal	**66,611**	**121,897**	**14,604**	**26,725**	**199,833**	**365,694**	**32,787**	**60,000**	**16,393**	**30,000**	**6,250**	**11,438**
Breton Sound Basin												
B. Terre aux Boeufs	10,230	18,721	2,714	4,967	30,690	56,163						
Caernarvon	16,175	29,600	4,397	8,047	48,525	88,801	*4,372*	*8,000*	*4,372*	*8,000*	*8,000*	*8,000*
White's Ditch							8,197	15,000			10,000	18,300
Bayou Lamoque	7,348	13,447	7,912	14,479	22,044	40,341	8,197	15,000	6,995	12,800	12,000	21,960
American Bay											110,000	201,300
Grand Bay	3,358	6,145	971	1,777	10,074	18,435						
Benny's Bay	0	0	0	0	0	0	27,322	50,000	10,929	20,000	0	0
basin subtotal	**37,111**	**67,913**	**15,994**	**29,270**	**111,333**	**203,740**	**48,087**	**88,000**	**22,295**	**40,800**	**140,000**	**249,560**
PU1 TOTAL	**103,722**	**189,810**	**30,598**	**55,995**	**311,166**	**569,434**	**80,874**	**148,000**	**38,689**	**70,800**	**146,250**	**260,998**

Existing diversions assumed to operate at full capacity
Discharge in excess of existing full diversion capacity

PU2

	R1 (Dec-May)		R2 (Pulse Flow 5)				R3 (State Master Plan)		R4 (HET Alt)		R5 (LCA PBMO)	
			Low Flow Year		High Flow Year							
	Ave. Flow (cfs)	High Flow (cfs)	Ave. Flow (cfs)	High Flow (cfs)	Ave. Flow (cfs)	High Flow (cfs)	Ave. Flow (cfs)	High Flow (cfs)	Ave. Flow (cfs)	High Flow (cfs)	Ave. Flow (cfs)	High Flow (cfs)
Barataria Basin												
Lagan	3,016	5,519	2,198	4,022	9,048	16,558	2,732	5,000			1,500	2,745
Edgard	3,533	6,465	967	1,773	10,599	19,396	2,732	5,000			1,500	2,745
Bayou Lafourche							1,000	1,000	186	*340*	1,000	1,000
Davis Pond	*10,650*	*10,650*	*273*	*500*	*10,650*	*10,650*	*5,820*	*10,650*	*5,820*	*10,650*	*10,650*	*10,650*
Naomi	1,091	1,997	328	600	3,273	5,990	*1,093*	*2,000*	*1,093*	*2,000*	*1,093*	*2,000*
Myrtle Grove	21,610	39,546	5,240	9,589	64,830	118,639	8,197	15,000	1,093	2,000	5,000	9,150
West Pointe-a-la-Hache	1,794	3,283	475	869	5,382	9,849	8,197	15,000	*1,093*	*2,000*	*1,093*	*2,000*
Pt. Sulphur-Homeplace	11,354	20,778	2,757	5,045	34,062	62,333						
Buras	3,803	6,959	1,315	2,406	11,409	20,878						
Fort Jackson	5,310	9,717	1,122	2,053	15,930	29,152			8,197	15,000	60,000	109,800
basin subtotal	**62,161**	**104,914**	**14,675**	**26,857**	**165,183**	**293,445**	**29,770**	**53,650**	**17,481**	**31,990**	**81,836**	**140,090**
Mississippi River Delta												
West Bay	*20,000*	*36,600*	*20,000*	*36,600*	*20,000*	*36,600*	**27,322**	**50,000**	**27,322**	**50,000**	*20,000*	*36,600*
PU2 TOTAL	**82,161**	**141,514**	**34,675**	**63,457**	**185,183**	**330,045**	**57,093**	**103,650**	**44,803**	**81,990**	**101,836**	**176,690**

TOTAL PU1 + PU2 Mississippi River Diversions	**185,883**	**331,324**	**65,273**	**119,452**	**496,349**	**899,479**	**137,967**	**251,650**	**83,492**	**152,790**	**248,086**	**437,688**
Existing Diversions	*30,650*	*74,250*	*20,273*	*37,100*	*30,650*	*47,250*	*11,284*	*20,650*	*12,377*	*22,990*	*40,836*	*59,250*

Existing diversions assumed to operate at full capacity
Discharge exceed maximum siphon capacity

Measure Description	Maximum PU3a and PU3b Diversion Discharges* R1 (cfs)	R2 (cfs)	R3 (cfs)	R4 (cfs)	R5 (cfs)
Multi-purpose HNC Lock operation					
Lower Bayou Grand Caillou	750	750	500	750	500
Bayou Dulac to L. Quitman		750	500	750	500
Falgout C. to L. Decade	500	500	250	500	250
Mississippi River Diversions					
Grand Bayou + Jean LaCroix	38,796				
East of Bayou Terrebonne	32,208				
Upper Lake Boudreaux	5,124				
FW Introduction via GIWW from Barataria					
Grand Bayou			1,000		
Convey Atch Water to N. Terrebonne					
Grand Bayou		6,000	4,000	6,000	4,000
St. Louis Canal		0	0	0	0
Humble Canal		500	500	500	500
Bayou Chauvin		500	0	500	0
Lower Bayou Grand Caillou	750	750	500	750	500
Bayou Dulac to L. Quitman		750	500	750	500
Falgout C. to L. Decade	500	500	250	500	250
Minors Canal w enlargement	2,000	2,000	1,000	2,000	1,000
Carencro Lake**	500	500	250	500	250
Avoca Island**	4,000	4,000	2,000	4,000	2,000
Blue Hammock Bayou	2,000	2,000	1,000	2,000	1,000
Penchant Basin Plan**					
Superior Canal	500	500	500	500	500
Brady Canal	500	500	500	500	500
Carencro Lake	500	500	250	500	250
Liners Canal enlargement	200	200	0	200	0
South Lake Decade (Lapeyrouse C.)	500	500	0	500	
Houma By-Pass Channel					
Grand Bayou		2,000	0	2,000	
St. Louis Canal		0	0	0	
Humble Canal		500	0	500	
Bayou Chauvin		500	0	500	
Totals	**89,328**	**24,700**	**13,500**	**24,700**	**12,500**

* *Listed inputs are in addition to any existing freshwater inputs*

** Benefits accrue to PU3b wetlands

ATTACHMENT F

WETLAND ACREAGE

December 2008

PU 1 2010 (Base Year) Acreage – 669,760										
Coastal Restoration Alternative	R1		R2		R3		R4		R5	
SLR	Existing	Medium	Existing	Medium	Existing	Medium	Existing	Medium	Existing	Medium
2110 Acreage	703,154	643,822	695,902	639,096	676,224	630,920	509,472	462,883	605,278	557,992
% of Baseline Sustained	105%	96%	104%	95%	101%	94%	76%	69%	90%	83%

PU 2 2010 (Base Year) Acreage – 533,130										
Coastal Restoration Alternative	R1		R2		R3		R4		R5	
SLR	Existing	Medium	Existing	Medium	Existing	Medium	Existing	Medium	Existing	Medium
2110 Acreage	575,497	557,009	584,871	554,796	536,034	524,359	501,080	484,671	483,199	463,040
% of Baseline Sustained	108%	104%	110%	104%	101%	98%	94%	91%	91%	87%

PU 3a 2010 (Base Year) Acreage – 437,585										
Coastal Restoration Alternative	R1		R2		R3		R4		R5	
SLR	Existing	Medium	Existing	Medium	Existing	Medium	Existing	Medium	Existing	Medium
2110 Acreage	482,463	438992	358,976	312,590	304,868	271,860	330,057	296,670	250,140	231,140
% of Baseline Sustained	110%	100%	82%	71%	70%	62%	75%	68%	57%	53%

PU 3b 2010 (Base Year) Acreage – 805,137										
Coastal Restoration Alternative	R1		R2		R3		R4		R5	
SLR	Existing	Medium	Existing	Medium	Existing	Medium	Existing	Medium	Existing	Medium
2110 Acreage	845,338	804,156	848,744	804,082	808,168	768,763	787,204	743,662	799,811	756,912
% of Baseline Sustained	105%	100%	105%	100%	100%	95%	98%	92%	99%	94%

PU 4 2010 (Base Year) Acreage – 827,003										
Coastal Restoration Alternative	R1		R2		R3		R4		R5	
SLR	Existing	Medium	Existing	Medium	Existing	Medium	Existing	Medium	Existing	Medium
2110 Acreage	874,028	827,011	871,320	824,282	841,614	794,761	828,214	782,015	793,544	746,543
% of Baseline Sustained	106%	100%	105%	100%	102%	96%	100%	95%	96%	90%

LOUISIANA COASTAL PROTECTION AND RESTORATION
FINAL TECHNICAL REPORT

NONSTRUCTURAL PLAN COMPONENT APPENDIX

June 2009

U. S. Army Corps of Engineers
New Orleans District
Mississippi Valley Division

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Attachments

Attachment 1– An Implementation Program for Flood Risk Reduction Using Nonstructural Measures
Attachment 2 – Examples of Cost Determination
Attachment 3 – Cost for Raising in Place

I. PURPOSE AND INTRODUCTION

The Louisiana Coastal Protection and Restoration (LACPR) Technical Report has been developed by the United States Army Corps of Engineers (USACE) in response to Public Laws 109-103 and 109-148. Under these laws, Congress and the President directed the Secretary of the Army, acting through the Chief of Engineers, to:

- Conduct a comprehensive hurricane protection analysis and design in close coordination with the State of Louisiana and its appropriate agencies;
- Develop and present a full range of flood control, coastal restoration, and hurricane protection measures exclusive of normal policy considerations for South Louisiana;
- Consider providing protection for a storm surge equivalent to a Category 5 hurricane; and
- Submit preliminary and final technical reports.

The purpose of this appendix is to support nonstructural plan formulation for LACPR, which is discussed in the main technical report.

Nonstructural measures are one component of an integrated system. This group of measures offers strategies for reducing exposure to storm hazards through management of development in the floodplain, in combination with, or perhaps instead of, structures such as levees and floodwalls. Nonstructural measures contribute to community resiliency through risk reduction of residential structures, commercial buildings, and especially critical facilities that provide a base for emergency response and a post-storm foothold for recovery. Nonstructural measures are one line in a multiple-lines-of-defense strategy for reducing and managing hurricane risks and for providing redundant risk reduction.

A. Authority and Guidance

Section 73 of the 1974 Water Resources Development Act states that nonstructural measures will be considered for all Federal civil works projects. The Supplemental Policy Guidance Memorandum, dated 28 Aug 2006, guidance specific to the LACPR, requires that nonstructural measures be considered with other structural and ecosystem restoration measures to create a comprehensive systems approach to risk reduction from tropical events.

The LACPR Supplemental Policy Guidance Memorandum directs the effort to:

- Integrate hurricane and storm damage reduction and coastal restoration, and include nonstructural measures.

- Coordinate all measures closely with FEMA and the Department of Interior, and utilize the USACE National Nonstructural Flood Proofing Committee.

To meet that directive the Nonstructural Flood Proofing Committee provided nonstructural plan formulation and evaluation to the LACPR effort.

B. Scope

The scope of the nonstructural analysis entails three aspects of investigation. The first aspect is a holistic evaluation of the entire southern Louisiana coast for opportunities for risk reduction to identify areas for further in-depth analysis. This broad-brush, generalized analysis establishes the maximum expected performance and cost effectiveness of nonstructural measures—demonstrating the maximum contribution that nonstructural measures could make to an overall risk reduction strategy. The intended culmination of this analysis is the creation of a programmatic approach to implement nonstructural measures in a comprehensive and systematic manner.

The second aspect of the investigation is to identify demonstration projects of specific size and location where nonstructural measures could be applied in the near-term. The development of demonstration projects requires close coordination with local communities, the State, Federal and local agencies, and supports local desires for risk reduction and economic recovery. These demonstration projects are intended to discover the challenges and opportunities that exist for future collaboration among the USACE, other agencies, and local governments in implementing nonstructural measures.

The third aspect of the nonstructural analysis is to identify public and private facilities that are critical to the health and safety of the public and to develop means whereby those facilities can be flood proofed to withstand assault from the forces of tropical events. These facilities are defined as hospitals, police and fire protection facilities, water treatment and wastewater treatment plants, public administration buildings, and schools that are highly vulnerable to risk based on their location but are important to the local communities in the aftermath of storms.

The scope of the nonstructural analysis was scaled to the time allocated, level of precision of the available data, and the spatial extent of the area of analysis. The LACPR evaluation covers a 26-parish area across the entire breadth of South Louisiana. The nonstructural analysis relies on information that was developed for the LACPR effort as a whole, such as the hydrology and structure inventory, and from secondary sources, such as delineated risk zones determined by FEMA or zones targeted for redevelopment as identified by the City of New Orleans.

Because of the gross level of analysis and the nature of the hazard in South Louisiana, two nonstructural measures are primarily applied to this analysis: buyout and/or permanent relocation of structures and raising-in-place (elevation) of structures. These measures were chosen because of their direct applicability to risk reduction in light of the hazards produced during coastal storm events. They were also chosen because these measures are directly implementable by the USACE with local sponsor participation. Although these two measures were applied to the majority of structures in the study area, other nonstructural measures, such as flood proofing, berms and walls, were considered and applied as appropriate. Additionally, other nonstructural measures would entail

initiation and implementation by local governing entities, such as changes to land use regulations.

II. NONSTRUCTURAL MEASURES

Nonstructural flood proofing measures as applied within the USACE planning arena can be defined as any combination of structural or nonstructural changes or adjustments incorporated in the design, construction, or alteration of individual structures or properties that will reduce flood damages. Simply stated, flood proofing includes any effort to reduce flood damage to individual structures and their contents. The term "nonstructural" is used in this report to distinguish Federal actions from the traditional larger Federal structural measures considered for risk reduction.

A. Variety

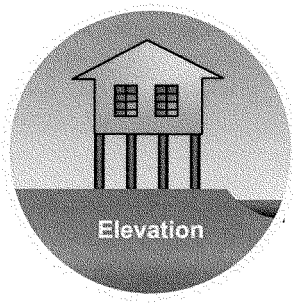
Nonstructural measures remediate risk, not by altering the nature of the hazard, but by removing vulnerable people and property from the storm and flood threat or by protecting vulnerable assets by actions taken to those assets. Nonstructural measures include wet and dry flood proofing, flood warning, raising-in-place from lifting on pilings or on fill, relocations of property improvements, and buyouts of properties. Except for flood warning systems, nonstructural measures generally take effect on privately-owned property and require that the non-Federal sponsor take an active role in implementation.

Flood proofing measures either reduce the number of times the structure is flooded or limit the potential damage to the structure and its contents when it is flooded. There are four general approaches to flood proofing:

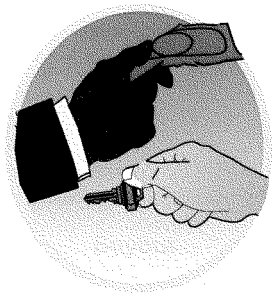
- Elevating the structure.
- Relocating the structure.
- Constructing barriers such as floodwalls or berms to stop floodwaters from damaging the structure.
- Modifying the structure through flood proofing and relocating contents to minimize flood damage.

1. Elevation

Elevation involves raising structures in place so that the lowest floor is above the flood level for which flood proofing protection is designed. The building is raised and set on a new or extended foundation. Temporary living expenses may be paid to the property owner as needed during the elevation process.

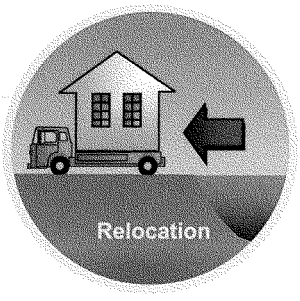


2. Relocation and Buyout



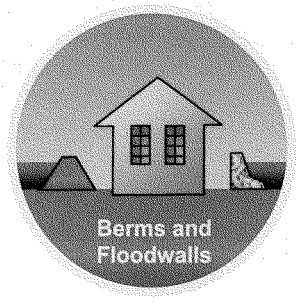
Buying out or relocating a structure is the most dependable way to flood proof. Buyouts entail selling the structure to the non-Federal sponsor for demolition or salvage, evacuating the property, and relocating the property owner to another site outside the 100-year floodplain.

In addition to receiving fair market value for the property acquired, owners of real property acquired for Federal projects are entitled to receive relocation assistance under Public Law 91-646, the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970. Such assistance generally consists of a replacement housing payment and payment for moving expenses. A displaced homeowner may receive up to $22,500 in supplemental housing assistance to acquire a comparable replacement dwelling over the acquisition price of their property. Generally the replacement housing payment is the difference between the fair market value of the home acquired and the cost to acquire a comparable home at a site with reduced flood risk, typically outside the 100-year floodplain. The displaced homeowner is entitled to decent, safe, and sanitary accommodations as part of relocation assistance.



Property relocation involves lifting and moving the flood-prone structure to another location away from flood hazards. This process involves physically moving the improvement to a site outside the floodplain. Temporary relocation assistance is provided as part of the cost of relocating structures.

3. Small Floodwalls and Berms (with/without Closures)

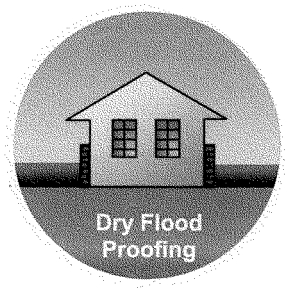


Small floodwalls and berms are located away from the structure to be protected and prevent the encroachment of floodwaters. They may completely surround the structure or protect only the low side of the property. These small structures are distinguished from large public investments by their scale and location on privately-owned land. Unlike some other flood proofing measures, a well-designed and constructed freestanding floodwall or berm results in no floodwater forces on the structure itself. Consequently, as long as the floodwall or berm is not overtopped or otherwise failed, the structure is not exposed to damaging hydrostatic or hydrodynamic forces. With these kinds of

measures, there is no need to make structural alterations to the building or structure to be protected. These measures require installation of a sump pump or other feature to drain seepage water flowing through or under the berm or floodwall, and rainwater falling inside the berm or floodwall.

4. Dry Flood Proofing

Dry flood proofing involves sealing the walls of structures such as buildings with waterproofing compounds, impermeable sheeting, or other materials and using closures for covering and protecting openings from floodwaters. Dry flood proofing is most applicable in areas of shallow, low-velocity flooding.



Dry flood proofing has limited applicability depending on flood depth, hydrodynamic forces, and building type. Conventionally constructed brick veneer on a wood frame or concrete block walls should not be flood proofed above a height of 3 feet because of the danger of structural failure from hydrostatic forces. Residential construction is not dry flood proofed as a matter of policy.

5. Wet Flood Proofing

If dry flood proofing is impossible or too costly, another option is wet flood proofing, which allows the structure to flood inside while ensuring minimal damage to the building and any contents. By allowing the force of the water to pass through a building, the interior flooding allows hydrostatic force on the inside of the building walls to equally counteract the hydrostatic force on the outside, thus eliminating the chance of structural failure. Wet flood proofing is most applicable to nonresidential buildings such as high-rise office buildings where the ground floor can be converted to an open lobby while other building uses are elevated to upper floors.

B. Flood Proofing Matrix

A flood proofing matrix (**Table 1**) has been included in this appendix to better associate the relationship of flood characteristics, site characteristics, and structure characteristics to the applicability of particular flood proofing measures. Aspects of the matrix are described as follows:

Flooding characteristics. This characteristic addresses four basic phenomena of floods: flood depth, flood velocity, warning time prior to a flood event, and the presence of ice and debris. Each of these flood characteristics is critical when applying the appropriate measure to mitigate flood effects.

Site characteristics. This characteristic addresses two basic site issues: (1) flooding, either coastal or riverine and (2) soil type, either permeable or impermeable. Coastal locations, especially at a beachfront location, dictate the use of site specific measures more so than does riverine flooding. Soil type becomes an issue if the soil has high permeability which excludes certain measures from consideration.

Building characteristics. Structure foundation, structure construction, and structure condition are very important elements for consideration when applying nonstructural measures. These factors, especially structure condition and structure foundation, dictate the appropriate use of various nonstructural measures.

National Economic Development (NED), National Ecosystem Restoration (NER), Recreational Opportunities and Social Characteristics. These characteristics deal directly with issues relative to the ability to implement and the impacts of implementing a flood damage reduction measure. Issues such as cost and the factors of cost such as flood insurance, emergency response, and disaster relief are important elements for consideration. Hydrologic and environmental impacts; potential for induced development; compatibility with ecosystem restoration or recreation uses; and population impacts are also important considerations for nonstructural measure implementation.

Table 1. Flood Damage Reduction Matrix

		FLOOD DAMAGE REDUCTION MEASURES																				
		NON-STRUCTURAL MITIGATION MEASURES																STRUCTURAL MITIGATON MEASURES				
															NFIP							
	FLOOD DAMAGE REDUCTION MATRIX	Elevation on Foundation Walls	Elevation on Piers	Elevation on Posts or Columns	Elevation on Piles	Elevation on Fill	Relocation	Buyout/ Acquisition	Floodwalls and Levees	Floodwalls and Levees with Closures	Dry Flood Proofing	Wet Flood Proofing	Flood Warning Preparedness	Flood Plain Regulation	Flood Insurance	Flood Mitigation [1]	Channel	Levee/Wall	Dams	Diversions
Flooding Characteristics	**Flood Depth**																				
	Shallow (<3 ft)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 6 ft)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Deep (greater than 6 ft)	Y	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Flood Velocity																				
	Slow (less than 3 fps)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 5 fps)	N	N	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fast (greater than 5 fps)	N	N	N	Y	N	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Flash Flooding																				
	Yes (less than 1 hour)	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
	No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Ice and Debris Flow																				
	Yes	N	N	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
	No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Site Characteristics	**Site Location**																				
	Coastal Flood Plain																				
	Beach Front	N	N	N	Y	N	Y	Y	N	N	N	N	Y	Y	Y	Y	N	[2]	N	N	
	Interior (Low Velocity)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N	
	Riverine Flood Plain	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Soil Type																				
	Permeable	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Impermeable	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Building Characteristics	**Structure Foundation**																				
	Slab on Grade	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Crawl Space	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Basement	Y	N	N	N	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Structure Construction																				
	Concrete or Masonry	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Metal	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Wood	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Structure Condition																				
	Excellent to Good	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Fair to Poor	N	N	N	N	N	N	Y	Y	Y	N	N	Y	Y	Y	[3]	Y	Y	Y	Y	
NED/NER/Recreation/Social Characteristics	**Economic**																				
	Structure Protected	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	[5]	N	Y	Y	Y	Y	Y	Y	
	Cost to Implement	M	M	M	M	M	H	H	M	M	L	L	L	L	L	H/M	H	H	H	H	
	Potential Flood Insurance Cost Reduction (Residential)	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	Y	-	Y	Y	Y	Y	Y	
	Potential Flood Insurance Cost Reduction (Commercial)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	-	Y	Y	Y	Y	Y	
	Potential Adverse Flooding Impact on Other Property	N	N	N	N	Y	N	N	Y	Y	N	N	N	Y	N	N	Y	Y	Y	Y	
	Reduction in Admin Costs of NFIP	N	N	N	N	Y	Y	Y	N	N	N	N	N	[6]	-	[3]	[7]	[7]	[7]	[7]	
	Reduction in Costs of Disaster Relief	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Reduction in Emergency Costs	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	[3]	Y	Y	Y	Y	
	Reduction in Damage to Public Infrastructure	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	[3]	Y	Y	Y	Y	
	Potential for Catastrophic Damages if Design Elevation Exceeded	N	N	N	N	N	N	N	Y	Y	Y	N	N	N	N	N	N	Y	Y	N	
	Promotes Flood Plain Development	N	N	N	N	N	N	N	N	N	N	N	N	N	[8]	N	Y	Y	Y	Y	
	Environmental																				
	Ecosystem Restoration Possible	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	
	Potential Adverse Environmental Impact	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	
	Recreation																				
	Recreation Potential	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	[3]	N	N	Y	N	
	Social																				
	Community Remains Intact	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	[3]	Y	Y	Y	Y	
	Population Protected	N	N	N	N	N	Y	Y	N	N	N	N	Y	N	N	[3]	Y	Y	Y	Y	
	Potential Structure Marketability Increase	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	[5]	N	Y	Y	Y	Y	Y	

[1] NFIP Flood Mitigation may vary but it is usually buyout/acquisition
[2] Not generally recommended
[3] Buyout/acquisition only
[4] Elevation only
[5] Post Flood Insurance Rate Map construction only
[6] Post FIRM structures elevation on fill
[7] Yes, if project provides 100 year or greater protection
[8] Yes, if in floodplains less frequent than the 100-year
Y – Yes
N – No
L – Low
M – Medium
H – High

C. Characteristics

An advantage of nonstructural measures includes the flexibility of their scale. Nonstructural measures can be implemented incrementally, on a structure-by-structure basis, or programmatically, across whole neighborhoods or communities. Also little time is required to implement nonstructural measures as compared with implementation of large-scale structural measures. The benefits of nonstructural measures are realized immediately upon implementation to each structure affected.

Nonstructural measures are differentiated from structural measures in that they are affected generally to privately-owned land whereas structural measures are implemented on publicly-held land that has been acquired by a non-Federal sponsor. Nonstructural measures can be either implemented voluntarily or mandatorily based on the political will of the non-Federal sponsor. Nonstructural measures, such as buyouts and relocations, can provide opportunities for alternate uses of the vacated floodplain, such as ecosystem restoration, recreational development, or urban green space if sufficient contiguous parcels are purchased for evacuation.

All nonstructural flood proofing measures can be effective in reducing damages from floods for which the measure was designed. However, the only way to ensure complete safety from storm or flood risk is either through buyout and demolition of structures or relocating structures to a site outside the floodplain.

D. Contribution to Systems Approach – Redundancy and Resiliency

Redundancy of risk reduction measures is a critical aspect of a hurricane risk reduction system. Nonstructural measures can function in combination with other risk reducing structural or ecosystem restoration measures to provide multiple lines of defense for the region. While structural components of the system are intended to provide a reduction in damages from storm surges, a complementary system of nonstructural measures can facilitate post-storm recovery in the event that the structural components are exceeded. Nonstructural measures reduce the adverse consequences when storm flooding does occur. As a redundant feature, nonstructural measures contribute to management of the risk of interior flooding, whether from rainfall or from hurricane surges exceeding the channel capacity, levees and floodwalls. An added benefit of this redundant system is found in the timing of implementation. Because nonstructural measures can typically be implemented in less time, they would reduce flood risk prior to completion of structural measures. Upon completion of the structural measures, the combined measures would provide redundancy to the risk reduction system.

Nonstructural measures also contribute to the resiliency of the communities in the region. Through a program of nonstructural activities, homes and businesses would be flood proofed, relocated or elevated and critical facilities would be designed and constructed with hardened features. Through these measures the region would improve its ability to

recover from storm events. The integration of structural, nonstructural, and ecosystem restoration measures creates a redundant system that contributes to community resiliency.

III. NONSTRUCTURAL PLAN FORMULATION

Nonstructural measures were formulated at the planning unit or watershed level across the LACPR planning area. Scales of measures were formulated at target levels of risk reduction for the LACPR evaluation which were established at the 100-year, 400-year, and the 1000-year stages. In compliance with the planning objectives for LACPR, nonstructural measures were formulated with the primary goal of reducing risk (limiting exposure) to population and property and with a secondary goal of managing risk to critical facilities.

The physical aspects of storms are a major consideration when formulating nonstructural measures at specific sites. Certain nonstructural measures function better given defined flooding conditions or when other interests are a consideration. For example, the only nonstructural measure that is reliable under high-velocity surge conditions is buyout of property and permanent evacuation of the population at risk. Conversely, flood proofing, such as raising-in-place either on fill or piers, works well for low-velocity flooding conditions. Raising-structures-in-place is effective when an interest exists in maintaining a local tax-base and when flooding conditions and structural integrity warrant its application, so long as elevating does not put the structure at further risk in the wind field. Also relocation of structures and population into clusters at flood-free sites can address both risk reduction and community cohesion concerns. There exist situations where it is infeasible to achieve a secure level of risk reduction. In such cases, managing risk can be achieved by flood proofing assets in place such as to facilities critical to the health and safety of the resident population.

For purposes of the LACPR plan formulation, two nonstructural measures, buyouts/relocations and raising-in-place, were investigated based either on the severity and nature of the risk or the expectation that redevelopment in the aftermath of Hurricanes Katrina and Rita would allow for building construction modifications, such as raising the flood threshold of buildings to targeted levels of risk reduction. Although these two measures were applied to the majority of structures in the study area, other nonstructural measures, such as flood proofing, berms and walls, were considered and applied as appropriate with regard to specific demonstration projects.

If a building is subject to flooding depths greater than 3 feet, elevating or relocating the structure are the most effective measures of flood proofing. Dry flood proofing is not appropriate because water depths greater than 3 feet may cause a hydrostatic force large enough to render structural damage or cause walls to collapse unless the building has been designed to accommodate such forces. Flood proofing with berms and floodwalls for depths less than 3 feet can be undertaken, but it may require devices to control seepage under the berm or floodwall.

A. Objectives for Nonstructural Plan Formulation

The primary objective of the LACPR effort is to reduce overall risk to population and economic assets from tropical events along the Louisiana coast while trying to preserve or restore the wetlands. Generally risk can be described as the product of exposure, defined as vulnerable people or assets, and the probability of occurrence of a threat resulting in undesirable consequences to people and assets at risk. Protective measures can be formulated to reduce risk from tropical events in two ways, either by reducing the probability of the adverse consequences of the occurrence or by reducing the exposure to the occurrence thereby reducing the consequences themselves. Structural measures are formulated to reduce risk by increasing protection with physical structures such as barriers and levees that are designed to withstand the onslaught of a tropical event. Nonstructural measures are formulated to reduce the exposure to the threat by either elevating or removing vulnerable people and assets away from the threat. This approach to nonstructural plan formulation is applied to the formulation and evaluation of measures for the LACPR effort.

As stated, the primary objective of nonstructural plan formulation for LACPR is to reduce risk to population and assets in combination with wetland restoration. Secondary goals of the nonstructural analysis are to manage risk to critical facilities and, also, to manage residual risk to population and assets following some Federal action.

Additional objectives of the nonstructural demonstration projects are as follows:

1. Demonstrate to governments, agencies, and residents of South Louisiana that nonstructural measures can be implemented by the USACE to reduce risk associated with hurricane storm surge and flooding; and
2. Demonstrate that non-Federal sponsors exist who support implementation of nonstructural measures.

In order to truly maximize opportunities to reduce storm surge and flood risk across South Louisiana from hurricanes, it is imperative that all "tools," structural, nonstructural, and coastal restoration, be implemented where appropriate based on cost effectiveness and potential for risk reduction.

B. Planning and Evaluation Assumptions

Some basic assumptions are necessary to complete the plan formulation and evaluation of nonstructural measures. These assumptions apply mostly to the overall effort, but bear repeating for this appendix. These assumptions are as follows:

1. The Fourth Emergency Supplemental work to the metropolitan New Orleans levee system is assumed to be complete and to provide uniform risk reduction from the 100-year event. This defines the near-term without project base condition for LACPR.

2. This effort assumes that all new development, during the reconstruction post-2005 hurricanes, conforms to base floor elevations established for compliance with the National Flood Insurance Program (NFIP). Economic damages projected over the project life from future development will reflect NFIP compliance.

3. For the purpose of this initial effort, the assumption is that all property owners will participate in the nonstructural measure proposed and the commensurate level of risk reduction will be realized. For consistency, relocation assistance is included as a cost component of nonstructural buyout measures. This assumption is consistent with the performance assumption of structural measures, i.e., 100 percent performance with full reliability, and, therefore, allows for an unbiased comparison of performance and cost effectiveness with structural measures.

4. The economic analysis is based on second quarter 2005 and 2050 conditions which were projected to the census block level from population growth estimates and redevelopment assumptions that were applied to the entire planning area. The housing inventory is assumed to mirror the resident population with no allowances for vacant and abandoned structures. The reader is referred to the *Economics Appendix* for a full description of the referenced method and the development of the structure inventory. However, a brief summary of the population and land use scenarios follows:

   Projections of population, number of households, and total non-agricultural employment for each of the five Metropolitan Statistical Areas (MSAs), New Orleans, Baton Rouge, Houma, Lafayette, and Lake Charles, and for each of the non-MSA parishes in southern Louisiana were developed for two future development scenarios: "high employment" and "business as usual." The projections considered factors such as net migration of population, employment demand by sectors of the economy, distribution of personal income, and residential construction patterns to project population, number of households, and non-agricultural employment for the period 4th Quarter 2005 through the year 2075.

   Two land use allocation scenarios (compact and dispersed) were also developed for each future development scenario. The specific location of the future development was primarily based on the existing and projected transportation systems in each area. However, other factors, including current and projected commercial activity, land elevation, susceptibility to flooding and other hazards, and environmental constraints such as wetlands, were also considered. The projected location and types of residential dwelling units varied under each of the two land use allocation scenarios.

   The "high employment" future development scenario was combined with the dispersed land use allocation scenario as the first future economic development scenario, and the "business as usual" future development

scenario was combined with the compact land use allocation scenario as the second future economic development scenario. The "high employment" future development with dispersed land use allocation was considered the scenario with the highest damage or residual risk potential, while the "business as usual" future development with compact land use allocation was considered the lowest potential damage or residual risk scenario. These two economic development scenarios were combined with two relative sea level rise projections to calculate the range of potential damage or residual risk throughout the period of analysis.

5. The period of analysis for all alternatives is from 2010 to 2075. Metric values (e.g. costs, impacts, etc.) are compounded or discounted to 2025 as the common base year for comparison of alternatives. Year 2025 also constitutes the first year in which full benefits are expected to be realized from nonstructural measure implementation. Nonstructural measures are expected to be implemented uniformly over a 15-year period, from 2010 to 2025.

6. The fiscal year 2008 discount rate of 0.04875 applies to the LACPR evaluation.

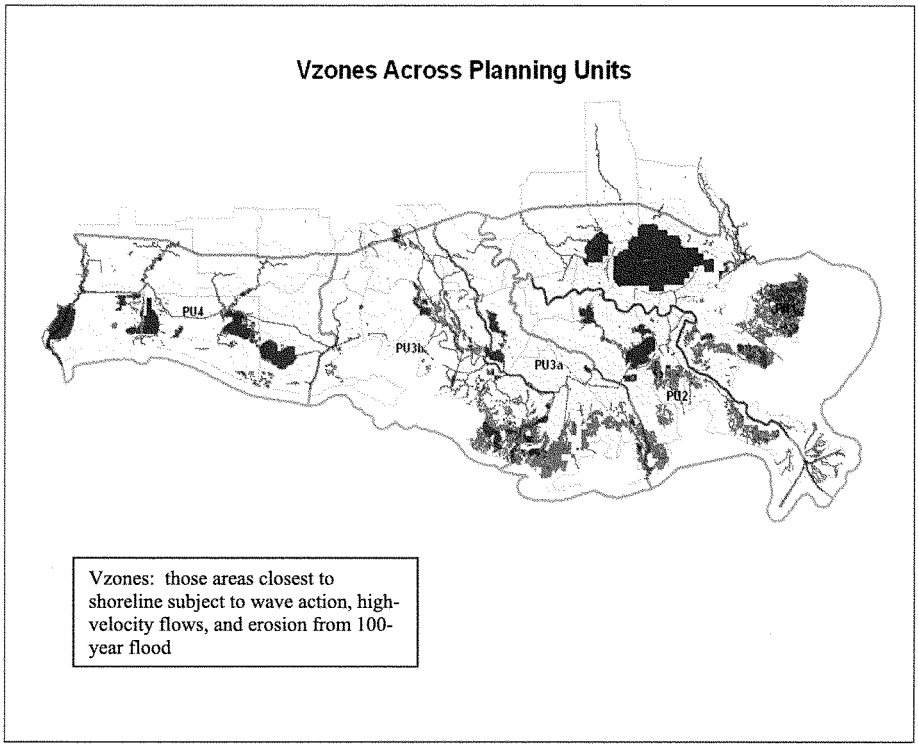
C. Applied Concepts

In order to evaluate risk with regard to storm surge, the concept of risk must be defined in a practical way so that metrics can be applied and plans be formulated in response to risk reduction. For the purposes of the nonstructural analysis, indicators of high risk from tropical events are defined as storm surge velocity and depth of flood inundation.

1. Storm Surge Velocity

Areas exposed to storm surge velocity, where the storm surge moves with great force, are defined by FEMA as those areas closest to shoreline subject to wave action, high-velocity flows, and erosion from a 100-year (1 percent annual chance) flood. The speed at which floodwaters move, i.e., velocity, is normally expressed in terms of feet per second. As floodwater velocity increases, hydrodynamic forces are added to the hydrostatic forces from the depth of still water, significantly increasing the possibility of structure failure. Greater velocities can quickly erode or scour the soil surrounding structures. These fast-moving waters can also induce failure by erosion, as their impact may move a structure from its foundation. When floodwater velocities exceed 3 feet per second and depths exceed 3 feet, it becomes difficult, if not impossible, for adults to maintain their balance while walking through a flooded area. For the purposes of this analysis, structures located in areas designated by FEMA as possessing high velocity flow characteristics with storm surge, Vzones, are subject to buyout and relocation assistance. **Figure 1** shows the location of velocity zones within the LACPR planning area.

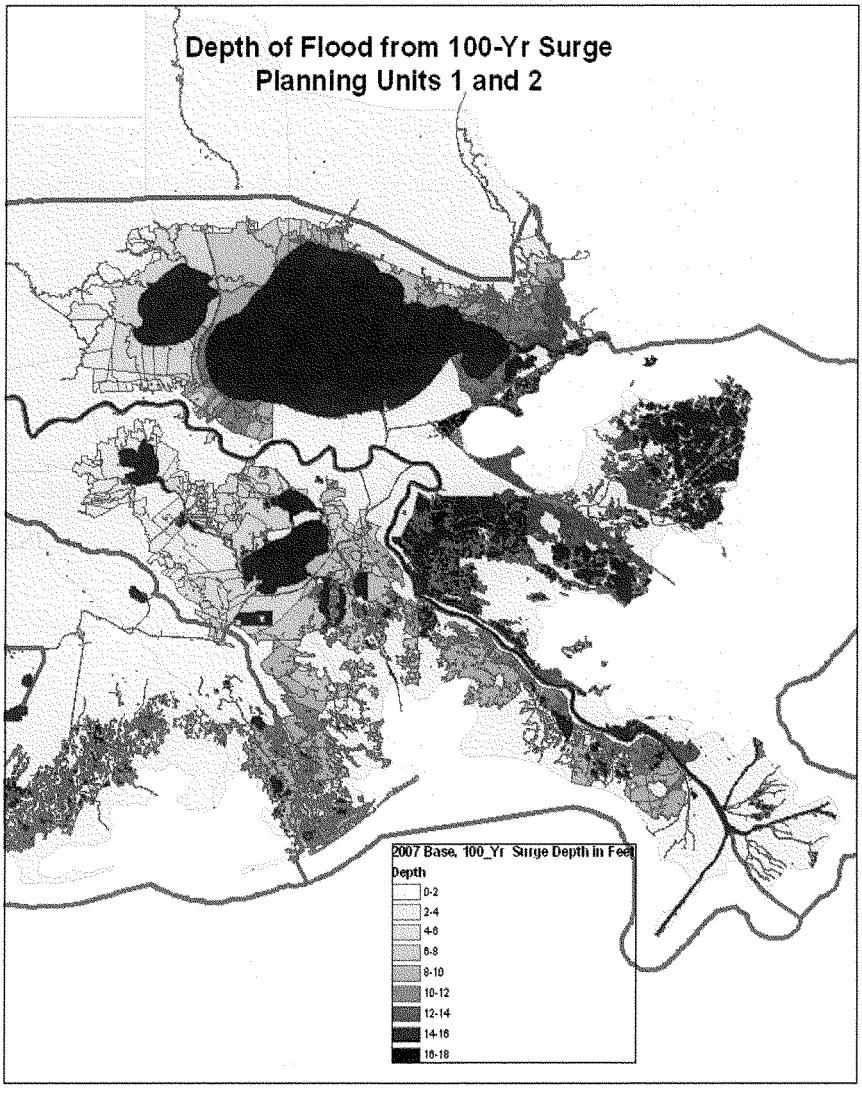
Figure 1. Location of Velocity Zones within the LACPR Planning Area



2. Depth of Flood Inundation

Areas of high risk to people and assets are also those areas where flood depths are high. The concept of risk was further defined with the determination of flood depths for the 100-year, the 400-year, and the 1000-year events. **Figure 2** shows the depth of flood inundation across Planning Units 1 and 2 of the LACPR planning area for a 100-year event. Flood stages were developed by the New Orleans District following established engineering principles and models, which are described in detail in the *Hydraulics and Hydrology Appendix*.

Figure 2. Depth of Flooding in Planning Units 1 and 2 for 100-year Event



D. Applying Decision Criteria to Plan Formulation

The formulation of nonstructural measures was based on the following decision criteria:

1. ***Storm surge velocity***: Areas noted as "high-velocity" Vzones by FEMA were investigated for population and property with the intent of reducing or eliminating exposure using buyout and permanent relocation. Velocity zones (Vzones) were spatially associated with census blocks to identify areas of high risk. Census blocks were identified and combined for processing using ESRI ArcMap software and the New Orleans District's economic spatial database. Outputs of the processing were an estimate of number of structures and the population flooded by various events as well as an estimate of damages to economic assets from those flood events. These areas were targeted for relocation/permanent evacuation based on the established decision criteria. Therefore, benefits and costs were developed for relocations to the 2010 structure inventory for the designated census blocks falling within FEMA's Vzones. A major assumption of the economic analysis is that property development will return over time to at least pre-Katrina levels by the year 2075 including those properties within the Vzones. Buyouts of these areas would eliminate risk to people and assets. In order to accomplish this, the cost of buying vacant lots projected to be developed over time was added to the cost of buying improved property as of 2010. The value of the vacant land was used as a proxy value for purchase of perpetual, restricted use easements for the vacant lots projected for development. Buyout of velocity zones is a nonstructural measure that was combined with all other nonstructural measures as a separate component.

2. ***Depth of inundation:*** Depth of inundation was applied as another indicator of risk. Areas of flood inundation were investigated for nonstructural measures such as raising-in-place for depths of inundation less than 14 feet. Where inundation depths are 14 feet or higher, buyout/permanent evacuation measures apply. FEMA publication, "Recommended Residential Construction for the Gulf Coast: Building on Strong and Safe Foundations," FEMA 550, April 2006, offers the rationale for the raising-in-place criterion decision. This manual contains closed foundation designs for elevating homes up to 8 feet above ground level and open foundation designs for elevating homes up to 15 feet above ground level. These upper limits are a function of constructability limitations and overturning and stability issues for more elevated foundations. Each census block in the planning area was assigned a hydrologic profile based on its location within a planning subunit. Planning subunits were developed to distinguish significant differences in the hydrologic condition across the projected area of inundation. Depth of inundation was calculated by census block based on the water surface of each hydrologic event when compared against the mean ground elevation of the census block. Flood depths, i.e., depth of flooding from the ground to the top of the water, from the 100-year, the 400-year, and the 1000-year events were aggregated into practical ranges of 2 feet or less, 3–6 feet, 7–13 feet, and 14 feet and higher.

Census blocks identified to be flooded 2 feet or less were removed from further consideration based on the assumption of negligible damage based on the assumption of an average 2-foot floor correction above ground. Census blocks identified as flooding 3 – 13 feet qualified for raising-in-place with the expectation that the integrity of the structures would be determined during the implementation phase of the project. Those census blocks that experienced depths of flooding of 14 feet or greater qualified for buyouts/permanent evacuation based on the decision criterion that lifting a structure above 13 feet would elevate it into an undesirable wind field and would violate the recommendations in FEMA publication 550. The nonstructural analysis used an upper limit of 14 feet for elevation because of the uncertainty of where the bottom of the lowest horizontal member of the structure frame might actually be. Using 14 feet as the upper limit was considered to be a conservative approach to the analysis but could be refined in subsequent studies. Different midpoint values for raising-in-place were used for estimating costs for elevating 3-6 and 7-13 feet.

The final two decision criteria should be considered during an implementation phase. These elements require more precise information and interagency coordination than is available during the generalized plan formulation phase.

3. ***Structural integrity:*** Determination of whether structures possess the integrity to be lifted or retrofitted for nonstructural measures would be determined in an implementation phase. The issue of structural integrity is a structure-specific metric that will not be known until more detailed planning is required for specific nonstructural project implementation. The economic database with which nonstructural measures were formulated and evaluated assumes that the structures in existence in 2010 are habitable because they reflect the resident population expected at that time. No allowance is made in the database for unoccupied, dilapidated, abandoned, or vacant housing. The corollary to this database assumption is that all structures evaluated over time possess the integrity to be raised since they are inhabited. Benefits and costs for raising structures assume full integrity.

4. ***Other agency involvement***: Implementation priority would be given to areas where the potential to collaborate with other agencies is high and nonstructural measures are compatible with other Federal, State, or local initiatives such as ecosystem restoration, FEMA acquisitions, or local initiatives for preserving communities/living cultures.

E. Methodology and Data

The level of detail for this nonstructural analysis deviates from a traditional nonstructural analysis. Usually, nonstructural measures rely on information more specific to individual structures and are more responsive to the particular characteristics of the structure and the flood threat. A structure-by-structure inventory with explicit data elements would have been the preferred database for a nonstructural analysis but the breadth of the evaluation

and the time allocated to the nonstructural effort precluded creation of such a database. As an example, the potential size of a structure inventory covering all of South Louisiana exceeds one million structures and would take several years to develop to the preferred level of detail. Rather, the nonstructural plan formulation is based on the New Orleans District database developed for the structural plan evaluation. The level of detail within the current economic database is commensurate with the conceptual level of nonstructural plan formulation deemed appropriate for the LACPR evaluation.

The LACPR structure database has its foundation based on the year 2000 U.S. Census data with structure characteristics, such as number, type, value, and elevation estimated at the block level. Census blocks are roughly equivalent to city blocks. There are approximately 72,000 census blocks covering the entire planning area. While the LACPR structure database lacks the level of specificity generally desired for nonstructural measure formulation, it is considered appropriate for purposes of this evaluation for identifying target areas for further in-depth analysis and for assessing the measures' maximum performance.

The demonstration projects are formulated and evaluated based on the traditional approach of a structure-by-structure inventory with explicit detail collected for each structure. The critical facilities information is derived from a spatially-referenced database which identifies the type and location of facility from Federal Emergency Management Agency's (FEMA's) Hazards U.S. Multi-Hazard (HAZUS-MH) database.

The format employed for the data analysis is compatible with the industry standard, ESRI ArcGIS, and data consisted of spatially referenced census block information, hydrology, and FEMA flood maps. A customized GIS spatial database similar to the one used by the Interagency Performance Evaluation Team (IPET) for the Hurricane Katrina IPET Report was used to accumulate data and assess damages to residential and non-residential structures, their contents, and vehicles in the LACPR planning area. The database was used to develop a water elevation-, or stage-, damage relationship for each census block in the LACPR planning area. Inputs to the database include elevation data, depreciated exposure values of residential and nonresidential structures, and depth-damage relationships. Hydrologic data were combined with stage-damage functions to estimate damages from various storm events.

Outputs from processing the database included damages to economic assets from various probabilistic storm events and the projected population and number of structures flooded by each event. A detailed description of the database and its attributes can be found in the *Economics Appendix*.

IV. Nonstructural Measures Identified for Evaluation

A. Stand Alone Measures

Using the decision criteria previously described, planning units were evaluated for depth of inundation based on base condition hydrology. Stand alone nonstructural plans were formulated with the following measures for all planning units.

1. Buyout of delineated FEMA velocity zones across each entire planning unit.
2. Buyout of all structures within census blocks not in velocity zones which demonstrate a depth of inundation from the ground of 14 feet or greater across each entire planning unit.
3. Raise-in-place for all structures in census blocks which demonstrate a depth of inundation between 3 and 13 feet from the ground across each entire planning unit.

Stand alone nonstructural plans with these combined measures were formulated for three levels of risk reduction from 100-year, the 400-year, and the 1000-year events. By applying this method a uniform level of risk reduction is achieved across each planning unit at three levels of risk reduction.

Table 2 demonstrates the distribution of structures evaluated for nonstructural measures based on the criteria described.

Table 2. Distribution of Structures Impacted by Stand Alone Measures

Distribution of Structures Impacted by Stand Alone Nonstructural Measure Level of Risk Reduction (LORR), Planning Unit, and Growth/Development Scenario

	100yr LORR		400yr LORR		1000yr LORR	
Planning Unit 1	count	percent	count	percent	count	percent
Compact Business as Usual	27,996	100%	160,724	100%	205,273	100%
Structures to be Bought Out	5,036	18%	8,453	5%	23,776	12%
Structures to be Raised in Place	22,960	82%	152,271	95%	181,497	88%
Dispersed High Employment	50,264	100%	219,381	100%	286,387	100%
Structures to be Bought Out	10,472	21%	15,649	7%	44,296	15%
Structures to be Raised in Place	39,792	79%	203,732	93%	242,091	85%
Planning Unit 2						
Compact Business as Usual	18,931	100%	128,761	100%	131,720	100%
Structures to be Bought Out	4,215	22%	16,621	13%	22,975	17%
Structures to be Raised in Place	14,716	78%	112,141	87%	108,745	83%
Dispersed High Employment	25,427	100%	168,124	100%	171,995	100%
Structures to be Bought Out	5,777	23%	23,085	14%	34,357	20%
Structures to be Raised in Place	19,650	77%	145,039	86%	137,638	80%
Planning Unit 3a						
Compact Business as Usual	35,485	100%	53,228	100%	59,484	100%
Structures to be Bought Out	614	2%	6,184	12%	9,748	16%
Structures to be Raised in Place	34,872	98%	47,043	88%	49,736	84%
Dispersed High Employment	43,637	100%	63,499	100%	69,579	100%
Structures to be Bought Out	738	2%	7,695	12%	12,747	18%
Structures to be Raised in Place	42,899	98%	55,804	88%	56,832	82%
Planning Unit 3b						
Compact Business as Usual	12,947	100%	22,358	100%	30,835	100%
Structures to be Bought Out	903	7%	957	4%	1,307	4%
Structures to be Raised in Place	12,044	93%	21,401	96%	29,528	96%
Dispersed High Employment	13,157	100%	24,378	100%	32,970	100%
Structures to be Bought Out	846	6%	907	4%	1,307	4%
Structures to be Raised in Place	12,311	94%	23,471	96%	31,663	96%
Planning Unit 4						
Compact Business as Usual	10,157	100%	16,957	100%	25,341	100%
Structures to be Bought Out	2,250	22%	2,509	15%	3,150	12%
Structures to be Raised in Place	7,907	78%	14,448	85%	22,191	88%
Dispersed High Employment	10,510	100%	19,387	100%	29,906	100%
Structures to be Bought Out	2,248	21%	2,547	13%	3,146	11%
Structures to be Raised in Place	8,262	79%	16,841	87%	26,760	89%
All Planning Units						
Compact Business as Usual	105,516	100%	382,028	100%	452,653	100%
Structures to be Bought Out	13,017	12%	34,724	9%	60,957	13%
Structures to be Raised in Place	92,499	88%	347,304	91%	391,696	87%
Dispersed High Employment	142,995	100%	494,768	100%	590,838	100%
Structures to be Bought Out	20,081	14%	49,882	10%	95,854	16%
Structures to be Raised in Place	122,913	86%	444,886	90%	494,984	84%

Depending upon the planning unit, growth/development scenario, and level of risk reduction, buyouts comprise at most 23% of the structures impacted (Planning Unit 2, Dispersed High Employment, 100-year level of risk reduction) and as low as 2 % of the structures impacted (Planning Unit 3a, Compact, Business as Usual, 100-year level of risk reduction).

Overall, of the 143,000 structures impacted by the stand alone nonstructural measure providing a 100-year level of risk reduction across all the planning units, 14% (20,000) are buyouts; of the 495,000 structures impacted by nonstructural measure providing a 400-year level of risk reduction, 10% (50,000) are buyouts, and of the 591,000 structures impacted by the 1000-year stand alone nonstructural measure, 16% (96,000) are buyouts. Therefore, raising-in-place is the major contributor to risk reduction for nonstructural measures with the greatest potential for protecting economic assets. Raising structures in place would also provide redundancy to the risk reduction system and would support efforts to create communities resilient to catastrophic events.

B. Combination Measures Developed in the Residual Floodplains of Structural Measures

The magnitude and distribution of nonstructural measures, that were formulated based on depth of flooding, change with the structural measure considered but generally conform to those areas lying outside or seaward of the structural alignments. As such, nonstructural measures were formulated in the residual floodplain of each structural measure to conform to the level of risk reduction provided by the structural measure. Decision criteria were applied in the same way as with the stand alone nonstructural measure formulation. As a result the nonstructural measures formulated in the residual floodplain of the structural measures share the same components of buyout of structures in velocity zones, buyout of structures in census blocks that demonstrate deep flooding of 14 feet or greater, and raising-in-place of structures in census blocks that demonstrated flooding between 3 and 13 feet. Once again, by applying this method, a uniform level of risk reduction is afforded to the entire planning unit whether structurally or nonstructurally.

C. Site Specific Measures

Levee segments that could be considered increments to the overall levee system were identified for the formulation of competing nonstructural measures for a cost effectiveness analysis. Nonstructural measures for specific sites conformed to the decision criterion of depth of inundation previously described and were formulated to the corresponding level of risk reduction provided by the levee segment. Nonstructural measures were formulated for the following sites:

Planning Unit 1

1. Slidell Ring Levee
2. Northshore Levee

3. LaPlace Levee
4. Oakville Levee
5. Plaquemines Levee

Planning Unit 2
1. Lafitte Levee
2. Golden Meadow Levee
3. Des Allemands Levee
4. Plaquemines Levee

D. Redundant Measures

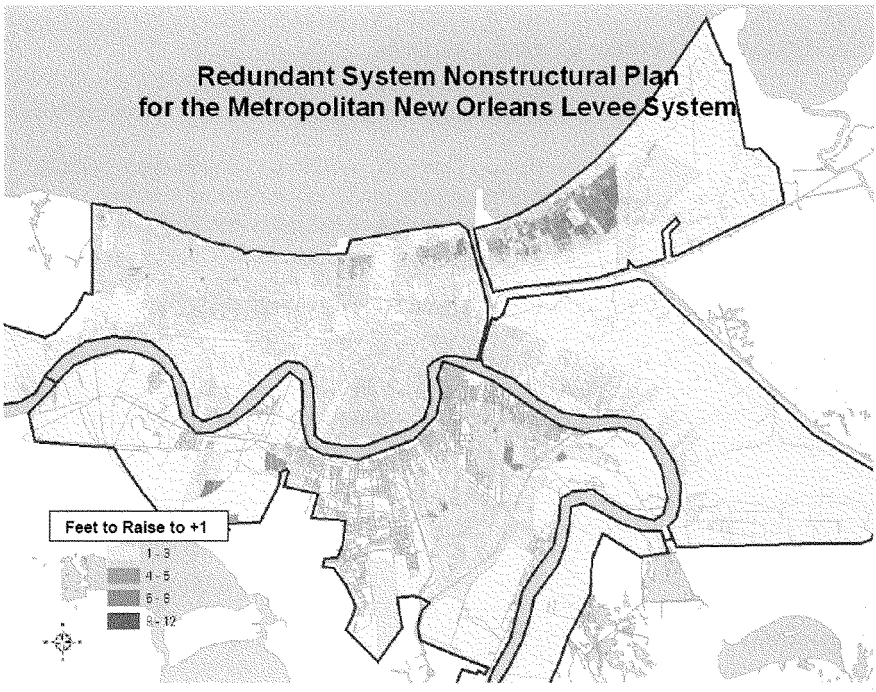
Redundant measures are those that would be included in a plan to provide backup risk reduction in the event that a structural component is exceeded by storm surge or has failed in some way. A single layer of hurricane risk reduction typically relies on project scale, for example the size of a levee, to protect an area and does not necessarily incorporate redundancy or system backup. The single-layer approach implies that the structural measures are fail-safe. However, fail-safe protection cannot be achieved through structural measures alone. Residual risk will always remain. To avoid the recurrence of the catastrophic consequences of Hurricane Katrina and Rita, vital economic and urban areas could receive additional risk reduction with a back-up system of nonstructural measures to support that provided by the structures measures.

A conceptual nonstructural measure that addresses redundancy within the metropolitan New Orleans levee system was developed and is shown in Figure 3. The metropolitan New Orleans area was chosen for a demonstration of a redundant plan because a levee system is in place; therefore, the nonstructural measures would contribute the redundant component. The Redundant System Nonstructural Plan is independent of depth of inundation but is based on the mean ground elevation of census blocks. A +1 foot elevation target for raising-in-place was chosen for evaluation because it is the first whole foot increment above sea level and demonstrates what would be involved in creating a back-up system for risk reduction in the face of catastrophic failure of the levee system. The assumption in the formulation process was that, following a catastrophic failure, structures raised to +1 elevation would remain dry as the flooding equalizes at sea level within the New Orleans Metropolitan Area.

The plan would elevate all structures with first floor elevations below +1 foot elevation to +1 foot elevation inside the metropolitan levee system. The Redundant System Nonstructural Plan was developed with the assumption that a levee breach would occur with little resulting velocity after the initial break and that all pumps would fail. No specific levee failure scenario was applied to the plan development, but rather a uniform application of the nonstructural plan formulation decision and cost criteria with regard to raising-in-place were applied. While it is acknowledged that nonresidential structures would more likely be flood proofed rather than elevated, the strategy applied to this analysis allows for a gross estimate of the magnitude of investment required for

implementation of such a plan, given that only 4 percent of all structures in the database are assumed to be nonresidential. Actual implementation would require more detailed information than what was available for the LACPR effort. However, this plan demonstrates conceptually the potential magnitude and cost for achieving a back-up system of risk reduction within the Metropolitan New Orleans area.

Figure 3. Redundant Plan for Metropolitan Levee System



Information upon which the analysis was based stems from data developed for the economic analysis. Topographical data obtained from the LIDAR digital elevation model using the NAVD88 (2004.65 epoch), which were used for the IPET study area, were combined with census block boundaries obtained from the 2000 Census using GIS mapping to determine the mean ground elevation for each census block in the New Orleans metropolitan area. The +1 foot value was calculated based on a difference between the mean ground elevations of census blocks, consistent with the reference datum of NAVD 88 (2004.65).

Elevating structures to +1 foot might not be sufficient to guarantee redundancy in a risk reduction system since relative sea level rise and other important considerations were not included in this particular analysis; however, this exercise was not intended to be a precise calculation of benefits and costs, in fact, no benefits were derived for this exercise

at all. The derivation of cost for a redundant nonstructural concept plan for the Greater New Orleans levee system was intended to demonstrate the minimum order of magnitude of effort and resources required in creating a back-up or redundant measure for risk reduction in the face of catastrophic failure of the levee system. Actual implementation would require more detailed information than what was available for the LACPR effort; however, this plan demonstrates conceptually the potential magnitude and cost for achieving a back-up system of risk reduction with the Metropolitan New Orleans area.

E. Measures to Protect Critical Facilities

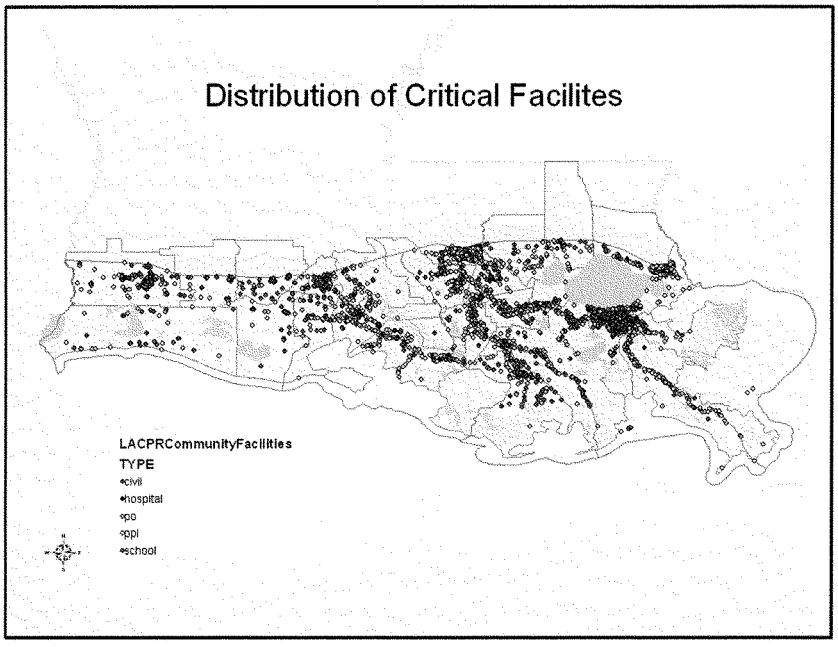
One way to create resiliency within the South Louisiana communities is to protect those public and private facilities that are critical to the health and safety of the resident population. These facilities are defined as hospitals, police and fire protection facilities, water treatment and wastewater treatment plants, public administration buildings, and schools that provide a base for emergency response and a post-storm foothold for recovery.

Critical facilities have been identified within the spatial extent of the LACPR planning area and are shown in Figure 4. Critical facilities are defined following the guidance and definitions contained in Executive Order 11988 (EO 11988), issued on 24 May 1977. The Executive Order is the guidance for flood risk management for all Federal activities within floodplains. EO 11988 is further implemented through guidance within the Federal Register dated 10 February 1978. Critical facilities are covered under what is named as "critical actions." The definition of a critical action is "any action for which even a slight chance of flooding would be too great." The interpretation of this term includes the following facilities: hospitals, water treatment plants, police and fire stations, city halls, emergency operations centers, and schools that could serve as centers to accommodate people evacuated from flooded areas. A total of 1,551 facilities have been identified within the LACPR planning area as meeting the critical action definition by using FEMA's HAZUS-MH database. These facilities are distributed into the following categories:

:

- Hospitals - 72
- Police Stations - 234
- Fire Stations – 223
- City Halls - 40
- Emergency Operations Centers - 10
- Schools that could serve as evacuation centers - 960
- Water treatment facilities – 12

Figure 4. Distribution of Critical Facilities in the LACPR Study Area.



The desired base flood elevation for these facilities as stated in Executive Order 11988 is outside the 500-year floodplain or protected to the 500-year stage. All nonstructural measures were considered to protect these facilities. Many critical facilities in South Louisiana are subject to high velocity storm surge or deep inundation, indicators of a high degree of risk. However, in order to best serve their surrounding communities, it is important that these facilities remain at their present locations. For the purposes of this evaluation, however, all structures within velocity zones are subject to buyout and/or relocation at a higher elevation. This is consistent with the decision criteria for nonstructural plan formulation.

Nonstructural measures formulation is site- and structure-specific to the individual facility being protected. Structure-specific information for every critical facility is required for the accurate formulation of appropriate nonstructural measures. These data include foundation type, use and type of building, exterior finish, size and height, condition, and other building characteristics. This type of explicit structure information was not collected for the LACPR report, but rather per square foot unit values for standard facilities were used instead.

Decision criteria based on depth of inundation and surge velocity was used in the formulation of nonstructural measures for critical facilities. Protection of critical facilities that are publicly owned such as public schools, colleges, city halls, police and

fire stations, and emergency services facilities can be addressed through either standard relocation contracts of the Engineer Federal Acquisition Regulation Supplement to demolish and rebuild or can be flood proofed by the use of veneer walls or ring walls. Veneer wall flood proofing was assigned to facilities with depths of inundation ranging from 0-3 feet with ring walls assigned to facilities with depths of 3-6 feet. Any critical facility that is located within a FEMA designated high velocity, "Vzone," or extreme high hazard area, however, was subject to buyout and/or relocation. For structures that had water depths greater than 6 feet, buyout and/or relocation at a higher elevation was selected as the most likely alternative nonstructural measure. Critical facilities that are privately owned can be acquired similarly to other commercial or residential properties through the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970.

Implementation of measures to protect critical facilities would require coordination with FEMA's Public Assistance and Hazard Mitigation Grant Program and Public Assistance Program to avoid duplication of effort.

F. Demonstration Projects

Nonstructural demonstration projects are of particular interest for LACPR because they can provide almost immediate risk reduction to a small area in a manner that is consistent with local interests. Demonstration of nonstructural measures offers the opportunity for USACE to work with State and local interests to achieve risk reduction in the near-term while large structural measures are constructed over a long period. Demonstration projects are intended to identify opportunities for and challenges of collaboration across the full spectrum of government entities.

The parameters for locating demonstration projects were as follows:

1. Identify locations that span across all of the South Louisiana planning area;
2. Identify locations that allow the use of nonstructural measures that are generally applicable to reducing risk across South Louisiana;
3. Identify locations that span the cultural, social, and economic range of South Louisiana;
4. Identify locations that have local governments that are strongly supportive of implementing nonstructural measures for risk reduction;
5. Concentrate the demonstration projects into those areas that sustained substantial damage and human suffering from the hurricanes of 2005;
6. Identify locations where USACE authorization complements nonstructural programs already underway or are potentially underway by other agencies such as FEMA and the Louisiana Recovery Authority (LRA); and
7. Identify locations where demonstration projects may be used as a catalyst for future implementation of nonstructural measures as part of an overall plan.

1. Coordination

Coordination of the demonstration project effort occurred at multiple levels within USACE and across other agencies. The New Orleans District, LACPR Team, and USACE Headquarters were included in the USACE coordination. The Louisiana Recovery Authority, the Louisiana Governor's Office of Homeland Security and Emergency Preparedness, and the Louisiana Office of Community Development were primary coordinators at the State level. Local governments at the locations selected for the demonstration projects were also involved. These locations are described below.

2. Applicable Nonstructural Measures

The demonstration projects included an assessment of all nonstructural measures applicable to the particular risk characteristics of the locale. The measures applied conformed to the interests of the local community and serve to support the needs for community resiliency and economic recovery.

3. Demonstration Project Areas Identified

City of New Orleans, Planning Unit 1. Potential demonstration projects within the City of New Orleans were identified within or immediately adjacent to target recovery areas designated by the City. The demonstration projects were developed in collaboration with the Office of Recovery Management, a division of the Mayor's office at the City of New Orleans. The Office of Recovery Management has developed a recovery plan that is based upon the Unified New Orleans Plan, which has been approved by the Louisiana Recovery Authority. A major component of the City's recovery plan is to focus public funding on redevelopment at the neighborhood level in a recognizable and sustainable pattern. A total of 17 target areas have been designated throughout the City. The target areas fall into three categories – rebuild areas that experienced severe impacts and are not recovering in terms of returning population; redevelop areas that were in need of redevelopment even before the storms and flooding; and renew areas where modest public investment can result in leveraging private and non-profit investment.
The United New Orleans Plan, a comprehensive public planning process conducted during 2006, strongly endorsed the concept of a neighborhood stabilization program, or "clustering." The goal of "clustering" is to concentrate population in areas of lower risk while removing people from areas of higher risk; this concept has widespread public support. Working closely with the City, demonstration nonstructural projects were identified on the basis of the following criteria:

- Projects located in Target Recovery Areas identified by the Office of Recovery Management;
- Projects located in areas with a high or medium risk of flooding to maximize the benefit of investing in nonstructural measures;
- Projects located in areas with a high incidence of blighted properties to facilitate the creation of clustered communities and to keep neighborhoods intact; and
- Projects that exhibit a wide variety of nonstructural options.

Residential redevelopment areas to accomplish "clustering" are part of the demonstration projects. These vary from where the USACE and the City will identify areas for

clustering that have existing infrastructure that may require purchase and clearing of blighted areas to areas that are currently somewhat open space, where infrastructure to support residential development will be placed as part of the demonstration project. Where areas will be evacuated of residential structures, the City would like the option of converting the vacated land to a use that is compatible with their associated risk (commercial or light industrial) rather than having to return the property to perpetual green space. Other demonstration projects involve the elevation of existing residential structures within or adjacent to target recovery areas.

In addition to the residential component, the demonstration program in New Orleans includes various measures to protect facilities, which are essential for improving resiliency during and after rare storm events. These measures include hospitals, a school, several groceries, and a pharmacy located in or near several target recovery areas.

City leadership views implementation of nonstructural measures as a high priority even with an enhanced Federal levee system and coastal restoration. The City realizes the mistakes of the past that allowed "slab on grade" construction to occur throughout the City, even in areas below sea level. The City firmly believes in the concept of "redundancy in flood risk reduction" especially in light of subsidence and a rising sea level.

A variety of nonstructural measures located in or near six target recovery areas have been identified. They are as follows:

1. Lower Ninth Ward—Buyout 150 residences in the low-lying high risk area. For an existing urbanized area with limited land available for development, the City desires the flexibility to redevelop the evacuated area in a manner appropriate to the risk and in conformance with target levels of risk reduction.
2. New Orleans East Plaza—Elevation of 25 existing slab on grade residential structures. In addition, the demonstration program envisions the elevation in place of an existing public school facility, dry flood proofing of a commercial facility (i.e., a pharmacy), and hardening (applying building techniques to make the structure more flood damage resistant and resilient) of two critical facilities (i.e., hospitals).
3. I-10 at Carrollton Avenue—Elevation of 40 existing residential structures.
4. Broad Street at Lafitte—Secondary levees or floodwalls to protect a large commercial facility (i.e., a supermarket).
5. South Claiborne at Toledano— Hardening (applying building techniques to make the structure more flood damage resistant and resilient) of a critical facility (i.e., a hospital).
6. St. Bernard at North Claiborne—Dry flood proofing to protect a mid-size commercial facility (i.e., a grocery store).

St Bernard Parish, Planning Unit 1. Potential demonstration projects in St. Bernard Parish were identified just to the east of Orleans Parish and north of Judge Perez Road. Two projects have been identified with approximately 100 homes in each project. These

projects consist of relocation and/or buyout with removal of the structure and conversion of the evacuated floodplain into new uses compatible with the risk associated with the locale.

Delcambre, Planning Unit 3b. Delcambre is located in South Central Louisiana. Potential demonstration projects were identified along Carlin Bayou, which directly connects with Vermilion Bay and the Gulf of Mexico. Delcambre has long had an important role in regional hurricane risk reduction as Carlin Bayou has been used over the years to temporarily harbor boats for risk reduction from hurricane induced storm surge.

Two basic demonstration projects were identified at Delcambre. They are relocation/buyout of existing residential and some commercial structures and flood proofing of existing critical facilities such as schools, water treatment facilities, police and fire stations, and city halls, as well as some commercial structures in the downtown areas considered critical to the community such as grocery stores and pharmacies. Approximately 128 structures would be evaluated for relocation or buyout, and approximately 35 would be evaluated for elevation-in-place, flood proofing, or low berms and walls. In Delcambre, the location of relocation/buyout of structures is in a very low area. The City is interested in converting the evacuated floodplain to activities that are appropriate for the risk levels and that take advantage of water connections to Carlin Bayou in order to facilitate access for water related recreation and for storage of boats during hurricanes.

Calcasieu Parish, Planning Unit 4. A potential demonstration project was identified north of the City of Lake Charles, Louisiana. It is located in Calcasieu Parish along the right bank of the West Fork, Calcasieu River. The area is not only subject to hurricane induced storm surge flooding, but also to riverine flooding. The area has 78 residential structures with varied type of foundation construction ranging from slab on-grade to elevated pier and beam. The area contains structures that meet criteria for classification as repetitive loss structures under the National Flood Insurance Program, meaning that they have filed two or more claims greater than $1,000 within a ten year period. Several of the structures have also received funding for mitigation to reduce flood risk through FEMA's hazard grant mitigation program. Approximately 30 to 40 residential structures would be considered under a demonstration program. The homes would be categorized according to depth of flooding. They would be elevated in place if indicated flood depths are less than 15 feet. Any structures subject to greater flood depths than 14 feet would be considered for relocation and/or buyout as discussed previously.

V. Evaluation Metrics

Nonstructural measures/alternatives were evaluated across 10 metrics as described in the main report. The following sections discuss a subset of those metrics related to residual damages, population impacted, regional economic impacts, and cost. Because no NED

analysis is required for the LACPR evaluation, no net excess benefit calculations were made.

A. Residual Damages

Base "without project" damages were calculated using the New Orleans District's economic spatial database as were all "with project" damages for stand alone plans, for combined structural, coastal and nonstructural plans and for site-specific plans. Both "with" and "without project" conditions are described in terms of future scenarios for development and land use as well as relative sea level rise. The Economics Appendix gives a full explanation of the derivation of the metrics used in the analysis.

B. Population Impacted

A similar method as applied to calculating damages was employed to calculate the population flooded for the various "with" and "without project" conditions. Assets protected by some nonstructural measures, such as raising-in-place, may require that the resident population evacuate their homes during the storm threat, but will return to homes protected to a defined level of risk reduction. In this instance, nonstructural measures do not protect the population from inundation, only assets are protected.

C. Regional Economic Impacts

Regional economic impacts were derived by eliminating flooding to census blocks that contained commercial and industrial structures. Protecting commercial and industrial structures from flood inundation was the only defined measure of regional economic impacts. No assessment was made of the potential impact of buyouts and relocations of businesses to the regional economy from implementation of nonstructural measures. Buyouts could depress the local economies of some areas and stimulate the local economies of others. How the region would be affected by massive buyouts and relocations of populations has yet to be investigated.

D. Project Cost

1. Costing Stand Alone, Complementary, Site Specific and Redundant Nonstructural Measures

Costs were generically applied to stand alone, complementary, site specific, and redundant nonstructural measures. Cost information was developed at a level commensurate with the level of detail of other information employed for evaluation purposes. Costs for buyout and permanent relocation of property were developed by the New Orleans District Real Estate Office. Representative property values were developed at the parish level and applied to the estimated number of properties required for buyout for nonstructural measures. Unit values for relocation assistance and acquisition costs were applied on a per structure basis to comprise the real estate cost for purchasing property for risk reduction. Nonresidential structures comprise only 4 percent of the total structures assumed for the base condition under both land use/development scenarios in the near-term and the future conditions and were, therefore, analyzed as residential with

no distinction for nonresidential type. **Table 3** below displays the costs applied to Planning Units 1 and 2.

Table 3. Cost for Evacuation/Buyout per Structure by Parish

PARISH	Unit Value (Land and Improvement)	Residential Value	Relocation Assistance*	Acquisition Costs	Total Real Estate Cost
Ascension	$150,000	$150,000	$100,000	$20,000	$270,000
Jefferson	$215,000	$215,000	$100,000	$20,000	$335,000
Lafourche	$100,000	$100,000	$100,000	$20,000	$220,000
Livingston	$150,000	$150,000	$100,000	$20,000	$270,000
Orleans	$150,000	$150,000	$100,000	$20,000	$270,000
Plaquemines	$100,000	$100,000	$100,000	$20,000	$220,000
St. Bernard	$110,000	$110,000	$100,000	$20,000	$230,000
St. Charles	$230,000	$230,000	$100,000	$20,000	$350,000
St. James	$150,000	$150,000	$100,000	$20,000	$270,000
St. John the Baptist	$170,000	$170,000	$100,000	$20,000	$290,000
St. Tammany	$240,000	$240,000	$100,000	$20,000	$360,000
Tangipahoa	$115,000	$115,000	$100,000	$20,000	$235,000

*As a conservative cost-estimating approach, relocation assistance costs are included in the cost of nonstructural measures for LACPR; however, P.L. 91-646 benefits may be applied differently during implementation of actual projects.

Unit values were applied to the estimated 2010 structure inventory for two land use and redevelopment scenarios developed by the New Orleans District. In order to maintain a level of risk reduction over time within the census block targeted for buyout and relocation, an assumption was made that a number of vacant lots equal to the growth projected within the block over the period of analysis would necessarily be bought to preclude future development from occurring. These costs represent a proxy value for a perpetual restricted use easement. These costs would be incurred during the construction period. The cost of vacant lots in parishes within the planning area was also provided by the New Orleans District Real Estate Office. **Table 4** below displays the unit costs applied to Planning Units 1 and 2.

Table 4. Costs for a Standard Vacant Lot by Parish

PARISH	Unit Value (Lot Only)	Residential Value	Relocation Assistance	Acquisition Costs	Total Real Estate Cost
Ascension	$40,000	$0	$0	$20,000	$60,000
Jefferson	$50,000	$0	$0	$20,000	$70,000
Lafourche	$10,000	$0	$0	$20,000	$30,000
Livingston	$40,000	$0	$0	$20,000	$60,000
Orleans	$20,000	$0	$0	$20,000	$40,000
Plaquemines	$10,000	$0	$0	$20,000	$30,000
St. Bernard	$20,000	$0	$0	$20,000	$40,000
St. Charles	$60,000	$0	$0	$20,000	$80,000
St. James	$40,000	$0	$0	$20,000	$60,000
St. John the Baptist	$30,000	$0	$0	$20,000	$50,000
St. Tammany	$60,000	$0	$0	$20,000	$80,000
Tangipahoa	$25,000	$0	$0	$20,000	$45,000

Costs for raising structures in place were developed by the Huntington District. The Huntington District provided costs for a new elevated structure where the existing structure was either destroyed or remained in a structural condition that would not support elevation and also for elevation of an existing structure. The costs employed in this analysis assumed that the structure was inhabited and was therefore an existing structure. These costs were separated into two height categories with the cost of the midpoint of each category applied to the number of structures raised between 3 feet and 6 feet and between 7 feet and 13 feet. Attachment 3 details the costs for raising-in-place as developed by the Huntington District and adjusted for the Gulf Coast region. For example, Gulfport, MS was chosen for the Marshall & Swift estimate while quotes were obtained from the New Orleans area. In certain instances, national averages were used. To these costs, Huntington District added unit values of $3,000 for temporary housing/relocation assistance and $25,000 for administration, oversight, and design.

Recovery and reconstruction are assumed to be ongoing activities throughout the project life. A basic assumption outlined in this analysis is that future growth will conform to the NFIP base flood elevation for first floor height above the 100-year flood elevation. Therefore, if a nonstructural measure proposes a level of risk reduction greater than the 100-year level, only the cost of the height increment above the 100-year was included as an economic cost of raising-in-place for future growth. Should the nonstructural measure be implemented, a requirement that future growth conform to the project's level of risk reduction, such as to the 400-year or 1000-year level, would be necessary in order to maintain the level of risk reduction throughout the 50-year period of analysis. The costs for incremental raising-in-place were derived from the cost information supplied by the Huntington District. A unit cost of $2,500 per foot of elevation above the 100-year elevation was calculated and applied to future growth, except when the raising to target exceeded the raising threshold of 13 feet. When this occurred, growth within the census block was assumed to be bought out and the vacant lot value was applied instead.

2. Costing Nonstructural Measures for Critical Facilities

Local governments provided information on the structure type, use, and depth of flooding at the structure. Numbers of students at schools were used to determine the school size. Since the building footprint size was unavailable for critical facility structures, standard public buildings sizes of 2,500 square feet (sf) and 5,000 sf were used for police and fire stations and city halls while building sizes for schools were based upon the number of students, using current national standards of square footage per student by school type. The following assumptions were made in order to develop general cost estimates for protecting critical facilities:

Hospitals

- Building condition is good.
- Building foundation will be slab on grade.
- Building type will be brick veneer.

- Building footprint will be 40,000 square feet.
- Each building will have eight door openings at 1 foot above the adjacent grade.
- Each building will have 200 feet of window located 3 feet above the adjacent grade.
- The building is four stories.
- The building must be usable during flood events.

Police Stations and City Halls

- Building condition is good.
- Building foundation is slab on grade.
- Building type will be brick veneer.
- Building foot print will be 2,500 square feet.
- Each building will have three doors at 1 foot above the adjacent grade.
- Each building will have 45 feet of window located 3 feet above the adjacent grade.
- Each building will have one story.
- Each building could be evacuated during a flood.

Fire Stations

- Use the same assumptions as police stations with the exception that three overhead doors of 10 feet in width will be present at 1 foot above the adjacent grade and window space will be reduced to 25 feet.

Emergency Operations Centers/Civil Defense

- Use the same assumptions as police stations with the exception that this facility must be in operation during floods.
- Use the same assumptions as hospitals except the building is one story.

Schools

- Base cost on student enrollment and other external sources.

Water Treatment Facilities

- The building condition is good.
- Building foundation is slab on grade.
- Building construction is masonry block.
- Building foot print is 20,000 square feet.
- Each building will have four door openings located 1 foot above the adjacent grade.
- Each building will have two overhead doors located 1 foot above the adjacent grade.
- Each building will be two stories.
- Each building will have 50 feet of window located 3 feet above the adjacent grade.
- Each building will be usable during floods.

The characteristics assumed and noted above were used for determining costs of implementation. These costs were calculated using cost versus depth versus type of nonstructural measure and were developed by Huntington District, USACE for use in both the LACPR and the Mississippi Coastal Improvement Program (MsCIP) reports.

VI. Evaluation of Nonstructural Measures

A. Stand Alone, Combination, and Site Specific Measures

Nonstructural measures/alternatives were evaluated against the same metrics as the structural measures/alternatives—residual damages, population impacted, regional economic impacts, costs, etc. The assessment of residual damages, population impacted and regional economic impacts to stand alone and nonstructural complements to structural measures was made by applying queries to a spatially referenced database described in the Methodology and Data section of this appendix. Outputs of these queries are reported in the *Evaluation Results Appendix*. Costs associated with site specific measures are included in the files.

B. Redundant Measures

The Redundant System Nonstructural Plan entailed raising-in-place of all eligible existing and projected future structures within the New Orleans metropolitan levee system under the two land use/population growth scenarios used in the evaluation of all LACPR plans. Existing structures were assumed to be built with a 2-foot floor correction above the mean ground elevation of the census block in which they are located. This is a consistent assumption made for all existing development. Structures projected for future growth were assumed to be built at the NFIP-required base flood elevation. However, for the purpose of redundancy, future development was raised to +1 foot elevation and the cost to elevate between the base flood stage and +1 foot elevation was added to the Redundant System Nonstructural Plan cost. The mean ground elevation for all census blocks showed no elevations within the range of eligibility for buyouts and relocations. The difference between the target +1 foot elevation and all estimated first floor elevations allowed for raising-in-place as the preferred nonstructural measure.

In total a plan for elevating all structures below +1 foot elevation within the metropolitan levee system to +1 foot elevation would cost between $19 and $21 billion. This plan would impact between 160,000 to 230,000 structures and an associated population between 320,000 and 460,000 residents. The levee system and coastal features would provide risk reduction from storm surge. The Redundant System Nonstructural Plan would provide back-up security to the City's economic assets from any flooding source by raising all eligible structures above sea level.

C. Measures to Protect Critical Facilities

Protecting critical facilities addresses the need for community resiliency, the ability of a community to rebound from rare and catastrophic natural events. As such, benefits calculated for the stand alone and complementary nonstructural measures were not computed for the critical facilities measures. Costs were computed based on generalized

assumptions noted previously. The results of the analysis are displayed in **Tables 5 through 9** below. In total 539 structures would be eligible for flood proofing or buyout and/or relocation based on depth of flooding at an estimated total cost of $2.7 billion.

Table 5. Costs for Nonstructural Measures Applied to Protect Critical Facilities, Planning Unit 1

	Veneer Wall 0-3 feet	Ring Wall 3-6 feet flood depth	Relocation greater than 6 feet
Critical Facility			
Schools			
Count	58	57	31
Average Cost	$479,000	$5,490,000	$12,149,000
Total Cost	$27,761,000	$312,927,000	$376,623,000
Hospitals			
Count	2	5	4
Unit Cost	$510,000	$5,905,000	$22,717,000
Total Cost	$1,020,000	$29,525,000	$90,868,000
Police Stations			
Count	3	1	6
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$270,000	$1,646,000	$5,220,000
Fire Stations			
Count	3	4	9
Unit Cost	$127,000	$2,025,000	$608,000
Total Cost	$381,000	$8,100,000	$5,472,000
Civil Defense			
Count	0	0	0
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$0	$0	$0
Total by Flood Depth	$29,432,000	$352,198,000	$478,183,000
Grand Total **$859,813,000**			

Table 6. Costs for Nonstructural Measures Applied to Protect Critical Facilities, Planning Unit 2

	Veneer Wall 0-3 feet	Ring Wall 3-6 feet flood depth	Relocation greater than 6 feet
Critical Facility			
Schools			
Count	2	22	68
Average Cost	$297,000	$5,370,000	$12,437,000
Total Cost	$593,000	$118,143,000	$845,686,000
Hospitals			
Count	0	0	3
Unit Cost	$510,000	$5,905,000	$22,717,000
Total Cost	$0	$0	$68,151,000
Police Stations			
Count	2	7	15
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$180,000	$11,522,000	$13,050,000
Fire Stations			
Count	1	4	25
Unit Cost	$127,000	$2,025,000	$608,000
Total Cost	$127,000	$8,100,000	$15,200,000
Civil Defense			
Count	0	0	0
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$0	$0	$0
Total by Flood Depth	$900,000	$137,765,000	$942,087,000
Grand Total			
$1,080,752,000			

Table 7. Costs for Nonstructural Measures Applied to Protect Critical Facilities, Planning Unit 3a

	Veneer Wall 0-3 feet	Ring Wall 3-6 feet flood depth	Relocation greater than 6 feet
Critical Facility			
Schools			
Count	16	21	30
Average Cost	$354,000	$4,971,000	$8,175,000
Total Cost	$5,669,000	$104,389,000	$245,237,000
Hospitals			
Count	0	2	2
Unit Cost	$510,000	$5,905,000	$22,717,000
Total Cost	$0	$11,810,000	$45,434,000
Police Stations			
Count	6	3	2
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$540,000	$4,938,000	$1,740,000
Fire Stations			
Count	2	9	14
Unit Cost	$127,000	$2,025,000	$608,000
Total Cost	$254,000	$18,225,000	$8,512,000
Civil Defense			
Count	0	0	0
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$0	$0	$0
Total by Flood Depth	$6,463,000	$139,362,000	$300,923,000
Grand Total **$446,748,000**			

Table 8. Costs for Nonstructural Measures Applied to Protect Critical Facilities, Planning Unit 3b

	Veneer Wall 0-3 feet	Ring Wall 3-6 feet flood depth	Relocation greater than 6 feet
Critical Facility			
Schools			
Count	7	7	17
Average Cost	$338,000	$4,944,000	$9,102,000
Total Cost	$2,368,000	$34,609,000	$154,729,000
Hospitals			
Count	1	0	0
Unit Cost	$510,000	$5,905,000	$22,717,000
Total Cost	$510,000	$0	$0
Police Stations			
Count	1	2	5
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$90,000	$3,292,000	$4,350,000
Fire Stations			
Count	0	2	10
Unit Cost	$127,000	$2,025,000	$608,000
Total Cost	$0	$4,050,000	$6,080,000
Civil Defense			
Count	0	1	0
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$0	$1,646,000	$0
Total by Flood Depth	$2,968,000	$43,597,000	$165,159,000
Grand Total			
$211,724,000			

Table 9. Costs for Nonstructural Measures Applied to Protect Critical Facilities, Planning Unit 4

	Veneer Wall 0-3 feet	Ring Wall 3-6 feet flood depth	Relocation greater than 6 feet
Critical Facility			
Schools			
Count	2	6	6
Average Cost	$299,000	$4,429,000	$5,554,000
Total Cost	$597,000	$26,572,000	$33,325,000
Hospitals			
Count	0	1	1
Unit Cost	$510,000	$5,905,000	$22,717,000
Total Cost	$0	$5,905,000	$22,717,000
Police Stations			
Count	4	2	6
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$360,000	$3,292,000	$5,220,000
Fire Stations			
Count	1	7	10
Unit Cost	$127,000	$2,025,000	$608,000
Total Cost	$127,000	$14,175,000	$6,080,000
Civil Defense			
Count	0	0	1
Unit Cost	$90,000	$1,646,000	$870,000
Total Cost	$0	$0	$870,000
Total by Flood Depth	$1,084,000	$49,944,000	$68,212,000
Grand Total **$119,240,000**			

D. Demonstration Projects

City of New Orleans

1. Lower Ninth Ward

Buyout of 150 residential structures. Metrics for the buyout of 150 residential structures with assistance with relocation include average annual equivalent damages reduced equaling $560,000; population protected of 300 persons, and costs approximating $22.5 million.

2. New Orleans East Plaza

Raise-in-place 25 residential structures. Metrics for the raising-in-place 25 residential structures to an elevation of 8 feet above grade include average annual equivalent

damages reduced equaling $1.8 million; 50 persons protected, and cost approximating $3.7 million.
Demolish and rebuild a public school: Cost of $21.3 million.
Dry flood proof a commercial building: Cost of $2.1 million
Flood proof a hospital: Cost of $4.4 million.

3. I-10 at Carrollton Ave.
Raise-in-place 40 residential structures. Metrics for the raising-in-place 40 residential structures to an elevation of 8 feet above grade include average annual equivalent damages reduced equaling $4.9 million; 90 persons protected, and cost approximating $5.9 million.

4. Broad St. at Lafitte Ave.
Dry flood proof a commercial structure. Cost to construct ring wall of $3.3 million.

5. South Claiborne at Toledano Ave.
Flood proof a hospital. Cost to construct at $4.4 million.

6. North Claiborne at St. Bernard.
Dry flood proof a commercial structure. Cost to construct impermeable veneer wall of $140,000.

St. Bernard Parish
Metrics for buyout of 200 residential structures with relocation assistance include average annual equivalent damages reduced equaling $8.4 million; 450 persons protected, and cost approximating $40.3 million.

E. Benefits and Costs Captured by Other Agency Actions

Following Hurricanes Katrina and Rita, the Federal government made available billions of dollars to assist with disaster recovery. *The Road Home* program, created by Louisiana Governor Blanco, the Louisiana Recovery Authority, and the Office of Community Development and funded by the U.S. Department of Housing and Urban Development, is the largest single housing recovery program in U.S. history. The program's objective is to help Louisiana residents get back into homes or apartments as quickly and fairly as possible.

These Federal investments are being made with the expectation that recovery complies with the National Flood Insurance Program's (NFIP) adjusted base flood elevations (ABFEs) and that this level of risk reduction provides a tolerable level of risk to the population. Conformance with NFIP building requirements for future growth is a basic assumption of LACPR's nonstructural measures formulation and evaluation.

However, the extent to which disaster recovery has influenced risk reduction has yet to be determined. For the purposes of the nonstructural measures analysis, any Federal contribution already made to risk reduction over and above the NFIP criteria cannot be ascertained without more detailed analysis. Some of the costs and some of the benefits

for risk reduction are captured by these existing recovery programs but the extent of their influence cannot be determined until the implementation phase of the authorized Federal project.

VII. Implementation

A strategy has been developed for a programmatic authorization for nonstructural measures implementation throughout southern Louisiana. The rationale and strategy for the program is described in Attachment 1.

VIII. Findings and Conclusions

Nonstructural measures were formulated with the primary goal of reducing risk to the population and assets of South Louisiana. The development of applicable measures was based on two primary sources of risk: storm surge velocity and inundation. Findings support that nonstructural measures perform well across all the metrics considered for the LACPR evaluation. They are efficient and effective in reducing risk from storm surge, as well as from other sources of flooding. Nonstructural measures bear few operational and maintenance costs and have little or no environmental mitigation requirement.

Overall, the raising-in-place component of any nonstructural plan contributes most to risk reduction due specifically to the magnitude of the application. Of the half million structures impacted by a 400-year stand alone nonstructural measure, over 90 percent would be raised-in-place thereby preserving neighborhoods, communities, and the local economy while contributing significantly to risk reduction.

These findings demonstrate the potential of the nonstructural measures; however, the evaluation assumed full participation in the program. The actual benefits and costs are dependent on local participation rates. The successful implementation of a coast wide program of nonstructural measures would require full agency endorsement as well as intense stakeholder and non-Federal sponsor involvement to address outstanding issues such as preserving living cultures and the social fabric of communities in addition to potential impacts to the regional economy.

A full collaboration among Federal agencies, State and local governments and the population at risk is necessary for any successful Federal action; however, the nonstructural measures developed through plan formulation can be implemented under existing USACE policy and local sponsor cooperation. Some incentives to encourage public participation may be required and creative options to direct property acquisition may require changes to public law and policies. It is the intention of the nonstructural program outlined in the following Attachment 1 to explore these opportunities for and obstacles to success by utilizing resources made available through a programmatic authority that may establish and maintain a continuous and adaptive implementation process.

Attachment 1
An Implementation Program for Flood Risk Reduction Using Nonstructural Measures

Purpose

This paper presents a rationale and potential strategy that may be used to create a program to implement nonstructural measures in support of LACPR objectives if further development is requested by the Administration or Congress. A United States Army Corps of Engineers (USACE) program for nonstructural risk reduction could strengthen the long term recovery of southern Louisiana. In concert with structural measures and coastal restoration, nonstructural measures could be the key component to reducing long-term risks and supporting sustainable redevelopment. Adaptive management practices are critical to insure success of the program because many of the ideas presented here, while based on precedence, have never been applied on such a large scale as the region affected by Hurricanes Katrina and Rita.

Introduction

The Louisiana Coastal Protection and Restoration (LACPR) plans should be based on a collaborative approach to flood risk management in southern Louisiana. The LACPR Technical Report outlines a multiple lines of defense strategy, and nonstructural measures are an integral part of that defense network. Nonstructural measures include elevated structures, residential buyouts, hardened structures, evacuation planning and flood warning systems, maintained evacuation routes, flood risk communication and education, and flood insurance programs. The nonstructural plans presented in this report include measures specifically related to protecting structures and assets – elevating, relocating, hardening (applying building techniques to make the structure more flood damage resistant and resilient), and protecting homes, businesses and critical facilities. The State Master Plan specifically addresses evacuation routes in the FY08 annual plan, and State, local and Federal emergency planners have already evaluated and updated regional evacuation plans. The Governor's Office of Homeland Security and Emergency Preparedness (GOHSEP) has enabled the Integrated Public Alert and Warning System (IPAWS) to create a comprehensive and modern public alert and warning system. All of these efforts would be incorporated into risk communication and education programs, which are a vital component of risk management.

Background

Louisiana is a working coast. People and assets are there for many good reasons; however, the people and assets are at risk from coastal storms. Residents need to balance risk against the desirable benefits of the region. This balancing act amounts to making risk-benefit (or risk-cost) tradeoff decisions. Nonstructural measures are particularly dependent upon successful collaboration with the public, across programs, and across levels of government as these trade-off decisions are made. Individual property owners and local governments have responsibility for local land-use decisions and building patterns and the success of many Federal programs depends upon the fulfillment of these responsibilities.

Over time flood damages across the nation have risen rather than declined, even after billions of dollars of investment have been made in protection and mitigation programs. Adopting an innovative and integrated program of nonstructural measures that augments structural structures can further reduce potential flood damage across southern Louisiana.

Need for a Sustainable Recovery

Federal agencies such as the Department of Housing and Urban Development (HUD) and the Federal Emergency Management Agency (FEMA) support Louisiana's economic recovery with billions of Federal dollars in rebuilding grants and payments to local communities and individual homeowners. As the recovery continues, compliance with the National Flood Insurance Program's (NFIP) base flood elevations remains the sole risk reducing criterion for reconstruction. Little local attention is paid to the storm risk that lead to the catastrophic event itself. With the exception of work to rebuild the hurricane risk reduction system for the Metropolitan New Orleans area, the population and economic assets of South Louisiana remain as vulnerable as they were pre-Hurricanes Katrina and Rita. While floodwalls, levees and pumps are being improved so that the areas within existing structures will have reduced risk levels, areas within the system continue to possess residual risk because existing structures are authorized to the 100-year level and can be exceeded by larger storms while threats from other interim flooding sources remain.

While recovery is the immediate goal, attention should be paid to opportunities to meet long-term goals for resilient, sustainable communities. Nonstructural measures not only reduce risk to people and assets, they also contribute to the sustainability and resiliency of the region. Resilience is defined here as the ability to bounce back from a catastrophic storm event. Homes and businesses can be flood proofed; relocated, or elevated and critical facilities can be designed and constructed with hardened features. Critical facilities can be modified to maintain the necessary operational requirements and the structural integrity to quickly return to operations in the storm's aftermath. Critical facilities are the base of operations for health, safety, public protection, and governance operations so that services can be restored to the impacted area. These are the operations that will ensure that roads, sewers, water, power, healthcare and other essential services

will be available to people and their homes, businesses, schools, and churches, in effect, the community, as quickly as possible so that residents can begin the recovery process. With these measures, the region would improve its ability to recover from these natural events in a timely manner.

Program Overview

Need for Programmatic Authority

Establishing a programmatic authority could create and maintain a continuous and adaptive implementation process. By establishing and funding at the program level rather than at the project level, efficiencies could be attained with regard to project execution. But most importantly, a programmatic approach could allow for the critical development and maintenance of collaboration among Federal agencies, State and local governments and the population at risk. Adaptive management practices should be an integral part of the program as described in the creation of any general LACPR implementation plan.

Precedence

Louisiana's Road Home program and USACE's Section 202 program could be administrative models for a nonstructural measures program. The prototype for nonstructural measures implementation for southern Louisiana is based on the USACE, Huntington District's experience with implementation of Public Law 96-367, Title II, Section 202(a) of the Energy and Water Development Appropriations Act of 1981. Section 202 and subsequent legislation noted below have created a program within which nonstructural measures can be effectively implemented. Aspects of the Section 202 program are worthy of consideration for application in the State of Louisiana.

> *Section 202* directed the Secretary of the Army, acting through the Chief of Engineers, to design and construct, at full Federal expense, flood damage reduction measures in those areas impacted by the flood of April, 1977, most notably along the Kanawha, Guyandotte, Big Sandy, Kentucky, Cumberland, and Tennessee Rivers. Benefits exceed the cost of the flood control measures authorized. This legislation established a level of protection commensurate with a historic event; introduced full Federal expense, and forgave the requirement for justification based on a benefit-cost analysis.
>
> *House Joint Resolution 492 (Public Law 98-332, 3 July 1984)* directed expeditious implementation of nonstructural features "such as relocation sites, flood proofing, and floodplain acquisition and evacuation" of the Section 202 General Plan for Project Implementation, dated 28 April 1982. This legislation emphasized the application of nonstructural measures.

Section 103b of Public Law 99-662 (Water Resources Development Act ((WRDA)) of 1986) states that "the non-Federal share of the cost of nonstructural flood control measures shall be 25 percent of the cost of such measures. The non-Federal interests for any such measures shall be required to provide all lands, easements, rights-of-way, dredged material disposal areas, and relocations necessary for the project, but shall not be required to contribute any amount in cash during construction of the project." This legislation changed the non-Federal sponsor's traditional cash contribution and reduced to 25 percent the cost-share by the non-Federal sponsor.

Section 336 of Public Law 106-541, WRDA 2000, directed the Secretary (of the Army) to determine the ability to pay by the non-Federal sponsor based on the criterion specified in Section 103(m)(3)(A)(i) of WRDA 86. The non-Federal cost share was to be based on the benefits test and county per capita income, omitting the state per capita income in the formula.

Applicable nonstructural measures

Nonstructural measures considered for application in the program could include acquisition and buyout, relocations of property improvements to higher ground, raising-in-place of improvements on existing property, wet flood proofing and dry flood proofing. For the purpose of this program, actions would be affected to individual properties in the interest of reducing risk to the resident population and economic assets by removing the population from the source of storm risk or by elevating assets above the flood risk. Facilities that cannot be elevated or moved away from risk because of their critical contribution to the local community could be assessed for elevation, and dry or wet flood proofing. Nonstructural measures could be applied based on the decision criteria established for LACPR which incorporate an assessment of risk and structural integrity.

Level of risk reduction

The level of risk reduction achieved by implementation of a nonstructural program could be at the levels of risk reduction described in the LACPR report (100-year, 400-year, or 1000-year).

Spatial scope

The area eligible for program participation could be the planning area of the LACPR report.

Nonstructural projects defined

The technical report identifies nonstructural measures at the gross planning unit level. Smaller geographical boundaries could be considered during an implementation phase, and nonstructural projects could be identified according to these smaller boundaries. For example, a nonstructural project may be defined at the parish, city or neighborhood level. Project boundaries would be influenced by the nature and extent of the flood risks, the complexity of the measures, available resources, sponsor's capability and similar issues that influence project evaluation and implementation.

Nonstructural project evaluation

Nonstructural projects could be evaluated using the same or similar metrics that have been used in the LACPR technical report. Risk reduced and residual risk could be explicitly considered using population and damage metrics. However, additional metrics would be necessary to characterize social effects and impacts to community cohesion. Coherence with recovery planning, and local land use planning efforts, could also be considered in the evaluation. Finally, the ability to leverage other public and private investment should be included in the metrics.

Need for collaboration with other agencies, local communities

Coordination and collaboration across Federal, State, and local agencies involved in the economic recovery of Louisiana is necessary to achieve risk reduction in a comprehensive and systematic manner. This approach may require collaboration among multiple agencies with each providing funding in order to achieve both objectives of risk reduction and disaster recovery within a comprehensive framework.

As part of the recovery process, the Road Home program offers compensation grants to homeowners who want to rebuild or repair their homes, move to another home within the State, or sell their property and move out of state. For those homeowners who want to repair, rebuild, or sell and move to another property in Louisiana, Road Home offers grants for rebuilding and repair and additional funding to elevate property. Any previously received FEMA or insurance, including NFIP, proceeds are subtracted from the total grant awarded. These Federal investments are being made with the expectation that recovery complies with the National Flood Insurance Program's (NFIP) adjusted base flood elevations (ABFEs). The Road Home requirement to elevate to the ABFE, however, is limited to new structures or those where the assessed flood damage was substantial, i.e. more than 50 percent of the structure value. Another Federal program being utilized to reduce risk in the planning area is FEMA's Hazard Mitigation Grant Program (HMGP). This program, however, has funding and eligibility limitations that constrain its effectiveness in reducing residual risk.

A USACE program for nonstructural implementation with a primary goal of risk reduction is needed to integrate that priority into the ongoing economic recovery. A USACE program could supplement existing Road Home and HMGP programs in which

requirements other than identified risk must be met for program eligibility. In other words, the USACE program would be intended to allow for a more systematic nonstructural implementation by providing funding for risk reduction while other Federal monies are committed to economic recovery. Additionally, in order to provide resiliency to the area and redundancy to the flood risk reduction system, the USACE's nonstructural measures program would provide a level of risk reduction that corresponds to at least that contained in the plans presented in the LACPR report. Should the level of risk reduction exceed the ABFE target elevations, that increment of elevation above the ABFE target would be considered part of the nonstructural project.

It is further noted that the Federal government forbids two or more Federal agencies from providing compensation to cover the same loss. Coordination across Federal agencies would also be required to avoid duplication of funding.

General Procedures

The USACE would develop a Procedures Manual upon receiving authorization and appropriation to create a program for implementation of nonstructural measures for southern Louisiana. This Procedures Manual would contain necessary elements for implementing the nonstructural program and would be patterned after the Huntington District's administration of its Section 202 program. Except for noted differences, all USACE standard operating procedures would be maintained. All environmental compliance, hazard and toxic waste abatement, and historic and cultural preservation laws and policies that apply to Federal civil works projects would apply to the implementation of the nonstructural measures program.

Elements to be addressed by the Procedures Manual could include but not be limited the topics discussed below.

Local community involvement in the planning process

Local community involvement is a requisite for program success. In order to achieve sustainable storm risk reduction, difficult decisions would be required, thereby necessitating intense stakeholder involvement. Program participation would stem from application by local or State governments that possess the authority to enter into cost-sharing agreements with the Federal government.

Individual participation and application

Individual participation in the program would evolve from the non-Federal sponsor. Owners of eligible properties would be required to apply to participate. The Huntington District has developed the process and forms for program application that have utility to a nonstructural program for Louisiana.

Ranking of participants would most likely be necessary for the disbursement of available funding. Applicants could be screened and ranked for participation with regard to storm risk associated with their property. The LACPR evaluation has produced indicators of risk based on storm velocity and depth of flood inundation. These criteria could be applied to screening and ranking of applicants. Additional ranking criteria may be needed to possibly include social effects, community cohesion, local or state recovery priorities, as well as any leveraging of funds from other programs.

Design, construction, inspection, operation and maintenance of nonstructural measures

The design, construction, and inspection of nonstructural measures could be the responsibility of the Federal government. Operation and maintenance activities could be responsibility of the non-Federal sponsor and the individual property owner.

Real estate and legal considerations

Interests in real property could be acquired by negotiated direct purchases and by negotiated flood proofing agreements. Interests acquired by direct purchase and by flood proofing agreements could be acquired directly in the name of the non-Federal sponsor.

Real estate procedures for property appraisals, land surveys, property acquisition, demolition, disposal and other requirements could be established in the Procedures Manual and could reflect standard methods employed by the Federal government. Acquisitions and flood proofing procedures could be established to conform to standard procedures. All legal agreements, covenants, and documents could be endorsed by the USACE with regard to Federal interests. The Huntington District has established procedures and forms which can be used as examples to address these procedural elements.

Negotiation procedures

The Huntington District example contains established procedures which outline negotiations procedures between the Federal government and the property owner.

Procedural support for applicants

Support could be provided to individual property owners with regard to the procedural details of program participation. This could include the proper completion and execution of necessary documents, counseling with regard to program eligibility and other concerns that may arise.

Property Acquisitions and Relocation Assistance

Property buyouts are an important nonstructural measure for risk reduction. Acquisitions entail owners selling property to the non-Federal sponsor so that improvements can be

cleared and the parcels left vacant or converted to a use that is compatible with their associated risk.

In addition to receiving fair market value for the property acquired, owners of real property acquired for Federal projects are entitled to receive relocation assistance under Public Law 91-646, the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (PL91-646). Such assistance generally consists of a replacement housing payment and payment for moving expenses. A displaced homeowner may receive up to $22,500 to acquire a comparable replacement dwelling. This amount can be increased if comparable homes are not available in the market. Generally the replacement housing payment is the difference between the fair market value of the home acquired and the cost to acquire a comparable home at a site with reduced flood risk, typically outside the 100-year floodplain. The displaced homeowner is entitled to decent, safe, and sanitary accommodations as part of relocation assistance.

Of specific interest to the LACPR effort is the situation in which the property targeted for buyout for risk reduction has lost its improvements or its improvements are uninhabitable as a result of the storm event. Generally, in order for a homeowner to be eligible for relocation assistance, that homeowner must occupy the property for 180 days prior to acquisition. But because many of the persons displaced by Hurricanes Katrina and Rita may not occupy the property when an acquisition phase would be commenced, there is some question regarding their eligibility for relocation assistance.

Some guidance on this question with respect to residential properties is provided by the Robert T. Stafford Disaster Relief and Emergency Assistance Act as amended, 42 USC § 5121 (Stafford Act) and PL91-646 regulations. Section 414 of the Stafford Act does not deny eligibility for relocation benefits to displaced persons whose property is uninhabitable because of a major disaster as determined by the President to meet the occupancy requirements set forth by PL91-646. In 49 CFR § 24.403(d) (additional rules governing replacement housing payments) reflects this § 414 requirement. That section provides that "No person is denied eligibility for a replacement housing payment solely because the person is unable to meet the occupancy requirements...for a reason beyond his or her control, including: (1) A disaster, an emergency, or an imminent threat to the public health or welfare, as determined by the President, the Federal Agency funding the project, or the displacing Agency."

Extending these provisions to implementation of nonstructural measures for risk reduction within South Louisiana and applying relocation assistance to all Federal project acquisitions in support of a nonstructural program in Louisiana could significantly influence the success of the nonstructural program. This aspect of the program could support local initiatives for redevelopment and population concentration to areas that are less risk-prone as is the goal of the City of New Orleans' Recovery Plan while also meeting the LACPR objective of overall risk reduction to the population. This application of relocation assistance would allow for both risk reduction and resilient economic recovery.

Alternatives to Direct Property Acquisitions

Other possible mechanisms for acquiring real property in support of risk reduction could require Congressional authorization but are worthy of consideration. Many local governments resist nonstructural buyouts for fear of losing their tax base along with the social fabric of their communities. Given the fact that many households have been reestablished since the devastation of 2005, a funding program could be established whereby options to purchase properties could be extended to homeowners in high risk areas. This would constitute a form of property lien to be exercised at the time that the property is vacated either by attrition or in the event of another catastrophe. Other real estate mechanisms for property acquisition that are available in the market such as reverse mortgages could be investigated for application in situations where property owners desire to live in their homes for the remainder of their lives. These mechanisms would not produce risk reduction immediately, but would allow for a gradual and permanent risk reduction without the overt disruption that many communities fear. These types of creative solutions could be explored in collaboration with local governments when determining the trade-offs between risk reduction and other societal concerns.

Relocations and Raising-in-place

The structural integrity of property improvements may allow for relocation of that structure by lifting and moving to a site having a target elevation for risk reduction or allow for lifting the structure in place to a target elevation. Temporary relocation assistance could be offered to participants in a manner that is consistent with normal USACE procedures.

Project justification, cost-sharing and ability-to-pay provisions

Section 202 of the Energy and Water Development Appropriations Act of 1981 was the first of a series of laws that set precedent for risk reduction in areas of West Virginia and Kentucky that had historically failed to compete for Federal assistance using traditional economic justification methodology. The social and economic plight within the State of Louisiana brought about by Hurricanes Katrina and Rita is very similar to that experienced in West Virginia and Kentucky, presenting another case whereby the results of catastrophic events are insufficiently captured in traditional expected annual damage calculations. As a result, the LACPR study has not been limited by "normal policy considerations" as directed by the Congressional authority for LACPR. To that end, a nonstructural measures program would seek to manage residual risk in a cost effective manner.

In order to achieve both objectives of economic recovery and storm risk reduction, special consideration could be granted for program participation. Non-Federal sponsors, strapped for funds with which to participate in the program, might have their traditional cost-sharing obligation reduced based on the shared interest of supporting economic recovery in a timely and risk-responsible manner. Ability to pay provisions could reflect the financial condition of the non-Federal sponsor.

Program Administration

The general implementation plan in the LACPR Technical Report outlines a new organizational framework. In that program management framework, the governing Decision Board and the Integration Support Team would be responsible for all LACPR project implementation, including the program for nonstructural measures implementation. The proposed new LACPR program management structure with its collaborative adaptive management focus incorporates both objectives of recovery and storm risk reduction. However, due to the need for extensive coordination with local and State government and communities, implementation of the LACPR nonstructural program would likely require a "nonstructural support team" that includes professional staff not normally involved in USACE projects. This staff could include urban planners, community outreach specialists, and residential construction experts.

Next Steps to Implementation

The next phase of work could be a transition from the high-level analysis performed thus far to a community-based collaboration and evaluation process. The nonstructural appendix describes the formulation and evaluation of nonstructural measures. The appendix also describes plans that could complement the levees and floodwall systems and plans that could substitute for levees and walls in some locations. The scale of these evaluations demonstrates the potential performance of these measures; however a number of analytical and procedural issues need to be resolved in order to transition to implementation.

Further analysis would be needed to refine the assessment of risks drawn from the storm modeling and flood risk mapping as well as to refine individual plan's effects and costs. In the nonstructural appendix, plan formulation criteria were based upon depth and velocity of flooding. The plans were then evaluated for their potential to reduce flood damages and to remove population from the floodplain as well as for their costs. During program implementation, these plans could be further evaluated in collaboration with local communities and other partners for a more explicit accounting of project impacts and a customized application of nonstructural measures. An appropriate mix of flood proofing, elevating-in-place, and buyouts could be determined for each participating community. The nonstructural program could continue to apply the risk-informed decision framework, relying heavily on collaboration with stakeholders to formulate and evaluate plans and to prioritize investments according to the risk reduction goals of the program.

The demonstration projects developed for LACPR apply a variety of nonstructural measures to the particular needs of communities. These demonstration projects would be an excellent opportunity to "kick start" a nonstructural program and could represent the initial phase of the nonstructural implementation program.

Summary

This paper presents the rationale and a proposed strategy for the creation of a programmatic approach to implementing nonstructural measures as part of LACPR. The nonstructural program would identify, evaluate and prioritize nonstructural projects according to their contributions towards achieving the risk reduction goals of LACPR. The program would continue to use the risk-informed decision framework that has been developed during the completion of the technical report. The decision framework emphasizes the importance of collaborative planning between the USACE team, partners and the community. The personal nature of nonstructural measures increases the importance of this collaborative approach. The program would rely upon adaptive management practices to assure that new knowledge is incorporated into program decisions to deliver nonstructural measures as efficiently and effectively as possible.

Attachment 2
Examples of Cost Determination

The following information is provided to show actual costs as provided by Huntington District for implementation of several nonstructural measures.
Costs shown in 2007 dollars.
All costs include E&D and S&A
Elevation of residential buildings with slab on grade attached

Elevate 0' – 6' above adjacent grade, existing structure = $85 per sq ft of building footprint

Elevate 7'- 15' above adjacent grade, existing structure = $95 per sq ft of building footprint

Nonstructural flood wall around to protect a school
2300 linear feet of flood wall
7' wall height
12' roller gate for vehicles
12' pedestrian gate
34' access ramp over wall
2 – 268 gpm pump stations for
Interior drainage
Cost--$5,100,000

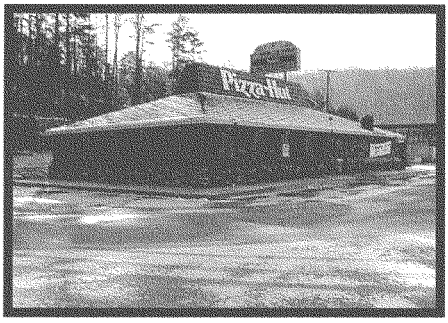
Combination Town Hall [TH] & Fire Station [FS]

Demolish existing building and reconstruct new building at a relocation site
T.H. – 1800 sq ft (offices, conference room and rest room)
F.S. – 2400 sq ft (office, BR/showers, bays to house 2 – 28' pumper trucks and 1 20' rescue truck)

$80,000 to demolish old structure
$950,000 construction

Dry Flood Proofing a Commercial Building

Dry flood proof an existing commercial building that is slab on grade, good condition, brick veneer type construction, building footprint of 4000 square feet, three door openings elevated 1 foot above the adjacent grade, 80 feet of window elevated 3 feet above the adjacent grade, single story.
$72,000 to dry flood proof 3 feet above the adjacent grade and add another layer of brick veneer.

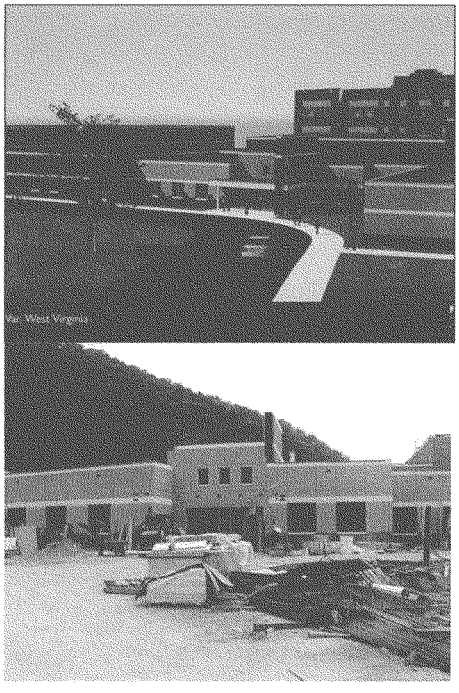


School Relocation

57,500 sq ft pre-K thru 8. Old building demolished and new building constructed at new development site

Total cost construction, E&D and S&A = $10,698,531

$186 per sq ft

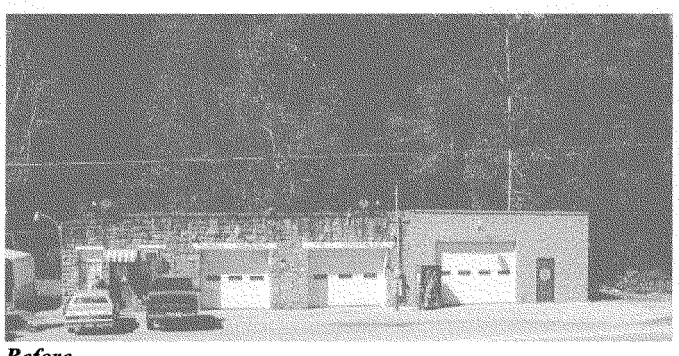


Acquisition

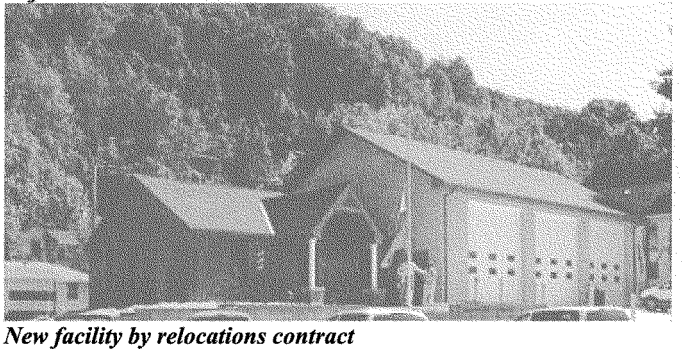
3,000 sf Brick Rancher with basement, garage & carport; .36 acre city lot
Acquisition: $133,000
Relocation: $ 26,000
Demolition: $ 71,000 (includes asbestos & underground kerosene tank removal)
TOTAL: $230,000

4,200 sf 1.5 story brick with basement, in ground pool, two car garage, .37 acre city lot
Acquisition: $250,000
Relocation: $ 38,000 (estimated Housing Differential)
Demolition: $ 60,000
TOTAL: $348,000

2,350 sf 2 story frame/brick no basement, .27 acre rural lot
Acquisition: $105,000
Relocation: $ 23,000
Demolition: $ 30,000
TOTAL: $158,000



Before



New facility by relocations contract

Attachment 3
Costs for Raising in Place

Prepared by:
Huntington District
USACE

Estimated by CELRH-ECT
Designed by CELRH-PD, CELRH-ECD
Prepared by Donald Whitmore, P.E.
Preparation Date 7/18/2007
Effective Date of Pricing 10/1/2007
Estimated Construction Time Days

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Date	Author	Note
7/18/2007		SCOPE

This cost estimate is comprised of 4 model estimates:

1. New house construction on pier foundation at a finished first floor of 6 FT above low ground. Costs included herein have been developed to represent requirements associated with constructing a new structure on an elevated pier foundation ranging from 0' - 6' above low ground.

2. New house construction on pier foundation at a finished first floor of 15 FT above low ground. Costs included herein have been developed to represent requirements associated with constructing a new structure on an elevated pier foundation ranging from 6.1' - 15' above low ground.

3. Raise of existing house on slab foundation to a finished first floor of 6 Ft above low ground. Costs included herein have been developed to represent requirements associated with elevating an existing structure on an elevated pier foundation ranging from 0' – 6' above low ground.

4. Raise of existing house on slab foundation to a finished first floor of 15 Ft above low ground. Costs included herein have been developed to represent requirements associated with elevating an existing structure on an elevated pier foundation ranging from 6.1' - 15' above low ground.

In each case, the structure is assumed to have a living area 1,600 SF. For the purposes of this estimate, the cost engineer assumed a simple rectangular house with outside dimensions of 25' x 64'. This yields an area of 1600 SF and a perimeter of 178 LF.

LEVEL OF EFFORT

This estimate is considered to be preliminary in nature and is to be used as such. The scopes provided to the cost engineer were very general. Indeed, the level of effort put forth by the cost engineer is commensurate to the general nature of the design.

PRICE LEVEL

The costs contained within this estimate have been prepared at a Price Level equivalent to 1 October 2007. Contingency has been included generally at 25%. However, this may have varied on an item by item basis as deemed appropriate by the engineer.

COST SOURCES

A variety of cost were used in preparing this estimate. The primary sources were:

-Marshall & Swift Residential Estimator 7
-LRH's Section 202 Implementation Floodproofing Cost Model
-MEANS Heavy Construction, 2005

Description	Quantity	UOM	ContractCost	Contingency	ProjectCost
Summary			**630,464.15**	**157,616.04**	**788,080.19**
New Structure - 6 feet off low ground	**1,600.00**	**SF**	*115.57* **184,915.53**	**46,228.88**	*144.47* **231,144.41**
New Structure - 15 feet off low ground	**1,600.00**	**SF**	*125.62* **200,996.71**	**50,249.18**	*157.03* **251,245.89**
Existing Structure - 6 feet off low ground	**1,600.00**	**SF**	*70.00* **112,000.00**	**28,000.00**	*87.50* **140,000.00**
Existing Structure - 15 feet off low ground	**1,600.00**	**SF**	*82.84* **132,551.91**	**33,137.98**	*103.56* **165,689.89**

Description			Quantity	UOM	ContractCost	Contingency	ProjectCost
Detail			**536,504.06**	**93,960.09**	**630,464.15**	**157,616.04**	**788,080.19**
			87.70		*115.57*		*144.47*
New Structure - 6 feet off low ground	**1,600.00**	**SF**	**140,326.56**	**44,588.97**	**184,915.53**	**46,228.88**	**231,144.41**
			41,585.06		*54,947.78*		*68,684.73*
Foundation & Structure Below Sill Plate	**1.00**	**EA**	**41,585.06**	**13,362.72**	**54,947.78**	**13,736.95**	**68,684.73**
			617.30		*815.66*		*1,019.58*
Timber Piles	**60.00**	**EA**	**37,038.06**	**11,901.61**	**48,939.67**	**12,234.92**	**61,174.59**
(Note: Assume a 6' grid for a house that is 25' x 64' (i.e., a 1600 SF house).)							
			13.72		*18.13*	*25.00*	*22.66*
Timber Piles	2,700.00	VLF	37,038.06	11,901.61	48,939.67	12,234.92	61,174.59
(Note: Material price taken from MEANS. Piles are assumed to be 12" diameter at the head and are to be embedded 40' into the ground.)							
			4,547.00		*6,008.11*		*7,510.14*
Pressure Treated Lumber	**1.00**	**EA**	**4,547.00**	**1,461.11**	**6,008.11**	**1,502.03**	**7,510.14**
(Note: Assume 2 9' braces per span. A 6x6 grid for a 25 x 64 house yields 60 piles with 55 spans. Therefore, total bracing = 2 x 9 x 55 = 990 LF of 4x4 bracing<---)							
			3.30		*4.36*	*25.00*	*5.45*
4x4 Cross Bracing	990.00	LF	3,267.00	1,049.80	4,316.80	1,079.20	5,396.00
(Note: Reference LRH's 202 floodproofing implementation model.)							
			2.00		*2.64*	*25.00*	*3.30*
Pressure Treated Lumber, 2x10	640.00	LF	1,280.00	411.31	1,691.31	422.83	2,114.14
(Note: Reference LRH's 202 floodproofing implementation model.)							
			53.19		*70.28*		*87.85*
Structure Above Sill Plate	**1,600.00**	**SF**	**85,104.00**	**27,346.85**	**112,450.85**	**28,112.71**	**140,563.57**
			53.19		*70.28*	*25.00*	*87.85*
New Structure - Above Sill Plate	1,600.00	SF	85,104.00	27,346.85	112,450.85	28,112.71	140,563.57
(Note: Cost estimated by Marshall-Swift for an average quality 1600 SF structure in the Gulfport, MS area. See backup sheet from Marshall Swift. Estimated unit price is $68.35/SF including O&P. Since the pier foundation is estimated elsewhere in this estimate, the standard CIP wall foundation should be deleted from this Marshall-Swift estimate. Also, the overhead and profit should be deleted here. MII will add O&P to the direct cost unit price under the Project Item tab. O&P is estimated to be 14.5% in the Marshall-Swift program. The foundation is estimated to cost $67/LF of perimeter (MEANS), including O&P. $67/LF x (25x2 + 64x2) = $11,926. Now, $11,926 / 1600 SF = $7.45/SF that is to be deducted from the estimated unit price for new construction. So, $68.35/SF - $7.45/SF = $60.90/SF (w/ O&P) Subtracting O&P, $60.90/SF / 1.145 = $53.19/SF<---)								
Misc	**1.00**	**LS**	**13,637.49**	**3,879.40**	**17,516.89**	**4,379.22**	**21,896.11**
Misc	1.00	LS	9,673.49	2,751.78	12,425.27	3,106.32	15,531.58
(Note: This item of work covers the cost of site work concrete, porches, as well as other items such as landscaping, exterminating, and construction cleanup for a structure whose first floor is 6' off low ground. Price estimated by LRH's 202 floodproofing implementation model.)							
			3,964.00		*5,091.63*	*25.00*	*6,364.53*
Utility Hookups	1.00	EA	3,964.00	1,127.62	5,091.63	1,272.91	6,364.53
(Note: This is an allowance to cover the costs of installing (or having installed) the water, electric, and gas meters.)							
			95.40		*125.62*		*157.03*
New Structure - 15 feet off low ground	**1,600.00**	**SF**	**152,633.68**	**48,363.03**	**200,996.71**	**50,249.18**	**251,245.89**
			48,992.68		*64,735.72*		*80,919.65*

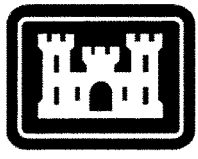
Description			Quantity	UOM	ContractCost	Contingency	ProjectCost
Foundation & Structure Below Sill Plate	**1.00**	**EA**	**48,992.68**	**15,743.04**	**64,735.72**	**16,183.93**	**80,919.65**
			740.76		*978.79*		*1,223.49*
Timber Piles	**60.00**	**EA**	**44,445.68**	**14,281.93**	**58,727.61**	**14,681.90**	**73,409.51**
(Note: Assume a 6' grid for a house that is 25' x 64' (i.e., a 1600 SF house).)							
			13.72		*18.13*	*25.00*	*22.66*
Timber Piles	3,240.00	VLF	44,445.68	14,281.93	58,727.61	14,681.90	73,409.51
(Note: Material price taken from MEANS. Piles are assumed to be 12" diameter at the head and are to be embedded 40' into the ground. Q*54)							
			4,547.00		*6,008.11*		*7,510.14*
Pressure Treated Lumber	**1.00**	**EA**	**4,547.00**	**1,461.11**	**6,008.11**	**1,502.03**	**7,510.14**
(Note: Assume 2 9' braces per span. A 6x6 grid for a 25 x 64 house yields 60 piles with 55 spans. Therefore, total bracing = 2 x 9 x 55 = 990 LF of 4x4 bracing<---)							
			3.30		*4.36*	*25.00*	*5.45*
4x4 Cross Bracing	990.00	LF	3,267.00	1,049.80	4,316.80	1,079.20	5,396.00
(Note: Reference LRH's 202 floodproofing implementation model. Assume 2 9' braces per span. A 6x6 grid for a 25 x 64 house yields 60 piles with 55 spans. Therefore, total bracing = 2 x 9 x 55 = 990 LF of 4x4 bracing<---)							
			2.00		*2.64*	*25.00*	*3.30*
Pressure Treated Lumber, 2x10	640.00	LF	1,280.00	411.31	1,691.31	422.83	2,114.14
(Note: Reference LRH's 202 floodproofing implementation model.)							
			53.19		*70.28*		*87.85*
Structure Above Sill Plate	**1,600.00**	**SF**	**85,104.00**	**27,346.85**	**112,450.85**	**28,112.71**	**140,563.57**
			53.19		*70.28*	*25.00*	*87.85*
New Structure - Above Sill Plate	1,600.00	SF	85,104.00	27,346.85	112,450.85	28,112.71	140,563.57
(Note: Cost estimated by Marshall-Swift for an average quality 1600 SF structure in the Gulfport, MS area. See backup sheet from Marshall Swift. Estimated unit price is $68.35/SF including O&P. Since the pier foundation is estimated elsewhere in this estimate, the standard CIP wall foundation should be deleted from this Marshall-Swift estimate. Also, the overhead and profit should be deleted here. MII will add O&P to the direct cost unit price under the Project Item tab. O&P is estimated to be 14.5% in the Marshall-Swift program. The foundation is estimated to cost $67/LF of perimeter (MEANS), including O&P. $67/LF x (25x2 + 64x2) = $11,926. Now, $11,926 / 1600 SF = $7.45/SF that is to be deducted from the estimated unit price for new construction. So, $68.35/SF - $7.45/SF = $60.90/SF (w/ O&P) Subtracting O&P, $60.90/SF / 1.145 = $53.19/SF<---)								
Misc	**1.00**	**LS**	**18,537.00**	**5,273.14**	**23,810.14**	**5,952.54**	**29,762.68**
Misc - 15' off low ground	1.00	LS	11,029.18	3,137.42	14,166.60	3,541.65	17,708.25
(Note: This item of work covers the cost of site work concrete, porches, as well as other items such as landscaping, exterminating, and construction cleanupfor a structure whose first floor is 6' off low ground. Price estimated by LRH's 202 floodproofing implementation model.)							
			3,964.00		*5,091.63*	*25.00*	*6,364.53*
Utility Hookups	1.00	EA	3,964.00	1,127.62	5,091.63	1,272.91	6,364.53
(Note: This is an allowance to cover the costs of installing (or having installed) the water, electric, and gas meters.)							
			11.81		*15.17*		*18.97*
300 SF Stoarge Area	**300.00**	**SF**	**3,543.82**	**1,008.09**	**4,551.91**	**1,137.98**	**5,689.89**
(Note: This would only apply to structures that area greater than 6 FT above low ground. In this estimate, that means that it only applies to the 8' - 15' raise category.)							
			6.53		*8.38*	*25.00*	*10.48*
4" Concrete Pad	300.00	SF	1,958.22	557.05	2,515.26	628.82	3,144.08
(Note: Price from LRH's floodproofing model for 4" concrete = $370/CY, direct cost. SAY = $400/CY for the gulf coast. Now, $400/CY x (4in/36in/yd) = $44.44/SY. So, $44.44/SY / 9 SF/SY = $4.94/SF<---)							

Description			Quantity	UOM	ContractCost	Contingency	ProjectCost
			13.21		*16.97*	*25.00*	*21.22*
Siding	80.00	EA	1,057.07	300.70	1,357.77	339.44	1,697.21
(Note: = 10 x 2 + 30 x 2 = 80 SF)							
			264.27		*339.44*	*25.00*	*424.30*
Door	1.00	EA	264.27	75.17	339.44	84.86	424.30
Electrical Allowance	1.00	LS	264.27	75.17	339.44	84.86	424.30
			70.00		*70.00*		*87.50*
Existing Structure - 6 feet off low ground	**1,600.00**	**SF**	**112,000.00**	**0.00**	**112,000.00**	**28,000.00**	**140,000.00**
(Note: This price already includes all contractor markups. Therefore, none have been added here.)							
			70.00		*70.00*	*25.00*	*87.50*
Raise Structure on Segmented Piles to 6' off low ground	1,600.00	SF	112,000.00	0.00	112,000.00	28,000.00	140,000.00
(Note: Reference Pat Davie of Davie Shoring. Pat said that costs for a turnkey job would normally run about $70/SF to raise a slab foundation house. This price would be for a slab foundation struture whose finished first floor would be greater than 4' above low ground. It is suspected that Pats pays significantly less than Davis-Bacon wages. PD was consulted on this issue. PD recommended that since this project is to be formulated on the basis that Davis-Bacon is not a requirement, the pricing info provided by Mr. Davie is acceptable.)							
			82.21		*82.84*		*103.56*
Existing Structure - 15 feet off low ground	**1,600.00**	**SF**	**131,543.82**	**1,008.09**	**132,551.91**	**33,137.98**	**165,689.89**
(Note: This price already includes all contractor markups. Therefore, none have been added here.)							
			80.00		*80.00*	*25.00*	*100.00*
Raise Structure on Segmented Piles to 15' off low ground	1,600.00	SF	128,000.00	0.00	128,000.00	32,000.00	160,000.00
(Note: Reference Pat Davie of Davie Shoring. Pat said that costs for a turnkey job would normally run about $70/SF to raise a slab foundation house. He said that costs would likely be higher than this for a raise as high as 15' off low ground. Therefore, add $10/SF to cover this higher raise. This price would be for a slab foundation struture whose finished first floor would be greater than 15' above low ground. PD was consulted on this issue. PD recommended that since this project is to be formulated on the basis that Davis-Bacon is not a requirement, the pricing info provided by Mr. Davie is acceptable.)							
			11.81		*15.17*		*18.97*
300 SF Stoarge Area	**300.00**	**SF**	**3,543.82**	**1,008.09**	**4,551.91**	**1,137.98**	**5,689.89**
(Note: This would only apply to structures that area greater than 6 FT above low ground. In this estimate, that means that it only applies to the 8' - 15' raise category.)							
			6.53		*8.38*	*25.00*	*10.48*
4" Concrete Pad	300.00	SF	1,958.22	557.05	2,515.26	628.82	3,144.08
(Note: Price from LRH's floodproofing model for 4" concrete = $370/CY, direct cost. SAY = $400/CY for the gulf coast. Now, $400/CY x (4in/36in/yd) = $44.44/SY. So, $44.44/SY / 9 SF/SY = $4.94/SF<---)							
			13.21		*16.97*	*25.00*	*21.22*
Siding	80.00	EA	1,057.07	300.70	1,357.77	339.44	1,697.21
(Note: = 10 x 2 + 30 x 2 = 80 SF)							
			264.27		*339.44*	*25.00*	*424.30*
Door	1.00	EA	264.27	75.17	339.44	84.86	424.30
Electrical Allowance	1.00	LS	264.27	75.17	339.44	84.86	424.30

LOUISIANA COASTAL PROTECTION AND RESTORATION
FINAL TECHNICAL REPORT

STRUCTURAL PLAN COMPONENT APPENDIX

June 2009



U. S. Army Corps of Engineers
New Orleans District
Mississippi Valley Division

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Louisiana Coastal Protection and Restoration (LACPR) Final Technical Report
Structural Plan Component Appendix

Purpose

The Louisiana Coastal Protection and Restoration (LACPR) Technical Report has been developed by the United States Army Corps of Engineers (USACE) in response to Public Laws 109-103 and 109-148. Under these laws, Congress and the President directed the Secretary of the Army, acting through the Chief of Engineers, to:

- Conduct a comprehensive hurricane protection analysis and design in close coordination with the State of Louisiana and its appropriate agencies;
- Develop and present a full range of flood control, coastal restoration, and hurricane protection measures exclusive of normal policy considerations for South Louisiana;
- Consider providing protection for a storm surge equivalent to a Category 5 hurricane; and
- Submit preliminary and final technical reports.

The purpose of this appendix is to support the formulation of structural hurricane risk reduction and flood control measures for LACPR, which is discussed in the main technical report.

Introduction

Structural, nonstructural, and coastal restoration measures are the building blocks of alternative plans for LACPR. An alternative plan is a set of one or more measures functioning together to address one or more planning objectives. Structural measures for LACPR primarily consist of physical structures that reduce surge and wave run-up, such as continuous or ring levees on land connected to floodgates acting as waterway barriers, where necessary.

The first step in the formulation of measures involved extensive public involvement in partnership with the State of Louisiana. The USACE partnered with the State of Louisiana to identify and evaluate hurricane risk reduction strategies for South Louisiana. Through this partnership, the State developed a Master Plan to provide a long-term vision for hurricane risk reduction and coastal restoration. Numerous risk reduction measures were identified during the development of the State Master Plan. The LACPR Plan Formulation Atlas, which can be viewed and downloaded at http://www.lacpr.usace.army.mil/ documents the extensive collaborative identification of the coastal protection and restoration measures for South Louisiana.

The next step in the plan formulation process was the screening and refinement of measures. This *Structural Plan Component Appendix* describes how structural measures were screened and refined to a smaller and more manageable set of options for integration with the nonstructural and coastal restoration components of the LACPR alternatives.

Project guidance for LACPR required that LACPR investigate measures that address hurricane storm risk reduction for a 100-year event, a Katrina like event (or low Category 5 event), and a high Category 5 event for coastal Louisiana. For LACPR, the Category 5 hurricane event is represented by a range of frequencies, i.e. the 400-year event represents a "low" Category 5 hurricane and the 1000-yr event represents a "high" Category 5 event. In addition, the alternatives developed vary in the geographical area receiving such risk reduction, ranging from

only providing risk reduction to specific areas of significant concentration of assets or population, as provided for by local or regional ring levees, to providing risk reduction for the entire coastal area, as considered in the nonstructural only and comprehensive alternatives. All the 400-yr and 1000-yr alternatives do provide some level of Category 5 risk reduction, to at least some, if not all of the coastal area, as stated. Also many of the 100-year measures or alternatives (e.g., the barrier-weirs) provide for varying levels of Category 5 risk reduction to some specific areas by increasing the design levels of existing or proposed levee systems by providing for an outer barrier line of defense.

The consideration and screening of nonstructural and coastal management features are described in the *Nonstructural Plan Component Appendix* and *Coastal Restoration Plan Component and Environmental Metrics Appendix,* respectively. The coastal appendix also contains discussions of direct and indirect environmental impacts and mitigation requirements that would result from construction of structural plans.

The final step in the plan formulation process, combining measures into alternative plans, entailed the consideration of reasonable and efficient integration of structural measures with nonstructural and coastal restoration measures into viable alternative plans. The Technical Report presents the performance of various alternative plans and illustrates tradeoffs between and among plans on specific objectives and overall program goals. Stakeholder input was incorporated into the plan comparison step using a Multi-Criteria Decision Analysis (MCDA) tool as described in the *Risk-informed Decision Framework Appendix.*

Alternative plans are not limited to those the U.S. Army Corps of Engineers (USACE) could implement directly under current authorities. Structural measures that could be implemented under the authorities of other Federal agencies, State and local entities, and non-government interests have also been considered. For more information on the LACPR Congressional authority, plan formulation strategy and planning objectives, refer to the main report.

Three-Tiered Screening Process

A three-tiered screening process was used to reduce possible structural measures, alignments and alternatives to a more manageable number for further evaluation and consideration across a wide range of stakeholder interests.

- **Tier 1 – Initial Screening of Structural Alignments.** Alignments from the Plan Formulation Atlas were screened considering preliminary construction costs, constructability, and environmental impacts.
- **Tier 2 – Initial Hydromodeling of Structural Measures.** Initial hydromodeling results were used to further screen the number of alignments and strategies.
- **Tier 3 – Final Screening of Structural Alternatives.** The final step set each remaining alignment at three design heights, 100-year, 400-year, and 1000-year, to create a set of structural alternatives, which were then screened using six attributes (see Table 1).

Table 1. Tier 3 Screening Attributes

ATTRIBUTE	DESCRIPTION
Cost Effectiveness	Ratio of present value costs/average annual risk reduction
Present Value Costs	Present value at 2025 for life-cycle costs
Annual Equivalent Flood Damages	With-project residual damages
Population Impacted	Number of people who would be inundated in the year 2075 for a 400-year frequency event
Construction Period	Years required to complete initial construction
Direct Impact – Wetlands	Wetland acreage impacted by proposed levees

For the third tier screening, each structural measure was rated based on these six attributes. In order to have comparable scores for each of these attributes, each had to be normalized or converted to a range of 0-1 where the lower value is preferred.

All screening attribute values presented in this appendix are based on earlier iterations of data development (or preliminary data) using primarily 2010 base conditions for estimating with-project damages. As such, values shown do not represent the metric and evaluation data presented in the *Evaluation Results Appendix*.

Details on the hydromodeling results used to screen measures in Tier 2 are contained in Volume 2 (Annex A) of the *Hydraulics and Hydrology Appendix*.

Organization of This Appendix

This appendix is organized by planning unit as shown in **Figure 1**.

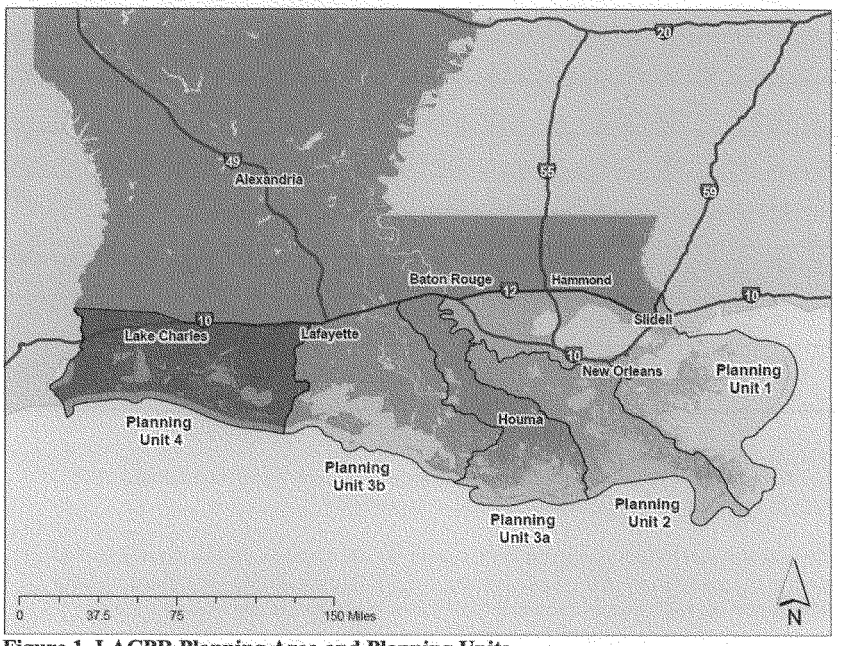

Figure 1. LACPR Planning Area and Planning Units

Each of the planning unit sections generally follows the same format:

- Brief description of the planning unit.
- Tier 1 screening – initial screening of structural alignments.
  - Codes used to refer to measures screened from the Plan Formulation Atlas.
  - Maps and text describing structural measure variations from the Plan Formulation Atlas.
  - Table(s) and text describing which measures passed/failed the Tier 1 screening and why.
- Tier 2 screening – initial hydromodeling of structural measures.
  - List of remaining formulation issues from Tier 1 screening.
  - Codes used to refer to measures in the Tier 2 and Tier 3 screening.
  - Maps showing reformulated structural alignments.
  - Tables and text describing how hydromodeling results were used to screen and/or reformulate measures.
- Tier 3 screening – final screening of structural alternatives using six attributes.
  - List of remaining formulation issues from Tier 2 screening.
  - Table showing ranking of measures followed by descriptions of why each measure was chosen for the overall LACPR alternatives.

Descriptions of each of the measures to be evaluated with the overall LACPR alternatives.

Planning Unit 1

The following sections provide details on the tiered screening of measures and alignments for Planning Unit 1. Planning Unit 1 is bordered between the (1) Mississippi River to the west, (2) Gulf of Mexico to the south and east, (3) Pearl River on the east, and (4) potential extent of surge inundation to the north. The western border of this planning unit is protected against hurricane surges translating up the Mississippi River by the Mississippi River levees.

Planning Unit 1 is the most densely populated planning unit in coastal Louisiana, containing approximately one million residents, or 47 percent, of the entire planning area's population. The major portion of greater New Orleans is located within the planning unit. The population at risk lives between the Mississippi River east bank levee system and the shoreline areas of Lake Pontchartrain and Lake Borgne.

Structural measures attenuate surge from two main water bodies. The first water body is Lake Borgne to the east of New Orleans. Lake Borgne is connected to the Gulf Intracoastal Waterway (GIWW) and its branch channels which includes the de-authorized portion of the Mississippi River Gulf Outlet (MRGO) and the Industrial Canal. This navigation system bisects East New Orleans. Structural measures would need to address levee improvements and/or navigation gates.

The second water body is Lake Pontchartrain which has two channels connecting it to Lake Borgne – Chef Menteur and The Rigoletes. Structural measures would need to address levee improvements and/or lake closures. The tradeoff for providing structural risk reduction to populated areas along the Lake Pontchartrain perimeter range from closing or limiting flow through the two passes – at least during surge conditions - to creating and/or raising levees and floodwalls between the lake and populated areas.

The lower portion of Plaquemines Parish is the area south of metropolitan New Orleans located along the "bird's foot" stretch of land terminating at the mouth of the Mississippi River. Lower Plaquemines Parish has limited opportunity for structural considerations other than ring levees to protect isolated communities and spillways in the Mississippi River levee system to lower the surge elevations. Levee height considerations are impacted by soil foundation strength and land availability for conventional levee width requirements. Screening of structural measures for this area is discussed following the details on Planning Unit 1 and Planning Unit 2.

Tier 1 – Initial Screening of Structural Alignments

The Plan Formulation Atlas identified two primary strategies for structural risk reduction in Planning Unit 1. They include a **Lake Pontchartrain surge reduction** alignment (**Figure 2**) at the mouth of Lake Pontchartrain and a **high level** alignment (**Figure 3**). The Lake Pontchartrain surge reduction alignment proposes to add a levee across the mouth of Lake Pontchartrain with storm gates closing the passes at Chef Menteur and The Rigoletes during a storm event. **Figure 4** displays six different surge reduction alignments (shown as 1 through 5 and the letter 'S') and two different alignments within the area known as the Golden Triangle (shown as a and b). The high level alignment proposes to raise levees on the South Shore of Lake Pontchartrain to a higher level of risk reduction and to add levees on the North Shore of Lake Pontchartrain. Within the two primary strategies, the Plan Formulation Atlas identified 17 variations. **Table 2** describes

the codes used in the Plan Formulation Atlas and for Tier 1 screening for measures in Planning Unit 1.

Table 2. Planning Unit 1 Codes from Plan Formulation Atlas used for Tier 1 Screening.

Code	Measure Code Description, e.g. PU1-LP-1a
PU1-	Planning Unit 1
-LP-	Lake Pontchartrain surge reduction alignment
-HL-	High level alignment
-State	Alignment that was part of the preliminary draft State Master Plan
-#	Variations to the primary alignments, if applicable (see Figure 4)
a	Golden Triangle alignment at the confluence of the GIWW and MRGO
b	Alignment at the edge of the Golden Triangle and Lake Borgne

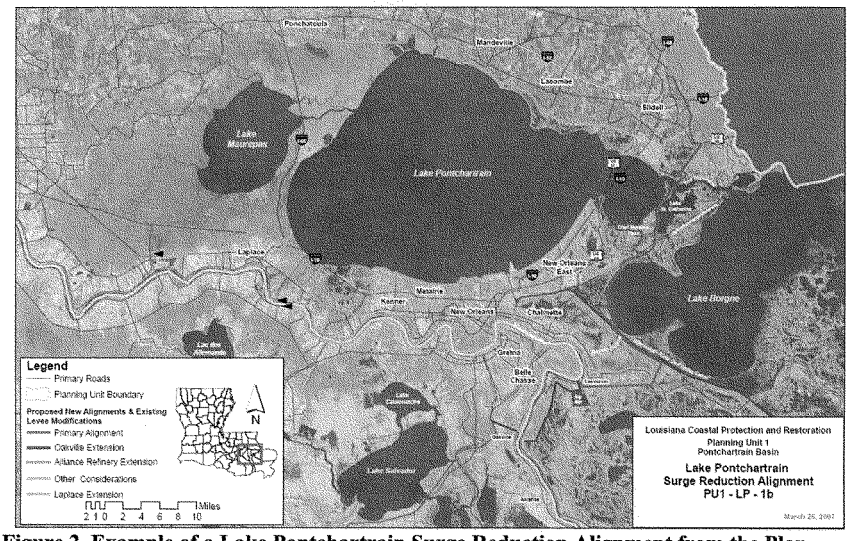

Figure 2. Example of a Lake Pontchartrain Surge Reduction Alignment from the Plan Formulation Atlas

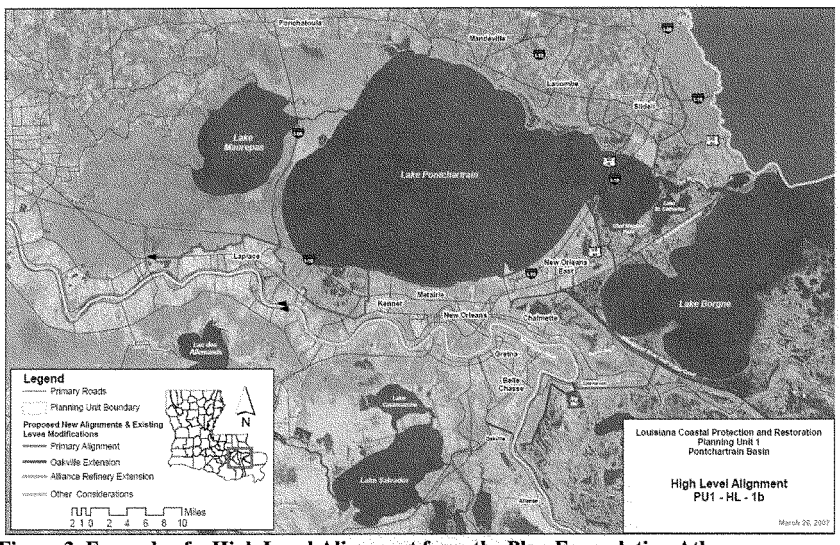

Figure 3. Example of a High Level Alignment from the Plan Formulation Atlas

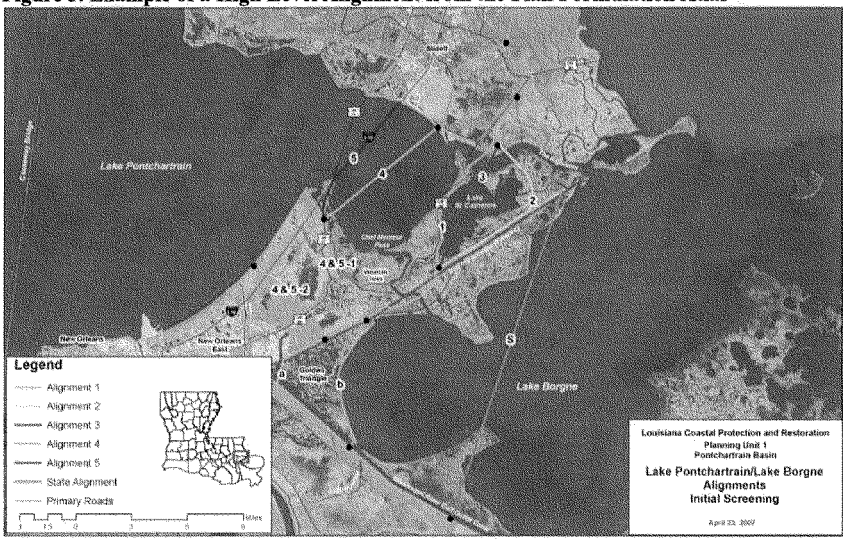

Figure 4. Various Surge Reduction Alignments (1 through 5 and 'S') and Golden Triangle Alignments ('a' and 'b')

Cost Considerations

Rough order of magnitude costs were developed for each of the Surge Reduction Alignments and the Golden Triangle alignments. Alignment 'a' refers to the levee alignment that would cross the Golden Triangle wetlands at the confluence of the Gulf Intracoastal Waterway and the Mississippi River Gulf Outlet. Alignment 'a' is part of the baseline conditions scheduled to be in place around 2011. Alignment 'b' follows along the edge of the Golden Triangle and Lake Borgne and would provide a secondary line of defense to Alignment 'a.' **Table 3** shows the initial construction and real estate costs for the levee alignments at Lake Ponchartrain and Lake Borgne.

Table 3. Rough Order of Magnitude Cost Estimates for Levee Alignments at Lake Pontchartrain and Lake Borgne in Planning Unit 1

A - Alignment		B - Alignment	
Alignment	**Initial Costs ($billions)**	**Alignment**	**Initial Costs ($billions)**
LP-1a	$10.8B	LP-1b	$10.1B
LP-2a	$10.8B	LP-2b	$10B
LP-3a	$20B	LP-3b	$19.2B
LP-4a1	$26.5B	LP-4b1	$25.7B
LP-5a1	$26.3B	LP-5b1	$25.5B

Note: Planning Unit 1 cost estimates assume the levees are 30 feet high and are built from the ground up. The cost estimates for the 'a' alignments would go down if the new 100-year levees being in place are taken into account. Costs assume geotextile levee construction (i.e. traditional construction methods).

Screened Alignments

Table 4 lists the variations of both the Lake Pontchartrain surge reduction alignments and the High Level alignments and describes why some alignment variations were eliminated from further consideration at this time. As indicated in **Table 4** alignments 3, 4 and 5 were eliminated from further screening due to the extremely high cost as compared to alignments 1 and 2 which provide similar output.

Table 4. Initial Screening of Planning Unit 1 Structural Measures

Measure Code(s)	Pass/ Fail	Comments
PU1-LP-1a and 1b	Pass	These alignments follow Highway 90 along the landbridge. The State screened this measure out because of public opposition (multiple landowners), so it is not included in the State Master Plan; however, the LACPR team felt that the multiple landowner issue is not insurmountable and carried this alignment forward into the next screening because of its good soil foundation. Costs for 1a and 1b are same magnitude as for 2a and 2b below (~$10 – 11 billion).
PU1-LP-2a and 2b	Pass	These alignments follow the GIWW/railroad and are essentially the same as those represented in the State Master Plan. Costs for 2a and 2b are same magnitude as for 1a and 1b above ($10 – 11 billion).
PU1-LP-3a and 3b	Fail	These alignments cross Lake St. Catherine and have significant constructability, operability, and environmental concerns. In comparison to alignments 1 and 2 above, alignment 3 has more constructability, operability, and environmental concerns. In addition, the cost is higher (~$19 – 20 billion).
PU1-LP-4a1, 4b1, 4a2, and 4b2	Fail	Constructability, operability, and cost concerns. Costs for these measures are approximately 2.5 times the costs of LP-1 and LP-2 (~$25 – 27 billion). In comparison to alignments 1 and 2 above, these alignments have more constructability and operability concerns. In addition, the costs are higher (~$25 – 27 billion)
PU1-LP-5a1, 5b1, 5a2, and 5b2	Fail	Constructability, operability, and cost concerns. Costs for these measures are approximately 2.5 times the costs of LP-1 and LP-2 (~$25 – 27 billion). In comparison to alignments 1 and 2 above, these alignments have more constructability and operability concerns. In addition, the costs are higher (~$25 – 27 billion)
PU1-LP-State	Pass	The State Master Plan presented three barrier alignments. Two of the alignments approximately correspond to PU1-LP-2a and PU1-LP-2b. Specific hydromodeling data will be available for the third State weir alignment ('S') across Lake Borgne.
PU1-HL-1a and 1b	Pass	Presents an alternative to the Surge Reduction Plan concept and will be carried through into the MCDA process.

Note: Planning Unit 1 preliminary cost estimates assumed the levees are 30 feet high and are built from the ground up. The cost estimates for the 'a' alignments would go down if the new 100-year levees being in place are taken into account. Costs assume geotextile levee construction (i.e. traditional construction methods).

Tier 2 – Initial Hydromodeling of Structural Measures

In addition to the initial screening evaluation, additional hydromodeling was necessary to resolve and further refine the possible structural measures in Planning Unit 1. Remaining formulation issues included:

- High level versus Lake Pontchartrain surge reduction alignments.
- Full barrier (non-overtopping) versus weir (overtopping) designs for the Lake Pontchartrain surge reduction alignments.
- Open versus closed tidal pass designs for the Lake Pontchartrain surge reduction alignments.
- Lake Borgne alignment ('S').
- Golden Triangle alignments ('a' or 'b').
- Inclusion or exclusion of North Shore, West Shore, and Oakville extension.
- Design level of risk reduction.

For this tier, barrier versus weir and open versus closed tidal gates were evaluated. During this step, a range of alignments were formulated to address the remaining formulation issues. With the inclusion of different levels of risk reduction, the naming convention for the structural measures was revised slightly from previous screening nomenclature. **Table 5** describes an example of the coding.

Table 5. Planning Unit 1 Codes used for Tier 2 and Tier 3 Screening

Code	Measure Code Description, e.g. PU1-LP-a-100-1
PU1-	Planning Unit 1
-LP-	Lake Pontchartrain surge reduction alignment
-HL-	High level alignment
-a-	Golden Triangle alignment at the confluence of the GIWW and MRGO
-b-	Alignment at the edge of the Golden Triangle and Lake Borgne
-100-	100-year design level
-400-	400-year design level
-1000-	1000-year design level
-1	All PU1 primary alternatives include the Lake Pontchartrain and Vicinity Project levees and upper Plaquemines levees. The primary alignments for 'LP' also include a barrier-weir across the mouth of Lake Pontchartrain with a tieback to high ground east of Slidell.
-2	Primary alignment plus North Shore and West Shore levees.
-3	Primary alignment plus Slidell and West Shore levees.

Full Barrier vs. Weir Options

The full barrier (non-overtopping) designs were compared to the weir barrier (overtopping) designs for the Lake Pontchartrain surge reduction alignments to determine the preferred design configuration.

Based on the preliminary surge level results (see **Table 6**), the non-overtopping design increased surges along parts of the Mississippi coastline by up to 5.4 feet while the weir design increased surge by 3.2 feet for hurricanes of intensity greater than a 400-year event.

Table 6. Variation in Surge Elevation Impacts Mississippi Coast

Distance from LA State Border	Area	Average/Maximum Difference from Baseline Surge Elevations	
		Weir (feet)	Barrier (feet)
0 miles	Pearl River (Hwy 90)	+2.3 / +3.2	+ 3.6 / +5.4
18 miles	Clermont Harbor	+0.7 / +0.9	+1.1 / +2.0
26 miles	Bay Saint Louis	+0.6 / +0.9	+1.0 / +1.9
49 miles	Gulfport	+0.2 / +0.5	+0.4 / +1.2
70 miles	Biloxi	+0.2 / +0.4	+0.3 / +1.0

As shown in the above table, measures in Planning Unit 1 have the potential to impact the Mississippi coast. Such impacts have been further addressed in a systems analysis conducted in coordination with the Mississippi Coastal Improvements Program (MsCIP) team. A summary of the potential regional impacts are addressed in the Systems Analysis section of the main report.

The design height of a non-overtopping levee along the Lake Pontchartrain surge reduction ('LP-') alignments would exceed 24 feet for the 100-year storm event (see **Table 7**), which means high costs and constructability issues.

Table 7. Design Elevations and Costs for Full Barrier vs. Weir Barrier

Alignment	Full Barrier			Weir Barrier	
	Geo Textile ($billions)	Soil Mix ($billions)	Elev. (ft)	Overflow ($billions)	Elev. (ft)
LP-b-100-1	$7B	$9.5B	25	$4.5B	12.5
LP-b-400-1	$18.5B	$19.9B	32	$12.8B	12.5
LP-b-1000-1	$22.4B	$24.9B	36	$16.1B	12.5
LP-b-100-2	$12.6B	$20.6B	25	$10.6B	12.5
LP-b-400-2	$27.1B	$33.5B	32	$22.4B	12.5
LP-b-1000-2	$32.2B	$40B	36	$27.3B	12.5

In summary, the non-overtopping barrier has been eliminated from further consideration because of cost constraints, engineering feasibility issues, and potential impacts to Mississippi.

State's Lake Borgne Alignment ('S')

The State's Lake Borgne alignment was screened out for the same reason that the full barrier options were screened out. Hydromodeling results show unacceptable increases in water levels to the State of Mississippi. Also, this alignment presents many costly constructability issues and challenges.

Open vs. Closed Tidal Passes

A second design consideration for the Lake Pontchartrain surge reduction measure was whether to close the tidal passes at The Rigoletes and Chef Menteur passes with floodgates or whether to leave the passes open for environmental reasons. Evaluation of the hydromodel output for the open tidal passes revealed limited reduction in surge levels within Lake Pontchartrain. Therefore, it was determined that the closed tidal passes provide the best engineering solution for all storm conditions if a barrier plan is selected.

Tier 3 – Final Screening of Structural Alternatives

Based on the Tier 2 screening, the preliminary measures or variations of measures for further consideration included:

- High level versus surge reduction plans.
- Golden Triangle alignment 'a' versus alignment 'b.'
- North Shore levee or Slidell ring levee.
- West Shore (Laplace).

As part of the Tier 3 screening, structural measures were subjected to analysis using 100, 400, and 1000-year design heights for each levee alignment considered. This resulted in the development of 16 variations of the High Level Plan and 18 variations of the Lake Pontchartrain Surge Reduction. These structural measures were then ranked using the multiple attributes previously described in **Table 1**.

Table 8 displays the ranking of the 34 measures and the screening attribute values used to conduct the ranking.

Table 8. Planning Unit 1 Ranking of Measures

Measures	Screening Attributes												Total Value Score***	Rank
	Cost Effectiveness		Annual Equiv. Flood Damages		2075 Pop. Impacted 400-yr Event		Present Value Costs		Construction Period		Direct Impact-Wetlands			
	Ratio*	Value**	$ Million	Value**	People	Value**	$ Million	Value**	Years	Value**	Acres	Value**		
LP-a-100-1	29.49	0.20	793	1.00	657,708	0.93	6,459	0.10	14	0.88	980	0.10	**3.21**	**1**
LP-b-100-1	42.86	0.29	781	0.98	634,659	0.90	9,900	0.15	14	0.88	1,554	0.16	**3.36**	**2**
HL-a-100-3	47.78	0.32	754	0.95	706,211	1.00	12,327	0.19	12	0.75	3,642	0.37	**3.59**	**3**
HL-a-100-2	49.44	0.35	714	0.90	691,138	0.98	14,732	0.23	12	0.75	4,686	0.48	**3.69**	**4**
LP-b-400-1	67.24	0.45	623	0.79	429,604	0.61	26,157	0.41	16	1.00	4,238	0.43	**3.69**	**5**
LP-a-100-3	55.77	0.38	684	0.86	649,395	0.92	18,291	0.29	14	0.88	3,668	0.37	**3.69**	**6**
LP-a-400-1	72.96	0.49	624	0.79	429,915	0.61	28,310	0.44	16	1.00	4,055	0.41	**3.74**	**7**
HL-b-100-3	59.79	0.40	751	0.95	705,491	1.00	15,605	0.24	12	0.75	4,220	0.43	**3.77**	**8**
LP-a-100-2	57.33	0.39	655	0.83	638,120	0.90	20,468	0.32	14	0.88	4,541	0.46	**3.78**	**9**
LP-b-100-3	63.92	0.43	672	0.85	626,346	0.89	21,732	0.34	14	0.88	4,242	0.43	**3.81**	**10**
HL-b-100-2	59.84	0.42	711	0.90	690,418	0.98	18,012	0.28	12	0.75	5,265	0.54	**3.87**	**11**
LP-b-100-2	64.79	0.44	643	0.81	615,071	0.87	23,908	0.37	14	0.88	5,115	0.52	**3.89**	**12**
LP-b-1000-1	87.47	0.59	614	0.77	415,159	0.59	34,813	0.54	16	1.00	5,100	0.52	**4.02**	**13**
HL-a-400-1	106.37	0.72	734	0.93	466,706	0.66	29,570	0.46	16	1.00	2,540	0.26	**4.03**	**14**
LP-a-1000-1	93.58	0.63	615	0.78	415,266	0.59	37,153	0.58	16	1.00	4,924	0.50	**4.08**	**15**
HL-b-400-3	92.13	0.62	522	0.66	376,731	0.53	45,143	0.70	16	1.00	5,661	0.58	**4.10**	**16**
HL-b-400-1	119.45	0.81	783	0.99	466,309	0.66	27,354	0.43	16	1.00	2,209	0.23	**4.11**	**17**
LP-b-400-3	83.40	0.56	488	0.62	350,257	0.50	43,701	0.68	16	1.00	7,587	0.78	**4.13**	**18**
LP-a-400-3	87.68	0.59	489	0.62	350,568	0.50	45,856	0.72	16	1.00	7,404	0.76	**4.18**	**19**
HL-a-400-3	96.85	0.65	523	0.66	377,128	0.53	47,359	0.74	16	1.00	5,993	0.61	**4.20**	**20**
LP-b-400-2	83.64	0.57	455	0.57	324,873	0.46	46,587	0.73	16	1.00	8,590	0.88	**4.20**	**21**
HL-b-400-2	91.44	0.62	477	0.60	343,385	0.49	48,920	0.76	16	1.00	7,498	0.77	**4.24**	**22**
LP-a-400-2	87.20	0.59	456	0.58	325,184	0.46	48,484	0.76	16	1.00	8,406	0.86	**4.24**	**23**
HL-a-400-2	95.76	0.65	478	0.60	343,782	0.49	51,136	0.80	16	1.00	7,830	0.80	**4.33**	**24**
HL-a-1000-1	131.12	0.89	722	0.91	436,473	0.62	38,025	0.59	16	1.00	3,211	0.33	**4.34**	**25**
HL-b-1000-1	147.97	1.00	772	0.97	436,275	0.62	35,512	0.55	16	1.00	2,940	0.30	**4.45**	**26**
LP-b-1000-3	100.76	0.68	471	0.59	330,322	0.47	54,510	0.85	16	1.00	9,042	0.92	**4.52**	**27**
HL-b-1000-3	111.76	0.76	501	0.63	337,952	0.48	57,111	0.89	16	1.00	7,491	0.77	**4.52**	**28**
LP-a-1000-3	105.28	0.71	472	0.60	330,429	0.47	56,850	0.89	16	1.00	8,865	0.91	**4.57**	**29**
LP-b-1000-2	100.88	0.68	441	0.56	307,571	0.44	57,603	0.90	16	1.00	10,081	1.03	**4.60**	**30**

Measures	Screening Attributes												Total Value Score***	Rank
	Cost Effectiveness		Annual Equiv. Flood Damages		2075 Pop. impacted 400-yr Event		Present Value Costs		Construction Period		Direct Impact-Wetlands			
	Ratio*	Value**	$ Million	Value**	People	Value**	$ Million	Value**	Years	Value**	Acres	Value**		
HL-a-1000-3	116.91	0.79	502	0.63	338,150	0.48	59,625	0.93	16	1.00	7,763	0.79	**4.63**	**31**
LP-a-1000-2	105.16	0.71	442	0.56	307,678	0.44	59,943	0.94	16	1.00	9,905	1.01	**4.65**	**32**
HL-b-1000-2	112.17	0.76	463	0.58	310,658	0.44	61,583	0.96	16	1.00	9,516	0.97	**4.71**	**33**
HL-a-1000-2	116.75	0.79	463	0.58	310,856	0.44	64,096	1.00	16	1.00	9,787	1.00	**4.81**	**34**

Indicates structural measure is included in the overall set of LACPR alternatives to be evaluated in detail.

* Cost Effectiveness Ratio = Total Present Value Costs /Average Annual Equivalent Risk Reduction

** Value is the normalized value for the attribute where a value of 1.00 represents the greatest is the largest (lower is better)

***Total of Normalized Values (lower is better)

Based on the ranking above and in consideration of the need to investigate a range of different ways to reduce the risk of hurricane storm damages the following structural measures were selected to be carried forward into the set of alternatives to be evaluated in the overall LACPR effort (listed in order of rankings):

LP-a-100-1: Of all variations considered, this is the least expensive and has the lowest cost per average annual risk reduction (or biggest bang for the buck) and has the least direct impact on wetlands than any other plan; however, the spatial extent of risk reduction is limited to metropolitan New Orleans and vicinity. It should be noted that although the LP-b-100-1 structural measure was ranked 2nd among all structural measures in Planning Unit 1, it costs considerably more than LP-a-100-1 and has greater wetland impacts. Therefore, LP-b-100-1 was eliminated from further consideration.

HL-a-100-3: This measure ranked 3rd among the structural measures in Planning Unit 1 and is the least costly High Level Plan.

HL-a-100-2: This measure ranked 4th among the structural measures in Planning Unit 1. This measure costs significantly less than the equivalent Surge Reduction measure (LP-a-100-2) and was selected because of its ranking.

LP-b-400-1: This measure ranked 5th. In regards to risk reduction benefits, LP-b-400-1 performs similarly to LP-a-400-1 (ranked 7th) but costs less.

LP-a-100-3: This measure ranked 6th among the structural measures in Planning Unit 1. It was selected to be included in the set of alternatives because it provides risk reduction to other areas besides metropolitan New Orleans (i.e., Laplace, Slidell, Oakville extension) and has similar overall score (3.69) with the previous 2 structural measures.

LP-a-100-2: This measure ranked 9th among the structural measures in Planning Unit 1. This measure was selected because it provides structural risk reduction for a 100-year frequency event to developed areas on the North Shore as well as Laplace, Slidell and Oakville extension. However, it is considerably more expensive than its equivalent High Level measure (HL-a-100-2) and will take longer to construct.

LP-b-1000-1: This measure ranked 13th among the structural measures in Planning Unit 1. This measure provides the least costly way to provide Category 5 level of risk reduction within Planning Unit 1.

HL-b-400-3: This measure ranked 16th among the structural measures in Planning Unit 1. While more expensive than its equivalent Surge Reduction plan (LP-b-400-3), it impacts considerably less wetlands. This measure provides 400-year level of protection to other areas besides metro New Orleans (i.e., Laplace, Slidell, Oakville extension).

LP-b-400-3: This measure ranked 18th among the structural measures in Planning Unit 1. This measure was selected for comparison with its equivalent Surge Reduction plan (HL-b-400-3).

HL-b-400-2: This measure ranked 22nd among the structural measures in Planning Unit 1. This measure was selected because it provides structural risk reduction for a 400-year frequency event to developed areas on the North Shore. This measure allows for incremental comparison to HL-b-400-3, which provides risk reduction to only the Slidell areas on the North Shore. Selection of this measure allows for consideration of a wider array of options for the North Shore using High Level measures.

LP-b-1000-2: This measure ranked 30th among the structural measures in Planning Unit 1. This measure provides the greatest average annual risk reduction benefits and Category 5 risk reduction to all areas (except Plaquemines).

While these ten structural measures do not represent all measures in terms of reducing average annual damages, this array encompasses a sufficient range of structural risk reduction measures from which a preferred comprehensive plan or strategy can be identified.

Absent from this array of options are measures that tradeoff risk reduction of site-specific areas within Planning Unit 1. These areas can be investigated incrementally allowing for comparison of structural vs. nonstructural measures. Specifically, risk reduction of the North Shore of Lake Pontchartrain will be evaluated incrementally to address costs, risk reduction, significant engineering problems/challenges (major water courses, large pumping requirements, and lack of acceptability from locals). In addition, other areas such as Laplace and Slidell will be evaluated independently and with various levels (100, 400 and 1000-year) of risk reduction. The following sections briefly describe the North and West Shore areas.

West Shore Alignment Variations

Figure 5 presents the West Shore or Laplace alignment variations being investigated through the West Shore Lake Pontchartrain Feasibility Study. For the level of analysis in the LACPR effort, the "LACPR Alignment" acts as a representative alignment of Alignments A through C. Selection of the exact alignment would take place through the West Shore Lake Pontchartrain Feasibility Study.

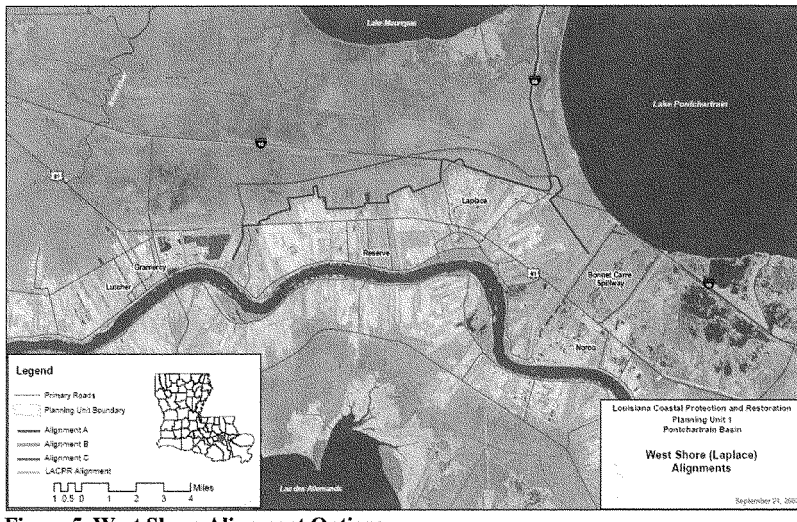

Figure 5. West Shore Alignment Options.

North Shore Alignment Refinements

Once inundation data became available, the team was able to refine the North Shore alignment from a continuous levee as shown previously in **Figure 2** to a series of ring levees as shown in **Figure 6**. These ring levees are expected to be more technically and economically viable and more publicly acceptable than a long continuous levee and will therefore be carried forward into the reevaluation in place of the continuous levee.

In addition, the Slidell ring levee previously shown in **Figure 3** was modified slightly as shown in **Figure 7**.

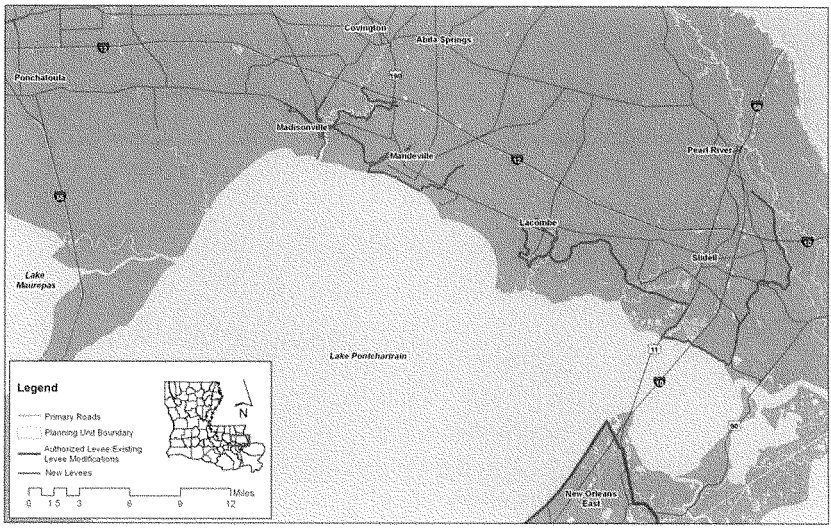

Figure 6. Reformulated North Shore Alignment.

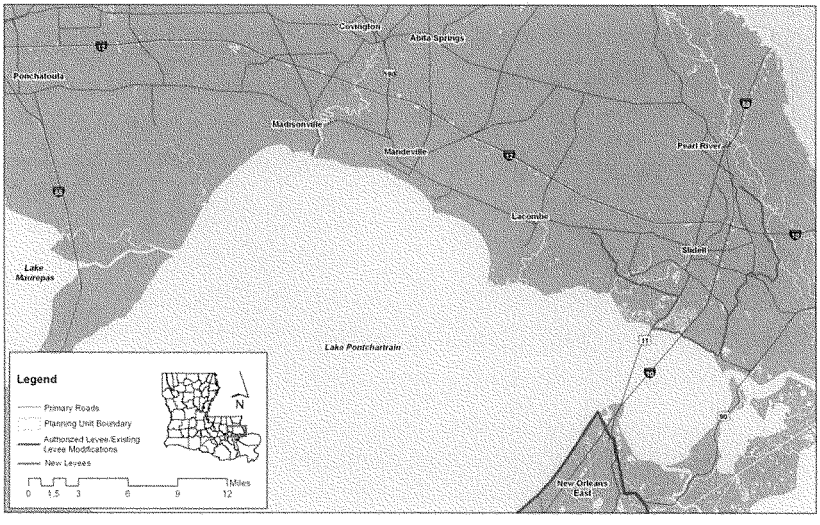

Figure 7. Reformulated Slidell Ring Levee.

Other Findings

Other findings from this analysis included the following:

1) The Golden Triangle alignment 'b' was generally more cost effective for the 400 and 1000-year level of risk reduction than alignment 'a.'

2) Providing 1000-year level of risk reduction through structural measures may appear to be a poor financial decision if considering average annual values. For the 1000-year plans, there is a 30 percent increase in cost and less than one percent increase in average annual damages prevented compared to the equivalent 400-year plans. This alone should not be reason to dismiss higher levels of risk reduction. Therefore, a structural measure that provides 1000-year level of risk reduction is kept for consideration during the MCDA process during which additional metrics can and will be considered.

Structural Measures to be Included in Planning Unit 1 Alternatives

Below is the array of options to be included as structural components of alternatives to be considered for detailed analysis for Planning Unit 1. These structural measures allow for comparison of further improvements to the Lake Pontchartrain and Vicinity project as well as the North Shore of Metro New Orleans (at similar levels and areas of risk reduction) for 100-year, 400-year and 1000-year levels of risk reduction. For the Planning Unit 1 alternatives, these structural components are combined with coastal restoration and nonstructural measures to provide comprehensive risk reduction.

Lake Pontchartrain Barrier Levee Alignments:

LP-a-100-1: This structural option targets a 100-year level of risk reduction. This structural option includes building a 12.5-foot elevation weir across the mouth of Lake Pontchartrain to act as a surge barrier and extending the levee system east of Slidell up to high ground near Interstate 59. Storm gates would close the passes at Chef Menteur and The Rigoletes.

LP-a-100-2: This structural option targets a 100-year level of risk reduction. This structural option contains the same surge barrier weir as LP-1a-100-1 but it adds levee on the North Shore, a levee around Laplace, and a levee in Plaquemines Parish on the east bank of the Mississippi River across from Oakville.

LP-a-100-3: This structural option targets a 100-year level of risk reduction. This structural option contains the same surge barrier weir as LP-1a-100-1 but it adds a ring levee around Slidell on the North Shore, a levee around Laplace, and a levee in Plaquemines Parish on the east bank of the Mississippi River across from Oakville.

LP-b-400-1: This structural option targets a 400-year level of risk reduction. This structural option contains the same surge barrier weir as LP-1a-100-1 but it includes raising existing levees to a 400-year level of risk reduction. This option also includes a new levee approximately between Chef Menteur Pass and Bayou Dupre that would follow Lake Borgne along the edge of the wetlands; construction would include sector gates on both the MRGO and GIWW.

LP-b-400-3: This structural option targets a 400-year level of risk reduction. This structural option contains the same surge barrier weir as LP-1a-100-1 but it adds a ring levee around Slidell on the North Shore, a levee around Laplace, and a levee in Plaquemines Parish on the east bank of the Mississippi River across from Oakville. This option also includes a new levee approximately between Chef Menteur Pass and Bayou Dupre that would follow Lake Borgne along the edge of the wetlands; construction would include sector gates on both the MRGO and GIWW.

LP-b-1000-1: This structural option targets a 1000-year level of risk reduction. This structural option contains the same surge barrier weir as LP-1a-100-1 but it includes raising existing levees to a 1000-year level of risk reduction. This option also includes a new levee approximately between Chef Menteur Pass and Bayou Dupre that would follow Lake Borgne along the edge of the wetlands; construction would include sector gates on both the MRGO and GIWW.

LP-b-1000-2: This structural option targets a 1000-year level of risk reduction. This structural option contains the same surge barrier weir as LP-1a-100-1 but it adds a levee across the North Shore, a levee around Laplace, and a levee in Plaquemines Parish on the east bank of the Mississippi River across from Oakville. This option also includes a new levee approximately between Chef Menteur Pass and Bayou Dupre that would follow Lake Borgne along the edge of the wetlands; construction would include sector gates on both the MRGO and GIWW. Of all the structural measures, this measure contains the most structural components to provide a comprehensive 1000-year level of risk reduction to both the North and South Shore.

High Level Levee Alignments:

HL-a-100-2: This structural option targets a 100-year level of risk reduction. This structural option involves building new levees but without a surge reduction barrier across Lake Pontchartrain. The new levees would include a levee on the North Shore, a levee around Laplace, and a levee in Plaquemines Parish on the east bank of the Mississippi River across from Oakville.

HL-a-100-3: This structural option targets a 100-year level of risk reduction. This structural option involves building new levees but without a surge reduction barrier across Lake Pontchartrain. The new levees would include a ring levee around Slidell on the North Shore, a levee around Laplace, and a levee in Plaquemines Parish on the east bank of the Mississippi River across from Oakville.

HL-b-400-2: This structural option targets a 400-year level of risk reduction. This structural option involves building new levees but without a surge reduction barrier across Lake Pontchartrain. The new levees would include a levee on the North Shore, a levee around Laplace, and a levee in Plaquemines Parish on the east bank of the Mississippi River from Oakville. This option also includes a new levee approximately between Chef Menteur Pass and Bayou Dupre that would follow Lake Borgne along the edge of the wetlands; construction would include sector gates on both the MRGO and GIWW.

HL-b-400-3: This structural option targets a 400-year level of risk reduction. This structural option involves raising existing levees and building new levees but without a surge reduction barrier across Lake Pontchartrain. The new levees would include a ring levee around Slidell on the North Shore, a levee around Laplace, and a levee in Plaquemines Parish on the east bank of the Mississippi River across from Oakville. This option also includes a new levee approximately between Chef Menteur Pass and Bayou Dupre that would follow Lake Borgne along the edge of the wetlands; construction would include sector gates on both the MRGO and GIWW.

Planning Unit 2

The following sections provide details on the tiered screening of measures and alignments for Planning Unit 2, a triangular shaped area beginning at Donaldsonville, then extending southeast along the Mississippi River to the Gulf of Mexico. This area then continues southwest of Grand Isle and Port Fourchon and northwest along Bayou Lafourche.

Approximately 300,000 residents, or 14 percent, of the planning area population inhabits Planning Unit 2, containing the portion of the New Orleans metropolitan area located on the West Bank of the Mississippi River. Additionally, this planning unit contains Venice, Grand Isle, and portions of towns located along Bayou Lafourche such as Port Fourchon, Larose, Thibodaux, and Donaldsonville.

The major Mississippi River ports, noted in the description of Planning Unit 1 also have infrastructure on the West Bank of the Mississippi River in Planning Unit 2. Additionally, this highly productive estuary is home to a population where the social and economic cultures have evolved around and are dependent upon the estuary's natural resources.

As discussed for Planning Unit 1, the lower portion of Plaquemines Parish is a special case; therefore, screening of structural measures for this area is discussed following the screening details of Planning Unit 2.

Tier 1 – Initial Screening of Structural Alignments

The Plan Formulation Atlas identified four primary strategies for structural risk reduction within Planning Unit 2. The alignment of the levees included the **GIWW** (three variations were considered including structural risk reduction for Lafitte and variations of where the levee ties into to the Mississippi River Levee System), **Highway 90** alignment, **Swamp** alignment (later modified/combined with Highway 90 alignment and renamed to Ridge alignment) and two alignments along the **West Bank Interior** (improvement to existing West Bank levee and extension of the existing West Bank levee). **Table 9** describes the codes used in the Plan Formulation Atlas and for Tier 1 screening for measures in Planning Unit 2. **Figures 8** through **11** show examples of the various alignments.

Table 9. Planning Unit 2 Codes from Plan Formulation Atlas used for Tier 1 Screening

Code	Measure Code Description (e.g. PU2-G-1)
PU2-	Planning Unit 2
-WBI-	West Bank interior alignments
-G-	GIWW levee alignment variation
-H	Highway 90 levee alignment
-S	Swamp alignment
-State	Alignment that was part of the preliminary draft State Master Plan
-#	Variations to the primary alignments (if applicable)

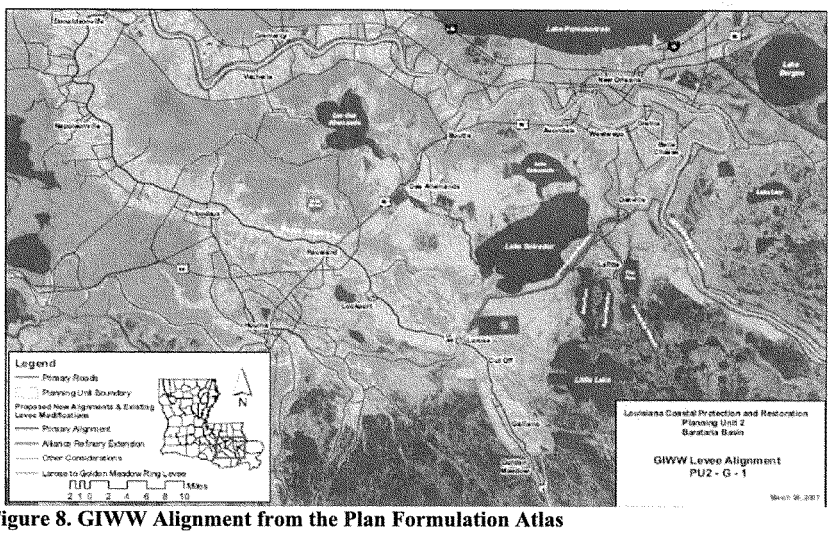

Figure 8. GIWW Alignment from the Plan Formulation Atlas

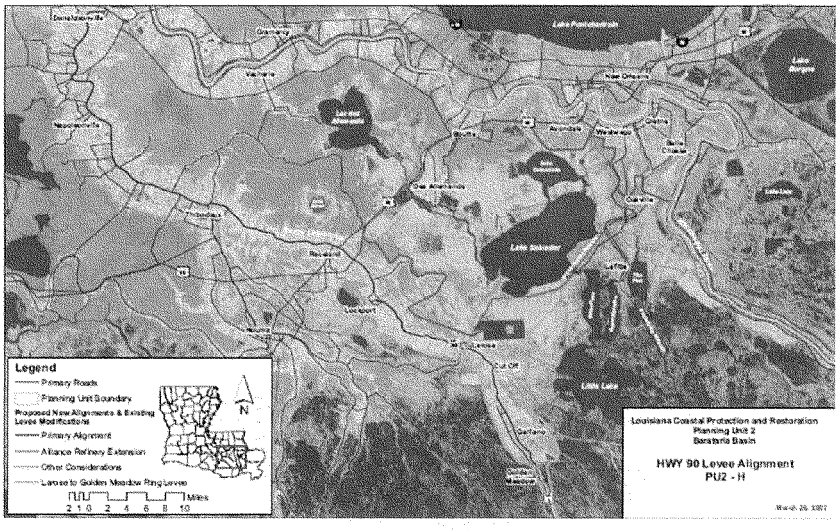

Figure 9. Highway 90 Alignment from the Plan Formulation Atlas

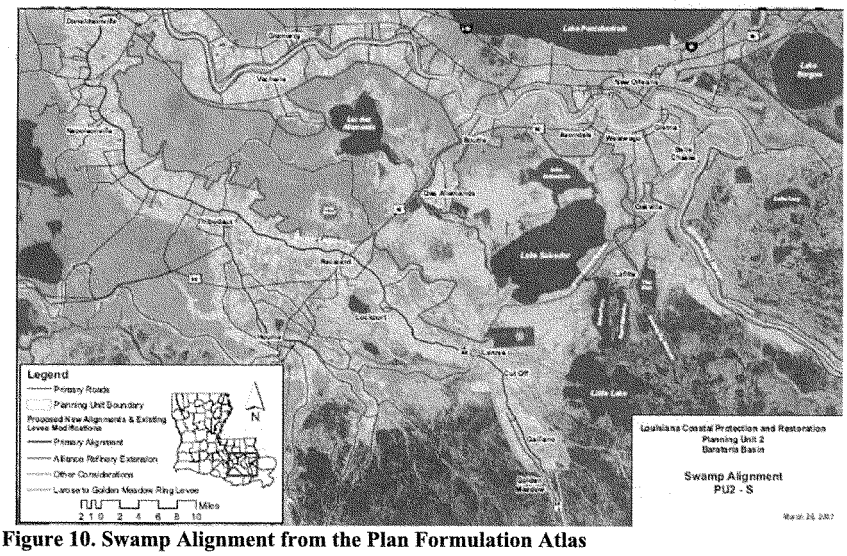

Figure 10. Swamp Alignment from the Plan Formulation Atlas

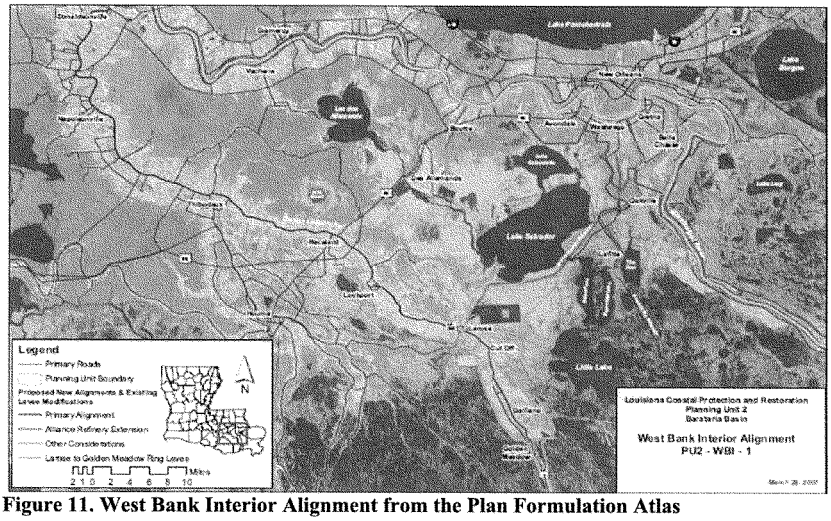

Figure 11. West Bank Interior Alignment from the Plan Formulation Atlas

Through initial screening, in which preliminary construction costs as well as direct and indirect environmental impacts were considered, the number of variations was screened to five. **Table 10** lists the variations of each of the alignments in Planning Unit 2 and describes why some alignment variations were eliminated from further consideration at this time.

Table 10. Initial Screening of Planning Unit 2 Structural Measures

Measure Code(s)	Pass/Fail	Comments
PU2-G-1	Pass	Essentially the same as the State's GIWW alignment; however, the State plan includes a ring levee around Lafitte. Cost estimates range from ~$5B - $9B depending on the height and levee construction method (i.e., 30 feet geotextile, 30 feet soil mix, or 35 feet soil mix).
PU2-G-2	Fail	Environmental concerns.
PU2-G-3	Fail	Environmental concerns.
PU2-H	Pass	Essentially the same as the State's Highway 90 alignment. For a 25-foot levee, costs range from ~$10 – 15B depending on levee construction method (geotextile versus soil mix).
PU2-S	Pass	Equivalent to the State's swamp alignment. For a 20-foot levee, costs range from ~$13 – 30B depending on the levee construction method (geotextile versus soil mix). If the swamp alignment only needs to be 20 feet up to Vacherie and Thibodaux, costs could range from $11-22B.

Measure Code(s)	Pass/Fail	Comments
PU2-WBI-1	Pass	A component of the swamp alignment and also the West Bank component of the high level plan considerations in PU1.
PU2-WBI-2	Pass	A component of the swamp alignment and also the West Bank component of the high level plan considerations in PU1.
PU2-G-State	Fail	This alignment was presented in the Preliminary Draft State Master Plan but was changed to more closely resemble the GIWW alignment. Same environmental concerns as G-2 and G-3; dropped from State Master Plan.

Tier 2 – Initial Hydromodeling of Structural Measures

In addition to the initial screening evaluation, additional hydromodeling was necessary to resolve and further refine the possible structural measures. Remaining formulation issues included:

- Non-overtopping versus weir designs for the GIWW and Highway 90 alignments.
- Comparison of GIWW, Highway 90 and swamp alignments.
- Potential impacts to Plaquemines and Larose to Golden Meadow areas.
- Inclusion or exclusion of Lafitte and Des Allemands (provide structural or nonstructural risk reduction).
- Design level of risk reduction.

For this tier, non-overtopping barrier versus weir and the three alignments were evaluated (resulting in the elimination of the Highway 90 and the Swamp alignments and the creation of the Ridge alignment). During this step, a range of alignments were formulated to address the remaining formulation issues. With the inclusion of different levels of risk reduction, naming conventions for the structural measures were revised slightly from previous screening nomenclature. **Table 11** describes the coding.

Table 11. Planning Unit 2 Codes used for Tier 2 and Tier 3 Screening

Code	Measure Code Description (e.g. PU2-WBI-100-1)
PU2-	Planning Unit 2
-WBI-	West Bank Interior Plan.
-R-	Ridge Alignment Plan
-G-	GIWW Alignment Plan
-100-	100-year design level
-400-	400-year design level
-1000-	1000-year design level
-1	All PU2 primary alignments include West Bank and Vicinity levees with new sector gate and Larose to Golden Meadow levees. Primary alignments for 'R' and 'G' also include Lafitte ring levees.
-2	Primary alignment plus Boutte levee.
-3	Primary alignment plus Boutte and Des Allemands levee.
-4	Primary alignment plus Boutte, Des Allemands, and Bayou Lafourche levees.

Full Barrier vs. Weir Options

The non-overtopping versus weir designs for the GIWW and Highway 90 alignments were evaluated using the surge maps produced by the hydromodels. Based on the surge level results, the weir alignments in Planning Unit 2 would be more cost effective since they perform nearly as well as their non-overtopping counterparts but would cost substantially less. In addition, the weir options have less direct and indirect wetland impacts and less constructability issues due to poor soil conditions. The weir options also minimize increases in water surface elevations along Plaquemines and Larose to Golden Meadow levees compared to the non-overtopping barriers.

Combining the Swamp and Highway 90 Alignments into the Ridge Alignment

As a result of the hydromodeling, which revealed that the estimated storm surge for the 1000-year event does not impact areas of concentrated assets beyond Highway 90, the swamp alignment and Highway 90 alignments were found to be unnecessary for risk reduction and were therefore modified to follow the natural ridges and portions of Highway 90. This reformulated alignment is referred to as the Ridge Alignment. **Figure 12** depicts an example Ridge alignment. A separate analysis was also done for structural improvements for the Lafitte area and was added as an increment to the GIWW and Ridge alignment plans.

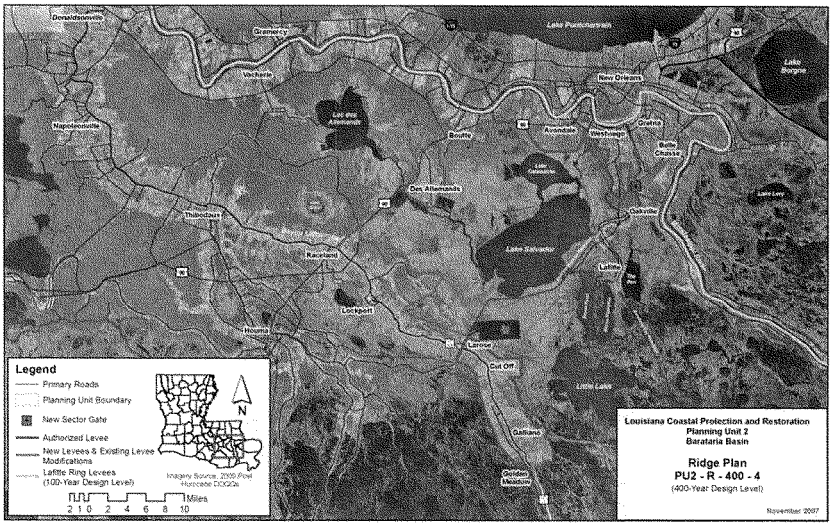

Figure 12. Reformulated Ridge Alignment

The remaining formulation issues would be addressed in subsequent screening (Tier 3) or in the case of structural versus nonstructural risk reduction, as part of the MCDA conducted after the structural measures are combined with nonstructural and restoration measures.

Tier 3 – Final Screening of Structural Alternatives

The Planning Unit 2 structural measures were then subjected to analysis using 100, 400, and 1000-year events. This resulted in the development of three variations of the West Bank Interior, six variations of the GIWW and nine variations of the Ridge Alignment. These structural measures were then ranked using the multiple attributes previously described in **Table 1**.

Table 12 displays the ranking of the 18 measures and the screening attribute values used to conduct the ranking.

Table 12. Planning Unit 2 Ranking of Measures

Measure	Screening Attributes												Total Value Score***	Rank
	Cost Effectiveness		Annual Equiv. Flood Damages		2075 Pop. Impacted 400-yr Event		Present Value Costs		Construction Period		Direct Impact-Wetlands			
	Ratio*	Value**	$ Million	Value**	# People	Value**	$ Million	Value**	Years	Value**	Acres	Value**		
G-100-1	13.83	0.23	510	0.70	174,599	0.43	6,281	0.18	11	0.85	969	0.10	**2.49**	**1**
WBI-100-1	2.79	0.05	725	1.00	398,872	0.99	750	0.02	6	0.46	0	0.00	**2.52**	**2**
G-100-4	21.47	0.35	435	0.60	178,505	0.44	11,509	0.33	11	0.85	2,241	0.24	**2.80**	**3**
R-100-2	9.31	0.15	684	0.94	403,309	1.00	2,849	0.08	11	0.85	704	0.07	**3.10**	**4**
R-100-3	13.89	0.23	635	0.88	403,309	1.00	4,937	0.14	11	0.85	993	0.10	**3.20**	**5**
R-100-4	19.78	0.32	613	0.85	403,012	1.00	7,461	0.21	11	0.85	1,635	0.17	**3.40**	**6**
WBI-400-1	40.16	0.65	588	0.81	168,022	0.42	15,751	0.45	12	0.92	3,688	0.39	**3.65**	**7**
R-400-2	41.08	0.67	540	0.74	159,309	0.40	17,966	0.51	13	1.00	4,392	0.46	**3.79**	**8**
R-400-3	41.43	0.67	487	0.67	150,132	0.37	20,233	0.58	13	1.00	4,687	0.50	**3.79**	**9**
R-400-4	44.66	0.73	462	0.64	144,021	0.36	22,906	0.66	13	1.00	5,323	0.56	**3.94**	**10**
G-400-1	46.68	0.76	485	0.67	142,734	0.35	22,591	0.65	12	0.92	6,161	0.65	**4.00**	**11**
WBI-1000-1	54.07	0.88	578	0.80	161,006	0.40	21,727	0.62	13	1.00	5,152	0.54	**4.24**	**12**
G-400-4	50.14	0.82	400	0.55	119,794	0.30	28,438	0.81	13	1.00	7,433	0.79	**4.26**	**13**
R-1000-3	53.15	0.86	476	0.66	142,402	0.35	26,518	0.76	13	1.00	6,146	0.65	**4.28**	**14**
R-1000-2	53.96	0.88	530	0.73	151,579	0.38	24,141	0.69	13	1.00	5,857	0.62	**4.30**	**15**
R-1000-4	55.99	0.91	452	0.62	135,800	0.34	29,250	0.84	13	1.00	6,787	0.72	**4.43**	**16**
G-1000-1	57.81	0.94	484	0.67	141,362	0.35	28,061	0.80	12	0.92	8,186	0.87	**4.55**	**17**
G-1000-4	61.46	1.00	399	0.55	117,457	0.29	34,927	1.00	13	1.00	9,458	1.00	**4.84**	**18**

Indicates structural measure is included in the overall set of LACPR alternatives to be evaluated.

* Cost Effectiveness Ratio = Total Present Value Costs /Average Annual Equivalent Risk Reduction

** Value is the normalized value for the attribute where a value of 1.00 represents the greatest is the largest (lower is better)

***Total of Normalized Values (lower is better)

Based on the ranking above and in consideration of the need to investigate a range of different ways to reduce the risk of hurricane storm damages the following 13 structural measures were selected (listed in order of rankings):

G-100-1: This measure ranked 1st among the structural measures in Planning Unit 2. This measure, although not the cheapest, provides flood risk reduction to the greatest number of people among all 100-year measures.

WBI-100-1: This measure ranked 2nd among the structural measures in Planning Unit 2 and is the least expensive of all measures.

G-100-4: This measure ranked 3rd among the structural measures in Planning Unit 2. Although considerably more expensive than the previous two measures (WBI-100-1 and G-100-1), it reduces average annual flood damages to levels comparable (and in most cases more efficiently) to the 400 and 1000-year measures.

R-100-2: This measure ranked 4th among the structural measures in Planning Unit 2. It is the least costly ridge alignment (modified swamp and Highway 90 alignments) measures.

R-100-3: This measure ranked 5th among the structural measures in Planning Unit 2.

R-100-4: This measure ranked 6th among the structural measures in Planning Unit 2. This measure provides the greatest protection among the 100-year ridge alignment measures.

WBI-400-1: This measure ranked 7th among the structural measures in Planning Unit 2 and is the least costly 400-year measure.

R-400-2: This measure ranked 8th among the structural measures in Planning Unit 2.

R-400-3: This measure ranked 9th among the structural measures in Planning Unit 2.

R-400-4: This measure ranked 10th among the structural measures in Planning Unit 2. This measure provides the greatest risk reduction among the 100-year Ridge Alignment measures.

WBI-1000-1: This measure ranked 12th among the structural measures in Planning Unit 2 and is the least costly 1000-year measure.

R-1000-4: This measure ranked 16th among the structural measures in Planning Unit 2 and was selected for comparison purposes with the other 1000-year measures.

G-1000-4: This measure ranked last among the structural measures in Planning Unit 2. This structural measure provides the greatest risk reduction in terms of average annual damages prevented and the number of people impacted by flooding from a hurricane event.

Structural Measures to be Included in Planning Unit 2 Alternatives

Below are descriptions of the measures to be included as structural components of alternatives to be considered for detailed analysis for Planning Unit 2. These structural measures allow for comparison of further improvements to the existing West Bank, as well as, detailed comparison of the GIWW versus Ridge alignments (at similar levels and areas of risk reduction) for 100-year, 400-year and 1000-year levels of risk reduction. For the Planning Unit 2 alternatives, these structural components have been combined with coastal restoration and nonstructural measures to provide comprehensive risk reduction.

West Bank Interior Levee Alignments:

WBI-100-1: This structural option targets a 100-year level of risk reduction. The only new feature in this option involves an improvement to the existing West Bank and Vicinity project, which would be to add Sector Gate South on Bayou Barataria to keep surge from entering the existing interior canals on the West Bank of Metro New Orleans. This option assumes that the existing Larose to Golden Meadow ring levee which is authorized at a 100-yr level of risk reduction will be raised to the new 100-year design heights as part of the baseline condition.

WBI-400-1: This structural option is similar to WBI-100-1 but targets a 400-year level of risk reduction. This option also includes raising the Larose to Golden Meadow ring levee to 400-year design heights.

WBI-1000-1: This structural option is similar to WBI-100-1 but targets a 1000-year level of risk reduction. This option also includes raising the Larose to Golden Meadow ring levee to 1000-year design heights and ring levee that provides 100-year level of risk reduction for Laffite.

Ridge Levee Alignments:

R-100-2: This structural option targets a 100-year level of risk reduction. This structural option builds on WBI-100-1 but also includes extending the existing West Bank and Vicinity levee along the edge of development to include the Luling/Boutte area. Further, this option includes 100-year level of risk reduction to the Laffite through a series of four ring levees (Crown Point, Jean Laffite, Laffite, and Barataria) known collectively as the Lafitte ring levees.

R-100-3: This structural option targets a 100-year level of risk reduction. This structural option builds on and includes the same features as R-100-2 but also includes extending the existing Larose to Golden Meadow levees along the edge of development to include communities along Bayou Lafourche south of Highway 90 and Lafitte ring levees would be raised to the 100-year level.

R-100-4: This structural option targets a 100-year level of risk reduction. This structural option builds on and includes the same features as R-100-2 but also includes extending the existing Larose to Golden Meadow levees along the edge of development to include communities along Bayou Lafourche south of Highway 90. In addition, existing Des Allemands and Lafitte ring levees would be raised to the 100-year level.

R-400-2: This structural option targets a 400-year level of risk reduction. This structural option contains the same features at R-100-2 but all levees would be raised or built to the 400-year level with the exception of the Lafitte ring levees which would be raised to the 100-year level.

R-400-3: This structural option targets a 400-year level of risk reduction. This structural option contains the same features at R-100-3 but all levees would be raised or built to the 400-year level with the exception of the Lafitte ring levees which would be raised to the 100-year level.

R-400-4: This structural option targets a 400-year level of risk reduction. This structural option includes the same features as R-100-4 but involves building those levees at a 400-year design height (except the Lafitte ring levees which would be at the 100-year design) as well as raising existing levees on the West Bank of New Orleans and the existing Larose to Golden Meadow ring levee to a 400-year design height.

R-1000-4: This structural option targets a 1000-year level of risk reduction. This structural option includes the same features as R-100-4 and R-400-4 but involves building those levees at a 1000-year design height (except the Lafitte ring levee which would be at the 100-year design) as well as raising existing levees on the West Bank of New Orleans and the existing Larose to Golden Meadow ring levee to a 1000-year design height.

GIWW Levee Alignments:

G-100-1: This structural option targets a 100-year level of risk reduction. This option builds on and includes the same features as WBI-100-1 and also consists of a surge reduction barrier in the form of a 12.5-foot elevation weir that roughly follows the GIWW, which already acts as a partial barrier. Structures would consist of sixteen 50-foot tainter gates, a 110-foot sector gate on Bayou Perot, and a 110-foot lock on Bayou Barataria and ring levees that provides 100-year level of risk reduction for Laffite

G-100-4: This structural option targets a 100-year level of risk reduction. The option includes the same new levee alignments as described in R-100-4 but also includes the 12.5-foot elevation surge reduction barrier weir that is described in G-100-1.

G-1000-4: This structural option targets a 1000-year level of risk reduction. The option includes the same weir and levees described in G-100-4 but levees would be at the 1000-year design height.

Special Case: Lower Plaquemines Parish

Plaquemines Parish, which is split roughly in half by the Mississippi River, lies in both Planning Units 1 and 2. The portion of Plaquemines Parish on the east side of the Mississippi River is contained in Planning Unit 1 and the west side is contained in Planning Unit 2. Because of its unique nature, the portions of Plaquemines Parish below Belle Chasse are handled as a special case for plan formulation.

Tier 1 – Initial Screening of Structural Alignments

The Plan Formulation Atlas presented four options for increased risk reduction in Plaquemines Parish:

1. **Ring Levees/Spillways (PL-RS)** – This option proposes spillways in combination with ring levees in multiple locations in Plaquemines Parish. The spillway concept was envisioned to reduce hurricane surge in the New Orleans area and Plaquemines Parish by degrading sections of the existing Plaquemines Parish levees to allow storm surge transfer between Breton Sound and Barataria Bay areas. Highway bridges would be constructed over degraded levee reaches.
2. **Closed Ring Levee System (PL-RL)** – This option includes a series of basins (ring levees) that would provide an increased level of risk reduction to critical facilities and more densely populated areas of lower Plaquemines Parish. Levee sections outside the closed ring levee areas would remain at existing height.
3. **Federal Levee Alignment (PL-FL)** – This option proposes to raise the height of all Federal levees in lower Plaquemines Parish to the 100-year design level and to leave the non-Federal levees at existing height.
4. **Existing Levee Alignment (PL-EL)** – This option would incorporate non-Federal levees in Plaquemines Parish into the Federal levee system and raise the height of all existing levees in lower Plaquemines Parish.

Figure 13 displays the ring levee/spillway concept in Plaquemines Parish. Note: The location and width of spillways is purely conceptual. For the hydromodeling evaluation used in the Tier 2 screening only three spillways were considered.

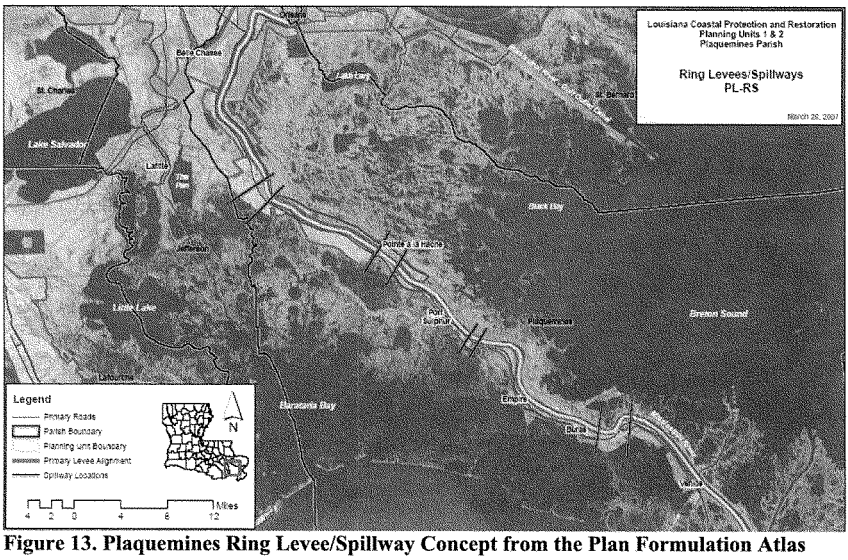

Figure 13. Plaquemines Ring Levee/Spillway Concept from the Plan Formulation Atlas

Following hurricanes Katrina and Rita, the USACE conducted a study to provide risk reduction though structural measures in lower Plaquemines Parish. Specifically, two options that provide 100-year level of risk reduction were developed for that study. These options include:

1. Creation of ring levees around the most populated portions of the Parish (estimated cost of roughly $3.6 billion) and
2. Providing 100-year risk reduction to the entire lower Plaquemines Parish by raising and armoring existing levees (estimated cost of roughly $5.8 billion).

As a result of the high cost and the potential surge increase in Louisiana and Mississippi created by levees in this area, both the State Master Plan stakeholder process and the USACE screening process eliminated most of the structural measures in lower Plaquemines Parish. **Table 13** summarizes the results of the Tier 1 screening.

Table 13. Screening Results for Lower Plaquemines Parish

Measure Code(s)	Pass/Fail	Comments
PL-RS	Pass	Spillway concept carried forward pending hydromodeling results to evaluate regional benefits.
PL-RL	Fail	Excessively high costs; constructability issues; lack of stakeholder support; transportation access issues (would require elevated roadways connecting areas inside and outside the ring levees).
PL-FL	Fail	Excessively high costs; constructability issues; lack of stakeholder support.
PL-EL	Fail	Excessively high costs; constructability issues.

Tier 2 – Initial Hydromodeling of Structural Measures

In order to understand the influence of the Mississippi River levees and adjacent back levees in lower Plaquemines Parish, the following two cases were modeled:

1. The creation of three spillways (totaling 9.5 miles) across the lower Mississippi River;
2. The removal of all levees (totaling 57 miles) along the Mississippi River within the delta which allows the relatively free flow of water across the Mississippi River.

This analysis was designed to understand how surge builds up along these levees from Breton Sound and propagates towards New Orleans and Baton Rouge in the Mississippi River. In addition, the effectiveness of building localized ring levees to provide a higher level of risk reduction in lower Plaquemines Parish can be ascertained.

The first case described above for the spillway concept did not produce significant regional reductions in water levels. The second case (tearing down all levees) did produce some reductions in regional water levels; however, this approach would not likely be acceptable. In general, the results are inconclusive for making a recommendation at this time. The spillway concept appears to have some merit but further study is needed; therefore, the spillway option was not carried forward as a risk reduction measure for LACPR.

Planning Unit 3a

The following sections provide details on the tiered screening of structural measures and alignments for Planning Unit 3a. Planning Unit 3a begins in Baton Rouge and continues south along the Mississippi River and Bayou Lafourche to the Gulf of Mexico. The boundary then extends westward to Bayou de West, and then generally follows Bayou de West north to Interstate Highway 10 and back to Baton Rouge. The Planning Unit consists of Terrebonne, St. Mary (East Bank), Lafourche (West Bank), Assumption (West Bank), and St. Martin (East Bank) Parishes.

This planning unit includes approximately 249,000, or 12 percent, of the population within the overall planning area. Communities at risk in this Planning Unit include a portion of the Baton Rouge metropolitan area as well Bayou Cane, Houma, Morgan City, Raceland and Thibodaux among others.

This planning unit contains infrastructure assets in and around population centers, consisting of oil and gas infrastructure, marinas, and port facilities.

Tier 1 – Initial Screening of Structural Alignments

The Plan Formulation Atlas identified three primary strategies for structural risk reduction in Planning Unit 3a. They include a **GIWW** alignment (**Figure 14**), a **Morganza to the Gulf** alignment (**Figure 15**) and an **Atchafalaya Backwater** alignment (**Figure 16**). The alignments proposed in PU3a would provide flood risk reduction to Lockport, Raceland, Houma, Thibodaux and Morgan City, among others. The GIWW alignment would consist of a new levee along the GIWW from Larose to Morgan City or to Thibodaux with a ring levee around Morgan City. The Morganza to the Gulf alignment proposes to add a levee using the Morganza to the Gulf alignment from Larose to Morgan City or Thibodaux with a ring levee around Morgan City. The Atchafalaya Backwater alignment would consist of a new levee around the backwaters of the Atchafalaya including ring levees and the recently authorized Morganza to the Gulf levee alignment. Within these three strategies, the Plan Formulation Atlas identified six variations including an alignment identified in the State Master Plan. **Table 14** describes the codes used in the Plan Formulation Atlas and for Tier 1 screening for measures in Planning Unit 3a.

Table 14. Planning Unit 3a Codes from Plan Formulation Atlas used for Tier 1 Screening

Code	Measure Code Description (e.g. PU3a-G-1)
PU3a-	Planning Unit 3a
-M-	Morganza levee alignment
-G-	GIWW levee alignment with Morganza Levee at 100-year design
-AB	Atchafalaya backwater alignment
-State	Alignment that was part of the preliminary draft State Master Plan
-#	Variations to the primary alignments (if applicable)

Figures 14 through **16** show examples of the various structural measure alignments.

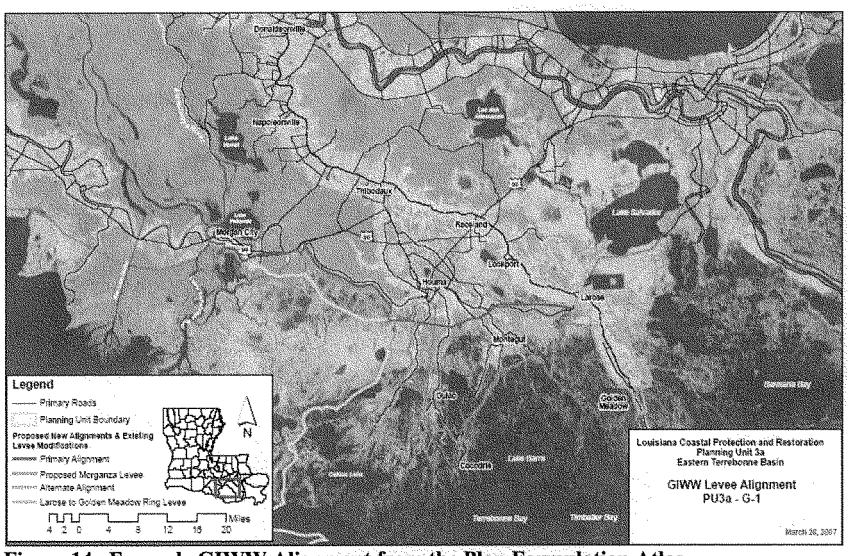

Figure 14. Example GIWW Alignment from the Plan Formulation Atlas

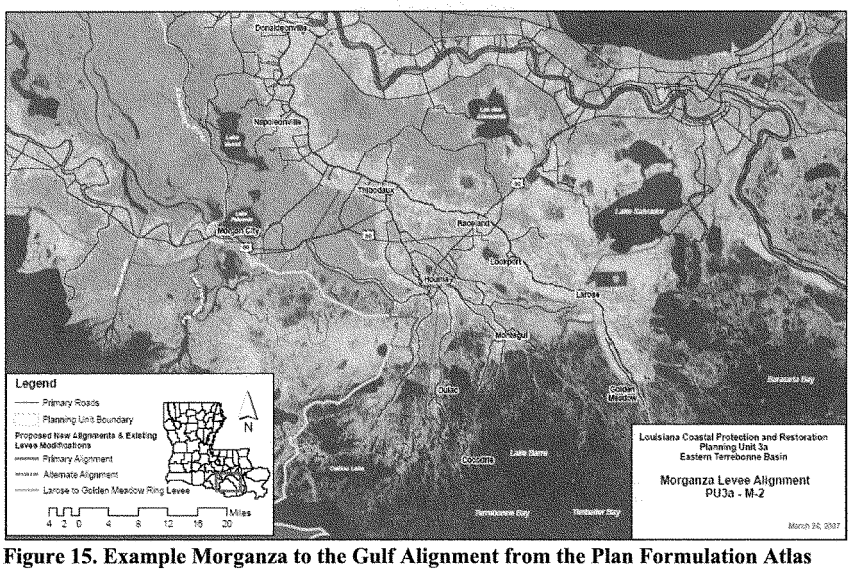

Figure 15. Example Morganza to the Gulf Alignment from the Plan Formulation Atlas

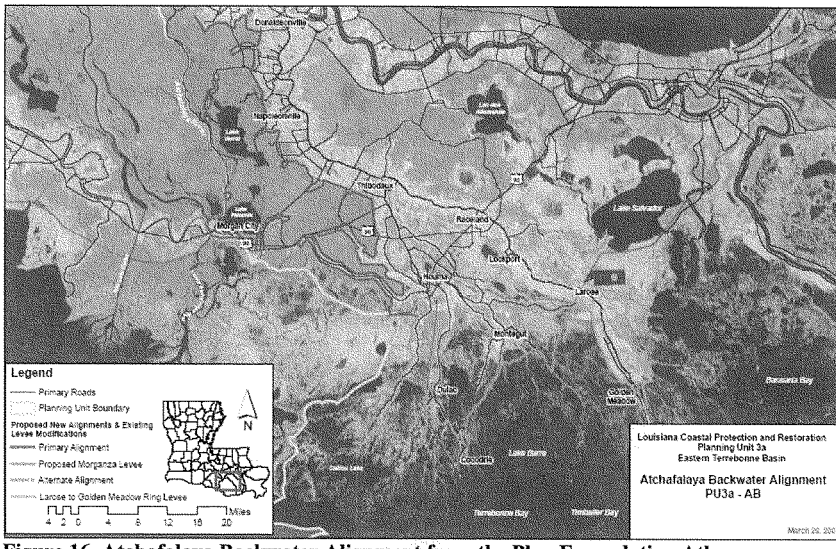

Figure 16. Atchafalaya Backwater Alignment from the Plan Formulation Atlas

Through the first tier of screening, in which preliminary construction costs, constructability as well as direct environmental impacts were considered, the number of variations was screened to three. **Table 15** lists the variations of the levee alignments and describes why some alignment variations were eliminated from further consideration at this time.

Table 15. Initial Screening of Planning Unit 3a Structural Measures

Measure Code(s)	Pass/Fail	Comments
PU3a-G-1	Pass	Similar to GIWW alignment in SMP; works well with bypass channel identified in the coastal restoration measures. The levee may only have to be built to 10 or 15 feet.
PU3a-G-2	Pass	Related to Morganza to the Gulf tie back associated with new 100-year surge data. This option may be incomplete because it would require parts of PU3a-AB to be implemented.
PU3a-M-1	Fail	Excessive costs; doesn't prevent flooding from hurricane surge and wave run-up.
PU3a-M-2	Fail	Excessive costs; doesn't prevent flooding from hurricane surge and wave run-up.
PU3a-AB	Fail	Excessive costs
PU3a-State	Pass	Similar to G-1 but includes additional alignment from Golden Meadow to Pointe au Chene that will likely be screened out due to environmental concerns and poor soil conditions (higher cost/mile). Bayou DuLarge levee alignment creates a surge amplification.

Tier 2 – Initial Hydromodeling of Structural Measures

In addition to the initial screening evaluation, additional hydromodeling was necessary to resolve and further refine the possible structural measures in Planning Unit 3a. Remaining formulation issues included:

- Comparison of the various GIWW alignments.
- A continuous levee or a ring levee for Morgan City.
- Design level of risk reduction.

The hydromodeling revealed that the measures from the Plan Formulation Atlas needed to be reformulated based on areas impacted and the location of concentrated assets. This resulted in three structural measures including:

- A continuous levee from Larose in the east to Morgan City in the west then north where it will tie into the ridge following the Bayou Black. This alignment is similar to the recently authorized Morganza levee (**Figure 17**).
- Modification to the Morganza Alignment by tying back the Morganza levee to high ground south of Thibodaux. This measure includes a ring levee around Morgan City (**Figure 18**).
- This measure is the same as described in the previous bullet but it includes a levee along the GIWW to create a secondary line of defense (**Figure 19**).

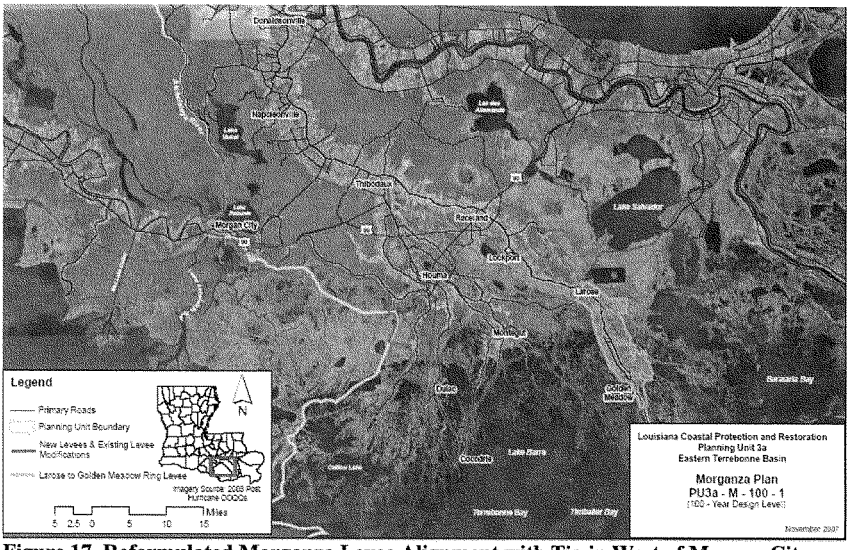

Figure 17. Reformulated Morganza Levee Alignment with Tie-in West of Morgan City

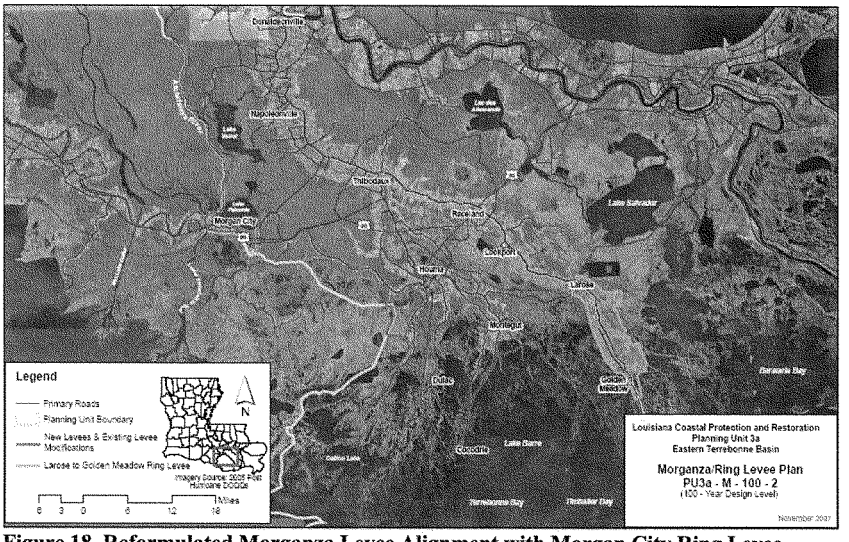

Figure 18. Reformulated Morganza Levee Alignment with Morgan City Ring Levee

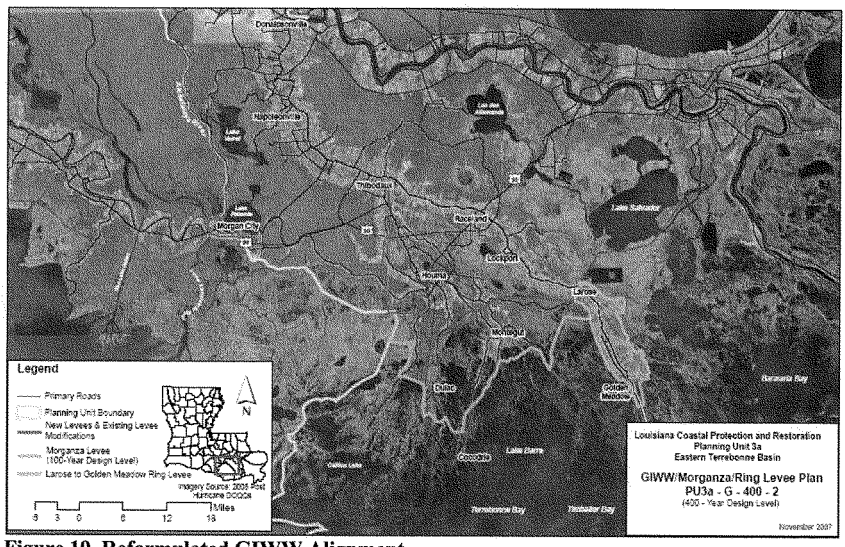

Figure 19. Reformulated GIWW Alignment

With the inclusion of different levels of risk reduction, name convention for the structural managements measures were revised slightly from previous screening nomenclature. **Table 16** describes the coding.

Table 16. Planning Unit 3a Codes used for Tier 2 and Tier 3 Screening

Code	Measure Code Description (e.g. PU3a-M-100-1)
PU3a-	Planning Unit 3a
-M-	Morganza Levee alignment
-G-	GIWW Alignment Plan with Morganza Levee at 100-year design
-100-	100-year design level
-400-	400-year design level
-1000-	1000-year design level
-1	Morganza alignment with tieback to high ground west of Morgan City
-2	Morganza alignment with tieback to high ground south of Thibodaux and ring levee around Morgan City

Tier 3 – Final Screening of Structural Alternatives

The Planning Unit 3a structural measures were then subjected to analysis using 100, 400, and 1000-year events. This resulted in the development of six variations of the Morganza Levee alignment and two variations of the GIWW alignments. These structural measures were then ranked using the multiple attributes previously described in **Table 1**.

Table 17 displays the ranking of the eight measures and the screening attribute values used to conduct the ranking.

Table 17. Planning Unit 3a Ranking of Measures

Measure	Screening Attributes												Total Value Score***	Rank
	Cost Effectiveness		Annual Equiv. Flood Damages		2075 Pop. Impacted 400-yr Event		Present Value Costs		Construction Period		Direct Impact-Wetlands			
	Ratio*	Value**	$ Million	Value**	# People	Value**	$ Million	Value**	Years	Value**	Acres	Value**		
G-400-2	15.50	0.36	1,184	0.84	51,913	0.43	20,207	0.44	10	0.71	5,261	0.62	**3.41**	**1**
G-1000-2	16.67	0.39	1,169	0.83	50,809	0.42	21,978	0.48	10	0.71	6,642	0.79	**3.62**	**2**
M-100-1	13.82	0.32	1,207	0.86	100,745	0.83	17,701	0.38	10	0.71	4,880	0.58	**3.69**	**3**
M-100-2	12.08	0.28	1,212	0.86	121,307	1.00	15,405	0.33	10	0.71	4,201	0.5	**3.69**	**4**
M-400-2	23.53	0.55	1,285	0.91	34,879	0.29	28,290	0.61	12	0.86	6,128	0.73	**3.95**	**5**
M-400-1	27.45	0.64	1,290	0.92	27,229	0.22	32,870	0.71	12	0.86	7,639	0.91	**4.26**	**6**
M-1000-2	35.98	0.84	1,401	1.00	33,590	0.28	39,070	0.85	14	1.00	6,313	0.75	**4.71**	**7**
M-1000-1	42.61	1.00	1,406	1.00	26,429	0.22	46,087	1.00	14	1.00	8,425	1.00	**5.22**	**8**

Indicates structural measure is included in the overall set of LACPR alternatives to be evaluated.

* Cost Effectiveness Ratio = Total Present Value Costs /Average Annual Equivalent Risk Reduction

** Value is the normalized value for the attribute where a value of 1.00 represents the greatest is the largest (lower is better)

***Total of Normalized Values (lower is better)

Based on the ranking above and in consideration of the need to investigate a range of different ways to reduce the risk of hurricane storm damages the following four structural measures were selected for the final array (listed in order of rankings):

G-400-2: This measure ranked 1st among the structural measures in Planning Unit 3a. It is the least costly among the measures designed to provide protection against the 400-year hurricane event.

G-1000-2: This measure ranked 2nd among the structural measures in Planning Unit 3a. It is the least costly among the measures designed to provide protection against the 1000-year hurricane event.

M-100-1: This measure ranked 3rd among the structural measures in Planning Unit 3a. This measure is the 2nd cheapest among PU3 structural measures but impacts twice as many people than any of the 3 previous measures.

M-100-2: This measure ranked 4th among the structural measures in Planning Unit 3a. This measure is the most cost effective among PU3a structural measures and is the least costly, however, it provides hurricane surge protection to the fewest people. The remaining structural measures in PU3a, ranked 5th – 8th, were eliminated do to the extremely high costs.

Structural Measures to be included in Planning Unit 3a Alternatives

Below is the array of options to be included as structural components of alternatives to be considered for detailed analysis for Planning Unit 3a. These structural measures allow for comparison of risk reduction improvements to Houma, Morgan City and other communities in Planning Unit 3a for 100-year, 400-year and 1000-year levels of risk reduction. For the Planning Unit 3a alternatives, these structural components are combined with coastal restoration and nonstructural measures to provide comprehensive risk reduction.

Morganza to the Gulf Levee Alignments:

M-100-1: This structural option targets a 100-year level of risk reduction. This option involves constructing the Morganza to the Gulf levee with extension tying into high ground west of Morgan City at 100-year design level.

M-100-2: This structural option targets a 100-year level of risk reduction. This option involves construct a portion of the Morganza to the Gulf levee from Larose west to a tieback to high ground south of Thibodaux. Included in this option is a ring levee around Morgan City at 100-year design level.

GIWW Levee Alignments:

G-400-2: This structural option targets a 400-year level of risk reduction. This option involves construct a portion of the Morganza to the Gulf levee from Larose west to a tieback to high ground south of Thibodaux at 100-year design level. A secondary levee would be constructed

along the GIWW that provides 400-year level of risk reduction. Included in this option is a ring levee around Morgan City that provides 400-year level of risk reduction.

G-1000-2: This structural option targets a 1000-year level of risk reduction. This option involves construct a portion of the Morganza to the Gulf levee from Larose west to a tieback to high ground south of Thibodaux at 100-year design level. A secondary levee would be constructed along the GIWW that provides 1000-year level of risk reduction. Included in this option is a ring levee around Morgan City that provides 1000-year level of risk reduction.

Planning Unit 3b

The following sections provide details on the tiered screening of measures and alignments for Planning Unit 3b. The planning unit extends from Bayou de West westward to Freshwater Bayou with Interstate Highway 10 forming the northern boundary and the southern boundary formed by the Gulf. The western boundary falls just to the west of the coastal wetlands, Abbeville and Lafayette, covering all or part of Terrebonne, St. Mary, Iberia, and Vermilion Parishes.

This planning unit includes a population of about 350,000, which represents approximately 16 percent of the population within the planning area. It includes the cities and towns of Berwick, Patterson, Franklin, Jeanerette, New Iberia, Abbeville, Garden City, Sorrel, Louisa, Avery Island, Delcambre, Erath, Henry, Intracoastal City, and others, as well as the southern portion of Lafayette. Most of the area population is located along Bayou Teche.

This planning unit contains infrastructure assets in and around population centers, consisting of oil and gas infrastructure, marinas, and port facilities.

Tier 1 – Initial Screening of Structural Alignments

The Plan Formulation Atlas presented two primary strategies for structural risk reduction in Planning Unit 3b. They include an alignment along the GIWW and the Franklin to Abbeville alignment which is inland from the GIWW. Within these two strategies, the Plan Formulation Atlas presented four variations. **Table 18** describes the codes used for Tier 1 screening of measures in Planning Unit 3b. **Figure 20** and **Figure 21** show examples of the various alignments.

Table 18. Planning Unit 3b Codes from Plan Formulation Atlas used for Tier 1 Screening

Code	Measure Code Description (e.g. PU3b-G-1)
PU3b-	Planning Unit 3b
-G-	GIWW levee alignment
-FA-	Franklin to Abbeville alignment (inland of the GIWW)
-State	Alignment that was part of the preliminary draft State Master Plan
-#	Variations to the primary alignments (if applicable)

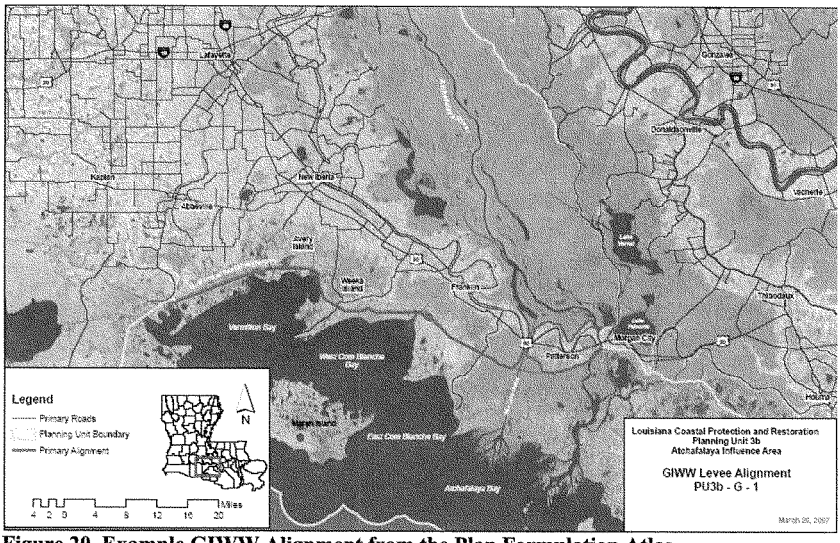

Figure 20. Example GIWW Alignment from the Plan Formulation Atlas

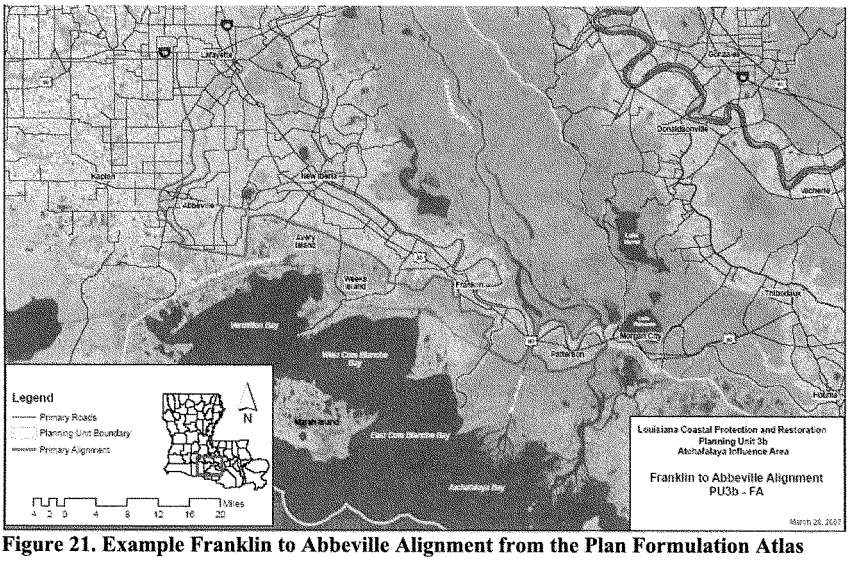

Figure 21. Example Franklin to Abbeville Alignment from the Plan Formulation Atlas

Through the first tier of screening, in which preliminary construction costs, constructability as well as direct environmental impacts were considered, the number of variations was screened to three. **Table 19** lists the variations of the levee alignments and describes why some alignment variations were eliminated from further consideration at this time.

Table 19. Initial Screening of Planning Unit 3b Structural Measures

Measure Code(s)	Pass/Fail	Comments
PU3b-G-1	Pass	Alignment that forms part of a continuous levee across all of South Louisiana.
PU3b-G-2	Fail	Captured in alignments 'G-1' and 'FA.' When comparing the 'G-2' alignment to the 'FA' alignment, 'FA' is the preferred alignment.
PU3b-FA and PU3b-State	Pass	The Franklin to Abbeville (FA) alignment is essentially same as the State Master Plan alignment.

Tier 2 – Initial Hydromodeling of Structural Measures

In addition to the initial screening evaluation, additional hydromodeling was necessary to resolve and further refine the possible structural measures in Planning Unit 3b. Remaining formulation issues included:

- Comparison of the GIWW and the Franklin to Abbeville alignment.
- Formulation of additional structural measures due to the dispersed population with isolated areas of higher density.
- Design level of risk reduction.

As a result of the high cost of a continuous levee (GIWW and Franklin to Abbeville alignments), a measure that includes a series of ring levees rather than a continuous levee was considered and evaluated. This resulted in a measure with ring levees in the west to protect the major population centers, with a continuous levee from Baldwin and across to the east. As a result of Tier 2 screening, the following three types of measures were carried to Tier 3:

- The GIWW alignment (similar to **Figure 20**);
- The Franklin to Abbeville alignment (similar to **Figure 21**);
- A series of ring levees around Patterson/Berwick, Franklin/Baldwin, New Iberia, Erath, Delcambre, and Abbeville (see **Figure 22 below**).

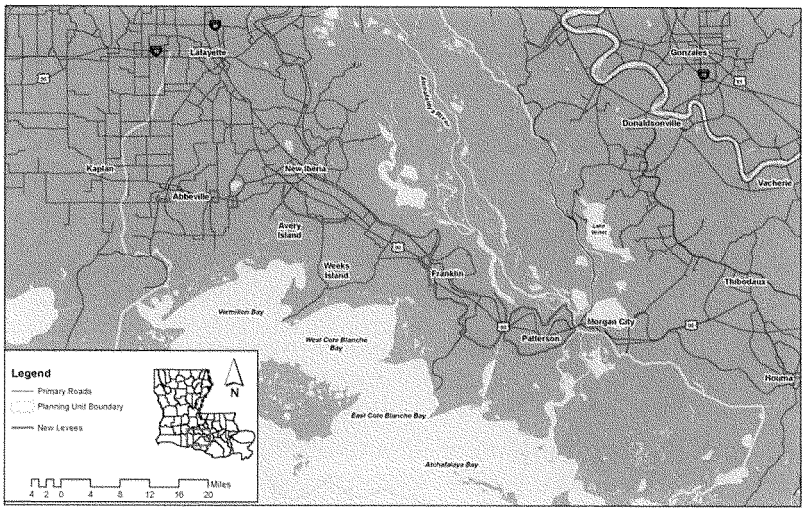

Figure 22. Reformulated Ring Levee Alignment

With the inclusion of different risk-reduction levels, name convention for the structural managements measures were revised slightly from previous screening nomenclature. **Table 20** describes the coding.

Table 20. Planning Unit 3b Codes used for Tier 2 and Tier 3 Screening

Code	Measure Code Description (e.g. PU3b-RL-100-1)
PU3b-	Planning Unit 3b
-G-	GIWW levee alignment
-F-	Franklin to Abbeville alignment (inland of the GIWW)
-RL-	Ring levee alignment
-100-	100-year design level
-400-	400-year design level
-1000-	1000-year design level
-1	Primary alignment for each plan strategy.

Tier 3 – Final Screening of Structural Alternatives

The Planning Unit 3b structural measures were then subjected to analysis using 100, 400, and 1000-year events. This resulted in the development of nine variations. These structural measures were then ranked using the multiple attributes previously described in **Table 1**.

Table 21 displays the ranking of the nine measures and the screening attribute values used to conduct the ranking.

Table 21. Planning Unit 3b Ranking of Measures

Measure	Screening Attributes												Total Value Score***	Rank
	Cost Effectiveness		Equiv. Annual Flood Damages		2075 Pop. Impacted 400-yr Event		Present Value Costs	Construction Period		Direct Impact- Wetlands				
	Ratio*	Value**	$ Million	Value**	# People	Value**	$ Million	Value**	Years	Value**	Acres	Value**		
G-100-1	33.61	0.35	353	0.64	11,793	0.16	13,876	0.47	10	0.71	2,296	0.29	**2.62**	**1**
F-100-1	35.48	0.37	411	0.75	67,980	0.90	12,589	0.43	10	0.71	2,466	0.31	**3.46**	**2**
F-400-1	62.15	0.64	411	0.75	8,053	0.11	22,069	0.75	12	0.86	3,878	0.49	**3.58**	**3**
G-400-1	56.14	0.58	385	0.70	2,964	0.04	21,403	0.73	12	0.86	5,506	0.69	**3.59**	**4**
RL-100-1	43.93	0.45	528	0.96	75,917	1.00	10,433	0.35	10	0.71	940	0.12	**3.60**	**5**
RL-400-1	71.63	0.74	529	0.96	40,911	0.54	16,966	0.57	12	0.86	1,702	0.21	**3.89**	**6**
F-1000-1	91.07	0.94	444	0.81	7,706	0.10	29,280	0.99	14	1.00	5,188	0.65	**4.49**	**7**
RL-1000-1	97.13	1.00	549	1.00	38,308	0.50	21,092	0.71	14	1.00	2,218	0.28	**4.50**	**8**
G-1000-1	85.63	0.88	421	0.77	2,870	0.04	29,519	1.00	14	1.00	7,987	1.00	**4.69**	**9**

Indicates structural measure is included in the overall set of LACPR alternatives to be evaluated.

* Cost Effectiveness Ratio = Total Present Value Costs /Average Annual Equivalent Risk Reduction

** Value is the normalized value for the attribute where a value of 1.00 represents the greatest is the largest (lower is better)

***Total of Normalized Values (lower is better)

Based on the ranking above and in consideration of the need to investigate a range of different ways to reduce the risk of hurricane storm damages the following four structural measures were selected for the final array (listed in order of rankings):

G-100-1: This measure ranked 1st among the structural measures in Planning Unit 3b. This measure performed considerably better than the other structural measures in PU3b. Although it is not the least cost, it was the most cost effective and protected the greatest number of people.

F-100-1: This measure ranked 2nd among the structural measures in Planning Unit 3b. This measure is less costly than G-100-1 but protects less people.

F-400-1: This measure ranked 3rd among the structural measures in Planning Unit 3b. This measure ranked highest among all the measures designed to provide protection against the 400-year hurricane event G-400-1 was more cost effective and protected more people, but the impacts to wetlands was much greater.

RL-100-1: This measure ranked 5th among the structural measures in Planning Unit 3b. This measure has the least cost and has the least impact to wetlands.

RL-400-1: This measure ranked 6th among the structural measures in Planning Unit 3b. This measure is included to provide a comparison between the management measures

F-1000-1: This measure ranked 7thamong the structural measures in Planning Unit 3b. This measure is the highest ranking measure designed to that provide protection against the 1000-year hurricane event, however it is not the least expensive.

Structural Measures to be included in Planning Unit 3b Alternatives

Below is the array of options to be included as structural components of alternatives to be considered for detailed analysis for Planning Unit 3b. These structural measures allow for comparison of risk reduction improvements in Planning Unit 3b. These structural components will be combined with coastal restoration and nonstructural measures to provide comprehensive risk reduction.

Continuous Levee Alignments:

G-100-1: Raise ring levee around Patterson/Berwick to 100-year design level and construct levee along the GIWW west to the boundary of Planning Unit 4 at the 100-year design level.

F-100-1: Raise ring levee around Patterson/Berwick to 100-year design level and construct levee along the edge of development north of the GIWW to high ground west of Abbeville at the 100-year design level.

F-400-1: Raise ring levee around Patterson/Berwick to 400-year design level and construct levee along the edge of development north of the GIWW to high ground west of Abbeville at the 400-year design level.

F-1000-1: Raise ring levee around Patterson/Berwick to 1000-year design level and construct levee along the edge of development north of the GIWW to high ground west of Abbeville at the 1000-year design level.

Ring Levee Alignments:

RL-100-1: Raise ring levee around Patterson/Berwick to 100-year design level and construct ring levees around Franklin/Baldwin, New Iberia, Erath, Delcambre, and Abbeville at the 100-year design level.

RL-400-1: Raise ring levee around Patterson/Berwick to 400-year design level and construct ring levees around Franklin/Baldwin, New Iberia, Erath, Delcambre, and Abbeville at the 400-year design level.

Planning Unit 4

The following sections provide details on the tiered screening of measures and alignments for Planning Unit 4. Planning Unit 4 extends from the western bank of Freshwater Bayou westward to the Louisiana/Texas state line in Sabine Lake, and from the Gulf of Mexico in the south to the northern boundary located just north of Sulphur, Lake Charles, and Interstate Highway 10. The planning unit includes all or parts of Vermilion, Cameron, Acadia, Jefferson Davis, and Calcasieu Parishes. The Chenier Plain extends from Freshwater Bayou westward to Sabine Pass, and is influenced by three interconnected rivers and marine processes. There are two major hydrologic basins in the Cheniers: the Mermentau Basin and the Calcasieu/Sabine Basin. The navigation channels of the Chenier Plain are the Sabine/Neches Waterway, Calcasieu River Navigation Channel, the GIWW, Mermentau Ship Channel, and Freshwater Bayou Canal, and all of them influence hydrology throughout the planning unit.

This planning unit represents approximately 250,000 residents, or 12 percent of the population, within the planning area. Major population centers within the planning unit include Duson, Rayne, Crowley, Estherwood, Mermentau, Jennings, Welsh, Iowa, Lake Charles, Sulphur, Vinton, Kaplan, Morse, and Lake Arthur.

Significant oil and gas facilities, chemical plants, and other coast-related industries are located in the Lake Charles area, Lafayette, Hackberry, Vinton, and smaller communities. Agricultural land and cattle land are the primary land uses in much of Planning Unit 4.

Tier 1 – Initial Screening of Structural Alignments

Five primary strategies were identified for structural risk reduction in Planning Unit 4. They include ring levees, GIWW alignment, Highway 82 alignment, ten-foot contour alignment and the State Master Plan alignment. The ring levees provide risk reduction to concentrated assets in communities such as Abbeville, Kaplin, Vinton, Sulphur, Westlake, Lake Charles and Gueydon. The GIWW alignment would provide a continuous levee from Patterson/Berwick to Abbeville along the GIWW while the Highway 92 alignment would provide a continuous levee along the highway from Vinton to Abbeville. The ten-foot contour alignment would provide a nearly continuous levee along the ten-foot contour from Texas to Abbeville. The State Master Plan alignment is a hybrid between the GIWW and the Ring Levee alignments. Within these five

strategies, six variations were identified. **Table 22** describes the codes used in the Plan Formulation Atlas and for Tier 1 screening for measures in Planning Unit 4. **Figures 23** through **26** show examples of the various alignments.

Table 22. Planning Unit 4 Codes from Plan Formulation Atlas used for Tier 1 Screening

Code	Measure Code Description (e.g. PU4-RL-2)
PU4-	Planning Unit 4
-RL-	Ring levee alignment
-G	GIWW levee alignment
-H	Highway 82 alignment
-C	10-foot contour alignment
-State	Alignment that was part of the preliminary draft State Master Plan
-#	Variations to the primary alignments (if applicable)

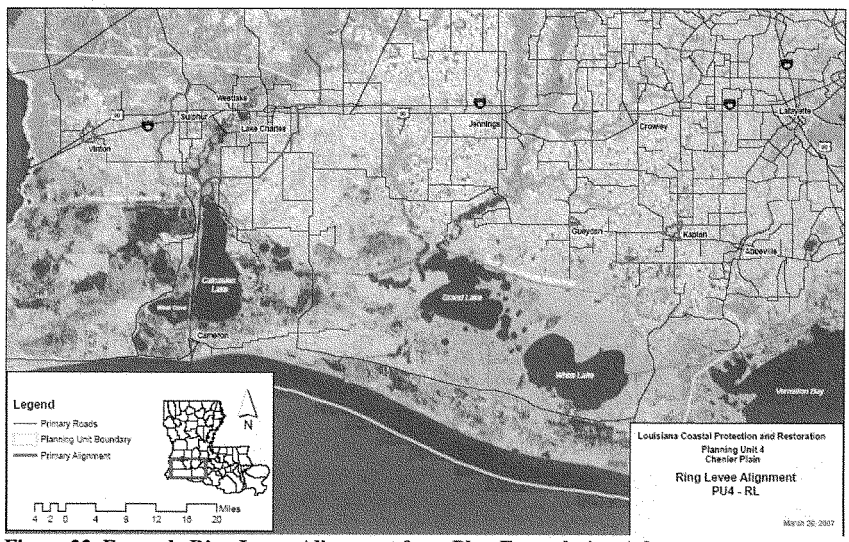

Figure 23. Example Ring Levee Alignment from Plan Formulation Atlas

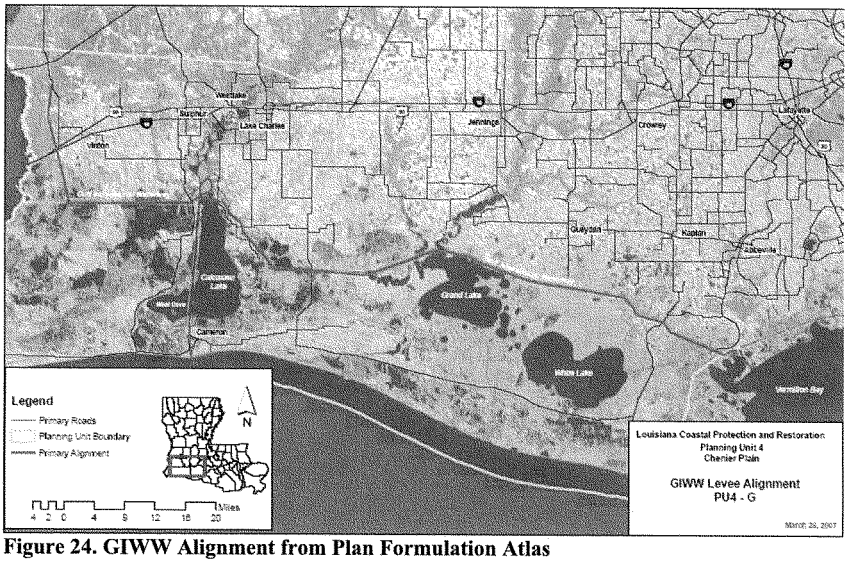

Figure 24. GIWW Alignment from Plan Formulation Atlas

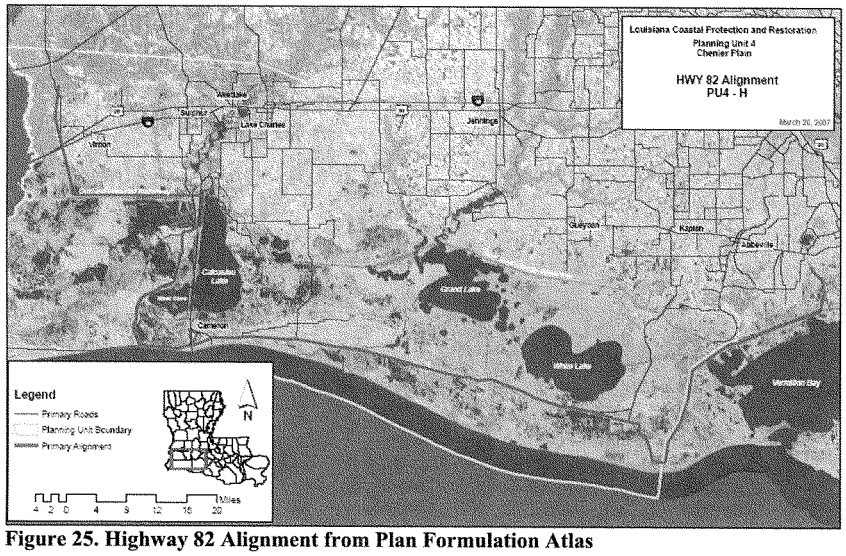

Figure 25. Highway 82 Alignment from Plan Formulation Atlas

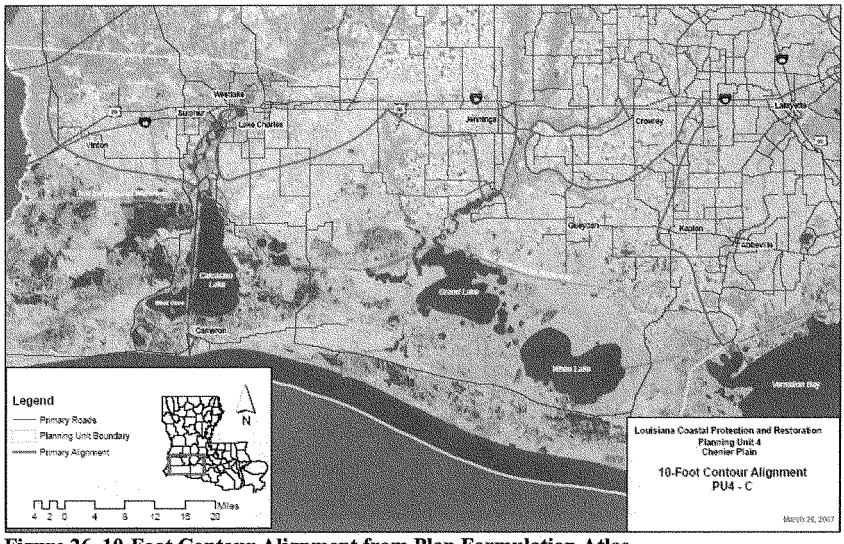

Figure 26. 10-Foot Contour Alignment from Plan Formulation Atlas

Through the first tier of screening, in which preliminary construction costs, constructability as well as direct environmental impacts were considered, the number of variations was screened to three. **Table 23** lists the variations of the levee alignments and describes why some alignment variations were eliminated from further consideration at this time.

Table 23. Initial Screening of Planning Unit 4 Structural Measures

Measure Code(s)	Pass/ Fail	Comments
PU4-RL	Pass	Consistent with State's ring levee concept.
PU4-RL-2	Fail	Ring levee concept captured better by 'RL' above; this version has excessive costs and would exacerbate Vermilion River flooding in comparison to 'RL.'
PU4-G	Pass	Forms part of a continuous levee from border to border for evaluation of a comprehensive "Category 5" structural option.
PU4-H	Fail	Strong local opposition; high cost; environmental concerns such as wetland impacts and drainage problems (e.g. trapping saltwater after a storm).
PU4-C	Fail	Long length (high life-cycle costs); environmental concerns such as wetland impacts and drainage problems (e.g. trapping saltwater after a storm).
PU4-State	Pass	Hybrid approach using both a ring levee and a GIWW alignment.

Tier 2 – Initial Hydromodeling of Structural Measures

In addition to the initial screening evaluation, additional hydromodeling was necessary to resolve and further refine the possible structural measures in Planning Unit 4. Remaining formulation issues included:

- Comparison of the various GIWW alignments.
- A continuous levee or a series of ring levees to protect isolated areas.
- Design level of risk reduction.

The hydromodeling results revealed that the measures needed to be reformulated based on areas impacted and the location of concentrated assets. This reformulation resulted in variations on the two structural strategies, including a levee along the GIWW that runs south of the majority of population-at-risk from flooding (**Figure 27** and **Figure 28**) and a series of site specific ring levees to protect major population centers (**Figure 29**).

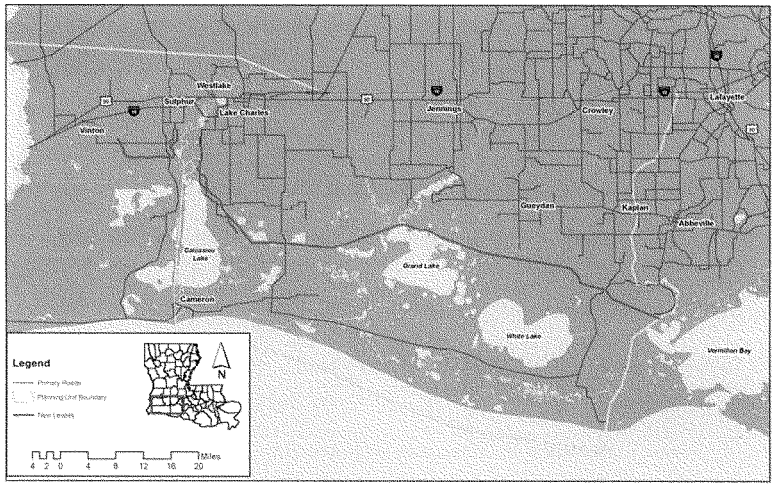

Figure 27. Reformulated GIWW Alignment (with tie in to Planning Unit 3b).

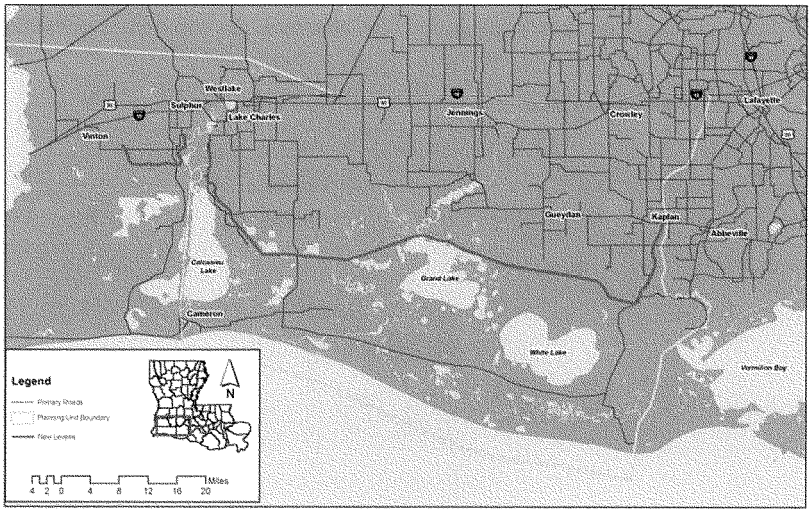

Figure 28. Reformulated GIWW Alignment (stand alone for Planning Unit 4).

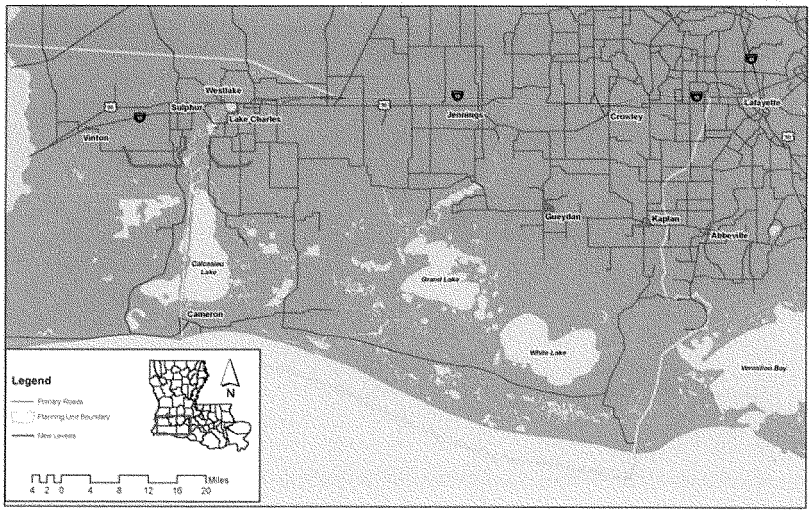

Figure 29. Reformulated Ring Levee Alignments.

With the inclusion of different levels of risk reduction, name convention for the structural managements measures were revised slightly from previous screening nomenclature. **Table 24** describes the coding.

Table 24. Planning Unit 4 Codes used for Tier 2 and Tier 3 Screening

Code	Measure Code Description (e.g. PU4-RL-100-1)
PU4-	Planning Unit 4
-G-	GIWW levee alignment
-RL-	Ring levee alignment
-100-	100-year design level
-400-	400-year design level
-1000-	1000-year design level
-1	For the 'G' alignments, the primary alignment follows the GIWW across the planning unit boundaries.
-2	GIWW alignment with tieback to high ground near Kaplan.
-3	GIWW alignment with the levee set at a height of 12 feet.

Tier 3 – Final Screening of Structural Alternatives

The Planning Unit 4 structural measures were then subjected to analysis using 100, 400, and 1000-year events. This resulted in the development of 11 variations. These structural measures were then ranked using the multiple attributes previously described in **Table 1**.

Table 25 displays the ranking of the 11 measures and the screening attribute values used to conduct the ranking.

Table 25. Planning Unit 4 Ranking of Measures

Measure	Screening Attributes												Total Value Score***	Rank
	Cost Effectiveness		Equiv. Annual Flood Damages		2075 Pop. Impacted 400-yr Event		Present Value Costs		Construction Period		Direct Impact-Wetlands			
	Ratio*	Value**	$ Million	Value**	# People	Value**	$ Million	Value**	Years	Value**	Acres	Value**		
RL-100-1	16.37	0.06	565	0.83	44,284	0.58	2,374	0.11	10	0.71	88	0.02	**2.31**	**1**
RL-1000-1	106.66	0.39	679	1.00	49,117	0.64	3,299	0.15	14	1.00	99	0.02	**3.20**	**2**
G-400-3	76.57	0.28	571	0.84	46,102	0.60	10,692	0.50	10	0.71	2,483	0.44	**3.38**	**3**
RL-400-1	105.38	0.39	681	1.00	76,409	1.00	3,057	0.14	12	0.86	95	0.02	**3.40**	**4**
G-100-2	75.29	0.28	568	0.83	73,948	0.97	10,736	0.50	10	0.71	1,763	0.31	**3.60**	**5**
G-100-1	73.51	0.27	562	0.83	73,304	0.96	10,907	0.51	10	0.71	2,221	0.39	**3.67**	**6**
G-400-2	111.49	0.41	567	0.83	27,530	0.36	15,946	0.74	12	0.86	2,939	0.52	**3.72**	**7**
G-400-1	109.15	0.40	562	0.82	26,439	0.35	16,209	0.75	12	0.86	3,719	0.66	**3.84**	**8**
G-1000-3	271.63	1.00	669	0.98	47,299	0.62	11,119	0.52	10	0.71	2,485	0.44	**4.27**	**9**
G-1000-2	156.40	0.58	577	0.85	26,968	0.35	20,861	0.97	14	1.00	4,277	0.76	**4.50**	**10**
G-1000-1	155.77	0.57	572	0.84	25,885	0.34	21,546	1.00	14	1.00	5,625	1.00	**4.75**	**11**

Indicates structural measure is included in the overall set of LACPR alternatives to be evaluated.

* Cost Effectiveness Ratio = Total Present Value Costs /Average Annual Equivalent Risk Reduction

** Value is the normalized value for the attribute where a value of 1.00 represents the greatest is the largest (lower is better)

***Total of Normalized Values (lower is better)

Based on the ranking above and in consideration of the need to investigate a range of different ways to reduce the risk of hurricane storm damages the following seven structural measures were selected for the final array (listed in order of rankings):

RL-100-1: This measure ranked 1st among the structural measures in Planning Unit 4. This management measure is the least costly and most cost effective management measure among structural measures considered.

RL-1000-1: This measure ranked 2nd among the structural measures in Planning Unit 4. This management measure provides protection to a greater population than RL-100-1 at a slightly higher cost. RL-1000-1 is the most cost effective management measure among the measures designed to provide protection against the 1000-year hurricane event.

G-400-3: This measure ranked 3rd among the structural measures in Planning Unit 4. This management measure is the most cost effective measure among the measures designed to provide protection against the 400-year hurricane event.

RL-400-1: This measure ranked 4th among the structural measures in Planning Unit 4. Although considerably less expensive than G-400-3, this measure provides structural protection to a significantly smaller population.

G-100-2: This measure ranked 5th among the structural measures in Planning Unit 4. This measure is included to provide a comparison between the management measures.

G-100-1: This measure ranked 6th among the structural measures in Planning Unit 4. This measure is included to provide a comparison between the management measures.

G-1000-3: This measure ranked 9th among the structural measures in Planning Unit 4. This measure is included to provide a comparison between the management measures.

Structural Measures to be included in Planning Unit 4 Alternatives

Below is the array of options to be included as structural components of alternatives to be considered for detailed analysis for Planning Unit 4. These structural measures allow for comparison of risk reduction improvements to communities in Planning Unit 4. For the Planning Unit 4 alternatives, these structural components will be combined with coastal restoration and nonstructural measures to provide comprehensive risk reduction.

GIWW (Continuous Levee) Alignments:

G-100-1: Construct a continuous levee (with gates) along the GIWW plus a ring levee to the west of the Calcasieu River and a series of levees within Lake Charles to separate the river from the land at the 100-year design level. Alignment joins with similar alignment in Planning Unit 3b.

G-100-2: Construct a continuous levee (with gates) along the GIWW plus a ring levee to the west of the Calcasieu River and a series of levees within Lake Charles to separate the river from

the land at the 100-year design level. Alignment ties to high ground to the west of the Vermilion River so this alternative can be evaluated as "stand alone" from alternatives in Planning Unit 3b.

G-400-3: Construct a continuous 12-foot levee (with gates) along the GIWW plus a ring levee to the west of the Calcasieu River and a series of levees within Lake Charles to separate the river from the land. Includes small ring levees around parts of Lake Charles, Gueydan, and Kaplan to provide 400-year level of risk reduction. Alignment ties to high ground to the west of the Vermilion River so this alternative can be evaluated as "stand alone" from alternatives in Planning Unit 3b.

G-1000-3: Construct a 12-foot continuous levee (with gates) along the GIWW plus a ring levee to the west of the Calcasieu River and a series of levees within Lake Charles to separate the river from the land. Includes small ring levees around parts of Lake Charles, Gueydan, and Kaplan to provide 1000-year level of risk reduction. Alignment ties to high ground to the west of the Vermilion River so this alternative can be evaluated as "stand alone" from alternatives in Planning Unit 3b.

Ring Levee Alignments:

RL-100-1: Construct ring levees to the east and west of Lake Charles; construct a series of levees within Lake Charles to separate the river from the land; and construct ring levees around Kaplan and Gueydan to the 100-year design level.

RL-400-1: Construct ring levees to the east and west of Lake Charles; construct a series of levees within Lake Charles to separate the river from the land; and construct ring levees around Kaplan and Gueydan to the 400-year design level.

RL-1000-1: Construct ring levees to the east and west of Lake Charles; construct a series of levees within Lake Charles to separate the river from the land; and construct ring levees around Kaplan and Gueydan to 1000-year design level.

Summary

This appendix described the steps taken to screen structural risk reduction measures for the LACPR technical evaluation. The process started with a wide array of concepts gathered from previous studies as well as input from the State Master Plan and other stakeholders. The three-tiered screening process first eliminated measures that were either undesirable on their own merits or in comparison to similarly performing measures. The next step was to evaluate and reformulate the remaining measures using quantitative hydromodeling data. The final screening used six attributes to rank the structural measures to determine which should be carried forward into the set of alternatives to be evaluated for the overall LACPR effort.

The coastal restoration and nonstructural measures, which are part of the overall LACPR alternatives, were developed on parallel tracks. The formulation of those measures is described in the *Coastal Restoration Plan Component and Environmental Metrics Appendix* and *Nonstructural Plan Component Appendix*, respectively.

LOUISIANA COASTAL PROTECTION AND RESTORATION
FINAL TECHNICAL REPORT

ECONOMICS APPENDIX

June 2009

U. S. Army Corps of Engineers
New Orleans District
Mississippi Valley Division

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Louisiana Coastal Protection and Restoration (LACPR) Final Technical Report
Economics Appendix

PURPOSE

The Louisiana Coastal Protection and Restoration (LACPR) Technical Report has been developed by the United States Army Corps of Engineers (USACE) in response to Public Laws 109-103 and 109-148. Under these laws, Congress and the President directed the Secretary of the Army, acting through the Chief of Engineers, to:

- Conduct a comprehensive hurricane protection analysis and design in close coordination with the State of Louisiana and its appropriate agencies;
- Develop and present a full range of flood control, coastal restoration, and hurricane protection measures exclusive of normal policy considerations for South Louisiana;
- Consider providing protection for a storm surge equivalent to a Category 5 hurricane; and
- Submit preliminary and final technical reports.

The purpose of this appendix is to support the economic, regional, and social evaluation for LACPR, which is discussed in the main technical report.

INTRODUCTION AND BACKGROUND

Congress directed that the LACPR analysis to be conducted "exclusive of normal policy considerations." Therefore, LACPR alternatives are being evaluated in a risk-informed decision framework across a wide range of metrics, rather than through the use of traditional methodology based on National Economic Development (NED) and/or environmental restoration benefits. This approach not only provides for the quantification of the damages reduced by the various alternatives plans, but it also allows for the quantification of other risk reduction parameters.

As a means to process data for approximately 72,000 census data blocks under multiple future scenarios, the LACPR team developed a customized geographic information system (GIS), which utilized remotely-sensed data to assess the damages to residential and nonresidential structures, their contents, and vehicles as well as agricultural resources, roads and railroads in the LACPR planning area. The application was also used to determine the number of structures, population, employment, income, and output affected by the stages associated with various frequency flood events. This inventory allows the LACPR team to evaluate alternatives and interact with stakeholders using a broader array of relevant outputs.

Planning Units and Subunits

Located in South Louisiana, the LACPR planning area contains all or portions of the 26 parishes that could be affected by the storm surge from hurricanes and tropical storms. It extends from the Pearl River on the Louisiana/Mississippi border west to the Sabine River on the Louisiana/Texas border. The area was divided into five planning units, which are based on hydrologic basins and watersheds rather than on existing political and economic boundaries.

Planning Unit 1 (PU1), the Lake Pontchartrain Basin, includes the city of New Orleans, the east bank of Jefferson Parish, and the north shore of Lake Pontchartrain and is the most densely populated planning unit in coastal Louisiana. It is bounded by the Mississippi River to the west, Interstate 12 to the north, the Pearl River to the east, and the Gulf of Mexico to the south.

Planning Unit 2 (PU2), the Barataria Basin, is a highly productive estuary that contains the heavily populated west bank of Orleans and Jefferson Parishes. It is a triangular shaped area bounded by Bayou Lafourche, the Mississippi River, and the Gulf of Mexico.

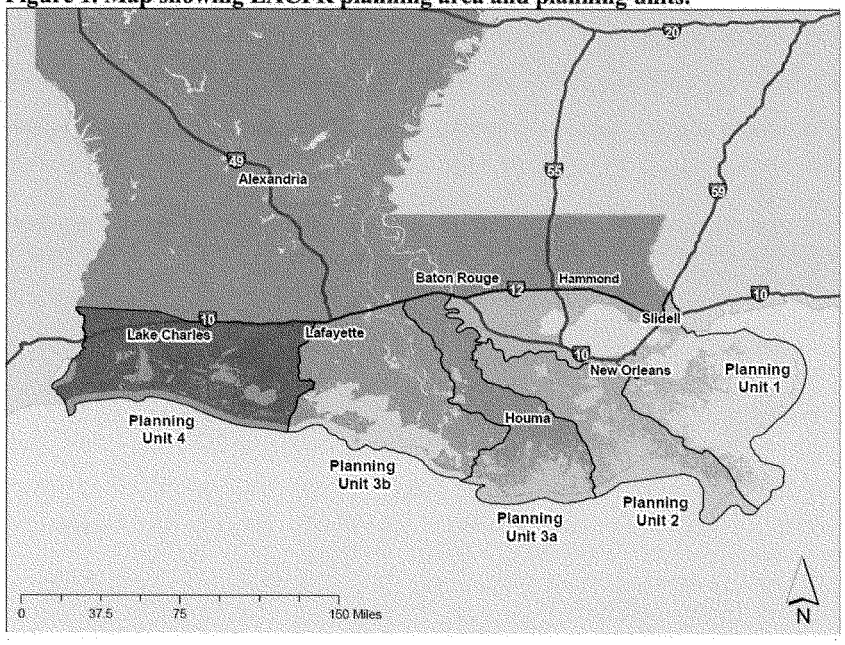
Planning Unit 3a (PU3a), the East Terrebonne Basin, contains the cities of Houma, Thibodaux, and Morgan City. It is bounded by Bayou Lafourche to the east, Interstate 10 to the north, and the Gulf of Mexico to the south. Its western border includes the East Atchafalaya Protection Levee to the GIWW in Morgan City, the GIWW to Miner's Canal, Miner's Canal to Lake de Cade, Lake de Cade to Lake Merchant, Lake Merchant to East Bay Junop, and East Bay Junop to the Gulf of Mexico.

Planning Unit 3b (PU3b), the Atchafalaya Influence Area, contains the city of Lafayette and the communities of New Iberia, Berwick, Abbeville, and Erath. It is bounded by Planning Unit 3a to the east, Interstate 10 to the north, and the Gulf of Mexico to the south. Its western border extends south from the city of Lafayette to Freshwater Bayou Canal and follows Freshwater Bayou Canal to the Gulf of Mexico.

Planning Unit 4 (PU4), the Chenier Plain, includes the city of Lake Charles and the communities of Sulphur, Crowley, Jennings, and Cameron. It is bounded by Planning Unit 3b to the east, Interstate 10 to the north, the Sabine River to the west, and the Gulf of Mexico.

The five planning units in the LACPR planning area were further delineated into planning subunits based on consistent topographical and hydrological characteristics. Planning subunits were developed for all or portions of 23 of the 26 parishes that are subject to the surges associated with storm events. The planning area contains a total of 963 planning subunits: 145 in PU1, 115 in PU2, 207 in PU3a, 231 in PU3b, and 265 in PU4. A total of 35,594 census blocks are included in the areas delineated as planning subunits. A map depicting the locations of the five planning units in the planning area is shown in Figure 1.

Figure 1. Map showing LACPR planning area and planning units.



Previous Flood Events

While the planning area has periodically experienced localized flooding from excessive rainfall events, the primary cause of the flood events that have taken place in South Louisiana has been the tidal surges from hurricanes and tropical storms. During the past 30 years, the planning area has been affected by numerous hurricanes and tropical storms of various intensities. The tidal surges associated with these storm events have inundated structures and resulted in billions of dollars in damages to coastal Louisiana. A summary of these storm events, the years of occurrence, and the planning units that were impacted is provided below.

Non-Tropical Events. Numerous rainfall events have affected the Metropolitan New Orleans area and other portions of urban areas in Louisiana; however, the most severe of these events in terms of damage occurred in May of 1995. Rainfall amounts of up to 17.5 inched were reported within a 24-hour period in some areas of Jefferson and Orleans Parishes (Planning Units 1 and 2). Approximately 43,000 residential structures incurred damage in the metropolitan area, with insurance flood claims totaling nearly $600 million dollars. Spring floods and rainfall caused backwater flooding in the city of Morgan City (Planning Unit 3b) in 1973, city of Baton Rouge (Planning Unit 1) in 1982, and the cities of Houma and Thibodaux (Planning Unit 3a) in 1991.

Hurricane Juan. Hurricane Juan caused extensive flooding throughout southern Louisiana due to its prolonged 5-day movement back and forth along the Louisiana coast in October 1985. The majority of the flood damage occurred in the Lincolnshire and Westminster subdivisions located on the west bank of Jefferson Parish (Planning Unit 2). Rainfall totals in the area ranged from five inches to almost 17 inches. The storm was responsible for storm surges of five to eight feet and tides of three to six above normal. According to FEMA officials, the estimated value of the residential and commercial damage and public assistance totaled $112.5 million.

Planning Unit 3a also incurred extensive damage as a result of Hurricane Juan. Over 800 homes were inundated in the coastal portion of Terrebonne Parish south of the city of Houma. Scattered pockets of flooding were also reported in the portions of Terrebonne and Lafourche Parishes north of Houma. Approximately 40 percent of the homes in the coastal areas of Lafourche Parish, including Pointe-aux-Chenes, were also inundated by the high tides.

Agricultural damages from the storm totaled $175 million, with 24 percent of these damages occurring in Lafourche and Terrebonne Parishes. The soybean crop suffered over half of the agricultural damage, while the sugar cane crop incurred 20 percent of the damage. Excessive rains oversaturated the fields and caused a reduction in crop yields. The saturated fields also made it easier for the winds to topple over the cane stalks.

Hurricane Andrew. Shortly after midnight on August 26, 1992, Hurricane Andrew made landfall in St. Mary Parish, 80 miles west of Morgan City. Following its landfall, the storm changed its course from northwest to north and battered the Acadiana Parishes of St. Mary, Iberia, and Lafayette (Planning Unit 3b) as well as Lafourche and Terrebonne Parishes (Planning Unit 3a). The rapid speed of the storm and the direction of its movement into Louisiana greatly reduced its storm surge and limited its flood damage potential. Because the storm skirted the coast before moving inland, its winds pushed the stages downward. These lowered stages were able to absorb much of the tidal surge when the eye moved ashore and the winds changed directions. As a result, tidal flooding in coastal parishes was minimized.

FEMA reported that over 2,000 flood claims were filed as a result of this storm in Louisiana. These claims had a total value of over $25 million. Over 90 percent of this flood damage occurred in the Terrebonne Parish communities south of Houma, where up to six feet of water was reported. Only minor flooding was reported in the lower elevation areas north of and within the city of Houma. The unleveed portion of Lafourche Parish along its border with Terrebonne Parish, which includes the community of Pointe-au-Chien, also incurred extensive flood damage. The majority of the agricultural damage in the area occurred as the result of wind damage to the sugar cane crop.

Tropical Storm Isidore and Hurricane Lili. Tropical Storm Isidore and Hurricane Lili caused widespread damage in the central and eastern coastal areas of the state during the fall of 2002. Tropical Storm Isidore made landfall west of the mouth of the Mississippi River near Grand Isle and Port Fourchon on the morning of September 26, 2002. After the storm moved inland, it took a northeasterly path across eastern New Orleans and Slidell. The approaching storm pushed high tides toward the southern shore of Lake Pontchartrain. This caused flooding in the portion of St. Charles Parish outside of the Federal levee protection (Planning Unit 1). However, as the center of the storm moved north of the lake, the winds shifted direction and pushed the high tides inland along the lakefront of St. Tammany Parish. This caused extensive flooding in the lakefront subdivisions of Mandeville and Slidell (Planning Unit 1).

One week later on October 3, 2002, Hurricane Lili made landfall on the western edge of Vermilion Bay south of the cities of Abbeville and New Iberia (Planning Unit 3b) as a weak Category 2 hurricane. Winds toppled trees and power lines leaving approximately half a million people without electricity immediately after the storm. The high winds caused tidal flooding in the communities east of the eye of the storm. The ridge communities in Terrebonne Parish south of the city of Houma, including Cocodrie, Dulac, Isle de Jean Charles, and Montegut, and the community of Pointe-aux-Chenes in Lafourche Parish were affected by tidal flooding (Planning Unit 3a). The only community south of Houma that did not flood was Chauvin. As the storm moved north, tidal flooding similar to that from Tropical Storm Isidore inundated the lakefront subdivisions of Mandeville and Slidell in St. Tammany Parish, the coastal communities of Lafitte and Grand Isle in Jefferson Parish, and the coastal portions of Plaquemines and St. Bernard Parishes (Planning Unit 1). Each of these areas is outside the existing Federal levee systems.

Insured losses from Tropical Storm Isidore and Hurricane Lili totaled nearly $600 million. New Orleans District has estimated that flooding caused approximately 80 percent of these damages, while the remainder was caused by wind and flying debris. Approximately $105 million of insured losses were related to Tropical Storm Isidore, while Hurricane Lili caused $471 million of insured losses. According to windshield surveys conducted by the American Red Cross, approximately 10,000 residential structures were damaged by the two storms. These surveys included both insured and uninsured structures. Tropical Storm Isidore caused damage to 2,905 structures, while Hurricane Lili caused damage to 7,356 structures.

In a revised report released in mid-November by the Louisiana State University Agricultural Center (LSU AgCenter), the estimated agricultural damages caused by Tropical Storm Isidore and Hurricane Lili totaled $454.3 million. This estimate also includes the agricultural damages caused by the continuation of rain during the month of October, which delayed the harvesting of crops. The excessive rains flooded the agricultural fields and increased the harvest costs.

The wind and waves of Tropical Storm Isidore and Hurricane Lili caused extensive beach erosion in the barrier islands of Louisiana. These islands protect the coastline of the state and provide a natural habitat for many species of wildlife. The barrier islands west of the mouth of the Mississippi River that were affected by the two storm events include the Isles Dernieres (Whiskey Bayou, Raccoon Island, Trinity Island, and East Island), Timbalier Island, East Timbalier Island, Elmer Island, and Grand Terre. Grand Isle incurred extensive damage along its eastern beach. Three small islands east of the mouth of the Mississippi River, Grand Gosier Island, Curlew Island, and Chandeleur Island, incurred extensive damage and beach erosion. A monetary value has not been determined for these environmental damages.

Hurricane Katrina. The most significant storm event to affect the Metropolitan New Orleans Area (Planning Unit 1) since Hurricane Betsy in 1965 was Hurricane Katrina. Hurricane Katrina made landfall on August 29, 2005, near the town of Buras in Plaquemines Parish as a Category 3 storm with winds in excess of 120 miles per hour. However, its storm surge of approximately 30 feet was more characteristic of a Category 5 hurricane. After tracking across the southeastern Louisiana coastline, it made a second landfall near the town of Waveland on the Mississippi Gulf Coast. The surge from Lake Pontchartrain pushed water into the three major outflow canals (London Avenue, Orleans, and 17th Street) of the city of New Orleans, which overwhelmed their adjacent floodwalls. The surge from Lake Borgne overwhelmed the levees protecting St. Bernard Parish, New Orleans East, and the Lower Ninth Ward. Many portions of the metropolitan area were submerged in more than 6 feet of water for more than 3 weeks. Area pump stations were left inoperable or inaccessible, which caused the dewatering process to take approximately 53 days.

According to the Department of Health and Hospitals (DHH), approximately 1,400 deaths were reported following Hurricane Katrina. Approximately 1.3 million residents were displaced immediately following the storm, and 900,000 residents remained displaced as of October 5, 2005. According to the Louisiana Recovery Authority (LRA), two years after the storm, approximately 210,000 FEMA applicants still have out-of state mailing addresses, while 230,000 FEMA applicants have an in-state mailing address in a different zip code.

The storm caused more than $40.6 billion of insured losses to the homes, businesses, and vehicles in six states. Approximately two thirds of these losses, or $25.3 billion, occurred in Louisiana based on data obtained from the Insurance Information Institute. According to the LRA, approximately 150,000 housing units were damaged, and according to the Department of Environmental Quality (DEQ), 350,000 vehicles, and 60,000 fishing and recreational vessels were damaged.

As of January 2007, approximately $30 billion in Federal funds have been obligated to Louisiana residents through Individual and Public Assistance Programs, National Flood Insurance claims, and Small Business Administration (SBA) disaster loan. Individual

assistance grants, which totaled approximately $5.7 billion, included $3.8 billion for Housing Assistance (temporary housing, repair and replacement, and permanent housing construction), $1.6 billion for Other Needs Assistance (personal property, transportation, medical and dental expenses, and moving and storage cost), and $320 million for Disaster Unemployment Assistance. Public Assistance Grants, which totaled approximately $4.5 billion and are projected to reach $6.3 billion, included assistance to state and local governments to rebuild publicly owned infrastructure, such as schools, government offices, parks, and sewer lines. The National Flood Insurance Program has paid approximately $12.9 billion in Federal flood insurance claims to residents in the State of Louisiana. In addition, the SBA has approved approximately $6.8 billion in low-interest loans for homeowners, renters and businesses.

The storm surge from Hurricane Katrina inundated marshes and farmland throughout the coastal area. According to the LSU AgCenter, agricultural losses totaled approximately $825 million. The agricultural resources impacted by the storm include sugarcane, cotton, rice, soybeans, timber, pecans, citrus, and livestock. The losses to aquaculture (crawfish, alligators, and turtles), fisheries (shrimp, oysters, and menhaden), and wildlife and recreational resources totaled approximately $175 million.

Hurricane Rita. The most significant flood event to affect the southwest portion of the planning area (Planning Unit 4) since Hurricane Audrey in 1957 was Hurricane Rita. Hurricane Rita made landfall along the Texas-Louisiana border on September 24, 2005, as a Category 3 storm with winds in excess of 120 miles per hour. A storm surge of approximately 15 - 20 feet affected the coastal region from Port Arthur, Texas to Terrebonne Parish, Louisiana. The flooding extended north to Lake Charles, where the downtown and residential areas around the lake were covered with 3 to 6 feet of flooding. With estimated insured losses of approximately $5 billion, Hurricane Rita became one of the most costly natural disasters in U.S. history. Approximately 55,000 housing units in Calcasieu, Cameron, and Vermilion parishes incurred flood damages as a result of this hurricane.

Approximately 2,000 square miles of farmland and marshes throughout the coastal area were inundated. According to the LSU AgCenter, agricultural losses totaled approximately $490 million. The agricultural resources impacted by the storm include sugarcane, cotton, rice, soybeans, timber, pecans, citrus, and livestock. The losses to aquaculture (crawfish, alligators, and turtles), fisheries (shrimp, oysters, and menhaden), and wildlife and recreational resources totaled approximately $100 million.

The total FEMA flood claims by parish within the planning area that were paid between 1978 and 2007 are summarized in Table 1. The table includes only those damages that were covered by flood insurance. The amount paid reflects the price level of the year in which the claim was paid to the policyholder.

STRUCTURE INVENTORY METHODOLOGY

GIS Application

A customized GIS framework, or application, similar to the one previously developed for the Interagency Performance Evaluation Task Force (IPET) for the Hurricane Katrina IPET Report was used to assess the damages to residential and non-residential structures, their contents, and vehicles in the LACPR planning area. The application was used to develop a water elevation-damage, or stage-damage, relationship for each census block in the LACPR planning area. Inputs to the application included elevation data, depreciated exposure values of residential and nonresidential structures, and depth-damage relationships.

Ground Elevations

Topographical data obtained from the LIDAR (Light Detection and Ranging) digital elevation model (DEM) using the NAVD88 (2004.65 epoch), which were used for the IPET study area, were combined with census block boundaries obtained from the 2000 Census using GIS mapping to determine the mean ground elevation for each census block in the New Orleans metropolitan area. For the portion of the LACPR planning area outside of the New Orleans metropolitan area, unadjusted NAVD88 data were used to determine the mean ground elevation for each census block.

Two sources of uncertainty associated with the topographical data assigned to the structure inventory, transportation infrastructure (roads and railroads), and agricultural resources were quantified: the uncertainty implicit within the LIDAR data and the uncertainty from using a single value to represent the elevation of an entire census block. According to the IPET report, the LIDAR topographical data is accurate to approximately plus or minus 1 foot at the 90 percent level of confidence. The error in each spot elevation based on the LIDAR data was assumed to be normally distributed with a mean of zero, a standard deviation of 0.61 feet, and a variance of 0.37 feet.

Aerial photography was used to identity the locations of the residential and nonresidential structures in each census block. A structure point with x,y coordinates was placed on the GIS maps to show these locations and to assign a ground elevation to each structure using LIDAR data. The variation of the ground elevation associated with each structure point within a census block was used to determine the variation of the ground elevations within that census block. The average standard deviation of the ground elevations across all census block was calculated to be .57 feet with a variance of .325 feet. Thus, the sum of the variances in the LIDAR data and in the ground elevation across all census blocks can be represented by a normal distribution with a variance of .70 feet and a standard deviation of .83 feet.

In order to quantify the variability of the ground elevations within each census block for the transportation infrastructure and the agricultural resources, an average standard deviation was calculated across all census blocks in the LACPR planning area. The average standard deviation of the ground elevations within each census block was

calculated to be 1.29 feet with a variance of 1.66 feet. Thus, the sum of the variances in the LIDAR data and in the ground elevation across all census blocks can be represented by a normal distribution with a variance of 2.03 feet and a standard deviation of 1.43 feet.

First Floor Elevations

An average height above ground was assigned to the residential structures in Jefferson and Orleans parishes based on data obtained from a first-floor elevation survey conducted by USACE personnel in 1991 by geographic areas known as traffic-zones. A sampling of residential structures in each traffic zone was used to estimate the percentage of residential structures with pier foundations and the percentage with slab foundations and to determine the average height of the pier and slab foundations above ground level. The surveys were also used to estimate the percentages of one-story and two-story residential structures in each traffic zone.

In St. Bernard, Plaquemines, and St. Charles parishes, the percentage of residential structures with pier and slab foundations, and the average pier and slab foundation heights were estimated for each community within these parishes based on the field surveys from previous feasibility studies in the area. Estimates were also made of the percentages of one-story and two-story residences in each community.

For each of the other parishes in the LACPR planning area, an average height above ground was assigned to the residential structures in each census block based on interviews with parish emergency management personnel. These officials were asked to estimate the percentage of residential structures with pier foundations and with slab foundations and to estimate the average height above ground level for each type of foundation. Mobile homes were assigned an average foundation height of 2.0 feet above ground level based on previous studies. For non-residential structures, an average height of 1.5 feet above ground was assigned to all non-residential properties in the planning area based on the information obtained during the interviews with parish emergency management personnel.

Assets at Risk

Asset and population data were processed within the GIS economic application for all or portions of 26 of the 64 civil parishes in the state, including approximately 72,000 census blocks and over one million residential and non-residential structures. The stages associated with storm events were modeled for planning subunits in 23 of these 26 parishes, including approximately 36,000 census blocks. The remaining three parishes, East Baton Rouge, West Baton Rouge, and Lafayette, do not contain planning subunits because the model showed that storm surges would not directly affect these areas. However, the assets and population of these parishes were included in the data processed within the GIS application because each of these parishes could be indirectly affected by population shifts resulting from the inundation of other areas. Tables 2 and 3 display the total number and value of residential and non-residential units, number of vehicles, and

miles of roads and railroads by planning unit for the portions of the 23 parishes subject to the surges associated with storm events for the years 2010 and 2075.

Residential Structure Inventory and Valuation

The general building stock portion of the Hazard-U.S.-Multihazard (HAZUS-MH) application, MR2 Release 44 (copyright 2006, FEMA), a GIS-based multi-hazard loss estimation tool developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS) was used as a proxy for the structure inventory. Due to the large number of structures, as well as time constraints for completing the analysis, it was not feasible to inventory all of the structures in the planning area. The HAZUS-MH database was also used to estimate damages in the Interagency Performance Evaluation Team (IPET) Report.

The building stock data, which were based on data from the 2000 Census, were updated to represent 2nd quarter 2005 (Pre-Katrina) based on census block group data obtained from Calthorpe Associates, an urban planning agency contracted by the state of Louisiana as part of the Louisiana Speaks forum. The demographic trends identified in each parish were used to adjust the number of households, the number of residential structures, and the depreciated exposure values for each census block group in the HAZUS database. As an example, a shift in the pre-Katrina population of the New Orleans MSA was noted between the year 2000 and the 2nd quarter of 2005. During this period, the population of Orleans Parish decreased by approximately 30,000 people, while the population of St. Tammany Parish increased by an almost identical amount.

The updated HAZUS-MH database was used in the GIS application to provide the total square footage, building count, and the total depreciated exposure value for residential occupancies by census block. HAZUS-MH combined data from the 2000 Census with data from the Department of Energy Building Characteristic Reports to assign a total square footage to each of six residential occupancy categories: single-family dwellings, manufactured housing/mobile homes, multi-family dwellings, temporary lodgings, institutional dormitories, and nursing homes. It then combined the square footage for each residential occupancy category with the average age of the buildings in the area and a corresponding depreciation schedule to derive the depreciated exposure value for that category. These values, which were expressed in 2005 price levels and updated to 2007 price levels using the Marshall and Swift Valuation Service, were entered into the GIS framework by census block.

The depreciated exposure values were also adjusted to reflect the underestimation of the HAZUS-MH data as noted in the Interagency Performance Evaluation Team (IPET) Report in 2006. In this report, the total depreciated exposure value for each census block was compared to the depreciated replacement cost for residential structures that was calculated by USACE personnel using field surveys and the Marshall and Swift Valuation Service. A sampling of 40 city blocks from structure inventories compiled as part of feasibility studies conducted since the year 2000 in the New Orleans Metropolitan Area was used in the comparison. The sampled depreciated replacements costs were

found to be approximately 16 percent higher than the depreciated exposure values calculated by HAZUS-MH. To account for this underestimation, the depreciated exposure values calculated within HAZUS-MH were increased by 16 percent.

The GIS application was used to allocate the depreciated exposure values that had been calculated for the residential occupancy category "single-family dwellings" within each census block into one-story and two-story structures and into pier and slab foundations. An estimate of the percentage of one and two-story residential structures in each parish within the planning area was provided by emergency management officials. This step was necessary in order to apply the depth-damage relationships to the different types of single-family dwellings.

Temporary lodgings, institutional dormitories, and nursing homes, which are normally valued as non-residential structures in USACE studies, were classified as residential structures in the GIS application for consistency with the HAZUS-MH database. However, the non-residential depth-damage relationships for public and semi-public buildings were used to calculate potential flood damages for these structures and their contents. The damages for these buildings are included in the GIS application as part of the residential multi-family damage category.

Non-Residential Structure Inventory and Valuation

The non-residential structure inventory was compiled using databases obtained from the Louisiana Department of Labor (LDOL) and the Louisiana State University GIS Department. The LDOL database provided a geo-referenced latitude/longitude coordinate for each business property in the planning area that had been registered for unemployment insurance. The latitude/longitude coordinates were used in the GIS application to relate the location of each business property to a census block in the planning area. The LDOL database provided a North American Industry Classification System (NAICS) code, which describes the type of business occupancy at each location, along with the number of employees, and total wages paid for second quarter 2005 (pre-Katrina conditions) for each business unit. Since many small businesses operate out of residential structures, and these structures were included in the residential inventory, only the businesses that employed more than one person were included in this analysis.

The NAICS codes were grouped into four general damage categories (commercial, industrial, agricultural, and public), and then assigned to one of eight non-residential occupancy classifications. The eight non-residential occupancy classifications include: eating and recreation, groceries and gas stations, professional buildings, public and semi-public facilities, repairs and home use, retail and personal services, warehouse and contractor services, and industrial facilities. An average depreciated replacement cost using 2007 price levels was calculated for each occupancy classification, except for industrial facilities, based on previous feasibility studies conducted by New Orleans District using the Marshall and Swift Valuation Service. Since the previous feasibility studies did not include a significant number of industrial properties, the Dun and

Bradstreet database within the HAZUS-MH application was used to determine the average depreciated replacement cost of industrial buildings.

The LDOL database provided only a single latitude/longitude coordinate for the central reporting office of the schools, post offices, and churches. In order to have a separate location and value for each individual school, church, and post office in the planning area, a separate database was obtained from Louisiana State University. The community layer within the LSU GEOLAGIS database provided a geo-referenced latitude/longitude coordinate for each school, church, and post office in the planning area and a description of the facility. Each of these buildings was assigned to the public damage category and the public occupancy classification to calculate the damages. The average depreciated replacement cost calculated for the public occupancy classification was used for these buildings.

Table 4 displays the average depreciated replacement costs that were assigned to each of the non-residential occupancy categories in the GIS application.

Residential and Non-Residential Contents Valuation

The contents for residential (one-story, two-story, mobile homes, and multi-family) and non-residential (eight categories) structures were determined based on limited field surveys and the experience of a building and insurance expert panel for the Jefferson and Orleans Parishes Feasibility Study in 1996; the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies in 1997; and the Donaldsonville to the Gulf, Louisiana Feasibility Study in 2006. The value of the contents of each structure category were totaled and then compared to the total value of a structure in order to develop the contents-to-structure ratios (CSVRs). More specific detail regarding the development of the content values can be found in the following final reports: *Depth-Damage Relationships for Structures, Contents, and Vehicles and Contents-to Structure-Value Ratios (CSVRs) in support of the Jefferson and Orleans Flood Control Feasibility Studies* dated May 1997, *Depth-Damage Relationships for Structures, Contents, and Vehicles and Contents-to Structure-Value Ratios (CSVRs) in support of the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies* dated May 1997, and *Donaldsonville to the Gulf, Louisiana Feasibility Study* dated March 2006.

The CSVRs and depth-damage relationships developed for the Jefferson and Orleans Studies were applied to residential and non-residential structures located in the eastern portion of the LACPR planning area that is west of the Louisiana/Mississippi state border and east of the Mississippi River. They were also applied to the west bank of the Mississippi River in Orleans and Jefferson parishes. The depth-damage relationships and CSVRs developed for the Donaldsonville area were applied to the areas east of Bayou Lafourche with the Mississippi River on the north, and the Jefferson Parish line on the east. The depth-damage relationships and CSVRs developed for the Lower Atchafalaya and Morganza to the Gulf study area were applied to the portion of the LACPR planning area that is west of the Mississippi River and west of Bayou Lafourche and extends to the

Louisiana and Texas border. In summary, Planning Unit 1 utilized the Jefferson and Orleans CSVRs and depth-damage relationships, Planning Unit 2 was analyzed with Jefferson and Orleans CSVRs and depth-damage relationships for part of the area and with the Donaldsonville relationships for the remainder of the area, and Planning Units 3a, 3b, and 4 were covered by the Morganza CSVRs and depth-damage relationships.

The CSVRs developed for each of the four residential structure categories and eight non-residential occupancy classifications for the three feasibility studies are shown in Table 5.

The GIS application used the CSVRs as a percentage of the total depreciated exposure value or total depreciated replacement cost to determine the total value of the contents for each residential and non-residential occupancy classification. The CSVR calculated for warehouses and contractor services was also assigned to the industrial non-residential occupancy classification.

Vehicles

Damages to private automobiles are based on the number of automobiles directly impacted per household. The elevation of each automobile is determined by the corresponding ground elevation near the structure. Automobile damages are then calculated by correlating the depth of flooding to the depth-damage relationships for vehicles.

Census data were used to determine the average number of privately owned vehicles per household (owner occupied housing or rental unit) within each census block group in the planning area. This relationship was used in the GIS application to determine the average number of vehicles per household within each census block. Approximately 1.4 million privately owned vehicles and 135,000 vehicles associated with businesses were estimated for the 23 parishes subject to surges from hurricanes in the LACPR planning area. Based on the Southeast Louisiana and Mississippi Clearance Time Updates for the 2006 Hurricane Season Final Report prepared by Federal Emergency Management Agency and U.S. Army Corps of Engineers, New Orleans District dated June 1, 2006, and the Southwest Louisiana Hurricane Evacuation Report prepared by Federal Emergency Management Agency and U.S. Army Corps of Engineers, New Orleans District dated 2003, between 65 and 80 percent of the privately owned vehicles in Southeast Louisiana were used for evacuation from Hurricane Katrina. For this analysis, it was assumed that the average household would use 70 percent of its vehicles to evacuate during a storm event, while the remaining 30 percent of its vehicles would remain parked at the residence.

Residential automobile damages were based on the number of privately owned vehicles that were not used by their owners during the evacuation process. The Manheim Used Vehicle Value Index, which is based on over 4 million automobile transactions conducted each year, was adjusted to reflect an average retail replacement value of $12,217 in 2007 prices for each of these vehicles. Depth-damage relationships for vehicles were developed based on interviews with the owners of automobile dealerships that had

experienced previous flood damages. These interviews were used to calculate flood damages to vehicles at the various levels of flooding. The automobiles not used for evacuation were assigned the mean ground elevation of the census block in which the vehicle was parked by the residence or business.

Commercial vehicle damages were based on the number of commercial licenses as reported by the Louisiana Department of Motor Vehicles for parishes in the planning area for October 2006 and the total number of business units for each parish. Based on these data, it was determined that there was an average of 2.7 vehicles associated with each business unit in the planning area. It was assumed that since the business owners were using their privately owned vehicle for evacuation, all commercial vehicles would remain parked at the business. The ground elevation assigned to these vehicles was the same as the ground elevation assigned to the business property. The Manheim average value, $12,217, and the vehicle depth-damage relationships were used to derive the potential damages to commercial vehicles.

Depth-Damage Relationships

Damages from flooding were calculated for residential and non-residential buildings, their contents, and vehicles based on the depth-damage relationships developed by a panel of building and construction experts for the Jefferson and Orleans Parishes Feasibility Study in 1996; the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies in 1997; and the Donaldsonville to the Gulf, Louisiana Feasibility Study in 2006. Saltwater, long-duration (one-week) depth damage curves were used to indicate the percentage of the structural value that was damaged at each depth of flooding. Damage percentages were determined for each one-half foot increment from one foot below first-floor elevation to two feet above first floor, and for each 1-foot increment from 2 feet to 15 feet above first-floor elevation.

Depth-damage relationships were developed for one-story and two-story residential structures, mobile homes, and non-residential structures, their contents and vehicles. The panel of experts developed depth-damage relationships for four residential structure categories (one-story, two-story, mobile homes, and multi-family dwellings) and for three commercial structure categories (masonry, wood or steel frame, and metal frame). Depth-damage relationships were also developed for the four residential content categories and for seven commercial content categories. The non-residential depth-damage relationships were assigned to the appropriate structure and content damage category based on the NCAIS code and occupancy classification.

Pre-Katrina (2nd Quarter 2005) Stage-Damage Relationships

Inputs to the GIS application have thus far included elevation data, structure inventory and valuation data, and depth-damage relationships. The application used these inputs to generate a water elevation or stage-damage relationship for each census block. Flood damages were calculated at one-foot increments from the beginning damage elevation to an elevation where damages for all the structural categories have reached a maximum. In order to insure that this maximum had been reached, the maximum height of a slab

foundation or of a pier foundation in each census block was added to the maximum depth of flooding (15 feet) included in the depth-damage relationships. Damages were calculated for eight structural damage categories: single-family residential, multi-family residential, manufactured housing/mobile homes, commercial, industrial, public, agricultural, and vehicles.

The GIS application was used to develop a stage-damage relationship for each of the approximately 72,000 census blocks in the LACPR planning area. These stage-damage relationships reflect pre-Katrina conditions (2nd Quarter 2005) and were developed using 2007 price levels. These relationships were used as the basis for the development of stage-damage relationships for any future year through the year 2075. Any residential and non-residential structures and their vehicles that incurred flood damages from Hurricanes Katrina and Rita were not included in this analysis until the properties were projected to be reoccupied.

FUTURE DEVELOPMENT AND LAND USE ALLOCATION SCENARIOS

Since uncertainty is implicit in all future projections, several future condition scenarios were considered in this analysis rather than only one "most-likely" scenario as in previous studies. These scenarios will provide the decision maker with a more comprehensive view of possible future conditions and their impact on potential flood damages. In this section of the analysis, three future development scenarios were used to project the growth in population, number of households, and non-agricultural employment that will take place in the LACPR planning area by the year 2050. Three future land use allocation scenarios, which show the placement of this growth within the planning area and the type of residential and non-residential construction, were considered for each of the three future development scenarios. Due to the uncertainty of the length of the project implementation period, the projections under each scenario were extended by New Orleans District to the year 2075.

Future Development Scenarios

Projections of population, number of households, and total non-agricultural employment for each of the five Metropolitan Statistical Areas (MSAs), New Orleans, Baton Rouge, Houma, Lafayette, and Lake Charles, and for each of the non-MSA parishes in southern Louisiana were provided by Calthorpe Associates under two future development scenarios: "high employment" and "business as usual". These projections were based on the results of a custom application of the U.S. Macro Model, a macro-economic model prepared by Moody's Economy.com, and acquired through the Brookings Institution. The Economy.com model used factors such as net migration of population, employment demand by sectors of the economy, distribution of personal income, and residential construction patterns to project population, number of households, and non-agricultural employment for the period 4th Quarter 2005 through 4th Quarter 2034. New Orleans District personnel developed a third set of projections, "modified high employment"," which was a more conservative adaptation of the "high employment" projections.

Estimates of the population for each of the parishes in South Louisiana as of July 1, 2006 obtained from Louisiana Tech University were used by New Orleans District personnel as a reference point for all three sets of population projections.

The "high employment" future development scenario assumes that the state of Louisiana will implement policies that will be conducive to increased employment in non-traditional Louisiana growth industries such as technology and medical services. Calthorpe Associates developed this scenario using the projections of the population, number of households, and total non-agricultural employment prepared by Economy.com for the period 4th Quarter 2005 through 2030 for five MSAs and for the rural parishes in South Louisiana. Calthorpe Associates then used the projected growth rate during this 25-year period to extend the projections to the year 2050. In the areas affected by Hurricanes Katrina and Rita, the 4th Quarter 2005 population was drastically reduced from its pre-Katrina level because a large portion of the population had evacuated from the impacted areas. Thus, the growth rate projected to occur between 4th Quarter 2005 and the year 2010 as the population returns to the area is relatively higher than the growth rate projected to occur between the year 2010 and 2030 when most of the evacuated residents have returned. Since Calthorpe Associates used the growth rate for the 25-year period beginning 4th quarter 2005 and extending through the year 2030, which includes the relatively high rate of growth expected during the five years following the two storms, to extend the Economy.com population projections through the year 2050, the projected growth rate in population accelerates during the 20-year period 2030 to 2050 relative to the projected growth rate during the 20-year period 2010 to 2030.

The "business as usual" future development scenario assumes that the state of Louisiana will continue to implement the economic policies that were in place before Hurricane Katrina. As a result, the majority of the projected future development in South Louisiana will take place in the more traditional Louisiana growth industries such as oil and gas and tourism. Calthorpe Associates provided this scenario using the "business-as-usual" projections prepared by Economy.com for each MSA and for each parish located outside of an MSA for the period 2010 through 2030. New Orleans District personnel extended these projections to the year 2050 based on the average annual "business-as-usual" growth rate between 2010 and 2034 as developed by Economy.com.

A third future development scenario, which was developed by New Orleans District personnel, used the "high employment" projections prepared by Economy.com for each MSA and for each coastal parish located outside of an MSA for the period 2010 through 2034. These projections were then extended to the year 2050 based on the "high employment" growth rate projected by Economy.com to occur between the years 2010 and 2034. Since the population growth rate for the five-year period following Hurricanes Katrina and Rita was not considered in the extension of the Economy.com projections, the growth rate used during the period 2034 to 2050 is relatively lower than the growth rate used by Calthorpe Associates for the period 2030 to 2050 in their "high employment" projections.

Future Land Use Allocation Scenarios

Calthorpe Associates also developed three land use allocation scenarios (compact, dispersed, and hybrid) for the "high employment" future development projections for the year 2050 to show the location and type of development expected to take place throughout southern Louisiana. New Orleans District personnel then applied the three land use allocation scenarios to the "business as usual" and to the "modified high employment"" future development scenarios. The specific location of the future development was primarily based on the existing and projected transportation systems in each area. However, other factors, including current and projected commercial activity, land elevation, susceptibility to flooding and other hazards, and environmental constraints such as wetlands, were also considered. The projected location and types of residential dwelling units varied under each of the three land use allocation scenarios.

Under the compact land use allocation scenario, residential development was primarily projected to occur in the census blocks located near the five major cities in the planning area, New Orleans, Baton Rouge, Houma, Lafayette, and Lake Charles. A larger proportion of multi-family dwelling units relative to the single-family residential construction was projected under this scenario. Under the dispersed land use allocation scenario, residential development was projected to spread out from the major cities, and there was more single-family residential construction relative to multi-family dwellings. The hybrid land use allocation is a combination of the compact and the dispersed land use allocations.

The projections by Calthorpe Associates included the number and classification of the residential and the non-residential properties for each of the three land use allocations projected by census block throughout the LACPR planning area for the year 2050. For example, it was projected that 32 percent of the total residential dwelling units would be single-family units under the compact land use allocation scenario, while 70 percent and 55 percent would be single-family units under the dispersed and the hybrid land use allocation scenarios, respectively.

Allocation of Future Development at the Parish Level

Thus far, the projections under the three future development scenarios and under the three land use allocation scenarios were made for the MSAs as a whole rather than for the individual parishes (with the exception of the more rural coastal parishes located outside of the five MSAs). In order to more accurately reflect the shifts in population that occurred as a result of Hurricanes Katrina and Rita, a method of allocating the growth to the individual parishes rather than the MSAs was developed by New Orleans District personnel. It was assumed that each parish would receive a percentage share of the population growth based on its share of the population within the MSA as projected for each of the three land use allocation scenarios with the "high employment" future development scenario for the year 2050. As an example, the population for Orleans Parish was projected to be 30 percent of the New Orleans MSA for the compact land use category, 25 percent for the disperse land use category, and 27 percent for the hybrid land use category. Thus, Orleans Parish was assumed to receive these percentages of the

population growth in each of the other time periods between 2006 and 2050 depending on which land use category was selected. This same method was also used to develop the projections of total households and total employment under each of the different scenarios.

Projected Structure Inventory

The projections of population, number of households, and non-agricultural employment between 2nd quarter 2005 and the year 2050 were used to develop the residential and non-residential stage-damage relationships for each census block in the planning area for the three future development and three land-use scenarios. Calthorpe Associates provided the incremental residential and non-residential development by census block expected to occur during the period under the "high employment" future development scenario and under each of the three land use scenarios for South Louisiana. This projected incremental level of residential and non-residential development was added to the pre-Katrina (2nd quarter 2005) residential and non-residential development.

For residential property, the projected number of single-family, townhouses, multi-family, and mobile home dwelling units and the average square footage for each type of dwelling for the year 2050 were provided by Calthorpe for each census block. The Marshall and Swift Residential Valuation Service was then used to develop an average replacement cost per square footage across the five three-digit zip code areas in the LACPR planning area. The average replacement cost per square footage was multiplied by the average square footage to derive the total construction cost for each type of residential dwelling unit.

For non-residential properties, Calthorpe provided the projected number of office, retail, and industrial buildings and the total square footage for each type of non-residential building for each census block for the year 2050. The Marshall and Swift Commercial Valuation Service was then used to develop an average cost per square footage for each type of non-residential building across five zip code areas in the LACPR planning area. The average cost per square footage was multiplied by the average square footage to derive the total construction cost for each type of non-residential dwelling unit. The total replacement cost or exposure value for each type of non-residential buildings was totaled by census block and used to calculate the potential flood damages for the year 2050 under each of the three land use allocation scenarios.

In order to calculate the potential flood damages for the non-residential properties, each non-residential building was assigned a damage category (commercial or industrial), a structure type (metal frame, steel frame, or masonry bearing walls), and a content type (professional, retail, and warehouse) depth damage category, similar to the existing condition inventory in the GIS application. LIDAR data were used to assign the mean ground elevation to each census block with projected non-residential development. The building characteristics, one or two stories, slab or pier foundation, and the corresponding average height above ground, were all assigned based on information collected from the emergency managers of each parish in the LACPR planning area.

Stage-Damage Relationships for the year 2050 Under the High Employment Future Development Scenario

The projected incremental structure inventory and valuation data for the "high employment" future development scenario under each of the three land use allocation scenarios was combined in the GIS application with the projected elevation data and the depth-damage relationships to generate a stage-damage relationship for each census block that contained incremental residential or non-residential development for the year 2050. Flood damages were calculated at one-foot increments from the beginning damage elevation to an elevation where damages for all the structural categories have reached a maximum. In order to insure that this maximum had been reached, the maximum height of a slab foundation or of a pier foundation in each census block was added to the maximum depth of flooding (15 feet) included in the depth-damage relationships. Eight structural damage categories were considered: single-family residential, multi-family residential, manufactured housing/mobile homes, commercial, industrial, public, agricultural, and vehicles using 2007 price levels.

The future development stage-damage relationships were adjusted to reflect FEMA elevation requirements for new construction. Any residential and non-residential development projected to take place after the 2nd quarter of 2005, including the rebuilding of structures damaged by Hurricanes Katrina and Rita, was assigned a first floor elevation greater than or equal to the stage associated with the 100-year frequency event for the year 2010. This storm event has a .01 exceedance probability and a .90 non-exceedance probability in any given year.

Stage-Damage Relationships for the Years between 2nd Quarter 2005 and 2050 and for the Year 2075 Under the High Employment Future Development Scenario

Stage-damage relationships for each census block in the LACPR planning area were developed for 2nd quarter 2005 and for the year 2050 for the "high employment" future development scenario under each of the three land use allocation scenarios. The projected number of households in the coastal parishes was used to adjust the residential stage-damage relationships at the census block level for each year between 2nd quarter 2005 and the year 2050, while the projected non-agricultural employment level in the coastal parishes was used to adjust the non-residential stage-damage relationships at the census block level for a each year during the period.

The number of households under the "high employment" future development scenario and under each of the three land use allocation scenarios for each parish in the planning area projected for each of the years between the 2nd quarter 2005 and the year 2050 was expressed as a percentage of the total number of households projected for the year 2050. These percentages at the parish level were then used as the basis for projecting the residential stage-damage relationships at the census block level for each of the years during the period. For example, using the "high employment" future development scenario and the hybrid land use allocation scenario, it was determined that the number of

households projected for Ascension Parish for the year 2040 was approximately 85 percent of the total number of households projected for Ascension Parish for the year 2050. Thus, the projected residential stage-damage relationship for each of the census blocks in Ascension Parish for the year 2040 would be 85 percent of the stage-damage relationship projected for that census block for the year 2050.

The level of non-agricultural employment under the "high employment" future development scenario under each of the three land use allocation scenarios for each parish in the planning area projected for each of the years between the 2nd quarter 2005 and the year 2050 was expressed as a percentage of the non-agricultural employment level projected for the year 2050. These percentages at the parish level were then used as the basis for projecting the non-residential stage-damage relationships at the census block level for each of the years during the period.

Stage-Damage Relationships Under the Business-As-Usual and Modified Full Employment Future Development Scenarios

A similar process was used to develop residential stage-damage relationships under the "business as usual" and the "modified high employment" future development scenarios with each of the three land use allocation scenarios for the year 2050 and for each of the years between 2nd quarter 2005 and the year 2050. However, since the breakdown by census blocks was not available for either of these future development scenarios, an additional adjustment was made to the residential stage-damage relationships developed for the "high employment" scenario in the year 2050. The total number of households projected for each parish under the "business as usual" and "modified high employment" future development scenarios in the year 2050 were expressed as percentages of the total number of households projected for the parish in the year 2050 under the "high employment" scenario. These percentages were then used to develop residential stage-damage relationships for each of the census blocks in the planning area under the "business as usual" and "modified high employment" scenarios for the year 2050.

This process was also used to adjust the non-residential stage-damage relationships projected for the year 2050 under the "business as usual" and "modified high employment"" future development scenarios with each of the three land use allocation scenarios to reflect the stage-damage relationships for each of the years between 2nd quarter 2005 and the year 2050. Again, since the breakdown of non-residential development by census blocks was not available under either of these future development scenarios, an additional adjustment was made to the non-residential stage-damage relationships developed under the "high employment" scenario for the year 2050. The level of non-agricultural employment projected for each parish under the "business as usual" and "modified high employment" future development scenarios in the year 2050 were expressed as percentages of the total non-agricultural employment level projected for the parish in the year 2050 under the "high employment" scenario with each of the three land use allocation scenarios. These percentages were then used to develop non-residential stage-damage relationships for each of the census blocks in the planning area

under the "business as usual" and "modified high employment" scenarios for the year 2050.

Extension of the Projections to the Year 2075

Since the length of the project implementation period is uncertain, the projections of population, number of households, and employment under each of the three future development scenarios and under each of the three land use scenarios scenario were extended by New Orleans District to the year 2075. The average annual growth rate projected to occur between 2010 and 2034 was used to extend each set of projections from the year 2050 to the year 2075. The projected number of households for the year 2075 was used to estimate the residential damages, while the projected employment for the year 2075 was used to estimate the non-residential damages. These projected damages were used to develop stage-damage relationships under each of the future development and land use allocation scenarios for the year 2075.

Two Economic Development Scenarios

The "high employment" future development scenario was combined with the dispersed land use allocation scenario as the first future economic development scenario, and the "business as usual" future development scenario was combined with the compact land use allocation scenario as the second future economic development scenario. The "modified high employment" future development scenario and the hybrid land use allocation were not used to develop the range of possible outcomes for the project alternatives. The "high employment" future development with dispersed land use allocation was considered the scenario with the highest damage or residual risk potential, while the "business as usual" future development with compact land use allocation was considered the lowest potential damage or residual risk scenario. These two economic development scenarios were combined with two sea-level rise scenarios to calculate the range of potential damage or residual risk throughout the period of analysis.

Tables 6 through 11 show the projected population, number of households and employment for the 26-parish LACPR planning area for the "high employment" future development with dispersed land use scenario and "business as usual" future development with compact land use scenario.

EMERGENCY AND OTHER POST-FLOOD COST CATEGORIES

A flooded community typically incurs a variety of flood-related costs not associated with structural damages. The emergency costs incurred by the Federal, state, and local governments during and after the storm event are designed to eliminate or reduce the immediate threat to life, public health, or safety. These costs include the following: search and rescue operations; the evacuation of emergency medical facilities and the setting up of temporary facilities; rescue, care, shelter, and essential needs for household pets and service animals; emergency repairs to protective facilities, including temporary levees and the bracing of damaged property; and security in the disaster area. The emergency costs associated with inundated residential properties include evacuation and subsistence, clean up and reoccupation costs, debris removal, and landscaping. The emergency costs associated with inundated non-residential properties include clean up and restoration costs, recovery of business records, and landscaping. These costs are incurred either by the Federal government, the occupants of inundated residential properties, or the owners of inundated non-residential properties. The depth-damage relationships developed for each of these emergency cost categories were used to develop emergency cost stage-damage relationships for the inundated residential and non-residential properties in the study area.

The costs required for repair of inundated highways, streets, and railroad tracks were also considered in the analysis. The depth-damage relationships developed for highway, street, and railroad track repairs were used to develop stage-damage relationships for each of these categories.

Federal, State, and Local Government Emergency Protective Measures

The actual costs of the Category B emergency protective measures were obtained from FEMA for Hurricanes Juan, Andrew, Katrina, and Rita. The total Category B spending for each of the hurricanes was adjusted to reflect the percentage of the total structures damaged by the storm that incurred flood damage. All of the structures damaged by Hurricane Juan incurred flood damages; however, only 10 percent of the structures damaged by Hurricane Andrew and only 40 percent of the structures damaged by Hurricanes Katrina and Rita incurred flood damages. These adjusted costs were then divided by the number of inundated structures in each flood event to estimate the average cost per inundated structure associated with the emergency protective measures taken by the federal, state, and local government during and following a storm event.

Hurricane Juan data were used for depths of flooding between one and two feet. This storm event caused localized flooding in two subdivisions on the west bank of Jefferson Parish. The average emergency protective measure cost per structure inundated with between one and two feet of flooding was determined by dividing the actual spending by federal, state, parish, and municipal entities during Hurricane Juan in 1985 (approximately $856,000) by the number of structures flooded (4, 445). Thus, the average cost of emergency protective measures totaled $193 per inundated structure, or $366 per inundated structure in 2007 price levels.

Hurricane Andrew data were used for depths of flooding between two and three feet. The tidal surge from this storm event caused extensive damage to the communities south of the city of Houma. The average emergency protective measure cost per structure inundated with between two and three feet of flooding was determined by dividing the actual government spending during Hurricane Andrew in 1992 (approximately $1.56 million) by the number of structures flooded (2,500). Thus, the average cost of emergency protective measures totaled $624 per inundated structure, or $998 per inundated structure in 2007 price levels.

Data from Hurricanes Katrina and Rita were used for depths of flooding greater than three feet. Hurricane Katrina caused extensive flood damages to southeastern Louisiana including the city of New Orleans, while Hurricane Rita caused extensive flood damages to southwestern Louisiana. The average emergency protective measure cost per structure inundated with more than three feet of flooding was determined by dividing the actual government spending during Hurricanes Katrina and Rita in 2005 (approximately $744.3 million) by the number of structures flooded (204,682). Thus, the average cost of emergency protective measures totaled $3,637 per inundated structure, or $3,894 per inundated structure in 2007 price levels.

Table 12 displays the average emergency protective measures expenditure per inundated structure in 2007 price levels based on previous storm events.

A depth-damage relationship for the costs of emergency protective measures was developed for each increment of flooding up to 15 feet above first floor elevation. These depth-damage relationships were then combined in the GIS application with the number of residential structures inundated at each one-foot increment of flooding to develop a stage-damage relationship for the costs of emergency protective measures. It should be noted that emergency costs were not included for the 10-year frequency storm event when calculating an expected annual value.

Evacuation and Subsistence Costs

The experiences of residents affected by previous flood events, including Hurricanes Katrina and Rita, were used to estimate the evacuation and subsistence costs incurred by property owners and the Federal government immediately following a storm event. Residents of structures inundated between one and three feet above first floor elevation were evacuated from their homes for approximately three months following the flood event. During this period, most of the residents of evacuated households lived in hotels in cities north and west of the planning area. Based on the fiscal year 2007 government per diem for lodging in Dallas, Houston, Shreveport, Monroe, Little Rock, and Memphis, the average hotel rate is $75.33 per day, or $6,780 for the 3-month evacuation period. It should be noted that the lodging component of the government per diem is usually less than the non-contracted rates typical of hotels and motor lodges.

The average daily subsistence cost per evacuated household was also based on the average government per diem in the cities north and west of the planning area. The fiscal year 2007 average cost for meals prepared outside of the home was $47.67 per person, per day. Since the average household in the planning area as reported by the U.S. Census in the year 2000 contains 2.6 people, each evacuated household spent an average of $123.94 per day for meals. According to the U.S. Department of Agriculture, each household would have spent $8.32 per person, or $21.63 per household, on meals prepared in the home. Thus, the net additional food expenditure per household totaled approximately $102.31. The total evacuation and subsistence cost for the 90-day evacuation period was approximately $16,000 per inundated household.

For depths of flooding ranging between three and six feet above first floor elevation, the evacuation period increased to approximately one year. Most of these residents moved to an apartment closer to their inundated structure or to a FEMA trailer in front of their home after the initial three months of the evacuation period. Based on the national fair market rental assistance by FEMA following Hurricane Katrina, the average cost of renting an apartment was $800 per month, or $7,200 for the nine-months following the initial three-month evacuation period. According to an article in the Times Picayune, the average cost of a FEMA trailer, including the purchase price of $13,000, the cost of delivery, installation, maintenance, cleaning, and disposal, is approximately $60,000 per trailer for an 18-month "life cycle." Since the cost of a FEMA trailer is significantly greater than the cost of an apartment, the lower cost temporary housing alternative was used in this analysis. The average total evacuation and subsistence cost for the one-year period was approximately $23,200 per household. For depths of flooding greater than six feet, the period of evacuation was increased to eighteen months, and the total evacuation and subsistence cost increased to approximately $28,000 per household.

A depth-damage relationship for evacuation and subsistence costs was developed for each increment of flooding up to 15 feet above first floor elevation. These depth-damage relationships were then combined in the GIS application with the number of residential structures inundated at each one-foot increment of flooding to develop a stage-damage relationship for evacuation and subsistence costs. It should be noted that emergency costs were not included for the 10-year frequency storm event when calculating an expected annual value.

Residential Clean Up and Reoccupation Costs

The experiences of residents affected by previous flood events, including Hurricanes Katrina and Rita, were used to estimate the residential clean up and reoccupation costs incurred by residential households immediately following a storm event. Included in this category are the costs of driving to and meeting with insurance adjustors and contractors, the costs of interior clean up and dehumidifying the property, and the opportunity cost for the time spent by the resident meeting with the adjustors and contractors and inspecting the repairs. While the rebuilding process will likely last longer than one year, the clean

up and reoccupation costs are based only on the actual hours estimated to be spent by residents on these activities.

Since the residents of properties inundated at least one foot above first floor elevation are evacuated for at least three months, they will periodically visit their properties during the evacuation period to inspect the extent of their damages, meet with insurance adjustors, and meet with contractors to determine the necessary repairs. Based on the experiences of residents evacuated from Hurricane Katrina, travel costs were estimated for a minimum of three visits during the evacuation period.

The average distance that the residents of each inundated household traveled to an evacuation destination was 350 miles, or 700 miles round trip. According to the Internal Revenue Service (IRS), the operation and maintenance cost, including gasoline, for each vehicle used in the evacuation process was $0.485 per mile. With a round trip cost of $339.50 per visit, the total transportation cost for three round trips to the inundated property during the period of evacuation was $1,019. This amount was applied to all residential structures that were inundated one foot or more above first floor elevation.

The estimated costs incurred by residents to clean up and gut their inundated properties were based on interviews with contractors and repair personnel in the planning area. The tasks involved in this cost category include obtaining permits, employing dehumidifiers, gutting the interior of the structure, sanitizing the salvageable items, and removing mold. A total of $13,500 was applied to each residential structure inundated at least one foot above first floor elevation. For mobile homes inundated at least one foot above first floor elevation, the clean up and gutting costs totaled $5,000.

During their period of evacuation, homeowners will devote many hours applying for governmental assistance, filing insurance claims, scheduling appointments, meeting with insurance adjustors and contractors, and supervising repair work. The opportunity cost associated with the time spent completing these tasks can be measured by the average hourly wage for residents in the planning area. According to a pre-Katrina homeowner survey completed by the Amite River Citizens Community Group following a non-hurricane related flood event in East Baton Rouge Parish, residents of structures inundated less than three feet above first floor elevation spent an average of 100 hours completing these tasks. The average nonagricultural wage rate in the planning area for 3rd quarter 2006, as derived from data reported by the Louisiana Department of Labor, was $18.08 per hour. Thus, the total opportunity cost for each resident whose property was inundated between one and three feet above the first floor elevation was determined to be $1,808.

For residential structures inundated three feet or more above first floor elevation, the experiences of residents flooded by Hurricane Katrina were considered. Several of these homeowners had accurately recorded the amount of time that they had spent completing various reoccupation tasks in the months following the storm. Based on these records, an

average of approximately 571 hours is required to complete the following tasks: the initial clean up of the lot and exterior of house, meetings with insurance adjustors, telephone conversations with non-profit groups and government agencies, meetings with contractors, the overseeing of repair work, and the purchasing of replacement items. With an average wage of $18.08 per hour, the total opportunity cost for each homeowner whose property was inundated more than three feet above first floor elevation was $10,308.

A depth-damage relationship for clean up and reoccupation costs was developed for each increment of flooding up to 15 feet above first floor elevation. These depth-damage relationships were then combined in the GIS application with the number of residential structures inundated at each one-foot increment of flooding to develop a stage-damage relationship for evacuation and subsistence costs. It should be noted that emergency costs were not included for the 10-year frequency storm event when calculating an expected annual value.

Landscaping

After the completion of the residential clean up and reoccupation process, the costs associated with restoring the exterior of the property were considered. The average lot size of the residential properties in the planning area is 5,000 square feet, with approximately one half of this amount, or 2,500 square feet, devoted to landscaping. If the residential property is inundated with saltwater at a depth of 2 feet or more above first floor elevation, the grass, shrubs, and an average of one tree per property would need to be replaced. Data regarding the landscaping replacement were obtained from a local landscaping company, from Value Engineering, and from the landscape architects of the USACE. Damage to the fencing surrounding the property was not considered in this analysis because of the difficulty in separating the portion of the damage caused by water from the portion of the damage caused by wind.

Before new grass, plants, and trees can be planted on the property, the soil damaged by the saltwater must be removed, disposed of, and replaced. The cost to replace 6 inches of topsoil throughout the property, or approximately 46 cubic yards at $50 per cubic yard plus administrative costs, is $3,000. Approximately 7 grass palettes, each costing $300 plus labor and administrative costs, would be required to re-sod the property; the total cost of this task is $4,000. According to the landscape architects of the USACE, it would cost $3,500 to replace the shrubs (azaleas, rose bushes, camellias, gardenias, etc.) on the property, $4,000 to remove one damaged tree, and $100 to plant a new tree. The cost of labor is included in each of these costs. Thus, the total landscaping cost for each residential property is $14,600.

The total landscaping cost was applied to all residential structures that incurred flooding of 2 feet or greater above first floor elevation. This cost was used in the GIS application together with the number of residential structures inundated at each one-foot increment of flooding to develop a stage-damage relationship for landscaping costs. It should be noted

that emergency costs were not included for the 10-year frequency storm event when calculating an expected annual value.

Debris Removal

The costs associated with the removal of debris from the curbside in front of inundated structures and the transporting of this debris to waste disposal sites were primarily incurred by the Federal government. According to emergency management officials from New Orleans District, each inundated residential structure created approximately 30 cubic yards of debris. The cost to remove this debris ranged from $15 to $25 per cubic yard with an average of $20 per cubic yard. Thus, the average cost of debris removal was $600 per inundated residential structure. This amount was applied to all residential structures that incurred flooding at least one-foot above the first floor elevation, and was used in the GIS application together with the number of residential structures inundated at each one-foot increment of flooding to develop a stage-damage relationship for debris removal. It should be noted that emergency costs were not included for the 10-year frequency storm event when calculating an expected annual value.

Total Residential Emergency Costs

A depth-damage relationship for the total of all residential emergency cost categories was developed for each increment of flooding up to 15 feet above first floor elevation. These depth-damage relationships were then combined in the GIS application with the number of residential structures inundated at each one-foot increment of flooding to develop a stage-damage relationship for the total of all residential emergency cost categories.

Table 13 displays the depth-damage relationships for each of the emergency cost categories applied to the inundated residential structures. (Non-residential structures are also included.)

Non-Residential Clean Up and Restoration Costs

Post-flood surveys of business owners and managers were conducted as part of the IWR Flood Damage Collection Program. These surveys consisted of personal interviews with the owners and managers of businesses in the New Orleans Metropolitan Area that experienced flooding due to Hurricane Katrina. Based on the responses to the survey of 161 businesses, the average cost of commercial clean up and business restoration was $134,947. Most of the non-residential structures included in the survey incurred flooding between two and eight feet above first floor elevation. Clean up and restoration costs include the cost of labor and materials to clean the interior and exterior of the building and to remove and dispose of debris. The average cost of salvaging and replacing business records was $4,946. The costs associated with restoring the exterior of the property, including landscaping, averaged $7,039. Thus, the clean up and restoration cost for each non-residential property that incurred flooding one or more feet above first-floor elevation totaled $146,932.

A depth-damage relationship for the total of all non-residential emergency cost categories was developed for each increment of flooding up to 15 feet above first floor elevation. These depth-damage relationships were then combined in the GIS application with the number of non-residential structures inundated at each one-foot increment of flooding to develop a stage-damage relationship for the total of all non-residential emergency cost categories. It should be noted that emergency costs were not included for the 10-year frequency storm event when calculating an expected annual value.

Table 13 displays the depth-damage relationships for each of the emergency cost categories applied to the inundated non-residential structures. (Residential structures are also included.)

Repairing of Highways, Streets, and Railroad Tracks

According to a report by the Louisiana Department of Transportation and Development, the total cost of repairing the road systems in Louisiana following Hurricanes Katrina and Rita was estimated to be $1.46 billion. Approximately $1.1 billion was needed to repair Federal roadways, and $359 million was needed to repair non-Federal roadways. While some of the major highways, streets, and railroad tracks throughout the area, which were inundated with floodwater for an extended period of time, experienced only minimal damages, other roadways and railways experienced major damages to both their surfaces and their foundations.

Based on data obtained from Engineering Division, the cost to repair each lane of an asphalt-paved highway is $205,300 per mile. Since a highway was defined in the analysis as containing four lanes, the total repair cost applied to each highway mile was $821,200. The cost to repair each lane of a street was $103,000 per mile. Since local streets contain two lanes, the total repair cost applied to each mile was $206,000. Based on data obtained from Engineering Division, railroad track repairs cost $103 per linear foot, or $542,000 per mile. Revised depth-damage relationships for highways, streets, and railroad tracks were developed for each one-foot increment up to 15 feet of flooding by using these data to update the data developed as part of the Economic Data Survey for the Mississippi River and Tributaries Protected Area.

The GIS database, which contains the total number of miles of major and secondary highways, roads and streets, and railroad tracks in each census block, was combined with LIDAR DEM data, which provides the mean ground elevation for each census block, to assign a mean ground elevation to the roadways and railways in the planning area. Based on a sampling of LIDAR DEM data, the railroad tracks in the planning area were located an average of approximately 3 feet above the mean ground elevation of the census block.

The mean ground elevation in each census block was combined with the depth-damage relationship for highways and streets to develop stage-damage relationship for the highways and streets in that census block. The mean ground elevation plus the average height above ground for the railroad tracks in each census block was combined with the

depth-damage relationship for railways to develop a stage-damage relationship for the railroad tracks in that census block. These relationships show the total number of highway, street, or railway miles inundated and the subsequent damage in each census block at each one-foot increment of flooding.

The GIS application was then used to determine the number of miles of highways, streets, and railroad tracks for the stages associated with each of the frequency storm events. Because fewer miles will flood with the project in place, the portion of the expected annual highway, street, and railroad track repair costs that will be reduced by the project alternatives is considered the highway, street, and railroad track repair costs saved.

Table 14 displays the depth-damage relationships for highways, roads and railroad tracks in the LACPR planning area.

AGRICULTURAL RESOURCES

National Economic Development (NED) agricultural benefits are defined as the value of increases in the agricultural output of the area and the cost savings in maintaining a given level of output. The benefits include reductions in production costs and in associated costs, the reduction in damage costs from floods, erosion, sedimentation, inadequate drainage, or inadequate water supply, the value of increased production of crops, and the economic efficiency of increasing the production of crops in the planning area.

The National Agricultural Statistics Service (NASS) GIS database for the year 2005 was used to provide the location of each of the various crops farmed in the LACPR planning area. Table 15 displays the total agricultural acres by planning unit. There are approximately 3.9 million agricultural acres in the LACPR planning area. These crops include corn, cotton, rice, sorghum, soybeans, winter wheat, small grains (alfalfa, oats, millet, and rye) and hay, sugar cane, fallow cropland, pecans, and pasture. The number of citrus acres in Plaquemines Parish was provided by the Louisiana State University Agricultural Center (LSU AgCenter) and their location was estimated based on the location of fallow cropland in the area. The LSU AgCenter provided the number of acres of crawfish farming for each parish, and it was assumed that these acres were located in the same area as the rice acres. The GIS layer containing the location of each crop in the planning area was combined with the LIDAR DEM in the GIS application to determine the number of cleared agricultural acres inundated for each one-foot increase in stage. The acres of agricultural land were assigned to census blocks in the GIS Application in order to combine the damages to crops for each one-foot increase in stage with the increase in damage to residential and non-residential property, if any, within that census block. The number of acres that could be inundated for each one-foot increase in stage is commonly referred to as a stage-area curve.

Crop Damage Rate

The crop damage rate per acre inundated is defined as the difference between the net return per cleared acre in a year in which a storm event occurs and the net return per cleared acre in a year in which a storm event does not occur. The damage rates per

inundated acre of all crops except pecans and citrus were developed based on farm budget analysis. Production cost and return data published by the LSU AgCenter and discussions with professors associated with the LSU AgCenter were used as inputs for each crops farm budget analysis. The crop damage rate per inundated acre of sugar cane was based on the damage rate developed as part of the Morganza to the Gulf, Louisiana Feasibility Study. The actual crop losses that resulted from saltwater inundation caused by Hurricanes Katrina and Rita were used to develop the damage rate per acre of small grains and hay, pecan and citrus crops.

In order to determine the flood damages to the corn, cotton, rice, sorghum, soybean, sugarcane and winter wheat crops and to crawfish farming, the monthly probability of a hurricane affecting the Louisiana coast, the production cycle of each crop, and the production costs and revenues per crop acre were considered. Data obtained from the National Oceanic and Atmospheric Administration (NOAA) for the period 1851 through 2005 were used to determine the probability of a storm affecting the Louisiana coast during each of the six months (June through November) in the hurricane season. Table 16 displays the number of historical hurricanes by month of occurrence between the years 1851 and 2005. The average yield for the period 2001 through 2005 (pre-Katrina/Rita) and the 2007 current normalized price (CNP) per crop were used to determine the gross annual revenue per crop. The average price received by crawfish farmers for the period 2001 through 2005 was applied to crawfish, since a CNP was not available for crawfish.

The production budgets obtained for each crop from the LSU AgCenter were used to determine the cumulative production costs expended for each month in the production cycle of each crop, beginning with the planting of the crop and ending with harvesting. These cumulative monthly expenditures were multiplied by the probability of a hurricane occurring during that month in order to calculate the expected value of the expended production costs. According to discussions with the professors associated with the LSU AgCenter, all revenues generated by crawfish farming will be lost if the ponds are inundated with saltwater. This same assumption was applied to corn, cotton, sorghum, and soybeans. Since winter wheat is harvested in May before the beginning of the hurricane season, it was assumed that there would be no loss to the crop. Also, it was assumed that there would be no crop loss to fallow land.

The damage rate per inundated crop acre is equal to the loss of the net income normally generated by the crop. It can be equivalently measured as gross revenues minus the expected value of the unexpended production costs for that year. For purposes of this analysis, it was assumed that total revenues would never be less than the cost of production for that crop (i.e. net returns are always greater than or equal to zero). This assumption was made because if net income is negative in a non-flood year, then the flood event would negate this loss and actually have a positive effect on the NED account.

The damage rate per inundated acre of pastureland was based on data obtained from the LSU AgCenter as part of a previous USACE study in Southwest Louisiana. According to this data, there are approximately 40,000 head of cattle grazing on 120,000 acres of pastureland in Vermilion Parish, with an average of three acres of pasture for each animal. The annual revenues generated by the pastureland averages about $16 million, or $133.33 per acre. In the event of a storm, the inundated acres from saltwater flooding would be completely unusable for one year. For small grains and hay, pecans and citrus crops, the total damage to these crops caused by Hurricanes Katrina and Rita as reported by the LSU AgCenter was divided by the number of inundated acres to derive a damage rate per crop acre flooded.

Non-Crop Damage Rate

In addition to the crop and pasture losses, there are other non-crop damages and expenses that would be incurred as the result of a storm event. These include losses to agricultural infrastructure (farm roads, fences, farm equipment, supplies, and drainage improvements) and agricultural land restoration costs. A weighted average of the non-crop flood damage rate per inundated acre was developed in June 2006 for Vicksburg District by Mississippi State University based on data obtained from eleven counties in Mississippi. This non-crop damage rate, which was calculated to be $77.59 in 2006 per inundated acre, was applied to each acre of agricultural land inundated in the LACPR planning area. A non-crop damage rate of $491 for crawfish farms was developed using the damages to crawfish infrastructure from Hurricanes Katrina and Rita and the number of acres impacted. The non-crop damage rates were updated to 2007 price levels.

Total Damage Rate

The total damage rate developed for each crop, including both crop loss and non-crop loss, was multiplied by the number of cleared acres inundated in order to calculate the total loss from inundation for each crop. Table 17 displays the damage rates per acre by crop in 2007 price levels. The reduction in the acres inundated under the with-project alternatives was compared to the without-project condition and multiplied by the damage rates in order to determine the damages and benefits associated with each project alternative.

EQUIVALENT ANNUAL DAMAGES

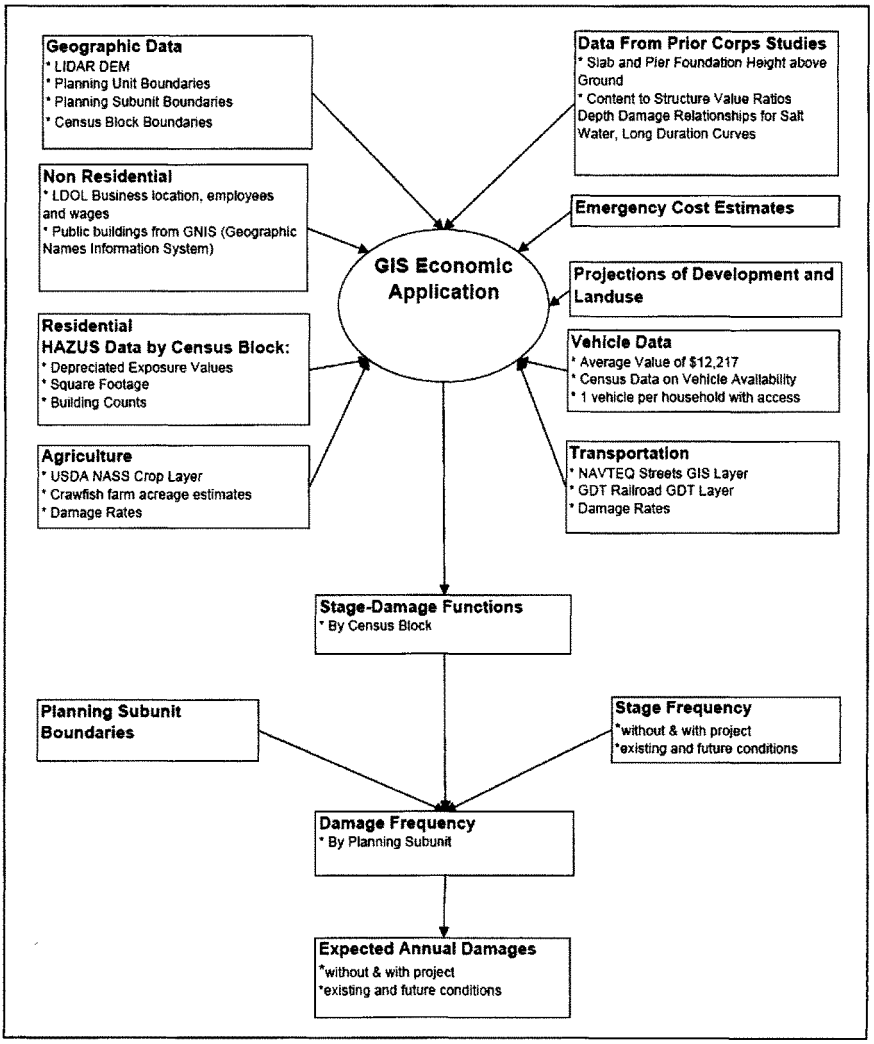
Aggregated Stage-Damage Relationships

The stage-damage relationships for residential and non-residential structures, contents, and vehicles were combined with the stage-damage relationships for emergency costs, road, highway, and railroad track repairs, and agricultural resources to develop one aggregated stage-damage relationship for each census block. The stage-damage relationships at the census block level were then combined to develop an aggregated stage-damage relationship for each planning subunit. The aggregated stage-damage relationships were developed under two future development and land use allocation

scenarios: "high employment" future development with dispersed land use allocation and "business as usual" future development with compact land use allocation. The aggregated stage-damage relationship under each scenario was developed for the years 2010 and 2075.

Figure 2 displays a flowchart that exhibits the databases used by the GIS economic application to produce damage estimates for the LACPR project alternatives.

Figure 2. LACPR GIS economic application flowchart.



Stage-Damage Uncertainty

Uncertainty is inherent in both the hydrologic and economic data used to calculate stage-damage relationships. While any of the economic variables could contain measurement errors, the most significant source of economic uncertainty arises from the methods used to assign ground elevations to the residential and non-residential structure inventory, transportation infrastructure and agricultural resources. Based on the error surrounding the LIDAR data and the error arising from the use of a single mean value to represent the elevation for an entire census block, this uncertainty was estimated to be plus or minus 1.38 feet for the structure inventory and plus or minus 2.34 feet for the transportation infrastructure and agricultural resources at the 90 percent level of confidence. (The uncertainty arising from the methods used to assign a mean elevation to each census block was discussed in the Ground Elevation section of the Economic Appendix.) As an example, when rounded to the nearest foot, the damages for residential and non-residential properties calculated at the three-foot stage could range from the damages calculated for the two-foot stage to the damages calculated for the four-foot stage. Alternatively, when rounded to the nearest foot, the damages for the transportation infrastructure and the agricultural resources calculated at the three-foot stage could range from the damages calculated for the one-foot stage to the damages calculated for the five-foot stage.

Stage-Frequency Data

The H&H Branch provided stage-frequency data for each planning subunit under existing and future without-project and with-project conditions. Stages were provided for five storm events with exceedance probabilities of .10, .01, .0025, .001, and .0005, respectively. Exceedance probabilities reflect the percentage chance that the actual stage associated with a storm event will be greater than the stage predicted by the H&H model in any given year. The five exceedance probabilities are more commonly referred to as the 10-year, 100-year, 400-year, 1000-year, and 2000-year frequency storm events.

Stages for each of the five frequency events were also provided for three non-exceedance probabilities: .10, .50, and .90. Non-exceedance probabilities quantify the uncertainty inherent in the hydrologic model and reflect the likelihood that the actual stage associated with a storm event will be less than or equal to the stage predicted by the H&H model in any given year. As an example, at the .90 non-exceedance probability, there is at least a 90 percent chance that the actual stage will be less than or equal to the stage predicted by the H&H model in any given year. Alternatively, there is a 10 percent chance that the actual stage will be greater than the stage predicted by the H&H model in any given year.

The stage-frequency data for the without and with-project conditions were provided for six future scenarios based on the condition of the Louisiana coastline and the rate of relative sea level rise expected to occur over time. The first three scenarios assume that the Louisiana coastline will continue to degrade with zero, low, and high rates of relative sea level rise, respectively. The second three scenarios assume that the Louisiana coastline will be sustained at its current (2010) condition with zero, low, and high rates of relative sea level rise, respectively. However, damages for each of the LACPR alternatives were calculated using only the low and high sea level rise scenarios.

Damage Calculations

The stage-frequency data were combined with the stage-damage relationships to develop frequency-damage relationships for each planning subunit. Frequency-damage relationships were estimated for the no-action alternative (degraded coastline) and the coastal restoration only alternative (coastline sustained at the 2010 condition). Both the nonstructural and the structural alternatives include coastal restoration measures. Each alternative was analyzed with a sustained (2010) Louisiana coastline and with low and high relative sea level rise, respectively. The alternatives were also analyzed under the "business as usual" future development and compact land use allocation scenario and under the "high employment" future development and dispersed land use scenario. The frequency-damage relationships for each alternative were calculated for three non-exceedance probabilities (.10, .50, and .90) in any given year to account for the hydrologic uncertainty inherent in the H&H model.

Frequency-damage relationships were developed for three nonstructural alternatives (including coastal restoration), which included the raising in place of all residential and non-residential structures in each planning unit to an elevation above the 100-year event, the 400-year event and the 1000-year event, respectively. If a structure was raised 14 feet or higher, then a buyout option was used, and the damages associated with that structure were removed from the analysis. The reduction in damages resulting from the buyout of all structures located in the V-zone areas where no structure-raising takes place that are highly susceptible to flooding were also removed from the analysis.

Frequency-damage relationships were developed for eleven structural alternatives (including coastal restoration) in PU1, thirteen structural alternatives (including coastal restoration) in PU2, four structural alternatives (including coastal restoration) in PU3a, six structural alternatives (including coastal restoration)in PU3b, and seven structural alternatives (including coastal restoration) in PU4. The structural alternatives were designed to contain the stages associated with the 100-year, 400-year, and 1000-year events. The comprehensive plans include these same relationships with the addition of the reduction in damages resulting from the complementary nonstructural measures for those areas not protected by the structural plans. The specific details regarding the LACPR alternatives can be found in the main report.

Tables 18 through 37 display the frequency damage relationships for the project alternatives by planning unit and by economic development scenario for the years 2010 and 2075.

The GIS application was used to weight the damages corresponding to each magnitude of flooding by the percentage chance of exceedance. From these weighted damages, the application was used to determine the expected annual damages for the year 2010 and the year 2075 for the no-action alternative, the coastal restoration only alternative, the combination coastal restoration and either structural or nonstructural alternatives, and the comprehensive alternatives.

Damages for the years 2010 and 2075 were calculated for each of the LACPR planning units using the projected population and number of households for the years 2010 and 2075. The expected annual damages for each year between 2010 and 2075 were computed using straight-line linear interpolation. The initial construction period for each of the structural alternatives was assumed to begin in the year 2010 and the implementation period of the structural alternatives ranged from six to sixteen years. Thus, each alternative was assumed to be operational through the year 2075.

For the structural alternatives, the no-action (degraded coastline) damages were used for the years between 2010 and the year in which the project becomes operational, and the residual damages relative to the no action alternative were used for the remaining years through the year 2075. For the nonstructural alternatives, a 15-year implementation period was used. The reduction in damages relative to the no-action alternative was assumed to occur at a uniform rate between the year 2010 and the year 2075.

Since the comprehensive plans included complementary nonstructural measures, the reduction in damages due to the nonstructural alternatives was estimated during the implementation period for each alternative. The reduction in damages resulting from the structural alternatives, which include a combination of coastal restoration and complementary nonstructural measures, was estimated through the year 2075.

The fiscal year 2008 Federal discount rate of 4-7/8 percent was used to compound the stream of expected annual flood damages before the base year (2025) and to discount the stream of expected annual damages occurring after the base year in order to calculate the total present value of the damages in the year 2025. The present value of the expected annual damages was then amortized using the Federal discount rate to calculate the equivalent annual damages. These equivalent annual damages were calculated for three non-exceedance probabilities (.10, .50, and .90) to account for the hydrologic uncertainty inherent in the H&H model.

Tables 38 through 57 display the expected annual metric values for the LACPR alternatives for the years 2010 and 2075. The expected annual metric values are displayed for residual damages, population, number of employees impacted, their wages and their output or sales. The equivalent annual metric values were calculated for a 2025 base year using a 4-7/8 percent interest rate. The metric values are displayed for the two economic development scenarios and for the two sea-level rise scenarios. The values are shown for the .10, .50 and .90 non-exceedance probabilities.

Table 58 displays the percentage of expected annual damages by damage category for each planning unit for the sustained cost alternative. The percentages are displayed for two economic development scenarios in combination with the low sea level rise scenario for the years 2010 and 2075. The damage categories include residential properties, non-residential properties, emergency activities, agricultural resources and transportation infrastructure including roads, streets and railroads.

PRESENT VALUE COSTS

Cost estimates were developed for each of the coastal restoration only alternatives and for each alternative combining coastal restoration with either nonstructural or structural alternatives. Comprehensive cost estimates were provided for a combination of a coastal restoration with both nonstructural and structural alternatives. These costs were based on the design criteria associated with the stages developed for the .90 non-exceedance probability.

The coastal restoration only alternatives for all five planning units were designed to sustain the Louisiana coastline at its condition in the year 2010 for both the low and high sea level rise scenarios. For PU1 and PU2, the coastal restoration measures include marsh creation, diversions, shore protection, reinforcement of natural ridges, and the building up of the barrier islands. Only the first three measures were considered for PU1, while all five measures were considered for PU2. Costs were initially developed for all five coastal restoration only alternatives (R1 through R5), but were then screened to only three alternatives (R1 through R3). When the coastal restoration alternatives were combined with a nonstructural alternative, a structural alternative, or both a nonstructural and a structural alternative for PU1 and PU2, only the costs for R2 were used.

Two coastal restoration alternatives, R1 and R2, were developed under both the low and high sea level scenarios for PU3a, PU3b, and PU4. Alternative R1 for PU3a includes marsh creation, diversions, the re-distribution of flows, the construction of a by-pass channel, and the building up of the barrier islands. Alternative R1 for PU3b includes marsh creation, relocation of a navigation channel, and shore protection. Alternative R1 for PU4 includes marsh creation and shore protection. Alternative R2 has the same coastal restoration measures as R1 but does not include the construction of a bypass channel for PU3a, or shore protection for PU3b and PU4. When the coastal restoration alternatives were combined with a nonstructural alternative, a structural alternative, or both a nonstructural and a structural alternative for PU3a, PU3b, and PU4, only the costs for R1 were used.

Table 59 displays the present value of the life-cycle costs for each alternative by planning unit using 2007 price levels. A 4-7/8 percent interest rate was used to calculate the equivalent annual coastal restoration costs for each alternative for a 2025 base year. The values are presented for two sea-level rise scenarios.

Costs were developed for three nonstructural alternatives (including coastal restoration), which included the raising all of residential and non-residential structures in each planning unit to an elevation above the 100-year event, the 400-year event and the 1000-year event, respectively. A buyout cost estimate was used for those structures that were required to be raised 14 feet or higher above the ground. Nonstructural cost estimates were also provided for the buyout of all structures located in the V-zone areas that are highly susceptible to flooding. The costs for each of the non-structural alternatives are provided in the Non-structural Appendix.

Cost estimates were provided for structural alternatives (including coastal restoration) in the five planning units. The structural alternatives were designed to contain the stages associated with the .01 (100-year), .0025 (400-year), and .001 (1000-year) exceedance probability storm events in any given year. The comprehensive plans include these same cost estimates with the addition of the costs of complementary nonstructural measures for those areas not protected by the structural plans.

Tables 60 and 61 displays the total present value of the life-cycle costs for each of the structural alternatives for PU1 and PU2, and PU3a, PU3b, and PU4, respectively. A 4-7/8 percent interest rate was used to display the equivalent annual cost values for each alternative in a 2025 base year using 2007 price levels. The costs for each of the alternatives were developed for a degraded and sustained coastline without sea level rise. The costs were also developed for each of the alternatives for a degraded and a sustained coastline in combination with a low and a high sea level rise scenario.

Costs for each of the coastal restoration only plans, the combination coastal restoration and either structural or nonstructural plans, and the comprehensive plans were estimated under four future condition scenarios based on the condition of the Louisiana coastline and the relative sea level rise. The first two scenarios assume that the Louisiana coastline will be sustained at its current condition with no further degradation and with low and high relative sea level rise, respectively. The third and fourth scenarios assume that the coastline will continue to degrade with low and high rates of relative sea level rise, respectively.

The cost estimates for each alternative were provided using October 2007 price levels over the period beginning in the year 2010 and ending in the year 2075. For the structural alternatives, the estimates included initial construction costs, mitigation costs, the costs of levee lifts, and the required operation and maintenance (O&M) expenditures. Since the initial construction period of the various structural alternatives ranges from six to sixteen years, the O&M expenditures for each cost estimate were extended through the year 2075 to insure that each alternative was operational through the year 2075. The implementation period for the coastal restoration only alternatives and for the coastal restoration alternative with nonstructural alternatives was assumed to be 15 years. The present value of the life cycle costs for each alternative was calculated using the fiscal year 2007 Federal discount rate of 4-7/8 percent. The cost for each alternative was either compounded or discounted to reflect a common base year, the year 2025, using the Federal discount rate.

REGIONAL ECONOMIC DEVELOPMENT AND OTHER SOCIAL EFFECTS

The customized GIS application used to assess flood damages to residential and non-residential properties in the LACPR planning area was also be used to determine the direct regional economic impacts of a storm event. These direct impacts were measured by changes in employment, wages, and output under without-project conditions and under the with-project conditions for each of the alternatives. Also discussed in this

section is the development of a regional model that will build upon these current estimates of direct regional effects to measure also the indirect impacts, or multiplier effects, on regional economic activity. The multiplier effects are captured by the use of a regional input-output model that was developed by Regional Economic Models, Inc. (REMI). The REMI results are displayed in Attachment 3 to this appendix. Finally, the social impacts of flooding caused by the surges associated with a storm event for a community or region are discussed in the Other Social Effects (OSE) section.

Methodology

The employment, wages, and output associated with each commercial property in a census block were adversely affected whenever the stage associated with a frequency storm event at the planning subunit level reaches or exceeds the first floor elevation of the structure. The impacts on employment were based on data provided by the Louisiana Department of Labor (LDOL) for 2nd quarter 2005 plus the incremental non-residential development projected by Calthorpe Associates to occur by the year 2050. These data were adjusted annually through the year 2034 using the population and employment projections provided by Economy.com, and they were extended through the year 2075 using data provided by Calthorpe Associates.

The increment of non-residential development projected for the year 2050 was separated into three non-residential categories: retail, office and mixed use, and industrial. A corresponding NAICS code (44, 54, and 32, respectively) was assigned to each non-residential category. The quarterly wages associated with the employees in each NAICS code for the 2nd quarter 2005 were annualized and then used to represent the impacted annual wages. The projected growth in output, or sales, for the businesses in each NAICS code was applied to the 2005 annual wages in order to adjust the growth in wages for each year. The annual wages were represented in 2007 prices.

The impact on output, or sales, of the commercial establishments in each census block in the planning area was based on the annual employment-to-output ratio developed by NAICS code for the 70-sector Regional Economic Model Incorporated (REMI) as part of the IPET Report. Output, or sales, per employee was linked to each two or three digit NAICS code assigned to businesses by LDOL to estimate the impact of flooding on annual output for the study year (2010), the base year (2025), and the year 2075. The annual employment-to-output ratio for the year 2050 was assumed to be constant through the year 2075.

Data were developed for five exceedance probabilities: .10, .01, .025, .001, and .0005. These exceedance probabilities correspond to the 10-year, 100-year, 400-year, 1000-year, and 2000-year storm events, respectively. The employment, wages, and output values were converted to average annual values and then to equivalent annual values. Finally, the total employment, total wages, and total output affected by each frequency storm event were then aggregated for each planning unit. These data are used to demonstrate the direct regional economic impacts for the without-project conditions and for the selected project alternatives on an equivalent annual basis.

Development of a Regional Model

In general, regional economic policy analysis models use simulations to assess the economic effects of various policies relating to economic development, transportation, energy, the environment and taxation, on regional areas. Regional economies compete with one another within a national economy, and as such exhibit different behavior than national economies, such as the presence of second and third-round multiplier effects.

The development of a regional model to measure regional impacts will build upon these current estimates of direct regional effects. The advancement will be centered upon the calculation of changes in regional output, income, and employment that results from second-round and third-round spending effects, or lack thereof. The multiplier effects captured in this approach are embedded within a regional input-output model that was developed by Regional Economic Models, Inc. (REMI). It was this model that was used by the Interagency Performance Evaluation Team (IPET) to estimate the regional economic impacts associated with Hurricane Katrina in September 2005. The advantage of the REMI model over a number of alternative regional input-output models lies with its superior ability to trace reductions in output, income, and employment associated with disruptions to the established interrelationships among industrial sectors, whereas more conventional models are restricted to measuring increases in these variables as a result of a positive stimulus that is introduced into the system.

REMI Model

The REMI model uses a wide variety of economic indicators to describe the effects of policies on regional economies. It uses a large set of inputs from the following five (5) categories:

1) *Output and Demand*: Describes the output in each industry based on demand for that industry. Demand is generated by consumption, investment, government spending, and intermediate income. Subsequent determinants include real per capita disposable income, relative prices, the elasticity of demand with respect to income, and the size of the population. In addition to being influenced by demand in the home region, output is also influenced by demand in other regions, the region's market share, and the exports to other nations. The REMI model is the only input-output model to account for the displacement or augmentation effects that location choices have on other local firms.

2) *Labor and Capital Demand*: Describes the characteristics of labor including productivity, intensity, and optimal amounts of capital relative to the availability of labor.

3) *Demographic/Population and Labor Force*: Demographic information about the region, including birth and survival rates for each group. Based on the size and labor force participation rates for each group, the labor supply can be determined. This block also accounts for migration characteristics of the population.

4) *Wages, Prices, and Costs*: The interactions between the costs of labor, goods, and production will dictate how and how much they will be used – the cost of production for each industry is the cost of its inputs (labor, capital, and fuel). Access is another important characteristic because of the resulting transport and transaction costs.

5) *Market Shares*: The proportion of markets, both local and export, that each industry has captured.

REMI software allows for discrete, single-event modeling of a regional system that is defined according to the parameters of the study. Because model execution is relatively labor-intensive, it was found not to constitute a suitable tool for screening through a series of over one hundred alternatives. This level of effort is accentuated by the requirement that sufficient runs for a range of frequency events be conducted within each construction alternative such that an average annual equivalent value can be derived. Finally, unlike specific estimates of direct impacts such as the number of residences damages and affected population, multiplier-based regional impacts span across planning units since the industrial linkages are defined for integrated economic regions. Therefore, the possibility and desirability of defining economic regions within the REMI model to coincide with that of planning units requires further investigation once the number of final alternatives has been determined. This effort will be conducted as part of follow-up investigations to be conducted after the final array of project alternatives is established.

Other Social Effects (OSE)

In addition to regional economic development impacts, water resource project alternatives can be assessed on the basis of their contribution to the social dynamics and quality of life in the local and regional communities. Two criteria, residual population and the number of historic districts affected by potential flooding, are currently being used as metrics for the Other Social Effects (OSE) account in the LACPR evaluation. A variety of other social statistics can be used in conjunction with these metrics to describe other changes in the social dynamics and quality of life in the planning area attributable to the project alternative. Examples of these social statistics include a comparison of the per capita rates of alcoholism, per capita rates of suicide, and the per capita availability of hospital beds throughout the planning area before and after Hurricanes Katrina and Rita. The expanded OSE criteria can also be augmented by involving members of the local and regional communities in a collaborative process, which would begin in the earliest stages of the evaluation. These issues are addressed more fully in Attachment 2 to this appendix.

METRICS

In previous water resource studies, project alternatives were compared and selected based on the ratio of the National Economic Development (NED) equivalent annual benefits derived from the alternative to the average annual project costs. The alternative that

generated the highest net benefits and maximized the ecosystem benefits was considered the NED/NER plan. However, for LACPR, a more comprehensive method was developed to compare the alternatives. This method encompasses a broader range of objectives and performance criteria to be used in the evaluation process. A system of quantifiable parameters, or metrics, was developed to evaluate and rank the alternatives based on the four planning objectives for LACPR: people, economy, environment, and culture. These metrics not only consider the criteria of the National Economic Development and National Ecosystem Restoration (NED/NER) account, as in previous studies, but also consider the criteria of the Regional Economic Development (RED), the Environmental Quality (EQ), and the Other Social Effects (OSE) accounts.

NED Metrics

Data from the economic analysis were used to evaluate each project alternative based on the criteria of the NED/NER, RED, and OSE accounts. The three metrics developed for the NED/NER account include equivalent annual damages, life cycle costs, and the length of time (in years) required to construct and implement each of the alternatives. Damages were calculated for the stages associated with five exceedance probabilities: .10, .01, .025, .001, and .0005, which correspond to the 10-year, 100-year, 400-year, 1,000-year, and 2,000-year storm events, to derive the expected annual damages. The expected annual damages were converted to an equivalent annual value using the Federal discount rate. The equivalent annual damage value includes damages to residential and non-residential properties, emergency losses, losses to agricultural resources, and damages to the transportation infrastructure. An equivalent annual damage value was provided for both the degraded and maintained coast, for the high-employment future development and dispersed land use allocation scenarios, and for the business-as-usual future development and compact land use allocation scenarios, and for the 10, 50, and 90 percent confidence intervals surrounding the hydrologic data.

Life-cycle costs, which were prepared for each alternative, include initial implementation costs, operations, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs, real estate costs, and mitigation costs. Since these costs occur at various times during the life cycle of the alternatives, the costs were discounted to the base year (2025) to reflect their present value and were then expressed in October 2007 price levels. This process allows for the comparison of alternatives with different investment patterns. The construction and implementation time metric considers the number of years required to complete the construction of each alternative and for the alternative to begin providing flood risk reduction. An alternative with a shorter construction and implementation period could provide less flood risk reduction to a community than other alternatives, but it would provide flood risk reduction to the community sooner. Thus, there could be a tradeoff between the time that flood risk reduction begins and the overall magnitude of the risk reduction provided.

RED Metrics

Three metrics were developed to assess the direct impacts of a storm event on the regional economy based on the criteria of the RED account. These metrics include gross regional output, number of people employed, and average earned income. Indirect

impacts, such as the reduced customer base following a storm event and the closing of related businesses, are not currently considered by the metrics for the RED account. However, these indirect impacts will be considered when the REMI model becomes available. The output, or sales, employment, and earned income associated with each commercial property in a census block under the no action condition and for each alternative are assumed to be affected whenever the stage associated with a frequency storm event at the planning subunit level reaches or exceeds the first floor elevation of the structure. Data were developed for the stage associated with five exceedance probabilities: .10, .01, .025, .001, and .0005, which correspond to the 10-year, 100-year, 400-year, 1000-year, and 2000 storm events, in order to derive the expected annual values. These expected annual values were converted to an equivalent annual value using the Federal discount rate.

OSE Metrics

A metric for residual population impacted was developed to assess the ability of alternatives to protect the health and safety of the public from a storm event based on the criteria of the OSE account. The impacted population is defined as the total number of residents in each census block in which the stage associated with a frequency storm event is greater than the mean ground elevation of that census block. The population metric does not consider the portion of the population that would evacuate before a storm event. Data were developed for the stage associated with five exceedance probabilities: .10, .01, .025, .001, and .0005, which correspond to the 10-year, 100-year, 400-year, 1000-year, and 2000 storm events, in order to derive the expected annual values. These expected annual values were converted to an equivalent annual value using the Federal discount rate.

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Table 1
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1978 to 2007
Louisiana Coastal Protection and Restoration

Parish	Number of Policies Dec. 2007	Number of Claims Filed	Total Amount Paid ($)	Average Amount Paid ($)
Acadia	2,942	471	$ 2,663,341	$ 5,655
Ascension	9,366	2,110	19,253,353	9,125
Assumption	1,617	830	3,330,322	4,012
Calcasieu	13,313	4,513	69,595,269	15,421
Cameron	1,876	1,952	108,383,612	55,524
East Baton Rouge	24,481	7,338	91,187,617	12,427
Iberia	5,624	1,708	46,110,435	26,997
Iberville	879	415	2,061,093	4,966
Jefferson	130,717	121,409	3,262,161,119	26,869
Jefferson Davis	991	202	2,721,731	13,474
Lafayette	15,372	2,561	22,869,286	8,930
Lafourche	13,956	3,956	47,655,683	12,046
Livingston	11,886	5,053	53,865,013	10,660
Orleans	112,064	119,399	7,107,694,720	59,529
Plaquemines	6,370	4,721	263,319,162	55,776
St. Bernard	12,415	23,008	2,225,735,411	96,737
St. Charles	11,849	5,502	95,168,286	17,297
St. James	1,002	88	717,194	8,150
St. John the Baptist	6,733	1,306	7,505,889	5,747
St. Martin	2,258	758	4,427,513	5,841
St. Mary	6,118	1,824	21,080,651	11,557
St. Tammany	52,502	29,517	1,519,000,430	51,462
Tangipahoa	5,629	882	7,762,764	8,801
Terrebonne	19,144	9,513	204,028,082	21,447
Vermilion	6,797	2,257	76,020,106	33,682
West Baton Rouge	569	93	648,924	6,978

Source: U.S. Federal Emergency Management Administration

Notes:
1. The amount paid reflects the price level of the year in which the claim was paid to the policyholder.
2. A single policy can have multiple claims.

Table 2
Total Number of Residential and Non-Residential Units and Miles of Roads and Railroads by Planning Unit
2010 & 2075
Louisiana Coastal Protection and Restoration

Planning Unit	Residential Units	Non Residential Units	Number of Vehicles	Roads (miles)	Railroads (miles)
High Employment Future Development Scenario and Dispersed Land Use Allocation Scenario					
			2010		
1	234,080	11,582	403,974	5,503	326
2	119,698	3,987	188,014	2,530	152
3a	57,830	2,888	94,018	1,973	46
3b	30,849	1,394	48,802	2,055	123
4	43,777	1,645	72,535	3,011	92
Total:	486,234	21,497	807,344	15,072	738
			2075		
1	438,340	23,121	746,444	5,503	326
2	172,021	6,080	270,645	2,530	152
3a	78,140	3,835	127,149	1,973	46
3b	39,527	1,520	62,031	2,055	123
4	56,108	2,197	92,985	3,011	92
Total:	784,136	36,753	1,299,255	15,072	738
Business As Usual Future Development Scenario and Compact Land Use Allocation Scenario					
			2010		
1	253,498	11,689	424,110	5,503	326
2	111,552	4,001	184,051	2,530	152
3a	56,477	2,788	87,991	1,973	46
3b	31,099	1,239	48,160	2,055	123
4	38,084	1,788	61,916	3,011	92
Total:	490,709	21,506	806,228	15,072	738
			2075		
1	312,345	14,480	519,292	5,503	326
2	130,678	4,720	215,425	2,530	152
3a	64,358	3,150	100,291	1,973	46
3b	39,229	1,767	61,670	2,055	123
4	45,805	2,139	74,280	3,011	92
Total:	592,415	26,256	970,957	15,072	738

Source: GIS Economic Application Databases

Notes:
1. Residential and non-residential include structures and vehicles were included in portions of 23 parishes that are directly affected by storm surges.

Table 3
Total Value of Assets by Planning Unit
2010 & 2075 (2007 Price Level)
Louisiana Coastal Protection and Restoration

Planning Unit	Residential ($1,000)	Non Residential ($1,000)	Roads ($1,000)	Railroads ($1,000)
	High Employment Future Development Scenario and Dispersed Land Use Allocation Scenario			
	2010			
1	51,875,588	14,967,869	12,127,003	352,946
2	27,567,369	8,931,551	4,975,878	164,694
3a	12,076,274	7,788,917	4,237,566	49,615
3b	5,507,509	3,692,715	3,596,335	132,982
4	9,005,410	4,599,943	6,074,581	100,196
Total:	106,032,150	39,980,995	31,011,363	800,433
	2075			
1	96,635,016	30,850,992	12,127,003	352,946
2	39,425,996	13,253,232	4,975,878	164,694
3a	16,446,755	10,620,182	4,237,566	49,615
3b	7,170,449	4,142,639	3,596,335	132,982
4	11,529,069	6,058,856	6,074,581	100,196
Total:	171,207,285	64,925,902	31,011,363	800,433
	Business As Usual Future Development Scenario and Compact Land Use Allocation Scenario			
	2010			
1	52,717,249	16,585,511	12,127,003	352,946
2	23,916,143	11,817,697	4,975,878	164,694
3a	10,398,174	7,322,588	4,237,566	49,615
3b	4,915,343	3,708,721	3,596,335	132,982
4	7,178,151	7,575,302	6,074,581	100,196
Total:	99,125,060	47,009,819	31,011,363	800,433
	2075			
1	64,439,657	20,581,624	12,127,003	352,946
2	28,003,882	13,908,533	4,975,878	164,694
3a	11,898,569	8,322,878	4,237,566	49,615
3b	6,227,461	5,405,167	3,596,335	132,982
4	8,618,310	8,845,542	6,074,581	100,196
Total:	119,187,879	57,063,744	31,011,363	800,433

Source: GIS Economic Application Databases

Notes:

Table 4
Average Building Value by
Non-residential Occupancy Category
2007 Price Level
Louisiana Coastal Protection and Restoration

Non-Residential Occupancy Category	Average Building Value ($)
Eating and Recreation	$ 166,644
Groceries and Gas Stations	151,613
Professional Buildings	503,583
Public and Semi-Public Buildings	699,987
Repair and Home Use	111,812
Retail and Personal Services	263,369
Warehouses and Contractor Services	241,252
Industrial Buildings	2,728,950

Source: USACE and Marshall and Swift Valuation Service

Table 5
Contents-to-Structure Value Ratios
Louisiana Coastal Protection and Restoration

Structure Category		Feasibility Study		
		Jefferson and Orleans Area (%)	Donaldsonville to the Gulf Area (%)	Lower Atchafalaya and Morganza to the Gulf Area (%)
Residential	One-story	69	69	71
	Two-story	59	67	50
	Mobile home	79	112	148
	Multi-family residence	37	27	23
Non-residential	Eating and Recreation	114	83	306
	Groceries and Gas Stations	127	397	128
	Professional Buildings	43	44	78
	Public and Semi-Public Buildings	114	79	82
	Repair and Home Use	206	74	251
	Retail and Personal Services	142	367	148
	Warehouses and Contractor Services	168	256	372
	Industrial Buildings	168	256	372

Source: USACE Feasibility Studies Depth Damage Panel of Experts.

Notes:
1. Depth-damage relationships developed by a panel of building and construction experts for the Jefferson and Orleans Parishes Feasibility Study in 1996; the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies in 1997; and the Donaldsonville to the Gulf, Louisiana Feasibility Study in 2006.

2. Saltwater, long-duration (one-week) depth damage curves were used to indicate the percentage of the structural value that was damaged at each depth of flooding.

Table 6
Historical and Projected Estimates of Population by Parish and MSA
26-Parish General Planning Area
High Employment Future Development/Dispersed Land Use Allocation Scenario
2005 to 2075
Louisiana Coastal Protection and Restoration

Parish	2nd Quarter 2005	4th Quarter 2005	July 2006	2010	2025	2030	2034	2050	2075
Baton Rouge MSA									
Ascension	86,259	98,039	97,478	110,542	132,814	139,071	144,080	212,002	262,591
East Baton Rouge	413,047	472,196	437,167	470,236	526,614	542,453	555,132	536,654	664,714
Iberville	32,611	35,323	33,567	37,623	44,538	46,481	48,036	65,822	81,529
Livingston	106,762	114,516	115,268	130,585	156,699	164,036	169,909	248,575	307,892
West Baton Rouge	22,077	24,312	22,554	27,513	35,968	38,343	40,245	80,480	99,685
Total	**660,756**	**744,386**	**706,034**	**776,499**	**896,633**	**930,384**	**957,402**	**1,143,533**	**1,416,411**
Houma MSA									
Lafourche	92,330	92,329	93,438	92,476	96,791	97,888	99,028	101,643	109,667
Terrebonne	106,632	108,844	108,938	107,676	113,334	114,773	116,268	133,285	143,807
Total	**198,962**	**201,173**	**202,376**	**200,152**	**210,125**	**212,661**	**215,296**	**234,928**	**253,473**
Lafayette MSA									
Lafayette	196,129	201,806	202,798	203,733	215,165	217,045	217,753	237,667	254,913
Saint Martin	50,961	52,223	51,114	51,362	54,400	54,899	55,087	63,145	67,727
Total	**247,090**	**254,029**	**253,912**	**255,095**	**269,565**	**271,944**	**272,840**	**300,812**	**322,640**
New Orleans MSA									
Jefferson	453,266	370,864	441,741	480,924	503,142	507,946	512,052	517,994	569,110
Orleans	463,283	140,534	201,474	235,315	254,505	258,654	262,200	447,382	491,530
Plaquemines	28,923	16,935	20,348	23,192	24,805	25,154	25,452	37,599	41,309
Saint Bernard	65,382	30,245	25,592	31,302	34,540	35,240	35,838	75,486	82,935
Saint Charles	50,313	46,984	50,969	55,556	58,157	58,719	59,200	60,637	66,621
Saint John the Baptist	45,380	45,380	48,742	52,967	55,362	55,881	56,323	55,852	61,363
Saint Tammany	210,352	186,304	223,432	269,800	296,092	301,778	306,636	612,982	673,471
Total	**1,316,899**	**837,246**	**1,012,298**	**1,149,056**	**1,226,603**	**1,243,372**	**1,257,701**	**1,807,932**	**1,986,339**
Lake Charles MSA									
Calcasieu	182,570	182,572	183,428	187,312	191,500	192,130	192,613	207,477	212,312
Cameron	9,960	7,752	8,086	8,218	8,360	8,381	8,397	7,036	7,200
Total	**192,530**	**190,324**	**191,514**	**195,530**	**199,860**	**200,511**	**201,011**	**214,513**	**219,512**
Non MSA									
Acadia	58,829	60,230	59,867	61,120	64,112	65,103	65,910	81,471	88,132
Assumption	23,377	24,081	23,671	23,683	24,247	24,427	24,577	30,821	32,035
Iberia	74,590	75,971	74,988	77,604	84,304	86,530	88,329	84,976	97,244
Jefferson Davis	31,583	31,583	31,057	31,558	31,859	31,309	31,282	43,396	43,001
Saint James	21,205	21,954	21,904	21,843	22,095	22,171	22,232	33,414	34,034
Saint Mary	52,437	54,097	52,065	51,861	49,665	49,397	49,266	50,671	48,033
Tangipahoa	104,956	109,527	112,464	116,045	142,527	151,354	158,461	195,676	270,689
Vermilion	54,925	54,925	55,074	55,816	61,237	63,028	64,476	64,027	74,407
Total	**421,902**	**432,368**	**431,090**	**439,530**	**480,046**	**493,319**	**504,533**	**584,452**	**687,574**
26-parish Total	**3,038,139**	**2,659,526**	**2,797,224**	**3,015,862**	**3,282,832**	**3,352,191**	**3,408,782**	**4,286,170**	**4,885,949**

Source: Calthorpe Associates, Moody's Economy.com, and Louisiana Tech University for July 2006.

Table 7
Historical and Projected Estimates of Population by Parish and MSA
26-Parish General Planning Area
Business as Usual Future Development/Compact Land Use Allocation Scenario
2005 to 2075
Louisiana Coastal Protection and Restoration

Parish	2nd Quarter 2005	4th Quarter 2005	July 2006	2010	2025	2030	2034	2050	2075
Baton Rouge MSA									
Ascension	86,259	98,039	97,478	106,669	118,266	121,304	123,646	136,476	159,300
East Baton Rouge	413,047	472,196	437,167	480,657	535,536	549,913	560,994	621,708	729,709
Iberville	32,611	35,323	33,567	35,393	37,697	38,301	38,766	41,315	45,850
Livingston	106,762	114,516	115,268	126,245	140,096	143,725	146,522	161,846	189,105
West Baton Rouge	22,077	24,312	22,554	28,232	35,397	37,275	38,721	46,648	60,750
Total	**660,756**	**744,386**	**706,034**	**777,196**	**866,992**	**890,517**	**908,649**	**1,007,993**	**1,184,713**
Houma MSA									
Lafourche	92,330	92,329	93,438	92,049	94,003	94,267	94,677	96,469	99,332
Terrebonne	106,632	108,844	108,938	107,503	109,522	109,795	110,219	112,070	115,028
Total	**198,962**	**201,173**	**202,376**	**199,551**	**203,525**	**204,062**	**204,896**	**208,538**	**214,360**
Lafayette MSA									
Lafayette	196,129	201,806	202,798	203,209	214,557	216,561	217,316	227,233	243,596
Saint Martin	50,961	52,223	51,114	51,191	53,309	53,684	53,824	55,676	58,731
Total	**247,090**	**254,029**	**253,912**	**254,399**	**267,867**	**270,245**	**271,140**	**282,908**	**302,327**
New Orleans MSA									
Jefferson	453,266	370,864	441,741	479,803	485,279	486,062	487,068	491,998	499,846
Orleans	463,283	140,534	201,474	240,485	246,098	246,900	247,931	252,985	261,028
Plaquemines	28,923	16,935	20,348	22,585	22,907	22,953	23,012	23,302	23,763
Saint Bernard	65,382	30,245	25,592	30,608	31,329	31,433	31,565	32,215	33,249
Saint Charles	50,313	46,984	50,969	54,808	55,360	55,439	55,541	56,038	56,829
Saint John the Baptist	45,380	45,380	48,742	52,322	52,837	52,911	53,005	53,469	54,207
Saint Tammany	210,352	186,304	223,432	262,145	267,715	268,511	269,534	274,550	282,532
Total	**1,316,899**	**837,246**	**1,012,298**	**1,142,757**	**1,161,526**	**1,164,209**	**1,167,656**	**1,184,557**	**1,211,455**
Lake Charles MSA									
Calcasieu	182,570	182,572	183,428	187,319	191,514	192,145	192,629	196,252	202,048
Cameron	9,960	7,752	8,086	8,211	8,346	8,366	8,381	8,498	8,684
Total	**192,530**	**190,324**	**191,514**	**195,530**	**199,859**	**200,511**	**201,011**	**204,750**	**210,732**
Non MSA									
Acadia	58,829	60,230	60,233	61,080	63,557	64,377	65,045	67,831	72,425
Assumption	23,377	24,081	23,488	23,661	24,074	24,205	24,315	24,761	25,475
Iberia	74,590	75,971	75,900	77,521	83,088	84,937	86,432	92,935	104,089
Jefferson Davis	31,583	31,583	31,501	31,557	31,316	31,256	31,223	31,003	30,662
Saint James	21,205	21,954	21,755	21,841	22,023	22,078	22,122	22,311	22,610
Saint Mary	52,437	54,097	53,213	51,801	49,038	48,701	48,536	46,475	43,428
Tangipahoa	104,956	109,527	109,956	115,567	135,215	141,764	147,037	172,645	221,873
Vermilion	54,925	54,925	54,451	55,748	60,272	61,766	62,975	68,306	77,553
Total	**421,902**	**432,368**	**430,497**	**438,775**	**468,583**	**479,085**	**487,686**	**526,268**	**598,115**
26-parish Total	**3,038,139**	**2,659,526**	**2,796,631**	**3,008,208**	**3,168,352**	**3,208,628**	**3,241,038**	**3,415,014**	**3,721,702**

Source: Calthorpe Associates, Moody's Economy.com, and Louisiana Tech University for July 2006.

Table 8
Historical and Projected Estimates of Number of Households by Parish and MSA
26-Parish General Planning Area
High Employment Future Development/Dispersed Land Use Allocation Scenario
2005 to 2075
Louisiana Coastal Protection and Restoration

Parish	2nd Quarter 2005	4th Quarter 2005	July 2006	2010	2025	2030	2034	2050	2075
Baton Rouge MSA									
Ascension	30,319	36,445	35,566	41,004	52,041	54,658	56,927	81,265	106,423
East Baton Rouge	156,290	179,942	159,504	172,805	199,796	206,197	211,746	198,742	260,270
Iberville	10,377	11,291	12,247	13,999	17,555	18,398	19,129	26,180	34,285
Livingston	37,758	40,065	42,056	48,766	62,382	65,611	68,411	100,259	131,298
West Baton Rouge	7,798	8,535	8,229	10,398	14,801	15,845	16,750	32,416	42,452
Total	**242,542**	**276,278**	**257,602**	**286,973**	**346,574**	**360,709**	**372,963**	**438,862**	**574,727**
Houma MSA									
Lafourche	33,001	33,371	32,846	32,919	35,593	36,012	36,473	38,662	42,293
Terrebonne	36,718	38,180	38,295	38,388	41,816	42,353	42,944	49,558	54,213
Total	**69,719**	**71,551**	**71,142**	**71,307**	**77,409**	**78,365**	**79,418**	**88,220**	**96,506**
Lafayette MSA									
Lafayette	74,465	78,024	76,281	77,646	84,735	85,150	85,129	93,212	100,754
Saint Martin	17,911	18,292	19,226	19,597	21,523	21,636	21,630	25,326	27,375
Total	**92,376**	**96,316**	**95,507**	**97,243**	**106,258**	**106,786**	**106,760**	**118,538**	**128,129**
New Orleans MSA									
Jefferson	175,509	139,874	167,758	184,300	197,441	198,809	199,931	217,587	239,763
Orleans	180,019	57,709	76,513	90,901	102,330	103,520	104,495	189,247	208,535
Plaquemines	9,740	5,822	7,727	8,924	9,874	9,973	10,054	15,737	17,341
Saint Bernard	24,369	11,498	9,719	12,142	14,067	14,267	14,432	31,872	35,120
Saint Charles	17,109	15,613	19,356	21,248	22,752	22,908	23,036	24,889	27,426
Saint John the Baptist	15,015	15,172	18,511	20,231	21,598	21,740	21,857	22,630	24,936
Saint Tammany	75,895	64,947	84,852	104,501	120,110	121,735	123,067	258,453	284,794
Total	**497,656**	**310,635**	**384,435**	**442,247**	**488,171**	**492,952**	**496,872**	**760,415**	**837,915**
Lake Charles MSA									
Calcasieu	68,432	68,432	68,737	71,126	75,181	75,138	75,059	83,995	87,843
Cameron	3,469	2,734	3,030	3,132	3,306	3,304	3,301	3,596	3,761
Total	**71,901**	**71,166**	**71,767**	**74,258**	**78,487**	**78,442**	**78,360**	**87,591**	**91,604**
Non MSA									
Acadia	21,163	21,665	21,558	22,501	24,444	24,730	24,960	32,602	36,323
Assumption	8,210	8,564	8,216	8,501	9,022	9,054	9,082	11,379	12,190
Iberia	25,708	26,621	26,023	27,303	30,768	31,458	32,010	32,960	38,899
Jefferson Davis	11,555	11,555	11,477	11,774	12,112	12,049	12,002	16,933	17,274
Saint James	6,998	7,370	7,005	7,362	7,737	7,733	7,728	12,325	12,964
Saint Mary	18,815	19,222	18,493	18,991	18,839	18,668	18,561	19,745	19,280
Tangipahoa	38,606	36,506	39,356	43,094	54,801	57,981	60,520	81,955	116,735
Vermilion	20,128	19,763	20,543	21,062	23,912	24,523	25,011	25,904	30,982
Total	**151,183**	**151,266**	**152,671**	**160,588**	**181,637**	**186,196**	**189,875**	**233,803**	**284,647**
26-parish Total	**1,125,377**	**977,212**	**1,033,124**	**1,132,617**	**1,278,537**	**1,303,450**	**1,324,247**	**1,727,429**	**2,013,529**

Source: Calthorpe Associates, Moody's Economy.com, and Louisiana Tech University for July 2006.

Table 9
Historical and Projected Estimates of Number of Households by Parish and MSA
26-Parish General Planning Area
Business as Usual Future Development/Compact Land Use Allocation Scenario
2005 to 2075
Louisiana Coastal Protection and Restoration

Parish	2nd Quarter 2005	4th Quarter 2005	July 2006	2010	2025	2030	2034	2050	2075
Baton Rouge MSA									
Ascension	30,319	36,445	35,601	39,289	45,349	46,641	47,767	54,473	66,982
East Baton Rouge	156,290	179,942	159,662	177,484	206,762	213,004	218,447	250,844	311,286
Iberville	10,377	11,291	12,259	13,014	14,253	14,517	14,747	16,119	18,677
Livingston	37,758	40,065	42,098	46,844	54,641	56,303	57,753	66,380	82,476
West Baton Rouge	7,798	8,535	8,237	10,720	14,798	15,668	16,426	20,939	29,359
Total	**242,542**	**276,278**	**257,857**	**287,351**	**335,804**	**346,134**	**355,141**	**408,756**	**508,781**
Houma MSA									
Lafourche	33,001	33,371	32,846	32,822	34,753	34,867	35,067	36,641	38,976
Terrebonne	36,718	38,180	38,295	38,271	40,225	40,341	40,543	42,137	44,501
Total	**69,719**	**71,551**	**71,142**	**71,093**	**74,978**	**75,208**	**75,609**	**78,779**	**83,478**
Lafayette MSA									
Lafayette	74,465	78,024	76,281	77,517	84,755	85,201	85,180	90,685	99,993
Saint Martin	17,911	18,292	19,226	19,461	20,834	20,918	20,914	21,959	23,724
Total	**92,376**	**96,316**	**95,507**	**96,978**	**105,589**	**106,119**	**106,095**	**112,644**	**123,717**
New Orleans MSA									
Jefferson	175,509	139,874	167,758	183,880	190,414	190,209	190,131	194,467	212,393
Orleans	180,019	57,709	76,513	93,141	99,880	99,668	99,588	104,060	122,548
Plaquemines	9,740	5,822	7,727	8,671	9,053	9,041	9,036	9,290	10,339
Saint Bernard	24,369	11,498	9,719	11,856	12,722	12,695	12,684	13,259	15,635
Saint Charles	17,109	15,613	19,356	20,966	21,619	21,598	21,590	22,023	23,813
Saint John the Baptist	15,015	15,172	18,511	19,989	20,588	20,569	20,562	20,960	22,604
Saint Tammany	75,895	64,947	84,852	101,321	107,996	107,787	107,707	112,137	130,449
Total	**497,656**	**310,635**	**384,435**	**439,823**	**462,272**	**461,567**	**461,299**	**476,195**	**537,780**
Lake Charles MSA									
Calcasieu	68,432	68,432	68,737	71,131	75,195	75,151	75,072	77,820	83,503
Cameron	3,469	2,734	3,030	3,127	3,293	3,291	3,288	3,399	3,630
Total	**71,901**	**71,166**	**71,767**	**74,258**	**78,487**	**78,442**	**78,360**	**81,219**	**87,134**
Non MSA									
Acadia	21,163	21,665	21,762	22,391	24,115	24,331	24,503	26,020	28,801
Assumption	8,210	8,564	8,323	8,510	8,968	8,980	8,991	9,327	9,950
Iberia	25,708	26,621	26,451	27,427	30,463	31,014	31,454	34,461	40,051
Jefferson Davis	11,555	11,555	11,571	11,759	12,071	12,001	11,950	12,080	12,378
Saint James	6,998	7,370	7,214	7,358	7,702	7,688	7,676	7,896	8,312
Saint Mary	18,815	19,222	19,325	19,087	18,699	18,498	18,375	17,915	17,160
Tangipahoa	38,606	36,506	40,196	42,860	51,883	54,184	56,018	66,965	89,493
Vermilion	20,128	19,763	20,185	20,962	23,437	23,926	24,316	26,845	31,566
Total	**151,183**	**151,266**	**155,027**	**160,354**	**177,338**	**180,622**	**183,283**	**201,509**	**237,713**
26-parish Total	**1,125,377**	**977,212**	**1,035,735**	**1,129,857**	**1,234,467**	**1,248,092**	**1,259,786**	**1,359,101**	**1,578,602**

Source: Calthorpe Associates, Moody's Economy.com, and Louisiana Tech University for July 2006.

Table 10
Historical and Projected Estimates of Employment by Parish and MSA
26-Parish General Planning Area
High Employment Future Development/Dispersed Land Use Allocation Scenario
2005 to 2075
Louisiana Coastal Protection and Restoration

Parish	2nd Quarter 2005	4th Quarter 2005	July 2006	2010	2025	2030	2034	2050	2075
Baton Rouge MSA									
Ascension	26,232	28,535	44,916	50,483	69,402	74,266	76,870	123,173	176,354
East Baton Rouge	216,505	238,352	201,436	216,283	266,729	279,698	286,640	328,432	470,236
Iberville	10,216	11,360	15,467	17,390	23,925	25,606	26,505	42,548	60,918
Livingston	16,414	17,295	53,113	61,100	88,239	95,216	98,951	176,690	252,978
West Baton Rouge	8,288	9,191	10,392	12,618	20,183	22,127	23,168	49,247	70,510
Total	**277,655**	**304,733**	**325,324**	**357,874**	**468,479**	**496,913**	**512,133**	**720,090**	**1,030,996**
Houma MSA									
Lafourche	29,259	31,355	39,269	38,538	43,146	43,492	42,870	35,055	40,339
Terrebonne	39,024	42,000	45,783	44,492	52,628	53,239	52,141	61,890	71,219
Total	**68,283**	**73,355**	**85,053**	**83,030**	**95,775**	**96,730**	**95,011**	**96,945**	**111,558**
Lafayette MSA									
Lafayette	95,010	103,364	112,794	113,381	136,306	138,723	137,290	155,052	187,089
St. Martin	8,811	9,565	28,429	28,531	32,492	32,910	32,663	26,797	32,334
Total	**103,821**	**112,929**	**141,223**	**141,912**	**168,798**	**171,633**	**169,952**	**181,849**	**219,423**
New Orleans MSA									
Jefferson	192,735	161,903	221,748	225,391	253,755	258,712	259,473	286,211	335,080
Orleans	230,284	102,821	101,137	104,342	129,290	133,650	134,320	251,748	294,733
Plaquemines	11,756	7,408	10,214	10,450	12,281	12,601	12,650	18,479	21,634
St. Bernard	15,454	9,908	12,847	13,152	15,524	15,938	16,002	23,936	28,023
St. Charles	18,841	17,648	25,586	25,945	28,744	29,233	29,308	28,242	33,064
St. John the Baptist	11,177	11,173	24,468	24,782	27,225	27,652	27,718	24,658	28,868
St. Tammany	59,933	55,542	112,160	115,668	142,983	147,757	148,490	275,625	322,687
Total	**540,180**	**366,403**	**508,160**	**519,730**	**609,802**	**625,544**	**627,962**	**908,899**	**1,064,090**
Lake Charles MSA									
Calcasieu	74,425	78,804	91,038	90,122	101,820	101,223	97,323	122,829	130,770
Cameron	2,340	2,476	4,013	3,994	4,234	4,222	4,142	2,515	2,678
Total	**76,765**	**81,280**	**95,052**	**94,116**	**106,054**	**105,445**	**101,465**	**125,344**	**133,448**
Non MSA									
Acadia	12,552	13,609	13,273	14,338	15,199	15,673	16,295	28,413	32,466
Assumption	3,104	3,453	4,154	4,353	4,490	4,564	4,686	4,593	4,960
Iberia	23,511	25,320	29,842	32,250	35,114	36,491	38,168	36,405	43,389
Jefferson Davis	6,616	7,298	7,377	7,932	7,967	8,095	8,328	12,763	13,427
St. James	6,604	6,864	6,983	7,291	7,466	7,559	7,725	12,639	13,423
St. Mary	19,344	20,987	24,056	24,802	23,767	23,898	24,377	20,612	20,244
Tangipahoa	26,222	28,834	35,438	39,789	48,492	52,051	55,777	64,334	91,463
Vermilion	9,193	10,170	12,850	13,724	15,147	15,785	16,538	14,242	17,296
Total	**107,146**	**116,535**	**133,971**	**144,478**	**157,643**	**164,116**	**171,894**	**194,001**	**236,668**
26-parish Total	**1,173,850**	**1,055,235**	**1,288,782**	**1,341,141**	**1,606,550**	**1,660,381**	**1,678,416**	**2,227,128**	**2,796,182**

Source: Calthorpe Associates, Moody's Economy.com, and Louisiana Tech University for July 2006.

Table 11
Historical and Projected Estimates of Employment by Parish and MSA
26-Parish General Planning Area
Business as Usual Future Development/Compact Land Use Allocation Scenario
2005 to 2075
Louisiana Coastal Protection and Restoration

Parish	2nd Quarter 2005	4th Quarter 2005	July 2006	2010	2025	2030	2034	2050	2075
Baton Rouge MSA									
Ascension	26,232	28,535	45,205	48,118	55,527	56,957	57,435	65,049	79,747
East Baton Rouge	216,505	238,352	202,735	225,488	283,370	294,537	298,277	357,752	472,577
Iberville	10,216	11,360	15,567	16,346	18,327	18,710	18,838	20,874	24,805
Livingston	16,414	17,295	53,455	56,493	64,222	65,713	66,212	74,153	89,484
West Baton Rouge	8,288	9,191	10,459	13,996	22,993	24,728	25,310	34,554	52,402
Total	**277,655**	**304,733**	**327,422**	**360,440**	**444,440**	**460,644**	**466,072**	**552,381**	**719,015**
Houma MSA									
Lafourche	29,259	31,355	39,269	38,069	41,416	41,280	40,160	41,617	44,002
Terrebonne	39,024	42,000	45,783	44,377	48,300	48,140	46,827	48,535	51,330
Total	**68,283**	**73,355**	**85,053**	**82,445**	**89,716**	**89,420**	**86,987**	**90,153**	**95,331**
Lafayette MSA									
Lafayette	95,010	103,364	112,794	112,266	132,589	134,585	132,507	147,732	174,682
Saint Martin	8,811	9,565	28,429	28,383	30,163	30,338	30,156	31,490	33,850
Total	**103,821**	**112,929**	**141,223**	**140,648**	**162,752**	**164,923**	**162,663**	**179,221**	**208,533**
New Orleans MSA									
Jefferson	192,735	161,903	221,748	224,556	239,555	240,549	237,412	246,582	261,944
Orleans	230,284	102,821	101,137	104,391	121,769	122,921	119,286	129,911	147,711
Plaquemines	11,756	7,408	10,214	10,390	11,328	11,390	11,194	11,767	12,727
Saint Bernard	15,454	9,908	12,847	13,099	14,446	14,535	14,253	15,077	16,457
Saint Charles	18,841	17,648	25,586	25,851	27,268	27,362	27,066	27,932	29,384
Saint John the Baptist	11,177	11,173	24,468	24,695	25,911	25,992	25,738	26,481	27,727
Saint Tammany	59,933	55,542	112,160	114,762	128,663	129,584	126,677	135,176	149,413
Total	**540,180**	**366,403**	**508,160**	**517,745**	**568,941**	**572,334**	**561,625**	**592,926**	**645,362**
Lake Charles MSA									
Calcasieu	74,425	78,804	91,038	90,055	101,074	100,266	96,200	100,523	106,195
Cameron	2,340	2,476	4,013	3,992	4,230	4,212	4,125	4,218	4,340
Total	**76,765**	**81,280**	**95,052**	**94,047**	**105,303**	**104,479**	**100,325**	**104,741**	**110,535**
Non MSA									
Acadia	12,552	13,609	12,082	13,773	14,497	15,087	15,861	17,426	20,789
Assumption	3,104	3,453	3,631	4,111	4,233	4,373	4,571	4,906	5,602
Iberia	23,511	25,320	26,861	30,838	33,425	35,102	37,162	42,083	53,135
Jefferson Davis	6,616	7,298	6,858	7,722	7,753	7,948	8,260	8,639	9,397
Saint James	6,604	6,864	6,080	6,864	7,008	7,221	7,531	8,011	8,995
Saint Mary	19,344	20,987	21,539	23,575	22,557	23,002	23,840	24,018	24,357
Tangipahoa	26,222	28,834	32,330	38,197	45,186	48,659	52,497	64,894	96,567
Vermilion	9,193	10,170	11,403	13,118	14,328	15,079	15,991	18,249	23,375
Total	**107,146**	**116,535**	**120,783**	**138,198**	**148,987**	**156,472**	**165,713**	**188,226**	**242,217**
26-parish Total	**1,173,850**	**1,055,235**	**1,277,691**	**1,333,523**	**1,520,138**	**1,548,271**	**1,543,384**	**1,707,648**	**2,020,994**

Source: Calthorpe Associates, Moody's Economy.com, and Louisiana Tech University for July 2006.

Table 12
Average Expenditure per Inundated Structure
Government Emergency Protective Measures
FEMA Category B Expenditures
Louisiana Coastal Protection and Restoration

Storm Event	Year of Event	FEMA Category B Protective Measures Expenditures (As Reported in Year of Event) ($)	Structures Inundated	Average Expenditure Per Inundated Structure (2007 Price Level) ($)
Hurricane Juan	1985	$ 856,000	4,445	$ 366
Hurricane Andrew	1992	1,560,000	2,500	998
May 1995 Flood	1995	1,359,026	43,400	46
Hurricanes Katrina & Rita	2005	744,358,412	204,682	3,894

Source: FEMA data and USACE Post Flood Reports

Note: The total Category B expenditures (wind and flood) were adjusted to reflect only inundation damage.

Table 13
Average Emergency Cost per Inundated Structure
Emergency Expenditures Depth-Damage Relationships
2007 Price Levels
Louisiana Coastal Protection and Restoration

Flood Depth (feet)	Government Emergency Response ($)	Residential (one and two story structures) ($)	Residential Mobile Home ($)	Non-Residential ($)
0	-	-	-	-
1	$ 366	$ 34,236	$ 25,511	$ 138,523
2	998	49,223	40,498	150,826
3	3,894	65,002	56,276	150,826
4	3,894	65,002	56,276	150,826
5	3,894	65,002	56,276	150,826
6	3,894	69,802	61,076	150,826
7	3,894	69,802	61,076	150,826
8	3,894	69,802	61,076	150,826
9	3,894	69,802	61,076	150,826
10	3,894	69,802	61,076	150,826
11	3,894	69,802	61,076	150,826
12	3,894	69,802	61,076	150,826
13	3,894	69,802	61,076	150,826
14	3,894	69,802	61,076	150,826
15	3,894	69,802	61,076	150,826

Source: GIS Economic Application Databases

Notes:
1. The average government emergency response expenditure per inundated structure includes search and rescue operations, emergency repairs to public properties and security by flood depth.
2. The average emergency expenditures per inundated residential structure includes the costs associated with evacuation and subsistence, clean-up and reoccupation, landscaping and debris removal by flood depth.
3. The average emergency expenditures per inundated non-residential structure includes the costs associated with clean-up and restoration by flood depth.

Table 14
Highways, Streets, and Railroad Depth-Damage Relationships
2007 Price Levels
Louisiana Coastal Protection and Restoration

Flood Depth (feet)	Damage per mile Highways ($)	Damage per mile Roads ($)	Damage per mile Single RR Track ($)
0	-	-	-
1	$ 689,808	$ 172,452	$ 452,962
2	698,020	174,505	462,333
3	714,444	178,611	471,705
4	739,080	184,770	481,076
5	755,504	188,876	490,448
6	771,928	192,982	499,820
7	788,352	197,088	510,753
8	804,776	201,194	520,125
9	821,200	205,300	531,058
10	821,200	205,300	541,992
11	821,200	205,300	541,992
12	821,200	205,300	541,992
13	821,200	205,300	541,992
14	821,200	205,300	541,992
15	821,200	205,300	541,992

Source: GIS Economic Application Databases

Notes: Based on repair costs per mile received from Engineering Division and damage percentage for each one-foot increment of flooding developed as part of the Economic Data Survey for the Mississippi River and Tributaries Protected Area.

Table 15
Agricultural Acres by Planning Unit
2005
Louisiana Coastal Protection and Restoration

Planning Unit	Acres
1	621,940
2	621,684
3a	573,928
3b	850,283
4	1,237,895
Total	3,905,730

Source: GIS Economic Application Databases

Table 16
Hurricanes Affecting the Louisiana Coast by Month
1851 - 2005
Louisiana Coastal Protection and Restoration

Month	Number of Occurrences	Percentage chance of occuring in that month (%)
June	3	6
July	3	6
August	14	27
September	22	43
October	9	18
November	0	0

Source: National Oceanic and Atmospheric Administration

Table 17
Agricultural Damage Rates
2007 Price Levels
Louisiana Coastal Protection and Restoration

Crop	Damage Rate Per Acre ($)
Corn	$ 215.81
Cotton	74.29
Sorghum	237.28
Soybeans	248.38
Winter Wheat	81.27
Small Grains & Hay	111.09
Sugar Cane	278.34
Fallow Cropland	80.21
Pecans	307.44
Fallow Idle Cropland	80.21
Pasture	218.05
Citrus	7,585.23
Rice (except for rice-crawfish parishes below)	317.84
Crawfish in St. Martin and Acadia Parishes	779.35
Rice-Crawfish double crop in Calcasieu Parish	415.74
Rice-Crawfish double crop in Jefferson Davis Parish	433.50
Rice-Crawfish double crop in Lafayette Parish	835.88
Rice-Crawfish double crop in Vermillion Parish	437.39

Source: USACE and LSU Agricultural Center

Table 18
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, No Sea Level Rise Scenario
2010
Planning Unit 1
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
Base Condition	Base	NONE	909,900	4,271,509	30,365,288	43,457,602	63,360,070	121,461	185,545	423,299	507,580	669,405
Comprehensive Plans	C-HL-a-100-2	NONE	618,610	1,055,382	30,336,365	41,654,089	62,321,814	112,657	131,951	422,820	501,613	664,784
	C-HL-a-100-3	NONE	615,875	1,061,991	30,064,308	41,486,899	62,241,315	113,491	133,816	421,609	500,290	663,917
	C-HL-b-400-2	NONE	610,640	852,072	1,098,445	3,721,212	13,429,739	111,297	116,808	144,543	253,657	380,822
	C-HL-b-400-3	NONE	608,989	870,819	1,127,444	3,796,369	13,511,740	112,131	119,558	149,618	260,160	386,629
	C-LP-a-100-1	NONE	605,007	1,003,552	7,566,851	27,070,074	56,271,487	111,894	137,819	261,826	408,105	640,254
	C-LP-a-100-2	NONE	614,327	924,366	8,400,173	27,601,131	57,270,897	112,064	116,936	266,311	408,875	639,474
	C-LP-a-100-3	NONE	609,588	930,109	8,341,970	27,604,247	57,288,707	112,497	118,440	267,956	411,147	641,738
	C-LP-b-400-1	NONE	596,930	903,087	1,183,650	6,090,525	17,381,356	109,822	134,008	179,090	280,688	386,312
	C-LP-b-400-3	NONE	604,673	845,013	993,291	4,905,498	16,473,082	111,539	115,050	133,522	249,630	374,242
	C-LP-b-1000-1	NONE	593,936	880,971	1,037,389	1,353,502	4,302,196	108,204	131,575	166,193	206,452	275,690
	C-LP-b-1000-2	NONE	607,037	822,850	860,125	1,077,991	2,247,846	109,857	111,462	117,618	142,591	213,699
Structural Plans	HL-a-100-2	NONE	799,160	1,748,331	31,391,617	42,796,990	63,478,360	116,344	137,578	428,560	507,353	671,082
	HL-a-100-3	NONE	821,711	1,898,148	31,258,054	42,741,759	63,493,997	117,416	139,726	427,631	506,312	670,497
	HL-b-400-2	NONE	798,052	1,564,486	2,698,021	5,574,812	15,143,109	116,344	124,175	152,023	261,137	388,860
	HL-b-400-3	NONE	821,687	1,727,242	2,997,192	6,003,942	15,542,637	117,416	127,208	157,380	267,922	394,949
	LP-a-100-1	NONE	827,711	2,462,676	9,544,326	29,124,694	58,249,599	114,549	145,536	270,281	417,239	649,389
	LP-a-100-2	NONE	787,963	1,701,240	9,361,733	28,766,810	58,474,985	114,312	122,810	272,347	415,590	646,190
	LP-a-100-3	NONE	788,382	1,796,483	9,433,565	28,896,780	58,615,883	114,904	124,597	274,275	418,145	648,736
	LP-b-400-1	NONE	826,603	2,415,459	5,523,724	10,193,632	20,592,339	114,549	144,177	189,997	292,274	397,899
	LP-b-400-3	NONE	787,274	1,733,397	2,382,164	6,561,204	18,082,338	114,904	122,545	141,179	257,966	382,578
	LP-b-1000-1	NONE	826,603	2,414,383	5,443,014	8,581,117	10,984,901	114,549	144,152	179,798	220,735	289,974
	LP-b-1000-2	NONE	786,855	1,627,694	2,095,876	2,804,581	4,075,169	114,312	119,999	126,317	151,969	223,078
Non-Structural Plans	NS-100	NONE	350,612	959,927	27,797,591	41,296,327	61,469,690	116,354	177,199	414,450	498,732	660,000
	NS-400	NONE	135,068	497,031	2,295,142	31,495,890	55,542,012	109,505	169,668	406,920	491,202	652,469
	NS-1000	NONE	63,337	365,161	1,369,386	2,223,385	45,845,753	80,158	139,428	362,889	447,169	608,437

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 19
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, No Sea Level Rise Scenario
2010
Planning Unit 2
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
Base Condition	Base	NONE	833,906	3,114,492	31,106,264	34,223,677	35,193,190	62,047	82,310	345,635	352,944	354,414
Comprehensive Plans	C-G-100-1	NONE	192,115	482,380	3,134,938	6,849,284	8,454,969	54,475	69,384	99,678	105,599	112,153
	C-G-100-4	NONE	161,554	361,856	3,364,549	6,764,212	8,099,390	38,904	50,892	99,827	105,185	111,605
	C-G-400-4	NONE	153,600	300,468	481,643	1,731,122	2,908,424	38,313	45,776	50,143	59,829	77,850
	C-G-1000-4	NONE	147,015	242,401	270,437	661,128	1,283,035	37,095	41,706	44,343	46,483	53,991
	C-S-100-2	NONE	188,237	731,798	26,320,052	29,686,277	30,695,523	50,240	61,815	307,917	315,779	317,218
	C-S-100-3	NONE	167,855	672,109	26,233,402	29,670,919	30,630,566	42,862	54,441	307,917	315,779	317,218
	C-S-100-4	NONE	164,754	652,238	26,218,478	29,538,121	30,390,746	41,486	49,458	307,633	315,495	316,934
	C-S-400-2	NONE	178,420	352,422	828,891	5,074,346	19,909,541	49,334	57,853	69,827	138,723	283,688
	C-S-400-3	NONE	162,607	317,525	783,812	4,925,605	19,667,752	42,234	50,753	62,729	132,311	280,479
	C-S-400-4	NONE	159,505	302,300	758,853	4,774,849	19,425,357	40,858	45,571	57,236	127,444	278,005
	C-S-1000-4	NONE	153,339	269,097	296,974	448,299	2,157,465	39,492	44,150	49,090	56,144	85,735
	C-WBI-100-1	NONE	192,839	781,689	26,044,634	29,731,103	30,894,742	59,090	72,783	308,166	316,264	317,733
	C-WBI-400-1	NONE	182,448	381,403	885,703	5,500,908	20,424,790	58,184	69,237	82,605	146,837	285,715
Structural Plans	G-100-1	NONE	643,113	2,446,375	4,844,227	8,541,937	10,024,504	57,432	76,567	106,861	112,782	119,336
	G-100-4	NONE	545,127	2,088,626	4,756,969	8,140,158	9,373,087	41,861	58,075	107,010	112,368	118,788
	G-400-4	NONE	545,127	2,069,327	2,653,969	3,823,025	4,915,533	41,861	55,827	60,194	69,880	87,901
	G-1000-4	NONE	545,127	2,069,310	2,638,608	3,608,756	4,470,708	41,861	55,480	58,117	60,257	67,765
	S-100-2	NONE	711,768	2,595,980	28,072,845	31,286,407	32,140,283	53,197	68,998	315,100	322,962	324,401
	S-100-3	NONE	631,693	2,394,289	27,815,626	31,120,885	31,933,313	45,819	61,624	315,100	322,962	324,401
	S-100-4	NONE	621,819	2,270,898	27,698,092	30,894,667	31,623,722	44,443	56,641	314,816	322,678	324,117
	S-400-2	NONE	711,768	2,587,989	4,557,341	8,879,521	23,003,100	53,197	68,271	80,245	149,141	294,106
	S-400-3	NONE	631,693	2,385,969	4,053,119	8,255,017	22,342,397	45,819	60,893	72,869	142,451	290,619
	S-400-4	NONE	621,819	2,261,102	3,706,605	7,798,270	21,827,487	44,443	55,711	67,376	137,584	288,145
	S-1000-4	NONE	621,819	2,261,088	3,635,830	4,651,963	5,852,986	44,443	55,711	60,651	67,705	97,296
	WBI-100-1	NONE	833,906	3,101,090	28,199,246	31,588,468	32,530,934	62,047	79,966	315,349	323,447	324,916
	WBI-400-1	NONE	833,906	3,095,958	5,619,672	10,180,348	24,099,104	62,047	79,655	93,023	157,255	296,133
Non-Structural Plans	NS-100	NONE	172,264	770,079	28,951,349	32,366,117	33,556,926	59,090	75,127	338,452	345,761	347,231
	NS-400	NONE	94,565	276,356	2,105,909	7,181,160	15,865,144	45,467	56,779	303,839	311,147	312,618
	NS-1000	NONE	85,258	234,140	1,078,226	1,458,962	5,006,690	42,997	54,097	283,986	291,294	292,765

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 20
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, No Sea Level Rise Scenario
2010
Planning Unit 3a
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
Base Condition	Base	NONE	678,443	5,588,896	13,381,441	18,168,040	20,217,479	30,027	110,166	142,477	151,022	152,627
Comprehensive Plans	C-M-100-1	NONE	104,486	281,037	1,551,085	12,676,100	16,258,438	9,816	11,245	50,119	149,305	152,966
	C-R-100-1	NONE	70,166	669,689	4,132,244	16,309,382	16,649,135	7,120	19,652	77,885	152,875	152,966
	C-R-400-2	NONE	56,846	499,787	1,265,052	7,163,722	8,006,823	5,886	17,833	36,116	137,061	139,989
	C-R-1000-2	NONE	52,421	451,721	1,049,864	1,383,750	2,178,289	5,400	17,150	34,872	37,055	53,033
Structural Plans	M-100-1	NONE	276,821	739,781	1,835,669	12,804,790	16,343,122	9,890	11,319	50,193	149,379	153,040
	M-400-1	NONE	276,821	734,366	975,276	1,068,476	1,163,782	9,890	11,131	11,319	12,157	14,937
	M-1000-1	NONE	276,821	734,366	971,126	1,038,555	1,062,933	9,890	11,131	11,131	11,319	11,567
	R-100-1	NONE	243,128	1,197,334	4,447,620	16,455,539	16,742,385	7,194	19,726	77,959	152,949	153,040
	R-400-1	NONE	243,128	1,188,959	2,149,687	2,638,946	3,308,863	7,194	18,944	22,095	27,304	34,153
	R-400-2	NONE	246,342	1,194,715	2,522,654	9,063,999	9,684,162	7,269	19,216	38,273	139,218	142,146
	R-1000-1	NONE	243,128	1,188,904	2,143,089	2,546,861	2,857,703	7,194	18,944	21,435	23,569	25,736
	R-1000-2	NONE	246,342	1,194,660	2,515,906	4,186,930	4,728,950	7,269	19,216	37,714	39,897	55,875
Non-Structural Plans	NS-100	NONE	97,809	710,624	10,054,952	16,603,838	19,341,122	29,179	109,318	141,629	150,174	151,779
	NS-400	NONE	60,070	473,112	1,675,105	8,473,190	13,951,482	18,631	97,906	130,217	138,762	140,367
	NS-1000	NONE	46,056	407,481	1,347,369	2,552,518	6,094,879	12,148	88,127	120,436	128,981	130,586

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 21
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, No Sea Level Rise Scenario
2010
Planning Unit 3b
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
Base Condition	Base	NONE	523,000	2,569,273	5,781,130	8,062,926	9,443,491	15,543	42,347	64,641	77,884	81,782
Comprehensive Plans	C-F-100-1	NONE	53,688	157,856	3,990,231	8,461,465	9,088,816	1,853	3,894	55,448	82,024	82,299
	C-F-400-1	NONE	41,526	113,178	297,473	715,525	1,390,063	1,849	3,799	6,856	10,079	21,933
	C-F-1000-1	NONE	38,004	103,959	230,952	507,171	937,460	1,827	3,777	6,762	7,790	8,300
	C-G-100-1	NONE	42,798	93,039	329,852	2,718,966	5,796,235	333	830	7,319	42,129	69,396
	C-R-100-1	NONE	72,614	291,931	4,243,219	7,144,594	8,183,576	4,651	17,009	57,894	73,729	76,522
	C-R-400-1	NONE	60,451	212,713	445,039	3,518,267	5,960,783	4,647	14,751	28,715	46,966	57,289
Structural Plans	F-100-1	NONE	136,425	479,642	4,233,493	8,661,525	9,273,249	2,110	4,508	56,062	82,638	82,913
	F-400-1	NONE	136,425	477,324	754,731	1,110,670	1,665,440	2,110	4,417	7,474	10,697	22,551
	F-1000-1	NONE	136,425	477,324	752,841	1,083,756	1,342,953	2,110	4,417	7,402	8,430	8,940
	G-100-1	NONE	98,277	276,180	483,414	2,855,878	5,925,248	562	1,082	7,571	42,381	69,648
	G-400-1	NONE	98,277	275,755	352,150	439,615	505,877	562	1,082	2,038	2,369	3,120
	G-1000-1	NONE	98,277	275,755	351,880	436,425	480,277	562	1,082	2,038	2,197	2,668
	R-100-1	NONE	168,309	949,870	4,648,093	7,430,056	8,436,064	4,908	17,996	58,881	74,716	77,509
	R-400-1	NONE	168,309	918,563	2,383,952	4,685,388	6,506,607	4,908	15,742	29,706	47,957	58,280
	R-1000-1	NONE	168,309	918,562	2,350,129	3,257,000	4,418,337	4,908	15,742	27,514	33,156	46,797
Non-Structural Plans	NS-100	NONE	75,893	414,517	4,647,573	7,513,639	9,078,207	15,286	41,360	63,654	76,897	80,795
	NS-400	NONE	63,605	318,505	798,245	5,090,770	8,155,109	15,282	41,356	63,650	76,893	80,791
	NS-1000	NONE	54,485	293,219	560,298	890,274	4,341,890	14,622	40,650	62,942	76,186	80,084

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 22
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, No Sea Level Rise Scenario
2010
Planning Unit 4
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
Base Condition	Base	NONE	300,064	2,355,067	4,721,996	7,470,019	9,418,434	7,480	28,802	46,683	67,098	78,611
Comprehensive Plans	C-G-100-1	NONE	144,213	336,310	2,421,494	5,343,473	6,279,327	5,096	10,524	47,630	72,360	74,394
	C-G-100-2	NONE	169,015	470,779	2,644,429	5,465,741	6,308,001	5,678	11,667	49,152	72,701	74,455
	C-G-400-3	NONE	144,908	396,143	941,070	6,016,759	8,276,695	6,229	12,492	26,587	86,229	90,942
	C-G-1000-3	NONE	110,469	262,674	749,846	1,965,186	4,186,604	5,657	11,497	24,394	44,614	67,459
	C-R-100-1	NONE	156,817	508,949	3,145,974	5,305,016	6,451,160	7,595	22,375	55,565	69,558	73,585
	C-R-400-1	NONE	149,464	429,773	709,030	5,659,873	8,557,855	7,121	21,522	31,870	86,781	93,856
	C-R-1000-1	NONE	129,519	396,644	593,800	1,058,346	3,794,308	6,353	20,688	29,838	45,327	70,534
Structural Plans	G-100-1	NONE	279,546	1,776,551	3,660,405	6,430,009	7,294,928	7,911	14,038	51,144	75,874	77,908
	G-100-2	NONE	312,436	1,953,242	3,929,319	6,598,342	7,367,123	8,495	15,183	52,668	76,217	77,971
	G-400-1	NONE	279,546	1,773,040	2,469,825	5,722,034	7,665,911	7,911	13,807	17,431	61,623	67,613
	G-400-2	NONE	312,436	1,949,738	2,723,543	6,002,882	7,955,338	8,495	14,952	18,630	62,883	68,927
	G-400-3	NONE	317,630	1,977,072	3,158,608	8,048,156	9,960,157	9,968	16,975	31,070	90,712	95,425
	G-1000-1	NONE	279,546	1,773,040	2,462,550	3,798,049	4,923,748	7,911	13,807	17,104	28,812	43,692
	G-1000-2	NONE	312,436	1,949,738	2,716,267	4,078,768	5,212,600	8,495	14,952	18,303	30,072	44,952
	G-1000-3	NONE	317,630	1,977,072	3,144,258	5,453,994	7,254,135	9,968	16,975	29,872	50,092	72,937
	R-100-1	NONE	327,289	2,226,035	4,614,667	6,537,288	7,595,808	10,450	25,955	59,155	73,148	77,175
	R-400-1	NONE	327,573	2,221,353	3,829,141	8,337,202	10,545,373	10,531	25,703	36,061	90,972	98,047
	R-1000-1	NONE	327,573	2,221,353	3,814,791	5,743,040	7,839,351	10,531	25,703	34,863	50,352	75,559
Non-Structural Plans	NS-100	NONE	129,590	525,687	3,210,002	6,227,885	8,269,555	4,625	25,222	43,093	63,508	75,021
	NS-400	NONE	121,953	417,469	823,052	4,238,632	7,226,103	4,070	24,621	42,492	62,907	74,420
	NS-1000	NONE	102,009	384,340	636,804	1,218,628	4,121,054	3,302	23,787	41,658	62,073	73,586

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 23
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, No Sea Level Rise Scenario
2010
Planning Unit 1
Louisiana Coastal Protection and Restoration

	Sea Level	Sea Level	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
Base Condition	Base	NONE	878,019	4,540,557	31,728,840	45,148,336	66,252,178	119,827	199,650	445,625	530,762	709,318
Comprehensive Plans	C-HL-a-100-2	NONE	569,696	994,770	32,067,911	43,195,247	65,369,671	108,863	126,321	448,534	525,647	705,794
	C-HL-a-100-3	NONE	566,017	999,983	31,712,567	42,986,070	65,272,029	109,497	128,629	446,318	523,713	704,827
	C-HL-b-400-2	NONE	563,301	796,293	1,026,774	3,542,834	13,819,556	108,126	111,577	137,311	250,736	389,608
	C-HL-b-400-3	NONE	560,690	814,566	1,059,473	3,662,300	13,954,322	108,760	114,575	144,757	260,165	396,573
	C-LP-a-100-1	NONE	557,405	964,859	7,640,987	28,157,089	58,487,457	107,975	143,322	278,723	428,289	681,214
	C-LP-a-100-2	NONE	566,287	872,499	8,439,909	28,420,599	59,565,199	108,425	113,123	284,856	431,166	679,566
	C-LP-a-100-3	NONE	560,829	876,825	8,365,425	28,398,782	59,552,759	108,613	114,817	286,376	433,441	682,243
	C-LP-b-400-1	NONE	548,969	862,152	1,181,615	6,838,320	18,732,065	105,779	139,353	196,191	300,895	410,717
	C-LP-b-400-3	NONE	557,137	792,540	940,546	4,981,120	17,271,670	108,120	111,738	129,421	253,618	389,972
	C-LP-b-1000-1	NONE	546,443	840,118	1,026,012	1,366,936	4,805,383	105,239	137,945	183,820	228,464	302,381
	C-LP-b-1000-2	NONE	560,773	771,621	806,649	1,018,942	2,178,373	107,780	109,259	113,786	138,171	212,888
Structural Plans	HL-a-100-2	NONE	749,776	1,713,300	32,885,686	44,032,341	66,208,721	112,037	131,444	453,782	530,894	711,154
	HL-a-100-3	NONE	774,229	1,877,831	32,684,310	43,947,591	66,217,915	112,937	134,067	451,881	529,275	710,502
	HL-b-400-2	NONE	748,683	1,533,243	2,106,832	4,721,015	14,946,717	112,037	117,888	143,747	257,171	396,156
	HL-b-400-3	NONE	774,204	1,711,727	2,442,880	5,230,594	15,417,658	112,937	121,201	151,508	266,915	403,436
	LP-a-100-1	NONE	788,770	2,306,718	9,532,614	30,000,823	60,214,959	110,692	150,464	286,754	436,566	689,490
	LP-a-100-2	NONE	740,303	1,505,931	9,176,914	29,238,322	60,392,895	110,615	118,264	290,224	436,780	685,180
	LP-a-100-3	NONE	740,589	1,609,814	9,246,282	29,356,405	60,516,579	110,980	120,272	292,059	439,370	688,172
	LP-b-400-1	NONE	787,677	2,260,911	5,636,201	11,090,948	21,943,822	110,692	149,142	206,869	311,819	421,640
	LP-b-400-3	NONE	739,497	1,547,355	1,969,913	6,168,161	18,454,962	110,980	118,137	136,048	260,491	396,845
	LP-b-1000-1	NONE	787,677	2,259,791	5,556,181	9,530,082	12,301,562	110,692	149,116	196,036	240,925	314,842
	LP-b-1000-2	NONE	739,211	1,432,022	1,674,320	2,108,083	3,318,648	110,615	115,579	120,333	144,964	219,681
Non-Structural Plans	NS-100	NONE	329,445	979,317	29,136,268	43,062,802	64,461,831	114,922	191,224	436,520	521,657	700,100
	NS-400	NONE	124,253	520,916	2,321,617	31,644,626	57,707,067	108,257	183,768	429,063	514,200	692,643
	NS-1000	NONE	60,675	397,453	1,431,659	2,341,872	47,134,267	80,316	155,033	388,798	473,935	652,378

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 24
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, No Sea Level Rise Scenario
2010
Planning Unit 2
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
Base Condition	Base	NONE	825,558	3,234,816	30,815,997	33,053,798	33,907,323	42,312	68,077	324,633	331,348	331,884
Comprehensive Plans	C-G-100-1	NONE	178,904	464,653	2,989,701	5,739,298	6,814,214	35,700	49,984	75,228	80,228	85,421
	C-G-100-4	NONE	153,094	346,046	3,343,126	5,838,514	6,647,972	21,519	32,218	76,695	79,975	85,053
	C-G-400-4	NONE	145,233	289,842	360,268	1,112,915	1,769,251	20,865	27,591	31,131	39,127	54,843
	C-G-1000-4	NONE	138,917	232,064	256,976	311,488	553,797	19,802	23,076	25,314	27,019	32,606
	C-S-100-2	NONE	172,355	413,237	26,393,198	28,900,568	29,765,161	29,890	45,348	292,119	299,392	299,893
	C-S-100-3	NONE	157,182	373,379	26,454,258	28,999,462	29,833,602	24,642	40,104	292,119	299,392	299,893
	C-S-100-4	NONE	154,675	352,861	26,116,367	28,458,455	29,170,344	23,770	31,998	291,759	299,032	299,645
	C-S-400-2	NONE	162,706	338,953	472,920	4,571,726	20,003,299	29,157	41,731	50,433	127,550	272,278
	C-S-400-3	NONE	151,884	308,645	437,345	4,469,066	19,823,712	23,913	36,487	45,191	122,473	268,280
	C-S-400-4	NONE	149,377	291,812	407,335	4,237,033	19,269,449	23,041	28,327	36,891	114,457	264,186
	C-S-1000-4	NONE	143,424	258,739	281,917	384,838	1,675,587	22,795	28,016	31,460	36,921	66,710
	C-WBI-100-1	NONE	177,397	467,369	26,087,990	28,958,220	30,017,721	39,476	56,940	292,401	300,003	300,538
	C-WBI-400-1	NONE	167,108	369,780	535,351	5,025,601	20,547,919	38,743	53,794	64,620	136,727	275,698
Structural Plans	G-100-1	NONE	622,134	2,555,145	4,862,845	7,473,154	8,415,450	38,537	57,733	82,977	87,977	93,170
	G-100-4	NONE	523,364	2,177,751	4,879,248	7,237,834	7,938,890	24,356	39,967	84,444	87,724	92,802
	G-400-4	NONE	523,364	2,158,847	2,728,049	3,194,629	3,737,203	24,356	38,198	41,738	49,734	65,450
	G-1000-4	NONE	523,364	2,158,830	2,712,950	2,979,780	3,259,310	24,356	37,856	40,094	41,799	47,386
	S-100-2	NONE	689,421	2,660,015	28,177,518	30,517,350	31,226,768	32,726	53,097	299,868	307,141	307,642
	S-100-3	NONE	607,321	2,443,827	28,047,973	30,448,536	31,136,668	27,478	47,853	299,868	307,141	307,642
	S-100-4	NONE	599,606	2,344,626	27,631,190	29,835,176	30,419,426	26,606	39,747	299,508	306,781	307,394
	S-400-2	NONE	689,421	2,651,883	4,091,506	7,863,983	22,692,482	32,726	52,377	61,079	138,196	282,924
	S-400-3	NONE	607,321	2,435,387	3,677,512	7,374,525	22,187,418	27,478	47,129	55,833	133,115	278,922
	S-400-4	NONE	599,606	2,334,805	3,071,404	6,561,917	21,283,427	26,606	38,969	47,533	125,099	274,828
	S-1000-4	NONE	599,606	2,334,793	3,004,380	3,290,566	4,419,917	26,606	38,969	42,413	47,874	77,663
	WBI-100-1	NONE	825,558	3,222,285	28,320,809	30,861,965	31,692,831	42,312	64,689	300,150	307,752	308,287
	WBI-400-1	NONE	825,558	3,217,235	5,251,789	9,283,842	23,915,358	42,312	64,440	75,266	147,373	286,344
Non-Structural Plans	NS-100	NONE	157,914	456,065	28,582,877	31,149,852	32,232,137	39,476	60,328	316,884	323,599	324,135
	NS-400	NONE	84,674	270,496	1,708,897	6,254,896	14,629,005	27,781	43,052	283,743	290,459	290,996
	NS-1000	NONE	76,732	229,558	1,068,746	1,330,711	4,149,359	26,951	42,058	267,569	274,285	274,821

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 25
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, No Sea Level Rise Scenario
2010
Planning Unit 3a
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
Base Condition	Base	NONE	664,421	5,502,549	12,670,135	16,674,927	18,470,531	26,740	107,008	142,304	147,953	149,324
Comprehensive Plans	C-M-100-1	NONE	100,366	268,853	1,513,010	11,929,999	15,184,147	8,763	9,765	44,822	147,741	148,919
	C-R-100-1	NONE	66,392	686,208	4,078,525	15,139,896	15,426,115	6,095	19,046	68,100	148,812	148,919
	C-R-400-2	NONE	52,003	517,870	1,313,036	6,428,539	7,199,732	4,820	17,189	33,461	132,365	135,322
	C-R-1000-2	NONE	47,426	461,444	1,066,193	1,275,623	2,006,882	4,330	16,514	32,230	33,108	44,336
Structural Plans	M-100-1	NONE	266,265	710,588	1,782,807	12,046,363	15,259,940	8,835	9,837	44,894	147,813	148,991
	M-400-1	NONE	266,265	705,437	942,752	1,028,404	1,124,827	8,835	9,679	9,837	10,653	13,221
	M-1000-1	NONE	266,265	705,437	938,834	1,000,258	1,029,169	8,835	9,679	9,679	9,837	10,092
	R-100-1	NONE	232,997	1,200,529	4,382,938	15,276,937	15,512,730	6,167	19,118	68,172	148,884	148,991
	R-400-1	NONE	232,997	1,192,472	2,187,968	2,550,331	3,160,690	6,167	18,351	20,344	24,205	29,622
	R-400-2	NONE	235,308	1,197,063	2,568,670	8,329,612	8,894,904	6,219	18,588	35,860	134,764	137,721
	R-1000-1	NONE	232,997	1,192,417	2,181,639	2,460,828	2,719,841	6,167	18,351	19,701	20,521	22,712
	R-1000-2	NONE	235,308	1,197,008	2,562,278	4,114,889	4,578,904	6,219	18,588	35,306	36,183	47,411
Non-Structural Plans	NS-100	NONE	94,592	687,938	9,429,654	15,179,692	17,624,832	25,668	105,936	141,232	146,881	148,252
	NS-400	NONE	56,623	452,777	1,535,325	7,414,043	12,647,560	15,234	94,925	130,221	135,870	137,241
	NS-1000	NONE	43,228	390,487	1,242,101	2,164,300	5,272,021	10,237	86,718	122,013	127,662	129,033

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 26
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, No Sea Level Rise Scenario
2010
Planning Unit 3b
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
Base Condition	Base	NONE	519,814	2,582,978	5,309,378	7,392,940	8,901,691	14,483	41,249	61,026	77,071	83,211
Comprehensive Plans	C-F-100-1	NONE	53,588	158,503	3,642,070	7,884,189	8,584,457	1,604	3,477	52,298	83,406	83,641
	C-F-400-1	NONE	41,425	114,057	231,676	526,449	1,212,716	1,601	3,378	5,679	11,147	22,694
	C-F-1000-1	NONE	37,898	104,711	196,965	388,074	769,693	1,578	3,355	5,582	9,446	9,902
	C-G-100-1	NONE	42,734	95,331	328,820	2,834,930	5,782,248	336	802	7,427	41,334	67,424
	C-R-100-1	NONE	72,363	290,689	3,881,153	6,539,132	7,577,990	3,538	15,597	54,910	72,552	76,171
	C-R-400-1	NONE	60,200	210,061	409,972	2,940,321	5,218,181	3,535	13,326	24,878	46,233	58,838
Structural Plans	F-100-1	NONE	136,539	478,156	3,877,214	8,077,223	8,762,422	1,864	4,068	52,889	83,997	84,232
	F-400-1	NONE	136,539	475,804	652,626	895,140	1,475,776	1,864	3,972	6,273	11,741	23,288
	F-1000-1	NONE	136,539	475,804	650,705	867,104	1,141,271	1,864	3,972	6,199	10,063	10,519
	G-100-1	NONE	97,958	276,965	480,980	2,970,827	5,910,376	566	1,055	7,680	41,587	67,677
	G-400-1	NONE	97,958	276,544	351,221	451,492	527,000	566	1,055	2,141	2,483	3,107
	G-1000-1	NONE	97,958	276,544	350,955	448,324	501,751	566	1,055	2,141	2,317	2,651
	R-100-1	NONE	168,040	960,231	4,283,071	6,819,581	7,826,704	3,798	16,602	55,914	73,557	77,176
	R-400-1	NONE	168,040	928,319	1,929,065	3,864,409	5,694,273	3,798	14,334	25,885	47,241	59,846
	R-1000-1	NONE	168,040	928,319	1,894,466	2,506,821	3,581,993	3,798	14,334	23,709	30,994	45,651
Non-Structural Plans	NS-100	NONE	75,408	412,885	4,185,652	6,856,380	8,543,956	14,223	40,244	60,022	76,066	82,206
	NS-400	NONE	63,120	314,752	752,804	4,641,486	7,674,369	14,220	40,241	60,019	76,063	82,203
	NS-1000	NONE	54,162	289,808	546,943	882,915	4,320,952	13,664	39,635	59,411	75,456	81,596

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 27
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, No Sea Level Rise Scenario
2010
Planning Unit 4
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
Base Condition	Base	NONE	298,076	2,356,108	5,833,693	8,562,112	10,644,632	7,327	26,501	40,391	56,703	68,530
Comprehensive Plans	C-G-100-1	NONE	165,275	359,494	3,005,113	5,689,674	6,658,172	4,570	9,980	43,791	63,461	64,846
	C-G-100-2	NONE	186,801	478,664	3,178,458	5,766,489	6,671,271	4,943	10,903	45,075	63,754	64,908
	C-G-400-3	NONE	165,351	411,926	978,115	5,644,785	8,258,750	5,443	11,653	24,776	74,845	78,749
	C-G-1000-3	NONE	131,274	284,748	751,788	1,766,918	3,914,604	4,861	10,638	22,333	38,889	57,820
	C-R-100-1	NONE	177,648	528,435	3,581,695	5,543,690	6,676,376	6,692	20,140	50,408	60,888	64,166
	C-R-400-1	NONE	170,447	450,300	757,338	5,493,022	8,499,415	6,273	19,345	29,225	74,952	81,055
	C-R-1000-1	NONE	150,438	416,891	599,513	938,633	3,552,329	5,493	18,497	26,949	39,163	60,293
Structural Plans	G-100-1	NONE	303,768	1,855,616	5,294,474	7,940,281	8,901,056	7,395	13,506	47,317	66,987	68,372
	G-100-2	NONE	331,544	2,006,180	5,501,944	8,051,393	8,946,732	7,770	14,431	48,603	67,282	68,436
	G-400-1	NONE	303,768	1,851,369	4,040,478	7,212,733	9,305,069	7,395	13,283	17,143	53,771	58,665
	G-400-2	NONE	331,544	2,001,937	4,232,780	7,422,407	9,520,999	7,770	14,208	18,091	54,781	59,730
	G-400-3	NONE	336,668	2,029,167	4,646,403	9,353,689	11,411,995	9,209	16,167	29,290	79,359	83,263
	G-1000-1	NONE	303,768	1,851,369	4,031,482	5,392,148	6,632,048	7,395	13,283	16,828	25,687	37,602
	G-1000-2	NONE	331,544	2,001,937	4,223,782	5,601,690	6,847,353	7,770	14,208	17,776	26,697	38,612
	G-1000-3	NONE	336,668	2,029,167	4,630,219	6,833,627	8,778,492	9,209	16,167	27,862	44,418	63,349
	R-100-1	NONE	346,296	2,253,133	5,849,942	7,825,729	8,928,971	9,557	23,734	54,012	64,491	67,769
	R-400-1	NONE	346,585	2,247,700	4,970,284	9,456,723	11,725,330	9,640	23,489	33,379	79,105	85,208
	R-1000-1	NONE	346,585	2,247,700	4,954,100	6,936,661	9,091,827	9,640	23,489	31,951	44,164	65,294
Non-Structural Plans	NS-100	NONE	129,427	521,606	3,522,521	6,269,988	8,387,522	4,462	22,907	36,787	53,100	64,927
	NS-400	NONE	121,937	415,767	838,943	4,103,573	7,222,619	3,960	22,357	36,237	52,550	64,377
	NS-1000	NONE	101,927	382,358	614,080	1,039,335	3,981,402	3,180	21,509	35,389	51,702	63,529

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 28a
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, Low Sea Level Rise Scenario
2075
Planning Unit 1
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	LOW	1,214,705	11,934,612	89,936,575	118,259,861	122,343,381	223,926	507,355	1,066,555	1,160,194	1,179,493
Coastal Restoration Plan	Sustained Coast	LOW	1,214,358	5,956,800	54,549,774	78,763,432	119,248,154	222,954	346,838	702,408	853,823	1,162,875
Comprehensive Plans	C-HL-a-100-2	LOW	716,770	1,367,891	49,812,878	69,880,282	114,191,801	191,314	222,390	682,760	825,676	1,139,461
	C-HL-a-100-3	LOW	720,636	1,440,408	49,753,691	70,153,753	114,932,839	194,245	231,636	685,275	826,620	1,145,415
	C-HL-b-400-2	LOW	702,830	979,849	1,531,483	5,671,954	22,470,497	187,917	198,345	238,656	398,268	611,582
	C-HL-b-400-3	LOW	707,872	1,023,459	1,793,220	6,558,019	23,779,246	190,848	209,798	256,861	418,748	634,197
	C-LP-a-100-1	LOW	722,673	1,702,525	16,335,100	50,410,262	104,180,487	197,083	273,243	478,784	695,339	1,106,913
	C-LP-a-100-2	LOW	713,305	1,108,635	14,015,724	47,839,255	102,967,163	187,949	200,000	464,377	679,742	1,095,905
	C-LP-a-100-3	LOW	713,540	1,165,782	14,212,249	48,364,214	103,665,057	189,903	207,496	472,989	689,546	1,106,192
	C-LP-b-400-1	LOW	703,513	1,174,997	2,761,127	14,209,192	33,493,920	192,736	264,820	335,337	485,475	635,310
	C-LP-b-400-3	LOW	701,761	994,803	1,337,373	6,866,024	25,731,077	187,540	200,011	231,555	396,474	591,046
	C-LP-b-1000-1	LOW	694,888	1,125,437	1,407,777	3,323,533	12,019,752	189,588	260,306	316,464	386,110	472,292
	C-LP-b-1000-2	LOW	696,330	930,992	995,773	1,361,549	3,099,340	183,717	188,747	200,986	244,854	339,148
Structural Plans	HL-a-100-2	LOW	959,558	2,156,297	52,132,712	72,432,963	116,818,647	202,292	235,659	696,310	840,617	1,154,403
	HL-a-100-3	LOW	1,010,674	2,398,443	52,212,826	72,825,463	117,663,718	205,893	245,611	699,531	842,267	1,161,061
	HL-b-400-2	LOW	958,357	1,952,289	5,473,693	9,481,809	26,063,523	202,292	215,689	256,281	417,284	630,599
	HL-b-400-3	LOW	1,010,649	2,208,836	6,515,891	11,051,361	28,008,867	205,893	227,848	275,192	438,470	653,918
	LP-a-100-1	LOW	1,034,463	4,200,197	19,737,437	54,344,508	108,113,562	211,021	293,457	499,019	717,245	1,128,820
	LP-a-100-2	LOW	940,687	2,536,483	16,182,803	50,576,082	105,784,082	199,227	214,311	478,709	695,746	1,111,910
	LP-a-100-3	LOW	960,318	2,741,660	16,544,507	51,238,017	106,606,096	201,772	222,512	488,026	706,255	1,122,902
	LP-b-400-1	LOW	1,033,262	4,143,569	11,215,608	20,433,671	39,642,179	211,021	290,059	360,597	512,406	662,242
	LP-b-400-3	LOW	959,117	2,668,346	4,448,440	10,316,221	29,258,308	201,772	218,068	249,633	416,224	610,797
	LP-b-1000-1	LOW	1,033,262	4,142,183	11,125,839	18,304,407	23,524,231	211,021	289,993	346,895	418,213	504,396
	LP-b-1000-2	LOW	939,486	2,451,310	3,853,001	5,329,878	7,207,611	199,227	207,968	220,229	265,769	360,064
Non-Structural Plans	NS-100	LOW	490,072	2,191,280	50,600,834	74,873,567	115,363,856	208,172	327,133	681,960	831,984	1,141,038
	NS-400	LOW	246,158	803,861	5,449,730	61,994,567	106,842,286	197,443	315,364	670,190	820,214	1,129,268
	NS-1000	LOW	139,471	618,258	2,089,732	5,056,654	89,282,714	135,599	251,801	577,823	727,846	1,036,899

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 28b
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, High Sea Level Rise Scenario
2075
Planning Unit 1
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	HIGH	1,471,952	34,000,280	116,204,431	122,422,904	125,885,785	248,566	637,105	1,158,319	1,179,082	1,184,847
Coastal Restoration Plan	Sustained Coast	HIGH	1,466,381	12,290,846	58,922,851	82,448,239	123,202,325	246,621	372,237	730,145	863,950	1,172,003
Comprehensive Plans	C-HL-a-100-2	HIGH	728,879	2,322,847	50,451,736	71,216,495	115,531,572	195,099	226,246	695,426	831,801	1,145,191
	C-HL-a-100-3	HIGH	736,424	2,773,974	50,952,916	72,279,283	117,538,188	199,945	239,027	702,251	834,924	1,154,313
	C-HL-b-400-2	HIGH	712,449	1,106,071	2,491,344	7,378,506	23,947,508	191,702	202,201	251,322	404,393	617,312
	C-HL-b-400-3	HIGH	721,159	1,248,135	3,387,124	9,085,800	26,611,378	196,548	217,189	273,837	427,052	643,095
	C-LP-a-100-1	HIGH	783,873	3,524,014	20,708,959	54,445,436	107,582,912	213,191	294,129	509,888	708,424	1,120,008
	C-LP-a-100-2	HIGH	733,892	1,310,384	14,461,891	48,457,545	103,783,873	192,505	205,058	475,707	680,909	1,101,139
	C-LP-a-100-3	HIGH	737,741	1,599,274	15,042,929	49,463,630	104,997,466	195,302	216,611	488,210	696,501	1,115,974
	C-LP-b-400-1	HIGH	749,085	1,543,968	8,697,308	18,516,232	37,673,412	208,382	285,706	366,441	498,560	648,405
	C-LP-b-400-3	HIGH	720,438	1,218,289	2,323,069	8,000,389	27,152,767	192,477	209,126	246,776	403,429	600,828
	C-LP-b-1000-1	HIGH	732,241	1,295,762	2,250,468	10,985,162	17,239,904	204,584	280,471	347,569	399,195	485,387
	C-LP-b-1000-2	HIGH	706,719	967,598	1,172,066	1,932,993	4,018,207	187,811	193,805	212,316	246,021	344,382
Structural Plans	HL-a-100-2	HIGH	1,039,451	3,965,312	52,964,890	73,855,572	118,268,211	206,864	239,795	710,367	846,742	1,160,133
	HL-a-100-3	HIGH	1,119,808	4,571,438	53,587,008	75,020,151	120,371,803	212,416	253,281	717,898	850,571	1,169,961
	HL-b-400-2	HIGH	1,038,250	3,761,304	6,305,871	10,904,418	27,513,087	206,864	219,825	270,338	423,409	636,329
	HL-b-400-3	HIGH	1,119,784	4,381,831	7,890,073	13,246,049	30,716,952	212,416	235,518	293,559	446,774	662,818
	LP-a-100-1	HIGH	1,211,350	6,144,894	24,112,335	58,423,963	111,525,230	229,531	314,343	531,795	730,332	1,141,915
	LP-a-100-2	HIGH	1,007,111	2,851,464	16,791,401	51,286,560	106,664,080	206,029	219,368	491,711	696,914	1,117,143
	LP-a-100-3	HIGH	1,051,726	3,298,932	17,507,414	52,430,042	108,011,126	209,496	231,627	504,919	713,212	1,132,684
	LP-b-400-1	HIGH	1,210,149	6,088,266	15,590,506	24,513,126	43,053,848	229,531	310,945	393,373	525,493	675,337
	LP-b-400-3	HIGH	1,050,525	3,225,618	5,411,347	11,508,246	30,663,338	209,496	227,183	266,526	423,181	620,579
	LP-b-1000-1	HIGH	1,210,149	6,086,880	15,500,737	22,383,863	26,935,900	229,531	310,879	379,671	431,300	517,491
	LP-b-1000-2	HIGH	1,005,910	2,766,291	4,461,599	6,040,355	8,087,608	206,029	213,025	233,231	266,937	365,297
Non-Structural Plans	NS-100	HIGH	529,161	8,385,710	55,036,143	78,489,284	119,181,410	231,004	352,253	708,306	842,112	1,150,164
	NS-400	HIGH	282,745	1,219,074	13,075,393	67,873,010	112,306,824	220,275	340,483	696,536	830,342	1,138,394
	NS-1000	HIGH	175,276	720,824	3,188,060	14,722,520	97,921,498	158,432	276,920	604,169	737,973	1,046,026

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 29a
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, Low Sea Level Rise Scenario
2075
Planning Unit 2
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	LOW	1,582,611	46,651,759	51,670,721	53,208,190	53,965,103	91,162	461,190	466,522	467,050	467,277
Coastal Restoration Plan	Sustained Coast	LOW	1,805,013	6,117,185	46,911,575	50,259,279	51,581,387	92,134	119,658	458,157	466,030	466,299
Comprehensive Plans	C-G-100-1	LOW	701,936	2,148,137	6,470,528	11,684,034	13,601,331	90,123	102,192	134,289	143,619	152,376
	C-G-100-4	LOW	335,834	1,396,144	5,784,894	10,537,118	12,166,819	63,180	73,306	132,502	141,661	150,122
	C-G-400-4	LOW	260,246	521,610	2,200,825	3,927,283	5,010,653	59,766	65,558	70,026	81,744	103,829
	C-G-1000-4	LOW	185,157	323,451	651,403	1,926,031	3,062,659	55,035	59,208	61,626	64,191	73,095
	C-S-100-2	LOW	361,124	2,783,140	37,566,336	41,457,297	42,667,995	72,713	89,126	382,431	392,007	392,247
	C-S-100-3	LOW	309,025	2,475,347	37,177,957	41,243,423	42,415,279	63,864	80,282	382,431	392,007	392,247
	C-S-100-4	LOW	288,122	2,293,399	36,989,854	40,878,570	41,942,185	59,850	73,768	382,094	391,670	391,910
	C-S-400-2	LOW	249,002	485,620	2,859,016	9,146,619	28,398,009	71,310	82,686	93,549	176,062	347,745
	C-S-400-3	LOW	225,645	443,896	2,584,168	8,675,200	27,832,498	62,794	74,170	85,038	168,373	343,898
	C-S-400-4	LOW	217,894	415,986	2,390,222	8,293,726	27,376,633	58,780	67,419	78,524	162,604	340,964
	C-S-1000-4	LOW	190,419	335,975	666,237	2,263,571	4,415,185	57,116	65,657	68,762	76,946	111,273
	C-WBI-100-1	LOW	649,608	3,493,172	38,148,839	42,170,358	43,450,897	87,905	104,614	383,395	392,672	392,938
	C-WBI-400-1	LOW	351,250	628,925	3,900,445	10,662,458	29,791,298	86,502	98,673	109,537	185,875	350,248
Structural Plans	G-100-1	LOW	1,477,409	4,302,526	8,510,333	13,630,193	15,564,193	98,249	113,935	146,032	155,362	164,119
	G-100-4	LOW	958,571	3,227,175	7,521,065	12,199,089	13,854,615	71,306	85,049	144,245	153,404	161,865
	G-400-4	LOW	958,571	3,207,522	5,118,385	6,641,336	7,692,226	71,306	82,361	86,829	98,547	120,632
	G-1000-4	LOW	958,571	3,207,504	5,102,738	6,424,096	7,228,397	71,306	81,950	84,368	86,933	95,837
	S-100-2	LOW	1,155,191	4,924,258	39,518,224	43,309,767	44,519,915	76,942	100,869	394,174	403,750	403,990
	S-100-3	LOW	1,012,198	4,439,890	38,984,877	42,957,361	44,130,697	68,093	92,025	394,174	403,750	403,990
	S-100-4	LOW	956,332	4,136,424	38,703,708	42,529,035	43,620,124	64,079	85,511	393,837	403,413	403,653
	S-400-2	LOW	1,155,191	4,916,002	7,968,725	13,048,810	32,053,526	76,942	99,980	110,843	193,356	365,039
	S-400-3	LOW	1,012,198	4,431,292	7,164,796	12,155,505	31,126,339	68,093	91,131	101,999	185,334	360,859
	S-400-4	LOW	956,332	4,126,334	6,628,128	11,468,316	30,381,652	64,079	84,380	95,485	179,565	357,925
	S-1000-4	LOW	956,332	4,126,321	6,540,762	7,327,890	8,995,443	64,079	84,380	87,485	95,669	129,996
	WBI-100-1	LOW	1,805,013	6,101,914	40,302,233	44,147,143	45,405,046	92,134	116,357	395,138	404,415	404,681
	WBI-400-1	LOW	1,805,013	6,096,528	9,802,124	15,046,561	33,812,113	92,134	115,967	126,831	203,169	367,542
Non-Structural Plans	NS-100	LOW	629,033	3,483,431	44,757,878	48,282,299	49,627,165	87,905	107,915	446,414	454,287	454,556
	NS-400	LOW	255,961	516,502	5,548,214	13,451,233	24,867,170	67,014	79,576	395,597	403,470	403,739
	NS-1000	LOW	155,073	349,049	1,949,841	4,675,246	9,861,727	63,880	76,135	364,621	372,494	372,762

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 29b
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, High Sea Level Rise Scenario
2075
Planning Unit 2
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	HIGH	2,833,612	49,466,651	53,124,117	54,188,144	54,716,464	96,481	465,955	467,011	467,389	467,392
Coastal Restoration Plan	Sustained Coast	HIGH	3,061,870	8,115,021	47,986,634	51,146,416	52,299,796	97,404	123,048	458,736	466,698	466,864
Comprehensive Plans	C-G-100-1	HIGH	1,208,538	4,027,152	8,139,541	13,014,254	14,558,741	97,540	104,812	135,666	144,720	153,193
	C-G-100-4	HIGH	611,475	2,674,413	6,754,188	11,351,880	12,656,471	68,068	75,167	132,708	142,006	150,443
	C-G-400-4	HIGH	491,823	1,342,565	3,288,186	4,868,557	5,634,766	63,409	67,419	70,232	82,089	104,150
	C-G-1000-4	HIGH	325,682	652,258	1,780,735	2,855,550	3,995,897	57,492	61,069	61,832	64,536	73,416
	C-S-100-2	HIGH	1,205,442	4,429,987	38,571,169	42,230,132	43,327,400	77,043	92,371	383,010	392,649	392,809
	C-S-100-3	HIGH	1,073,259	3,893,248	38,085,783	41,945,646	43,007,616	68,194	83,527	383,010	392,649	392,809
	C-S-100-4	HIGH	1,033,587	3,554,334	37,779,385	41,462,433	42,447,430	62,773	77,013	382,673	392,312	392,472
	C-S-400-2	HIGH	395,981	1,449,744	4,392,485	10,221,231	29,261,613	75,640	85,931	94,128	176,704	348,307
	C-S-400-3	HIGH	365,619	1,353,553	3,923,309	9,603,695	28,595,414	67,124	77,415	85,617	169,015	344,460
	C-S-400-4	HIGH	347,276	1,296,172	3,576,319	9,129,517	27,999,340	61,703	70,664	79,103	163,246	341,526
	C-S-1000-4	HIGH	291,312	606,669	1,941,619	3,423,026	5,715,922	60,039	68,902	69,341	77,588	111,835
	C-WBI-100-1	HIGH	1,774,840	5,734,224	39,402,357	43,092,674	44,241,765	93,175	108,004	383,974	393,340	393,503
	C-WBI-400-1	HIGH	671,885	1,933,081	5,888,953	12,004,695	30,866,892	91,772	102,063	110,116	186,543	350,813
Structural Plans	G-100-1	HIGH	2,146,712	5,779,124	10,064,641	14,956,890	16,481,866	107,891	116,555	147,409	156,463	164,936
	G-100-4	HIGH	1,352,467	4,104,585	8,394,913	13,026,331	14,328,874	78,419	86,910	144,451	153,749	162,186
	G-400-4	HIGH	1,352,467	4,084,931	5,992,233	7,468,577	8,166,485	78,419	84,222	87,035	98,892	120,953
	G-1000-4	HIGH	1,352,467	4,084,913	5,976,586	7,251,338	7,702,656	78,419	83,811	84,574	87,278	96,158
	S-100-2	HIGH	2,153,786	6,496,404	40,414,325	44,076,329	45,135,963	81,272	104,114	394,753	404,392	404,552
	S-100-3	HIGH	1,931,301	5,798,931	39,790,203	43,656,175	44,688,437	72,423	95,270	394,753	404,392	404,552
	S-100-4	HIGH	1,833,342	5,360,843	39,406,562	43,131,316	44,106,567	67,002	88,756	394,416	404,055	404,215
	S-400-2	HIGH	2,153,786	6,488,148	8,864,826	13,815,371	32,669,573	81,272	103,225	111,422	193,998	365,601
	S-400-3	HIGH	1,931,301	5,790,333	7,970,122	12,854,319	31,684,079	72,423	94,376	102,578	185,976	361,421
	S-400-4	HIGH	1,833,342	5,350,754	7,330,981	12,070,597	30,868,095	67,002	87,625	96,064	180,207	358,487
	S-1000-4	HIGH	1,833,342	5,350,740	7,243,615	7,930,171	9,481,886	67,002	87,625	88,064	96,311	130,558
	WBI-100-1	HIGH	3,061,870	8,099,750	41,377,292	45,034,280	46,123,455	97,404	119,747	395,717	405,083	405,246
	WBI-400-1	HIGH	3,061,870	8,094,364	10,877,184	15,933,699	34,530,522	97,404	119,357	127,410	203,837	368,107
Non-Structural Plans	NS-100	HIGH	1,754,265	5,724,482	46,011,396	49,204,615	50,418,032	93,175	111,305	446,993	454,955	455,121
	NS-400	HIGH	576,597	1,820,658	7,536,722	14,793,469	25,942,764	72,284	82,966	396,176	404,138	404,304
	NS-1000	HIGH	288,209	669,966	3,902,024	6,758,504	11,766,222	69,150	79,525	365,200	373,162	373,327

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 30a
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, Low Sea Level Rise Scenario
2075
Planning Unit 3a
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	LOW	1,460,217	10,628,865	22,650,012	26,921,611	28,658,919	67,853	168,812	187,940	191,287	193,184
Coastal Restoration Plan	Sustained Coast	LOW	1,465,549	10,573,680	22,760,105	27,034,265	28,781,026	67,535	170,481	189,541	192,916	194,813
Comprehensive Plans	C-M-100-1	LOW	106,502	421,947	1,852,120	15,181,675	20,184,098	12,373	12,616	61,631	189,325	194,166
	C-R-100-1	LOW	152,116	1,548,367	5,132,878	20,469,397	20,694,485	20,168	26,998	95,851	194,166	194,166
	C-R-400-2	LOW	124,922	1,188,291	2,109,618	9,203,965	9,920,953	18,505	24,815	46,295	176,594	179,222
	C-R-1000-2	LOW	102,382	977,039	1,651,413	2,271,591	3,155,935	17,858	23,915	44,865	47,403	66,875
Structural Plans	M-100-1	LOW	346,794	873,003	2,015,086	15,269,581	20,249,817	12,471	12,714	61,729	189,423	194,264
	M-400-1	LOW	346,794	867,667	1,158,124	1,228,314	1,311,807	12,471	12,489	12,714	13,689	17,186
	M-1000-1	LOW	346,794	867,667	1,154,017	1,198,796	1,212,238	12,471	12,489	12,489	12,714	13,004
	R-100-1	LOW	399,139	2,082,038	5,311,787	20,566,942	20,763,455	20,266	27,096	95,949	194,264	194,264
	R-400-1	LOW	399,139	2,073,683	3,099,601	3,555,578	4,116,345	20,266	26,323	27,718	33,197	40,951
	R-400-2	LOW	402,514	2,079,600	3,482,652	10,992,792	11,503,155	20,348	26,658	49,171	179,470	182,098
	R-1000-1	LOW	399,139	2,073,628	3,093,016	3,466,374	3,686,535	20,266	26,323	27,064	29,527	31,499
	R-1000-2	LOW	402,514	2,079,545	3,475,906	5,200,405	5,655,299	20,348	26,658	48,641	51,179	70,651
Non-Structural Plans	NS-100	LOW	178,648	5,110,660	20,975,747	26,214,739	28,307,861	66,404	169,350	188,410	191,785	193,682
	NS-400	LOW	122,857	1,270,811	8,151,101	19,435,643	23,655,015	51,180	154,128	173,189	176,564	178,461
	NS-1000	LOW	79,249	717,230	3,067,910	8,155,585	16,544,707	38,862	141,322	160,383	163,758	165,655

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 30b
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, High Sea Level Rise Scenario
2075
Planning Unit 3a
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	HIGH	2,471,942	15,966,006	25,236,252	28,128,021	29,317,051	106,702	180,746	189,371	191,583	193,184
Coastal Restoration Plan	Sustained Coast	HIGH	2,479,036	15,992,689	25,350,585	28,243,652	29,437,304	106,564	182,313	191,000	193,212	194,813
Comprehensive Plans	C-M-100-1	HIGH	162,251	613,525	1,933,655	15,207,241	20,196,059	12,379	12,616	61,631	189,325	194,166
	C-R-100-1	HIGH	423,229	2,236,427	5,406,158	20,630,851	20,723,165	25,417	27,422	97,660	194,166	194,166
	C-R-400-2	HIGH	330,507	1,628,406	2,557,323	9,504,687	10,024,720	23,754	25,239	48,104	176,594	179,222
	C-R-1000-2	HIGH	275,798	1,357,958	1,950,690	2,717,756	3,313,285	23,107	24,339	46,674	47,403	66,875
Structural Plans	M-100-1	HIGH	444,521	996,257	2,046,058	15,273,310	20,251,060	12,477	12,714	61,729	189,423	194,264
	M-400-1	HIGH	444,521	990,920	1,189,096	1,232,043	1,313,050	12,477	12,489	12,714	13,689	17,186
	M-1000-1	HIGH	444,521	990,920	1,184,989	1,202,526	1,213,481	12,477	12,489	12,489	12,714	13,004
	R-100-1	HIGH	725,166	2,670,068	5,528,326	20,701,579	20,780,359	25,515	27,520	97,758	194,264	194,264
	R-400-1	HIGH	725,166	2,661,713	3,316,140	3,690,215	4,133,249	25,515	26,747	29,527	33,197	40,951
	R-400-2	HIGH	728,541	2,667,630	3,699,191	11,127,429	11,520,060	25,597	27,082	50,980	179,470	182,098
	R-1000-1	HIGH	725,166	2,661,658	3,309,555	3,601,011	3,703,440	25,515	26,747	28,873	29,527	31,499
	R-1000-2	HIGH	728,541	2,667,575	3,692,445	5,335,042	5,672,204	25,597	27,082	50,450	51,179	70,651
Non-Structural Plans	NS-100	HIGH	400,703	12,047,160	24,215,081	27,710,610	29,085,679	105,433	181,182	189,869	192,081	193,682
	NS-400	HIGH	221,434	3,001,624	15,181,511	22,703,493	25,585,853	90,213	165,961	174,648	176,860	178,461
	NS-1000	HIGH	158,584	1,232,093	4,819,333	15,159,921	20,336,318	77,403	153,155	161,842	164,054	165,655

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 31a
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, Low Sea Level Rise Scenario
2075
Planning Unit 3b
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	LOW	1,023,608	4,254,108	8,571,095	11,203,265	12,280,780	28,512	59,280	80,944	93,025	96,453
Coastal Restoration Plan	Sustained Coast	LOW	1,021,995	4,253,090	8,576,084	11,196,808	12,280,382	28,489	59,280	81,054	93,110	96,453
Comprehensive Plans	C-F-100-1	LOW	82,519	417,970	5,299,557	10,719,824	11,244,757	3,179	5,971	66,682	94,801	96,004
	C-F-400-1	LOW	69,819	243,856	763,294	1,369,233	1,921,437	3,175	5,847	9,433	13,003	28,379
	C-F-1000-1	LOW	65,051	153,482	555,652	1,125,412	1,506,813	3,148	5,820	9,310	10,149	11,611
	C-G-100-1	LOW	67,548	147,467	426,093	2,732,951	6,239,531	523	1,782	7,634	45,442	78,965
	C-R-100-1	LOW	107,020	1,038,276	6,485,701	9,359,617	10,261,466	9,318	26,656	71,361	86,205	88,936
	C-R-400-1	LOW	94,840	291,493	1,826,624	6,160,791	8,635,434	9,314	23,695	39,194	61,569	72,642
Structural Plans	F-100-1	LOW	222,001	713,115	5,507,880	10,913,172	11,431,384	3,559	6,579	67,290	95,409	96,612
	F-400-1	LOW	222,001	710,785	1,237,799	1,678,727	2,166,951	3,559	6,459	10,045	13,615	28,991
	F-1000-1	LOW	222,001	710,785	1,235,898	1,651,548	1,843,518	3,559	6,459	9,949	10,788	12,250
	G-100-1	LOW	158,165	318,052	567,287	2,866,635	6,368,286	738	2,018	7,870	45,678	79,201
	G-400-1	LOW	158,165	317,628	443,240	525,162	603,534	738	2,018	2,554	2,863	4,258
	G-1000-1	LOW	158,165	317,628	442,971	521,981	579,153	738	2,018	2,554	2,693	3,822
	R-100-1	LOW	315,969	1,664,428	6,800,097	9,637,207	10,524,587	9,884	27,729	72,435	87,279	90,010
	R-400-1	LOW	315,969	1,627,893	3,993,028	6,852,055	9,058,225	9,884	24,772	40,272	62,647	73,720
	R-1000-1	LOW	315,969	1,627,892	3,953,567	4,999,636	6,222,659	9,884	24,772	37,392	43,539	60,469
Non-Structural Plans	NS-100	LOW	140,695	2,343,595	7,953,725	10,804,915	11,993,302	27,923	58,207	79,980	92,036	95,379
	NS-400	LOW	115,546	537,164	3,643,033	9,690,893	11,524,275	27,919	58,203	79,976	92,032	95,375
	NS-1000	LOW	103,294	432,996	817,084	3,928,421	9,273,742	27,111	57,394	79,167	91,224	94,567

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 31b
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, High Sea Level Rise Scenario
2075
Planning Unit 3b
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	HIGH	1,522,790	5,716,563	9,628,481	11,827,150	12,591,429	40,667	70,871	88,114	95,598	96,602
Coastal Restoration Plan	Sustained Coast	HIGH	1,521,534	5,720,763	9,629,148	11,823,410	12,589,697	40,657	70,859	88,029	95,554	96,602
Comprehensive Plans	C-F-100-1	HIGH	101,849	630,952	5,481,804	10,825,567	11,327,508	3,747	8,438	67,349	95,657	96,058
	C-F-400-1	HIGH	87,544	375,756	1,051,175	1,519,988	2,016,600	3,743	8,314	10,100	13,859	28,433
	C-F-1000-1	HIGH	81,246	226,397	811,305	1,365,102	1,636,329	3,716	8,287	9,977	11,005	11,665
	C-G-100-1	HIGH	82,918	203,651	478,427	2,754,362	6,285,931	743	2,034	7,634	46,082	79,019
	C-R-100-1	HIGH	128,237	1,859,428	7,015,689	9,686,389	10,468,411	13,911	32,524	74,589	88,095	89,085
	C-R-400-1	HIGH	112,630	376,431	3,226,825	6,695,518	8,885,138	13,907	29,563	42,422	63,459	72,791
Structural Plans	F-100-1	HIGH	282,130	878,766	5,679,529	11,012,562	11,510,321	4,148	9,046	67,957	96,265	96,666
	F-400-1	HIGH	282,130	876,436	1,409,448	1,778,116	2,245,888	4,148	8,926	10,712	14,471	29,045
	F-1000-1	HIGH	282,130	876,436	1,407,547	1,750,937	1,922,455	4,148	8,926	10,616	11,644	12,304
	G-100-1	HIGH	193,723	358,560	614,397	2,883,446	6,412,434	979	2,270	7,870	46,318	79,255
	G-400-1	HIGH	193,723	358,136	490,350	541,972	647,682	979	2,270	2,554	3,503	4,312
	G-1000-1	HIGH	193,723	358,136	490,081	538,792	623,301	979	2,270	2,554	3,333	3,876
	R-100-1	HIGH	453,497	2,320,868	7,302,385	9,951,337	10,722,751	14,497	33,598	75,663	89,169	90,159
	R-400-1	HIGH	453,497	2,284,333	4,495,316	7,166,185	9,256,389	14,497	30,641	43,500	64,537	73,869
	R-1000-1	HIGH	453,497	2,284,333	4,455,855	5,313,766	6,420,823	14,497	30,641	40,620	45,429	60,618
Non-Structural Plans	NS-100	HIGH	331,209	4,541,540	9,163,312	11,504,705	12,328,310	40,071	69,785	86,955	94,480	95,528
	NS-400	HIGH	166,930	852,995	6,792,763	10,926,560	12,009,099	40,067	69,781	86,951	94,476	95,524
	NS-1000	HIGH	138,579	564,842	1,370,382	7,609,001	10,829,653	39,259	68,972	86,143	93,668	94,716

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 32a
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, Low Sea Level Rise Scenario
2075
Planning Unit 4
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	LOW	471,501	3,033,543	6,592,287	10,315,843	12,755,215	11,207	36,802	61,739	82,956	95,140
Coastal Restoration Plan	Sustained Coast	LOW	472,215	3,022,998	6,577,491	10,304,157	12,731,366	11,194	36,845	61,794	82,843	95,124
Comprehensive Plans	C-G-100-1	LOW	156,639	520,248	3,172,465	7,197,593	8,212,659	6,952	12,397	56,703	84,812	87,450
	C-G-100-2	LOW	206,574	712,845	3,488,194	7,412,251	8,298,491	8,075	13,947	58,811	85,266	87,531
	C-G-400-3	LOW	173,405	469,169	1,384,116	8,519,463	11,032,194	8,916	15,132	33,145	100,680	106,280
	C-G-1000-3	LOW	122,301	304,055	864,213	3,219,875	6,444,720	7,941	14,120	30,603	53,600	79,780
	C-R-100-1	LOW	182,787	1,012,423	4,738,721	7,607,555	8,928,103	11,639	28,786	69,096	83,885	87,847
	C-R-400-1	LOW	174,810	501,571	1,585,342	8,800,546	12,030,504	11,192	27,938	42,070	103,529	110,947
	C-R-1000-1	LOW	153,536	456,100	836,084	2,456,260	6,837,091	10,421	27,151	39,753	56,674	84,672
Structural Plans	G-100-1	LOW	394,314	1,866,835	422,100	8,170,468	9,112,930	9,815	15,501	59,807	87,916	90,554
	G-100-2	LOW	463,698	2,113,482	4,588,161	8,435,206	9,247,423	10,941	17,054	61,918	88,373	90,638
	G-400-1	LOW	394,314	1,862,600	2,841,182	7,272,259	9,578,441	9,815	15,240	20,637	69,275	76,407
	G-400-2	LOW	463,698	2,109,254	3,193,009	7,650,679	9,965,502	10,941	16,793	22,312	70,955	78,158
	G-400-3	LOW	469,040	2,136,816	3,644,956	10,276,525	12,550,769	12,681	19,139	37,152	104,687	110,287
	G-1000-1	LOW	394,314	1,862,600	2,832,221	4,854,994	6,108,179	9,815	15,240	20,268	32,105	49,230
	G-1000-2	LOW	463,698	2,109,254	3,184,047	5,233,285	6,494,659	10,941	16,793	21,943	33,785	50,910
	G-1000-3	LOW	469,040	2,136,816	3,628,083	6,997,541	9,114,550	12,681	19,139	35,622	58,619	84,799
	R-100-1	LOW	503,940	2,666,140	5,957,516	8,700,700	9,937,082	14,546	31,950	72,267	87,056	91,018
	R-400-1	LOW	504,357	2,660,865	5,007,108	11,013,871	13,725,057	14,655	31,660	45,799	107,258	114,676
	R-1000-1	LOW	504,357	2,660,865	4,990,235	7,734,887	10,288,839	14,655	31,660	44,269	61,190	89,188
Non-Structural Plans	NS-100	LOW	150,868	1,248,511	5,339,652	9,205,985	11,720,233	8,287	33,681	58,623	79,672	91,953
	NS-400	LOW	142,474	503,549	2,213,514	7,706,516	10,905,489	7,731	33,123	58,065	79,114	91,395
	NS-1000	LOW	121,200	457,937	934,521	3,146,175	8,277,771	6,960	32,336	57,278	78,327	90,608

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 32b
Residual Risk/Frequency Damage and Population
High Employment Growth, Dispersed Land Use, High Sea Level Rise Scenario
2075
Planning Unit 4
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	HIGH	724,883	4,142,404	7,874,130	11,580,791	13,904,059	18,774	46,397	73,798	94,654	101,883
Coastal Restoration Plan	Sustained Coast	HIGH	725,617	4,125,466	7,868,997	11,559,813	13,897,526	18,727	46,418	74,275	94,000	101,905
Comprehensive Plans	C-G-100-1	HIGH	169,815	995,999	3,665,966	7,793,997	8,726,497	8,933	13,447	64,254	87,182	89,394
	C-G-100-2	HIGH	242,870	1,247,100	4,002,840	8,018,749	8,819,093	10,068	15,040	66,362	87,636	89,475
	C-G-400-3	HIGH	193,842	554,226	2,159,303	9,251,830	11,588,099	10,908	16,225	40,696	103,050	108,224
	C-G-1000-3	HIGH	129,975	356,846	1,126,654	4,471,312	7,377,854	9,896	15,213	38,154	55,970	81,724
	C-R-100-1	HIGH	210,993	2,062,051	5,704,046	8,554,358	9,835,884	17,552	32,560	77,902	87,697	90,628
	C-R-400-1	HIGH	195,756	653,904	3,182,264	10,117,055	13,033,817	17,104	31,681	50,876	107,341	113,728
	C-R-1000-1	HIGH	173,887	538,083	1,267,707	4,572,048	8,526,017	16,315	30,894	48,559	60,486	87,453
Structural Plans	G-100-1	HIGH	562,110	2,232,145	4,667,814	8,688,565	9,540,904	11,996	16,551	67,358	90,286	92,498
	G-100-2	HIGH	661,353	2,533,617	5,055,104	8,961,150	9,681,052	13,134	18,147	69,469	90,743	92,582
	G-400-1	HIGH	562,110	2,227,910	3,288,896	7,790,357	10,006,415	11,996	16,290	28,188	71,645	78,351
	G-400-2	HIGH	661,353	2,529,388	3,659,952	8,176,623	10,399,131	13,134	17,886	29,863	73,325	80,102
	G-400-3	HIGH	666,696	2,556,951	4,111,900	10,802,469	12,984,398	14,874	20,232	44,703	107,057	112,231
	G-1000-1	HIGH	562,110	2,227,910	3,279,935	5,373,092	6,536,154	11,996	16,290	27,819	34,475	51,174
	G-1000-2	HIGH	661,353	2,529,388	3,650,990	5,759,229	6,928,288	13,134	17,886	29,494	36,155	52,854
	G-1000-3	HIGH	666,696	2,556,951	4,095,026	7,523,484	9,548,180	14,874	20,232	43,173	60,989	86,743
	R-100-1	HIGH	751,749	3,524,355	6,826,493	9,566,383	10,733,182	20,674	35,723	81,073	90,868	93,799
	R-400-1	HIGH	752,166	3,519,080	5,860,116	11,875,803	14,520,668	20,783	35,402	54,605	111,070	117,457
	R-1000-1	HIGH	752,166	3,519,080	5,843,243	8,596,819	11,084,450	20,783	35,402	53,075	65,002	91,969
Non-Structural Plans	NS-100	HIGH	181,261	2,570,313	6,737,406	10,544,657	12,999,101	15,605	43,255	71,104	90,829	98,734
	NS-400	HIGH	164,833	682,472	4,520,144	9,628,655	12,344,156	15,048	42,697	70,546	90,271	98,176
	NS-1000	HIGH	142,964	557,183	1,465,627	6,249,547	10,868,036	14,259	41,910	69,759	89,484	97,389

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 33a
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, Low Sea Level Rise Scenario
2075
Planning Unit 1
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	LOW	1,081,120	9,878,938	62,688,250	81,963,449	84,350,812	134,638	349,414	699,378	767,109	774,563
Coastal Restoration Plan	Sustained Coast	LOW	1,080,804	5,945,972	40,241,605	56,290,157	82,753,537	133,957	230,372	483,309	574,689	768,518
Comprehensive Plans	C-HL-a-100-2	LOW	591,663	1,106,312	38,074,846	51,501,476	80,010,549	117,432	136,348	475,710	561,059	753,273
	C-HL-a-100-3	LOW	590,116	1,156,606	37,969,132	51,580,973	80,285,126	118,523	141,839	476,416	561,252	760,911
	C-HL-b-400-2	LOW	584,656	837,174	1,178,097	4,048,892	16,517,150	116,628	120,828	147,372	269,668	415,132
	C-HL-b-400-3	LOW	584,194	869,197	1,389,032	4,589,897	17,140,992	117,719	127,063	158,488	282,104	431,321
	C-LP-a-100-1	LOW	594,248	1,516,162	11,351,775	35,864,805	73,592,663	121,109	176,905	313,407	474,125	735,442
	C-LP-a-100-2	LOW	593,335	951,917	9,601,510	33,835,579	72,510,860	116,242	122,008	303,714	460,711	726,080
	C-LP-a-100-3	LOW	589,907	990,783	9,672,371	34,032,548	72,776,674	116,864	125,677	308,200	466,309	731,841
	C-LP-b-400-1	LOW	579,420	995,225	2,366,844	11,120,595	25,056,764	118,784	172,670	225,926	339,528	445,314
	C-LP-b-400-3	LOW	582,501	854,636	1,127,446	5,668,295	20,496,549	116,331	122,383	141,756	275,324	417,897
	C-LP-b-1000-1	LOW	572,589	953,188	1,194,501	2,636,225	10,021,506	117,882	171,155	212,935	263,653	331,346
	C-LP-b-1000-2	LOW	581,602	806,522	854,100	1,137,398	2,488,021	115,453	117,866	122,415	151,297	228,540
Structural Plans	HL-a-100-2	LOW	822,768	1,879,195	39,022,628	52,485,681	81,009,976	121,441	141,835	481,332	566,802	759,017
	HL-a-100-3	LOW	872,610	2,115,666	39,049,132	52,668,093	81,361,919	122,854	147,665	482,377	567,335	766,995
	HL-b-400-2	LOW	821,659	1,694,864	2,590,565	5,396,948	17,818,274	121,441	127,594	154,273	276,690	422,155
	HL-b-400-3	LOW	872,585	1,945,552	3,270,330	6,319,771	18,776,118	122,854	134,168	165,728	289,466	438,684
	LP-a-100-1	LOW	906,233	3,193,750	13,417,773	37,801,326	75,416,586	126,673	185,523	322,034	483,008	744,327
	LP-a-100-2	LOW	810,807	1,677,563	10,505,213	34,816,240	73,501,187	120,640	127,765	309,481	466,734	732,103
	LP-a-100-3	LOW	828,169	1,853,080	10,728,561	35,143,964	73,882,882	121,546	131,773	314,306	472,671	738,204
	LP-b-400-1	LOW	905,124	3,146,264	8,665,770	14,819,409	28,406,654	126,673	184,088	237,353	351,211	456,999
	LP-b-400-3	LOW	827,060	1,788,708	2,452,150	7,047,827	21,860,918	121,546	129,487	148,870	282,694	425,268
	LP-b-1000-1	LOW	905,124	3,145,093	8,583,801	13,108,808	16,729,731	126,673	184,060	226,017	276,992	344,686
	LP-b-1000-2	LOW	809,699	1,601,486	1,998,824	2,505,357	3,852,996	120,640	124,887	129,446	158,584	235,827
Non-Structural Plans	NS-100	LOW	372,406	1,945,350	37,765,997	54,169,491	80,707,735	127,815	221,351	473,575	564,833	758,662
	NS-400	LOW	161,859	656,623	4,086,986	44,769,794	74,337,286	120,839	213,546	465,770	557,028	750,857
	NS-1000	LOW	90,320	514,275	1,761,037	3,981,271	63,810,670	90,425	182,371	422,082	513,340	707,169

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 33b
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, High Sea Level Rise Scenario
2075
Planning Unit 1
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	HIGH	1,345,047	26,075,648	80,694,136	84,514,752	86,336,357	150,961	444,758	766,017	774,436	776,799
Coastal Restoration Plan	Sustained Coast	HIGH	1,339,029	9,991,565	42,875,460	58,415,356	84,993,695	149,599	247,326	497,450	579,675	771,651
Comprehensive Plans	C-HL-a-100-2	HIGH	599,027	1,405,869	38,237,260	51,963,531	80,442,719	119,144	137,049	480,026	563,162	754,660
	C-HL-a-100-3	HIGH	599,477	1,711,927	38,451,928	52,419,649	81,501,896	121,170	145,222	483,024	564,584	763,863
	C-HL-b-400-2	HIGH	589,306	911,894	1,432,362	4,586,087	16,965,556	118,340	121,529	151,688	271,771	416,519
	C-HL-b-400-3	HIGH	590,828	1,028,527	2,018,610	5,527,158	18,415,446	120,366	130,446	165,096	285,436	434,273
	C-LP-a-100-1	HIGH	646,122	2,954,940	14,331,488	38,371,184	75,636,519	131,548	192,070	332,132	482,544	742,209
	C-LP-a-100-2	HIGH	612,105	1,062,077	9,802,745	34,042,677	72,749,361	118,111	123,017	307,484	461,023	727,569
	C-LP-a-100-3	HIGH	610,786	1,257,052	10,068,523	34,503,555	73,317,762	119,138	129,057	314,633	469,789	736,139
	C-LP-b-400-1	HIGH	614,229	1,277,479	6,867,739	13,954,948	27,508,434	128,900	187,835	244,651	347,947	452,081
	C-LP-b-400-3	HIGH	597,482	1,024,301	1,513,865	6,172,371	21,082,072	118,282	125,763	148,189	278,804	422,195
	C-LP-b-1000-1	HIGH	598,624	1,086,118	1,750,134	8,711,103	13,277,586	127,723	186,152	231,660	272,072	338,113
	C-LP-b-1000-2	HIGH	588,910	832,467	968,661	1,375,556	2,790,221	116,999	118,875	126,185	151,609	230,029
Structural Plans	HL-a-100-2	HIGH	900,604	2,253,874	39,216,172	52,963,260	81,443,501	123,582	142,671	485,769	568,904	760,403
	HL-a-100-3	HIGH	980,787	2,717,097	39,535,647	53,490,951	82,565,491	125,947	151,183	489,107	570,666	769,946
	HL-b-400-2	HIGH	899,495	2,069,543	2,784,109	5,874,527	18,251,799	123,582	128,430	158,710	278,792	423,541
	HL-b-400-3	HIGH	980,762	2,546,984	3,756,845	7,142,629	19,979,689	125,947	137,686	172,458	292,797	441,635
	LP-a-100-1	HIGH	1,074,231	4,731,305	16,201,870	40,212,565	77,362,160	138,117	200,688	341,015	491,428	751,093
	LP-a-100-2	HIGH	870,281	1,816,223	10,729,563	35,037,024	73,744,668	123,439	128,774	313,507	467,046	733,592
	LP-a-100-3	HIGH	913,172	2,159,000	11,127,713	35,611,775	74,416,801	124,789	135,153	320,995	476,152	742,502
	LP-b-400-1	HIGH	1,073,122	4,683,819	11,449,867	17,230,647	30,352,227	138,117	199,253	256,334	359,631	463,765
	LP-b-400-3	HIGH	912,063	2,094,629	2,851,301	7,515,638	22,394,837	124,789	132,867	155,559	286,175	429,566
	LP-b-1000-1	HIGH	1,073,122	4,682,648	11,367,897	15,520,047	18,675,305	138,117	199,225	244,998	285,412	351,452
	LP-b-1000-2	HIGH	869,173	1,740,146	2,223,175	2,726,142	4,096,477	123,439	125,896	133,472	158,896	237,316
Non-Structural Plans	NS-100	HIGH	399,275	6,799,139	40,721,717	56,319,938	82,931,700	143,005	238,170	487,594	569,820	761,796
	NS-400	HIGH	186,002	987,061	9,939,908	48,443,616	77,619,418	136,029	230,365	479,789	562,015	753,991
	NS-1000	HIGH	114,033	599,938	2,579,493	10,921,318	69,580,522	105,613	199,191	436,101	518,326	710,303

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 34a
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, Low Sea Level Rise Scenario
2075
Planning Unit 2
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	LOW	1,512,293	37,218,424	40,614,206	41,776,538	42,385,699	55,526	346,129	349,174	349,551	349,704
Coastal Restoration Plan	Sustained Coast	LOW	1,691,659	4,915,496	37,200,624	39,600,465	40,485,339	56,541	78,663	342,851	348,815	349,027
Comprehensive Plans	C-G-100-1	LOW	586,127	1,747,652	4,780,776	8,052,285	9,114,993	51,790	61,236	83,390	87,550	93,854
	C-G-100-4	LOW	220,190	1,092,283	4,344,510	7,286,339	8,131,863	29,254	36,162	82,315	85,798	91,065
	C-G-400-4	LOW	176,916	412,452	1,157,526	1,994,220	2,623,419	27,206	31,310	34,101	42,431	58,893
	C-G-1000-4	LOW	156,715	279,511	395,366	782,106	1,168,534	23,800	26,575	28,007	29,804	35,582
	C-S-100-2	LOW	261,826	1,636,522	31,510,452	34,342,468	35,178,450	38,288	52,039	307,157	314,346	314,454
	C-S-100-3	LOW	216,403	1,488,353	31,415,289	34,354,982	35,176,900	32,844	46,599	307,157	314,346	314,454
	C-S-100-4	LOW	210,324	1,177,243	30,738,127	33,481,368	34,174,208	28,140	37,641	306,768	313,957	314,186
	C-S-400-2	LOW	196,939	419,751	1,705,306	6,868,129	24,117,457	37,519	48,242	54,729	134,664	285,367
	C-S-400-3	LOW	181,398	385,858	1,530,278	6,564,819	23,766,933	32,080	42,803	49,294	129,400	281,222
	C-S-400-4	LOW	175,441	354,019	1,236,989	5,791,155	22,872,775	27,376	33,787	40,336	120,748	276,804
	C-S-1000-4	LOW	163,995	300,467	488,372	1,253,674	2,977,916	27,118	33,461	34,673	39,967	70,593
	C-WBI-100-1	LOW	510,273	2,289,186	32,015,095	35,033,643	35,961,366	53,564	66,975	308,164	315,061	315,272
	C-WBI-400-1	LOW	295,880	546,730	2,673,339	8,317,179	25,438,267	52,795	63,666	70,153	144,260	289,062
Structural Plans	G-100-1	LOW	1,326,131	3,829,292	6,603,450	9,687,129	10,712,359	57,417	69,377	91,531	95,691	101,995
	G-100-4	LOW	800,000	2,832,459	5,851,913	8,629,720	9,448,672	34,881	44,303	90,456	93,939	99,206
	G-400-4	LOW	800,000	2,813,404	3,505,728	4,014,579	4,570,196	34,881	42,457	45,248	53,578	70,040
	G-1000-4	LOW	800,000	2,813,387	3,490,507	3,798,583	4,080,817	34,881	42,101	43,533	45,330	51,108
	S-100-2	LOW	1,039,037	3,727,787	33,220,892	35,875,585	36,663,131	41,265	60,180	315,298	322,487	322,595
	S-100-3	LOW	891,743	3,382,222	32,963,865	35,733,480	36,509,254	35,821	54,740	315,298	322,487	322,595
	S-100-4	LOW	859,357	2,978,219	32,214,664	34,810,790	35,477,614	31,117	45,782	314,909	322,098	322,327
	S-400-2	LOW	1,039,037	3,719,553	5,405,111	9,666,897	26,734,756	41,265	59,430	65,917	145,852	296,555
	S-400-3	LOW	891,743	3,373,679	4,849,612	9,073,057	26,133,701	35,821	53,986	60,477	140,583	292,405
	S-400-4	LOW	859,357	2,968,294	3,894,508	7,931,685	24,894,251	31,117	44,970	51,519	131,931	287,987
	S-1000-4	LOW	859,357	2,968,282	3,819,611	4,158,704	5,448,322	31,117	44,970	46,182	51,476	82,102
	WBI-100-1	LOW	1,691,659	4,902,537	33,950,309	36,705,439	37,560,156	56,541	75,116	316,305	323,202	323,413
	WBI-400-1	LOW	1,691,659	4,897,391	7,207,429	11,651,837	28,473,074	56,541	74,854	81,341	155,448	300,250
Non-Structural Plans	NS-100	LOW	490,791	2,278,311	35,265,110	37,928,468	38,886,473	53,564	70,522	334,710	340,674	340,886
	NS-400	LOW	211,336	445,347	4,015,784	9,816,043	18,767,332	41,208	52,312	299,837	305,801	306,014
	NS-1000	LOW	130,819	309,513	1,573,035	3,345,649	7,640,590	40,337	51,268	282,738	288,702	288,914

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 34b
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, High Sea Level Rise Scenario
2075
Planning Unit 2
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	HIGH	2,129,325	39,132,999	41,659,241	42,555,588	42,963,361	57,805	348,775	349,498	349,765	349,767
Coastal Restoration Plan	Sustained Coast	HIGH	2,315,755	6,428,536	37,872,144	40,134,201	40,926,249	58,772	79,977	343,058	349,284	349,337
Comprehensive Plans	C-G-100-1	HIGH	888,082	2,871,109	5,812,267	8,754,091	9,812,410	58,094	62,962	85,594	90,973	96,250
	C-G-100-4	HIGH	302,790	1,671,852	4,799,934	7,550,667	8,352,911	32,636	37,119	82,456	86,232	91,474
	C-G-400-4	HIGH	224,518	636,556	1,764,346	2,365,661	2,966,446	29,776	32,267	34,242	42,865	59,302
	C-G-1000-4	HIGH	183,223	393,046	803,952	1,296,668	1,592,366	25,412	27,532	28,148	30,238	35,991
	C-S-100-2	HIGH	468,963	2,976,703	32,135,737	34,784,608	35,544,327	40,230	53,212	307,364	314,712	314,761
	C-S-100-3	HIGH	325,971	2,664,424	31,992,985	34,764,852	35,510,558	34,786	47,772	307,364	314,712	314,761
	C-S-100-4	HIGH	308,095	1,962,990	31,163,427	33,744,489	34,394,823	29,398	38,814	306,975	314,323	314,493
	C-S-400-2	HIGH	244,241	714,896	2,982,445	7,455,729	24,663,624	39,461	49,415	54,936	135,030	285,674
	C-S-400-3	HIGH	221,442	661,006	2,679,792	7,071,555	24,256,495	34,022	43,976	49,501	129,766	281,529
	C-S-400-4	HIGH	211,699	598,709	1,978,158	6,162,107	23,210,197	28,634	34,960	40,543	121,114	277,111
	C-S-1000-4	HIGH	188,106	443,560	978,871	1,944,983	3,362,724	28,376	34,634	34,880	40,333	70,900
	C-WBI-100-1	HIGH	1,002,262	4,210,920	32,911,520	35,646,327	36,478,794	55,795	68,289	308,371	315,530	315,582
	C-WBI-400-1	HIGH	489,660	1,145,337	4,409,219	9,194,024	26,218,742	55,026	64,980	70,360	144,729	289,372
Structural Plans	G-100-1	HIGH	1,850,986	4,824,952	7,466,644	10,342,083	11,369,654	65,262	71,103	93,735	99,114	104,391
	G-100-4	HIGH	1,060,717	3,290,549	6,163,759	8,866,267	9,655,427	39,804	45,260	90,597	94,373	99,615
	G-400-4	HIGH	1,060,717	3,271,494	3,817,574	4,251,127	4,776,952	39,804	43,414	45,389	54,012	70,449
	G-1000-4	HIGH	1,060,717	3,271,477	3,802,353	4,035,131	4,287,573	39,804	43,058	43,674	45,764	51,517
	S-100-2	HIGH	1,404,364	4,847,601	33,699,054	36,270,940	36,984,916	43,207	61,353	315,505	322,853	322,902
	S-100-3	HIGH	1,145,531	4,355,760	33,401,456	36,099,801	36,808,636	37,763	55,913	315,505	322,853	322,902
	S-100-4	HIGH	1,083,847	3,577,955	32,511,999	35,047,324	35,675,983	32,375	46,955	315,116	322,464	322,634
	S-400-2	HIGH	1,404,364	4,839,368	5,883,273	10,062,252	27,056,541	43,207	60,603	66,124	146,218	296,862
	S-400-3	HIGH	1,145,531	4,347,217	5,287,203	9,439,378	26,433,083	37,763	55,159	60,684	140,949	292,712
	S-400-4	HIGH	1,083,847	3,568,030	4,191,844	8,168,220	25,092,620	32,375	46,143	51,726	132,297	288,294
	S-1000-4	HIGH	1,083,847	3,568,018	4,116,946	4,395,239	5,646,691	32,375	46,143	46,389	51,842	82,409
	WBI-100-1	HIGH	2,315,755	6,415,576	34,621,829	37,239,175	38,001,066	58,772	76,430	316,512	323,671	323,723
	WBI-400-1	HIGH	2,315,755	6,410,431	7,878,949	12,185,573	28,913,984	58,772	76,168	81,548	155,917	300,560
Non-Structural Plans	NS-100	HIGH	982,779	4,200,045	36,161,535	38,541,152	39,403,901	55,795	71,836	334,917	341,143	341,196
	NS-400	HIGH	405,116	1,043,954	5,751,664	10,692,888	19,547,808	43,439	53,626	300,044	306,270	306,324
	NS-1000	HIGH	186,941	491,230	2,652,321	5,179,951	8,658,647	42,568	52,582	282,945	289,171	289,224

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 35a
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, Low Sea Level Rise Scenario
2075
Planning Unit 3a
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	LOW	1,422,417	9,695,051	17,847,802	20,766,247	21,942,249	51,139	141,866	153,993	154,768	155,226
Coastal Restoration Plan	Sustained Coast	LOW	1,427,745	9,682,853	17,925,052	20,854,771	22,034,719	51,019	143,153	155,222	156,023	156,481
Comprehensive Plans	C-M-100-1	LOW	99,195	434,345	1,751,569	12,875,494	16,612,989	9,160	9,344	46,009	154,766	156,029
	C-R-100-1	LOW	152,964	1,549,520	4,777,103	16,774,499	16,943,837	16,149	21,011	69,728	156,029	156,029
	C-R-400-2	LOW	124,625	1,168,331	1,916,830	7,399,619	8,048,131	14,784	19,173	35,253	140,368	142,756
	C-R-1000-2	LOW	98,359	931,267	1,437,904	1,853,229	2,626,628	14,260	18,450	34,057	34,738	46,231
Structural Plans	M-100-1	LOW	328,948	859,298	1,891,029	12,947,567	16,667,494	9,238	9,422	46,087	154,844	156,107
	M-400-1	LOW	328,948	854,314	1,066,416	1,135,245	1,213,002	9,238	9,253	9,422	10,226	12,918
	M-1000-1	LOW	328,948	854,314	1,062,606	1,108,028	1,120,181	9,238	9,253	9,253	9,422	9,671
	R-100-1	LOW	390,016	2,055,998	4,933,294	16,856,674	17,002,187	16,227	21,089	69,806	156,107	156,107
	R-400-1	LOW	390,016	2,048,378	2,813,035	3,060,759	3,558,821	16,227	20,417	21,211	24,486	29,513
	R-400-2	LOW	392,385	2,053,027	3,197,605	9,147,545	9,600,275	16,282	20,671	37,821	142,936	145,324
	R-1000-1	LOW	390,016	2,048,324	2,807,053	2,976,903	3,144,172	16,227	20,417	20,645	21,264	23,041
	R-1000-2	LOW	392,385	2,052,973	3,191,557	4,661,417	5,034,831	16,282	20,671	37,350	38,031	49,524
Non-Structural Plans	NS-100	LOW	161,235	4,257,124	16,213,074	20,074,957	21,586,758	49,871	142,005	154,074	154,875	155,333
	NS-400	LOW	111,590	1,147,880	6,365,625	14,870,147	18,101,938	38,088	130,222	142,291	143,092	143,550
	NS-1000	LOW	72,525	651,966	2,199,208	5,917,331	12,660,448	29,392	121,424	133,493	134,294	134,752

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 35b
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, High Sea Level Rise Scenario
2075
Planning Unit 3a
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	HIGH	2,424,857	13,659,231	19,692,554	21,591,362	22,347,693	78,554	148,409	154,661	154,987	155,226
Coastal Restoration Plan	Sustained Coast	HIGH	2,431,178	13,697,197	19,778,666	21,682,984	22,440,067	78,419	149,606	155,916	156,242	156,481
Comprehensive Plans	C-M-100-1	HIGH	161,825	592,675	1,830,091	12,895,893	16,622,544	9,165	9,344	46,009	154,766	156,029
	C-R-100-1	HIGH	471,742	2,128,816	4,984,716	16,877,321	16,979,607	19,631	21,095	69,781	156,029	156,029
	C-R-400-2	HIGH	369,794	1,539,928	2,273,481	7,638,410	8,159,851	18,266	19,257	35,306	140,368	142,756
	C-R-1000-2	HIGH	289,252	1,249,777	1,681,367	2,230,202	2,795,506	17,742	18,534	34,110	34,738	46,231
Structural Plans	M-100-1	HIGH	431,136	946,371	1,923,883	12,950,761	16,668,553	9,243	9,422	46,087	154,844	156,107
	M-400-1	HIGH	431,136	941,387	1,099,270	1,138,439	1,214,061	9,243	9,253	9,422	10,226	12,918
	M-1000-1	HIGH	431,136	941,387	1,095,460	1,111,222	1,121,241	9,243	9,253	9,253	9,422	9,671
	R-100-1	HIGH	761,919	2,532,075	5,088,213	16,936,563	17,027,712	19,709	21,173	69,859	156,107	156,107
	R-400-1	HIGH	761,919	2,524,455	2,967,953	3,140,648	3,584,345	19,709	20,501	21,264	24,486	29,513
	R-400-2	HIGH	764,287	2,529,104	3,352,524	9,227,434	9,625,799	19,764	20,755	37,874	142,936	145,324
	R-1000-1	HIGH	761,919	2,524,401	2,961,971	3,056,792	3,169,696	19,709	20,501	20,698	21,264	23,041
	R-1000-2	HIGH	764,287	2,529,050	3,346,475	4,741,305	5,060,355	19,764	20,755	37,403	38,031	49,524
Non-Structural Plans	NS-100	HIGH	365,069	9,796,430	18,693,913	21,177,863	22,107,001	77,271	148,458	154,768	155,094	155,333
	NS-400	HIGH	225,554	2,601,322	11,875,310	17,414,864	19,452,594	65,488	136,675	142,985	143,311	143,550
	NS-1000	HIGH	144,780	1,107,655	3,554,893	11,434,964	15,570,362	56,690	127,877	134,187	134,513	134,752

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 36a
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, Low Sea Level Rise Scenario
2075
Planning Unit 3b
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	LOW	1,012,730	4,148,297	7,771,594	10,886,290	12,369,822	26,345	56,166	78,016	94,540	98,612
Coastal Restoration Plan	Sustained Coast	LOW	1,011,628	4,147,235	7,770,948	10,876,911	12,368,845	26,306	56,166	78,133	94,641	98,612
Comprehensive Plans	C-F-100-1	LOW	82,295	351,499	4,922,593	10,476,917	11,154,354	2,921	5,351	65,215	97,431	97,788
	C-F-400-1	LOW	69,518	185,289	539,692	1,154,722	1,790,138	2,916	5,215	9,250	14,823	29,477
	C-F-1000-1	LOW	64,786	144,402	402,472	956,259	1,368,256	2,888	5,187	9,119	12,589	13,201
	C-G-100-1	LOW	68,111	145,597	435,306	2,815,408	6,191,979	454	1,686	7,251	43,098	75,409
	C-R-100-1	LOW	104,571	925,582	5,972,765	8,744,709	9,833,219	8,275	24,889	70,235	86,182	88,213
	C-R-400-1	LOW	92,391	283,730	1,412,908	5,279,561	8,156,384	8,270	21,760	37,182	64,346	76,762
Structural Plans	F-100-1	LOW	223,322	635,513	5,128,055	10,667,921	11,338,532	3,306	5,913	65,777	97,993	98,350
	F-400-1	LOW	223,322	633,142	985,428	1,461,552	2,034,383	3,306	5,782	9,817	15,390	30,044
	F-1000-1	LOW	223,322	633,142	983,491	1,433,161	1,695,549	3,306	5,782	9,714	13,184	13,796
	G-100-1	LOW	158,902	317,965	578,669	2,950,432	6,321,396	651	1,902	7,467	43,314	75,625
	G-400-1	LOW	158,902	317,544	454,522	550,754	619,639	651	1,902	2,539	2,852	3,382
	G-1000-1	LOW	158,902	317,544	454,256	547,589	594,453	651	1,902	2,539	2,703	2,975
	R-100-1	LOW	314,976	1,564,025	6,294,353	9,031,825	10,107,095	8,879	26,005	71,350	87,296	89,327
	R-400-1	LOW	314,976	1,526,088	3,116,598	5,916,550	8,573,155	8,879	22,881	38,302	65,465	77,881
	R-1000-1	LOW	314,976	1,526,088	3,075,488	4,018,748	5,354,836	8,879	22,881	35,303	43,584	60,667
Non-Structural Plans	NS-100	LOW	136,708	2,237,432	7,132,716	10,465,112	12,068,314	25,702	55,050	77,018	93,527	97,498
	NS-400	LOW	112,146	523,604	3,185,111	9,314,344	11,536,094	25,697	55,045	77,013	93,522	97,493
	NS-1000	LOW	100,176	424,235	800,901	3,962,892	9,373,583	25,008	54,356	76,322	92,831	96,802

Source: GIS Economic Application Databases
Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 36b
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, High Sea Level Rise Scenario
2075
Planning Unit 3b
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	HIGH	1,543,136	5,447,079	8,781,521	11,680,354	12,768,788	38,428	67,224	88,942	98,023	98,712
Coastal Restoration Plan	Sustained Coast	HIGH	1,545,157	5,451,942	8,778,612	11,673,345	12,766,160	38,412	67,205	88,852	97,568	98,712
Comprehensive Plans	C-F-100-1	HIGH	102,214	508,380	5,091,999	10,643,294	11,235,593	3,488	6,981	68,502	97,616	97,788
	C-F-400-1	HIGH	87,699	276,838	800,066	1,364,855	1,883,722	3,483	6,845	12,537	15,008	29,477
	C-F-1000-1	HIGH	81,564	195,573	616,166	1,227,573	1,491,164	3,455	6,817	12,406	12,774	13,201
	C-G-100-1	HIGH	84,202	200,244	495,556	2,839,298	6,211,202	656	1,986	7,251	43,108	75,409
	C-R-100-1	HIGH	125,168	1,584,659	6,398,804	9,112,817	10,074,640	13,012	29,746	75,521	87,643	88,313
	C-R-400-1	HIGH	109,572	363,910	2,466,412	5,812,408	8,441,303	13,007	26,617	42,468	65,807	76,862
Structural Plans	F-100-1	HIGH	285,170	749,622	5,287,236	10,827,789	11,415,691	3,892	7,543	69,064	98,178	98,350
	F-400-1	HIGH	285,170	747,251	1,144,609	1,621,420	2,111,542	3,892	7,412	13,104	15,575	30,044
	F-1000-1	HIGH	285,170	747,251	1,142,672	1,593,029	1,772,708	3,892	7,412	13,001	13,369	13,796
	G-100-1	HIGH	196,234	357,355	633,175	2,969,104	6,338,016	872	2,202	7,467	43,324	75,625
	G-400-1	HIGH	196,234	356,934	509,028	569,425	636,259	872	2,202	2,539	2,862	3,382
	G-1000-1	HIGH	196,234	356,934	508,762	566,260	611,074	872	2,202	2,539	2,713	2,975
	R-100-1	HIGH	455,965	2,055,069	6,693,614	9,388,221	10,340,475	13,635	30,861	76,635	88,757	89,427
	R-400-1	HIGH	455,965	2,017,132	3,515,859	6,272,946	8,806,535	13,635	27,737	43,587	66,926	77,981
	R-1000-1	HIGH	455,965	2,017,131	3,474,750	4,375,143	5,588,216	13,635	27,737	40,588	45,045	60,767
Non-Structural Plans	NS-100	HIGH	346,785	4,259,215	8,294,044	11,338,097	12,492,489	37,789	66,090	87,738	96,454	97,598
	NS-400	HIGH	162,190	825,012	6,048,404	10,694,621	12,143,614	37,784	66,085	87,733	96,449	97,593
	NS-1000	HIGH	135,285	554,601	1,309,291	7,535,509	10,929,434	37,095	65,395	87,042	95,758	96,902

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 37a
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, Low Sea Level Rise Scenario
2075
Planning Unit 4
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	LOW	510,574	3,315,417	8,001,213	11,241,476	13,421,682	12,120	34,699	52,560	68,966	78,702
Coastal Restoration Plan	Sustained Coast	LOW	510,968	3,205,878	7,966,840	11,229,214	13,395,037	12,099	34,725	52,611	68,867	78,687
Comprehensive Plans	C-G-100-1	LOW	180,931	529,425	3,902,559	7,369,673	8,296,312	6,960	12,562	50,868	71,935	73,524
	C-G-100-2	LOW	224,358	697,287	4,167,913	7,547,657	8,381,570	7,849	13,874	52,717	72,343	73,610
	C-G-400-3	LOW	194,376	475,332	1,326,353	8,008,736	10,469,385	8,431	14,792	30,603	84,310	88,550
	C-G-1000-3	LOW	145,148	325,816	853,666	2,760,741	6,097,268	7,304	13,618	27,543	45,402	65,899
	C-R-100-1	LOW	206,496	992,576	5,195,654	7,517,467	8,540,864	11,038	26,660	60,292	70,074	72,874
	C-R-400-1	LOW	198,732	530,359	1,511,749	8,227,734	11,133,468	10,572	25,810	37,096	85,259	91,105
	C-R-1000-1	LOW	176,377	477,267	760,746	2,006,576	6,170,585	9,654	24,870	34,270	46,585	68,688
Structural Plans	G-100-1	LOW	468,003	2,574,811	6,333,851	9,786,643	10,777,977	10,392	16,291	54,597	75,664	77,253
	G-100-2	LOW	526,419	2,785,067	6,646,574	10,013,070	10,912,752	11,284	17,606	56,449	76,075	77,342
	G-400-1	LOW	468,003	2,569,970	4,937,093	8,806,386	11,099,389	10,392	16,052	20,535	59,116	64,553
	G-400-2	LOW	526,419	2,780,230	5,233,634	9,132,716	11,438,439	11,284	17,367	21,936	60,522	66,034
	G-400-3	LOW	531,703	2,807,691	5,660,053	11,568,986	13,834,303	12,948	19,605	35,416	89,123	93,363
	G-1000-1	LOW	468,003	2,569,970	4,926,718	6,678,162	7,973,023	10,392	16,052	20,196	28,814	41,700
	G-1000-2	LOW	526,419	2,780,230	5,223,256	7,004,359	8,311,446	11,284	17,367	21,597	30,220	43,106
	G-1000-3	LOW	531,703	2,807,691	5,641,572	8,534,137	10,747,208	12,948	19,605	33,530	51,389	71,886
	R-100-1	LOW	565,419	2,870,672	7,613,564	9,957,419	10,961,887	14,526	30,462	64,103	73,885	76,685
	R-400-1	LOW	565,853	2,864,789	6,591,584	11,953,539	14,329,106	14,641	30,192	41,487	89,650	95,496
	R-1000-1	LOW	565,853	2,864,789	6,573,103	8,918,689	11,242,011	14,641	30,192	39,601	51,916	74,019
Non-Structural Plans	NS-100	LOW	151,859	1,209,393	5,529,871	8,783,916	10,971,794	8,611	30,923	48,800	65,056	74,876
	NS-400	LOW	143,660	507,461	1,972,790	7,162,304	10,061,461	8,030	30,343	48,220	64,476	74,296
	NS-1000	LOW	121,306	454,241	820,490	2,560,958	7,422,625	7,112	29,403	47,280	63,536	73,356

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 37b
Residual Risk/Frequency Damage and Population
Business as Usual Growth, Compact Land Use, High Sea Level Rise Scenario
2075
Planning Unit 4
Louisiana Coastal Protection and Restoration

	Alternative	Sea Level Rise	Damages at each Frequency Storm Event ($1000's)					Population Impacted at each Frequency Storm Event				
			10yr	100yr	400yr	1000yr	2000yr	10yr	100yr	400yr	1000yr	2000yr
No Action Scenario	Degraded Coast	HIGH	794,229	5,182,611	9,282,981	12,313,476	14,372,660	18,938	42,043	61,154	79,743	84,244
Coastal Restoration Plan	Sustained Coast	HIGH	794,732	5,224,467	9,263,331	12,299,273	14,387,342	18,882	42,056	61,906	78,954	84,264
Comprehensive Plans	C-G-100-1	HIGH	195,022	1,384,000	4,418,079	7,935,584	8,745,342	9,028	14,266	55,759	73,788	74,927
	C-G-100-2	HIGH	258,597	1,596,174	4,705,068	8,125,159	8,839,801	9,929	15,580	57,608	74,196	75,013
	C-G-400-3	HIGH	214,761	559,640	2,358,964	8,791,730	10,981,277	10,513	16,498	35,494	86,163	89,953
	C-G-1000-3	HIGH	153,422	375,060	1,073,239	4,216,415	6,970,486	9,339	15,324	32,434	47,255	67,302
	C-R-100-1	HIGH	234,690	2,405,245	6,087,644	8,246,569	9,253,917	16,915	30,305	65,898	73,375	74,779
	C-R-400-1	HIGH	219,858	665,916	3,320,850	9,394,238	11,932,755	16,450	29,422	42,702	88,560	93,010
	C-R-1000-1	HIGH	196,782	557,435	1,090,048	4,148,239	7,581,106	15,510	28,482	39,876	49,886	70,593
Structural Plans	G-100-1	HIGH	674,073	3,735,265	6,816,964	10,411,185	11,093,856	12,710	17,995	59,488	77,517	78,656
	G-100-2	HIGH	757,811	3,990,594	7,152,286	10,649,409	11,238,530	13,614	19,312	61,340	77,928	78,745
	G-400-1	HIGH	674,073	3,730,424	5,420,207	9,430,928	11,415,268	12,710	17,756	25,426	60,969	65,956
	G-400-2	HIGH	757,811	3,985,757	5,739,345	9,769,055	11,764,216	13,614	19,073	26,827	62,375	67,437
	G-400-3	HIGH	763,095	4,013,218	6,165,764	12,205,326	14,160,081	15,278	21,311	40,307	90,976	94,766
	G-1000-1	HIGH	674,073	3,730,424	5,409,831	7,302,704	8,288,903	12,710	17,756	25,087	30,667	43,103
	G-1000-2	HIGH	757,811	3,985,757	5,728,968	7,640,698	8,637,223	13,614	19,073	26,488	32,073	44,509
	G-1000-3	HIGH	763,095	4,013,218	6,147,283	9,170,476	11,072,986	15,278	21,311	38,421	53,242	73,289
	R-100-1	HIGH	843,499	4,570,188	8,523,335	10,673,414	11,662,544	20,670	34,107	69,709	77,186	78,590
	R-400-1	HIGH	843,932	4,564,305	7,484,787	12,665,627	15,029,264	20,785	33,804	47,093	92,951	97,401
	R-1000-1	HIGH	843,932	4,564,305	7,466,306	9,630,777	11,942,169	20,785	33,804	45,207	55,217	75,924
Non-Structural Plans	NS-100	HIGH	182,198	2,968,776	6,818,273	9,869,128	11,977,617	15,127	38,254	58,095	75,143	80,453
	NS-400	HIGH	166,191	667,643	4,523,906	8,854,850	11,202,059	14,547	37,674	57,515	74,563	79,873
	NS-1000	HIGH	143,114	550,499	1,229,497	5,665,354	9,552,362	13,607	36,734	56,575	73,623	78,933

Source: GIS Economic Application Databases

Note: There is a 90 percent chance that values are less than the indicated value, or only a 10 percent chance that values exceed the indicated value. All damages are in 2007 prices.

Table 38
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, Low Sea Level Rise Scenario
Planning Unit 1
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU1-0	NA	10	172,658	293,245	442,270	13,923	26,486	37,371	580	961	1,471	17,682	81,216	76,072	62,571	317,040	287,017
Degraded Coast PU1-0	NA	50	247,932	555,458	715,884	15,139	30,240	41,502	858	2,851	3,036	28,965	264,860	203,877	112,826	1,019,409	786,767
Degraded Coast PU1-0	NA	90	445,123	1,190,034	1,401,187	17,091	41,065	51,017	1,590	6,470	6,339	58,049	597,237	448,539	216,861	2,341,417	1,741,951
Sustained Coast PU1-R	NA*	10	172,658	260,477	422,566	13,923	25,896	37,016	580	915	1,443	17,682	77,299	73,716	62,571	302,864	278,493
Sustained Coast PU1-R	NA*	50	247,932	389,549	616,120	15,139	28,146	40,243	858	1,490	2,219	28,965	130,010	122,790	112,826	519,649	486,254
Sustained Coast PU1-R	NA*	90	445,123	699,090	1,105,974	17,091	31,247	45,113	1,590	4,214	4,983	58,049	388,302	322,903	216,861	1,502,437	1,237,459
Comprehensive Plans																	
C-HL-a-100-2	12	10	74,557	86,523	264,239	11,378	19,299	31,018	257	279	882	6,347	20,615	35,523	22,278	72,398	128,643
C-HL-a-100-2	12	50	106,061	136,959	399,042	12,286	20,694	33,710	427	659	1,594	12,911	57,828	82,892	49,649	233,627	325,363
C-HL-a-100-2	12	90	273,035	421,526	872,515	14,073	23,634	39,008	1,171	2,046	3,709	42,627	186,504	213,832	156,233	718,950	816,653
C-HL-a-100-3	12	10	74,920	88,187	263,143	11,488	19,682	31,233	252	283	874	6,206	21,238	35,572	21,801	74,818	128,960
C-HL-a-100-3	12	50	106,394	140,939	397,973	12,418	21,302	34,023	423	701	1,601	12,843	61,166	84,005	49,431	245,137	329,260
C-HL-a-100-3	12	90	271,823	425,427	869,609	14,194	24,230	39,309	1,163	2,108	3,717	42,406	193,462	215,898	155,457	745,426	824,517
C-HL-b-400-2	16	10	72,952	83,157	279,388	11,210	18,911	31,154	253	253	924	6,150	18,018	37,253	21,531	61,726	135,803
C-HL-b-400-2	16	50	73,782	84,889	394,922	11,340	19,179	33,173	254	259	1,494	6,182	18,575	76,162	21,694	63,800	291,777
C-HL-b-400-2	16	90	81,039	97,576	708,260	11,702	19,751	37,294	289	326	2,864	7,537	24,722	159,305	27,188	86,227	609,504
C-HL-b-400-3	16	10	73,516	84,793	276,886	11,322	19,297	31,321	247	248	910	5,996	17,711	36,770	21,010	60,672	134,093
C-HL-b-400-3	16	50	74,584	87,315	391,404	11,485	19,821	33,435	248	263	1,481	6,045	19,233	75,916	21,223	65,560	290,717
C-HL-b-400-3	16	90	82,105	102,320	704,215	11,904	20,549	37,636	287	351	2,853	7,529	27,575	159,475	27,102	95,961	609,744
C-LP-a-100-1	14	10	74,918	93,811	270,868	11,540	20,715	31,885	224	255	825	5,657	20,263	35,308	20,124	79,198	131,824
C-LP-a-100-1	14	50	87,287	124,488	386,921	12,078	22,428	34,496	277	520	1,421	7,681	44,624	77,864	29,588	157,203	299,368
C-LP-a-100-1	14	90	151,337	265,482	744,483	13,500	25,316	39,725	591	1,423	3,102	19,471	127,186	183,109	73,712	509,233	709,793
C-LP-a-100-2	14	10	74,396	85,735	275,534	11,156	18,732	30,998	260	270	884	6,444	19,750	36,502	22,895	70,908	133,405
C-LP-a-100-2	14	50	91,170	111,661	398,509	11,572	19,496	33,212	326	389	1,479	8,895	30,705	75,855	33,076	111,756	292,473
C-LP-a-100-2	14	90	152,427	222,796	751,189	12,511	21,251	37,747	611	1,013	3,057	19,780	86,925	172,108	72,215	347,770	661,309
C-LP-a-100-3	14	10	74,513	87,017	274,673	11,229	19,103	31,162	254	269	876	6,290	20,064	36,441	22,369	73,235	133,544
C-LP-a-100-3	14	50	90,953	113,430	397,038	11,671	19,986	33,433	320	417	1,477	8,729	33,003	76,359	32,542	119,181	294,070
C-LP-a-100-3	14	90	152,240	227,177	749,919	12,614	21,756	37,976	607	1,077	3,068	19,725	93,110	173,942	72,189	365,261	666,557
C-LP-b-400-1	16	10	72,604	87,648	271,995	11,325	20,239	31,572	219	220	816	5,495	16,701	33,685	19,243	57,732	123,355
C-LP-b-400-1	16	50	75,067	93,991	378,498	11,727	21,705	34,075	224	263	1,346	5,691	20,639	72,120	19,968	72,457	277,363
C-LP-b-400-1	16	90	86,650	123,947	684,397	12,658	23,736	38,960	288	586	2,758	8,102	50,151	160,943	28,442	174,881	610,980

Table 38--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, Low Sea Level Rise Scenario
Planning Unit 1
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
C-LP-b-400-3	16	10	72,065	82,972	279,371	11,094	18,785	31,109	247	248	878	6,000	17,746	35,668	21,020	60,777	129,652
C-LP-b-400-3	16	50	72,925	84,777	392,769	11,229	19,141	33,133	248	257	1,449	6,024	18,561	74,757	21,078	63,084	286,339
C-LP-b-400-3	16	90	81,898	99,393	704,620	11,572	19,776	37,263	293	382	2,830	7,795	30,666	159,668	27,497	102,501	605,372
C-LP-b-1000-1	16	10	71,390	85,774	269,955	11,170	19,917	31,285	219	219	816	5,491	16,618	33,655	19,233	57,388	123,237
C-LP-b-1000-1	16	50	73,390	89,309	375,093	11,516	21,315	33,710	219	219	1,326	5,491	16,658	70,648	19,234	57,464	271,841
C-LP-b-1000-1	16	90	76,772	98,799	667,472	12,307	23,150	38,446	228	303	2,618	5,827	24,154	150,973	20,335	81,968	575,394
C-LP-b-1000-2	16	10	71,319	80,904	279,695	10,894	18,231	30,761	253	253	889	6,150	17,989	35,998	21,531	61,532	130,805
C-LP-b-1000-2	16	50	71,744	81,617	393,197	10,973	18,411	32,697	253	253	1,459	6,150	17,990	74,885	21,531	61,536	286,951
C-LP-b-1000-2	16	90	72,941	83,338	697,418	11,103	18,703	36,596	255	258	2,780	6,230	18,476	155,397	21,763	63,168	591,337
Structural Plans																	
HL-a-100-2	12	10	108,455	129,928	318,440	11,823	20,398	31,894	383	447	1,085	11,108	35,377	45,820	38,473	125,198	164,468
HL-a-100-2	12	50	149,022	194,043	468,376	12,752	21,913	34,647	561	879	1,823	17,904	75,303	94,307	66,938	303,228	367,706
HL-a-100-2	12	90	321,122	484,534	949,847	14,546	24,854	39,955	1,311	2,505	4,019	47,857	229,980	233,586	174,208	884,930	889,671
HL-a-100-3	12	10	114,174	140,034	326,397	11,957	20,846	32,157	392	473	1,101	11,387	38,012	46,998	39,506	135,722	169,110
HL-a-100-3	12	50	156,665	208,154	479,233	12,909	22,587	35,012	571	937	1,853	18,210	80,472	96,438	68,051	322,100	375,483
HL-a-100-3	12	90	328,788	499,604	961,074	14,694	25,519	40,309	1,325	2,581	4,058	48,445	237,603	236,830	176,608	913,985	902,153
HL-b-400-2	16	10	107,897	129,291	335,692	11,793	20,352	32,301	382	446	1,139	11,067	35,245	48,500	38,330	124,763	175,524
HL-b-400-2	16	50	119,344	151,927	470,465	11,961	20,773	34,414	407	641	1,797	12,070	53,284	93,991	42,840	212,060	363,120
HL-b-400-2	16	90	133,683	178,929	796,752	12,331	21,346	38,544	449	987	3,261	13,677	88,310	186,381	48,959	343,178	715,262
HL-b-400-3	16	10	113,826	139,620	342,333	11,928	20,803	32,516	391	472	1,152	11,347	37,882	49,451	39,367	135,297	179,277
HL-b-400-3	16	50	127,749	167,080	480,031	12,132	21,481	34,727	419	703	1,822	12,427	58,774	95,836	44,142	232,156	369,871
HL-b-400-3	16	90	144,556	200,535	809,722	12,560	22,213	38,940	473	1,090	3,306	14,635	98,414	189,959	52,609	380,755	728,618
LP-a-100-1	14	10	121,130	182,018	353,750	11,985	21,920	32,794	471	781	1,285	14,362	68,329	60,661	49,884	251,163	220,866
LP-a-100-1	14	50	157,004	254,389	510,977	12,596	24,047	35,620	609	1,070	1,991	18,710	96,203	107,099	66,941	371,535	410,660
LP-a-100-1	14	90	243,939	421,502	904,144	14,045	27,047	40,916	967	1,946	3,715	32,383	175,913	213,725	121,818	687,400	822,814
LP-a-100-2	14	10	104,523	140,617	328,754	11,519	19,697	31,733	442	625	1,213	12,951	56,045	55,567	45,894	204,893	202,554
LP-a-100-2	14	50	133,478	190,576	473,818	11,993	20,770	34,111	521	792	1,839	15,830	71,508	96,831	57,028	289,539	376,332
LP-a-100-2	14	90	203,907	315,829	841,899	12,934	22,541	38,655	829	1,388	3,435	27,606	124,655	193,204	105,147	491,068	745,286
LP-a-100-3	14	10	107,443	146,964	332,833	11,613	20,131	31,942	447	658	1,227	13,024	58,332	56,390	46,225	212,804	205,453
LP-a-100-3	14	50	137,186	199,243	479,204	12,113	21,324	34,379	528	828	1,856	15,990	74,204	97,850	57,625	298,595	379,795
LP-a-100-3	14	90	209,058	329,210	849,835	13,059	23,110	38,931	840	1,460	3,467	27,990	131,263	195,696	106,432	510,269	752,639
LP-b-400-1	16	10	120,732	181,470	358,920	11,979	21,902	32,873	470	778	1,291	14,320	68,028	60,193	49,753	250,194	219,647
LP-b-400-1	16	50	152,051	243,870	517,480	12,472	23,793	35,618	589	1,027	2,021	18,050	92,626	109,276	64,749	358,930	419,929

Table 38--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, Low Sea Level Rise Scenario
Planning Unit 1
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
LP-b-400-1	16	90	195,149	329,310	878,455	13,430	25,937	40,570	748	1,516	3,598	24,157	137,805	207,393	90,710	534,771	797,311
LP-b-400-3	16	10	105,712	145,034	339,048	11,575	20,074	32,087	441	650	1,235	12,792	57,487	56,142	45,258	209,541	204,869
LP-b-400-3	16	50	120,642	175,968	478,385	11,787	20,751	34,302	468	727	1,859	13,835	65,142	98,575	49,171	265,052	382,668
LP-b-400-3	16	90	141,732	210,891	811,093	12,134	21,403	38,442	545	854	3,279	16,904	77,018	184,975	65,703	304,918	714,000
LP-b-1000-1	16	10	120,732	181,470	358,920	11,979	21,902	32,873	470	778	1,291	14,320	68,028	60,193	49,753	250,194	219,647
LP-b-1000-1	16	50	151,951	243,751	517,384	12,458	23,775	35,605	589	1,027	2,021	18,048	92,610	109,269	64,741	358,877	419,909
LP-b-1000-1	16	90	190,719	322,680	873,815	13,284	25,738	40,423	716	1,455	3,561	22,910	132,303	205,008	86,246	514,409	788,575
LP-b-1000-2	16	10	102,743	138,632	335,357	11,479	19,635	31,899	437	617	1,223	12,717	55,197	55,417	44,918	201,612	202,310
LP-b-1000-2	16	50	116,132	166,420	472,831	11,637	20,142	34,031	460	689	1,843	13,640	62,344	97,627	48,460	255,668	379,454
LP-b-1000-2	16	90	128,013	186,249	795,506	11,770	20,450	37,940	491	708	3,203	14,875	63,750	179,813	58,245	260,529	696,326
Non-Structural Plans																	
NS-100	15	10	50,946	79,804	204,285	13,268	24,278	32,289	47	252	542	1,598	23,052	21,464	5,152	92,096	78,648
NS-100	15	50	81,608	168,277	319,466	14,462	26,408	35,151	270	756	1,146	9,958	71,641	53,898	38,714	285,732	211,928
NS-100	15	90	244,327	460,296	732,412	16,403	29,502	39,672	948	3,373	3,236	37,043	313,629	179,877	136,739	1,227,410	687,404
NS-400	15	10	27,007	44,929	166,594	12,584	23,207	31,188	1	2	413	25	119	12,594	101	583	44,631
NS-400	15	50	31,946	55,229	228,670	13,758	25,301	34,018	11	69	642	401	6,497	22,986	2,486	26,443	90,929
NS-400	15	90	86,018	163,494	462,664	15,684	28,377	38,517	326	863	1,760	13,465	82,958	81,951	67,017	368,066	342,937
NS-1000	15	10	17,157	31,384	151,334	9,662	17,049	25,999	0	0	411	0	0	12,529	0	0	44,337
NS-1000	15	50	21,334	37,833	211,362	10,797	19,069	28,761	3	5	613	139	695	20,895	1,474	5,929	83,438
NS-1000	15	90	40,499	73,197	383,568	12,637	21,965	33,107	132	305	1,370	6,212	32,518	58,182	43,586	192,917	262,371

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 39
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, High Sea Level Rise Scenario
Planning Unit 1
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU1-0	NA	10	172,658	425,399	521,736	13,923	28,867	38,803	580	1,994	2,092	17,682	178,032	134,288	62,571	710,770	523,773
Degraded Coast PU1-0	NA	50	247,932	912,039	930,302	15,139	36,301	45,147	858	4,897	4,267	28,965	447,690	313,816	112,826	1,743,220	1,222,006
Degraded Coast PU1-0	NA	90	445,123	2,400,566	2,129,099	17,091	48,932	55,748	1,590	14,286	11,040	58,049	1,343,018	896,989	216,861	5,165,302	3,439,998
Sustained Coast PU1-R	NA*	10	172,658	361,699	483,432	13,923	27,831	38,180	580	1,587	1,847	17,682	139,826	111,315	62,571	551,275	427,866
Sustained Coast PU1-R	NA*	50	247,932	517,611	693,125	15,139	29,993	41,354	858	3,164	3,225	28,965	286,955	217,164	112,826	1,058,989	810,567
Sustained Coast PU1-R	NA*	90	445,123	1,043,568	1,313,115	17,091	33,687	46,581	1,590	4,872	5,378	58,049	446,046	357,625	216,861	1,679,444	1,343,896
Comprehensive Plans																	
C-HL-a-100-2	12	10	74,557	95,917	281,377	11,378	19,657	31,392	257	443	1,048	6,347	37,217	51,387	22,278	146,172	195,855
C-HL-a-100-2	12	50	106,061	163,570	444,623	12,286	20,973	34,415	427	730	1,837	12,911	63,428	104,623	49,649	257,757	411,766
C-HL-a-100-2	12	90	273,035	473,171	1,014,276	14,073	24,056	39,947	1,171	2,083	4,498	42,627	189,686	288,977	156,233	733,169	1,102,035
C-HL-a-100-3	12	10	74,920	101,009	281,693	11,488	20,323	31,712	252	520	1,066	6,206	45,261	54,094	21,801	176,366	206,088
C-HL-a-100-3	12	50	106,394	178,282	447,582	12,418	21,854	34,829	423	854	1,875	12,843	76,043	109,093	49,431	304,362	428,338
C-HL-a-100-3	12	90	271,823	499,322	1,019,587	14,194	24,934	40,352	1,163	2,239	4,540	42,406	205,451	294,301	155,457	786,292	1,119,758
C-HL-b-400-2	16	10	72,952	85,580	299,461	11,210	19,269	31,611	253	257	1,076	6,150	18,307	51,432	21,531	63,052	193,349
C-HL-b-400-2	16	50	73,782	90,261	448,951	11,340	19,457	34,153	254	286	1,801	6,182	21,102	103,608	21,694	74,907	400,825
C-HL-b-400-2	16	90	81,039	110,558	890,271	11,702	20,174	38,583	289	360	4,031	7,537	27,638	270,592	27,188	100,028	1,031,707
C-HL-b-400-3	16	10	73,516	88,130	297,165	11,322	19,938	31,863	247	259	1,063	5,996	18,810	51,122	21,010	64,312	192,067
C-HL-b-400-3	16	50	74,584	96,100	446,337	11,485	20,374	34,496	248	319	1,796	6,045	25,104	104,291	21,223	86,753	402,494
C-HL-b-400-3	16	90	82,105	124,279	888,717	11,904	21,253	39,009	287	442	4,037	7,529	36,437	272,487	27,102	124,662	1,036,210
C-LP-a-100-1	14	10	74,918	114,708	295,442	11,540	22,892	32,929	224	594	1,068	5,657	53,273	58,524	20,124	166,897	211,194
C-LP-a-100-1	14	50	87,287	179,025	450,075	12,078	24,727	36,027	277	942	1,815	7,681	84,571	113,855	29,588	343,062	450,517
C-LP-a-100-1	14	90	151,337	381,601	933,294	13,500	27,215	41,341	591	1,768	4,183	19,471	163,282	287,332	73,712	677,039	1,115,342
C-LP-a-100-2	14	10	74,396	90,197	293,963	11,156	19,221	31,467	260	283	1,017	6,444	21,056	48,993	22,895	74,377	184,305
C-LP-a-100-2	14	50	91,170	120,027	445,681	11,572	19,903	34,100	326	435	1,746	8,895	35,058	99,768	33,076	151,518	394,128
C-LP-a-100-2	14	90	152,427	236,388	905,182	12,511	21,756	38,891	611	1,099	4,049	19,780	95,614	266,975	72,215	368,754	1,016,507
C-LP-a-100-3	14	10	74,513	94,166	294,131	11,229	19,839	31,715	254	346	1,030	6,290	27,020	50,804	22,369	91,176	189,245
C-LP-a-100-3	14	50	90,953	129,966	447,067	11,671	20,612	34,395	320	518	1,763	8,729	43,513	102,362	32,542	177,305	401,960
C-LP-a-100-3	14	90	152,240	254,569	908,626	12,614	22,521	39,208	607	1,223	4,081	19,725	108,903	271,220	72,189	412,378	1,030,628
C-LP-b-400-1	16	10	72,604	95,049	293,051	11,325	22,385	32,555	219	293	987	5,495	24,132	49,851	19,243	78,005	186,298
C-LP-b-400-1	16	50	75,067	113,478	436,301	11,727	23,983	35,646	224	662	1,768	5,691	59,418	110,719	19,968	181,802	416,452
C-LP-b-400-1	16	90	86,650	176,050	878,138	12,658	25,615	40,681	288	1,001	4,039	8,102	91,182	283,565	28,442	311,086	1,068,791

Table 39--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, High Sea Level Rise Scenario
Planning Unit 1
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
C-LP-b-400-3	16	10	72,065	86,919	299,737	11,094	19,489	31,666	247	292	1,044	6,000	22,260	51,278	21,020	72,618	190,895
C-LP-b-400-3	16	50	72,925	93,353	447,792	11,229	19,746	34,208	248	354	1,781	6,024	28,241	104,729	21,078	92,510	402,312
C-LP-b-400-3	16	90	81,898	117,054	888,854	11,572	20,520	38,647	293	477	4,015	7,795	40,549	272,933	27,497	137,793	1,033,742
C-LP-b-1000-1	16	10	71,390	91,031	290,347	11,170	21,994	32,247	219	226	966	5,491	17,276	47,723	19,233	58,612	180,280
C-LP-b-1000-1	16	50	73,390	97,072	429,265	11,516	23,553	35,269	219	278	1,642	5,491	22,205	98,954	19,234	74,373	382,302
C-LP-b-1000-1	16	90	76,772	121,541	852,120	12,307	24,964	40,146	228	617	3,867	5,827	54,703	270,349	20,335	173,371	1,019,329
C-LP-b-1000-2	16	10	71,319	82,383	299,383	10,894	18,680	31,242	253	254	1,042	6,150	18,085	50,293	21,531	62,023	188,675
C-LP-b-1000-2	16	50	71,744	83,282	446,225	10,973	18,797	33,707	253	258	1,763	6,150	18,378	102,059	21,531	63,596	394,690
C-LP-b-1000-2	16	90	72,941	87,185	877,568	11,103	19,187	37,903	255	267	3,939	6,230	19,328	265,959	21,763	66,582	1,010,177
Structural Plans																	
HL-a-100-2	12	10	108,455	149,035	338,586	11,823	20,863	32,301	383	659	1,265	11,108	54,462	62,453	38,473	215,737	236,872
HL-a-100-2	12	50	149,022	227,710	516,143	12,752	22,210	35,358	561	1,192	2,141	17,904	107,070	124,142	66,938	424,957	484,336
HL-a-100-2	12	90	321,122	581,849	1,105,752	14,546	25,332	40,911	1,311	2,546	4,810	47,857	233,348	308,789	174,208	900,661	1,175,521
HL-a-100-3	12	10	114,174	165,123	348,747	11,957	21,598	32,670	392	751	1,306	11,387	63,225	65,888	39,506	248,656	249,765
HL-a-100-3	12	50	156,665	253,813	531,418	12,909	23,160	35,824	571	1,333	2,201	18,210	120,478	129,309	68,051	474,604	503,451
HL-a-100-3	12	90	328,788	619,504	1,125,301	14,694	26,280	41,369	1,325	2,720	4,884	48,445	250,001	315,359	176,608	957,077	1,198,084
HL-b-400-2	16	10	107,897	148,398	360,932	11,793	20,817	32,792	382	658	1,355	11,067	54,330	68,501	38,330	215,302	260,700
HL-b-400-2	16	50	119,344	185,594	533,258	11,961	21,070	35,400	407	953	2,193	12,070	85,050	130,492	42,840	333,789	506,430
HL-b-400-2	16	90	133,683	276,244	1,004,882	12,331	21,824	39,851	449	1,028	4,430	13,677	91,678	297,809	48,959	358,909	1,138,062
HL-b-400-3	16	10	113,826	164,708	369,349	11,928	21,555	33,092	391	750	1,388	11,347	63,094	71,271	39,367	248,230	271,101
HL-b-400-3	16	50	127,749	212,740	546,384	12,132	22,054	35,795	419	1,098	2,243	12,427	98,780	134,783	44,142	384,660	522,316
HL-b-400-3	16	90	144,556	320,435	1,024,557	12,560	22,974	40,330	473	1,229	4,504	14,635	110,812	304,067	52,609	423,847	1,159,540
LP-a-100-1	14	10	121,130	244,561	391,222	11,985	24,550	33,978	471	1,148	1,537	14,362	104,937	84,992	49,884	378,350	312,466
LP-a-100-1	14	50	157,004	334,538	582,064	12,596	26,563	37,219	609	1,470	2,379	18,710	133,792	142,360	66,941	523,143	551,201
LP-a-100-1	14	90	243,939	548,885	1,096,444	14,045	29,062	42,568	967	2,330	4,808	32,383	215,798	319,121	121,818	882,092	1,236,690
LP-a-100-2	14	10	104,523	166,900	353,940	11,519	20,534	32,310	442	682	1,360	12,951	61,502	69,344	45,894	250,152	266,397
LP-a-100-2	14	50	133,478	212,871	525,304	11,993	21,293	35,036	521	811	2,097	15,830	72,870	119,818	57,028	295,169	467,416
LP-a-100-2	14	90	203,907	337,843	998,500	12,934	23,154	39,833	829	1,488	4,432	27,606	134,699	288,490	105,147	518,036	1,102,337
LP-a-100-3	14	10	107,443	180,011	360,312	11,613	21,216	32,603	447	755	1,387	13,024	67,955	71,579	46,225	269,023	273,010
LP-a-100-3	14	50	137,186	232,800	534,505	12,113	22,069	35,378	528	904	2,133	15,990	81,830	122,959	57,625	323,069	477,263
LP-a-100-3	14	90	209,058	366,367	1,011,566	13,059	23,988	40,198	840	1,624	4,485	27,990	148,563	293,440	106,432	564,011	1,118,762
LP-b-400-1	16	10	120,732	244,013	397,054	11,979	24,533	34,007	470	1,145	1,553	14,320	104,635	85,395	49,753	377,381	315,702
LP-b-400-1	16	50	152,051	324,020	594,071	12,472	26,309	37,263	589	1,428	2,443	18,050	130,215	147,505	64,749	510,538	572,108

Table 39--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, High Sea Level Rise Scenario
Planning Unit 1
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
LP-b-400-1	16	90	195,149	456,694	1,095,511	13,430	27,952	42,333	748	1,900	4,869	24,157	177,690	329,660	90,710	729,463	1,273,236
LP-b-400-3	16	10	105,712	178,081	368,426	11,575	21,159	32,762	441	747	1,417	12,792	67,110	73,335	45,258	265,761	279,857
LP-b-400-3	16	50	120,642	209,524	541,145	11,787	21,496	35,421	468	802	2,184	13,835	72,768	127,911	49,171	289,526	497,108
LP-b-400-3	16	90	141,732	248,048	1,001,366	12,134	22,280	39,867	545	1,017	4,485	16,904	94,317	300,538	65,703	358,659	1,148,084
LP-b-1000-1	16	10	120,732	244,013	397,054	11,979	24,533	34,007	470	1,145	1,553	14,320	104,635	85,395	49,753	377,381	315,702
LP-b-1000-1	16	50	151,951	323,901	593,975	12,458	26,291	37,249	589	1,428	2,443	18,048	130,199	147,499	64,741	510,485	572,088
LP-b-1000-1	16	90	190,719	450,063	1,090,872	13,284	27,753	42,186	716	1,840	4,832	22,910	172,188	327,275	86,246	709,101	1,264,499
LP-b-1000-2	16	10	102,743	164,914	362,727	11,479	20,471	32,500	437	674	1,393	12,717	60,653	71,373	44,918	246,871	274,044
LP-b-1000-2	16	50	116,132	188,716	532,248	11,637	20,666	35,084	460	708	2,152	13,640	63,706	125,103	48,460	261,298	488,299
LP-b-1000-2	16	90	128,013	208,262	981,283	11,770	21,064	39,287	491	807	4,390	14,875	73,794	293,222	58,245	287,497	1,122,462
Non-Structural Plans																	
NS-100	15	10	50,946	137,747	222,231	13,268	26,103	32,854	47	923	750	1,598	90,687	42,411	5,152	366,529	163,644
NS-100	15	50	81,608	279,620	353,950	14,462	28,233	35,717	270	2,314	1,628	9,958	211,692	97,273	38,714	795,459	369,797
NS-100	15	90	244,327	788,563	834,080	16,403	31,885	40,410	948	4,001	3,430	37,043	368,859	196,982	136,739	1,396,225	739,688
NS-400	15	10	27,007	53,634	169,290	12,584	25,031	31,753	1	28	421	25	2,795	13,423	101	10,416	47,677
NS-400	15	50	31,946	78,623	235,915	13,758	27,126	34,583	11	327	722	401	32,565	31,060	2,486	120,541	120,073
NS-400	15	90	86,018	226,942	482,315	15,684	30,760	39,255	326	1,050	1,818	13,465	102,691	88,062	67,017	437,769	364,525
NS-1000	15	10	17,157	38,095	153,413	9,662	18,874	26,564	0	0	411	0	53	12,546	0	171	44,390
NS-1000	15	50	21,334	46,128	213,931	10,797	20,894	29,326	3	59	629	139	6,109	22,572	1,474	23,692	88,939
NS-1000	15	90	40,499	96,577	390,809	12,637	24,348	33,845	132	449	1,414	6,212	46,421	62,488	43,586	237,981	276,328

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 40
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, Low Sea Level Rise Scenario
Planning Unit 2
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU2-0	NA	10	128,933	986,481	791,776	6,334	20,393	22,019	429	4,288	3,239	19,424	423,469	284,556	152,158	2,039,494	1,460,742
Degraded Coast PU2-0	NA	50	277,720	2,362,345	1,848,273	8,163	28,122	29,484	1,020	11,129	8,264	42,462	1,063,023	704,614	238,059	5,115,575	3,442,747
Degraded Coast PU2-0	NA	90	372,357	2,644,708	2,163,829	8,802	29,269	31,156	1,386	11,508	9,054	56,918	1,100,079	749,163	344,510	5,409,609	3,783,515
Sustained Coast PU1-R	NA*	10	128,933	232,403	338,337	6,334	9,663	15,567	429	903	1,203	19,424	78,812	77,308	152,158	546,117	562,750
Sustained Coast PU1-R	NA*	50	277,720	489,798	722,281	8,163	11,878	19,716	1,020	2,184	2,885	42,462	202,082	186,917	238,059	1,157,967	1,062,974
Sustained Coast PU1-R	NA*	90	372,357	653,695	966,601	8,802	12,624	21,148	1,386	2,780	3,806	56,918	268,914	249,370	344,510	1,646,366	1,520,617
Comprehensive Plans																	
C-G-100-1	11	10	27,160	80,698	231,522	5,276	9,176	14,977	13	260	747	436	18,641	57,924	2,018	100,280	329,522
C-G-100-1	11	50	34,866	127,845	494,788	5,861	9,442	17,773	89	661	2,062	3,104	50,205	147,540	15,440	290,834	751,394
C-G-100-1	11	90	55,231	180,511	632,898	6,416	9,823	19,020	185	894	2,558	7,192	77,380	176,175	35,840	599,694	983,642
C-G-100-4	11	10	23,115	45,710	217,631	3,898	6,574	12,898	13	120	713	433	7,910	54,118	1,998	58,488	315,040
C-G-100-4	11	50	29,479	81,703	476,710	4,330	6,776	15,549	83	402	1,986	2,939	29,475	140,037	14,691	192,602	716,484
C-G-100-4	11	90	48,840	122,785	610,784	4,814	7,192	16,755	188	604	2,484	7,312	53,771	168,047	36,567	484,387	944,920
C-G-400-4	13	10	20,711	32,802	234,405	3,811	6,172	13,140	8	46	781	257	3,391	61,361	1,075	10,425	335,701
C-G-400-4	13	50	23,215	39,601	521,436	4,051	6,230	15,847	9	72	2,097	297	6,320	155,085	1,250	46,701	768,412
C-G-400-4	13	90	26,185	52,223	643,912	4,261	6,308	16,772	17	127	2,492	611	11,272	174,428	3,471	65,520	898,970
C-G-1000-4	13	10	18,209	22,633	228,248	3,650	5,640	12,782	8	43	780	253	3,194	61,295	1,062	8,791	335,180
C-G-1000-4	13	50	19,377	25,362	512,416	3,791	5,689	15,367	8	47	2,088	253	3,649	154,204	1,062	15,436	758,505
C-G-1000-4	13	90	20,632	29,723	630,447	3,962	5,723	16,250	10	68	2,465	309	5,709	172,349	1,485	41,463	889,166
C-R-100-2	11	10	33,718	73,167	228,912	5,143	7,532	14,215	37	230	758	1,295	18,571	58,620	5,655	126,145	333,261
C-R-100-2	11	50	85,536	195,535	555,731	6,210	8,818	17,793	313	1,070	2,403	11,921	108,261	176,393	54,198	729,347	937,101
C-R-100-2	11	90	199,946	373,101	820,868	7,055	9,828	19,510	756	1,836	3,367	29,449	179,667	232,581	133,188	1,085,447	1,245,191
C-R-100-3	11	10	31,051	65,102	226,403	4,437	6,652	13,324	36	193	755	1,279	16,029	57,580	5,555	107,703	327,110
C-R-100-3	11	50	81,961	181,090	550,566	5,496	7,954	16,902	307	945	2,368	11,700	94,442	171,621	53,304	672,391	917,512
C-R-100-3	11	90	195,698	353,727	813,516	6,363	8,999	18,650	756	1,718	3,340	29,433	166,578	228,264	133,157	1,031,735	1,227,721
C-R-100-4	11	10	30,370	62,652	225,807	4,214	6,187	12,971	34	167	752	1,181	13,377	56,575	4,800	90,024	320,791
C-R-100-4	11	50	80,791	175,486	548,822	5,224	7,455	16,497	296	854	2,332	11,169	82,318	166,680	49,412	573,241	877,852
C-R-100-4	11	90	194,329	342,587	810,053	6,057	8,499	18,217	746	1,586	3,307	29,017	150,327	222,563	130,066	910,897	1,185,495
C-R-400-2	13	10	23,696	30,086	226,321	4,878	7,172	14,201	8	9	750	255	738	60,339	1,070	3,086	325,205
C-R-400-2	13	50	27,525	40,024	512,351	5,278	7,593	17,159	12	63	2,068	375	6,046	155,389	1,807	33,582	764,546
C-R-400-2	13	90	38,991	63,991	642,466	5,564	7,924	18,227	50	152	2,481	1,882	14,923	176,516	8,714	94,752	909,335

Table 40--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, Low Sea Level Rise Scenario
Planning Unit 2
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
C-R-400-3	11	10	21,314	26,909	204,931	4,200	6,325	12,988	8	9	670	255	738	51,668	1,070	3,086	289,446
C-R-400-3	11	50	25,017	36,368	452,721	4,578	6,745	15,664	12	56	1,800	370	5,351	131,521	1,789	30,016	659,943
C-R-400-3	11	90	36,166	59,056	572,768	4,859	7,079	16,679	49	143	2,188	1,828	14,036	151,551	8,503	90,724	799,234
C-R-400-4	13	10	20,691	25,661	227,721	3,976	5,860	13,119	8	9	776	255	725	60,640	1,070	2,997	329,271
C-R-400-4	13	50	24,173	34,585	514,721	4,294	6,232	16,002	11	51	2,098	343	4,870	155,481	1,590	26,183	764,845
C-R-400-4	13	90	34,961	55,978	645,385	4,515	6,533	17,014	46	128	2,522	1,687	12,120	176,625	7,469	76,000	910,179
C-R-1000-4	13	10	18,911	22,816	224,702	3,839	5,693	12,903	8	8	776	252	609	60,601	1,059	2,672	329,160
C-R-1000-4	13	50	20,969	26,047	508,508	4,137	6,039	15,761	9	15	2,084	259	1,283	154,280	1,085	7,226	758,413
C-R-1000-4	13	90	22,343	31,313	625,894	4,228	6,185	16,628	11	30	2,462	334	2,683	172,435	1,589	17,875	886,372
C-WBI-100-1	6	10	34,525	86,795	199,685	5,878	8,976	14,954	39	306	637	1,331	24,233	46,682	5,890	152,359	289,942
C-WBI-100-1	6	50	87,330	222,761	458,805	7,083	10,250	18,200	328	1,287	1,984	12,372	124,260	141,621	56,171	795,428	793,845
C-WBI-100-1	6	90	201,441	424,227	739,028	7,990	11,272	20,047	760	2,136	3,055	29,548	209,531	211,433	134,439	1,242,688	1,182,165
C-WBI-400-1	12	10	24,320	33,698	215,656	5,614	8,618	15,094	8	15	707	255	1,054	56,674	1,070	4,274	309,593
C-WBI-400-1	12	50	28,723	47,069	480,081	6,198	9,080	18,072	13	136	1,930	417	11,630	145,478	2,031	59,029	721,272
C-WBI-400-1	12	90	41,396	82,129	605,080	6,584	9,469	19,210	55	263	2,337	2,084	22,574	167,329	9,812	126,311	869,337
Structural Plans																	
G-100-1	11	10	98,420	193,617	352,174	5,633	10,086	15,688	385	755	1,347	18,317	67,058	94,418	140,994	559,015	638,696
G-100-1	11	50	142,484	266,912	667,254	6,386	10,448	18,715	497	1,049	2,672	22,120	91,006	183,039	161,597	690,097	1,050,782
G-100-1	11	90	181,048	332,049	831,106	6,941	10,829	19,963	659	1,315	3,258	29,071	119,987	215,676	225,046	939,214	1,316,286
G-100-4	11	10	84,121	137,392	319,376	4,256	7,484	13,610	321	518	1,206	16,191	48,652	85,684	128,121	466,139	592,940
G-100-4	11	50	123,703	197,286	625,797	4,855	7,781	16,492	408	711	2,472	19,319	63,355	170,226	145,546	551,470	984,963
G-100-4	11	90	158,241	249,968	781,712	5,339	8,198	17,697	562	946	3,040	25,944	89,476	201,508	206,599	783,073	1,241,864
G-400-4	13	10	84,045	137,314	342,923	4,250	7,478	14,073	321	518	1,303	16,191	48,650	94,537	128,119	466,134	629,592
G-400-4	13	50	121,583	194,954	687,823	4,759	7,665	17,142	399	700	2,760	18,933	62,247	194,812	143,640	545,283	1,094,033
G-400-4	13	90	142,405	231,099	839,048	4,968	7,743	18,067	473	844	3,262	21,951	78,306	220,847	188,765	729,029	1,327,256
G-1000-4	13	10	84,045	137,314	342,923	4,250	7,478	14,073	321	518	1,303	16,191	48,650	94,537	128,119	466,134	629,592
G-1000-4	13	50	121,571	194,942	687,810	4,756	7,661	17,138	399	700	2,760	18,932	62,246	194,812	143,639	545,280	1,094,031
G-1000-4	13	90	142,010	230,695	838,629	4,927	7,694	18,021	472	844	3,261	21,933	78,264	220,821	188,678	728,810	1,327,117
R-100-2	11	10	114,500	174,420	357,399	5,500	8,085	14,816	388	660	1,313	18,072	61,437	92,068	146,308	472,682	609,702
R-100-2	11	50	205,146	338,181	743,722	6,734	9,648	18,681	696	1,438	2,977	30,567	142,243	209,337	198,887	944,450	1,177,689
R-100-2	11	90	324,233	524,313	1,017,136	7,580	10,658	20,398	1,225	2,238	4,056	51,850	220,951	272,301	326,733	1,432,105	1,585,263
R-100-3	11	10	103,178	153,617	340,539	4,794	7,205	13,925	354	592	1,260	17,493	55,040	89,157	140,480	435,568	590,882
R-100-3	11	50	191,592	310,365	722,419	6,020	8,785	17,790	644	1,299	2,883	28,549	127,820	202,216	189,283	878,594	1,144,870

Table 40--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, Low Sea Level Rise Scenario
Planning Unit 2
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
R-100-3	11	90	309,422	491,416	992,897	6,888	9,829	19,537	1,177	2,105	3,967	50,001	207,259	265,593	317,521	1,369,493	1,553,998
R-100-4	11	10	99,214	144,495	333,930	4,571	6,741	13,571	321	508	1,202	16,203	46,890	85,016	129,819	376,367	559,791
R-100-4	11	50	185,872	296,951	712,785	5,748	8,285	17,385	606	1,166	2,802	27,005	111,769	194,842	176,886	751,300	1,086,268
R-100-4	11	90	302,130	472,286	979,836	6,582	9,329	19,105	1,105	1,945	3,849	47,036	188,291	255,985	295,715	1,232,090	1,484,141
R-400-2	13	10	108,068	165,945	369,843	5,345	7,901	14,989	370	634	1,378	17,458	58,712	98,978	144,096	461,967	639,294
R-400-2	13	50	157,075	274,086	740,608	6,020	8,789	18,421	495	1,143	2,984	22,771	113,258	215,521	167,932	814,452	1,206,132
R-400-2	13	90	193,332	348,560	916,172	6,306	9,120	19,489	637	1,389	3,570	28,204	137,308	246,069	224,571	1,027,346	1,457,707
R-400-3	11	10	96,745	145,142	332,243	4,639	7,021	13,733	337	566	1,236	16,878	52,313	87,628	138,266	424,845	585,029
R-400-3	11	50	143,299	246,021	659,869	5,291	7,908	16,883	443	1,002	2,611	20,723	98,749	184,919	158,191	748,134	1,070,404
R-400-3	11	90	176,822	313,753	820,768	5,573	8,241	17,898	583	1,249	3,173	26,122	122,802	214,447	214,370	961,074	1,316,318
R-400-4	13	10	92,778	136,016	348,573	4,416	6,556	13,863	304	482	1,278	15,588	44,162	92,529	127,601	365,637	593,719
R-400-4	13	50	137,382	232,396	712,103	5,008	7,395	17,220	403	868	2,823	19,125	82,571	202,129	145,384	619,890	1,121,614
R-400-4	13	90	168,145	293,084	878,954	5,229	7,696	18,233	503	1,080	3,366	22,826	103,062	230,207	190,216	818,104	1,359,744
R-1000-4	13	10	92,773	136,011	348,568	4,415	6,555	13,863	304	482	1,278	15,585	44,146	92,521	127,590	365,587	593,694
R-1000-4	13	50	136,746	231,563	711,364	4,989	7,372	17,199	402	866	2,821	19,091	82,415	202,049	145,236	619,242	1,121,282
R-1000-4	13	90	160,686	283,203	870,245	5,081	7,519	18,067	474	1,037	3,331	21,735	98,732	227,914	186,179	800,569	1,350,725
WBI-100-1	6	10	125,684	227,664	352,918	6,235	9,529	15,555	413	876	1,264	18,821	76,325	83,845	149,699	535,359	581,471
WBI-100-1	6	50	226,369	408,454	683,490	7,607	11,080	19,088	779	1,749	2,670	32,912	164,341	178,732	208,240	1,033,066	1,050,285
WBI-100-1	6	90	355,322	615,552	983,303	8,514	12,102	20,935	1,326	2,613	3,883	54,532	256,024	255,873	338,289	1,609,535	1,540,880
WBI-400-1	12	10	119,261	219,199	387,259	6,081	9,347	15,882	396	849	1,431	18,207	73,600	100,727	147,487	524,644	646,803
WBI-400-1	12	50	179,395	345,514	753,673	6,940	10,276	19,334	582	1,457	3,024	25,229	135,661	213,724	177,780	904,454	1,194,423
WBI-400-1	12	90	229,947	446,040	944,492	7,325	10,665	20,472	761	1,795	3,660	31,850	175,600	250,513	241,245	1,222,130	1,486,990
Non-Structural Plans																	
NS-100	15	10	35,556	89,316	158,962	5,977	9,110	14,024	50	329	462	1,762	26,262	23,877	7,662	161,225	166,357
NS-100	15	50	136,550	301,974	443,695	7,639	11,048	17,787	565	1,718	1,890	21,755	161,558	104,561	85,320	918,493	548,991
NS-100	15	90	216,330	460,223	649,380	8,277	11,793	19,187	816	2,298	2,611	31,767	221,978	144,763	139,991	1,277,682	797,076
NS-400	15	10	14,944	23,675	115,478	4,561	6,940	11,761	0	7	306	0	428	13,896	0	1,552	108,297
NS-400	15	50	26,457	46,814	241,005	6,049	8,595	15,241	109	289	935	4,321	26,499	43,149	18,479	130,816	229,957
NS-400	15	90	38,352	81,333	332,115	6,571	9,180	16,460	523	981	1,873	20,815	91,802	92,144	89,557	462,553	487,969
NS-1000	15	10	12,529	19,524	111,480	4,296	6,600	11,358	0	0	304	0	0	13,763	0	0	107,817
NS-1000	15	50	19,042	28,960	227,146	5,699	8,115	14,699	21	47	761	838	4,377	32,385	3,557	23,269	179,887
NS-1000	15	90	22,814	39,909	301,832	6,215	8,693	15,909	42	93	1,058	1,769	9,336	45,210	8,091	52,753	269,540

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 41
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, High Sea Level Rise Scenario
Planning Unit 2
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU2-0	NA	10	128,933	2,068,695	1,442,529	6,334	26,930	25,950	429	9,678	6,480	19,424	915,977	580,709	152,158	3,911,340	2,586,312
Degraded Coast PU2-0	NA	50	277,720	2,688,274	2,044,260	8,163	29,487	30,305	1,020	11,544	8,513	42,462	1,102,941	728,618	238,059	5,383,689	3,603,968
Degraded Coast PU2-0	NA	90	372,357	2,845,938	2,284,831	8,802	29,743	31,441	1,386	11,958	9,325	56,918	1,152,082	780,433	344,510	5,714,440	3,966,815
Sustained Coast PU1-R	NA*	10	128,933	346,560	406,981	6,334	10,138	15,853	429	1,431	1,521	19,424	132,458	109,567	152,158	793,215	711,334
Sustained Coast PU1-R	NA*	50	277,720	616,919	798,721	8,163	12,371	20,012	1,020	2,499	3,074	42,462	237,068	207,955	238,059	1,374,197	1,192,997
Sustained Coast PU1-R	NA*	90	372,357	813,553	1,062,726	8,802	13,029	21,392	1,386	3,136	4,020	56,918	311,528	274,994	344,510	1,859,443	1,648,743
Comprehensive Plans																	
C-G-100-1	11	10	27,160	151,266	354,816	5,276	9,789	15,799	13	734	1,396	436	60,412	116,475	2,018	506,384	638,170
C-G-100-1	11	50	34,866	226,942	561,737	5,861	9,960	18,099	89	934	2,203	3,104	76,919	161,199	15,440	586,166	881,559
C-G-100-1	11	90	55,231	303,990	696,996	6,416	10,292	19,250	185	1,136	2,693	7,192	96,327	188,350	35,840	681,767	1,043,970
C-G-100-4	11	10	23,115	81,342	327,145	3,898	6,894	13,607	13	374	1,278	433	33,041	106,303	1,998	378,928	591,458
C-G-100-4	11	50	29,479	141,245	528,242	4,330	7,068	15,789	83	493	2,059	2,939	42,086	148,295	14,691	422,465	821,558
C-G-100-4	11	90	48,840	202,804	658,055	4,814	7,504	16,924	188	644	2,543	7,312	57,234	174,303	36,567	499,189	979,590
C-G-400-4	13	10	20,711	54,367	363,434	3,811	6,403	13,960	8	106	1,406	257	9,596	118,720	1,075	60,254	566,769
C-G-400-4	13	50	23,215	72,787	570,576	4,051	6,466	16,089	9	160	2,176	297	13,317	162,187	1,250	77,633	813,869
C-G-400-4	13	90	26,185	108,656	686,590	4,261	6,564	16,922	17	268	2,590	611	26,174	185,188	3,471	323,973	1,014,856
C-G-1000-4	13	10	18,209	36,246	354,814	3,650	5,813	13,584	8	62	1,393	253	4,768	117,220	1,062	15,427	552,870
C-G-1000-4	13	50	19,377	45,315	557,458	3,791	5,873	15,593	8	87	2,152	253	7,364	160,290	1,062	48,643	804,666
C-G-1000-4	13	90	20,632	58,321	664,505	3,962	5,925	16,383	10	142	2,542	309	12,677	180,651	1,485	71,849	934,417
C-R-100-2	11	10	33,718	137,518	349,888	5,143	7,934	14,942	37	708	1,408	1,295	71,495	121,509	5,655	387,614	594,238
C-R-100-2	11	50	85,536	299,494	623,568	6,210	9,272	18,087	313	1,239	2,503	11,921	120,755	184,782	54,198	794,961	987,193
C-R-100-2	11	90	199,946	496,839	886,226	7,055	10,184	19,688	756	2,060	3,493	29,449	202,403	245,875	133,188	1,162,633	1,301,917
C-R-100-3	11	10	31,051	119,232	343,379	4,437	7,053	14,051	36	582	1,372	1,279	57,592	116,347	5,555	330,201	573,847
C-R-100-3	11	50	81,961	272,432	613,553	5,496	8,409	17,197	307	1,114	2,469	11,700	106,936	180,010	53,304	738,005	967,604
C-R-100-3	11	90	195,698	462,176	873,065	6,363	9,355	18,828	756	1,942	3,466	29,433	189,315	241,558	133,157	1,108,920	1,284,447
C-R-100-4	11	10	30,370	111,041	340,445	4,214	6,465	13,650	34	461	1,334	1,181	42,521	110,675	4,800	213,087	530,099
C-R-100-4	11	50	80,791	257,220	608,070	5,224	7,815	16,755	296	965	2,411	11,169	88,893	172,823	49,412	598,591	912,750
C-R-100-4	11	90	194,329	441,867	866,090	6,057	8,792	18,371	746	1,789	3,424	29,017	170,771	234,957	130,066	967,475	1,233,730
C-R-400-2	13	10	23,696	40,274	353,333	4,878	7,574	15,069	8	63	1,383	255	5,849	118,588	1,070	37,985	553,305
C-R-400-2	13	50	27,525	62,836	559,773	5,278	8,047	17,471	12	157	2,150	375	14,138	162,928	1,807	94,801	816,970
C-R-400-2	13	90	38,991	125,797	689,476	5,564	8,280	18,406	50	479	2,642	1,882	44,616	192,483	8,714	277,882	1,003,498

Table 41--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, High Sea Level Rise Scenario
Planning Unit 2
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
C-R-400-3	11	10	21,314	36,701	308,175	4,200	6,727	13,715	8	55	1,181	255	5,206	98,946	1,070	34,558	477,019
C-R-400-3	11	50	25,017	57,460	493,949	4,578	7,200	15,958	12	148	1,876	370	13,250	138,487	1,789	90,727	708,517
C-R-400-3	11	90	36,166	116,846	616,627	4,859	7,435	16,857	49	374	2,316	1,828	34,763	164,223	8,503	231,160	875,551
C-R-400-4	13	10	20,691	34,698	353,558	3,976	6,138	13,943	8	50	1,399	255	4,652	117,688	1,070	30,458	549,903
C-R-400-4	13	50	24,173	54,257	560,171	4,294	6,592	16,281	11	125	2,171	343	10,648	162,062	1,590	69,342	810,078
C-R-400-4	13	90	34,961	111,039	689,282	4,515	6,826	17,170	46	301	2,634	1,687	27,255	187,972	7,469	174,578	976,917
C-R-1000-4	13	10	18,911	26,217	348,793	3,839	5,971	13,727	8	19	1,389	252	1,437	116,689	1,059	6,614	542,508
C-R-1000-4	13	50	20,969	36,940	551,238	4,137	6,399	16,040	9	70	2,152	259	5,501	160,377	1,085	28,657	796,916
C-R-1000-4	13	90	22,343	56,273	660,469	4,228	6,478	16,784	11	119	2,548	334	10,467	181,506	1,589	65,790	937,419
C-WBI-100-1	6	10	34,525	176,119	287,924	5,878	9,451	15,428	39	970	1,137	1,331	89,698	94,835	5,890	461,640	499,612
C-WBI-100-1	6	50	87,330	362,535	537,357	7,083	10,742	18,493	328	1,702	2,186	12,372	164,090	161,839	56,171	1,015,284	911,435
C-WBI-100-1	6	90	201,441	590,875	827,345	7,990	11,678	20,265	760	2,570	3,272	29,548	257,272	235,944	134,439	1,470,847	1,303,093
C-WBI-400-1	12	10	24,320	49,730	334,650	5,614	9,092	15,917	8	136	1,310	255	11,445	111,885	1,070	63,451	528,064
C-WBI-400-1	12	50	28,723	82,199	530,747	6,198	9,573	18,389	13	238	2,021	417	20,693	154,298	2,031	131,871	783,116
C-WBI-400-1	12	90	41,396	170,694	661,851	6,584	9,875	19,407	55	821	2,575	2,084	79,373	192,580	9,812	472,994	1,019,450
Structural Plans																	
G-100-1	11	10	98,420	282,905	481,266	5,633	10,882	16,567	385	1,154	1,973	18,317	100,293	150,325	140,994	813,233	900,302
G-100-1	11	50	142,484	370,555	735,610	6,386	11,066	19,072	497	1,332	2,817	22,120	116,413	196,294	161,597	894,666	1,152,836
G-100-1	11	90	181,048	442,703	891,232	6,941	11,398	20,223	659	1,600	3,407	29,071	143,548	229,281	225,046	1,049,594	1,385,382
G-100-4	11	10	84,121	186,876	433,181	4,256	7,986	14,375	321	712	1,753	16,191	65,588	135,331	128,121	643,718	825,111
G-100-4	11	50	123,703	258,350	677,800	4,855	8,174	16,762	408	818	2,550	19,319	74,858	178,140	145,546	691,289	1,062,150
G-100-4	11	90	158,241	315,345	824,448	5,339	8,610	17,897	562	1,038	3,114	25,944	97,919	209,306	206,599	828,579	1,286,044
G-400-4	13	10	84,045	186,798	480,599	4,250	7,980	14,977	321	712	1,970	16,191	65,586	155,219	128,119	643,713	900,225
G-400-4	13	50	121,583	256,018	745,597	4,759	8,057	17,432	399	807	2,844	18,933	73,750	203,310	143,640	685,102	1,173,214
G-400-4	13	90	142,405	296,477	884,497	4,968	8,155	18,265	473	935	3,344	21,951	86,749	229,606	188,765	774,536	1,377,190
G-1000-4	13	10	84,045	186,798	480,599	4,250	7,980	14,977	321	712	1,970	16,191	65,586	155,219	128,119	643,713	900,225
G-1000-4	13	50	121,571	256,006	745,585	4,756	8,054	17,429	399	807	2,844	18,932	73,749	203,310	143,639	685,099	1,173,212
G-1000-4	13	90	142,010	296,072	884,078	4,927	8,107	18,219	472	935	3,343	21,933	86,707	229,579	188,678	774,317	1,377,051
R-100-2	11	10	114,500	258,433	484,466	5,500	8,487	15,543	388	1,065	1,941	18,072	106,558	152,540	146,308	688,242	856,461
R-100-2	11	50	205,146	433,517	808,888	6,734	10,102	18,975	696	1,600	3,075	30,567	155,992	218,114	198,887	1,028,973	1,233,637
R-100-2	11	90	324,233	650,845	1,083,360	7,580	11,015	20,576	1,225	2,460	4,180	51,850	243,770	285,620	326,733	1,514,398	1,643,572
R-100-3	11	10	103,178	226,399	463,291	4,794	7,607	14,652	354	925	1,860	17,493	92,052	146,515	140,480	621,929	826,426
R-100-3	11	50	191,592	393,017	782,714	6,020	9,239	18,084	644	1,460	2,981	28,549	141,570	210,993	189,283	963,117	1,200,819

Table 41--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, High Sea Level Rise Scenario
Planning Unit 2
Louisiana Coastal Protection and Restoration

Alternative	Years to implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
R-100-3	11	90	309,422	603,491	1,053,568	6,888	10,185	19,716	1,177	2,327	4,092	50,001	230,077	278,913	317,521	1,451,786	1,612,306
R-100-4	11	10	99,214	209,750	453,791	4,571	7,019	14,251	321	761	1,772	16,203	72,860	138,133	129,819	473,533	761,079
R-100-4	11	50	185,872	369,355	769,144	5,748	8,645	17,643	606	1,272	2,879	27,005	119,965	201,486	176,886	799,192	1,128,147
R-100-4	11	90	302,130	575,329	1,037,039	6,582	9,622	19,259	1,105	2,143	3,965	47,036	208,561	268,326	295,715	1,286,009	1,531,552
R-400-2	13	10	108,068	249,959	519,719	5,345	8,303	15,857	370	1,039	2,120	17,458	103,832	169,619	144,096	677,526	923,347
R-400-2	13	50	157,075	369,421	810,492	6,020	9,243	18,733	495	1,304	3,087	22,771	127,007	224,813	167,932	898,975	1,265,774
R-400-2	13	90	193,332	475,092	983,229	6,306	9,476	19,668	637	1,612	3,698	28,204	160,127	259,907	224,571	1,109,639	1,520,639
R-400-3	11	10	96,745	217,924	454,996	4,639	7,422	14,459	337	899	1,837	16,878	89,324	144,986	138,266	611,206	820,573
R-400-3	11	50	143,299	328,674	720,163	5,291	8,363	17,177	443	1,164	2,710	20,723	112,499	193,696	158,191	832,657	1,126,352
R-400-3	11	90	176,822	425,828	881,440	5,573	8,598	18,076	583	1,471	3,298	26,122	145,621	227,766	214,370	1,043,367	1,374,626
R-400-4	13	10	92,778	201,270	491,821	4,416	6,834	14,687	304	734	1,966	15,588	70,132	156,404	127,601	462,804	835,940
R-400-4	13	50	137,382	304,800	773,884	5,008	7,755	17,499	403	974	2,906	19,125	90,767	209,458	145,384	667,782	1,168,313
R-400-4	13	90	168,145	396,127	937,711	5,229	7,989	18,389	503	1,278	3,486	22,826	123,332	243,145	190,216	872,022	1,412,651
R-1000-4	13	10	92,773	201,265	491,816	4,415	6,833	14,687	304	734	1,966	15,585	70,115	156,395	127,590	462,753	835,915
R-1000-4	13	50	136,746	303,967	773,145	4,989	7,733	17,478	402	973	2,905	19,091	90,611	209,379	145,236	667,134	1,167,981
R-1000-4	13	90	160,686	386,246	929,003	5,081	7,812	18,223	474	1,235	3,451	21,735	119,002	240,852	186,179	854,488	1,403,631
WBI-100-1	6	10	125,684	341,821	448,848	6,235	10,004	16,029	413	1,404	1,722	18,821	129,971	128,337	149,699	782,457	771,882
WBI-100-1	6	50	226,369	535,575	758,123	7,607	11,573	19,381	779	2,063	2,840	32,912	199,327	197,449	208,240	1,249,296	1,166,752
WBI-100-1	6	90	355,322	775,410	1,069,517	8,514	12,508	21,153	1,326	2,969	4,075	54,532	298,639	278,796	338,289	1,822,613	1,657,137
WBI-400-1	12	10	119,261	333,356	536,644	6,081	9,821	16,705	396	1,378	2,160	18,207	127,246	169,335	147,487	771,742	923,476
WBI-400-1	12	50	179,395	472,635	832,830	6,940	10,769	19,651	582	1,771	3,181	25,229	170,647	230,573	177,780	1,120,684	1,300,676
WBI-400-1	12	90	229,947	605,898	1,023,344	7,325	11,071	20,669	761	2,151	3,836	31,850	218,215	271,370	241,245	1,435,207	1,595,723
Non-Structural Plans																	
NS-100	15	10	35,556	178,640	186,626	5,977	9,585	14,171	50	994	668	1,762	91,727	44,152	7,662	470,506	262,145
NS-100	15	50	136,550	441,748	486,985	7,639	11,540	17,939	565	2,134	2,019	21,755	201,388	116,897	85,320	1,138,349	617,084
NS-100	15	90	216,330	626,871	700,993	8,277	12,199	19,312	816	2,732	2,745	31,767	269,719	159,549	139,991	1,505,841	867,740
NS-400	15	10	14,944	39,707	120,444	4,561	7,415	11,908	0	127	343	0	10,819	17,114	0	60,728	126,625
NS-400	15	50	26,457	81,944	251,885	6,049	9,087	15,394	109	390	966	4,321	35,562	45,956	18,479	203,658	252,517
NS-400	15	90	38,352	169,898	359,545	6,571	9,585	16,586	523	1,539	2,045	20,815	148,601	109,736	89,557	809,236	595,341
NS-1000	15	10	12,529	25,726	113,401	4,296	7,074	11,505	0	12	308	0	976	14,066	0	5,135	109,407
NS-1000	15	50	19,042	44,363	231,916	5,699	8,607	14,852	21	117	783	838	10,208	34,191	3,557	57,395	190,456
NS-1000	15	90	22,814	72,889	312,047	6,215	9,098	16,035	42	319	1,128	1,769	28,050	51,006	8,091	167,615	305,114

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 42
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, Low Sea Level Rise Scenario
Planning Unit 1
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU1-0	NA	10	175,959	282,285	440,763	14,280	16,883	32,147	607	945	1,503	18,625	82,342	78,200	65,589	314,208	289,961
Degraded Coast PU1-0	NA	50	257,628	477,767	684,100	15,674	19,515	35,876	931	2,247	2,785	31,853	208,415	174,385	120,635	781,701	655,858
Degraded Coast PU1-0	NA	90	465,354	915,397	1,267,205	17,839	27,201	43,832	1,700	4,372	5,246	62,112	407,436	340,666	231,480	1,505,274	1,261,682
Sustained Coast PU1-R	NA*	10	175,959	253,968	423,736	14,280	16,379	31,844	607	887	1,468	18,625	75,475	74,071	65,589	286,346	273,207
Sustained Coast PU1-R	NA*	50	257,628	360,559	613,621	15,674	17,930	34,923	931	1,257	2,189	31,853	111,129	115,885	120,635	424,521	441,079
Sustained Coast PU1-R	NA*	90	465,354	596,568	1,075,488	17,839	20,200	39,623	1,700	3,190	4,536	62,112	297,663	274,657	231,480	1,039,175	981,409
Comprehensive Plans																	
C-HL-a-100-2	12	10	69,326	72,690	256,924	10,937	11,764	27,282	262	269	907	6,379	19,560	36,022	22,513	66,765	128,702
C-HL-a-100-2	12	50	102,135	111,599	387,502	11,862	12,780	29,896	438	497	1,551	13,213	42,370	74,244	51,916	163,724	283,896
C-HL-a-100-2	12	90	277,975	323,398	831,222	13,777	14,821	34,845	1,277	1,529	3,480	46,568	140,622	183,179	170,362	538,044	684,802
C-HL-a-100-3	12	10	69,619	73,669	255,293	11,034	11,933	27,407	257	269	897	6,216	19,854	35,923	21,972	67,810	128,431
C-HL-a-100-3	12	50	102,351	113,903	385,404	11,995	13,079	30,093	434	518	1,549	13,131	44,197	74,780	51,744	170,214	285,948
C-HL-a-100-3	12	90	276,231	325,453	826,836	13,906	15,144	35,048	1,261	1,559	3,468	45,952	144,266	183,675	168,904	552,159	687,392
C-HL-b-400-2	16	10	67,879	70,675	274,408	10,830	11,649	27,820	259	260	964	6,246	18,591	38,830	22,006	63,864	140,129
C-HL-b-400-2	16	50	68,617	71,662	387,297	10,918	11,786	29,799	260	263	1,503	6,270	18,907	71,669	22,168	65,348	268,126
C-HL-b-400-2	16	90	75,786	80,601	683,014	11,271	12,175	33,628	296	307	2,688	7,649	23,029	136,035	28,026	82,301	504,445
C-HL-b-400-3	16	10	68,371	71,663	271,299	10,929	11,819	27,914	253	254	948	6,072	18,243	38,293	21,419	62,662	138,223
C-HL-b-400-3	16	50	69,356	73,239	382,975	11,067	12,102	29,965	255	267	1,489	6,142	19,472	71,361	21,680	66,397	266,671
C-HL-b-400-3	16	90	76,860	83,788	677,865	11,490	12,595	33,867	297	332	2,676	7,799	25,893	136,218	28,191	90,182	503,995
C-LP-a-100-1	14	10	70,076	79,295	263,555	11,477	12,796	28,339	225	240	870	5,643	18,835	36,015	20,078	66,648	131,495
C-LP-a-100-1	14	50	83,389	103,230	377,788	12,088	14,062	30,883	280	420	1,411	7,763	35,485	70,801	27,947	117,181	263,199
C-LP-a-100-1	14	90	149,283	206,000	711,586	13,699	16,142	35,788	643	985	2,869	21,468	86,944	151,821	75,996	303,450	557,174
C-LP-a-100-2	14	10	69,451	73,130	269,847	10,861	11,632	27,582	268	270	943	6,581	19,655	37,908	23,466	68,187	137,230
C-LP-a-100-2	14	50	87,154	93,612	391,426	11,308	12,120	29,762	345	362	1,512	9,491	28,300	71,640	34,734	100,992	269,036
C-LP-a-100-2	14	90	149,309	168,276	720,766	12,277	13,188	33,915	656	763	2,892	21,381	65,477	147,183	76,667	239,774	544,007
C-LP-a-100-3	14	10	69,461	73,809	268,554	10,913	11,780	27,654	261	267	932	6,406	19,626	37,670	22,871	68,764	136,608
C-LP-a-100-3	14	50	86,771	94,466	389,303	11,390	12,326	29,874	338	371	1,503	9,305	29,061	71,598	34,134	104,031	269,045
C-LP-a-100-3	14	90	148,914	170,599	718,323	12,378	13,422	34,048	652	797	2,894	21,329	69,069	148,191	76,675	250,201	546,912
C-LP-b-400-1	16	10	67,664	73,660	266,404	11,249	12,538	28,231	221	222	882	5,496	17,058	36,150	19,380	59,201	132,136
C-LP-b-400-1	16	50	70,501	78,946	371,997	11,712	13,663	30,703	227	255	1,371	5,722	20,112	68,010	20,089	69,162	256,569

Table 42--Continued

Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, Low Sea Level Rise Scenario
Planning Unit 1
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
C-LP-b-400-1	16	90	83,572	102,627	661,032	12,840	15,230	35,332	306	509	2,581	8,712	44,063	136,855	29,808	144,095	504,798
C-LP-b-400-3	16	10	67,000	70,404	275,114	10,815	11,660	27,852	253	254	952	6,073	18,249	38,378	21,423	62,694	139,108
C-LP-b-400-3	16	50	67,826	71,755	387,877	10,903	11,809	29,818	254	259	1,489	6,086	18,743	71,159	21,462	64,223	266,827
C-LP-b-400-3	16	90	77,239	83,742	684,458	11,246	12,219	33,650	300	344	2,688	7,886	27,159	136,958	28,337	93,651	505,648
C-LP-b-1000-1	16	10	66,556	72,347	264,666	11,200	12,447	28,145	221	221	881	5,495	17,001	36,131	19,377	58,918	132,044
C-LP-b-1000-1	16	50	68,875	75,155	368,927	11,609	13,535	30,547	221	221	1,353	5,495	17,035	66,785	19,377	59,109	252,603
C-LP-b-1000-1	16	90	72,731	82,751	644,536	12,592	14,953	35,039	234	293	2,447	6,003	23,701	128,059	21,003	79,886	477,237
C-LP-b-1000-2	16	10	66,455	69,290	276,103	10,746	11,488	27,765	259	259	964	6,246	18,559	38,742	22,006	63,648	140,384
C-LP-b-1000-2	16	50	66,872	69,821	389,155	10,771	11,546	29,663	259	259	1,502	6,246	18,559	71,431	22,006	63,651	267,835
C-LP-b-1000-2	16	90	68,045	71,093	678,632	10,880	11,701	33,279	262	263	2,651	6,325	18,924	133,837	22,234	64,931	494,594
Structural Plans																	
HL-a-100-2	12	10	103,776	114,635	311,336	11,327	12,195	27,886	380	401	1,089	11,049	31,422	45,311	38,494	108,074	160,711
HL-a-100-2	12	50	145,635	162,068	455,434	12,276	13,261	30,543	559	630	1,738	17,958	53,209	83,306	68,301	207,347	317,107
HL-a-100-2	12	90	325,833	376,975	905,359	14,200	15,302	35,503	1,405	1,689	3,683	51,580	154,507	193,506	187,520	588,804	721,153
HL-a-100-3	12	10	110,026	124,885	319,740	11,451	12,395	28,051	391	426	1,106	11,360	33,957	46,476	39,654	118,160	165,285
HL-a-100-3	12	50	153,982	175,438	466,540	12,438	13,591	30,784	571	670	1,761	18,298	57,069	84,980	69,628	222,037	323,501
HL-a-100-3	12	90	333,966	391,136	916,597	14,358	15,657	35,750	1,413	1,730	3,704	51,875	158,669	195,257	189,640	604,989	728,686
HL-b-400-2	16	10	103,221	114,064	330,339	11,297	12,163	28,540	379	399	1,150	11,006	31,318	48,495	38,342	107,725	173,355
HL-b-400-2	16	50	113,914	126,454	458,729	11,430	12,372	30,596	394	438	1,718	11,632	34,966	83,090	41,401	127,036	310,356
HL-b-400-2	16	90	126,375	141,108	762,580	11,792	12,762	34,436	438	521	2,925	13,354	42,663	148,976	48,079	153,445	550,590
HL-b-400-3	16	10	109,681	124,527	337,341	11,421	12,364	28,675	389	425	1,164	11,318	33,855	49,436	39,507	117,821	177,054
HL-b-400-3	16	50	123,116	140,740	468,519	11,608	12,720	30,806	409	481	1,740	12,091	39,186	84,620	43,054	142,799	316,032
HL-b-400-3	16	90	138,364	159,842	775,370	12,040	13,214	34,720	471	593	2,966	14,676	49,872	151,913	52,711	177,862	560,631
LP-a-100-1	14	10	117,395	146,516	341,268	11,892	13,326	29,002	416	553	1,197	12,939	44,101	52,612	43,091	155,103	186,560
LP-a-100-1	14	50	150,427	194,766	486,741	12,570	14,729	31,669	558	729	1,841	17,412	61,032	90,315	58,995	207,333	328,452
LP-a-100-1	14	90	235,898	313,511	849,025	14,216	16,863	36,632	954	1,282	3,335	32,532	110,581	172,445	112,209	387,645	626,791
LP-a-100-2	14	10	98,874	109,310	316,429	11,189	12,046	28,104	385	410	1,128	11,401	33,061	47,856	38,876	117,356	170,987
LP-a-100-2	14	50	125,132	139,261	451,228	11,685	12,628	30,373	469	511	1,708	14,582	42,217	82,072	51,107	152,884	304,794
LP-a-100-2	14	90	192,360	218,733	788,156	12,657	13,700	34,531	793	908	3,102	26,930	78,963	158,032	96,388	290,547	583,445
LP-a-100-3	14	10	102,005	115,513	320,599	11,264	12,224	28,214	390	424	1,136	11,482	33,923	48,201	39,246	121,281	172,562
LP-a-100-3	14	50	129,117	147,210	456,553	11,791	12,865	30,523	477	528	1,719	14,746	43,422	82,588	51,758	157,753	306,874
LP-a-100-3	14	90	197,899	229,498	795,462	12,783	13,965	34,704	803	951	3,123	27,226	83,023	159,603	97,668	302,875	588,466

Table 42--Continued
Expected and Equivalent Annual Metric Values by Alternative

2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, Low Sea Level Rise Scenario
Planning Unit 1
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage $1000s	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages $1000s	Expected Annual Output Impacted $1000s		Equivalent Annual Output $1000s
			2010	2075		2010	2075		2010	2075		2010	2075		2010	2075	
LP-b-400-1	16	10	116,998	146,094	348,155	11,884	13,319	29,237	415	552	1,217	12,908	43,978	53,400	42,993	154,701	190,104
LP-b-400-1	16	50	145,641	189,015	496,431	12,437	14,587	31,861	538	704	1,884	16,747	58,911	93,283	56,914	200,225	341,436
LP-b-400-1	16	90	187,605	255,028	833,316	13,600	16,208	36,549	730	1,002	3,243	24,077	85,096	168,038	80,182	284,551	608,866
LP-b-400-3	16	10	100,149	113,605	328,351	11,218	12,175	28,496	383	417	1,158	11,199	33,092	49,138	38,053	117,869	176,191
LP-b-400-3	16	50	111,374	127,975	457,650	11,377	12,427	30,580	402	441	1,724	12,021	35,380	83,448	41,553	127,833	310,685
LP-b-400-3	16	90	128,357	147,965	765,810	11,725	12,841	34,419	464	529	2,943	14,399	43,813	149,947	52,481	157,179	554,353
LP-b-1000-1	16	10	116,997	146,094	348,154	11,884	13,319	29,237	415	552	1,217	12,908	43,978	53,400	42,993	154,701	190,104
LP-b-1000-1	16	50	145,543	188,914	496,342	12,425	14,574	31,850	538	704	1,884	16,745	58,902	93,278	56,906	200,194	341,423
LP-b-1000-1	16	90	183,219	249,972	829,171	13,452	16,053	36,414	699	964	3,214	22,874	81,509	166,247	75,633	270,164	601,853
LP-b-1000-2	16	10	96,965	107,348	324,574	11,140	11,995	28,396	378	402	1,151	11,117	32,226	48,831	37,672	113,923	174,791
LP-b-1000-2	16	50	106,520	119,143	452,101	11,241	12,158	30,418	394	423	1,713	11,821	34,098	82,946	40,780	122,683	308,690
LP-b-1000-2	16	90	113,548	126,972	750,649	11,354	12,317	34,039	409	432	2,881	12,413	34,865	146,094	44,536	124,812	539,954
Non-Structural Plans																	
NS-100	15	10	49,720	66,202	201,034	13,635	15,661	30,285	47	221	551	1,632	20,698	21,441	4,641	70,593	73,551
NS-100	15	50	82,667	135,205	317,283	15,002	17,162	33,272	314	567	1,187	11,729	55,910	53,061	41,600	201,440	194,596
NS-100	15	90	252,858	355,887	723,993	17,155	19,428	37,927	1,021	2,696	3,186	39,785	258,211	168,672	145,628	902,084	606,990
NS-400	15	10	26,799	35,097	165,654	12,969	14,964	29,321	1	2	432	21	102	13,252	84	437	46,705
NS-400	15	50	32,315	43,089	232,195	14,312	16,440	32,274	12	61	692	477	5,909	24,937	2,712	24,065	95,980
NS-400	15	90	87,505	121,040	465,521	16,448	18,689	36,904	352	679	1,810	14,555	67,566	81,287	72,987	307,327	341,190
NS-1000	15	10	17,778	25,086	152,421	10,186	11,936	25,257	0	0	430	0	0	13,197	0	0	46,475
NS-1000	15	50	22,539	30,403	217,284	11,496	13,380	28,162	3	6	664	145	714	22,954	1,610	5,781	89,079
NS-1000	15	90	42,674	56,994	395,328	13,559	15,549	32,686	140	241	1,436	6,614	27,028	59,812	47,495	172,032	270,653

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 43
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, High Sea Level Rise Scenario
Planning Unit 1
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU1-0	NA	10	175,959	396,560	509,478	14,280	18,425	33,074	607	1,696	1,954	18,625	151,446	119,754	65,589	538,131	424,610
Degraded Coast PU1-0	NA	50	257,628	756,854	851,919	15,674	24,032	38,592	931	3,480	3,526	31,853	316,510	239,384	120,635	1,152,446	878,792
Degraded Coast PU1-0	NA	90	465,354	1,800,937	1,799,694	17,839	32,891	47,254	1,700	10,463	8,909	62,112	1,004,546	699,717	231,480	3,913,514	2,709,795
Sustained Coast PU1-R	NA*	10	175,959	346,908	479,622	14,280	17,670	32,620	607	1,470	1,818	18,625	130,668	107,259	65,589	460,682	378,038
Sustained Coast PU1-R	NA*	50	257,628	465,739	676,868	15,674	19,270	35,729	931	2,530	2,955	31,853	233,236	189,310	120,635	768,498	647,918
Sustained Coast PU1-R	NA*	90	465,354	819,948	1,209,810	17,839	21,800	40,585	1,700	3,755	4,876	62,112	347,855	304,838	231,480	1,190,107	1,072,167
Comprehensive Plans																	
C-HL-a-100-2	12	10	69,326	77,068	270,244	10,937	11,910	27,491	262	305	994	6,379	23,723	44,326	22,513	80,634	156,089
C-HL-a-100-2	12	50	102,135	120,831	418,819	11,862	12,863	30,375	438	529	1,687	13,213	44,689	86,008	51,916	176,048	325,705
C-HL-a-100-2	12	90	277,975	339,634	925,437	13,777	14,955	35,460	1,277	1,559	4,095	46,568	143,118	243,329	170,362	550,763	928,424
C-HL-a-100-3	12	10	69,619	80,563	269,701	11,034	12,267	27,686	257	350	1,000	6,216	28,620	45,826	21,972	98,355	161,562
C-HL-a-100-3	12	50	102,351	130,239	419,406	11,995	13,350	30,641	434	639	1,718	13,131	56,106	89,997	51,744	212,353	338,412
C-HL-a-100-3	12	90	276,231	356,262	926,402	13,906	15,461	35,731	1,261	1,691	4,121	45,952	156,752	247,521	168,904	592,933	941,398
C-HL-b-400-2	16	10	67,879	72,157	291,649	10,830	11,795	28,091	259	262	1,075	6,246	18,789	49,088	22,006	64,981	173,437
C-HL-b-400-2	16	50	68,617	74,243	429,249	10,918	11,868	30,492	260	281	1,690	6,270	20,523	88,104	22,168	74,752	325,666
C-HL-b-400-2	16	90	75,786	86,247	815,585	11,271	12,308	34,510	296	334	3,597	7,649	25,229	225,095	28,026	94,556	864,641
C-HL-b-400-3	16	10	68,371	73,839	288,688	10,929	12,153	28,241	253	263	1,061	6,072	19,154	48,734	21,419	65,478	171,931
C-HL-b-400-3	16	50	69,356	78,623	425,689	11,067	12,373	30,714	255	312	1,683	6,142	24,118	88,628	21,680	84,010	326,442
C-HL-b-400-3	16	90	76,860	95,943	812,269	11,490	12,913	34,803	297	410	3,600	7,799	33,255	226,745	28,191	113,662	867,296
C-LP-a-100-1	14	10	70,076	98,234	284,736	11,477	14,330	29,053	225	414	1,022	5,643	35,900	50,293	20,078	114,281	175,190
C-LP-a-100-1	14	50	83,389	147,152	427,525	12,088	15,731	32,008	280	660	1,644	7,763	57,549	91,556	27,947	188,205	332,830
C-LP-a-100-1	14	90	149,283	294,901	851,071	13,699	17,446	36,932	643	1,223	3,701	21,468	112,280	234,025	75,996	413,374	891,270
C-LP-a-100-2	14	10	69,451	76,890	285,423	10,861	11,833	27,843	268	276	1,038	6,581	20,209	46,617	23,466	69,765	165,392
C-LP-a-100-2	14	50	87,154	99,188	427,847	11,308	12,300	30,381	345	376	1,669	9,491	29,440	85,334	34,734	104,861	316,003
C-LP-a-100-2	14	90	149,309	175,663	832,468	12,277	13,339	34,669	656	774	3,646	21,381	66,557	221,139	76,667	243,918	842,167
C-LP-a-100-3	14	10	69,461	79,489	284,869	10,913	12,101	27,956	261	309	1,039	6,406	23,656	47,546	22,871	79,880	167,971
C-LP-a-100-3	14	50	86,771	105,639	427,686	11,390	12,627	30,534	338	424	1,673	9,305	34,934	86,898	34,134	122,677	321,032
C-LP-a-100-3	14	90	148,914	186,908	833,091	12,378	13,722	34,853	652	851	3,663	21,329	75,364	223,918	76,675	272,951	851,394
C-LP-b-400-1	16	10	67,664	79,586	284,613	11,249	14,051	28,906	221	268	1,005	5,496	21,848	47,654	19,380	72,200	168,719
C-LP-b-400-1	16	50	70,501	94,486	417,360	11,712	15,318	31,862	227	464	1,615	5,722	41,048	90,233	20,089	130,463	329,585
C-LP-b-400-1	16	90	83,572	141,654	802,981	12,840	16,519	36,557	306	752	3,555	8,712	68,578	232,512	29,808	220,979	883,717

Table 43--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, High Sea Level Rise Scenario
Planning Unit 1
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
C-LP-b-400-3	16	10	67,000	73,568	292,804	10,815	11,959	28,167	253	286	1,072	6,073	21,552	49,582	21,423	71,477	174,838
C-LP-b-400-3	16	50	67,826	78,435	431,033	10,903	12,096	30,571	254	317	1,689	6,086	24,909	89,002	21,462	84,498	327,766
C-LP-b-400-3	16	90	77,239	95,077	818,817	11,246	12,505	34,577	300	403	3,608	7,886	33,586	227,270	28,337	117,045	869,156
C-LP-b-1000-1	16	10	66,556	76,268	282,254	11,200	13,927	28,809	221	225	992	5,495	17,373	46,267	19,377	59,675	164,835
C-LP-b-1000-1	16	50	68,875	80,990	411,285	11,609	15,173	31,700	221	263	1,545	5,495	21,056	83,769	19,377	71,041	310,329
C-LP-b-1000-1	16	90	72,731	99,792	779,675	12,592	16,222	36,257	234	501	3,410	6,003	44,319	222,508	21,003	141,241	851,346
C-LP-b-1000-2	16	10	66,455	70,376	293,213	10,746	11,663	28,043	259	261	1,075	6,246	18,629	48,986	22,006	64,004	173,613
C-LP-b-1000-2	16	50	66,872	71,014	430,711	10,771	11,711	30,381	259	264	1,685	6,246	18,908	87,535	22,006	65,568	323,284
C-LP-b-1000-2	16	90	68,045	73,516	810,366	10,880	11,837	34,161	262	270	3,555	6,325	19,564	222,424	22,234	67,787	851,990
Structural Plans																	
HL-a-100-2	12	10	103,776	125,373	326,625	11,327	12,379	28,107	380	433	1,175	11,049	34,179	53,180	38,494	123,132	188,465
HL-a-100-2	12	50	145,635	175,357	488,008	12,276	13,354	31,025	559	693	1,883	17,958	58,764	96,073	68,301	228,202	361,558
HL-a-100-2	12	90	325,833	400,200	1,001,738	14,200	15,461	36,126	1,405	1,724	4,300	51,580	157,219	253,723	187,520	603,269	965,316
HL-a-100-3	12	10	110,026	140,881	336,966	11,451	12,770	28,342	391	491	1,204	11,360	39,655	55,428	39,654	143,086	196,676
HL-a-100-3	12	50	153,982	196,978	502,154	12,438	13,874	31,336	571	816	1,937	18,298	70,845	100,775	69,628	267,098	376,871
HL-a-100-3	12	90	333,966	428,637	1,018,235	14,358	16,002	36,442	1,413	1,870	4,360	51,875	171,623	259,248	189,640	648,314	983,482
HL-b-400-2	16	10	103,221	124,803	350,448	11,297	12,347	28,823	379	432	1,271	11,006	34,075	59,546	38,342	122,782	210,981
HL-b-400-2	16	50	113,914	139,742	503,998	11,430	12,466	31,293	394	501	1,919	11,632	40,520	100,745	41,401	147,891	371,443
HL-b-400-2	16	90	126,375	164,333	900,595	11,792	12,921	35,325	438	555	3,837	13,354	45,376	238,195	48,079	167,910	911,470
HL-b-400-3	16	10	109,681	140,523	359,009	11,421	12,739	29,014	389	490	1,295	11,318	39,553	61,360	39,507	142,748	217,610
HL-b-400-3	16	50	123,116	162,280	516,237	11,608	13,003	31,559	409	627	1,966	12,091	52,962	104,715	43,054	187,860	384,305
HL-b-400-3	16	90	138,364	197,343	917,623	12,040	13,559	35,665	471	733	3,910	14,676	62,827	244,172	52,711	221,187	930,078
LP-a-100-1	14	10	117,395	188,995	369,739	11,892	15,018	29,765	416	724	1,347	12,939	60,566	66,704	43,091	201,680	229,929
LP-a-100-1	14	50	150,427	254,915	541,504	12,570	16,496	32,824	558	963	2,072	17,412	81,791	110,666	58,995	274,603	396,920
LP-a-100-1	14	90	235,898	411,453	991,310	14,216	18,213	37,791	954	1,542	4,173	32,532	137,763	255,220	112,209	502,666	962,466
LP-a-100-2	14	10	98,874	120,747	334,383	11,189	12,361	28,401	385	420	1,224	11,401	33,853	56,638	38,876	120,252	199,557
LP-a-100-2	14	50	125,132	149,896	489,216	11,685	12,854	31,006	469	522	1,864	14,582	43,019	95,661	51,107	156,031	351,538
LP-a-100-2	14	90	192,360	229,460	900,893	12,657	13,894	35,298	793	928	3,859	26,930	80,846	232,237	96,388	296,409	882,136
LP-a-100-3	14	10	102,005	131,883	340,224	11,264	12,660	28,552	390	465	1,242	11,482	37,848	58,045	39,246	132,695	204,017
LP-a-100-3	14	50	129,117	165,696	497,201	11,791	13,213	31,198	477	581	1,889	14,746	49,053	97,814	51,758	176,134	358,779
LP-a-100-3	14	90	197,899	250,635	911,725	12,783	14,310	35,522	803	1,018	3,896	27,226	90,273	235,626	97,668	327,997	893,683
LP-b-400-1	16	10	116,998	188,574	377,685	11,884	15,010	29,968	415	723	1,379	12,908	60,443	68,520	42,993	201,279	237,087
LP-b-400-1	16	50	145,641	249,164	555,610	12,437	16,354	33,054	538	937	2,136	16,747	79,670	115,451	56,914	267,495	416,302

Table 43-Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, High Sea Level Rise Scenario
Planning Unit 1
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
LP-b-400-1	16	90	187,605	352,970	993,511	13,600	17,558	37,792	730	1,263	4,223	24,077	112,277	264,520	80,182	399,572	999,597
LP-b-400-3	16	10	100,149	129,976	350,131	11,218	12,612	28,854	383	457	1,281	11,199	37,017	60,535	38,053	129,284	212,736
LP-b-400-3	16	50	111,374	146,461	504,461	11,377	12,775	31,353	402	494	1,922	12,021	41,011	101,125	41,553	146,215	371,037
LP-b-400-3	16	90	128,357	169,101	903,206	11,725	13,186	35,364	464	595	3,865	14,399	51,063	240,513	52,481	182,301	918,397
LP-b-1000-1	16	10	116,997	188,573	377,685	11,884	15,010	29,968	415	723	1,379	12,908	60,443	68,520	42,993	201,279	237,087
LP-b-1000-1	16	50	145,543	249,062	555,521	12,425	16,341	33,043	538	937	2,136	16,745	79,661	115,446	56,906	267,464	416,288
LP-b-1000-1	16	90	183,219	347,914	989,366	13,452	17,403	37,657	699	1,225	4,193	22,874	108,691	262,730	75,633	385,185	992,583
LP-b-1000-2	16	10	96,965	118,785	344,889	11,140	12,310	28,718	378	412	1,265	11,117	33,018	59,299	37,672	116,820	208,807
LP-b-1000-2	16	50	106,520	129,778	496,583	11,241	12,384	31,154	394	434	1,899	11,821	34,900	99,190	40,780	125,831	364,520
LP-b-1000-2	16	90	113,548	137,699	884,955	11,354	12,511	34,940	409	452	3,789	12,413	36,748	235,066	44,536	130,673	898,280
Non-Structural Plans																	
NS-100	15	10	49,720	116,095	216,487	13,635	16,912	30,673	47	867	751	1,632	86,380	41,784	4,641	294,784	142,986
NS-100	15	50	82,667	226,326	345,504	15,002	18,490	33,684	314	2,015	1,636	11,729	191,856	95,166	41,600	625,295	325,870
NS-100	15	90	252,858	609,726	802,610	17,155	21,000	38,414	1,021	3,226	3,351	39,785	305,564	183,338	145,628	1,043,744	650,864
NS-400	15	10	26,799	42,031	167,802	12,969	16,214	29,708	1	25	439	21	2,503	13,996	84	9,169	49,409
NS-400	15	50	32,315	61,103	237,774	14,312	17,768	32,685	12	277	759	477	27,918	31,753	2,712	106,870	121,626
NS-400	15	90	87,505	169,067	480,396	16,448	20,261	37,391	352	822	1,855	14,555	82,674	85,966	72,987	363,488	358,583
NS-1000	15	10	17,778	30,505	154,099	10,186	13,186	25,644	0	0	430	0	44	13,211	0	183	46,532
NS-1000	15	50	22,539	37,014	219,331	11,496	14,707	28,574	3	47	677	145	4,999	24,282	1,610	21,182	93,849
NS-1000	15	90	42,674	74,303	400,689	13,559	17,122	33,173	140	347	1,469	6,614	37,559	63,073	47,495	207,312	281,580

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 44
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, Low Sea Level Rise Scenario
Planning Unit 2
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage $1000s	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages $1000s	Expected Annual Output Impacted $1000s		Equivalent Annual Output $1000s
			2010	2075		2010	2075		2010	2075		2010	2075		2010	2075	
Without Project																	
Degraded Coast PU2-0	NA	10	128,022	829,310	695,863	4,595	15,130	16,175	424	3,559	2,793	18,672	351,443	240,089	148,926	1,749,253	1,281,236
Degraded Coast PU2-0	NA	50	281,805	1,941,156	1,601,299	6,405	20,670	22,294	1,033	8,387	6,635	41,729	811,140	552,025	236,551	3,973,115	2,753,445
Degraded Coast PU2-0	NA	90	375,050	2,117,588	1,851,010	7,098	21,381	23,789	1,356	8,637	7,283	54,285	837,737	587,356	333,768	4,217,062	3,049,872
Sustained Coast PU1-R	NA*	10	128,022	220,237	329,618	4,595	6,061	10,722	424	899	1,193	18,672	77,545	75,389	148,926	516,951	540,234
Sustained Coast PU1-R	NA*	50	281,805	412,776	682,259	6,405	7,715	14,505	1,033	1,768	2,655	41,729	160,701	160,906	236,551	954,529	938,321
Sustained Coast PU1-R	NA*	90	375,050	532,880	898,100	7,098	8,358	15,958	1,356	2,199	3,411	54,285	212,598	211,450	333,768	1,337,503	1,318,348
Comprehensive Plans																	
C-G-100-1	11	10	26,359	68,167	211,485	3,436	5,260	10,008	13	251	676	427	17,809	50,621	1,888	82,530	294,089
C-G-100-1	11	50	33,357	103,803	448,995	4,015	5,444	12,546	87	521	1,778	2,885	37,721	119,913	11,541	197,373	611,462
C-G-100-1	11	90	51,599	143,418	568,767	4,483	5,802	13,727	176	694	2,201	6,516	57,159	142,517	30,784	406,655	791,156
C-G-100-4	11	10	22,788	33,565	198,436	2,198	3,112	8,213	13	92	635	425	5,686	46,303	1,867	35,860	277,797
C-G-100-4	11	50	28,659	60,057	432,764	2,613	3,247	10,604	82	277	1,708	2,743	19,241	113,292	10,787	104,757	578,708
C-G-100-4	11	90	46,304	92,027	550,441	2,985	3,558	11,692	176	409	2,125	6,528	34,806	134,718	30,631	288,389	750,175
C-G-400-4	13	10	19,832	24,371	212,543	2,104	2,866	8,471	8	26	690	240	1,198	52,022	1,050	3,643	297,691
C-G-400-4	13	50	21,838	28,058	470,869	2,344	2,904	10,895	8	47	1,793	257	3,486	125,289	1,151	27,005	632,579
C-G-400-4	13	90	23,842	35,927	577,117	2,477	2,961	11,765	14	83	2,127	495	6,571	140,664	3,241	36,752	741,686
C-G-1000-4	13	10	17,397	19,954	208,248	1,950	2,477	8,165	8	24	689	240	1,115	51,996	1,050	2,711	297,402
C-G-1000-4	13	50	18,465	21,377	464,749	2,066	2,509	10,440	8	27	1,787	240	1,428	124,631	1,050	6,962	626,250
C-G-1000-4	13	90	19,171	23,532	567,846	2,165	2,531	11,274	9	46	2,110	279	3,203	139,375	1,411	24,132	735,675
C-R-100-2	11	10	31,481	46,638	203,226	3,336	4,203	9,506	37	186	676	1,303	14,594	50,310	5,388	84,747	289,452
C-R-100-2	11	50	82,529	133,867	495,111	4,361	5,210	12,718	307	714	2,033	11,384	70,956	138,905	48,243	480,373	734,512
C-R-100-2	11	90	183,013	276,497	718,603	5,245	6,035	14,404	741	1,313	2,880	27,877	127,813	185,856	126,391	766,434	1,000,327
C-R-100-3	11	10	29,450	42,616	203,114	2,846	3,662	8,914	37	162	679	1,296	13,344	49,767	5,301	69,471	284,666
C-R-100-3	11	50	80,114	127,014	494,224	3,853	4,676	12,115	304	661	2,031	11,269	64,769	137,243	47,555	443,461	723,192
C-R-100-3	11	90	180,777	266,813	717,315	4,753	5,525	13,823	741	1,263	2,882	27,882	121,972	184,438	126,408	731,826	990,668
C-R-100-4	11	10	28,702	39,397	201,962	2,566	3,011	8,445	35	124	669	1,213	9,332	48,226	4,617	48,967	277,019
C-R-100-4	11	50	78,479	118,633	490,733	3,527	4,009	11,604	293	509	1,969	10,768	46,762	130,029	44,146	336,017	680,311
C-R-100-4	11	90	177,437	247,202	708,602	4,316	4,874	13,231	728	1,074	2,817	27,362	99,892	176,173	123,801	603,454	944,067
C-R-400-2	13	10	22,442	26,323	205,992	3,076	3,932	9,509	8	9	667	243	687	51,815	1,062	3,095	289,562
C-R-400-2	13	50	25,768	31,741	463,262	3,424	4,232	12,110	11	43	1,767	357	3,924	125,145	1,800	23,168	626,296

Table 44--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, Low Sea Level Rise Scenario
Planning Unit 2
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage $1000s	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages $1000s	Expected Annual Output Impacted $1000s		Equivalent Annual Output $1000s
			2010	2075		2010	2075		2010	2075		2010	2075		2010	2075	
C-R-400-2	13	90	35,546	49,896	575,111	3,769	4,492	13,199	51	141	2,130	1,867	13,745	143,357	8,460	73,352	751,377
C-R-400-3	11	10	20,518	23,931	188,869	2,586	3,391	8,575	8	9	604	243	687	44,712	1,062	3,095	259,359
C-R-400-3	11	50	23,731	29,062	412,726	2,909	3,691	10,933	11	40	1,557	356	3,716	106,805	1,791	20,870	542,559
C-R-400-3	11	90	33,274	46,366	516,783	3,248	3,952	11,975	50	137	1,899	1,836	13,344	123,988	8,294	70,591	661,844
C-R-400-4	13	10	19,832	22,602	208,102	2,307	2,740	8,549	8	8	692	243	608	51,996	1,062	2,751	292,910
C-R-400-4	13	50	22,837	27,118	466,376	2,574	3,014	11,085	11	27	1,794	329	2,334	125,145	1,601	15,203	626,299
C-R-400-4	13	90	31,835	42,229	578,878	2,764	3,250	12,058	46	106	2,162	1,658	9,841	142,961	7,246	52,109	749,888
C-R-1000-4	13	10	18,074	20,451	205,324	2,281	2,714	8,511	8	8	692	240	585	51,985	1,050	2,672	292,875
C-R-1000-4	13	50	20,119	22,894	462,105	2,527	2,964	11,021	8	13	1,788	247	1,024	124,659	1,097	6,000	622,910
C-R-1000-4	13	90	21,140	26,223	564,587	2,587	3,065	11,856	10	30	2,110	319	2,558	139,524	1,551	13,228	732,469
C-WBI-100-1	6	10	32,338	59,725	180,485	4,136	5,567	10,244	39	308	611	1,359	24,796	43,835	5,793	133,197	267,173
C-WBI-100-1	6	50	84,475	159,180	411,506	5,307	6,562	13,205	332	1,019	1,761	12,269	96,433	117,697	53,613	640,218	668,049
C-WBI-100-1	6	90	184,626	322,652	650,055	6,243	7,456	15,036	746	1,728	2,703	27,992	169,845	177,422	127,837	1,020,841	1,003,725
C-WBI-400-1	12	10	23,096	29,847	196,575	3,877	5,297	10,433	8	19	636	243	1,447	49,328	1,062	6,027	278,463
C-WBI-400-1	12	50	27,040	38,406	433,936	4,422	5,637	13,083	13	161	1,666	421	14,176	119,407	2,196	71,977	603,625
C-WBI-400-1	12	90	38,118	66,674	540,538	4,862	6,012	14,265	58	329	2,036	2,182	29,237	139,593	10,438	139,007	736,291
Structural Plans																	
G-100-1	11	10	97,366	179,373	331,302	3,792	5,890	10,632	378	716	1,259	17,597	62,202	85,014	138,531	525,099	595,451
G-100-1	11	50	146,163	243,804	627,987	4,565	6,141	13,423	490	887	2,375	21,297	75,834	153,854	156,253	594,312	908,393
G-100-1	11	90	184,019	288,435	772,895	5,033	6,499	14,604	627	1,047	2,852	27,129	92,000	178,091	212,280	697,391	1,099,422
G-100-4	11	10	82,469	121,839	297,533	2,555	3,742	8,837	314	465	1,112	15,501	42,851	75,939	125,961	429,910	549,043
G-100-4	11	50	126,926	175,336	586,618	3,163	3,944	11,481	403	570	2,185	18,620	50,982	142,212	140,905	465,313	846,824
G-100-4	11	90	160,896	211,408	725,195	3,535	4,255	12,569	532	689	2,641	24,156	63,290	164,735	194,681	542,207	1,026,032
G-400-4	13	10	82,393	121,763	317,927	2,550	3,737	9,277	314	464	1,193	15,498	42,840	83,265	125,934	429,825	579,839
G-400-4	13	50	124,760	173,053	639,524	3,079	3,857	12,074	393	558	2,414	18,208	49,778	161,210	138,590	458,222	931,383
G-400-4	13	90	145,200	194,086	772,016	3,212	3,914	12,944	452	599	2,813	20,720	53,620	179,554	178,789	495,962	1,094,979
G-1000-4	13	10	82,393	121,763	317,927	2,550	3,737	9,277	314	464	1,193	15,498	42,840	83,265	125,934	429,825	579,839
G-1000-4	13	50	124,748	173,042	639,512	3,077	3,854	12,072	393	558	2,414	18,208	49,777	161,209	138,589	458,220	931,381
G-1000-4	13	90	144,797	193,679	771,590	3,176	3,876	12,905	451	598	2,812	20,685	53,521	179,494	178,526	495,186	1,094,521
R-100-2	11	10	112,256	159,034	335,157	3,693	4,590	10,055	378	600	1,214	17,202	55,029	81,950	142,548	419,546	558,059
R-100-2	11	50	205,282	276,687	686,937	4,911	5,788	13,558	685	1,059	2,595	29,469	101,421	170,084	190,444	669,531	964,072
R-100-2	11	90	325,823	423,022	935,691	5,795	6,613	15,244	1,186	1,620	3,510	48,983	158,262	220,663	314,016	1,039,003	1,310,335

Table 44--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, Low Sea Level Rise Scenario
Planning Unit 2
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
R-100-3	11	10	100,473	140,752	318,903	3,203	4,049	9,462	340	539	1,161	16,555	49,396	79,279	135,949	383,039	538,867
R-100-3	11	50	191,530	254,870	667,783	4,403	5,254	12,955	630	989	2,525	27,310	94,548	165,753	179,852	622,500	937,710
R-100-3	11	90	310,915	398,210	914,481	5,303	6,102	14,663	1,132	1,553	3,442	46,904	151,733	216,527	303,594	994,276	1,284,992
R-100-4	11	10	97,231	132,493	313,191	2,923	3,398	8,994	316	460	1,112	15,615	41,436	75,485	128,151	332,713	513,428
R-100-4	11	50	186,430	240,562	658,292	4,077	4,587	12,444	599	807	2,430	26,082	73,721	156,792	170,334	494,843	881,224
R-100-4	11	90	303,063	372,505	898,457	4,866	5,452	14,071	1,074	1,344	3,316	44,553	127,703	205,455	287,547	854,006	1,218,545
R-400-2	13	10	105,409	151,127	344,401	3,526	4,417	10,200	357	575	1,263	16,441	52,497	87,337	140,109	410,462	582,912
R-400-2	13	50	155,566	219,351	677,429	4,165	5,011	13,242	473	811	2,559	21,377	77,153	173,098	159,702	566,931	984,560
R-400-2	13	90	192,252	268,758	831,310	4,510	5,271	14,331	598	936	3,034	26,265	90,520	196,471	213,177	710,844	1,194,957
R-400-3	11	10	93,624	132,844	310,500	3,036	3,875	9,265	319	514	1,135	15,793	46,862	77,709	133,507	373,947	533,462
R-400-3	11	50	141,604	197,316	606,561	3,650	4,469	12,064	417	740	2,262	19,189	70,209	150,042	148,969	519,454	873,936
R-400-3	11	90	175,525	242,025	748,416	3,988	4,730	13,106	541	865	2,715	24,039	83,579	172,436	201,922	663,419	1,078,258
R-400-4	13	10	90,380	124,582	324,509	2,756	3,224	9,240	295	435	1,170	14,854	38,901	81,422	125,706	323,616	542,152
R-400-4	13	50	136,355	182,853	651,096	3,314	3,791	12,216	385	557	2,408	17,912	49,251	160,817	139,024	390,667	907,816
R-400-4	13	90	166,508	215,056	794,328	3,505	4,028	13,189	475	646	2,846	21,388	58,682	181,809	183,225	515,736	1,105,068
R-1000-4	13	10	90,376	124,577	324,505	2,756	3,224	9,240	295	435	1,170	14,850	38,885	81,414	125,694	323,569	542,126
R-1000-4	13	50	135,679	182,074	650,348	3,295	3,772	12,195	383	555	2,406	17,857	49,050	160,707	138,829	389,963	907,431
R-1000-4	13	90	158,719	206,084	785,710	3,355	3,872	13,029	444	610	2,811	20,213	54,973	179,677	179,068	501,490	1,097,127
WBI-100-1	6	10	124,688	216,360	340,034	4,493	5,954	10,792	407	879	1,230	18,069	75,721	79,698	146,542	509,454	552,934
WBI-100-1	6	50	228,904	350,051	644,275	5,857	7,139	14,045	788	1,470	2,449	32,508	133,834	153,615	204,204	854,997	915,632
WBI-100-1	6	90	360,465	513,995	920,737	6,793	8,034	15,876	1,300	2,121	3,491	52,035	206,216	217,595	327,179	1,316,365	1,334,931
WBI-400-1	12	10	117,850	208,463	365,822	4,327	5,781	11,124	386	855	1,349	17,308	73,189	92,065	144,103	500,370	603,552
WBI-400-1	12	50	180,377	293,931	697,439	5,162	6,415	14,215	580	1,227	2,678	24,560	109,937	178,089	174,167	754,302	1,021,719
WBI-400-1	12	90	232,886	366,076	867,445	5,603	6,790	15,397	747	1,476	3,220	30,792	142,725	209,142	235,409	1,015,504	1,278,247
Non-Structural Plans																	
NS-100	15	10	33,569	61,499	147,468	4,238	5,674	9,774	51	323	458	1,793	26,172	23,351	7,459	138,745	156,875
NS-100	15	50	135,353	219,882	419,821	5,855	7,138	13,326	573	1,313	1,783	21,325	122,866	91,576	85,259	737,855	491,908
NS-100	15	90	197,170	339,496	592,376	6,548	7,780	14,794	798	1,802	2,415	30,076	175,792	126,694	133,726	1,040,085	708,840
NS-400	15	10	14,302	20,886	113,248	3,008	4,375	7,989	0	11	303	0	847	13,493	0	3,307	106,550
NS-400	15	50	25,138	37,337	239,483	4,463	5,668	11,306	110	277	942	4,194	25,518	42,183	18,075	125,697	226,849
NS-400	15	90	34,599	63,800	324,378	4,989	6,136	12,534	527	881	1,826	20,170	82,787	86,762	87,526	395,477	457,302
NS-1000	15	10	12,022	17,640	109,682	2,908	4,270	7,845	0	0	300	0	0	13,231	0	0	105,526
NS-1000	15	50	18,579	25,527	228,458	4,286	5,482	11,051	21	43	769	805	3,976	31,704	3,445	20,935	177,969
NS-1000	15	90	21,821	33,310	300,582	4,810	5,948	12,275	40	95	1,035	1,617	9,483	43,218	7,770	49,747	260,637

Source: GIS Economic Application Databases
* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 45
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, High Sea Level Rise Scenario
Planning Unit 2
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU2-0	NA	10	128,022	1,730,382	1,237,692	4,595	20,040	19,128	424	7,288	5,035	18,672	701,053	450,314	148,926	3,145,439	2,120,786
Degraded Coast PU2-0	NA	50	281,805	2,166,127	1,736,577	6,405	21,468	22,774	1,033	8,794	6,880	41,729	852,224	576,730	236,551	4,270,103	2,932,029
Degraded Coast PU2-0	NA	90	375,050	2,244,316	1,927,214	7,098	21,614	23,929	1,356	8,972	7,484	54,285	878,751	612,019	333,768	4,538,312	3,243,045
Sustained Coast PU1-R	NA*	10	128,022	287,949	370,334	4,595	6,445	10,953	424	1,298	1,433	18,672	117,455	99,388	148,926	762,890	688,121
Sustained Coast PU1-R	NA*	50	281,805	509,000	740,121	6,405	8,036	14,697	1,033	2,104	2,857	41,729	200,660	184,934	236,551	1,233,532	1,106,090
Sustained Coast PU1-R	NA*	90	375,050	638,391	961,545	7,098	8,524	16,058	1,356	2,459	3,568	54,285	246,439	231,800	333,768	1,613,454	1,484,281
Comprehensive Plans																	
C-G-100-1	11	10	26,359	117,968	311,088	3,436	5,842	10,671	13	652	1,152	427	51,032	93,445	1,888	375,911	517,924
C-G-100-1	11	50	33,357	172,466	495,509	4,015	5,942	12,812	87	856	1,943	2,885	69,978	135,774	11,541	506,855	748,723
C-G-100-1	11	90	51,599	217,293	608,463	4,483	6,184	13,899	176	1,103	2,388	6,516	95,043	160,722	30,784	668,099	919,704
C-G-100-4	11	10	22,788	51,925	285,629	2,198	3,323	8,734	13	296	1,036	425	25,309	83,950	1,867	248,434	471,403
C-G-100-4	11	50	28,659	93,129	465,383	2,613	3,433	10,750	82	363	1,779	2,743	29,989	120,926	10,787	266,225	659,227
C-G-100-4	11	90	46,304	126,367	574,836	2,985	3,758	11,794	176	475	2,182	6,528	41,121	140,859	30,631	318,661	790,217
C-G-400-4	13	10	19,832	33,162	316,850	2,104	3,026	9,081	8	120	1,140	240	10,740	94,360	1,050	53,760	471,481
C-G-400-4	13	50	21,838	40,434	501,253	2,344	3,053	11,041	8	149	1,875	257	12,255	132,982	1,151	63,280	679,435
C-G-400-4	13	90	23,842	52,182	597,785	2,477	3,125	11,853	14	218	2,210	495	20,225	149,796	3,241	217,697	834,887
C-G-1000-4	13	10	17,397	23,564	310,950	1,950	2,591	8,760	8	82	1,128	240	6,706	93,110	1,050	27,685	463,406
C-G-1000-4	13	50	18,465	26,687	492,945	2,066	2,615	10,573	8	103	1,860	240	8,780	131,885	1,050	49,970	675,191
C-G-1000-4	13	90	19,171	32,719	586,326	2,165	2,652	11,349	9	135	2,178	279	11,787	146,935	1,411	61,436	784,388
C-R-100-2	11	10	31,481	79,612	295,272	3,336	4,463	10,036	37	471	1,106	1,303	46,632	92,583	5,388	268,192	478,423
C-R-100-2	11	50	82,529	200,145	540,314	4,361	5,438	12,876	307	858	2,121	11,384	82,588	146,835	48,243	544,911	784,797
C-R-100-2	11	90	183,013	354,499	759,339	5,245	6,181	14,481	741	1,383	2,936	27,877	134,514	192,022	126,391	816,003	1,047,702
C-R-100-3	11	10	29,450	70,750	293,174	2,846	3,921	9,443	37	417	1,099	1,296	40,376	90,392	5,301	230,840	465,984
C-R-100-3	11	50	80,114	183,931	535,779	3,853	4,905	12,273	304	805	2,119	11,269	76,402	145,173	47,555	507,999	773,477
C-R-100-3	11	90	180,777	332,170	753,216	4,753	5,671	13,899	741	1,333	2,938	27,882	128,673	190,604	126,408	781,395	1,038,044
C-R-100-4	11	10	28,702	58,719	288,530	2,566	3,195	8,945	35	226	1,031	1,213	18,266	81,974	4,617	101,431	417,056
C-R-100-4	11	50	78,479	156,892	525,086	3,527	4,184	11,741	293	595	2,035	10,768	52,073	135,551	44,146	354,870	713,243
C-R-100-4	11	90	177,437	292,139	736,667	4,316	4,989	13,296	728	1,113	2,861	27,362	103,101	180,984	123,801	616,377	976,954
C-R-400-2	13	10	22,442	31,270	309,300	3,076	4,192	10,146	8	79	1,112	243	7,341	93,716	1,062	30,070	458,758
C-R-400-2	13	50	25,768	44,812	495,211	3,424	4,461	12,279	11	160	1,853	357	14,451	133,396	1,800	71,001	676,606
C-R-400-2	13	90	35,546	72,885	599,518	3,769	4,638	13,277	51	402	2,251	1,867	36,845	155,358	8,460	216,472	833,659

Table 45--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, High Sea Level Rise Scenario
Planning Unit 2
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
C-R-400-3	11	10	20,518	28,662	271,680	2,586	3,650	9,104	8	76	966	243	7,188	78,978	1,062	27,913	398,385
C-R-400-3	11	50	23,731	41,206	440,415	2,909	3,919	11,090	11	156	1,637	356	14,047	114,332	1,791	68,188	587,510
C-R-400-3	11	90	33,274	67,384	538,951	3,248	4,098	12,051	50	369	2,005	1,836	34,696	134,692	8,294	189,966	730,840
C-R-400-4	13	10	19,832	26,552	310,368	2,307	2,923	9,160	8	57	1,124	243	5,225	92,463	1,062	20,713	454,406
C-R-400-4	13	50	22,837	37,321	496,162	2,574	3,188	11,235	11	99	1,864	329	7,871	131,586	1,601	41,944	668,197
C-R-400-4	13	90	31,835	59,580	600,113	2,764	3,366	12,125	46	219	2,236	1,658	18,834	150,433	7,246	103,251	801,842
C-R-1000-4	13	10	18,074	22,766	307,084	2,281	2,897	9,121	8	27	1,114	240	2,230	91,532	1,050	6,918	450,123
C-R-1000-4	13	50	20,119	28,583	490,493	2,527	3,139	11,172	8	74	1,854	247	5,785	130,860	1,097	20,499	661,017
C-R-1000-4	13	90	21,140	37,279	583,873	2,587	3,180	11,922	10	98	2,170	319	8,008	145,899	1,551	42,538	777,661
C-WBI-100-1	6	10	32,338	115,582	243,203	4,136	5,951	10,613	39	860	991	1,359	78,104	80,470	5,793	448,581	461,105
C-WBI-100-1	6	50	84,475	259,398	468,440	5,307	6,882	13,392	332	1,498	1,986	12,269	145,162	141,626	53,613	951,803	826,626
C-WBI-100-1	6	90	184,626	443,252	711,409	6,243	7,622	15,126	746	2,077	2,871	27,992	209,613	197,451	127,837	1,317,096	1,157,882
C-WBI-400-1	12	10	23,096	39,723	292,971	3,877	5,681	11,061	8	197	1,084	243	17,607	91,348	1,062	78,898	453,935
C-WBI-400-1	12	50	27,040	62,131	469,243	4,422	5,957	13,281	13	301	1,770	421	27,315	129,896	2,196	146,373	672,499
C-WBI-400-1	12	90	38,118	113,460	573,790	4,862	6,178	14,350	58	894	2,259	2,182	87,938	163,828	10,438	547,224	910,781
Structural Plans																	
G-100-1	11	10	97,366	249,957	437,343	3,792	6,599	11,334	378	1,053	1,715	17,597	87,890	125,505	138,531	668,578	772,860
G-100-1	11	50	146,163	318,319	676,313	4,565	6,708	13,711	490	1,232	2,543	21,297	106,394	169,190	156,253	801,359	1,013,929
G-100-1	11	90	184,019	365,295	813,516	5,033	6,950	14,798	627	1,465	3,042	27,129	130,716	196,553	212,280	958,774	1,227,951
G-100-4	11	10	82,469	156,462	389,762	2,555	4,080	9,397	314	622	1,499	15,501	55,558	111,445	125,961	503,435	699,584
G-100-4	11	50	126,926	211,231	620,111	3,163	4,199	11,649	403	674	2,261	18,620	60,491	149,463	140,905	525,760	896,055
G-100-4	11	90	160,896	247,164	750,028	3,535	4,525	12,693	532	778	2,704	24,156	71,248	171,384	194,681	576,165	1,067,215
G-400-4	13	10	82,393	156,386	430,234	2,550	4,075	9,942	314	622	1,663	15,498	55,548	126,583	125,934	503,350	760,879
G-400-4	13	50	124,760	208,948	677,192	3,079	4,111	12,253	393	663	2,496	18,208	59,287	169,132	138,590	518,669	985,725
G-400-4	13	90	145,200	229,842	798,724	3,212	4,183	13,065	452	688	2,882	20,720	61,578	186,921	178,789	529,921	1,142,656
G-1000-4	13	10	82,393	156,386	430,234	2,550	4,075	9,942	314	622	1,663	15,498	55,548	126,583	125,934	503,350	760,879
G-1000-4	13	50	124,748	208,937	677,180	3,077	4,109	12,250	393	663	2,496	18,208	59,287	169,132	138,589	518,667	985,723
G-1000-4	13	90	144,797	229,434	798,298	3,176	4,145	13,026	451	686	2,880	20,685	61,479	186,861	178,526	529,144	1,142,198
R-100-2	11	10	112,256	198,061	429,078	3,693	4,850	10,584	378	803	1,619	17,202	78,236	121,487	142,548	552,049	731,252
R-100-2	11	50	205,282	343,511	732,309	4,911	6,016	13,716	685	1,166	2,671	29,469	111,220	177,447	190,444	727,108	1,012,201
R-100-2	11	90	325,823	496,680	975,082	5,795	6,759	15,321	1,186	1,687	3,565	48,983	164,958	226,828	314,016	1,091,223	1,358,532
R-100-3	11	10	100,473	173,219	410,304	3,203	4,308	9,992	340	732	1,562	16,555	71,294	118,314	135,949	504,578	707,849
R-100-3	11	50	191,530	311,639	709,293	4,403	5,482	13,113	630	1,095	2,601	27,310	104,347	173,115	179,852	680,077	985,839

Table 45--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, High Sea Level Rise Scenario
Planning Unit 2
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
R-100-3	11	90	310,915	459,501	949,122	5,303	6,248	14,740	1,132	1,620	3,497	46,904	158,430	222,692	303,594	1,046,496	1,333,189
R-100-4	11	10	97,231	154,715	400,658	2,923	3,581	9,494	316	511	1,458	15,615	46,224	107,950	128,151	352,701	643,408
R-100-4	11	50	186,430	278,164	692,441	4,077	4,762	12,581	599	858	2,485	26,082	77,460	161,826	170,334	509,343	912,808
R-100-4	11	90	303,063	413,469	925,291	4,866	5,567	14,136	1,074	1,377	3,358	44,553	130,723	210,208	287,547	864,003	1,250,525
R-400-2	13	10	105,409	190,154	458,264	3,526	4,676	10,837	357	778	1,749	16,441	75,703	134,364	140,109	542,965	784,791
R-400-2	13	50	155,566	286,175	726,026	4,165	5,239	13,411	473	918	2,642	21,377	86,951	181,123	159,702	624,508	1,037,888
R-400-2	13	90	192,252	342,417	871,411	4,510	5,417	14,409	598	1,002	3,095	26,265	97,216	203,392	213,177	763,065	1,249,087
R-400-3	11	10	93,624	165,311	401,901	3,036	4,134	9,795	319	708	1,536	15,793	68,759	116,744	133,507	495,486	702,444
R-400-3	11	50	141,604	254,085	648,071	3,650	4,697	12,222	417	847	2,338	19,189	80,007	157,404	148,969	577,030	922,065
R-400-3	11	90	175,525	303,316	783,056	3,988	4,876	13,182	541	932	2,770	24,039	90,275	178,600	201,922	715,639	1,126,455
R-400-4	13	10	90,380	146,804	432,434	2,756	3,408	9,850	295	486	1,602	14,854	43,689	121,942	125,706	343,605	704,276
R-400-4	13	50	136,355	220,454	689,368	3,314	3,966	12,366	385	608	2,471	17,912	52,990	166,701	139,024	405,168	945,923
R-400-4	13	90	166,508	256,019	822,877	3,505	4,143	13,256	475	680	2,895	21,388	61,703	187,432	183,225	525,733	1,144,279
R-1000-4	13	10	90,376	146,799	432,430	2,756	3,407	9,850	295	486	1,602	14,850	43,674	121,934	125,694	343,557	704,250
R-1000-4	13	50	135,679	219,675	688,619	3,295	3,946	12,346	383	606	2,469	17,857	52,789	166,591	138,829	404,464	945,538
R-1000-4	13	90	158,719	247,047	814,259	3,355	3,988	13,096	444	643	2,860	20,213	57,994	185,300	179,068	511,487	1,136,338
WBI-100-1	6	10	124,688	284,072	406,423	4,493	6,338	11,162	407	1,278	1,563	18,069	115,631	112,183	146,542	755,393	725,358
WBI-100-1	6	50	228,904	446,275	699,972	5,857	7,460	14,233	788	1,805	2,629	32,508	173,793	174,828	204,204	1,134,000	1,064,118
WBI-100-1	6	90	360,465	619,506	977,418	6,793	8,200	15,966	1,300	2,381	3,632	52,035	240,057	235,788	327,179	1,592,316	1,482,799
WBI-400-1	12	10	117,850	276,175	480,131	4,327	6,165	11,752	386	1,254	1,866	17,308	113,099	141,441	144,103	746,309	832,626
WBI-400-1	12	50	180,377	390,156	755,201	5,162	6,735	14,412	580	1,562	2,842	24,560	149,896	196,885	174,167	1,033,305	1,153,962
WBI-400-1	12	90	232,886	471,587	918,885	5,603	6,956	15,481	747	1,735	3,349	30,792	176,567	225,677	235,409	1,291,455	1,411,772
Non-Structural Plans																	
NS-100	15	10	33,569	117,355	164,768	4,238	6,058	9,893	51	875	628	1,793	79,479	39,861	7,459	454,129	254,554
NS-100	15	50	135,353	320,100	450,859	5,855	7,458	13,425	573	1,792	1,931	21,325	171,594	106,668	85,259	1,049,441	588,411
NS-100	15	90	197,170	460,096	629,727	6,548	7,946	14,846	798	2,151	2,523	30,076	215,561	139,011	133,726	1,336,339	800,594
NS-400	15	10	14,302	30,762	116,307	3,008	4,759	8,108	0	189	359	0	17,007	18,498	0	76,178	129,120
NS-400	15	50	25,138	61,061	246,830	4,463	5,988	11,406	110	417	985	4,194	38,657	46,252	18,075	200,093	249,890
NS-400	15	90	34,599	110,585	338,868	4,989	6,302	12,585	527	1,446	2,001	20,170	141,487	104,942	87,526	803,694	583,732
NS-1000	15	10	12,022	22,115	111,068	2,908	4,654	7,963	0	24	307	0	2,104	13,883	0	6,216	107,451
NS-1000	15	50	18,579	34,590	231,265	4,286	5,802	11,150	21	122	794	805	10,610	33,759	3,445	46,640	185,930
NS-1000	15	90	21,821	51,640	306,259	4,810	6,114	12,326	40	424	1,137	1,617	38,803	52,299	7,770	206,841	309,291

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 46
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, Low Sea Level Rise Scenario
Planning Unit 3a
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU3a-0	NA	10	183,351	347,564	491,402	4,662	8,761	12,448	774	1,892	2,329	33,862	192,853	168,121	183,499	974,858	868,832
Degraded Coast PU3a-0	NA	50	281,375	529,489	751,778	6,359	11,218	16,540	1,372	3,038	3,941	60,436	292,433	268,932	317,813	1,448,673	1,360,623
Degraded Coast PU3a-0	NA	90	386,427	719,878	1,028,069	7,552	12,368	19,069	1,859	4,322	5,462	79,029	408,473	367,345	393,115	1,986,686	1,800,122
Sustained Coast PU1-R	NA*	10	183,351	345,837	490,363	4,662	8,774	12,456	774	1,872	2,317	33,862	190,678	166,813	183,499	967,069	864,148
Sustained Coast PU1-R	NA*	50	281,375	526,281	749,849	6,359	11,304	16,592	1,372	3,019	3,929	60,436	290,472	267,752	317,813	1,443,086	1,357,263
Sustained Coast PU1-R	NA*	90	386,427	718,067	1,026,980	7,552	12,445	19,115	1,859	4,303	5,451	79,029	406,402	366,100	393,115	1,980,028	1,796,119
Comprehensive Plans																	
C-M-100-1	10	10	13,736	19,480	191,472	1,045	1,188	5,906	69	246	933	3,067	28,898	56,970	17,297	159,332	303,944
C-M-100-1	10	50	21,571	26,322	296,096	1,142	1,320	7,646	277	314	1,718	14,526	36,465	98,891	81,966	190,170	516,738
C-M-100-1	10	90	42,123	53,925	425,799	1,403	1,687	9,095	375	414	2,332	18,767	45,620	129,778	100,885	230,307	651,495
C-M-100-2	10	10	13,424	33,786	196,351	929	1,766	6,042	53	302	942	2,726	38,640	60,555	19,364	199,068	321,016
C-M-100-2	10	50	33,247	69,723	322,411	1,318	2,265	8,171	295	424	1,775	15,916	50,836	105,767	90,805	253,903	549,037
C-M-100-2	10	90	74,872	131,069	482,902	1,820	2,898	9,925	488	577	2,490	25,174	65,120	142,825	129,892	336,637	716,606
C-G-400-2	10	10	17,082	31,593	198,415	917	1,745	5,990	56	99	873	2,262	10,169	51,070	16,158	61,567	274,055
C-G-400-2	10	50	27,233	57,929	310,858	1,204	2,123	7,986	70	135	1,412	3,066	13,459	78,737	20,272	82,209	410,972
C-G-400-2	10	90	41,781	84,728	433,591	1,469	2,472	9,429	112	174	1,938	5,170	17,500	104,466	31,766	103,922	528,499
C-G-1000-2	10	10	10,578	21,491	189,059	747	1,522	5,747	23	52	828	962	5,748	48,247	10,222	41,887	261,348
C-G-1000-2	10	50	19,447	41,236	297,920	1,033	1,899	7,742	34	69	1,357	1,659	7,124	75,193	13,704	53,424	394,684
C-G-1000-2	10	90	31,033	62,730	415,491	1,286	2,235	9,168	70	94	1,871	3,377	9,396	99,920	23,200	64,432	506,523
Structural Plans																	
M-100-1	10	10	42,227	53,738	236,338	1,053	1,198	5,918	123	321	1,022	5,499	36,942	62,386	31,851	196,761	333,037
M-100-1	10	50	51,439	61,269	342,831	1,149	1,330	7,658	330	343	1,790	16,783	39,045	102,403	95,887	206,970	538,679
M-100-1	10	90	73,672	87,565	474,151	1,410	1,697	9,106	459	447	2,444	22,962	48,475	135,707	117,597	247,116	676,795
M-100-2	10	10	44,413	71,835	245,395	937	1,776	6,053	112	381	1,036	5,371	47,194	66,384	38,017	247,330	358,391
M-100-2	10	50	66,079	108,757	373,976	1,326	2,275	8,182	352	457	1,854	18,389	53,995	109,719	108,836	281,664	579,313
M-100-2	10	90	109,966	169,121	536,883	1,827	2,908	9,937	576	611	2,606	29,585	68,078	149,044	150,703	353,804	746,945
G-400-2	10	10	50,638	79,220	253,511	1,055	1,928	6,212	144	425	1,081	6,666	51,331	69,113	43,917	265,909	370,719
G-400-2	10	50	68,683	112,105	377,475	1,343	2,308	8,210	363	476	1,871	18,847	55,844	110,839	111,089	290,023	584,528

Table 46--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, Low Sea Level Rise Scenario
Planning Unit 3a
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
G-400-2	10	90	92,165	149,034	514,086	1,611	2,662	9,659	484	507	2,489	26,064	58,454	142,273	134,446	308,309	715,257
G-1000-2	10	10	44,637	72,072	245,675	934	1,772	6,050	111	380	1,036	5,366	47,183	66,375	37,988	247,263	358,339
G-1000-2	10	50	62,682	104,956	369,638	1,222	2,151	8,047	331	432	1,826	17,548	51,696	108,102	105,161	271,377	572,149
G-1000-2	10	90	86,016	141,747	506,072	1,487	2,503	9,493	451	462	2,442	24,721	54,229	139,469	128,373	289,391	702,650
Non-Structural Plans																	
NS-100	15	10	32,372	94,031	195,405	4,577	8,662	11,127	84	838	902	3,509	84,239	54,025	18,505	412,764	278,648
NS-100	15	50	61,513	190,489	327,470	6,275	11,191	15,021	290	2,415	2,047	11,802	230,560	127,488	58,608	1,126,765	640,004
NS-100	15	90	105,731	384,866	511,778	7,468	12,332	17,559	479	3,950	3,078	18,586	374,085	192,734	85,423	1,799,003	931,683
NS-400	15	10	16,846	33,998	159,372	3,481	7,198	9,442	18	111	603	832	11,396	28,457	4,968	57,465	153,402
NS-400	15	50	27,110	60,726	248,637	5,178	9,677	13,320	54	373	1,149	2,239	33,972	55,861	11,880	162,155	288,763
NS-400	15	90	45,266	129,510	364,773	6,371	10,817	15,858	147	1,040	1,805	6,171	101,416	94,340	29,263	480,976	460,389
NS-1000	15	10	12,556	24,904	151,736	2,739	5,970	8,229	3	19	557	118	1,913	24,719	555	9,533	133,600
NS-1000	15	50	21,258	39,216	235,401	4,383	8,444	12,045	11	72	1,007	423	6,655	45,360	2,153	30,033	236,917
NS-1000	15	90	32,077	64,629	329,863	5,546	9,565	14,544	60	232	1,457	2,258	20,842	64,990	9,325	96,814	319,015

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 47
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, High Sea Level Rise Scenario
Planning Unit 3a
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU3a-0	NA	10	183,351	521,763	596,150	4,662	11,880	14,323	774	2,795	2,872	33,862	283,638	222,712	183,499	1,410,714	1,130,919
Degraded Coast PU3a-0	NA	50	281,375	795,008	911,438	6,359	13,846	18,121	1,372	4,719	4,951	60,436	455,524	367,001	317,813	2,226,625	1,828,417
Degraded Coast PU3a-0	NA	90	386,427	1,038,601	1,219,722	7,552	14,705	20,475	1,859	5,246	6,018	79,029	501,550	423,314	393,115	2,465,641	2,088,125
Sustained Coast PU1-R	NA*	10	183,351	519,275	594,654	4,662	11,882	14,325	774	2,796	2,873	33,862	283,832	222,828	183,499	1,410,811	1,130,977
Sustained Coast PU1-R	NA*	50	281,375	792,760	910,087	6,359	13,953	18,185	1,372	4,720	4,952	60,436	455,583	367,036	317,813	2,226,995	1,828,640
Sustained Coast PU1-R	NA*	90	386,427	1,040,881	1,221,093	7,552	14,785	20,522	1,859	5,257	6,024	79,029	502,829	424,083	393,115	2,469,191	2,090,260
Comprehensive Plans																	
C-M-100-1	10	10	13,736	25,323	207,273	1,045	1,208	6,153	69	438	1,075	3,067	52,249	72,757	17,297	281,210	384,154
C-M-100-1	10	50	21,571	34,932	319,836	1,142	1,368	7,866	277	456	1,903	14,526	54,088	118,430	81,966	290,872	616,480
C-M-100-1	10	90	42,123	66,168	454,894	1,403	1,687	9,273	375	572	2,466	18,767	65,121	144,705	100,885	339,153	731,722
C-M-100-2	10	10	13,424	68,017	223,567	929	2,326	6,504	53	579	1,118	2,726	73,261	80,910	19,364	365,313	420,421
C-M-100-2	10	50	33,247	115,196	360,947	1,318	2,692	8,542	295	629	1,986	15,916	77,842	129,041	90,805	401,007	667,226
C-M-100-2	10	90	74,872	178,210	525,877	1,820	3,163	10,209	488	789	2,646	25,174	93,114	161,186	129,892	475,659	809,784
C-G-400-2	10	10	17,082	57,653	223,101	917	2,305	6,452	56	142	977	2,262	14,601	62,076	16,158	87,788	330,094
C-G-400-2	10	50	27,233	92,722	346,086	1,204	2,550	8,358	70	216	1,584	3,066	25,094	97,251	20,272	125,903	497,134
C-G-400-2	10	90	41,781	117,776	472,201	1,469	2,737	9,714	112	263	2,056	5,170	30,214	118,095	31,766	150,293	592,982
C-G-1000-2	10	10	10,578	40,707	211,625	747	2,082	6,210	23	80	927	962	8,692	58,792	10,222	61,150	315,231
C-G-1000-2	10	50	19,447	69,930	331,260	1,033	2,326	8,114	34	100	1,514	1,659	10,291	91,084	13,704	68,864	472,095
C-G-1000-2	10	90	31,033	90,936	452,602	1,286	2,500	9,453	70	154	1,980	3,377	16,590	111,839	23,200	101,928	568,257
Structural Plans																	
M-100-1	10	10	42,227	61,282	252,666	1,053	1,218	6,165	123	466	1,149	5,499	54,822	76,479	31,851	297,936	406,834
M-100-1	10	50	51,439	69,991	366,606	1,149	1,377	7,878	330	489	1,977	16,783	56,943	122,027	95,887	307,681	638,424
M-100-1	10	90	73,672	98,114	502,721	1,410	1,697	9,285	459	606	2,578	22,962	68,087	150,669	117,597	356,688	757,246
M-100-2	10	10	44,413	108,333	273,313	937	2,336	6,516	112	615	1,199	5,371	76,974	85,240	38,017	408,715	456,291
M-100-2	10	50	66,079	154,776	412,682	1,326	2,701	8,554	352	663	2,065	18,389	81,045	133,006	108,836	427,362	697,067
M-100-2	10	90	109,966	213,572	579,025	1,827	3,173	10,221	576	827	2,763	29,585	96,564	167,557	150,703	503,168	843,326
G-400-2	10	10	50,638	115,719	281,429	1,055	2,489	6,675	144	659	1,243	6,666	81,111	87,969	43,917	427,294	468,619

Table 47--Continued

Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, High Sea Level Rise Scenario
Planning Unit 3a
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
G-400-2	10	50	68,683	158,124	416,180	1,343	2,735	8,582	363	683	2,082	18,847	82,894	134,126	111,089	435,721	702,282
G-400-2	10	90	92,165	193,485	556,228	1,611	2,927	9,943	484	722	2,645	26,064	86,940	160,787	134,446	457,672	811,638
G-1000-2	10	10	44,637	108,570	273,594	934	2,332	6,512	111	615	1,199	5,366	76,963	85,232	37,988	408,647	456,240
G-1000-2	10	50	62,682	150,974	408,344	1,222	2,578	8,419	331	639	2,038	17,548	78,746	131,389	105,161	417,075	689,903
G-1000-2	10	90	86,016	186,198	548,214	1,487	2,768	9,778	451	677	2,599	24,721	82,714	157,982	128,373	438,754	799,030
Non-Structural Plans																	
NS-100	15	10	32,372	188,422	224,639	4,577	11,769	12,090	84	1,654	1,154	3,509	170,653	80,788	18,505	827,275	407,028
NS-100	15	50	61,513	443,973	405,977	6,275	13,841	15,841	290	4,041	2,550	11,802	385,259	175,401	58,608	1,839,957	860,889
NS-100	15	90	105,731	749,281	624,642	7,468	14,672	18,284	479	4,707	3,313	18,586	442,607	213,956	85,423	2,124,425	1,032,471
NS-400	15	10	16,846	53,545	165,426	3,481	10,255	10,389	18	192	628	832	19,378	30,930	4,968	95,097	165,058
NS-400	15	50	27,110	128,427	269,605	5,178	12,326	14,140	54	976	1,335	2,239	95,215	74,829	11,880	448,956	377,589
NS-400	15	90	45,266	253,710	403,240	6,371	13,158	16,583	147	1,645	1,992	6,171	162,074	113,126	29,263	762,977	547,729
NS-1000	15	10	12,556	35,479	155,011	2,739	8,980	9,161	3	96	581	118	9,573	27,091	555	46,439	145,030
NS-1000	15	50	21,258	64,090	243,105	4,383	11,052	12,852	11	280	1,071	423	26,600	51,538	2,153	127,802	267,198
NS-1000	15	90	32,077	109,132	343,646	5,546	11,883	15,262	60	1,106	1,727	2,258	106,356	91,475	9,325	500,311	443,983

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 48
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, Low Sea Level Rise Scenario
Planning Unit 3b
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage $1000s	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages $1000s	Expected Annual Output Impacted $1000s		Equivalent Annual Output $1000s
			2010	2075		2010	2075		2010	2075		2010	2075		2010	2075	
Without Project																	
Degraded Coast PU3b-0	NA	10	75,289	144,002	202,555	1,628	3,032	4,331	464	768	1,176	20,497	77,484	78,163	91,491	336,385	343,192
Degraded Coast PU3b-0	NA	50	126,488	218,681	326,320	2,468	3,929	6,163	796	1,037	1,849	37,053	101,280	117,972	149,395	453,733	502,943
Degraded Coast PU3b-0	NA	90	185,226	306,294	469,473	3,153	4,654	7,655	960	1,279	2,248	42,953	124,383	140,952	183,408	550,497	613,517
Sustained Coast PU1-R	NA*	10	75,289	144,155	202,647	1,628	3,025	4,326	464	769	1,177	20,497	77,534	78,193	91,491	336,757	343,416
Sustained Coast PU1-R	NA*	50	126,488	218,988	326,505	2,468	3,927	6,162	796	1,033	1,847	37,053	100,951	117,774	149,395	452,677	502,308
Sustained Coast PU1-R	NA*	90	185,226	306,187	469,410	3,153	4,654	7,655	960	1,279	2,247	42,953	124,254	140,874	183,408	550,108	613,283
Comprehensive Plans																	
C-F-100-1	10	10	7,235	11,303	80,217	223	341	1,904	4	11	432	264	1,118	23,003	548	3,376	100,994
C-F-100-1	10	50	13,507	21,767	137,223	326	500	2,825	30	70	773	1,376	6,707	41,604	5,111	27,506	170,912
C-F-100-1	10	90	38,801	61,468	229,238	625	853	3,839	111	196	1,046	4,477	19,019	55,792	19,117	77,621	238,359
C-F-400-1	12	10	5,672	8,605	85,020	218	336	2,092	3	6	482	196	699	26,022	284	1,641	114,510
C-F-400-1	12	50	7,126	11,457	140,995	249	406	3,014	6	9	821	270	961	43,986	549	3,172	180,910
C-F-400-1	12	90	9,788	20,314	208,578	315	490	3,801	10	51	1,017	469	5,485	53,588	1,724	19,989	229,252
C-F-1000-1	14	10	5,185	7,508	91,138	216	333	2,269	3	3	530	181	393	29,030	238	670	128,013
C-F-1000-1	14	50	6,498	10,008	152,424	246	403	3,280	3	5	900	190	569	48,854	287	1,801	201,660
C-F-1000-1	14	90	8,559	14,412	224,224	307	480	4,128	7	16	1,104	329	1,780	58,293	1,137	7,384	250,885
C-G-100-1	10	10	4,652	6,780	77,846	27	41	1,624	1	3	432	50	312	22,639	233	1,368	100,393
C-G-100-1	10	50	6,459	9,395	128,505	51	78	2,429	6	30	744	275	3,016	39,400	1,304	13,377	162,848
C-G-100-1	10	90	12,114	16,439	191,469	148	210	3,191	30	53	928	1,266	5,121	47,761	6,169	25,399	207,515
C-RL-100-1	10	10	14,714	25,942	90,998	700	1,367	2,711	37	54	472	1,738	6,693	26,319	11,720	42,947	125,877
C-RL-100-1	10	50	25,175	46,383	154,128	950	1,662	3,807	72	172	841	3,234	18,033	47,384	18,294	86,262	204,426
C-RL-100-1	10	90	45,784	96,543	244,217	1,392	2,148	4,988	127	284	1,085	5,255	28,809	59,951	27,637	136,063	267,098
C-RL-400-1	12	10	10,010	14,783	87,810	652	1,303	2,767	19	21	492	1,087	3,640	27,472	7,993	27,691	128,954
C-RL-400-1	12	50	13,031	20,177	143,368	841	1,528	3,864	22	32	832	1,210	4,609	45,774	8,529	32,064	196,263
C-RL-400-1	12	90	20,101	35,018	213,341	1,119	1,830	4,882	41	79	1,037	1,915	9,049	55,759	11,656	50,327	246,597

Table 48--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, Low Sea Level Rise Scenario
Planning Unit 3b
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage $1000s	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages $1000s	Expected Annual Output Impacted $1000s		Equivalent Annual Output $1000s
			2010	2075		2010	2075		2010	2075		2010	2075		2010	2075	
Structural Plans																	
F-100-1	10	10	23,729	32,446	106,597	257	381	1,958	81	80	546	3,610	7,003	28,850	14,834	29,252	126,185
F-100-1	10	50	32,626	43,942	167,079	360	550	2,881	105	108	875	4,582	9,623	46,362	19,024	41,982	192,125
F-100-1	10	90	59,552	83,311	260,953	670	903	3,909	186	234	1,148	7,704	21,941	60,578	33,172	92,119	259,748
F-400-1	12	10	23,673	32,389	114,030	253	376	2,146	81	80	598	3,591	6,964	32,044	14,769	29,089	140,427
F-400-1	12	50	28,535	38,942	175,249	283	456	3,071	85	85	940	3,693	7,387	50,092	15,354	32,200	207,702
F-400-1	12	90	34,332	52,431	248,036	360	541	3,871	90	124	1,135	3,881	11,630	59,594	16,545	47,862	255,704
F-1000-1	14	10	23,673	32,389	121,073	253	376	2,327	81	80	647	3,591	6,964	35,164	14,769	29,089	154,286
F-1000-1	14	50	28,532	38,940	187,876	283	456	3,340	85	85	1,023	3,693	7,387	55,178	15,354	32,200	229,190
F-1000-1	14	90	34,216	52,315	266,811	354	534	4,201	89	123	1,236	3,846	11,557	65,550	16,371	47,455	281,612
G-100-1	10	10	14,760	19,042	93,796	51	64	1,660	57	52	514	2,782	5,160	27,425	12,074	22,282	121,107
G-100-1	10	50	17,822	22,511	146,228	75	101	2,465	59	55	816	2,868	5,464	43,276	12,586	25,254	180,092
G-100-1	10	90	24,399	29,634	210,327	172	232	3,227	83	77	1,000	3,860	7,569	51,638	17,462	37,276	224,771
RL-100-1	10	10	38,815	64,327	131,863	743	1,440	2,785	132	150	615	6,063	15,079	34,115	29,316	80,051	158,525
RL-100-1	10	50	56,492	89,916	205,265	993	1,746	3,885	169	224	974	7,548	22,275	53,885	36,880	109,664	234,019
RL-100-1	10	90	84,336	138,228	303,480	1,457	2,232	5,093	228	330	1,221	9,749	32,478	66,491	47,568	155,814	297,178
RL-400-1	12	10	36,774	61,573	134,482	695	1,377	2,842	118	133	646	5,594	13,652	35,991	26,387	71,240	164,558
RL-400-1	12	50	50,119	82,254	207,186	885	1,612	3,943	132	178	1,009	6,058	17,946	55,733	29,376	88,182	238,709
RL-400-1	12	90	69,394	120,664	299,133	1,184	1,915	4,988	162	259	1,238	7,137	25,825	67,234	34,683	122,577	296,660
Non-Structural Plans																	
NS-100	15	10	15,256	35,012	81,328	1,585	2,951	3,848	23	94	383	990	9,275	18,509	4,513	40,178	82,342
NS-100	15	50	30,208	73,449	146,308	2,424	3,843	5,662	96	592	855	4,045	56,281	48,230	17,322	257,043	204,926
NS-100	15	90	54,320	170,176	244,970	3,088	4,570	7,118	153	936	1,142	6,300	89,968	65,376	31,854	395,758	288,312
NS-400	15	10	11,373	20,007	72,320	1,585	2,951	3,848	1	8	333	47	828	14,833	193	3,400	66,098
NS-400	15	50	17,546	32,647	119,447	2,424	3,843	5,661	14	59	598	579	5,961	28,752	2,934	30,879	118,718
NS-400	15	90	29,111	60,352	182,639	3,087	4,570	7,117	44	164	781	1,707	16,177	37,363	8,168	75,387	162,483
NS-1000	15	10	10,132	17,693	70,209	1,525	2,871	3,755	0	1	329	10	115	14,571	37	426	65,003
NS-1000	15	50	15,189	24,400	114,245	2,358	3,762	5,562	2	8	568	53	718	26,537	235	3,435	107,186
NS-1000	15	90	21,243	35,681	166,161	3,019	4,489	7,016	10	45	705	397	4,072	32,142	1,978	19,533	138,231

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 49
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, High Sea Level Rise Scenario
Planning Unit 3b
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage $1000s	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages $1000s	Expected Annual Output Impacted $1000s		Equivalent Annual Output $1000s
			2010	2075		2010	2075		2010	2075		2010	2075		2010	2075	
Without Project																	
Degraded Coast PU3b-0	NA	10	75,289	209,624	242,014	1,628	3,899	4,852	464	1,052	1,347	20,497	103,074	93,550	91,491	452,552	413,046
Degraded Coast PU3b-0	NA	50	126,488	305,869	378,748	2,468	4,939	6,771	796	1,316	2,017	37,053	127,069	133,479	149,395	567,057	571,087
Degraded Coast PU3b-0	NA	90	185,226	405,511	529,135	3,153	5,801	8,345	960	1,462	2,357	42,953	139,839	150,245	183,408	636,295	665,109
Sustained Coast PU1-R	NA*	10	75,289	209,814	242,128	1,628	3,903	4,854	464	1,052	1,347	20,497	103,091	93,560	91,491	452,692	413,130
Sustained Coast PU1-R	NA*	50	126,488	306,170	378,928	2,468	4,923	6,761	796	1,315	2,017	37,053	127,056	133,472	149,395	567,029	571,070
Sustained Coast PU1-R	NA*	90	185,226	405,658	529,223	3,153	5,800	8,344	960	1,463	2,358	42,953	139,933	150,302	183,408	636,574	665,276
Comprehensive Plans																	
C-F-100-1	10	10	7,235	16,341	87,454	223	418	2,002	4	46	465	264	4,388	26,002	548	16,943	114,289
C-F-100-1	10	50	13,507	32,029	148,076	326	580	2,934	30	104	808	1,376	10,424	45,066	5,111	41,008	184,999
C-F-100-1	10	90	38,801	73,668	241,653	625	1,003	3,987	111	197	1,060	4,477	19,093	57,007	19,117	78,080	245,130
C-F-400-1	12	10	5,672	10,879	92,662	218	413	2,207	3	7	511	196	786	28,607	284	2,003	126,284
C-F-400-1	12	50	7,126	16,813	151,959	249	486	3,144	6	45	862	270	4,964	48,004	549	17,852	197,504
C-F-400-1	12	90	9,788	29,012	221,797	315	640	3,970	10	53	1,036	469	5,598	55,163	1,724	20,638	238,011
C-F-1000-1	14	10	5,185	9,486	100,048	216	410	2,403	3	7	566	181	754	32,305	238	1,826	142,754
C-F-1000-1	14	50	6,498	13,178	164,473	246	484	3,431	3	11	937	190	1,271	52,358	287	5,410	217,140
C-F-1000-1	14	90	8,559	20,118	238,555	307	630	4,320	7	51	1,137	329	5,491	61,351	1,137	19,650	265,279
C-G-100-1	10	10	4,652	8,414	83,669	27	58	1,697	1	28	461	50	2,778	25,363	233	11,602	112,545
C-G-100-1	10	50	6,459	12,186	136,352	51	100	2,515	6	33	766	275	3,274	41,473	1,304	16,316	172,682
C-G-100-1	10	90	12,114	20,138	200,540	148	233	3,288	30	53	942	1,266	5,155	48,955	6,169	25,642	214,167
C-RL-100-1	10	10	14,714	41,626	103,046	700	1,625	2,882	37	167	535	1,738	17,915	32,371	11,720	83,904	149,720
C-RL-100-1	10	50	25,175	79,754	174,261	950	2,016	4,026	72	237	889	3,234	24,510	52,027	18,294	115,025	224,666
C-RL-100-1	10	90	45,784	140,292	269,044	1,392	2,658	5,280	127	309	1,110	5,255	31,262	62,249	27,637	144,033	277,270
C-RL-400-1	12	10	10,010	18,472	96,871	652	1,561	2,949	19	27	525	1,087	4,231	30,596	7,993	29,736	142,588
C-RL-400-1	12	50	13,031	27,037	156,173	841	1,882	4,095	22	49	869	1,210	6,355	49,304	8,529	38,596	211,259
C-RL-400-1	12	90	20,101	46,857	229,243	1,119	2,340	5,184	41	82	1,058	1,915	9,359	57,619	11,656	51,464	256,203

Table 49--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, High Sea Level Rise Scenario
Planning Unit 3b
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage $1000s	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages $1000s	Expected Annual Output Impacted $1000s		Equivalent Annual Output $1000s
			2010	2075		2010	2075		2010	2075		2010	2075		2010	2075	
Structural Plans																	
F-100-1	10	10	23,729	39,765	114,540	257	468	2,059	81	85	569	3,610	7,347	30,942	14,834	31,663	136,024
F-100-1	10	50	32,626	55,147	178,225	360	631	2,991	105	142	910	4,582	13,386	49,838	19,024	55,756	206,296
F-100-1	10	90	59,552	94,984	273,205	670	1,054	4,057	186	236	1,163	7,704	22,067	61,809	33,172	92,947	266,634
F-400-1	12	10	23,673	39,708	123,234	253	464	2,264	81	84	628	3,591	7,307	34,708	14,769	31,501	152,836
F-400-1	12	50	28,535	50,147	188,024	283	538	3,201	85	119	980	3,693	11,150	54,036	15,354	45,974	224,016
F-400-1	12	90	34,332	64,104	262,176	360	692	4,041	90	126	1,154	3,881	11,757	61,173	16,545	48,690	264,518
F-1000-1	14	10	23,673	39,708	131,638	253	464	2,463	81	84	684	3,591	7,307	38,433	14,769	31,501	169,416
F-1000-1	14	50	28,532	50,144	202,414	283	538	3,492	85	119	1,069	3,693	11,150	59,631	15,354	45,974	247,819
F-1000-1	14	90	34,216	63,988	282,990	354	684	4,394	89	125	1,259	3,846	11,684	67,497	16,371	48,283	292,463
G-100-1	10	10	14,760	22,402	100,154	51	80	1,733	57	52	536	2,782	5,226	29,407	12,074	23,479	130,460
G-100-1	10	50	17,822	26,067	154,313	75	124	2,551	59	58	838	2,868	5,722	45,349	12,586	28,193	189,925
G-100-1	10	90	24,399	33,449	219,433	172	256	3,324	83	78	1,014	3,860	7,603	52,832	17,462	37,519	231,423
RL-100-1	10	10	38,815	88,363	146,498	743	1,709	2,959	132	216	664	6,063	21,945	38,819	29,316	105,264	177,493
RL-100-1	10	50	56,492	124,542	225,787	993	2,101	4,104	169	298	1,025	7,548	29,640	58,804	36,880	139,192	254,497
RL-100-1	10	90	84,336	179,042	327,398	1,457	2,742	5,385	228	372	1,252	9,749	36,420	69,250	47,568	168,503	308,812
RL-400-1	12	10	36,774	85,609	149,845	695	1,646	3,027	118	199	698	5,594	20,517	41,058	26,387	96,454	185,368
RL-400-1	12	50	50,119	116,880	228,590	885	1,968	4,174	132	252	1,064	6,058	25,312	61,004	29,376	117,710	260,826
RL-400-1	12	90	69,394	161,478	324,010	1,184	2,425	5,289	162	301	1,272	7,137	29,768	70,220	34,683	135,266	309,843
Non-Structural Plans																	
NS-100	15	10	15,256	64,186	90,364	1,585	3,819	4,117	23	499	509	990	48,325	30,603	4,513	217,027	137,114
NS-100	15	50	30,208	160,982	173,418	2,424	4,838	5,970	96	967	971	4,045	94,201	59,974	17,322	411,492	252,761
NS-100	15	90	54,320	292,126	282,740	3,088	5,715	7,473	153	1,221	1,230	6,300	116,607	73,627	31,854	512,710	324,533
NS-400	15	10	11,373	27,268	74,569	1,585	3,819	4,116	1	26	338	47	2,534	15,361	193	10,965	68,442
NS-400	15	50	17,546	50,526	124,984	2,424	4,838	5,969	14	114	615	579	11,273	30,397	2,934	54,262	125,960
NS-400	15	90	29,111	93,592	192,934	3,087	5,714	7,472	44	373	845	1,707	37,422	43,943	8,168	183,528	195,976
NS-1000	15	10	10,132	22,775	71,783	1,525	3,738	4,024	0	3	330	10	307	14,630	37	1,031	65,190
NS-1000	15	50	15,189	32,467	116,744	2,358	4,757	5,870	2	30	575	53	2,598	27,119	235	11,419	109,659
NS-1000	15	90	21,243	50,255	170,675	3,019	5,634	7,370	10	101	723	397	9,959	33,966	1,978	42,565	145,364

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 50
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, Low Sea Level Rise Scenario
Planning Unit 4
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU4-0	NA	10	95,289	116,535	216,843	1,115	1,519	2,630	326	312	690	16,543	34,768	46,387	93,449	185,471	255,462
Degraded Coast PU4-0	NA	50	123,250	154,485	282,730	1,563	2,300	3,791	373	361	792	17,922	40,344	51,863	104,156	214,835	289,611
Degraded Coast PU4-0	NA	90	159,386	212,273	373,137	2,038	2,683	4,752	425	568	996	20,065	59,437	66,646	113,242	316,757	364,892
Sustained Coast PU1-R	NA*	10	95,289	116,306	216,705	1,115	1,510	2,625	326	316	692	16,543	35,227	46,663	93,449	189,235	257,725
Sustained Coast PU1-R	NA*	50	123,250	154,321	282,631	1,563	2,298	3,790	373	359	791	17,922	40,270	51,819	104,156	214,573	289,453
Sustained Coast PU1-R	NA*	90	159,386	211,707	372,797	2,038	2,685	4,753	425	567	996	20,065	59,433	66,644	113,242	316,740	364,882
Comprehensive Plans																	
C-G-100-1	10	10	21,956	25,261	98,432	658	763	1,811	26	51	267	846	3,634	16,530	3,990	20,721	91,459
C-G-100-1	10	50	28,407	35,987	131,374	831	1,055	2,506	55	82	344	1,957	6,307	20,286	9,423	38,092	113,521
C-G-100-1	10	90	40,695	55,938	181,956	1,048	1,279	3,197	86	274	490	3,056	24,503	30,734	15,442	148,139	173,407
C-G-100-2	10	10	29,631	36,273	108,540	738	890	1,929	100	143	363	6,637	16,717	26,493	35,276	84,195	142,434
C-G-100-2	10	50	36,631	48,000	142,341	915	1,188	2,629	132	177	445	7,896	19,671	30,484	41,338	102,008	165,194
C-G-100-2	10	90	49,499	69,231	193,917	1,137	1,415	3,325	162	369	590	8,936	37,752	40,837	47,047	211,406	224,563
C-G-400-3	10	10	24,742	28,778	100,139	792	974	1,979	25	45	243	895	3,544	15,508	3,114	13,564	81,887
C-G-400-3	10	50	28,310	34,504	128,276	906	1,200	2,599	35	66	295	1,307	5,604	18,242	5,139	24,671	97,788
C-G-400-3	10	90	38,154	48,181	173,729	1,118	1,415	3,282	68	133	404	2,467	11,817	25,058	10,034	67,420	135,507
C-G-1000-3	10	10	16,416	18,735	87,017	713	878	1,855	20	31	232	596	1,653	14,564	1,803	5,434	77,793
C-G-1000-3	10	50	19,189	22,452	113,593	824	1,101	2,471	22	37	271	639	2,219	16,391	2,015	7,080	88,584
C-G-1000-3	10	90	24,163	29,046	151,844	986	1,257	3,089	28	60	337	850	4,395	20,855	3,123	19,075	112,322
C-RL-100-1	10	10	25,944	35,328	104,718	1,080	1,416	2,421	32	113	272	1,256	12,098	18,660	6,174	61,864	100,847
C-RL-100-1	10	50	37,295	54,040	143,563	1,394	2,011	3,355	64	153	351	2,465	16,048	22,685	11,932	87,356	124,853
C-RL-100-1	10	90	52,943	88,745	200,938	1,771	2,344	4,221	94	382	515	3,430	37,050	34,398	17,954	204,852	188,879
C-RL-400-1	12	10	23,038	27,753	98,626	1,017	1,355	2,294	21	35	232	629	2,322	14,633	2,056	8,740	78,271
C-RL-400-1	12	50	28,560	35,281	128,134	1,256	1,865	3,156	26	54	275	845	4,080	16,884	3,249	19,468	92,444
C-RL-400-1	12	90	38,667	51,260	173,473	1,623	2,186	4,020	60	128	396	2,013	10,837	24,398	8,161	64,934	132,233
C-RL-1000-1	14	10	20,383	24,840	94,197	937	1,277	2,145	20	30	227	566	1,581	14,149	1,713	5,124	75,898
C-RL-1000-1	14	50	25,244	30,147	122,820	1,174	1,785	3,027	20	31	260	570	1,690	15,708	1,734	5,624	85,702
C-RL-1000-1	14	90	29,844	37,072	161,187	1,492	2,049	3,849	25	55	338	751	3,932	20,891	2,608	17,814	110,913

Table 50--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, Low Sea Level Rise Scenario
Planning Unit 4
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage $1000s	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages $1000s	Expected Annual Output Impacted $1000s		Equivalent Annual Output $1000s
			2010	2075		2010	2075		2010	2075		2010	2075		2010	2075	
Structural Plans																	
G-100-1	10	10	88,285	95,136	199,823	962	1,050	2,266	262	232	607	10,804	21,373	33,997	61,536	120,707	191,617
G-100-1	10	50	104,419	112,971	246,610	1,135	1,343	2,961	298	276	697	11,786	25,581	38,073	69,752	143,046	218,563
G-100-1	10	90	123,912	138,191	307,487	1,366	1,577	3,672	355	396	851	13,794	36,505	47,362	79,269	217,423	271,607
G-100-2	10	10	98,605	109,749	214,228	1,043	1,178	2,384	342	329	712	16,943	35,066	44,566	94,706	187,885	246,004
G-100-2	10	50	115,307	128,689	261,927	1,220	1,476	3,085	381	376	806	18,072	39,555	48,878	103,551	210,667	273,648
G-100-2	10	90	135,402	155,292	323,857	1,455	1,713	3,800	437	496	959	20,021	50,365	58,071	112,758	284,395	326,176
G-400-3	10	10	99,317	110,447	215,097	1,190	1,352	2,576	342	329	712	16,940	35,055	44,560	94,702	187,850	245,986
G-400-3	10	50	114,737	127,652	261,040	1,305	1,578	3,196	373	366	796	17,788	38,789	48,336	102,979	209,079	272,539
G-400-3	10	90	135,428	155,093	323,798	1,530	1,803	3,899	436	494	958	19,961	50,469	58,063	113,406	287,521	327,965
G-1000-3	10	10	99,317	110,447	215,097	1,190	1,352	2,575	342	329	712	16,940	35,055	44,560	94,702	187,850	245,986
G-1000-3	10	50	114,672	127,567	260,952	1,303	1,575	3,193	373	366	795	17,786	38,783	48,332	102,967	209,036	272,512
G-1000-3	10	90	132,092	150,879	319,347	1,479	1,744	3,832	419	470	935	19,432	48,712	56,922	111,432	280,454	323,499
RL-100-1	10	10	98,275	118,362	217,402	1,389	1,708	2,883	346	342	720	17,047	36,246	45,125	95,166	193,323	248,562
RL-100-1	10	50	124,104	148,985	277,344	1,704	2,304	3,817	396	382	821	18,578	40,015	49,482	105,970	215,702	277,669
RL-100-1	10	90	152,449	190,645	352,140	2,094	2,647	4,704	439	547	982	20,068	54,961	59,951	113,892	303,696	334,843
RL-400-1	12	10	97,605	117,601	216,109	1,384	1,702	2,843	344	340	716	17,004	36,114	44,787	94,916	192,531	246,844
RL-400-1	12	50	121,391	145,818	273,984	1,623	2,213	3,705	386	369	806	18,210	38,902	48,547	105,078	213,010	274,820
RL-1000-1	14	50	121,326	145,732	274,142	1,621	2,210	3,696	386	369	805	18,208	38,896	48,438	105,065	212,967	274,159
RL-1000-1	14	90	147,901	185,176	349,003	1,953	2,486	4,539	421	521	958	19,472	53,311	58,694	112,338	299,240	330,007
Non-Structural Plans																	
NS-100	15	10	22,410	32,425	102,734	805	1,218	2,072	12	87	272	701	11,079	15,940	4,379	57,769	89,028
NS-100	15	50	34,690	55,001	143,334	1,254	2,005	3,138	41	122	349	1,807	14,582	19,245	10,112	83,350	110,976
NS-100	15	90	54,199	103,818	205,972	1,714	2,381	4,106	71	402	505	2,808	41,522	30,232	16,250	217,896	165,979
NS-400	15	10	19,821	24,423	97,349	748	1,163	1,990	1	7	234	79	938	12,101	427	4,535	68,101
NS-400	15	50	26,302	33,919	127,382	1,196	1,950	3,056	7	29	282	339	3,014	14,013	1,725	16,189	80,755
NS-400	15	90	35,588	51,353	168,818	1,656	2,326	4,024	33	101	369	1,222	9,950	18,672	5,354	60,236	104,912
NS-1000	15	10	17,164	21,485	93,454	668	1,085	1,876	0	1	232	16	184	11,797	84	894	66,587
NS-1000	15	50	22,817	27,897	121,602	1,116	1,872	2,942	0	3	266	22	319	12,822	115	1,485	74,393
NS-1000	15	90	28,441	37,199	156,407	1,576	2,248	3,911	8	36	321	269	3,240	15,523	1,196	15,751	86,463

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 51
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, High Sea Level Rise Scenario
Planning Unit 4
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU4-0	NA	10	95,289	151,991	238,163	1,115	2,134	3,000	326	360	719	16,543	39,397	49,170	93,449	216,048	273,849
Degraded Coast PU4-0	NA	50	123,250	212,719	317,747	1,563	2,723	4,046	373	584	926	17,922	62,920	65,439	104,156	357,397	375,335
Degraded Coast PU4-0	NA	90	159,386	285,052	416,901	2,038	3,559	5,278	425	707	1,080	20,065	74,509	75,709	113,242	483,060	464,893
Sustained Coast PU1-R	NA*	10	95,289	151,883	238,098	1,115	2,139	3,003	326	378	729	16,543	41,652	50,526	93,449	233,385	284,274
Sustained Coast PU1-R	NA*	50	123,250	212,322	317,508	1,563	2,712	4,039	373	584	926	17,922	62,920	65,439	104,156	357,397	375,335
Sustained Coast PU1-R	NA*	90	159,386	284,214	416,397	2,038	3,559	5,279	425	707	1,080	20,065	74,515	75,713	113,242	483,088	464,909
Comprehensive Plans																	
C-G-100-1	10	10	21,956	30,311	104,218	658	974	1,943	26	61	279	846	4,516	17,750	3,990	33,969	101,823
C-G-100-1	10	50	28,407	48,243	141,612	831	1,165	2,584	55	254	427	1,957	23,677	28,711	9,423	161,166	172,918
C-G-100-1	10	90	40,695	82,669	198,331	1,048	1,456	3,335	86	335	529	3,056	31,497	35,133	15,442	277,027	240,285
C-G-100-2	10	10	29,631	45,070	115,849	738	1,109	2,065	100	156	377	6,637	17,943	27,851	35,276	98,102	153,062
C-G-100-2	10	50	36,631	64,459	154,277	915	1,300	2,708	132	350	527	7,896	37,043	38,910	41,338	225,145	224,616
C-G-100-2	10	90	49,499	99,962	211,904	1,137	1,595	3,465	162	430	628	8,936	44,749	45,237	47,047	340,357	291,467
C-G-400-3	10	10	24,742	32,878	105,993	792	1,193	2,115	25	79	263	895	8,747	18,098	3,114	35,425	94,977
C-G-400-3	10	50	28,310	40,398	136,940	906	1,313	2,678	35	116	340	1,307	12,951	23,563	5,139	70,862	133,379
C-G-400-3	10	90	38,154	57,607	185,117	1,118	1,595	3,422	68	162	433	2,467	16,425	28,719	10,034	83,572	167,475
C-G-1000-3	10	10	16,416	20,891	92,269	713	1,092	1,989	20	39	244	596	2,660	15,854	1,803	9,313	85,314
C-G-1000-3	10	50	19,189	25,078	121,245	824	1,209	2,549	22	48	304	639	3,417	19,807	2,015	13,222	111,772
C-G-1000-3	10	90	24,163	34,631	162,043	986	1,435	3,228	28	77	362	850	6,035	23,596	3,123	26,869	141,702
C-RL-100-1	10	10	25,944	50,700	115,056	1,080	1,877	2,654	32	136	288	1,256	14,417	20,279	6,174	84,201	113,981
C-RL-100-1	10	50	37,295	87,694	162,534	1,394	2,329	3,516	64	366	450	2,465	36,912	32,620	11,932	219,972	188,632
C-RL-100-1	10	90	52,943	146,701	229,699	1,771	2,838	4,486	94	451	557	3,430	44,511	39,021	17,954	335,170	256,440
C-RL-400-1	12	10	23,038	32,706	105,535	1,017	1,815	2,526	21	44	242	629	3,209	15,722	2,056	16,060	86,084
C-RL-400-1	12	50	28,560	43,065	138,975	1,256	2,181	3,315	26	89	319	845	7,940	21,451	3,249	53,883	124,898
C-RL-400-1	12	90	38,667	68,383	189,392	1,623	2,679	4,289	60	145	421	2,013	11,989	27,002	8,161	68,850	159,332
C-RL-1000-1	14	10	20,383	28,979	100,768	937	1,737	2,377	20	34	236	566	2,246	15,101	1,713	8,357	81,912
C-RL-1000-1	14	50	25,244	34,603	132,690	1,174	2,100	3,187	20	44	296	570	3,037	19,468	1,734	12,305	109,128
C-RL-1000-1	14	90	29,844	46,465	174,747	1,492	2,541	4,124	25	81	366	751	6,188	23,819	2,608	27,472	139,047

Table 51--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
High Employment, Dispersed Land Use, High Sea Level Rise Scenario
Planning Unit 4
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage $1000s	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages $1000s	Expected Annual Output Impacted $1000s		Equivalent Annual Output $1000s
			2010	2075		2010	2075		2010	2075		2010	2075		2010	2075	
Structural Plans																	
G-100-1	10	10	88,285	111,845	209,221	962	1,277	2,403	262	289	633	10,804	27,927	36,974	61,536	164,024	211,293
G-100-1	10	50	104,419	134,967	259,864	1,135	1,472	3,045	298	409	767	11,786	40,155	45,632	69,752	257,713	275,356
G-100-1	10	90	123,912	166,191	324,255	1,366	1,763	3,813	355	497	902	13,794	48,443	53,292	79,269	374,766	347,298
G-100-2	10	10	98,605	130,454	225,225	1,043	1,413	2,525	342	390	740	16,943	41,964	47,682	94,706	231,862	265,944
G-100-2	10	50	115,307	155,072	276,938	1,220	1,608	3,170	381	510	876	18,072	54,131	56,438	103,551	325,397	330,467
G-100-2	10	90	135,402	187,404	342,271	1,455	1,902	3,943	437	597	1,010	20,021	62,305	64,002	112,758	441,801	401,892
G-400-3	10	10	99,317	131,152	226,094	1,190	1,586	2,716	342	390	740	16,940	41,953	47,675	94,702	231,826	265,926
G-400-3	10	50	114,737	154,036	276,050	1,305	1,709	3,281	373	499	866	17,788	53,366	55,896	102,979	323,809	329,358
G-400-3	10	90	135,428	187,205	342,213	1,530	1,992	4,041	436	595	1,009	19,961	62,409	63,994	113,406	444,926	403,681
G-1000-3	10	10	99,317	131,152	226,094	1,190	1,586	2,716	342	390	740	16,940	41,953	47,675	94,702	231,826	265,926
G-1000-3	10	50	114,672	153,950	275,962	1,303	1,707	3,278	373	499	866	17,786	53,359	55,892	102,967	323,766	329,330
G-1000-3	10	90	132,092	182,991	337,761	1,479	1,933	3,975	419	571	986	19,432	60,652	62,853	111,432	437,860	399,215
RL-100-1	10	10	98,275	150,027	232,787	1,389	2,185	3,121	346	396	745	17,047	42,289	47,898	95,166	236,144	268,040
RL-100-1	10	50	124,104	194,229	299,905	1,704	2,642	3,985	396	565	911	18,578	59,308	58,929	105,970	346,118	340,767
RL-100-1	10	90	152,449	248,610	380,904	2,094	3,151	4,972	439	658	1,037	20,068	67,773	66,231	113,892	463,699	411,599
RL-400-1	12	10	97,605	149,260	231,289	1,384	2,178	3,079	344	394	740	17,004	42,157	47,472	94,916	235,352	265,652
RL-400-1	12	50	121,391	191,046	296,422	1,623	2,550	3,871	386	552	896	18,210	58,195	57,894	105,078	343,427	337,006
RL-1000-1	14	50	121,326	190,960	296,640	1,621	2,547	3,862	386	552	894	18,208	58,188	57,755	105,065	343,384	335,908
RL-1000-1	14	90	147,901	243,065	377,582	1,953	2,988	4,817	421	632	1,013	19,472	66,123	64,891	112,338	459,243	404,705
Non-Structural Plans																	
NS-100	15	10	22,410	50,032	108,187	805	1,831	2,262	12	113	280	701	13,618	16,727	4,379	80,903	96,193
NS-100	15	50	34,690	99,724	157,185	1,254	2,399	3,260	41	381	429	1,807	40,387	27,237	10,112	230,792	156,641
NS-100	15	90	54,199	177,572	228,815	1,714	3,246	4,374	71	500	535	2,808	51,253	33,246	16,250	354,558	208,306
NS-400	15	10	19,821	30,173	99,129	748	1,776	2,180	1	17	237	79	1,984	12,425	427	12,199	70,474
NS-400	15	50	26,302	44,745	130,735	1,196	2,344	3,178	7	71	295	339	7,661	15,452	1,725	53,275	92,241
NS-400	15	90	35,588	73,743	175,753	1,656	3,191	4,292	33	123	376	1,222	11,529	19,161	5,354	65,998	106,696
NS-1000	15	10	17,164	26,195	94,913	668	1,698	2,066	0	6	233	16	870	12,009	84	4,186	67,607
NS-1000	15	50	22,817	33,704	123,401	1,116	2,265	3,063	0	18	271	22	1,886	13,308	115	9,064	76,740
NS-1000	15	90	28,441	49,158	160,111	1,576	3,113	4,178	8	67	331	269	5,900	16,347	1,196	26,793	89,883

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 52
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, Low Sea Level Rise Scenario
Planning Unit 3a
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU3a-0	NA	10	180,802	330,513	477,224	4,299	6,904	10,774	777	1,765	2,259	34,234	179,576	160,711	185,715	927,221	843,601
Degraded Coast PU3a-0	NA	50	276,742	493,603	723,064	6,098	9,189	14,918	1,384	2,790	3,809	60,891	270,600	256,504	315,719	1,305,334	1,271,205
Degraded Coast PU3a-0	NA	90	376,456	643,209	966,609	7,246	10,104	17,236	1,854	3,844	5,167	78,911	364,993	341,019	389,722	1,719,645	1,634,320
Sustained Coast PU1-R	NA*	10	180,802	329,211	476,441	4,299	6,894	10,768	777	1,764	2,258	34,234	179,480	160,653	185,715	925,626	842,641
Sustained Coast PU1-R	NA*	50	276,742	491,513	721,807	6,098	9,255	14,958	1,384	2,790	3,809	60,891	270,694	256,560	315,719	1,305,928	1,271,562
Sustained Coast PU1-R	NA*	90	376,456	643,314	966,672	7,246	10,168	17,274	1,854	3,837	5,163	78,911	364,301	340,603	389,722	1,717,019	1,632,741
Comprehensive Plans																	
C-M-100-1	10	10	13,207	19,090	187,700	918	895	5,238	64	275	937	2,865	32,401	57,626	16,215	180,403	310,309
C-M-100-1	10	50	20,691	25,808	288,818	1,006	996	7,030	261	353	1,711	13,678	41,204	98,844	77,301	214,419	510,524
C-M-100-1	10	90	40,158	50,549	408,904	1,257	1,269	8,377	359	437	2,290	17,915	48,938	127,074	96,188	248,727	632,476
C-M-100-2	10	10	12,929	33,676	192,697	798	1,372	5,330	49	336	948	2,519	42,954	61,528	18,118	231,218	331,629
C-M-100-2	10	50	32,631	69,066	315,265	1,202	1,755	7,496	277	475	1,773	14,945	57,256	106,288	85,476	299,188	550,643
C-M-100-2	10	90	73,790	124,930	465,556	1,695	2,260	9,137	467	616	2,449	23,887	70,354	140,520	124,643	373,702	704,455
C-G-400-2	10	10	15,688	29,257	193,173	783	1,356	5,275	55	106	874	2,253	11,149	51,165	16,073	75,864	280,148
C-G-400-2	10	50	26,216	55,737	302,859	1,100	1,652	7,334	68	153	1,418	3,015	15,652	78,992	19,968	108,490	412,424
C-G-400-2	10	90	41,723	80,602	417,980	1,372	1,935	8,700	112	193	1,917	5,141	19,852	102,818	32,594	130,725	520,453
C-G-1000-2	10	10	9,983	20,639	185,077	614	1,175	5,049	21	59	828	885	6,580	48,298	9,483	48,132	264,548
C-G-1000-2	10	50	19,023	39,828	290,714	930	1,470	7,106	32	80	1,361	1,550	8,358	75,165	12,811	62,708	390,552
C-G-1000-2	10	90	31,205	58,806	400,058	1,189	1,741	8,455	64	111	1,843	3,104	11,366	97,940	20,912	83,176	492,614
Structural Plans																	
M-100-1	10	10	40,676	51,942	230,901	925	903	5,249	111	350	1,017	4,970	40,463	62,654	27,872	212,661	334,317
M-100-1	10	50	49,418	59,047	333,652	1,013	1,004	7,041	308	377	1,776	15,689	43,284	101,906	88,593	227,511	528,156
M-100-1	10	90	70,507	82,317	455,234	1,264	1,276	8,388	436	466	2,392	21,753	51,344	132,433	110,108	262,162	653,374
M-100-2	10	10	43,022	70,598	240,314	805	1,379	5,341	100	415	1,034	4,856	51,574	67,007	34,253	275,310	364,685
M-100-2	10	50	64,474	106,684	365,202	1,209	1,763	7,507	329	503	1,844	17,192	59,967	109,830	101,256	324,254	577,380
M-100-2	10	90	107,889	161,088	517,753	1,702	2,268	9,148	548	646	2,556	27,959	72,873	146,196	143,041	387,528	730,858
G-400-2	10	10	48,339	76,267	246,991	923	1,506	5,489	134	452	1,077	6,214	55,049	69,524	40,746	292,056	376,771

Table 52--Continued

Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, Low Sea Level Rise Scenario
Planning Unit 3a
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
G-400-2	10	50	66,562	109,052	367,880	1,240	1,803	7,549	341	518	1,860	17,707	61,349	110,810	104,077	331,533	582,632
G-400-2	10	90	91,058	143,679	496,833	1,517	2,090	8,923	456	547	2,441	24,450	63,685	139,609	127,483	344,657	700,801
G-1000-2	10	10	43,166	70,747	240,493	803	1,378	5,339	100	415	1,034	4,851	51,563	66,999	34,226	275,248	364,638
G-1000-2	10	50	61,387	103,532	361,382	1,121	1,675	7,399	308	481	1,817	16,345	57,864	108,286	97,556	314,726	570,499
G-1000-2	10	90	85,733	138,022	490,154	1,393	1,959	8,768	422	509	2,397	23,047	60,108	137,014	120,828	327,526	688,426
Non-Structural Plans																	
NS-100	15	10	31,874	81,069	189,025	4,193	6,780	9,856	85	662	852	3,584	66,546	48,893	19,228	336,027	257,265
NS-100	15	50	60,076	159,446	312,959	5,991	9,141	13,882	303	2,158	1,989	12,291	207,968	121,363	57,149	977,224	590,567
NS-100	15	90	99,813	313,221	475,876	7,139	10,054	16,267	480	3,466	2,926	18,522	330,368	179,039	83,621	1,528,436	843,457
NS-400	15	10	16,144	30,770	155,777	3,123	5,635	8,300	20	99	604	895	10,334	28,463	5,331	53,192	154,057
NS-400	15	50	26,194	53,763	242,169	4,922	7,969	12,317	59	354	1,157	2,461	33,219	56,199	12,197	161,545	287,446
NS-400	15	90	42,106	109,022	347,812	6,069	8,882	14,702	135	983	1,770	5,639	98,114	92,636	28,029	501,253	462,880
NS-1000	15	10	11,976	22,954	148,674	2,530	4,778	7,368	3	16	560	148	1,624	24,927	635	8,490	134,937
NS-1000	15	50	20,412	35,043	229,877	4,276	7,110	11,326	9	59	1,009	368	5,487	45,259	2,061	27,877	234,663
NS-1000	15	90	30,053	54,026	317,241	5,397	8,011	13,678	45	192	1,424	1,608	17,396	63,109	8,282	100,502	316,580

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 53
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, High Sea Level Rise Scenario
Planning Unit 3a
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU3a-0	NA	10	180,802	484,804	570,001	4,299	9,216	12,164	777	2,756	2,854	34,234	280,336	221,299	185,715	1,421,011	1,140,524
Degraded Coast PU3a-0	NA	50	276,742	713,448	855,260	6,098	11,142	16,092	1,384	4,298	4,715	60,891	418,328	345,335	315,719	1,991,273	1,683,671
Degraded Coast PU3a-0	NA	90	376,456	890,801	1,115,490	7,246	11,660	18,171	1,854	4,876	5,787	78,911	471,417	405,013	389,722	2,232,899	1,942,948
Sustained Coast PU1-R	NA*	10	180,802	482,811	568,803	4,299	9,227	12,171	777	2,753	2,853	34,234	280,241	221,242	185,715	1,419,952	1,139,887
Sustained Coast PU1-R	NA*	50	276,742	712,955	854,964	6,098	11,225	16,142	1,384	4,298	4,716	60,891	418,310	345,324	315,719	1,991,246	1,683,654
Sustained Coast PU1-R	NA*	90	376,456	893,438	1,117,076	7,246	11,719	18,207	1,854	4,878	5,789	78,911	471,840	405,268	389,722	2,233,976	1,943,595
Comprehensive Plans																	
C-M-100-1	10	10	13,207	25,377	202,133	918	912	5,422	64	497	1,097	2,865	59,581	75,661	16,215	319,573	401,999
C-M-100-1	10	50	20,691	34,671	309,155	1,006	1,015	7,187	261	516	1,892	13,678	61,475	118,274	77,301	329,766	609,130
C-M-100-1	10	90	40,158	61,462	432,013	1,257	1,269	8,496	359	619	2,442	17,915	71,438	144,223	96,188	374,317	722,032
C-M-100-2	10	10	12,929	68,178	218,480	798	1,821	5,687	49	654	1,147	2,519	82,703	84,636	18,118	427,123	447,132
C-M-100-2	10	50	32,631	112,897	349,634	1,202	2,084	7,777	277	706	1,981	14,945	87,576	129,718	85,476	463,589	668,746
C-M-100-2	10	90	73,790	168,562	501,673	1,695	2,421	9,320	467	861	2,626	23,887	102,454	161,549	124,643	536,775	809,968
C-G-400-2	10	10	15,688	54,966	216,232	783	1,806	5,632	55	162	992	2,253	16,973	63,766	16,073	114,911	347,070
C-G-400-2	10	50	26,216	88,532	333,810	1,100	1,982	7,615	68	243	1,583	3,015	28,483	97,005	19,968	160,073	495,586
C-G-400-2	10	90	41,723	111,621	450,191	1,372	2,096	8,884	112	292	2,049	5,141	33,791	118,222	32,594	185,347	592,377
C-G-1000-2	10	10	9,983	38,626	205,744	614	1,625	5,405	21	94	939	885	10,208	60,219	9,483	71,860	326,725
C-G-1000-2	10	50	19,023	65,266	319,387	930	1,800	7,387	32	123	1,511	1,550	13,064	90,662	12,811	94,286	467,518
C-G-1000-2	10	90	31,205	84,438	430,601	1,189	1,902	8,638	64	187	1,968	3,104	20,520	111,863	20,912	137,859	564,556
Structural Plans																	
M-100-1	10	10	40,676	59,660	245,777	925	920	5,433	111	521	1,161	4,970	61,652	78,833	27,872	332,590	420,048
M-100-1	10	50	49,418	67,853	353,972	1,013	1,023	7,198	308	545	1,958	15,689	63,882	121,437	88,593	343,201	626,868
M-100-1	10	90	70,507	91,312	477,749	1,264	1,277	8,507	436	649	2,544	21,753	73,967	149,619	110,108	388,546	743,176
M-100-2	10	10	43,022	107,136	266,728	805	1,829	5,698	100	685	1,218	4,856	85,786	88,400	34,253	464,128	477,993
M-100-2	10	50	64,474	150,832	399,669	1,209	2,092	7,788	329	737	2,053	17,192	90,362	133,283	101,256	487,452	695,110
M-100-2	10	90	107,889	201,815	552,971	1,702	2,429	9,331	548	895	2,735	27,959	105,511	167,391	143,041	561,898	839,869
G-400-2	10	10	48,339	112,805	273,404	923	1,955	5,846	134	722	1,260	6,214	89,260	90,916	40,746	480,873	490,079

Table 53--Continued

Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, High Sea Level Rise Scenario
Planning Unit 3a
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
G-400-2	10	50	66,562	153,200	402,348	1,240	2,132	7,830	341	752	2,069	17,707	91,744	134,263	104,077	494,731	700,362
G-400-2	10	90	91,058	184,407	532,051	1,517	2,251	9,106	456	796	2,619	24,450	96,323	160,804	127,483	519,027	809,812
G-1000-2	10	10	43,166	107,285	266,907	803	1,827	5,696	100	685	1,218	4,851	85,775	88,392	34,226	464,066	477,946
G-1000-2	10	50	61,387	147,679	395,849	1,121	2,004	7,680	308	715	2,026	16,345	88,259	131,739	97,556	477,923	688,229
G-1000-2	10	90	85,733	178,750	525,372	1,393	2,120	8,951	422	758	2,575	23,047	92,745	158,209	120,828	501,895	797,437
Non-Structural Plans																	
NS-100	15	10	31,874	156,047	212,247	4,193	9,113	10,579	85	1,528	1,120	3,584	158,568	77,394	19,228	793,250	398,873
NS-100	15	50	60,076	367,471	377,387	5,991	11,111	14,492	303	3,563	2,424	12,291	342,055	162,892	57,149	1,573,755	775,321
NS-100	15	90	99,813	604,831	566,192	7,139	11,605	16,747	480	4,290	3,181	18,522	407,001	202,774	83,621	1,864,559	947,559
NS-400	15	10	16,144	47,312	160,900	3,123	7,941	9,014	20	186	631	895	19,245	31,223	5,331	108,489	171,184
NS-400	15	50	26,194	112,704	260,424	4,922	9,939	12,927	59	957	1,343	2,461	95,866	75,602	12,197	489,786	389,107
NS-400	15	90	42,106	212,681	379,917	6,069	10,432	15,183	135	1,707	1,995	5,639	171,637	115,407	28,029	802,731	556,251
NS-1000	15	10	11,976	31,800	151,414	2,530	7,065	8,076	3	79	579	148	7,922	26,878	635	40,890	144,972
NS-1000	15	50	20,412	55,596	236,242	4,276	9,063	11,931	9	264	1,073	368	25,668	51,509	2,061	147,258	271,636
NS-1000	15	90	30,053	91,838	328,952	5,397	9,557	14,157	45	1,030	1,683	1,608	102,067	89,333	8,282	533,828	450,787

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 54
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, Low Sea Level Rise Scenario
Planning Unit 3b
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage $1000s	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages $1000s	Expected Annual Output Impacted $1000s		Equivalent Annual Output $1000s
			2010	2075		2010	2075		2010	2075		2010	2075		2010	2075	
Without Project																	
Degraded Coast PU3b-0	NA	10	75,126	142,294	201,276	1,532	2,819	4,055	434	848	1,178	19,182	85,856	81,172	86,675	377,284	360,369
Degraded Coast PU3b-0	NA	50	125,537	215,090	322,696	2,363	3,698	5,863	747	1,123	1,826	34,947	109,071	119,413	141,673	509,639	524,667
Degraded Coast PU3b-0	NA	90	182,822	296,753	460,035	3,035	4,394	7,317	900	1,366	2,207	40,561	131,697	141,665	175,335	623,443	644,946
Sustained Coast PU1-R	NA*	10	75,126	142,456	201,374	1,532	2,813	4,051	434	849	1,179	19,182	85,914	81,207	86,675	377,715	360,628
Sustained Coast PU1-R	NA*	50	125,537	215,391	322,877	2,363	3,696	5,862	747	1,119	1,823	34,947	108,664	119,168	141,673	508,217	523,811
Sustained Coast PU1-R	NA*	90	182,822	296,639	459,966	3,035	4,393	7,316	900	1,366	2,207	40,561	131,613	141,615	175,335	623,260	644,836
Comprehensive Plans																	
C-F-100-1	10	10	7,147	10,870	79,718	195	316	1,775	4	8	414	255	837	22,584	488	2,588	100,395
C-F-100-1	10	50	13,099	20,881	135,488	292	453	2,672	25	75	739	1,224	7,102	40,598	4,673	30,496	170,129
C-F-100-1	10	90	36,558	56,256	222,562	581	808	3,666	83	167	970	3,488	15,476	52,242	16,704	74,240	234,410
C-F-400-1	12	10	5,580	8,203	84,491	192	311	1,953	2	3	464	190	351	25,656	236	574	114,326
C-F-400-1	12	50	6,971	10,762	139,431	221	363	2,857	3	7	785	201	698	42,822	313	2,617	179,643
C-F-400-1	12	90	9,297	16,192	203,586	279	449	3,624	8	21	960	400	2,118	50,966	1,528	11,293	226,383
C-F-1000-1	14	10	5,161	7,427	90,754	190	309	2,119	2	3	512	190	341	28,869	233	469	128,741
C-F-1000-1	14	50	6,453	9,673	150,982	219	360	3,112	3	5	866	198	586	47,882	282	2,045	201,599
C-F-1000-1	14	90	8,277	13,064	220,125	272	440	3,939	6	15	1,057	324	1,558	56,793	1,142	7,737	252,367
C-G-100-1	10	10	4,667	6,855	77,648	27	38	1,526	1	4	415	47	371	22,336	219	1,625	100,167
C-G-100-1	10	50	6,529	9,473	127,561	51	72	2,322	5	36	713	262	3,601	38,549	1,246	16,085	162,115
C-G-100-1	10	90	12,331	16,485	188,973	146	197	3,066	27	61	887	1,152	5,932	46,641	5,842	30,464	208,511
C-RL-100-1	10	10	14,148	24,431	89,649	599	1,259	2,487	35	54	455	1,733	6,659	26,038	11,789	45,369	126,785
C-RL-100-1	10	50	24,022	43,178	150,767	837	1,549	3,563	64	167	802	3,006	17,452	45,999	17,915	91,159	204,691
C-RL-100-1	10	90	43,326	87,908	235,846	1,258	2,010	4,704	103	255	1,014	4,441	25,110	56,577	25,848	137,944	266,153
C-RL-400-1	12	10	9,870	14,507	87,297	548	1,189	2,537	20	21	478	1,182	3,823	27,441	8,733	29,961	130,810
C-RL-400-1	12	50	12,760	19,250	141,732	726	1,408	3,613	23	33	801	1,288	4,826	44,925	9,187	34,760	197,059
C-RL-400-1	12	90	19,039	31,666	208,453	982	1,684	4,591	37	68	990	1,839	7,880	53,970	11,803	51,386	247,903

Table 54--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, Low Sea Level Rise Scenario
Planning Unit 3b
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage $1000s	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages $1000s	Expected Annual Output Impacted $1000s		Equivalent Annual Output $1000s
			2010	2075		2010	2075		2010	2075		2010	2075		2010	2075	
Structural Plans																	
F-100-1	10	10	23,629	32,117	106,114	230	356	1,829	75	85	523	3,354	7,458	28,360	13,734	31,532	125,285
F-100-1	10	50	32,156	43,094	165,281	327	501	2,729	94	118	835	4,191	10,433	45,196	17,532	46,882	190,665
F-100-1	10	90	57,170	77,610	253,958	625	856	3,734	153	210	1,067	6,471	18,813	56,862	29,672	90,684	255,096
F-400-1	12	10	23,570	32,057	113,509	227	352	2,008	74	84	575	3,333	7,414	31,622	13,663	31,354	140,003
F-400-1	12	50	28,252	38,088	173,480	256	412	2,914	76	94	899	3,366	8,115	48,925	13,986	35,940	206,403
F-400-1	12	90	33,541	47,320	242,377	323	498	3,692	81	105	1,074	3,549	9,217	56,951	15,185	43,344	252,731
F-1000-1	14	10	23,570	32,057	120,516	227	352	2,178	74	84	624	3,333	7,414	34,838	13,663	31,354	154,455
F-1000-1	14	50	28,249	38,085	185,988	256	412	3,172	76	94	981	3,366	8,115	54,023	13,986	35,940	228,573
F-1000-1	14	90	33,420	47,198	260,928	318	491	4,011	80	104	1,173	3,512	9,136	62,973	15,008	42,894	279,927
G-100-1	10	10	14,709	19,150	93,530	51	59	1,562	54	61	496	2,620	6,059	27,192	11,371	26,141	121,168
G-100-1	10	50	17,817	22,682	145,224	75	92	2,357	56	65	782	2,704	6,429	42,362	11,871	29,841	179,151
G-100-1	10	90	24,523	29,786	207,752	170	218	3,101	78	90	957	3,595	8,760	50,454	16,477	44,220	225,559
RL-100-1	10	10	38,403	63,366	130,870	643	1,340	2,565	120	152	587	5,593	15,315	33,361	27,653	83,959	157,810
RL-100-1	10	50	55,677	87,521	202,562	882	1,637	3,644	151	224	925	6,879	22,098	52,095	34,753	116,229	232,700
RL-100-1	10	90	82,423	130,303	295,984	1,325	2,098	4,811	195	308	1,141	8,463	29,291	62,708	43,793	160,119	294,597
RL-400-1	12	10	36,518	60,620	133,619	592	1,270	2,616	108	133	618	5,171	13,657	35,283	25,237	74,158	164,342
RL-400-1	12	50	49,276	79,389	204,263	771	1,496	3,695	119	172	960	5,560	17,177	53,888	27,887	90,685	236,864
RL-400-1	12	90	66,786	110,655	290,325	1,048	1,772	4,698	139	229	1,163	6,273	21,960	63,663	32,032	120,524	293,639
Non-Structural Plans																	
NS-100	15	10	14,783	33,465	80,202	1,488	2,733	3,603	19	95	358	838	9,273	17,406	4,149	44,577	79,884
NS-100	15	50	28,842	70,165	143,082	2,318	3,608	5,396	80	625	812	3,414	58,543	46,730	15,701	289,310	207,627
NS-100	15	90	51,349	160,806	237,028	2,969	4,305	6,818	127	975	1,082	5,349	92,529	63,406	29,630	447,428	296,097
NS-400	15	10	11,222	19,782	71,964	1,487	2,732	3,602	1	7	311	39	721	13,860	161	3,295	62,618
NS-400	15	50	17,294	31,821	118,235	2,318	3,607	5,395	11	60	560	464	6,046	27,157	2,550	34,460	113,924
NS-400	15	90	28,132	57,104	178,831	2,968	4,304	6,818	35	164	727	1,355	15,933	35,197	6,959	83,266	157,845
NS-1000	15	10	9,975	17,493	69,855	1,432	2,664	3,519	0	1	308	8	118	13,638	30	444	61,588
NS-1000	15	50	14,994	24,134	113,271	2,262	3,539	5,311	1	9	534	49	805	25,068	219	4,022	101,879
NS-1000	15	90	20,990	35,100	163,993	2,910	4,236	6,732	9	47	662	340	4,196	30,423	1,798	22,455	133,214

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 55
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, High Sea Level Rise Scenario
Planning Unit 3b
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU3b-0	NA	10	75,126	205,601	239,344	1,532	3,677	4,571	434	1,105	1,332	19,182	107,195	94,003	86,675	495,353	431,365
Degraded Coast PU3b-0	NA	50	125,537	298,552	372,883	2,363	4,665	6,445	747	1,408	1,997	34,947	134,973	134,989	141,673	642,664	604,656
Degraded Coast PU3b-0	NA	90	182,822	389,376	515,730	3,035	5,529	8,000	900	1,584	2,338	40,561	150,125	152,746	175,335	724,867	705,934
Sustained Coast PU1-R	NA*	10	75,126	205,823	239,477	1,532	3,683	4,574	434	1,105	1,332	19,182	107,175	93,991	86,675	495,295	431,331
Sustained Coast PU1-R	NA*	50	125,537	298,838	373,055	2,363	4,656	6,440	747	1,408	1,997	34,947	134,957	134,979	141,673	642,630	604,636
Sustained Coast PU1-R	NA*	90	182,822	389,683	515,915	3,035	5,527	7,998	900	1,585	2,339	40,561	150,242	152,816	175,335	725,258	706,169
Comprehensive Plans																	
C-F-100-1	10	10	7,147	15,446	86,597	195	376	1,866	4	50	447	255	4,673	25,455	488	18,458	114,657
C-F-100-1	10	50	13,099	29,050	145,175	292	533	2,779	25	81	763	1,224	7,797	42,860	4,673	35,744	182,421
C-F-100-1	10	90	36,558	65,749	233,415	581	928	3,801	83	177	991	3,488	16,486	54,059	16,704	77,265	243,402
C-F-400-1	12	10	5,580	10,230	91,803	192	372	2,061	2	4	490	190	480	27,847	236	1,073	126,402
C-F-400-1	12	50	6,971	14,345	149,324	221	444	2,983	3	16	816	201	1,717	45,751	313	9,196	195,200
C-F-400-1	12	90	9,297	22,878	215,385	279	569	3,781	8	32	985	400	3,171	53,182	1,528	14,523	237,641
C-F-1000-1	14	10	5,161	9,184	99,298	190	369	2,246	2	4	545	190	444	31,547	233	869	143,517
C-F-1000-1	14	50	6,453	12,236	162,310	219	441	3,258	3	9	903	198	1,166	51,274	282	5,806	219,315
C-F-1000-1	14	90	8,277	17,578	233,203	272	560	4,119	6	30	1,088	324	3,050	59,556	1,142	13,379	266,709
C-G-100-1	10	10	4,667	8,526	83,321	27	52	1,597	1	33	444	47	3,311	24,884	219	13,825	113,096
C-G-100-1	10	50	6,529	12,255	135,124	51	92	2,404	5	40	736	262	3,960	40,672	1,246	20,263	173,950
C-G-100-1	10	90	12,331	20,173	197,542	146	221	3,162	27	62	904	1,152	5,986	48,071	5,842	30,832	216,406
C-RL-100-1	10	10	14,148	37,658	100,566	599	1,517	2,657	35	137	504	1,733	14,432	30,405	11,789	77,718	147,400
C-RL-100-1	10	50	24,022	71,122	168,448	837	1,874	3,767	64	207	841	3,006	20,868	49,411	17,915	113,920	224,064
C-RL-100-1	10	90	43,326	123,311	256,830	1,258	2,485	4,981	103	283	1,044	4,441	27,751	59,153	25,848	146,422	277,677
C-RL-400-1	12	10	9,870	17,784	95,876	548	1,447	2,718	20	24	506	1,182	4,038	29,836	8,733	30,955	143,849
C-RL-400-1	12	50	12,760	25,043	153,520	726	1,732	3,829	23	43	836	1,288	5,809	48,042	9,187	39,666	213,172
C-RL-400-1	12	90	19,039	41,693	222,652	982	2,159	4,878	37	75	1,016	1,839	8,597	56,247	11,803	53,520	259,368

Table 55--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, High Sea Level Rise Scenario
Planning Unit 3b
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage $1000s	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages $1000s	Expected Annual Output Impacted $1000s		Equivalent Annual Output $1000s
			2010	2075		2010	2075		2010	2075		2010	2075		2010	2075	
Structural Plans																	
F-100-1	10	10	23,629	39,021	113,715	230	424	1,922	75	93	546	3,354	8,051	30,227	13,734	35,146	135,751
F-100-1	10	50	32,156	51,718	175,109	327	582	2,836	94	124	859	4,191	11,178	47,473	17,532	52,453	203,057
F-100-1	10	90	57,170	86,851	264,733	625	976	3,869	153	221	1,088	6,471	19,876	58,696	29,672	94,065	264,198
F-400-1	12	10	23,570	38,962	122,332	227	420	2,118	74	93	604	3,333	8,008	33,957	13,663	34,968	153,043
F-400-1	12	50	28,252	46,711	184,935	256	493	3,040	76	101	930	3,366	8,860	51,768	13,986	41,512	221,648
F-400-1	12	90	33,541	56,561	254,967	323	619	3,849	81	116	1,099	3,549	10,280	59,170	15,185	46,725	264,035
F-1000-1	14	10	23,570	38,962	130,655	227	420	2,307	74	93	659	3,333	8,008	37,668	13,663	34,968	170,226
F-1000-1	14	50	28,249	46,708	199,193	256	493	3,319	76	101	1,019	3,366	8,860	57,466	13,986	41,512	246,850
F-1000-1	14	90	33,420	56,439	275,470	318	612	4,191	80	115	1,204	3,512	10,200	65,604	15,008	46,275	293,569
G-100-1	10	10	14,709	22,670	99,775	51	72	1,633	54	62	516	2,620	6,139	28,854	11,371	27,581	130,764
G-100-1	10	50	17,817	26,275	153,037	75	113	2,439	56	69	806	2,704	6,788	44,484	11,871	34,019	190,986
G-100-1	10	90	24,523	33,654	216,376	170	242	3,198	78	90	973	3,595	8,814	51,884	16,477	44,588	233,454
RL-100-1	10	10	38,403	85,263	144,472	643	1,605	2,737	120	192	623	5,593	18,942	36,443	27,653	101,366	173,798
RL-100-1	10	50	55,677	116,770	220,646	882	1,963	3,848	151	272	966	6,879	26,247	55,735	34,753	140,089	252,413
RL-100-1	10	90	82,423	162,798	316,068	1,325	2,574	5,088	195	349	1,174	8,463	33,151	65,661	43,793	172,816	307,428
RL-400-1	12	10	36,518	82,517	147,964	592	1,535	2,799	108	173	658	5,171	17,284	38,735	25,237	91,565	182,464
RL-400-1	12	50	49,276	108,637	223,316	771	1,821	3,911	119	220	1,006	5,560	21,327	57,986	27,887	114,544	258,846
RL-400-1	12	90	66,786	143,150	311,482	1,048	2,248	4,986	139	271	1,200	6,273	25,820	66,912	32,032	133,221	308,375
Non-Structural Plans																	
NS-100	15	10	14,783	60,267	88,503	1,488	3,595	3,870	19	482	478	838	45,421	28,601	4,149	229,835	137,261
NS-100	15	50	28,842	153,489	168,888	2,318	4,567	5,693	80	1,016	933	3,414	98,093	58,979	15,701	467,083	262,686
NS-100	15	90	51,349	275,026	272,403	2,969	5,438	7,169	127	1,318	1,188	5,349	124,466	73,297	29,630	586,714	339,235
NS-400	15	10	11,222	26,741	74,120	1,487	3,594	3,869	1	23	316	39	2,142	14,300	161	10,523	64,856
NS-400	15	50	17,294	48,572	123,423	2,318	4,567	5,692	11	115	577	464	11,252	28,769	2,550	59,141	121,569
NS-400	15	90	28,132	88,466	188,544	2,968	5,438	7,169	35	362	788	1,355	36,210	41,477	6,959	200,162	194,049
NS-1000	15	10	9,975	22,510	71,409	1,432	3,526	3,786	0	3	309	8	249	13,679	30	865	61,719
NS-1000	15	50	14,994	31,962	115,695	2,262	4,498	5,609	1	31	540	49	2,638	25,635	219	12,575	104,528
NS-1000	15	90	20,990	49,284	168,386	2,910	5,369	7,083	9	105	680	340	10,193	32,280	1,798	47,339	140,921

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 56
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, Low Sea Level Rise Scenario
Planning Unit 4
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU4-0	NA	10	95,399	127,777	223,772	1,045	1,565	2,551	316	392	722	15,517	42,356	49,370	87,821	226,906	271,708
Degraded Coast PU4-0	NA	50	125,378	171,491	296,234	1,471	2,225	3,603	360	451	825	16,765	49,202	55,408	98,080	261,401	308,252
Degraded Coast PU4-0	NA	90	165,749	235,205	396,727	1,877	2,562	4,432	416	642	1,027	19,125	66,216	69,273	107,468	351,027	376,605
Sustained Coast PU1-R	NA*	10	95,399	127,504	223,608	1,045	1,555	2,545	316	403	729	15,517	43,668	50,159	87,821	236,419	277,429
Sustained Coast PU1-R	NA*	50	125,378	171,482	296,229	1,471	2,219	3,600	360	451	825	16,765	49,273	55,451	98,080	262,021	308,625
Sustained Coast PU1-R	NA*	90	165,749	229,709	393,422	1,877	2,563	4,432	416	642	1,027	19,125	66,243	69,290	107,468	351,226	376,725
Comprehensive Plans																	
C-G-100-1	10	10	24,209	28,059	103,028	588	763	1,702	31	52	273	1,005	3,760	17,071	3,823	18,279	92,465
C-G-100-1	10	50	31,490	41,140	138,465	750	1,002	2,339	58	76	345	2,099	5,775	20,586	9,376	33,185	114,095
C-G-100-1	10	90	45,840	60,957	195,934	969	1,245	2,980	89	273	496	3,182	23,850	30,764	15,350	131,216	167,086
C-G-100-2	10	10	30,932	38,040	112,117	648	867	1,794	88	140	354	5,421	16,272	25,690	27,678	78,990	136,308
C-G-100-2	10	50	38,676	51,829	148,223	814	1,112	2,436	117	167	430	6,627	18,611	29,428	33,711	94,444	158,555
C-G-100-2	10	90	53,478	72,488	206,405	1,037	1,358	3,081	147	364	580	7,665	36,587	39,529	39,449	191,922	211,129
C-G-400-3	10	10	26,584	30,867	104,470	694	923	1,829	30	47	256	1,036	3,929	16,595	3,295	14,480	87,016
C-G-400-3	10	50	29,940	35,873	132,996	810	1,114	2,408	38	64	305	1,378	5,529	19,121	5,060	22,990	102,112
C-G-400-3	10	90	39,633	48,514	182,476	1,019	1,345	3,035	74	122	417	2,642	10,884	25,564	10,177	58,341	134,589
C-G-1000-3	10	10	18,526	21,031	91,736	614	812	1,698	27	33	248	808	2,062	15,743	2,293	6,392	83,306
C-G-1000-3	10	50	21,215	24,572	119,024	727	1,000	2,273	28	39	285	849	2,604	17,579	2,484	7,882	94,334
C-G-1000-3	10	90	25,917	30,542	161,281	891	1,178	2,842	33	56	353	1,050	4,128	21,632	3,508	16,721	113,914
C-RL-100-1	10	10	28,006	37,550	109,206	943	1,367	2,238	37	121	288	1,377	13,119	19,963	5,617	63,266	105,421
C-RL-100-1	10	50	39,722	57,841	150,905	1,258	1,834	3,092	67	169	366	2,567	17,972	24,282	11,483	93,610	131,122
C-RL-100-1	10	90	57,086	90,713	212,072	1,587	2,156	3,855	104	393	534	3,785	37,828	35,477	18,107	192,750	186,632
C-RL-400-1	12	10	25,195	30,230	102,965	885	1,303	2,122	27	38	246	831	2,756	15,713	2,482	9,868	83,309
C-RL-400-1	12	50	30,540	37,072	134,006	1,136	1,702	2,918	31	52	286	1,016	4,041	17,870	3,587	18,099	96,885
C-RL-400-1	12	90	40,648	52,612	181,702	1,452	2,009	3,672	68	119	404	2,278	10,026	24,864	8,717	56,683	131,800
C-RL-1000-1	14	10	22,499	27,137	98,138	804	1,211	1,972	26	32	240	783	1,987	15,140	2,218	6,076	80,557
C-RL-1000-1	14	50	27,295	32,147	128,526	1,053	1,606	2,786	26	33	273	786	2,042	16,803	2,232	6,358	90,716
C-RL-1000-1	14	90	31,618	38,176	168,836	1,324	1,865	3,502	31	50	346	948	3,640	21,494	3,018	15,340	112,552

Table 56--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, Low Sea Level Rise Scenario
Planning Unit 4
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage $1000s	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages $1000s	Expected Annual Output Impacted $1000s		Equivalent Annual Output $1000s
			2010	2075		2010	2075		2010	2075		2010	2075		2010	2075	
Structural Plans																	
G-100-1	10	10	92,534	113,416	211,614	894	1,108	2,178	278	323	654	11,447	30,519	37,913	64,076	169,836	211,849
G-100-1	10	50	114,205	139,058	268,243	1,057	1,348	2,815	312	365	739	12,370	34,436	41,812	72,450	194,702	239,956
G-100-1	10	90	138,122	187,566	346,101	1,288	1,602	3,474	356	448	871	14,016	41,279	49,188	80,882	237,757	278,875
G-100-2	10	10	101,233	126,254	223,964	955	1,213	2,271	339	416	741	16,128	43,573	47,019	89,368	233,888	258,454
G-100-2	10	50	123,382	152,683	281,304	1,122	1,458	2,913	375	462	830	17,164	47,815	51,141	98,222	259,303	287,178
G-100-2	10	90	147,768	202,112	359,920	1,356	1,716	3,576	418	543	961	18,764	54,559	58,440	106,417	301,804	325,680
G-400-3	10	10	101,921	126,921	224,801	1,097	1,377	2,454	338	415	741	16,112	43,511	46,981	89,250	233,453	258,182
G-400-3	10	50	122,466	151,327	280,002	1,213	1,568	3,033	365	450	818	16,790	46,890	50,461	97,064	256,030	284,909
G-400-3	10	90	147,187	201,299	359,114	1,435	1,810	3,679	416	541	958	18,660	54,515	58,336	106,711	303,304	326,524
G-1000-3	10	10	101,921	126,920	224,801	1,097	1,376	2,454	338	415	741	16,112	43,511	46,981	89,250	233,453	258,182
G-1000-3	10	50	122,390	151,219	279,896	1,211	1,565	3,030	365	450	818	16,783	46,859	50,443	97,043	255,923	284,849
G-1000-3	10	90	143,936	197,410	354,862	1,388	1,759	3,620	398	519	934	18,057	52,850	57,170	104,445	296,552	321,943
RL-100-1	10	10	100,552	131,820	225,627	1,255	1,718	2,721	342	434	752	16,259	45,341	47,835	89,759	241,102	261,666
RL-100-1	10	50	128,509	168,992	292,082	1,570	2,186	3,576	390	475	848	17,687	49,241	52,146	100,519	263,813	290,888
RL-100-1	10	90	161,806	212,348	375,654	1,912	2,520	4,358	440	601	1,002	19,429	59,829	61,101	108,953	322,272	335,976
RL-400-1	12	10	99,821	130,956	223,888	1,249	1,712	2,687	340	429	744	16,156	44,882	47,184	89,321	239,162	258,736
RL-400-1	12	50	125,494	165,560	287,969	1,501	2,111	3,483	377	459	829	17,188	47,798	50,866	98,980	258,945	286,174
RL-1000-1	14	50	125,419	165,452	287,791	1,499	2,108	3,477	377	459	826	17,182	47,767	50,678	98,959	258,839	285,212
RL-1000-1	14	90	156,675	206,430	371,308	1,783	2,379	4,213	417	572	972	18,640	57,757	59,527	106,615	315,514	330,079
Non-Structural Plans																	
NS-100	15	10	22,322	32,410	102,709	734	1,204	1,938	10	90	263	579	11,445	15,191	3,594	58,576	84,408
NS-100	15	50	34,886	56,057	145,389	1,159	1,867	2,922	37	136	339	1,642	16,108	18,713	9,037	88,648	107,104
NS-100	15	90	55,471	102,203	211,409	1,552	2,198	3,755	70	434	508	2,798	44,242	30,396	15,459	221,704	162,179
NS-400	15	10	19,869	24,627	97,544	681	1,147	1,861	1	7	227	61	981	11,368	329	4,780	64,079
NS-400	15	50	26,163	33,240	128,524	1,106	1,809	2,845	6	25	270	293	2,625	13,021	1,558	14,277	75,670
NS-400	15	90	35,440	49,759	172,667	1,500	2,141	3,678	30	89	357	1,169	8,731	17,568	5,034	51,972	97,901
NS-1000	15	10	17,172	21,511	93,549	600	1,054	1,741	0	1	225	12	200	11,071	65	966	62,600
NS-1000	15	50	22,742	27,525	122,911	1,025	1,717	2,725	0	3	256	19	322	12,001	88	1,481	70,055
NS-1000	15	90	28,025	35,712	159,986	1,418	2,048	3,558	7	30	312	259	2,739	14,691	1,104	12,884	81,380

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 57
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, High Sea Level Rise Scenario
Planning Unit 4
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages	Expected Annual Output Impacted $1000s		Equivalent Annual Output
			2010	2075	$1000s	2010	2075		2010	2075		2010	2075	$1000s	2010	2075	$1000s
Without Project																	
Degraded Coast PU4-0	NA	10	95,399	168,561	248,296	1,045	2,090	2,866	316	471	770	15,517	50,470	54,249	87,821	281,500	304,537
Degraded Coast PU4-0	NA	50	125,378	242,166	338,732	1,471	2,638	3,851	360	678	961	16,765	71,807	69,001	98,080	393,996	387,983
Degraded Coast PU4-0	NA	90	165,749	346,073	463,393	1,877	3,278	4,862	416	772	1,104	19,125	80,518	77,874	107,468	493,091	462,031
Sustained Coast PU1-R	NA*	10	95,399	168,696	248,377	1,045	2,095	2,870	316	490	782	15,517	52,939	55,734	87,821	295,548	312,984
Sustained Coast PU1-R	NA*	50	125,378	234,496	334,120	1,471	2,635	3,850	360	679	962	16,765	71,929	69,074	98,080	394,636	388,368
Sustained Coast PU1-R	NA*	90	165,749	348,037	464,574	1,877	3,279	4,863	416	772	1,105	19,125	80,524	77,877	107,468	493,116	462,046
Comprehensive Plans																	
C-G-100-1	10	10	24,209	34,554	110,354	588	938	1,815	31	59	289	1,005	4,425	18,713	3,823	29,397	105,532
C-G-100-1	10	50	31,490	54,846	152,431	750	1,154	2,433	58	249	426	2,099	22,341	28,513	9,376	132,730	162,690
C-G-100-1	10	90	45,840	106,249	224,658	969	1,445	3,116	89	305	524	3,182	27,470	33,958	15,350	222,288	218,160
C-G-100-2	10	10	30,932	47,669	120,731	648	1,050	1,909	88	152	371	5,421	17,309	27,482	27,678	90,821	149,661
C-G-100-2	10	50	38,676	68,830	163,538	814	1,266	2,532	117	341	510	6,627	35,180	37,356	33,711	194,057	207,178
C-G-100-2	10	90	53,478	120,958	236,426	1,037	1,559	3,217	147	396	608	7,665	40,209	42,723	39,449	283,061	262,230
C-G-400-3	10	10	26,584	34,583	111,254	694	1,106	1,944	30	80	280	1,036	9,183	19,692	3,295	35,359	103,171
C-G-400-3	10	50	29,940	41,412	144,762	810	1,269	2,503	38	109	346	1,378	12,450	24,061	5,060	63,000	132,275
C-G-400-3	10	90	39,633	59,099	200,763	1,019	1,546	3,171	74	156	446	2,642	16,210	29,286	10,177	76,318	163,031
C-G-1000-3	10	10	18,526	23,235	98,051	614	989	1,811	27	42	264	808	3,147	17,549	2,293	10,570	94,289
C-G-1000-3	10	50	21,215	27,012	129,830	727	1,149	2,367	28	48	315	849	3,630	20,693	2,484	13,365	113,803
C-G-1000-3	10	90	25,917	35,977	177,973	891	1,377	2,978	33	69	375	1,050	5,420	24,105	3,508	23,598	138,919
C-RL-100-1	10	10	28,006	53,867	120,773	943	1,755	2,435	37	155	311	1,377	16,626	22,469	5,617	90,454	123,233
C-RL-100-1	10	50	39,722	91,361	171,198	1,258	2,162	3,257	67	371	460	2,567	36,764	33,278	11,483	195,680	182,026
C-RL-100-1	10	90	57,086	165,771	252,880	1,587	2,627	4,099	104	427	563	3,785	41,575	38,767	18,107	284,243	237,990
C-RL-400-1	12	10	25,195	34,987	110,684	885	1,690	2,318	27	43	260	831	3,307	17,206	2,482	14,940	93,677
C-RL-400-1	12	50	30,540	45,347	146,501	1,136	2,029	3,081	31	81	327	1,016	7,213	22,033	3,587	45,670	124,508
C-RL-400-1	12	90	40,648	69,678	203,869	1,452	2,479	3,917	68	133	427	2,278	11,225	27,326	8,717	60,235	154,874
C-RL-1000-1	14	10	22,499	31,269	105,533	804	1,597	2,168	26	37	254	783	2,701	16,618	2,218	9,548	90,034
C-RL-1000-1	14	50	27,295	36,282	139,962	1,053	1,932	2,948	26	43	308	786	3,197	20,411	2,232	12,266	111,821
C-RL-1000-1	14	90	31,618	46,979	188,137	1,324	2,333	3,749	31	70	371	948	5,469	24,156	3,018	23,584	136,514

Table 57--Continued
Expected and Equivalent Annual Metric Values by Alternative
2010, 2075, and 2025 Equivalent Annual Value in 2007 Price Level
Business As Usual Employment, Compact Land Use, High Sea Level Rise Scenario
Planning Unit 4
Louisiana Coastal Protection and Restoration

Alternative	Years to Implement	% Chance Less than Indicated Value	Expected Annual Damage $1000s		Equivalent Annual Damage $1000s	Expected Annual Population Impacted		Equivalent Annual Population	Expected Annual Employees Impacted		Equivalent Annual Employment	Expected Annual Wages Impacted $1000s		Equivalent Annual Wages $1000s	Expected Annual Output Impacted $1000s		Equivalent Annual Output $1000s
			2010	2075		2010	2075		2010	2075		2010	2075		2010	2075	
Structural Plans																	
G-100-1	10	10	92,534	137,685	224,444	894	1,303	2,296	278	403	692	11,447	39,528	42,140	64,076	230,025	240,114
G-100-1	10	50	114,205	186,767	292,741	1,057	1,523	2,917	312	472	800	12,370	46,241	48,265	72,450	278,982	283,824
G-100-1	10	90	138,122	256,288	382,081	1,288	1,814	3,614	356	539	917	14,016	52,095	54,611	80,882	370,379	342,818
G-100-2	10	10	101,233	154,034	238,200	955	1,415	2,391	339	500	781	16,128	52,955	51,395	89,368	294,791	287,005
G-100-2	10	50	123,382	204,017	307,253	1,122	1,635	3,015	375	569	891	17,164	59,622	57,595	98,222	343,650	331,073
G-100-2	10	90	147,768	274,287	397,282	1,356	1,928	3,716	418	635	1,007	18,764	65,377	63,863	106,417	434,493	389,650
G-400-3	10	10	101,921	154,701	239,037	1,097	1,578	2,574	338	499	781	16,112	52,893	51,357	89,250	294,355	286,733
G-400-3	10	50	122,466	202,661	305,951	1,213	1,745	3,135	365	557	878	16,790	58,697	56,914	97,064	340,378	328,803
G-400-3	10	90	147,187	273,475	396,476	1,435	2,022	3,818	416	632	1,005	18,660	65,333	63,760	106,711	435,993	390,494
G-1000-3	10	10	101,921	154,700	239,037	1,097	1,578	2,574	338	499	781	16,112	52,893	51,357	89,250	294,355	286,733
G-1000-3	10	50	122,390	202,553	305,845	1,211	1,742	3,132	365	557	878	16,783	58,666	56,897	97,043	340,271	328,744
G-1000-3	10	90	143,936	269,585	392,224	1,388	1,971	3,759	398	610	980	18,057	63,668	62,593	104,445	429,241	385,913
RL-100-1	10	10	100,552	169,322	243,756	1,255	2,124	2,924	342	512	789	16,259	54,176	51,992	89,759	298,726	288,904
RL-100-1	10	50	128,509	218,800	317,420	1,570	2,538	3,748	390	628	927	17,687	65,242	60,278	100,519	364,939	341,500
RL-100-1	10	90	161,806	312,698	424,295	1,912	3,003	4,607	440	697	1,050	19,429	71,276	66,776	108,953	456,580	400,594
RL-400-1	12	10	99,821	168,453	241,747	1,249	2,118	2,888	340	508	780	16,156	53,717	51,244	89,321	296,786	285,380
RL-400-1	12	50	125,494	215,351	313,322	1,501	2,463	3,653	377	612	908	17,188	63,775	58,995	98,980	360,015	336,560
RL-1000-1	14	50	125,419	215,243	313,367	1,499	2,460	3,647	377	612	906	17,182	63,744	58,876	98,959	359,909	335,790
RL-1000-1	14	90	156,675	306,702	418,939	1,783	2,861	4,464	417	668	1,020	18,640	69,204	65,167	106,615	449,822	393,085
Non-Structural Plans																	
NS-100	15	10	22,322	50,781	108,399	734	1,725	2,099	10	128	275	579	15,211	16,357	3,594	86,681	93,112
NS-100	15	50	34,886	101,114	159,344	1,159	2,259	3,044	37	417	426	1,642	43,300	27,134	9,037	224,870	149,294
NS-100	15	90	55,471	196,473	240,605	1,552	2,902	3,973	70	502	529	2,798	50,822	32,434	15,459	320,779	192,864
NS-400	15	10	19,869	30,099	99,239	681	1,667	2,022	1	14	229	61	1,669	11,581	329	10,183	65,752
NS-400	15	50	26,163	44,216	131,923	1,106	2,201	2,967	6	63	281	293	6,678	14,277	1,558	45,218	85,253
NS-400	15	90	35,440	72,039	179,567	1,500	2,845	3,896	30	110	363	1,169	10,327	18,062	5,034	56,976	99,451
NS-1000	15	10	17,172	26,143	94,983	600	1,574	1,902	0	7	226	12	924	11,296	65	4,467	63,685
NS-1000	15	50	22,742	32,906	124,577	1,025	2,107	2,846	0	18	261	19	1,945	12,503	88	9,060	72,403
NS-1000	15	90	28,025	46,863	163,440	1,418	2,751	3,776	7	55	320	259	4,993	15,389	1,104	23,541	84,681

Source: GIS Economic Application Databases

* The Louisiana coastline is sustained at 2010 conditions throughout the analysis.

Table 58
Percentage of Expected Annual Damages by Damage Category for each Planning Unit
Without Structural Action Sustained Coastline Alternative
2010 & 2075 (2007 Price Level)
Louisiana Coastal Protection and Restoration

Planning Unit	Residential (%)	Non Residential (%)	Emergency Activities (%)	Agricultural Resources (%)	Transportation Infrastructure (%)
High Employment Future Development Dispersed Land Use Allocation Low Sea Level Rise Scenario					
2010					
1	64	10	19	2	5
2	55	18	22	2	3
3a	51	22	20	2	4
3b	49	21	20	5	5
4	33	27	17	11	12
2075					
1	64	12	19	1	3
2	59	18	19	1	2
3a	55	22	19	1	3
3b	53	20	19	4	4
4	42	21	18	9	10
Business As Usual Future Development Compact Land Use Allocation Low Sea Level Rise Scenario					
2010					
1	64	11	19	2	5
2	53	20	22	2	3
3a	51	22	21	2	3
3b	49	20	20	6	5
4	31	32	16	11	11
2075					
1	63	11	20	1	4
2	55	21	20	2	2
3a	53	23	20	1	3
3b	50	23	20	4	4
4	36	31	16	8	9

Source: GIS Economic Application Databases

Note: Percentage of total expected annual damages for each damage category by planning unit with a sustained coast and low sea level rise scenario.

Table 59
Coastal Restoration Costs by Planning Unit
Life-Cycle Costs, Total Present Value and Annual Equivalent
2007 Price Levels, Base Year 2025, 4.875 Percent Federal Discount Rate
Louisiana Coastal Protection and Restoration

Alternative	PV Life-Cycle Costs 2025 ($)	Annual Equivalent 2025 ($)	Alternative	PV Life-Cycle Costs 2025 ($)	Annual Equivalent 2025 ($)
Low Sea Level Rise Scenario SLR 1			**High Sea Level Rise Scenario SLR 2**		
		Planning Unit 1			
R1	$ 9,476,216,146	$ 483,897,372	R1	$ 9,709,760,355	$ 495,823,169
R2	10,665,775,709	544,641,527	R2	10,899,319,919	556,567,324
R3	15,208,149,906	776,595,179	R3	15,618,392,295	797,543,963
R4	7,877,277,687	402,248,525	R4	8,086,372,307	412,925,818
R5	860,347,505	43,933,136	R5	873,240,040	44,591,486
		Planning Unit 2			
R1	15,000,587,972	765,996,151	R1	15,032,520,906	767,626,788
R2	15,656,858,627	799,508,224	R2	15,688,791,562	801,138,860
R3	18,244,990,105	931,669,627	R3	18,355,142,891	937,294,514
R4	21,014,813,079	1,073,108,999	R4	21,095,749,145	1,077,241,951
R5	7,910,967,053	403,968,853	R5	7,943,451,547	405,627,654
		Planning Unit 3a			
R1	23,275,709,069	1,188,560,315	R1	23,703,011,871	1,210,380,280
R2	22,767,146,032	1,162,590,844	R2	23,194,448,834	1,184,410,809
		Planning Unit 3b			
R1	4,755,693,600	242,846,680	R1	4,796,312,058	244,920,838
R2	6,907,066,410	352,705,260	R2	6,974,894,697	356,168,872
		Planning Unit 4			
R1	10,783,189,179	550,637,177	R1	11,077,439,106	565,662,875
R2	13,308,834,086	679,607,740	R2	13,708,099,109	699,995,972

Source: USACE cost estimates

Table 60
Costs of Structural Alternatives
Life-Cycle Costs, Total Present Value and Annual Equivalent
Planning Unit 1 and 2
2007 Price Levels, Base Year 2025, 4.875 Percent Federal Discount Rate
Louisiana Coastal Protection and Restoration

Alternative		PV Life-Cycle Costs 2025 ($)	Annual Equivalent 2025 ($)
		Planning Unit 1	
LP-1b-400-3	Total	$ 41,002,489,553	$ 2,093,767,874
	TSLR1	45,080,731,719	2,302,020,897
	TSLR2	45,237,657,978	2,310,034,245
	TDSLR1	45,252,687,240	2,310,801,705
	TDSLR2	45,729,618,144	2,335,155,899
	TD	44,628,890,709	2,278,947,904
LP-1a-100-3	Total	18,884,138,104	964,307,341
	TSLR1	21,091,812,926	1,077,040,950
	TSLR2	21,278,697,396	1,086,584,095
	TDSLR1	21,144,196,998	1,079,715,912
	TDSLR2	21,240,362,519	1,084,626,547
	TD	21,127,991,997	1,078,888,413
LP-1a-100-1	Total	6,351,779,267	324,349,851
	TSLR1	7,023,873,129	358,669,926
	TSLR2	7,132,174,353	364,200,264
	TDSLR1	7,102,779,099	362,699,213
	TDSLR2	7,117,989,706	363,475,933
	TD	7,076,147,767	361,339,300
LP-1b-1000-2	Total	54,130,685,904	2,764,151,455
	TSLR1	59,397,725,297	3,033,109,706
	TSLR2	59,605,080,201	3,043,698,161
	TDSLR1	59,911,487,303	3,059,344,658
	TDSLR2	60,303,778,508	3,079,376,777
	TD	58,991,397,522	3,012,360,818
LP-1b-400-1	Total	23,272,685,805	1,188,405,934
	TSLR1	25,537,741,834	1,304,069,680
	TSLR2	25,620,106,214	1,308,275,568
	TDSLR1	25,458,781,759	1,300,037,631
	TDSLR2	25,918,836,489	1,323,530,053
	TD	24,914,869,799	1,272,263,087

Table 60--Continued
Costs of Structural Alternatives
Life-Cycle Costs, Total Present Value and Annual Equivalent
Planning Unit 1 and 2
2007 Price Levels, Base Year 2025, 4.875 Percent Federal Discount Rate
Louisiana Coastal Protection and Restoration

Alternative		PV Life-Cycle Costs 2025 ($)	Annual Equivalent 2025 ($)
LP-1b-1000-1	Total	30,579,363,007	1,561,517,082
	TSLR1	33,338,727,846	1,702,422,416
	TSLR2	33,561,511,551	1,713,798,734
	TDSLR1	33,557,248,171	1,713,581,027
	TDSLR2	33,927,996,866	1,732,513,090
	TD	32,937,377,640	1,681,927,705
HL-1a-100-3	Total	14,611,578,492	746,131,612
	TSLR1	15,893,412,618	811,587,714
	TSLR2	15,927,954,706	813,351,585
	TDSLR1	15,927,026,713	813,304,197
	TDSLR2	16,138,961,617	824,126,527
	TD	15,893,190,720	811,576,383
HL-1b-400-3	Total	41,624,535,916	2,125,532,303
	TSLR1	44,894,897,434	2,292,531,380
	TSLR2	45,102,928,020	2,303,154,339
	TDSLR1	45,706,077,473	2,333,953,809
	TDSLR2	46,335,055,857	2,366,072,217
	TD	44,988,328,577	2,297,302,386
LP-1a-100-2	Total	20,291,496,420	1,036,173,261
	TSLR1	22,443,195,110	1,146,048,482
	TSLR2	22,582,076,265	1,153,140,366
	TDSLR1	22,710,149,477	1,159,680,349
	TDSLR2	22,815,125,785	1,165,040,902
	TD	22,535,350,313	1,150,754,333
HL-1a-100-2	Total	17,506,588,315	893,963,576
	TSLR1	19,193,842,960	980,122,237
	TSLR2	19,250,908,409	983,036,250
	TDSLR1	19,227,457,055	981,838,720
	TDSLR2	19,461,915,320	993,811,193
	TD	18,788,200,543	959,408,346

Table 60--Continued
Costs of Structural Alternatives
Life-Cycle Costs, Total Present Value and Annual Equivalent
Planning Unit 1 and 2
2007 Price Levels, Base Year 2025, 4.875 Percent Federal Discount Rate
Louisiana Coastal Protection and Restoration

Alternative		PV Life-Cycle Costs 2025 ($)	Annual Equivalent 2025 ($)
HL-1b-400-2	Total	45,741,098,175	2,335,742,120
	TSLR1	49,568,537,217	2,531,188,031
	TSLR2	49,807,516,554	2,543,391,369
	TDSLR1	50,379,717,256	2,572,610,459
	TDSLR2	51,039,644,391	2,606,309,248
	TD	49,104,890,836	2,507,512,202
	Planning Unit 2		
G-1-100-4 Mod	Total	13,324,704,326	680,418,145
	TSLR1	14,521,411,827	741,527,305
	TSLR2	14,699,942,386	750,643,862
	TDSLR1	14,798,120,600	755,657,275
	TDSLR2	14,877,313,201	759,701,197
	TD	14,627,479,624	746,943,593
G-1-400-4 Mod	Total	31,977,328,376	1,632,903,357
	TSLR1	34,745,450,470	1,774,255,875
	TSLR2	34,880,253,459	1,781,139,509
	TDSLR1	34,874,999,831	1,780,871,236
	TDSLR2	35,051,652,952	1,789,891,923
	TD	33,433,655,186	1,707,269,824
G-1-1000-4 Mod	Total	38,903,051,804	1,986,561,328
	TSLR1	42,334,822,310	2,161,802,659
	TSLR2	42,457,433,306	2,168,063,716
	TDSLR1	42,502,228,645	2,170,351,163
	TDSLR2	42,685,102,247	2,179,689,496
	TD	40,720,031,546	2,079,344,323
G-1-100-1 Mod	Total	7,093,684,425	362,234,799
	TSLR1	7,604,471,817	388,317,855
	TSLR2	7,747,826,987	395,638,202
	TDSLR1	7,825,001,790	399,579,088
	TDSLR2	7,837,462,975	400,215,410
	TD	7,721,802,251	394,309,264

Table 60--Continued
Costs of Structural Alternatives
Life-Cycle Costs, Total Present Value and Annual Equivalent
Planning Unit 1 and 2
2007 Price Levels, Base Year 2025, 4.875 Percent Federal Discount Rate
Louisiana Coastal Protection and Restoration

Alternative		PV Life-Cycle Costs 2025 ($)	Annual Equivalent 2025 ($)
S-1-100-4	Total	12,283,125,381	627,230,532
	TSLR1	13,347,656,638	681,590,190
	TSLR2	13,419,759,181	685,272,064
	TDSLR1	13,480,639,860	688,380,900
	TDSLR2	13,569,116,884	692,898,926
	TD	13,402,780,231	684,405,044
S-1-400-4	Total	28,761,420,852	1,468,684,942
	TSLR1	31,466,448,269	1,606,815,567
	TSLR2	31,605,204,008	1,613,901,046
	TDSLR1	31,716,753,695	1,619,597,265
	TDSLR2	31,895,295,224	1,628,714,383
	TD	30,583,044,886	1,561,705,095
S-1-1000-4	Total	36,465,926,824	1,862,110,982
	TSLR1	39,174,221,170	2,000,408,430
	TSLR2	39,773,613,631	2,031,016,052
	TDSLR1	39,911,476,988	2,038,055,962
	TDSLR2	40,094,969,319	2,047,425,890
	TD	39,057,807,756	1,994,463,848
S-1-100-2	Total	7,281,907,277	371,846,287
	TSLR1	7,729,640,102	394,709,499
	TSLR2	7,770,111,956	396,776,170
	TDSLR1	7,808,851,152	398,754,365
	TDSLR2	7,834,066,799	400,041,987
	TD	7,762,622,212	396,393,711
S-1-400-2	Total	23,344,649,676	1,192,080,726
	TSLR1	25,409,065,722	1,297,498,910
	TSLR2	25,514,969,596	1,302,906,829
	TDSLR1	25,570,671,112	1,305,751,193
	TDSLR2	25,683,508,911	1,311,513,189
	TD	24,469,814,168	1,249,536,585

Table 60--Continued
Costs of Structural Alternatives
Life-Cycle Costs, Total Present Value and Annual Equivalent
Planning Unit 1 and 2
2007 Price Levels, Base Year 2025, 4.875 Percent Federal Discount Rate
Louisiana Coastal Protection and Restoration

Alternative		PV Life-Cycle Costs 2025 ($)	Annual Equivalent 2025 ($)
WBI-100-1	Total	949,899,327	48,506,048
	TSLR1	999,127,829	51,019,872
	TSLR2	1,023,742,080	52,276,783
	TDSLR1	1,072,970,582	54,790,607
	TDSLR2	1,100,319,750	56,187,176
	TD	1,023,742,080	52,276,783
S-1-100-3	Total	9,419,445,296	480,998,401
	TSLR1	10,146,620,609	518,131,180
	TSLR2	10,201,422,847	520,929,623
	TDSLR1	10,209,194,089	521,326,457
	TDSLR2	10,304,069,727	526,171,225
	TD	10,189,633,988	520,327,631
S-1-400-3	Total	25,947,102,046	1,324,973,416
	TSLR1	28,317,944,647	1,446,039,091
	TSLR2	28,439,562,703	1,452,249,445
	TDSLR1	28,522,866,427	1,456,503,302
	TDSLR2	28,666,244,493	1,463,824,818
	TD	28,106,117,780	1,435,222,278
W-1-400-1	Total	18,244,876,972	931,663,850
	TSLR1	18,294,179,839	934,181,472
	TSLR2	18,318,831,273	935,440,282
	TDSLR1	18,368,134,140	937,957,904
	TDSLR2	18,395,524,622	939,356,583
	TD	18,318,831,273	935,440,282

Source: USACE cost estimates

Notes:
Total = Costs Under 2010 Conditions
TSLR1 = Costs with Sustain Coastline with Sea Level Rise Option 1 (Low Sea Level Rise)
TSLR2 = Costs with Sustain Coastline with Sea Level Rise Option 2 (High Sea Level Rise)
TDSLR1 = Costs with Degraded Coastline and Sea Level Rise Option 1 (Low Sea Level Rise)
TDSLR2 = Costs with Degraded Coastline and Sea Level Rise Option 2 (High Sea Level Rise)
TD = Costs with Degraded Coastline Conditions

Table 61
Costs of Structural Alternatives
Life-Cycle Costs, Total Present Value and Annual Equivalent
Planning Unit 3a, 3b, and 4
2007 Price Levels, Base Year 2025, 4.875 Percent Federal Discount Rate
Louisiana Coastal Protection and Restoration

Alternative		PV Life-Cycle Costs 2025 ($)	Annual Equivalent 2025 ($)
		Planning Unit 3a	
PU3a-M-100-2	Total	$ 18,113,975,186	$ 924,979,428
	TSLR1	18,982,639,808	969,337,273
	TSLR2	19,097,861,585	975,221,004
	TDSLR1	19,003,679,214	970,411,638
	TDSLR2	19,118,900,991	976,295,370
	TD	18,113,975,186	924,979,428
PU3a-M-400-2	Total	32,341,913,836	1,651,520,698
	TSLR1	33,765,451,792	1,724,212,822
	TSLR2	34,083,529,240	1,740,455,258
	TDSLR1	33,790,248,762	1,725,479,065
	TDSLR2	34,108,326,210	1,741,721,501
	TD	32,341,913,836	1,651,520,698
PU3a-M-1000-2	Total	42,454,767,932	2,167,927,611
	TSLR1	44,199,165,497	2,257,004,240
	TSLR2	44,271,710,180	2,260,708,691
	TDSLR1	44,236,100,272	2,258,890,293
	TDSLR2	44,341,045,410	2,264,249,254
	TD	42,454,767,932	2,167,927,611
PU3a-G-400-2	Total	23,980,293,148	1,224,539,484
	TSLR1	25,212,348,239	1,287,453,649
	TSLR2	25,284,574,961	1,291,141,863
	TDSLR1	25,255,436,245	1,289,653,912
	TDSLR2	25,450,444,260	1,299,611,881
	TD	23,980,293,148	1,224,539,484
PU3a-G-1000-2	Total	26,285,582,200	1,342,257,706
	TSLR1	27,625,147,579	1,410,661,820
	TSLR2	27,702,581,935	1,414,615,959
	TDSLR1	27,672,021,584	1,413,055,413
	TDSLR2	27,776,971,438	1,418,414,615
	TD	26,285,582,200	1,342,257,706

Table 61--Continued
Costs of Structural Alternatives
Life-Cycle Costs, Total Present Value and Annual Equivalent
Planning Unit 3a, 3b, and 4
2007 Price Levels, Base Year 2025, 4.875 Percent Federal Discount Rate
Louisiana Coastal Protection and Restoration

Alternative		PV Life-Cycle Costs 2025 ($)	Annual Equivalent 2025 ($)
PU3a-M-100-1	Total	20,559,835,693	1,049,875,848
	TSLR1	21,412,231,587	1,093,402,940
	TSLR2	21,928,172,989	1,119,749,182
	TDSLR1	21,441,726,777	1,094,909,094
	TDSLR2	21,956,876,639	1,121,214,917
	TD	20,559,835,693	1,049,875,848
PU3a-M-400-1	Total	37,191,919,750	1,899,183,381
	TSLR1	38,699,958,870	1,976,190,507
	TSLR2	38,999,788,009	1,991,501,104
	TDSLR1	38,742,586,154	1,978,367,243
	TDSLR2	39,040,505,418	1,993,580,315
	TD	37,191,919,750	1,899,183,381
PU3a-M-1000-1	Total	50,311,083,067	2,569,105,695
	TSLR1	52,221,422,825	2,666,656,065
	TSLR2	52,261,232,244	2,668,688,910
	TDSLR1	52,279,045,426	2,669,598,529
	TDSLR2	52,346,720,979	2,673,054,341
	TD	50,311,083,067	2,569,105,695
	Planning Unit 3b		
PU3b-RL-100-1	Total	10,433,139,439	532,762,094
	TSLR1	11,579,104,009	591,280,097
	TSLR2	11,611,788,200	592,949,095
	TDSLR1	11,608,031,639	592,757,269
	TDSLR2	11,633,987,670	594,082,698
	TD	10,433,139,439	532,762,094
PU3b-RL-400-1	TOTAL	16,966,452,078	866,381,839
	TSLR1	17,996,217,325	918,966,192
	TSLR2	18,024,048,819	920,387,390
	TDSLR1	18,033,986,523	920,894,854
	TDSLR2	18,060,798,625	922,263,997
	TD	16,966,452,078	866,381,839

Table 61--Continued
Costs of Structural Alternatives
Life-Cycle Costs, Total Present Value and Annual Equivalent
Planning Unit 3a, 3b, and 4
2007 Price Levels, Base Year 2025, 4.875 Percent Federal Discount Rate
Louisiana Coastal Protection and Restoration

Alternative		PV Life-Cycle Costs 2025 ($)	Annual Equivalent 2025 ($)
PU3b-RL-1000-1	Total	21,092,083,124	1,077,054,747
	TSLR1	22,318,092,931	1,139,660,213
	TSLR2	22,368,524,012	1,142,235,447
	TDSLR1	22,419,122,645	1,144,819,236
	TDSLR2	22,074,288,458	1,127,210,482
	TD	21,092,083,124	1,077,054,747
PU3b-G-100-1	Total	13,875,503,041	708,544,355
	TSLR1	15,213,991,328	776,893,467
	TSLR2	15,238,204,179	778,129,882
	TDSLR1	15,213,991,328	776,893,467
	TDSLR2	15,245,100,038	778,482,015
	TD	13,875,503,041	708,544,355
PU3b-G-400-1	Total	21,402,662,628	1,092,914,306
	TSLR1	22,899,693,909	1,169,359,323
	TSLR2	22,972,759,898	1,173,090,395
	TDSLR1	22,899,693,909	1,169,359,323
	TDSLR2	22,972,759,898	1,173,090,395
	TD	21,402,662,628	1,092,914,306
PU3b-G-1000-1	Total	29,519,480,305	1,507,394,799
	TSLR1	31,690,702,400	1,618,266,971
	TSLR2	31,761,540,761	1,621,884,290
	TDSLR1	31,690,702,400	1,618,266,971
	TDSLR2	31,761,540,761	1,621,884,290
	TD	29,519,480,305	1,507,394,799
PU3b-F-100-1	Total	12,589,465,638	642,873,615
	TSLR1	13,918,228,814	710,726,122
	TSLR2	13,954,617,339	712,584,280
	TDSLR1	13,952,010,594	712,451,168
	TDSLR2	13,997,918,488	714,795,427
	TD	12,589,465,638	642,873,615

Table 61--Continued
Costs of Structural Alternatives
Life-Cycle Costs, Total Present Value and Annual Equivalent
Planning Unit 3a, 3b, and 4
2007 Price Levels, Base Year 2025, 4.875 Percent Federal Discount Rate
Louisiana Coastal Protection and Restoration

Alternative		PV Life-Cycle Costs 2025 ($)	Annual Equivalent 2025 ($)
PU3b-F-400-1	Total	22,069,176,757	1,126,949,456
	TSLR1	23,444,549,384	1,197,182,045
	TSLR2	23,639,274,027	1,207,125,544
	TDSLR1	23,470,259,830	1,198,494,935
	TDSLR2	23,638,106,727	1,207,065,937
	TD	22,069,176,757	1,126,949,456
PU3b-F-1000-1	Total	29,280,034,085	1,495,167,620
	TSLR1	31,073,875,930	1,586,769,093
	TSLR2	31,087,396,414	1,587,459,508
	TDSLR1	31,106,844,871	1,588,452,632
	TDSLR2	31,114,259,713	1,588,831,267
	TD	29,280,034,085	1,495,167,620
	Planning Unit 4		
PU4-RL-100-1	Total	2,373,687,756	121,210,962
	TSLR1	2,701,601,680	137,955,692
	TSLR2	2,719,819,121	138,885,954
	TDSLR1	2,728,696,431	139,339,270
	TDSLR2	2,737,805,151	139,804,400
	TD	2,373,687,756	121,210,962
PU4-RL-400-1	Total	3,056,534,710	156,080,137
	TSLR1	3,470,747,702	177,231,678
	TSLR2	3,493,759,535	178,406,763
	TDSLR1	3,504,156,698	178,937,689
	TDSLR2	3,516,771,368	179,581,850
	TD	3,056,534,710	156,080,137
PU4-RL-1000-1	Total	3,299,222,878	168,472,864
	TSLR1	3,756,449,865	191,820,890
	TSLR2	3,798,570,346	193,971,748
	TDSLR1	3,793,804,992	193,728,408
	TDSLR2	3,834,505,259	195,806,743
	TD	3,299,222,878	168,472,864

Table 61--Continued
Costs of Structural Alternatives
Life-Cycle Costs, Total Present Value and Annual Equivalent
Planning Unit 3a, 3b, and 4
2007 Price Levels, Base Year 2025, 4.875 Percent Federal Discount Rate
Louisiana Coastal Protection and Restoration

Alternative		PV Life-Cycle Costs 2025 ($)	Annual Equivalent 2025 ($)
PU4-G-100-1	Total	10,907,164,470	556,967,901
	TSLR1	11,989,407,009	612,231,976
	TSLR2	12,271,970,936	626,660,936
	TDSLR1	12,055,367,103	615,600,190
	TDSLR2	12,315,049,503	628,860,718
	TD	10,907,164,470	556,967,901
PU4-G-400-1	Total	16,208,936,970	827,699,777
	TSLR1	18,061,358,705	922,292,598
	TSLR2	18,148,409,469	926,737,794
	TDSLR1	18,160,529,349	927,356,688
	TDSLR2	18,217,802,110	930,281,287
	TD	16,208,936,970	827,699,777
PU4-G-1000-1	Total	21,546,382,413	1,100,253,272
	TSLR1	24,033,882,787	1,227,276,007
	TSLR2	24,161,955,356	1,233,815,957
	TDSLR1	24,173,128,003	1,234,386,481
	TDSLR2	24,231,465,161	1,237,365,435
	TD	21,546,382,413	1,100,253,272
PU4-G-100-2	Total	10,736,160,334	548,235,677
	TSLR1	11,784,788,679	601,783,263
	TSLR2	12,065,485,151	616,116,862
	TDSLR1	11,850,748,774	605,151,476
	TDSLR2	12,115,929,047	618,692,749
	TD	10,736,160,334	548,235,677
PU4-G-400-2	Total	15,946,166,377	814,281,552
	TSLR1	17,738,183,989	905,789,872
	TSLR2	17,825,959,478	910,272,075
	TDSLR1	17,837,354,632	910,853,962
	TDSLR2	17,901,638,110	914,136,560
	TD	15,946,166,377	814,281,552

Table 61--Continued
Costs of Structural Alternatives
Life-Cycle Costs, Total Present Value and Annual Equivalent
Planning Unit 3a, 3b, and 4
2007 Price Levels, Base Year 2025, 4.875 Percent Federal Discount Rate
Louisiana Coastal Protection and Restoration

Alternative		PV Life-Cycle Costs 2025 ($)	Annual Equivalent 2025 ($)
PU4-G-1000-2	Total	20,861,148,556	1,065,262,210
	TSLR1	23,283,349,147	1,188,950,451
	TSLR2	23,412,836,268	1,195,562,634
	TDSLR1	23,422,594,363	1,196,060,926
	TDSLR2	23,497,747,924	1,199,898,598
	TD	20,861,148,556	1,065,262,210
PU4-G-400-3	Total	10,691,853,094	545,973,153
	TSLR1	11,731,773,662	599,076,082
	TSLR2	12,011,986,368	613,384,978
	TDSLR1	11,803,916,746	602,760,025
	TDSLR2	11,909,909,139	608,172,465
	TD	10,691,853,094	545,973,153
PU4-G-1000-3	Total	11,119,090,351	567,789,772
	TSLR1	12,205,327,721	623,257,840
	TSLR2	12,488,113,583	637,698,133
	TDSLR1	12,282,164,058	627,181,443
	TDSLR2	12,401,350,205	633,267,613
	TD	11,119,090,351	567,789,772

Source: USACE cost estimates

Notes:
Total = Costs Under 2010 Conditions
TSLR1 = Costs with Sustain Coastline with Sea Level Rise Option 1 (Low Sea Level Rise)
TSLR2 = Costs with Sustain Coastline with Sea Level Rise Option 2 (High Sea Level Rise)
TDSLR1 = Costs with Degraded Coastline and Sea Level Rise Option 1 (Low Sea Level Rise)
TDSLR2 = Costs with Degraded Coastline and Sea Level Rise Option 2 (High Sea Level Rise)
TD = Costs with Degraded Coastline Conditions

Attachment 2 –
Other Social Effects Report

Expanding the Identification and Measurement of the Human Consequences of Disastrous Flooding: Toward the Refinement of the "Other Social Effects" Account

Submitted to the

U.S. Army Corps of Engineers

by

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September 8, 2008

Executive Summary

The **social** effects of water resources projects are equally as important as are their economic and environmental counterparts. When viewed from the community level, the supportive role which projects can play in social dynamics and quality of life make the social effects key to the reasoning for the creation and ongoing support of the projects. EC 1105-2-400, May 2005, "Planning in a Collaborative Environment" reiterates the importance of Other Social Effects (OSE) and that any alternate plan can be selected and recommended if it has net beneficial effects considering NED, EQ, RED, and **OSE** accounts.

In order for water resources projects to be assessed on the basis of the contribution which they may make to community/regional function, ***it is necessary to revisit the OSEs with renewed vigor.*** This report attempts to make a contribution to this effort both conceptually and practically in terms of implementation.

Measuring OSEs has always been challenging; recent expanded conversation about what comprises a successful community, and how to determine whether the qualities exist, has made doing so even more difficult. Resiliency, social well being, community capital, social capital are terms recently introduced to the more traditional and still used project effect analysis dominated (outside of the Corps) for the last few decades by Social Impact Assessment (SIA).

The "Handbook on Applying 'Other Social Effects' Factors in Corps of Engineers Water Resources Planning" states the importance of defining the social life in the local and regional area. "Social statistics" can be used to describe the quality of life in the area. As an appendix report to the LACPR, this document proposes a framing of OSEs, and describes the way they can be applied both in a qualitative and quantitative way, including per capita measures, to understand what social impact Hurricane Katrina and the consequent levee breaches and overtopping had. The case of this hurricane can demonstrate on a quantified basis how the viability of a community, and changes in that viability, can be measured through changes in social statistics. Two examples are a comparison of alcoholism per capita before and after hurricane Katrina and the suicide rate per capita before and after the storm. Increases and decreases in social statistics can be used as indicators of social well being and resiliency.

Whether the proposed concepts can stand the test of a summary, easy to appreciate, efficiently measured "capture" of OSE needed for Corps work will require more discussion than the recent IWR "white paper," the new "Handbook on Applying 'Other Social Effects'" and the ideas contained within this report can offer. These, it is proposed, however, are a substantial start.

The contribution that this specific post-Katrina report hopes to achieve is to argue not only for the importance of augmenting the current limited OSE account elements — residual population and historic districts — with enhanced measures but also for revising the means of engagement of the community in the application of the expanded OSEs. Simply, we propose that to be most effective the expanded OSEs must be used to engage the affected community in a robust, collaborative process that begins way in advance of the usual Corps engagement schedule – from the earliest consideration of the prospect of a water resources project benefiting a community -- and also continuing throughout all of the phases. From this process will emerge the most important social effects -- as defined by the community itself. Then what is valued will be known and from

that know what needs to be the focus of flood risk reduction. Expanded OSEs without the community engagement will produce very little improvement over the slim OSE effort undertaken before Katrina.

Additionally this report argues for the consideration of the contribution that a water resources project can make to the viability/sustainability of a community within a collaborative context of multiple resource stakeholders of which the Corps is one. While existing legislation and their promulgated rules reinforce "silo" insularity in bringing resources to a community, it is incumbent upon the Corps to encourage the weighing of the respective contributions of each of the possible resource stakeholders and in taking the lead in garnering them in a collaborative manner. The Planning in a Collaborative Environment EC in fact already recognizes that the Corps can help facilitate bringing together various agencies and programs to solve water resources problems. We present an example from the New Orleans office to demonstrate that the Corps already has acted in this leadership manner for a related goal – Louisiana coastal restoration.

Finally, the report recommends the required use of the OSEs in a community collaborative process of assessing the impacts of structure breaches or overtopping after every federally declared flood disaster involving a Corps project.

Overview of the Report

What was the logic of work? How it was done? And what is the focus?

"Planning in a Collaborative Environment" (EC 1105-2-409) initiated a new awareness for the need for the assessment of Other Social Effects (OSEs) within the efforts of the Interagency Performance Evaluation Taskforce (IPET). The impacts of the levees overtopping and breaching during Hurricanes Katrina and Rita reinforced the need to re-introduce social effects to the core considerations (national and regional economic, environmental and **social**) when reviewing potential projects or when reviewing the performance of existing ones. This University of New Orleans-led team of social scientists proposed to support the renewed interest by refining the OSEs that have been used over the last few decades utilizing observations following the two storms. The team's work is an extension of that presented in recently prepared preliminary white papers that were produced by the Institute of Water Resources in anticipation of an OSE handbook, now released (Dunning, 2008).

Once the preliminary OSEs proposed by Dunning and Durden (2007) had been reviewed, the team suggested revisions based primarily upon the OSEs proposed in the internationally-recognized process called Social Impact Assessment. This revised list was then reviewed for additions from more recent work on social resiliency, social well-being and social/community capital to produce a list of impacts the team felt was representative and captured the core impacts that would occur both for the construction of a Corps civil project and for the "post-mortem" assessment of harmful impacts of an overtopping or breaching of a protective structure, especially one that is as catastrophic as Hurricane Katrina.

In order to demonstrate how such OSEs could be examined for a catastrophic event, the next step was to describe, in narrative form, what the OSEs were in Hurricane Katrina, then to quantify these impacts as much as possible to achieve the Corps' goal of numeric assessment and impact comparison. Appendices were developed to provide additional narrative detail about Katrina to reinforce the social impact perspective and to add quantitative detail to the OSEs.

In addition to proposing refined categories and specific OSEs, the team included an expanded description of the Social Impact Assessment (SIA) process. The team feels very strongly that this method can bring to the planners a useful representation of project impacts – both positive and negative – as they are viewed by the affected community and its active stakeholders. While it is important to have the assessment process be led by a professional SIA specialist, the process engages the community to express a common vision and to thereby identify what flood safety means. The linkage between the method and the planning process was described.

In addition, the SIA process put into place must engage the entire community rather than just a project sponsor or highly visible stakeholders. This engagement should occur much earlier than is done now. The purpose of the early timing is to be sure that

- there is consensus about what the community considers the most important elements/functions to protect,
- determination that a structural solution is the best option,

- how the structural can be combined with non-structural to effect the greatest safety including through redundancy, and
- to engage all of the possible "resource stakeholders" into the conversation for the best flood protection achievable at an early enough time that the definition of the protection system has not "hardened" to only the structural measure.

It is believed that a list of OSEs is most important in its suggestive role, rather than in any definitive representation of what absolutely has to be addressed as of concern in any project. Because of this belief, community-based assessment procedures that would support this assumption are offered and advocated.
Robust community engagement also reduces the likelihood that resistance by community subgroups to the project will afflict the entire project and decision-making process, as occurs today.

Finally, four additional application issues relevant to the more productive use of the OSEs are considered in the report:

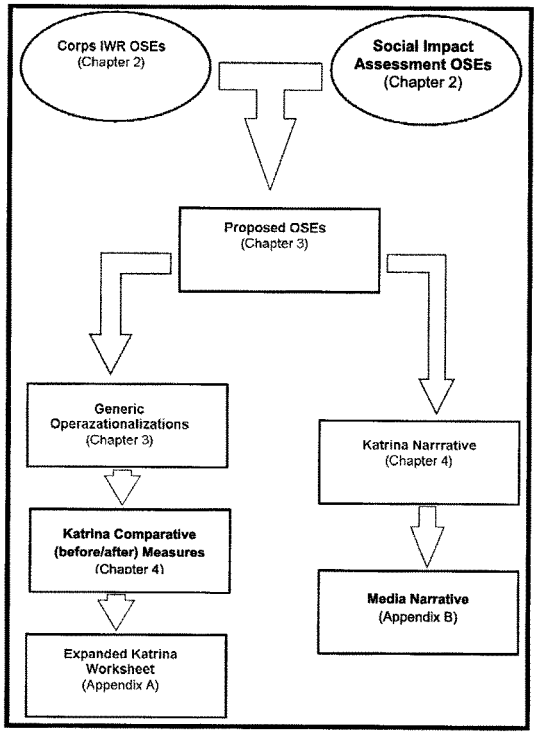
- The first is to incorporate the SIA approach of eliciting OSEs into the "defining and bounding the problem" approach the Corps already uses regularly.
- The second is for the Corps to utilize the results of the SIA process to collaborate with other resource stakeholders to conceive and implement the best package of risk reduction actions, the Corps' structural and non structural being just two.
- The third is to review the proposed OSEs and to embrace a more comprehensive array of them within the Multi-Criteria Decision Analysis (MCDA) currently being utilized by the Corps in the LACPR project selection process.
- The fourth is to use the OSEs and the SIA approach to refine the post-mortem assessment of flood disasters and to require legislatively such an analysis after every declared flood disaster.

In addition a description of the use of historical community analysis as part of the SIA is offered in an appendix.

What has not been considered in this report is the range of impacts from modest residual (overtopping) to major deep flooding caused by a breach and rapidly flowing water. This will be undertaken in Phase II of this project because it requires a project case, preferably case comparisons, to analyze the differences in degree of impact. Generally, the lower the level of flooding, the less impact; however, it is evident from Katrina that the higher ground, less-flooded areas suffer from co-dependency impacts with the more-deeply flooded such as being the recipient of those driven out of the deeply flooded areas.

Special thanks go to team members, Michelle Gremillion, a recent University of New Orleans Sociology masters graduate, who located all of the quantitative measures and prepared the quantitative portions of the report and Brad Ott, a current Sociology graduate student, who located the media vignettes and prepared that appendix to the report. The Association of State Floodplain Managers Foundation provided support for the participation of team member Chad Berginnis who brought the perspective of a participating mitigation expert with experience at the local and state level. In addition, the group would like to thank Joyce Broden-Douglas, UNO-CHART office coordinator, for logistical assistance for team meetings and Carrie Beth Lasley, UNO-CHART Research Associate, for managing the details of the report and for using Microsoft Word 2007 to its ultimate capacity in preparing the final document.

Report Flowchart



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Chapter 1: Introduction and Background of the Project

The U.S. Army Corps of Engineers has been specifying the benefits of their flood control projects for at least 72 years to determine which possible projects are appropriate for implementation. Over the decades four non-physical benefit "accounts" have been defined: National Economic Development (NED), Regional Economic Development (RED), Environmental Benefits (ENV) and Other Social Effects (OSEs). Interest in the Other Social Effects (OSEs) has vacillated over the decades but has never had much attention or refinement. The tremendous social impacts of the flooding caused by the breaching and overtopping of the hurricane protection levees surrounding New Orleans and its vicinity during Hurricane Katrina in late August of 2005 have prompted another surge of interest in the OSEs by the Corps. This project and report stem from that interest. The report team shares with the Corps the goal of contributing to the refinement of the OSEs in a manner that will make permanent a balanced consideration and use of all four accounts from now into the future.

A. History of OSEs

The Flood Control Act of 1936 differentiated between "tangible" effects – prevention of flood damage, 'higher' use of land and collateral benefits related to water and navigation – and "intangible" – loss of life, personal injury, sickness and epidemic, general preservation of community morale, recreation and wildlife (U.S. Army Corps of Engineers, 1943). While this early description only contains the concept "community morale," the text does make mention that the intangible benefits consist of the remaining "physical, social and economic security of the people."

It is not surprising for there to have been an underestimation of the importance of the social effects of flood-control measures when this legislation was implemented; the Corps was a physical science/engineering agency and the social sciences were in their infancy. However, as social sciences developed and attention was brought by their efforts to community processes and functioning during the mid-to-late 20th Century, a similar growing consideration and use of what the social sciences could reveal was not forthcoming in the Economic and Environmental Principles and Guidelines for Water and related Land Resources Implementation Studies of 1983, the guidance of Corps projects. As Dunning and Durden (2007:2) explain:

> "(G)uidance and plan selection criteria did not support the effects in the RED or OSE accounts as of primary importance to plan selection so such (prospective, *sic.)*) plans were marginalized and not the basis of plan formulation, selection or recommendation. In nearly all cases, this meant that such plans were not even developed or few resources were expended on them."

B. Recent Effort Pre-Dating This Report: IPET Report

"Planning in a Collaborative Environment" (EC 1105-2-409) initiated a new awareness for the need for the assessment of OSEs within the Interagency Performance Evaluation Task Force (IPET) although there was no specific requirement in the charge to the study team. Hurricane Katrina functioned as a wake-up call and reinforced this need. Recognition of the deficiencies in assessing projects absent of OSEs became clearly evident, but the lack of the OSEs being required placed the report as an appendix rather than part of the body of the report: Appendix 4. "Social, Cultural, and Historic Consequence," (U.S. Army Corps, 2006) although a "Social and Cultural Consequences Assessment Digest" was included in Vol. VII of the report. A very wide array of OSEs are represented therein grouped into **social, institutional/cultural and population**. Its focus is the impacts of the early recovery period and as such, contributes most to an appreciation of those very first effects. This report benefited from and draws from the IPET effort. Of special interest is the use and application by the IPET social science team of the concept "social well being."

C. Concurrently to IPET: IWR Documents

While this report was being developed, the latest Corps document considering OSEs was in its final edit stages. The research team for this report reviewed the two "white papers" that preceded the handbook's final draft (Dunning and Durden, 2007; Institute of Water Resources, 2007). Then, following completion of this first draft we reviewed the draft of the handbook (Dunning, 2008) and include comments herein responding to that document.

The two white papers by Dunning and Durden, prepared post-Katrina in 2006 and 2007, focused on OSEs, one a review of the Guidance and Procedures (G&P) and the second a review of the theoretical underpinnings of the OSEs. They surveyed numerous approaches for measuring social well-being, including human-needs literature, environmental justice, civic indices, quality-of-life assessments, and social-connectedness literature. They concluded that there were five key domains of well-being: material, distributive justice, status/recognition, health and safety, and connectedness. They also conclude that further work and an increased emphasis on OSE will be required in coming years. We draw heavily from their work because we support their intellectual arguments and believe that our best contribution to this effort comes in extending previous work to encourage important refinements with regard to honing framings of social impacts and arguing the importance of some as core elements.

D. Additional Frameworks for Informing the OSE Process

1. Social Impact Assessment

We emphasize an approach to assessing social effects that was not a focus either of the IPET report or the IWR work -- Social Impact Assessment (SIA). We believe that the SIA approach can be a very useful approach for the Corps to implement the community- and issue-engagement processes required for a full and successful consideration of the OSE account.

Accordingly, this report is aimed at extending the OSE analysis in two ways. First, the overall organization of the report is designed to show how SIA can be utilized to result in concrete measurable social effects co-evolved by the community and the Corps team. Second, we show how to extend the SIA methodology – usually used in future planning --to post-event analysis in order to examine after-the-fact extreme events such as Katrina.

Created initially in the 1970s, SIA has evolved and gained support and momentum from practitioners whose responsibility it is to consider the benefits/damages of community/regional projects, namely development. During its 40-year existence SIA specialists have created an international organization –

International Association for Impact Assessment – and gained an active international following with an annual conference. We appreciate that this approach was considered earlier by the Corps when the earlier interest in OSE prompted such methodology needs; however, we have been told that those who proposed it did not adequately connect it to the planning process existing at the time and thus it was found wanting. The approach we demonstrate will make that SIA/planning connection.

Social Impact Assessment

Social Impact Assessment: Determining in advance the consequences of an action to the way human populations live, work, play, interrelate, organize and cope, as well as the changes to societal norms, values beliefs routines and self-sustainability.

For more information visit the International Association for Impact Assessment: http://www.iaia.org/modx/

Social Impact Assessment (SIA) came out of the National Environmental Policy Act (NEPA) which required federal agencies, or agencies using federal funds, to assess and attempt to mitigate the environmental effects of their proposed actions. NEPA calls for a systematic, interdisciplinary approach to measure environmental impacts. NEPA led to a variety of social impact assessment techniques, summarized by Burdge (1994) and condensed into guidelines by the Inter-organizational Committee on Guidelines and Principles for Social Impact Assessment (1993; 2003). The Inter-organizational Committee on Guidelines and Principles for Social Impact Assessment (1993) is the most generally agreed upon, and in practice, used, description of the process of SIA.

There are two fundamentals to keep in mind. First, SIA is a process. Second, SIA was developed as a predictive tool. The process attempts to assess or estimate in advance what will happen if a particular action is taken. Gramling and Freudenburg (1992) developed a format (discussed below) to extend the assessment process temporally, but the original process is discussed with its focus on projection. In the next chapter the process of extracting relevant indicators and processes from SIA is discussed.

The Inter-organizational Committee on Guidelines and Principles for Social Impact Assessment argues that social impact assessment itself should occur as a series of steps. The steps below are selected from these guidelines which are patterned after the Council on Environmental Quality's (CEQ) Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (40 CFR 1500-1508). The relevant steps are paraphrased below. As you read them, think "water/flood protection project."

1. Public Involvement: Develop a plan to involve potentially affected community stakeholders. This step involves identifying and working with potentially affected groups. This should occur at the very beginning of conceptualizing a potential project.

2. Baseline Conditions: Describe the relevant human environment, the potential area of impact – both positive and negative -- and the baseline conditions. The baseline conditions are those existing conditions associated with the human environment in which the proposed activity is to take place. These would generally include:

- Relationships with the biophysical environment, including the ecological setting and those aspects of the environment that are seen as resources or problems; areas having economic, recreational, aesthetic or symbolic significance to specific people.

- Historical background, including initial settlement and subsequent shifts in population; developmental events and eras; general employment trends past or present; past or current application of particular technology (harvest techniques, hazard mitigation) relating to the environment.[1]
- Political and social resources, including the capacities of relevant systems or institutions (e.g., the school system); levels of residential stability; distributions of socio-demographic characteristics such as age and ethnicity; presence of distinctive or potentially vulnerable groups (e.g., low income).
- Culture, attitudes and community norms concerning the role of humans in the environment.
- Population characteristics including major economic activities; the labor markets and available work force; unemployment and underemployment; availability of housing, infrastructure and services; and seasonal migration patterns.

The level of effort devoted to the description will be commensurate with the size, cost, and/or degree of expected impacts of the proposed action. On-site investigations and the use of previous field studies and surveys, if appropriate, will be used. The specific variables to be measured are in Chapter 2.

3. Scoping: After obtaining a technical understanding of the proposal and the baseline, identify the range of probable social impacts to be addressed based on discussion with those potentially affected. During this step the specific SIA variables for further assessment will be selected. Ideally, all affected people or groups will contribute to the selection of the variables. The potential core variables are outlined in Chapter 2.

Relevant criteria for selecting significant impacts spelled out in the CEQ Regulations (40 CFR 1508.27) include the:

- Probability of the event occurring;
- Number of people including local populations that will be affected;
- Duration of impacts (long-term vs. short-term);
- Value of benefits and costs to impacted groups;
- Extent that the impact is reversible or can be mitigated;
- Uncertainty over possible effects; and
- Presence or absence of controversy over the issue.

Throughout the scoping process it must be realized that all communities are different, and that variables that, ultimately, prove to be very important in one community might not be so important in another. Ultimately which variables are critical involves some type of judgment, and by involving the affected population in making those judgments, the Corps practitioner ensures that the process to determine the social effects of the proposed project are the ones relevant to the community and thus will form the basis of the most successful project. The job of the Corps practitioner is also to suggest potential omissions for consideration and to assess the reasoning behind the community perspective. Sometimes, community frustrations with perceived lack of attention to community concerns, leads to resistance to an aspect of a project or the project *in toto*. This is the stage in the OSE process where real attention to community concerns can lead to a "buy in" to the subsequent actions. Avoidance of the concerns will inevitably lead to conflict among community members and between them and the Corps. Early partnering with responsiveness can build the basis for effective, successful project partnerships.

1 Note that we advocate for a full history of the community being conducted in Phase One when the project(s) considered to address the community's funding are large. See Appendix C of this report for a recommended approach to compiling such a history.

4. Projection of Estimated Effects: Investigate the probable impacts. The probable social impacts will be formulated in terms of predicted conditions without the actions (baseline projection); predicted conditions with the actions; and predicted impacts which can be interpreted as the differences between the future with and without the proposed action. This approach fully mimics the usual Corps planning process.

The empirical procedures are based on five major sources of information:

- Data from project proponents;
- Records of previous experience with similar actions as represented in reference literature as well as in Environmental Impact Statements;
- Census and vital statistics;
- Documents and secondary sources;
  Field research, including informant interviews, hearings, group meeting, and surveys of the general population. [2]

5. Predicting Responses to Impacts: Determining the significance to the identified social impacts. After direct impacts have been estimated the next step is to estimate how the affected people will respond. The actions of affected groups will be estimated using comparable cases and interviews with affected people about what they expect to do. Adaptation and response of affected parties can have positive or negative consequences of their own, both for the agency that proposes an action and for the affected communities, whether in the short-term or in the long-term.

6. Indirect and Cumulative Impacts: Estimate subsequent impacts and cumulative impacts. Indirect impacts are those caused by the direct impacts; they often occur later than the direct impact or farther away.

Information Sources

The following resources can be invaluable in collecting data for OSEs:

- U.S. Census Bureau: http://www.census.gov.
- FedStats: http://www.fedstats.gov
- National Park Service: History and Culture: http://www.nps.gov/history/
- Public Meetings
- Local Newpapers
- Local Historians
- Local Telephone Books
- Surveys

[2] Methods of projecting the future lie at the heart of social assessment, and much of the process of refined analysis is tied up in this endeavor. In spite of the long lists of methods available, most useful to the Corps OSE assessment, as to the other Corps "accounts," needs fall into the following categories:

- Comparative method, comparisons to other projects with known effects;
- Trend projections (straight line or curvilinear), taking an existing trend and simply projecting the same range of change into the future;
- Population multiplier methods, each specified increase in population implies designated multiples of some other variable, e.g. jobs, housing units;
- Scenarios, (1) logical-imaginations based on construction of hypothetical futures through a process of mentally modeling the assumptions about the variables in question; and (2) fitted empirical-similar past cases used to analyze the present case with experts adjusting the scenario by taking into account the unique characteristics of the present case;
- Expert testimony, experts can be asked to present scenarios and assess their implications;
- Computer modeling, involving the mathematical formulation of premises and a process of quantitative weighing of variables;

Cumulative impacts are those impacts which result from the incremental impacts of an action added to other past, present and reasonably foreseeable future actions regardless of which agency or person undertakes them (see 40 CFR 1508.7). A community residential and retail growth and pressures on government services following the siting of a major project are examples of indirect and cumulative impacts.

7. **Mitigation:** Where appropriate, explore a mitigation plan. Social Impact Assessment cannot only forecast impacts, but also identify means to mitigate undesirable impacts and enhance desirable impacts. Mitigation may be accomplished by modifying the project or how it is implemented, or by supplying additional information or support for the potentially impacted population or community. Mitigation potential should be identified early on as clearly as possible to assist project management to avoid problems where possible.

8. **Monitoring:** Develop a monitoring program where positive or negative impacts are expected to occur. A monitoring program should be able to identify deviations from the expected impacts from the project (i.e. unanticipated impacts). The monitoring plan should be able to compare real impacts with projected impacts. Recognizing the potential for unanticipated consequences and identifying some early warning signs of deviation from the expected is an important first step toward mitigating unanticipated consequences. While the response to these impacts may ultimately be done by the community, county or state government rather than the Corps, the consideration of the potential impacts during the creation of the project will assist those governments to be responsive.

a) Increasing Temporal Flexibility for SIA

Assessing impacts of development activities after they happen has a long history, particularly in rural sociology (Field and Birch 1988; see Landis 1933). This focus was sharpened in the early 1970s with studies of the effects of the construction of coal-fired generating plants in areas with large deposits of coal in the rural western United States. This "boomtown" model focused on population growth, which led to a host of associated and, frequently deemed, undesirable effects (Brabant and Gramling, 1986).

In specifically attempting to provide a more flexible tool for assessing socioeconomic impacts Gramling and Freudenburg (1992) developed a typology that allowed assessment over both time and the various human systems that are affected by the types of changes potentially brought about by developmental activities. Both of these traditions were combined in the National Research Council's *Cumulative Environmental Effects of Alaska North Slope Oil and Gass Activities.* (National Research Council, 2003).

This focus on post event assessment expands the analytical ability of the Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning (Dunning 2008). The SIA approach to OSE's will be applied in Chapter 2, by comparing its concepts with those proposed by Dunning and Durden, culminating in a set of OSE concepts, combining those proposed by the SIA and those proposed by Dunning and Durden.

2. Social Capital

Some relevant elements, such as natural capital, economic capital and physical capital, are measured, at least in part, when the Corps does economic and environmental assessments. The two most related to Other Social Effects are human capital and social capital. At the community level, human capital refers to the aggregate of individual capital such as education, knowledge and skills present in a community. **Social capital** is more complex and difficult to measure. The current state-of-the-science measure of social capital focuses on interpersonal relationships and involves a complex series of survey questions about the individual's involvement in social networks. Obtaining adequate data to create valid social capital metrics to evaluate the performance of alternative plans, or even of the

effects of a no-action plan, would be difficult. Because we believe that social capital is extremely important in the successful functioning of a community, we present the concept and its content below for appreciation of its importance and for consideration of possible future use. In addition, it is possible to appreciate the harm done to the social capital of New Orleans and communities in the vicinity by the levee breaks during Katrina in the narrative impact descriptions in Chapter 5 and Appendix B.

The concept has been gaining popularity, particularly over the past decade. Social capital can be defined as "the networks, norms and social trust that facilitate coordination and cooperation for mutual benefit" (Putnam 1995: 67). It is the quality and quantity of social interaction that define a given geographical location as a community. Social capital is not just the sum of a community's resources or institutions; it is the glue that binds them together.

Due to increasing evidence of the crucial role of social capital in economic prosperity and sustainable development, the World Bank now uses a Social Capital Implementation Framework for its projects, convinced that it enhances their quality, effectiveness and sustainability (http://go.worldbank.org/C0QTRW4QF0). This framework defines four dimensions of social capital:

- Groups and networks (collections of individuals that promote and protect personal relationships that improve welfare);
- Trust and solidarity (elements of interpersonal behavior that foster greater cohesion and more robust collective action);
- Collective action and cooperation (ability to work together to resolve community issues);
- Information and communication (open dialogue that includes both downward and upward flows of information).

Social capital is more complex and thus more difficult to measure than other types of capital. Measurement examples are available, however, such as those developed for the World Bank (Grootaert, et al., 2004). While the concept of social capital is a promising one, detailed examination of the Worlds Bank's measurement process has convinced us that this assessment process is not yet refined to the point that it would be appropriate for Corps projects.

We do believe that the concept of "community interpersonal capital" is a useful one, however, because it can be measured at the community level sometimes with already available secondary data. In Chapter 2 we detail this concept, which breaks out into two elements: 1) Ideal community interpersonal conditions and 2) interaction means to achieve the conditions.

3. Community Capital and Social Resilience

A community can be described in terms of its capital or assets. These assets run the gamut from natural resources to social networks to cultural norms and together they describe the well-being or quality of life of a community. A capital-based approach is often used when assessing a community's sustainability and resilience (cf. Callaghan and Colton 2006). Emphasis on sustainability, simply defined as being able to meet today's needs without compromising the ability of future generations to meet theirs, has given way to the more complex concept of resilience.

A simple but useful definition of resilience is "the capacity of a system to absorb disturbance and re-organize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks" (Walker et al., 2004: 5:1). When a community has high and sustainable levels of capital, it also will be more resilient. Measuring the total effects of an event/activity/incident/episode (hereafter event) requires looking at communities in

a more comprehensive and collective manner. This can be accomplished by examining the component categories of capital that make up a community.

The group believes that an important consideration for any proposed project is how well and in what way it contributes to the sustainability and resilience of the community, and that these considerations should be forefront in Corps practitioners' minds as they work with community members to identify potential project impacts, both positive and negative.

These principles of sustainability and resilience are values. While such value decisions are negotiated in the process of the community considering the "neutral" concepts offered by the SIA approach, recent work evolving in parallel with SIA work argues that the values should be stated in the approach, not taken for granted.

E. Regulatory Guidance

The social science experts comprising the team for this project commend the Corps of Engineers for recognizing the needs that have been articulated — in Congress, in affected regions, and in the expert community itself — to address the social impacts and effects of Corps projects. In particular, the team noted the importance of the planning objectives identified by the Corps — including reductions in risk to public safety as well as the economy from catastrophic storm inundation, and sustaining the unique heritage of coastal Louisiana by supporting traditional cultures.

Where the team saw a greater need is in the relatively specific performance metrics for achieving these planning objectives. This process is aided by the existence of two key resources. The first is the clear regulatory guidance, in the Regulations for Implementing the National Environmental Policy Act of 1970, as amended (42 U.S.C. 4371 et seq.), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609) and E.O. 11514, Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977) (see 43 CFR [Code of Federal Regulations] 1500 *et seq*; online at http://www.nepa.gov/nepa/regs/ceq/1500.htm.

The second is the additional guidance provided by the professional community — the internationally recognized *Guidelines and Principles For Social Impact Assessment*, (paraphrased above) initially prepared by the Inter-organizational Committee on Guidelines and Principles for Social Impact Assessment (SIA), and subsequently published both in the peer-reviewed technical literature and in the form of agency guidance (Inter-organizational Committee on Guidelines and Principles for Social Impact Assessment 1994). For online access, see http://www.nmfs.noaa.gov/sfa/social_impact_guide.htm.

One of the principles that comes through clearly from both the CFR regulations and from the *Guidelines and Principles* is that assessments should focus on the impacts that are most important, and not those which are simply easiest to measure or for which there is "low hanging" data. In the language of 43 CFR 1502.2(b), "(i)mpacts shall be discussed in proportion to their significance." This significance for SIA is arrived at during the scoping process discussed above. The issue of significance also receives a clear definition (see 43 CFR 1508.27), as requiring considerations of both context and intensity:

"(a) Context. This means that the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of the proposed action. For instance, in the case of a site-specific action, significance would usually depend upon the effects in the locale rather than in the world as a whole. Both short- and long-term effects are

relevant.

"(b) Intensity. This refers to the severity of impact. Responsible officials must bear in mind that more than one agency may make decisions about partial aspects of a major action." The considerations identified in the regulations for evaluating intensity include, among others,

- the degree to which the proposed action affects public health or safety,
- the degree to which the effects are likely to be highly controversial, and notably,
- the degree to which possible effects are uncertain or involve unique or unknown risks (CITATION: 43 FR 56003, Nov. 29, 1978; 44 FR 874, Jan. 3, 1979).

The regulations also specify that "significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment." Lest there be any ambiguity, the following clarification is provided in the next sentence of the regulations: "Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts" (43 CFR 1502.27(b)7).

A comparable theme is picked up and spelled out in *Guidelines and Principles*, having to do with the importance of clearly identifying both those who will win and those who will lose — a process that, based on decades of accumulated experience, requires an emphasis on vulnerable and under-represented groups:

"Impacts should be specified differentially across affected groups and not just measured in the aggregate. Identification of all groups likely to be affected by an agency action is central to the concept of impact equity.... [N]o category of persons, particularly those that might be considered more sensitive or vulnerable as a result of age, gender, ethnicity, race, occupation or other factors, should have to bear the brunt of adverse social impacts.... SIA has a special duty to identify those whose adverse impacts might get lost in the aggregate benefits."

Sec. 1502.6 Interdisciplinary preparation. Environmental impact statements shall be prepared using an interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts (section 102(2)(A) of the Act). The disciplines of the preparers shall be appropriate to the scope and issues identified in the scoping process (Sec. 1501.7).

Chapter 2: Proposed Other Social Effects

Recommending a framework of OSEs for selective application to assessment of projects and impacts is extremely challenging. One can run the gamut from declaring, only in abstraction, the principles upon which to undertake the assessment and encouraging the iteration of them in practice, to over-specifying the concepts that should be considered in an attempt to provide assistance in appreciating the possibilities. While we want to emphasize that the community in conjunction with the Corps should select their measures of project success, we want to also participate in the "conversation" begun by IPET and the IWR documents about the key OSEs.

A. Selecting Other Social Effects (OSEs) Assessment Concepts Using the Social Impact Assessment (SIA) Approach

Measuring "other social effects" of an event involves two conditions. First, for an effect to occur there must be a change in social conditions. Second, in order to determine the existence and extent of change there must be measurement before and after the event or project. Measuring this change requires assessments at two points in time, each requiring different tasks. If assessment occurs before the event (such as the building of a levee), measurement of both current conditions and a projection of post-event conditions with various scenarios, if appropriate, are needed.

The measurement of current conditions in this case is the "without project" condition and the various projections are the "comparisons of different alternatives."

If assessment occurs after the event (such as the overtopping of a levee), a measurement of current conditions and an historical measure of pre-event conditions are necessary. The comparison of various scenarios in this case is not appropriate because the actual facts of the historical event dictate the "after" scenario. One comparison that can be made is the early post-event condition and then the later, i.e. short- and long-term impacts.

Two conditions are important when selecting social indicators. First, they need to be available historically, currently, and be possible to project for the future. Second, social effects are virtually infinite; they can range from psychological states influenced by social dynamics to national economics. Katrina, as discussed in Chapter 3 and Appendix B, is a major event that has affected both of these and everywhere in-between. Thus, it is almost impossible to capture all social impacts (Inter-organizational Committee on Guidelines and Principles for Social Impact Assessment 1993; 2003).

Therefore, parsimony is critical in the selection of indicators. Individual level changes would be impossible to measure because individuals respond differently. National indicators are likely to go beyond the scope of most events and thus not be relevant (Katrina being an exception). For these reasons, it is most appropriate to measure Other Social Effects at the community level.

In developing OSE indicators for this project, it was important to build on earlier efforts. For this reason we used relevant indicators from the SIA literature as a starting point, particularly those referenced in the Inter-organizational Committee on Guidelines and Principles for Social Impact Assessment, the most widely recognized standard. These were then compared to indicators previously identified by the Corps' Institute of Water Resources social scientists as Other Social Effects (Durden & Dunning, 2007). In many cases they were virtually identical; in others, differences are in the level of detail, but in some cases, one set addressed an issue that the other did not. The two sets of indicators are arranged side by side in the following table for comparison purposes.

Table 2.1: Comparison of SIA and Corps IWR OSE Concepts

SIA OSEs	Corps IWR OSEs
Population Characteristics	**Population Characteristics**
Population	Population size, population density
Ethnic, racial and gender distribution	Community homogeneity or diversity
	Ethnic diversity
	Age diversity
Identification of vulnerable populations	
Influx or outflows of temporary workers	Net migration, internal migration
Seasonal residents	
Displacement/relocation	Displacement, people, businesses and farms
Community and Institutional Structures and Resources	**Community**
Housing characteristics	Housing supply
	Neighborhood quality
	Social institutional stability
	Housing costs
Voluntary associations	Community ties
	Strength of community identification
	Community values
Residential stability	Residential stability
Commercial/business stability	
Industrial/commercial diversity	
Interest group activity	
Identifications of stakeholders	

SIA OSEs	Corps IWR OSEs
Identifications of stakeholders	
Employment/jobs/income characteristics	**Income and Employment Measures**
	Income opportunities
	Personal income
	Income dispersion
	Income stability
	Labor force characteristics
	Economic activity of the population
	Employment distribution (especially to minorities)
	Labor/job stability
	Occupational distribution
Local/regional/national linkages	
Historical experience with change	
Income equality (e.g. Gini coefficient, % below poverty)	Socioeconomic diversity
Density of acquaintanceship	
Family and friendship networks	
Informal exchange networks	
Perceptions of risk, health, and safety	
Community infrastructure	Other community services
	Adequacy of water supply and utility service
	Adequacy of transportation infrastructure
	Adequacy of other community services
Educational infrastructure and personnel	Educational opportunities
	School enrollment
	Protection of educational facilities

SIA OSEs	Corps IWR OSEs
Health/medical care facilities and personnel	**Life, Health and Safety Measure**
	Personal health and safety
	Risk of injury
	Morbidity, especially exposure to water and air pollution
	Mortality [death dates moved to "population" in proposed column]
	Population segment differences in health and safety
	Safety of property
	Risk of property damage
	Effects of damage on quality of life
	Population segment differences in risk to property
	Institutional protection
	Adequacy of medical facilities and personnel
	Adequacy of emergency protection
	Population segment differences in access to institutional protection
Community social services	
Land use patterns	
Access/proximity to basic goods and supplies	
Effects on cultural, historical, and archaeological resources	
	Recreational and Cultural Opportunities
	Recreational and cultural participation
	Diversity of recreational and cultural opportunities
	Adequacy of recreation areas and cultural opportunities
Political and Organizational Resources	Fiscal condition of state, regional and local government
Size and structure of local government	
Planning and zoning environment	
Interested and affected publics	
Leadership capability and characteristics	

SIA OSEs	Corps IWR OSEs
NGOs, local associations	**Emergency Preparedness Measure**
	Water transportation needs
	Waterway accessibility of major distributive centers
	Efficiency of the water transportation system
	Water transportation protection
	Water supply needs
	Quality of water supply
	Quantity of water supply
	Diversion potential of water supply
	Power supply needs
	Overload capacities of power supply
	Efficiency of water-related energy sources
	Protection of infrastructure
	International treaty requirements
	Compliance with water-related treaty requirements
	Aesthetics Measure
	Resources
	Visual unity
	Visual compatibility
	View shed
	Fragility/scarcity
	Naturalness
	Social
	Preferences
	Community values

As a final step, we compiled a new refined list of what the team considered to be relevant indicators. They are grouped under three broad concepts labeled as population characteristics, community capacity (institutional resources) and community capital.

One additional source of ideas for the indicators also was utilized because of the quality of the effort. The U.S. Forest Service (Bright, Cordell, Hoover, and Tarrant 2003) has developed a human dimensions framework, a set of guidelines for conducting social assessments. The guidelines are organized around the five concepts: 1) historical background, 2) population characteristics, 3) cultural, 4) social organization structures and processes, and 5) public perceptions and well-being. Because of their level of specificity and their focus on Forest Service concerns we did not incorporate the guidelines into this document. However, because we feel that doing an initial historical analysis of the affected community is such an important beginning step, Appendix C provides an example of the way in which this federal agency approaches the dimension of "historical background" (Appendix C).

Chapter 3: Proposed OSEs and Sample Operationalizations

This chapter is comprised of the list of proposed OSEs created with the assistance of the SIA literature and those suggested by Durden and Dunn at the Corps' Institute of Water Resources. Following the list, a second list shows a sample of operationalizations of these OSEs.

In Chapter 4, following the narrative description of the OSEs in New Orleans after Katrina, some of the OSEs are applied quantitatively showing the calculated differences in them before and after the storm.

Childhood Anxiety

34% of New Orleans' children were separated from their primary caregiver after Katrina.
14% of New Orleans' children saw family members or friends killed during Katrina
For more Katrina social statistics, view Appendix A

Finally, the detailed list of OSEs quantitatively applied to Katrina in New Orleans is found in Appendix A followed by the qualitative vignettes from the media.

Figure 3.1 Proposed OSEs: Population Characteristics

1. POPULATION CHARACTERISTICS

- Size, density, births, deaths
- Ethnic, racial, age and gender composition
- Vulnerable populations (culturally unique populations)
- Permanent and temporary (im/e)migration
- Transient residents (including tourists, seasonal residents, and migrant workers. Homeless persons are a unique transient population considered under housing.)

Figure 3.1.2 Proposed OSEs: Community and Institutional Structures and Resources

2. Community and Institutional Structures and Resources

Education

- Educational opportunities
- Educational physical infrastructure and personnel
- Traditional knowledge, especially ecological

Criminal Justice

- Community crime/violence safety
- Police, court, incarceration, domestic violence shelter facilities and personnel
- Informal 'policing' by community members

Neighborhood/Housing

- Housing characteristics: supply, cost, condition, tenancy (rent vs. own)
- Residential stability
- Community sub-area infrastructure, public service and neighborhood businesses
- Homelessness
- Historic buildings and districts

Household/Family

- Density/Home sharing
- Dissolution

Business

- Commercial/business stability/diversity
- Small business sector
- Informal exchange (bartering) networks
- Family livelihood systems

Income, Employment, Labor Force

- Economic activity of population
- Livelihood activities of community
- Personal/household income
- Personal household livelihood
- Employment/income dispersion/stability
- Occupational diversity
- Community socioeconomic characteristics

2. Community and Institutional Structures and Resources

Health and Physical Safety

- Healthy lifestyle
- Access to clinical care services (especially: trauma, gastrointestinal, neurological, diarrheal outbreak investigation, poison control referrals, national pharmaceutical stockpile, etc.)
- Access to disaster mental health services (especially: psychological first aid, mental-health referral)
- Access to environmental health services (especially: septic and water inspections, food service inspections, surveillance for vector-borne diseases)
- Access to specialized high-technology lifesaving equipment and therapy (e.g.: dialysis, ventilators, ACLS, ATLS, etc.)
- Informal care-giving systems
- Access to specialized services for vulnerable populations unable to physically or psychologically access necessary care
- Community health risk factors – environmental, mental health exposure, vulnerable populations

Mortality rates, causes

- Surge facilities and personnel (e.g.: emergency-worker liability, ESAR-VHP volunteer call-up systems)

Governmental Organization

- Organizational structure and functioning of government
- Sustained critical infrastructure (especially: telecommunications, water, sewage, power, streets, public buildings, etc.)
- Provision of public services (e.g.: planning, taxation, permitting, public transportation, education, public health, emergency ops/incident command, etc.)
- Exercise of democratic participation (e.g.: voting, letters to the editor, civil action groups, billboards and posters, etc.)

Community Social Services

- Availability and access to basic range of formal social service programs (e.g.: family counseling, parenting, family violence, seniors, chemical dependency, children services including child care, disabilities, welfare benefits/job training, foster care, mental health, disabled transportation, etc.)
- Informal instrumental support services, especially for the children, elderly, physically or mentally disabled, and other vulnerable populations. (e.g.: extended family members caring for the young and the old, or faith communities providing meals-on-wheels, home repair, shopping, transportation, or emergency first response.)

Figure 3.1.3 Proposed OSEs: Community Interpersonal Capital

3. COMMUNITY INTERPERSONALCAPITAL

Ideal Interpersonal Conditions

- Trust of government
- Community identification/attachment
- Community cohesiveness
- Community cooperation and tolerance
- Density of social networks and linkages between networks
- Distribution and sharing of resources and power
- Civil and human rights
- Environmental justice
- Community diversity
- Shared narratives, places, meanings, histories and spirit

Interaction Means to Achieve Conditions (Social Structures Mediating Human Interactions)

- Community leadership – informal and formal
- Informal governance
- Political organizations and citizen political involvement
- NGO adequacy vis-à-vis community needs
- Voluntary associations and membership
- Religious organizations
- Neighborhood (place based) voluntary organizations and sharing
- Friendship/family networks
- Regional/national linkages
- Print and electronic media array, diversity, access

Following the development of a consensus for the important OSEs, the next step is to develop agreed-upon generic operationalizations of the concepts, utilizing the common ways developed by the relevant social sciences and economics. While not applied to each of the examples below, many operationalizations can be calculated based on a rate per number of residents. The use of such a rate permits comparison of the affected area with itself before the event, or before the structure is built and between it and other communities.

Table 3.1.1 Operationalization Examples of Proposed Population OSEs

Population Characteristics	
Dimension	**Examples of Generic Operationalization**
Population Patterns	▪ Population estimates. ▪ Number of birth & deaths per 1,000 residents.
Demographics	▪ Number of males per 100 females. ▪ Racial and age breakdowns of the area's population.
Vulnerable Populations	▪ Number of residents living below the national poverty line. ▪ Number of residents over 65 years of age. ▪ Number of disabled residents.
Immigration & Emigration	▪ Number of residents moving out of the area each year. ▪ Number of new people moving in each year.
Transient residents	▪ Number of tourists to the community per year. ▪ Estimated number of migrant workers to the area per year.

Table 3.1.2 Operationalization Examples of Proposed Community Capacity OSEs

Community Capacity	
Dimension	**Examples of Generic Operationalization**
Education	▪ Number of Students enrolled in school (by type). ▪ Educational Achievement (measured by standardized test scores). ▪ Number of open schools. ▪ Number of educators employed.
Criminal Justice	▪ Number of violent crimes per 1,000 residents. ▪ Number of police officers and court personnel employed.
Neighborhood/Housing	▪ Average home values. ▪ Number of home sales per month. ▪ Average monthly rent. ▪ Breakdown by housing type (Single-family, multi-family, etc.). ▪ Tenancy (percentage owner-occupied and rental). ▪ Estimated number of homeless people in area.
Business	▪ Number of employers total and by sector. ▪ Number of small businesses in the area.
Income, Employment & Labor Force	▪ Local sales-tax collection. ▪ Median individual & household income. ▪ Median income by age, race and gender.
Health & Physical Safety	▪ Analysis of the types of medical services offered (ex: MRI). ▪ Number of hospital beds per 1,000 residents. ▪ Number of hospitals, pharmacies, mental-health facilities and nursing homes. ▪ Number of licensed healthcare professionals practicing in the area.
Governmental Organization	▪ Resident satisfaction with local government.
Community Social Services	▪ Number of childcare facilities. ▪ Access to public transportation. ▪ Number of chemical-dependency treatment centers ▪ Number of job-training centers, etc.
Cultural, Historical Landmarks, Aesthetic Support	▪ Number of county/parish-run parks, playgrounds, community centers, senior centers and other facilities. ▪ Number of museums, parks, arenas, etc. ▪ Number of annual festivals held.

Table 3.1.3: Operationalization Examples of Community Interpersonal Capital OSEs

Community Interpersonal Capital	
Dimension	**Generic Operationalization**
Ideal Interpersonal Conditions	▪ Attachment to place, likelihood residents will leave the area. ▪ Participation at public meetings. ▪ Environmental justice, civil rights and sexual harassment lawsuits. ▪ Ethnic breakdown of the area.
Interaction Means to Achieve Conditions	▪ Approval ratings of leading local officials. ▪ Number of non-profits. ▪ Charitable giving. ▪ Voter turnout. ▪ Number of religious/worship centers.

Chapter 4: Applying the OSE Concepts to Hurricane Katrina Impacts: A New Orleans Example

Increased Homelessness
13.22/1,000 Estimated homeless rate in New Orleans prior to Katrina
50.18/1,000 Estimated homeless rate in New Orleans after Katrina
For more Katrina social statistics see Appendix A.

This chapter provides an extended example of the considerations that would be necessary in order to apply the proposed OSE indicators to what might be considered an almost worst-case scenario: the overtopping and breaching of the levees and flood walls in New Orleans during Hurricane Katrina. As such it does ***not*** represent an OSE analysis of that event, but an example of the types of measures that would be core. An actual OSE analysis of the overtopping and breaching of the levees and flood walls in New Orleans during Hurricane Katrina would involve the actual data collection associated with each of the potential indicators which are discussed in a conceptual format below. There would then be a comparison of before/after to see what the effect had been. We have attempted to demonstrate such data collection at the end of this chapter. While we have not captured measures of all of the OSEs that may be useful in understanding the impact, we have provided, we believe, sufficient numbers to demonstrate the approach and selected effects. It is also important to remember that the final list of variables/indicators would be arrived at in conjunction with the affected population, not done in this fashion, i.e. by the team without input from them.

Borrowing from the SIA approach, each indicator is considered to be "neutral," (neither negative nor positive), while it is understood that the difference between pre- and post-event measurements will be considered differentially "good" or "bad" and by different segments of the population. By taking this approach the process is useful for the analysis of projects – both benefits and drawbacks – of proposed actions and structures, and for assessing the residual damage, and breach damage, of different existing risk reduction actions and structures.

For the sake of the example presented herein, the first author of this report has made a value judgment as to what "direction" of the concept is negative, for example, **increased** rate of homelessness, a **decreased** rate of hospital beds per a specific number of residents. Each of the indicators is discussed based on local knowledge about the effects of the flooding associated with Katrina It is compiled out of conversations with other locals over the past

three years and from media reports. Because the author's expertise and access to information about each of these categories of variables has not been uniform, the level of detail in the discussions varies. And the economic variables that are socially relevant have not been described because they are not her specialty. However these discussions are examples both of the types of issues that Corps practitioners would take into the field to decide which indicators are most critical in order to inform data collection and an example of the wealth of local knowledge that is available to residents and investigators.

A. Population Characteristics

- *Size, density, births, deaths*
- *Ethnic, racial, age and gender composition*
- *Vulnerable populations (culturally unique populations)*
- *Permanent and temporary (im/e)migration*
- *Transient residents (including tourists, seasonal residents and migrant workers)*
- *[Note: Homeless persons are a unique transient population considered under Housing.]*

Currently, the OSE account is represented by only two human social effects and their measures, the one relevant to this grouping being the concept "Residual Population Impacted." This is the population affected by the proposed project, either benefited or negatively affected. For damage from an overtopping (or breach), the same term can be applied. What population was harmed due to the overtopping or the breach that would not have been if the structure had been higher or had not breached.

Population size, density, births and deaths. These include the size of the population, its density, and birth and death rates. Because flood reduction projects are community (space) based, density fluctuations must be considered along with the basic birth and death rates.

The flooding of Hurricane Katrina has reduced the population within New Orleans about 30 percent at the three-year-out date. This population reduction has been caused by all of the measures mentioned within this section:

- **Birth decline** due to the absence of the population, especially women of child-bearing age, the severe damage to hospitals with maternity wards and anticipated lack of child care and other support services.
- **Death increase** due to those killed by initial force of water through the breaches, those who drowned as waters rose in residents' homes and those who died of heat prostration as they remained in their homes trapped by the surrounding flood waters. In addition, the deaths, especially of those elderly and medically frail, in the evacuation process and shortly thereafter, contributed to the mortality impact of the breaching. In addition, indirect mortality due to mental stress and disruption of care has been documented, though the magnitude of mortality remains controversial.
- Residential, commercial and neighborhood **density** were affected in the flooded areas as they initially became ghost towns and now continue to suffer from limited, and scattered recovery. Termed "the jack o' lantern affect" – lights scattered widely at night, reduction in density challenges the ability of the community to provide public and commercial services economically and adequately and to have neighborhood family and friends contribute supportively such as in child care, crime alerts, assistance to the elderly, etc. It also lowers the streetscape expectations of urban residents.

Ethnic, racial and gender composition reflect a community's identity and in terms of gender, functionality with regard to reproduction. The authors of this report make the assumption that the **ethnic** and **racial** groups represented within a community prior to a disaster should have equal rights to return to the community to which they are attached and to the homes and businesses which they own and the apartments many inhabit. A similar assumption is made with regard to **gender** composition; when it shifts significantly after a disaster, there is a need to ask if the shift was forced rather than being due to choices people are making:

- Following Katrina, the **African-American** composition of New Orleans declined significantly. To a great extent this was due to their residential location in two large areas that received dramatic damage: the Lower Ninth Ward and New Orleans East. However, for lower-income African Americans the ability to return also was reduced by the limited personal resources upon which to base the initial capacity to return. The vast majority of lower-income residents were not homeowners. Public housing was shuttered and then demolished, reducing the ability of the very poor from the beginning to re-establish themselves in inner-city neighborhoods. Rental housing was slower to recover as this was not prioritized in recovery programs.
- For upper-income African Americans in New Orleans East, professional training and some personal wealth permitted families to relocate to urban business centers within the south such as Houston, Dallas and Atlanta where new beginnings could occur.
- The group most severely impacted by the flooding of the city were lower-income, pre-dominantly African-American female-headed households, many of whom continue to live as displaced persons. This impact reduced the **ratio of women to men** within the city. In addition, construction labor, coming to the city without families, enhanced the ratio of men to women. Both of these dynamics continue at this report time, three years after the floods.

Vulnerable populations. This concept, like the right of original racial/ethnic groups to return to their homes and neighborhoods, must be analyzed in order to ascertain a community's value system vis-à-vis it. However, general assumptions can be made that certain groups within the population are more vulnerable to harm, in terms of a disaster, than others. Vulnerable groups include the poor, children, the elderly, the infirmed, the physically and mentally ill and mentally challenged, women subject to domestic violence by their partners, ethnic groups whose dominant language is not English, and undocumented workers who fear legal impacts. The manner in which residual or breach flooding affects the vulnerable populations became extremely evident in Katrina:

Katrina's impact on the elderly

Recalling neighbors who have left New Orleans following Hurricane Katrina, a reporter writes: "Some of our relatives and friends were too old and feeble to rebuild. They are gone from the city for good, and we ache for them. Others were too angry to stay, overcome by the levees' unnecessary failures. We understand their need to move on." (Saulny, 2007)

Vulnerable Populations More, pages 81-82.

- The **poor** did not have cars, money for gas, lodging, food etc., for an evacuation, not to mention an extended period away from the city.
- The fate of lower-income **children** was extended out from the initial need to safely evacuate: access to adequate temporary and long-term housing, to child care, enrollment in school, health care, mental health assistance, and adequate/healthy food, etc.
- The **elderly** resisted evacuation because of the uncertainties of being able to negotiate the experience, not knowing where they were being taken, lacking significant others to care for them, access to health care of familiar caretakers, etc. Many died prematurely or were subject to being in dependency situations with relatives who were not expecting it to occur at their age. The elderly in nursing homes were subject to inadequate evacuation plans. Some facilities never attempted to evacuate their residents. Others discovered that their contracts for evacuation vehicles were not honored because the same vehicles had been contracted to other homes as well. Still others who were evacuated were too frail and sickly to survive the trip.
- **Special-needs populations**, defined as those whose illnesses required special equipment and special handling, were challenged by inadequate vehicles, illnesses that precluded moving and decisions about the

safety and functionality of hospitals that did not bear out with the severity of the flooding and the lengthy delays in rescue.

- **Domestic violence victims** lost the judicial protection with the loss of the criminal-justice system. Additionally, some victims were placed in situations where they had to share evacuation with the partner who abused them. Similarly, domestic violence specialists believe that more violence occurred within the inordinately tight and stressful living conditions that prevailed. Also, the inability of men to protect and provide for their families, a traditional cultural expectation on men, put stress on them that may have led to more domestic violence in the evacuation and long-term temporary housing situations.
- **Foreign language-speaking ethnic groups.** The inadequate information translation and communication into other languages reduced access by ethnic groups to necessary evacuation and recovery information.
- **Undocumented construction workers.** The disaster encouraged the in-migration of undocumented workers who did not have access to legal protection from wage and rental abuse. Health care was difficult for them to access. In the event of another disaster, these in-migrant groups suffer from inadequate evacuation knowledge and reluctance to participate in the public evacuation process for fear of being discovered as illegal immigrants. In addition, the desire to benefit from employment opportunities immediately post storm will lead to the undocumented workers remaining here if another storm threatens.

Permanent and temporary (im/e)migration. Population changes occur after a flood disaster. Pre-storm residents leave temporarily and out-of-town residents decide to come temporarily to volunteer and for the purpose of recovery-related employment. In addition, both original population and in-migrant members decide to leave or come into the community for permanent relocation.

The **decimation of the population** within New Orleans (Orleans Parish) was striking. Its recovery has been slow, still one-third smaller than pre-Katrina, though the greater New Orleans area appears currently to be down about 10 percent. The storm appeared to exacerbate a trend of longer-term population decline in Orleans Parish. Labor shortages slowed recovery immediately after the flood as some businesses recovered and recovery jobs began to be identified.

- The **in-migration** of new residents positively contributes to human resources but it also requires adjustments: competition for housing with original residents trying to return; increasing cost of rental housing due to this competition; competition for jobs held by original residents before the event; adjustment in translation needs as immigrants come from new ethnic groups; even provision of food such as was demonstrated by the public debate about taco trucks functioning as restaurants for the in-migrant Hispanic construction laborers. Ethnic tensions also may occur as was demonstrated by the resistance to allowing the trucks to continue operating.
- New Orleans is notable in having the highest nativity rate of any major metropolitan area of the country. This resulted in special difficulties associated with immediate and prolonged displacement. Many of not all of the households in the extended families were local and thus also flooded.
- For those original residents who had to remain in temporary housing away from the city for extended periods of time, the struggle to maintain adequate employment, child care, schooling of children, ability to supervise house repair, participate in neighborhood association activities, etc., was overwhelming to many. Some were able to succeed in achieving balance until they were able to return. Others were not and evolved to a decision not to return.
- When elderly family members yearned to be back in familiar surroundings, the challenges for them and their younger family members in making return/relocation decisions was (is, as the dilemma continues for many) tremendously taxing. When the decision of the elderly and the younger family members deviates, the elderly return to a situation much more at risk to crime and inadequate evacuation than was the case before the storm.
- For those who decided **to emigrate** permanently out of the city, the pain of loss of place in a city that may in fact warrant its self-proclaimed title as the most place-attached city in the country, has haunted many. Visits by former residents to the city to participate in festivals are a reflection of the continued attachment.

Transient population for New Orleans is the tourists, who support the prime economic sector, and the homeless, some of whom come during the mild winters. No agriculture exists within the city and consequently agricultural labor is not an issue for the area. Since the storm, tourism has been challenged to return to pre-storm levels, especially the larger conventions and most particularly during hurricane season. This decline in the recreational/convention population is a dramatic threat to the economic viability of the tourism-based economy. Especially at risk are the internationally renowned restaurants within the tourist sector. Unlike other businesses whose employees can fluctuate with the rhythm of the tourists, fluctuating restaurant staffs is much more difficult for these businesses. The lack of tourists during hurricane seasons may plunge the city into an economic recession after the burst of reconstruction activity recedes in a few years.

B. Community Capacity

1. Education

- *Educational opportunities*
- *Educational physical infrastructure and personnel*
- *Traditional knowledge, especially ecological*

Educational opportunity within the city came to a full halt following the storm.

- The public school system has been divided following the flood between city schools, state-controlled (those who were below state standards before the storm) and charter schools within both systems. This change to a predominantly charter system may, in the future, be assessed as beneficial, but the assessment has not yet been made; it is feared that the achievement of the students within them is due the informal selection process and may preclude some children from public education. To have to make such a **dramatic organizational change** post-catastrophe put severe strain on the K-12 system. The truancy rate for the children who have returned to the city has been reported to be extremely high. However, the storm also opened the opportunity for needed structural change in the educational system, one recognized to be among the most failed systems in the country.

Disaster capitalism?

New Orleans' public school system was in crisis even before Hurricane Katrina devastated it. Since then said a report, a grand educational experiment has unfolded. Officials converted 43 salvaged schools to free-market charter schools – with varying levels of results.. (Berger, 2007)

Schools More, page 83.

- Following the storm, all public school **teachers and staff** were put on furlough without pay because of the lack of funds and the uncertainty of need. This financial hardship caused many to leave the area, not to return when the schools finally re-opened. Recruitment of teachers has been a challenge. Bonuses have been necessary to attract out-of-town teachers. An extensive planning process was required to identify where new schools should be built. Financing a charter system has posed some cash-flow problems. Cafeteria and bus services have been restricted. The mental-health challenges of the children, because of storm stress, have put extreme pressure on school counseling. Similarly, parents struggle with transportation issues to get their children to schools not located in the neighborhoods in which they live. And some teenagers are living alone in order to return to New Orleans schools while their adult family members are still within the diaspora living somewhere else.

The educational **infrastructure** of the city was severely damaged, the personnel were scattered and many were terminated from employment.

- The three historically black colleges/universities received the most serious damage from the flooding. One --Southern University of New Orleans-- continues to hold classes in prefab buildings while repairs proceed slowly. Dillard University held classes and housed faculty and staff in downtown hotels for a year.
- Public, private, religious K-12 and colleges/universities (except for Loyola University and Holy Cross College) all suffered very expensive **damage** from the flooding. Many of the public school buildings have not been restored; rather, they will be demolished.
- **Enrollment** efforts remain challenged at several of the colleges and universities, namely Dillard, the University of New Orleans and Southern University of New Orleans. All the universities experienced some degree of flooding and wind damage and have taken varying lengths of time to recover. The devastation of the surrounding neighborhoods has discouraged students from returning to "isolated" campuses.

Much knowledge that a society holds is acquired by citizens by virtue of their interaction with their surroundings; especially important is knowledge of the ecosystem in which it lives. This is called **traditional knowledge, especially ecological (TEK).** The storm and the floods threatened this knowledge by virtue of the physical destruction of the communities, and thus, the fracturing of the interpersonal and human/ecosystem dynamics. This then threatens the acquisition of such knowledge by the younger generation who is removed from that learning environment which would be provided by elders. Such subtle, fragile learning processes may not be able to be reconstituted. The local natural-resource extractors, would be an example of a group who holds TEK and whose knowledge base is threatened. An example is the Louisiana coastal shrimpers, including the fleet within Orleans parish. It might even be proposed that a paramount example of such traditional knowledge is that of jazz. Emanating from the neighborhoods, this unique indigenous American music and a core New Orleans cultural element, has been severely threatened.

2. Criminal Justice

- *Community crime/violence safety*
- *Police, court, incarceration, domestic violence shelter facilities and personnel*

Issues of **community safety** weighed heavily on residents from the very inception of the levee/flood wall breaches and remain among the most significant concern for the community. Concern with private property – homes and their content, commercial buildings and their content – all challenged the available police force. In fact, fear of harm to emergency personnel prevented the earlier evacuation of those trapped in the city. All of the facilities that support community safety were badly damaged or totally destroyed -- police headquarters, prisons, precinct buildings, courts and domestic-violence shelters. Except for the police force, all security personnel evacuated, some remaining during the first week, trapped along with the prisoners whom they guarded. Others shifted from permanent positions to assist in emergency efforts.

Violent Crime Skyrockets

New Orleans violent crime rates:
2005: 229.5/ 1,000 residents
2007: 380.4/1,000 residents
2008: 292.5.1,000residents
For more Katrina social statistics see Appendix A.

Rates of violent crime have soared post-Katrina in a city that already had among the highest levels of violent crime in the country. The increase in crime is due to a number of factors, including changes in the dynamics of the illicit

drug trade, increase in abandoned/blighted property, and the slow recovery of the **criminal justice system**. When the full system – crime investigation, arrest, temporary incarceration, court hearings and trials and sentencing are not all available, the criminal justice system flounders. Concerns with crime have kept residents and businesses from returning and rebuilding, tourists from visiting, and prospective new in-migrants and businesses from moving to the city. Fractured neighborhoods have reduced the **informal community policing** that occurs within stable neighborhoods.

3. Neighborhood/Housing

- *Housing characteristics: supply, cost, condition, storm resistance*
- *Residential stability*
- *Community sub-area infrastructure, public services and neighborhood businesses*
- *Homelessness*
- *Historic buildings and districts*

Some 80 percent of the **housing** within New Orleans was damaged by flood water; much of the remaining had wind damage (as noted by the number of visible "blue roofs" – temporary tarp protection applied by FEMA contractors). Never before in the history of the United States had such devastation occurred to a city's neighborhood system and its housing stock:

- Flood waters entered the homes and created mini whirlwinds of water moving furniture and appliances with unbelievable force.
- The water remained in some homes for many weeks, weakening wood and other permeable materials.
- Equally damaging was the mold which began to grow almost immediately in the humid heat of September, un-mitigated by air conditioning. All materials that contained organic matter were damaged beyond repair.
- Houses could not be inhabited without threat to the health of the occupants due to the mold.
- Later it was discovered that those who occupied FEMA trailers, when they did return, are now determined to be subject to health risks from the formaldehyde contained within the trailers.
- Housing that was not flooded has been in such demand that the value – both in sales and rent – has remained extremely high and thus prevented lower-income residents from returning.
- It is feared that some lower-income residents have returned to unhealthy housing conditions because they could not afford to have the mold remediated; others because they do not appreciate the danger; still others because they were not able to hire mold remediation contractors due to the demand.
- In reconstruction of the housing, there is concern that care will not be taken to build the housing up to the International Building Codes, which are now required, and to the National Flood Insurance Program.

Rent hikes prompt homelessness

Many former renters whose New Orleans-area apartments flooded or were evicted after the storm by landlords seeking higher rents, found themselves literally 'under the bridge' and homeless. Hundreds of people remain camped out in parks, backyards, and in one infamous concentration, underneath the Interstate 10 expressway towering over Claiborne Avenue. (Thomas, 2008)

Homelessness More, pages 85-86.

The term **residential stability** has taken on an entirely different meaning since the floods. No neighborhood that was severely flooded has shown a high degree of resident retention. To the extent that long-term neighborhood attachment and friendship ties are seen as important to a neighborhood, each New Orleans neighborhood has declined in social capital potential. The rate of return of the original residents for most neighborhoods is still uncertain. It is anticipated that residential stability will have to be re-established over the next decades. This will be

challenged by residents who change their mind about returning and those new in-migrants who also decide not to stay. Future threat of hurricanes and flooding will play a big role in determine the neighborhoods' future.

For most of the 70 square miles of flooded neighborhoods within the city, **infrastructure** was severely damaged – water in the gas lines, broken water lines, clogged drains, streets broken and with cave ins. In addition, post offices, bus lines, other **public services** were not available and most **neighborhood businesses** were damaged and have not returned.

Homelessness was increased by the storm, even for some who owned their homes before the storm. Twice as many people are homeless in New Orleans post-storm than they were pre-storm. Some of those who were marginal in their housing before the storm lost it. Others came to the city seeking employment in the recovery and were not able to get housing, even if they became employed. Still others became homeless due to the stress of the storm which incapacitated them in terms of employment.

Finally, the flooding has challenged the **historic districts and the historic housing**, the largest such stock in any city in the country. The historic housing is seen as the base of the unusual and much coveted culture which is practiced and revered here. To lose it is to lose that base. Much concern is focused on repairing it to retain its historic appearance at the same time attempting to repair it more safely. Currently, funds for historic preservation are grossly inadequate in comparison with the size of historical assets that New Orleans possesses.

4. Household/Family

- *Density/Home sharing*
- *Dissolution*

The effects on the **household/family** were startlingly dramatic. First, when an extended family did not have members located outside of the area, arrangements had to be made in shelters or motels for multiple members per room. When the extended family had members located outside, the doubling up was beyond belief for the American experience. A remarkable accounting of such a situation can be seen in the documentary by Dr. Kate Brown, Professor of Anthropology at Colorado State University. "Still Waiting: Life after Katrina" shows the reception of 150 family members by one couple in Dallas. For many families this doubling up lasted several months, or it continues. And, it also had the effect of placing one family member in a position of dependency upon another in ways that challenged them. The independent elderly were especially frustrated by being put into a dependent situation with their grown children. Much of the desire by the elderly to go home was to return to that independent condition.

Couple and extended-family dissolution appeared to increase. The tensions of the evacuation and recovery experiences – all domains of post-Katrina decisions – placed inordinate stress on relationships. Additionally the separation of partners/spouses and extended family members broke family bonds. Even the decision whether to return to New Orleans and the coast or not became the "last straw" for fractured marriages/relationships. The extended family is a very important family form in coastal Louisiana, including New Orleans. As family members spread out from the regular, easy social interaction which they experienced here, those ties weakened. As Dr. Brown's documentary demonstrates, visiting and assisting one another regularly was altered to "We'll see you when we see you." Having to say that devastates members of these tight extended families.

5. Business

- *Commercial/business stability/diversity*
- *Small business sector*
- *Informal exchange (bartering) networks*

An estimated 110,000 **businesses** were impacted in Louisiana by Katrina, many of them by flooding within the levee system. The pattern of business recovery in some sectors was striking. Local businesses returned before regional businesses, which, in turn, returned before national chains. This pattern demonstrates the importance of community capabilities to restore and recover as a precondition for attracting back national business enterprises.

This damage began the spiral of economic impact as so many residents were unable to return to work in the area because the companies they worked for were no longer in business. Similarly, former residents desiring to return were confronted by a lack of services and products available to them. As these dynamics continued, businesses that attempted to open were unable to locate employees trained in the skills that their businesses required. Especially evident were the restaurants that were staffed with skeleton crews, reduced hours of being open and speed of service, and limited menu options.

Restaurant owners face daunting challenge

Celebrated culturally for providing visitors and residents alike the food that New Orleans is acclaimed the world over for, restaurants were amongst the first businesses which reopened following Hurricane Katrina, said a national news story. Nevertheless as businesses they face indomitable odds staying in business. While finding and retaining workers with decent wages remains a challenge, returning owners also grappled with sporadic power outages and even water in natural gas lines, which threatened to damage kitchen equipment. Said one proprietor: "I know people say, 'My God, a year later and you're not any further than this?' They just don't understand. We're all taking a whipping down here." (Severson, 2006)

Small Business More, pages 87-89.

An often-seen pattern of business recovery was that the original businesses did not re-open and other, new ones took their place. Thus **business stability** was dramatically interrupted. In addition, the **diversity of businesses** was initially limited and focused on the needs of recovery and rebuilding. Another constraint was the rebuilding of the building occupied by the business. An example of a critical gap was in grocery stores, large structures that required significant time for rebuilding. Most box grocery stores around the city were destroyed; to this date many broad areas of the city are without access to them. This challenge leads the residents to live on fast-food chain and corner-store fare, none of which is likely healthy for them. This is especially critical for children and the poor without cars and thus unable to travel the longer distances to the existing stores.

Small businesses in neighborhoods were especially hard hit but were particularly key to the city's recovery. Their loss diminished the motivation of residents to return; they were pre-storm anchor activities for the neighborhoods and their absence symbolically labels the neighborhoods as challenged for recovery.

Some activities within a community are conducted by individuals in a **barter mode**. Most commonly recognized in rural communities where seafood catches might be swapped for vegetables grown in someone's garden, some bartering activities, informal exchange of goods and services, also occur in urban neighborhoods, child care for hair care for example. These activities were reflective of the support systems within the neighborhoods before the storm that just about halted completely after the residents were scattered.

- *Personal household livelihood*
- *Employment/income dispersion/stability*
- *Occupational diversity*
- *Community socioeconomic characteristics*

7. Health and Physical Safety

- *Healthy lifestyle*
- *Access to clinical care services (especially: trauma, gastrointestinal, neurological, diarrheal outbreak investigation, poison control referrals, national pharmaceutical stockpile, etc.)*
- *Access to disaster mental health services (especially: psychological first aid, mental health referral)*
- *Access to environmental health services (especially: septic and water inspections, food-service inspections, surveillance for vector-borne diseases)*
- *Access to specialized high-technology lifesaving equipment and therapy (e.g.: dialysis, ventilators, ACLS, ATLS, etc.)*
- *Informal care giving systems*
- *Access to specialized services for vulnerable populations unable to physically or psychologically access necessary care*
- *Community health risk factors – environmental, mental health exposure, vulnerable populations*
- *Mortality rates, causes*
- *Surge facilities and personnel (e.g. including emergency worker liability, ESAR-VHP volunteer call-up systems.)*

Both residents who remained away from the city for a long period of time and those who returned were likely to be unable to maintain a **healthy lifestyle**. Overcrowding, use of alcohol and drugs to quell anxiety, lack of grocery stores to buy fresh produce, extreme over work and limited opportunities to exercise, etc., posed risks to health.

No room for the sick

3.26/1,000 residents is the rate of hospital beds allocated nationally
3.03/1,000 residents was the rate of hospital beds allocated in New Orleans prior to Katrina
1.99/1,000 residents is the rate of hospital beds in post-Katrina New Orleans
For more Katrina social statistics see Appendix A.

The health sector was particularly vulnerable to the effects of the storm, which rendered the **health and medical services** almost nonexistent early on. Because of the massive population displacement, many health care personnel were terminated by their employers. Others left for fear of termination because of the reduced population size. The health care system recovery was problematic as its underlying economics are built around a population base, whose return was difficult to predict. While acute and ambulatory care facilities have been slow to return, they are currently judged to be generally adequate, except in specialty areas.

Access to health/medical services was severely affected by the storm immediately after the storm due to the particular nature of New Orleans' public health care system. The Charity Hospital system was the major source of care for low-income residents. The primary hospital was severely damaged by the storm. Care was disrupted, and private providers were particularly affected by a larger burden of uninsured residents. New Orleans, before the storm, had among the highest levels of uninsured residents in the country. Especially lacking post storm were **mental health services** and **clinical/high-tech equipment and therapy** because all hospitals in the city had suffered building damage.

Closed hospital psychiatric facility leads to death

Depressed about his brother who suffered from sickle cell anemia, a young man "tried to inhabit his sibling's world and take the mantle of his pain. He could not sleep or eat and began disappearing on rambling walks." Just days later "his family took him to the hospital for a psychiatric evaluation, initiating a tragic chain of events that would end with him becoming the latest patient to suffer or perish because of the dearth of mental health beds in the city, especially for patients without health insurance." The 23-year-old died after jumping from the back of an ambulance that carried him from University Hospital in downtown New Orleans which lacked mental health beds, to go almost fifty miles away to a state psychiatric hospital in Mandeville, according to a front-page newspaper report. (Moran, 2007)

Healthcare Access More, pages 91-93.

A myriad of **community health risks** – environmental, emotional/behavioral, and an exacerbation of risk conditions of those in vulnerable populations arose. Katrina resulted in a number of concerns related to environmental contamination, accidents, and mental health risks. Ultimately, mental health effects are believed to be the most widespread of these issues. Suicide rates and substance-abuse rates have increased greatly.

Environmental exposures have been less than initially suspected although some new analyses of the environmental contamination data suggests there were more risks than had been previously thought. The lack of **environmental monitoring** prevented the government and the public from getting accurate assessments of their environmental exposure. The delayed release of information on the high level of formaldehyde in the FEMA trailers is an example of flawed monitoring. In addition, various risks are compounded within **vulnerable populations**. Recent research found that 60 percent of the homeless are more at risk from dying from chronic diseases than the population in general. Their homelessness is exacerbating their health conditions and their homelessness reduces their access to health care.

The slow recovery of the health care system was striking, and it retarded the re-establishment of population initially. Many hospitals were severely damaged, some to the point where they were demolished. In some, so many patients died that it will take time for the public to want to enter them for service. Another large hospital used for indigent patients was kept closed in order to speed the creation of a new public hospital. This left a huge gap that continues while the smaller public hospital struggles to develop additional "temporary" space for services such as adequate mental health intake.

Examination of the availability of **informal care-giving systems** showed that most were fractured. As families scattered, support systems for those who needed health care stopped. As in all communities such informal assistance serves as a basic contribution to the vulnerable being able to live in their own homes or to at least not having to be placed in a hospital or long-term care facility.

Two final impacts are of important note. The first is the identification of the causes of deaths post-Katrina and the death rate. Anecdotally it is believed that many have died from stress, inducing both physical causes of death as well as psychological. The difficulty in determining the post-Katrina death rate prompted the city's health director to use newspaper obituary data to demonstrate that increase rate.

The last indicator of health and physical safety social effects is that of what Katrina has done to place the area at likely more risk if another disaster befalls it. While it might be expected that the earlier disaster would result in a better response, the challenge to the medical system, like the challenge to the other parts of emergency response, may reduce response capability such as **surge facilities and personnel.** The struggle the city had in "mounting" a full-service emergency room trauma facility is such an example. Temporarily, it was located in the suburbs.

8. Governmental Organization

- *Organizational structure and functioning of government*
- *Sustained critical infrastructure (especially: telecommunications, water, sewage, power, streets, public buildings, etc.)*
- *Provision of public services (e.g.: planning, taxation, permitting, public transportation, education, public health, emergency ops/incident command, etc.)*
- *Exercise of democratic participation (e.g.: voting, letters to the editor, civil action groups, billboards and posters, etc.)*

All of the **governmental functions** came to a halt after Katrina. Residents watched, first from afar and after returning, from within the city, as the government struggled to be reconstituted. Even three years from the storm, some **governmental services, infrastructure and basic functions** have not been restored. Similarly, exercise of **democratic participation** faltered and took more than two years to recover. Some argue it has not completely done so because residents living in other communities are being purged from voter roles in New Orleans.

9. Community Social Services

- *Availability and access to basic range of formal social service programs (e.g. family counseling, parenting, family violence, seniors, chemical dependency, children services including child care, disabilities, welfare benefits/job training, foster care, mental health, disabled transportation, etc.)*
- *Informal instrumental support services, especially for the children, elderly, physically or mentally disabled, and other vulnerable populations (e.g.: extended family members caring for the young and the old, or faith communities providing meals-on-wheels, home repair, shopping, transportation, or emergency first response.)*

Availability and access to basic range of social services was cut completely after the flood. Gradually the government has been able to reinstate the services, but at a slow pace. As described within the non-governmental section below, some of New Orleans' major private-sector social-service providers were able to come back quite quickly because their facilities were not in the severely flooded areas. These included Kingsley House and Catholic Charities. However, those which were in the flooded area such as the American Red Cross had to relocate to the suburbs and have struggled with their temporary facility since that forced relocation. With such challenges, the availability and access to social services was curtailed for quite some time. Such social-service limitations then reduced the ability of lower-income residents and those, for example with mobility challenges, from returning to New Orleans. When one considers returning home a human right, these limitations challenged those rights.

10. Cultural, Historical Landmarks, Aesthetic Support

- *Recreational and cultural opportunities and participation*
- *Diversity of recreational and cultural opportunities*
- *Museum, sports, recreational facilities and personnel*
- *Historical landmark condition, access*
- *Festival infrastructure and voluntary/commercial personnel*
- *Maintenance of valued cultural characteristics*

Prior to Katrina, it may have been thought that this category of OSEs was less important than the others. However, it quickly became evident that the desire to repopulate the area had much to do with the expectation that the **unique cultural and historical characteristics** of the area would be restored and continued. These behaviors when defined within New Orleans include so many daily neighboring, eating, music, public activities not "culture" as in a performance event within an arena or stadium. It is what most residents of all incomes value about living in this community. Damage to so much of the culture infrastructure threatened the very future of the city as former

Festival brings reunion

A national news report noted the healing power of the old Louisiana festival tradition: "Jazzfest's essence was in the gathering of a 50-woman choir from the Franklin Avenue Baptist Church, which sustained $9 million in damage and now holds services for parts of its congregation in Houston and Baton Rouge as well as New Orleans. Some choir members had not seen one another since the hurricane. They, and other performers at the festival, kept saying, "It's like a reunion." (Pareles, 2006)

Community Activities More, page 97.

residents and those considering moving to the city measure the recovery progress in terms of the restoration of the valued cultural qualities.

One need go no further than the powerful desire to continue creating jazz musicians and jazz music to appreciate the point. Habitat for Humanity concentrated their efforts on building housing for the musicians. Tipitinas Foundation assisted musicians in getting paid to play within the city, and the Musicians Clinic was reinstated and funded by donations so that the musicians would have access to health care. The effect of the storm was very threatening to so many aspects of this prized culture.

C. Community Interpersonal Capital

1. Ideal Interpersonal Conditions

- *Community identification/attachment*
- *Community cohesiveness*
- *Distribution of resources and power*
- *Civil and human rights*
- *Environmental justice*

Recent consideration of the community conditions that create community resilience has spot lighted the ability of the residents and their leaders to use their own personal skills and talents in conjunction with other residents to achieve community goals collaboratively. Realization that **community interpersonal capital** is the underpinning of the more formal institutions described above has brought some applied scholars to argue that they require more identification and appreciation than those institutions.

The research team of this project contends that community interpersonal capital is the underpinning of the social institutions that cannot function successfully and cannot serve the residents in the most effective, egalitarian manner if the social capital is not fully in place. The two – more formal community capacity and community social capital – must be considered as they support one another.

Rationale – first five concepts. The strength of community interpersonal capital can often be seen by the degree to which residents **identify with their community and declare attachment** to it: desire to stay, to brag about it, to work on behalf of it. Similarly, a community using its interpersonal capital effectively will demonstrate **community cohesiveness** among its members. While not always agreeing, nor sharing common vested interests, successful community members "agree to disagree" and to negotiate compromises among the different interests, to declare social identification with other residents and groups. When residents perceive that the **available resources and power to control the resources** are fairly distributed among groups and individuals, it is more likely that they will work toward and be able to utilize the cohesiveness.

Attachment to Place

New Orleanians asked to evacuate ahead of Hurricane Katrina typically struggled to find a suitable place to go. City residents and other Louisianans remain close to their birthplace at rates higher than the typical American. This leaves many residents with no place to go for a self-evacuation except to other places in harm's way. Other states with similar nativity rates include New York, Michigan and Pennsylvania, all areas much less likely to experience a mass evacuation. Fellow Gulf states have nativity rates that ranged from Florida's 32.7 to Mississippi's 74.3, according to the 2000 Census.

Staying Close to Home	N.O.	La.	U.S.
Born in State of Residence	77.4	79.4	60
Born in Different State in the South	10.2	11.1	9
Same House for past 5 years	56.8	59	54.1
Same County or Parish for past 5 years	85.4	83.5	79
Same State for past 5 years	91.4	92.8	88.7

Source: U.S. Census 2000.

Members of minority groups often struggle to share community resources and power. They are skeptical that their interests will be served when resources are distributed. Key to engendering that trust is when a community is able to give solid respect to the **civil and human rights** of those in a minority status. Within that framework, **environmental justice** is seen as an example of such equity.

More difficult to place in the usual vocabulary of Corps "accounts" than are the institutional structures and resources outlined above under community capacity, it is possible to ask and to answer these questions:

- How can a Corps' project enhance (or detract) from a community's interpersonal capital?
- How can the residual damage or damage from the failure of a Corps project impact community interpersonal capital?

As more research demonstrates the importance of community interpersonal capital in the resiliency and sustainability of communities, it is incumbent on Corps OSE experts to understand how such capital can be threatened by residual/structural failure damage, as well as how Corps projects can contribute to its enhancement.

Katrina examples – first five concepts. The following paragraphs will demonstrate how damage to community interpersonal capital occurred in the flooding of Hurricane Katrina. However, while this damage did occur to the interpersonal capital, it is important to appreciate that disasters also engender, at least for a period of time, the enhancement of such capital because residents "pull together" to address the challenges which they face. Following Katrina such an enhancement occurred in many dramatic ways. It is yet to be determined whether that enhancement will continue after the reconstruction phase. As local victims are wont to say: "Why did we have to have a Katrina to pull us together as a community?" They also say, "We did what we had to do; we pulled together and got it done."

Examples of the damage done to pre-existing community interpersonal capital have been seen in terms of who benefits most quickly and most effectively from the recovery efforts. Questions are asked about whose area of the city is patrolled more by police, where was debris first cleaned up, plans for rebuilding identified and accomplished.

Expressions of concern about government leadership at all levels discourage former residents from retaining their **attachment** and commitment. Social class and racial divisions in terms of whose interests are being served reduce **cohesiveness**. For example, lower-income residents ask why the public housing (**resources**) was demolished when much of it could have been re-occupied, at least until new rental housing was made available. Similarly, mental health services for lower-income residents have been non-existent due to lack of facilities, but Charity Hospital has numerous floors that were not damaged. The poor ask why. They try to exert **power** over garnering these resources by public protest and lawsuits.

Particularly striking in the Katrina event was the realization that not only the **civil rights** of the residents might have been harmed – such as loss of polling equipment, polling sites and long distances between the evacuees' temporary homes and their polling booths, their **human rights** also were threatened. Cited are the delays in rescuing those trapped in the city when the breaches occurred. How could it have taken so long to rescue Americans at risk on U.S. soil? Also, the prohibition of housing-development occupants to return to their apartments to get their personal belongings is a clear violation of basic human rights. One would have expected for all residents of a flooded American community, especially because the developments' buildings were not compromised and could have been entered without harm to the residents.

An important concept in the lexicon of human rights is that of **environmental justice**. Created originally to apply to the disproportionate threat of chemical plants and waste sites to the health of minority residents, the term is relevant to the Katrina flooding in two ways. The first is the concern that contaminants might have more likely been in the water that flooded lower-income areas. The second is the fact that the needed height of levee/flood wall flood protection was lower in areas that were inhabited predominantly by minorities – the Lower 9th Ward and New Orleans East. Minority victims see the latter as an example of environmental racism, similar to the threat of disproportionate toxic contamination.

We turn now to the means to achieve such community interpersonal social capital. We will note the impacts that Katrina had on these means and the ways in which the community had to exert itself in times crisis to hold the social capital together and functioning by implementing, augmenting and over using these means.

2. Interaction Means to Achieve Conditions

- *Community leadership*
- *Political organizations and citizen political involvement*
- *Non Governmental Organizations adequacy vis-à-vis community needs*
- *Voluntary associations and membership*
- *Religious organizations*
- *Neighborhood (place-based) voluntary organizations*
- *Friendship/family networks*
- *Regional/national linkages*
- *Print and electronic media array, diversity, access*

Post-storm local **community leadership** has run the gamut in terms of citizen evaluations of performance. Some systematic analysis suggests a dichotomy from leaders who enhance their assertiveness after the storm and accomplished significant outcomes to others who seemed stunned by it. Either example puts an extreme stress price on the psyche of the leadership. In some cases the leadership has acted in an autocratic manner in order to overcome the challenges of negotiating with the large governmental agencies. What lasting negative legacy this has on egalitarian community dynamics is yet to be learned.

The Power of Friendship

A national news article quoted a mourner commemorating the second anniversary of Hurricane Katrina: "Most of my good friends are not here any longer. That's one of the things that's wrong. The fabric of this city will never be the same." (Nossiter, 2006)

Informal Networks More, pages 99-100.

Like the community leadership observations, the storm revealed both negative impacts and positive ones with regard to **political organizations and citizen political involvement**. With the population decimated, political participation was hampered but citizens tried their best to vote, even those who were living many miles away from New Orleans. This commitment, however, declined in the second election following the storm. Frustrations were experienced in trying to have access to voting and some in the diaspora felt more effort should have been undertaken. Overall the state spent significant resources to try to make satellite voting successful.

The post-Katrina status of **non-governmental organizations** is a very fascinating situation. Some NGOs floundered, even closing their doors. Others thrived. Research by Dr. Pamela Jenkins of this team suggests that the successful ones learned to evolve by providing their services in a manner unique to a post-catastrophe situation. Oftentimes that meant undertaking entirely different activities such as building homes when home building was never part of pre-storm activities.

Initially the adequacy of the **service provision vis-à-vis community needs** was extremely poor. Day care for anyone, but especially lower-income parents, was non-existent. The strain this put on the capacity of parents of young children to work was extreme; this was especially true of single parents. Gradually the NGOs reconstituted themselves, identified buildings in which to provide their service or repaired their original structures, and began trying to locate their clients to assess the change in needs.

Organizations such as the Greater New Orleans Community Data Center tried to document the return with accompanying maps so that residents could learn where the services were available. The duration of the decline, the loss of NGOs, the post-storm service provision capacity all are still being examined.

Most active post-storm were **voluntary associations** that were providing a service that the community needed. Some political action groups formed or grew and advocated for reforms that were glaringly needed. Some focused on inadequate treatment of lower-income residents, others on the causes of the disasters such a levee construction or inadequate treatment of homeowners who were trying to get their funds from the state program in order to rebuild. Given the weight of recovery which each resident experienced, membership in such organizations was not overwhelming, but was sufficient for the groups to have public visibility about their issues.

The contradiction of the experience of the **faith-based organizations** was symbolic of what happened after the storm. The congregations were struck a serious blow as many of them were located in buildings that sustained serious flooding or were not retrofitted for the winds. Yet, they have been one of the most important providers of support –spiritual, emotional and material – of any other type of organization. Much of this support has occurred with congregations doubling up and others having a diaspora location while they rebuild their local one. In addition, the faith-based organizations from outside of the area have provided the most consistent and large contribution to the recovery of the region by virtue of their donations but especially their volunteerism to undertake the most menial but so useful roles. While the faith community has always been present at disasters, the response to Katrina has exceeded expectation.

'Hurricanes' Spirit

"The Hurricanes" defiantly faced the wreckage of their school and community, this report continued: Little has returned to normal in the two and a half years since Katrina destroyed the tiny fishing, oil and citrus villages of Port Sulphur, Buras, Boothville and Venice in lower Plaquemines Parish, where the Mississippi River runs to the Gulf of Mexico. "Football is the only thing that will bring this community together; there's nothing else here," said Corey Buie, an assistant coach and the recreation director of Plaquemines Parish. (Longman, 2007)

Voluntary Associations More, page 100.

The tension about whether residents of particularly hard-hit neighborhoods should be permitted to rebuild sparked unbelievable growth and solidification of **neighborhood voluntary organizations**. While New Orleans neighborhoods pride themselves on being friendly places, they have never been known for high concentrations of civic involvement. This characterization changed completely after Katrina. While that involvement has waned somewhat as it would be expected to do, the contribution which the post-storm involvement made to planning for and implementing recovery has been remarkable and without precedent nationally. The city has rewritten the books about neighborhood civic involvement. Similarly, when possible, friendship networks were strengthened by the self-help dynamics that were required for survival post-Katrina.

The outpouring of concern and assistance from regional, national and international organizations and governments resulted in incredible donations many of which never reached the affected area because the federal government did not dispense them. Those governments and organizations that went directly to the locals to aid them were successful in achieving their goals. The plus side of the interest did result in collaboration and offers for partnership that were pursued by both the governor and lieutenant governor as well as universities and non-governmental organizations.

Finally, the print and electronic media were both extremely damaged but also managed to be the lifeline for the community. This was especially true of the print and the radio. The diaspora relied on both for detailed information about the rescue and recovery. The intense reporting went on throughout the event and is still going on today, especially by the radio. Without these media, the community would have floundered beyond belief.

D. Postscript on the OSE of Community Interpersonal Capital

This last major section discusses both the harm to interpersonal community capital that occurred and the "therapeutic community" that arose after the disaster. We want to point out, however, that that enhancement was not without incredible cost. It occurred at a price to the residents. In fact, it actually took lives from stress, mental illness, drug/alcohol abuse, car accidents and loss of jobs because so much work was put toward these social capital activities. Slower personal recovery occurred because the energy was going toward the communal efforts, family tensions were enhanced because people were" spreading themselves so thin," etc. The list is very, very long. The price to the residents to create, sustain and enhance interpersonal social capital has been tremendous, and higher than some could bear. If the severe flooding had not occurred, such an inordinate level of effort would not have had to be expended and the negative social, psychological and health effects on the residents to retain and enhance community interpersonal capital would not have had to be expended.

The second point is that not all residents were in a position to participate in holding together and in enhancing their community social capital within the area. The forced absence of the poor by virtue of their inability to return and for public-housing residents, the demolition of their housing, made it extremely difficult for them to participate. Social capital for the poor is often very important and informal, communicating across a stoop with a neighbor, checking on an elderly neighbor, watching a neighbor's children while the mother goes to the corner store or to work, participating in a Sunday social and pleasure club parade, etc. The dispersal of the New Orleans poor all around the

country slowed this place-specific community capital and it is only gradually coming back as residents struggle to return and re-establish that connectivity. In substitution they are trying to hold it together in the diaspora by long commutes to work within the city while having to live outside and by extended visits to returned family members and thus to over crowed conditions, to name just two. Their efforts to hold such social capital together long distance is another full story to be told..

Table 4.1.1 Sample Pre-Post Comparative Measures of New OSEs for New Orleans Katrina Example: Population Characteristics

Population Characteristics			
Dimension	**New Orleans Pre-Katrina**	**New Orleans Post-Katrina**	**Total Loss**
Population Patterns	▪ 2005 census estimate-453,726 ▪ 11.3 deaths/1,000 residents.	▪ 2007 census estimate-239,124 ▪ 14.3 deaths/1,000 residents.	▪ 214,602 population loss (47.3%) ▪ 3.0 deaths/1,000 residents.
Demographics	▪ 53 female/100 residents	▪ 46 female /100 residents	▪ 7 females/100 residents
Transient residents	▪ 8.5 million tourists/year	▪ 3.7 million/year (2006)	▪ 4.7 million tourists/year.

Table 4.1.2 Sample Pre-Post Comparative Measures of New OSEs for New Orleans Katrina Example : Community Capacity

Community Capacity			
Dimension	**New Orleans Pre-Katrina**	**New Orleans Post-Katrina**	**Total Loss**
Education	▪ 66,372 students (public). ▪ 26,008 students (private). ▪ 64,348 students (university). ▪ 128 open public schools. ▪ 93 open private schools.	▪ 32,887 students (public). ▪ 18,151 students (private). ▪ 47,674 students (university). ▪ 79 open public schools. ▪ 63 open private schools.	▪ 33,485 students (public). ▪ 7,857 students (private). ▪ 16,674 students (university). ▪ 49 open public schools. ▪ 30 open private schools.
Criminal Justice	▪ 229.3 violent crimes/1,000 residents (2005). ▪ 1,668 police officers.	▪ 368.4 violent crimes/1,000 residents (2007). ▪ 1,470 police officers.	▪ 139.1 violent crimes per 1,000 residents. ▪ 198 police officers.
Neighborhood/ Housing	▪ $244,793 average house sale price. ▪ $531 monthly rent for one-bedroom. ▪ 13.22 homeless/1,0000 residents	▪ $180,793 average house sale price (2008). ▪ $846 monthly rent for one-bedroom. ▪ 50.18 homeless/1,000 residents	▪ $64,000 loss in property sale price. ▪ $315 increase in monthly rent. ▪ 36.96 homeless/1,000 residents ▪ Estimated loss of 11,000 historic buildings.
Business	▪ 9,592 employers (second quarter 2005).	▪ 7,482 employers (second quarter 2007).	▪ 2,110 employers.

Community Capacity			
Dimension	**New Orleans Pre-Katrina**	**New Orleans Post-Katrina**	**Total Loss**
Income, Employment & Labor Force	▪ $13,562,270 local sales-tax collection (Jan. 2005).	▪ $8,520,490 local sales-tax collection (Jan. 2006).	▪ $5,041,780 local sales-tax collection.
Health & Physical Safety	▪ 3.03 hospital beds/1,000 residents. ▪ 51.82 physicians/10,000 residents.	▪ 1.99 hospital beds/1,000 residents. ▪ 35.95 physicians/10,000 residents (2006).	▪ 1.04 hospital beds per 1,000 residents. ▪ 15.87 physicians/10,000 residents.
Community Social Services	▪ 275 childcare facilities. ▪ 8.11 operational buses/10,000 residents.	▪ 98 childcare facilities (2007). ▪ 2.88 operational buses/10,000 residents.	▪ 177 childcare facilities. ▪ 5.23 operational buses/10,000 residents.

Table 4.1.3 Sample Pre-Post Comparative Measures of New OSEs for New Orleans Katrina Example: Community Interpersonal Capital

Community Interpersonal Capital			
Dimension	**New Orleans Pre-Katrina**	**New Orleans Post-Katrina**	**Total Loss**
Interaction Means to Achieve Conditions	▪ 47 percent approval for Mayor Nagin/black voters. ▪ 84 percent approval for Mayor Nagin/white voters. ▪ 46 percent of registered voters (mayoral 2002).	▪ 61 percent approval for Mayor Nagin/black voters. ▪ 23 percent approval for Mayor Nagin/white voters. ▪ 36 percent of registered voters (mayoral 2006).	▪ 14 percent increase in approval. ▪ 61 percent decrease in approval. ▪ 10 percent registered voters.

Chapter 5: Application Issues of Proposed OSEs

A. Introduction

Recognition that the Other Social Effects (OSEs) are as integral a part in determining projects as Economic (NED, RED) and Environmental (ENV) effects is extremely important. This conclusion leads to the question: How to use the OSEs most effectively?

Four uses are seen by this study team as key to the Corps' success in contributing to flood risk reduction.

1. The first is to incorporate the SIA approach of eliciting OSEs into the "defining and bounding the problem" approach the Corps already uses regularly.
2. The second is for the Corps to utilize the results of the SIA process to collaborate with other resource stakeholders to conceive and implement the best package of risk reduction actions, the Corps structural and non structural being just two. This approach would be an extension of the collaborative dynamics developed by co-located collaborative agencies piloted by the Corps' New Orleans office to address coastal restoration.
3. The third is to review the proposed OSEs and to embrace a more comprehensive array of them within the Multi-Criteria Decision Analysis (MCDA) currently being utilized by the Corps in the LACPR project selection process. Now there are only four – population, historic buildings and districts and archaeological sites, the latter being considered due to NEPA regulations.
4. The fourth is to use the OSEs and the SIA approach to refine the post-mortem assessment of flood disasters and to require legislatively such an analysis after every declared disaster.

Each application issue will be discussed below.

To reiterate, the study team believes that the most effective role of this study effort is to propose extensions and refinements of existing Corps processes rather than 180-degree changes. The declared commitment by the Corps' Institute of Water Resources and the New Orleans Corps to refine the OSE's demonstrates an appreciation that adding a robust "account" of OSEs to their efforts is imperative. The charge at hand is to do so with clarity, focusing on key OSEs and then their robust use through appropriate processes of community and stakeholder engagement to identify them. The remainder of this chapter will include discussion of these four uses of OSEs and how they might be implemented effectively.

1. Using the (Broader) Community's Flood Protection Goals When Identifying Prospective Corps Projects

Two key points will be made in this section. The first point is that the Initial Reconnaissance should include an active, detailed engagement of the **broader** community to identify the flood risks that they perceive—what is at risk, what does the community want to protect, and how the Corps might be able to assist in addressing the **broader** community's concerns. The Corps does this already with local sponsors who are representatives of **particular** community-stakeholder interests. Often they are community elites. These meetings take place before a study is funded by Congress and initiated.

However, it is clear that the Corps recognizes that there is a disparity of interests and opinions about what should be protected. Why, then, does the Corps hold risk decision-making meetings, to which they invite the **broader** community, *after* they develop alternative plans in partnership with **particular** community-stakeholder interest? We propose the same diversity of interests holds true early on, when the initial project decision is made – to "levee" or not to levee at all. Those who represent the interests of **particular** community-stakeholders do not possess an understanding of the entire breadth of risk and safety aspects that could be discussed. As the Corps does not currently hold **broad** public meetings to discuss the same "problems and opportunities" as it does with **particular** community-stakeholders, this study team suggests that it should, so that the broader public can contribute to identifying flood risk and solutions along with the parish officials, water and levee boards, and state water resource agencies. Such meetings also would alert the Corps to the disparity of interests and opinions that exists among *all* stakeholders, thus enhancing the efficient development of a consensus of support for one project or another earlier in the process.

Public meetings are a required part of NEPA compliance, but they currently take place *after* alternative plans have been developed, and only then does the broader public have an opportunity to share its perspectives. Richard Burroughs (1999) suggests that the shift from holding public hearings to the engagement of stakeholders in the broader community leads to the formulation of more tenable plans, to which the broader community is amenable. Similarly, we propose that a more fruitful approach would be for the Corps to hold risk assessment and **possible** solution formulation meetings with representatives of *all* stakeholder groups (not necessarily organized with formal organizations) at the table. Additionally, we suggest the utilization of the OSEs proposed in this report to facilitate that community participation. What does the community value? What do community members have consensus on that they want protected and/or enhanced?

We refer the reader to the Dunning and Durden white paper prepared in March, 2007 entitled "Theoretical Underpinnings of the Others Social Effects Account" in which they present the comprehensive table "A Comparison of the Role of OSE Information in the Current Planning Framework with the 4-Account Planning Framework." The first row, "define and bound the problem" is presented here for discussion. What follows below is a reinforcement of what they present here on Row One. **We concur and offer the steps already in existence in the Social Impact Assessment (SIA) approach that can be used to accomplish the new goals of OSE in the new Corps planning approach:** "identification and analysis of social conditions and stakeholder identification and analysis." It continues: "'Consensus-forming activities' help build common definitions of problems, opportunities, and constraints, and help determine planning objectives" (Dunning and Durden, 2007: 27) In this way, the community and the Corps contribute to the analysis and understanding of the desired change.

Figure 5.1. A Comparison of the Role of OSE Information in the Current Planning Framework with the 4-Account Planning Framework. [Line one, excerpted from Dunning and Durden, 2007: 27.]

Planning step	Current planning framework	Role of OSE/ social information in current framework	4-Account planning framework	Role of OSE/ social information in 4-account framework
Define and bound the problem * Opportunities * Constraints * Planning Objectives	Current paradigm defines problems narrowly, according to specified authorities. Projects are largely single purpose Problems, constraints, and planning objectives are defined by Sponsor/Corps	Role may include conducting scoping workshops, generally as part of the EIS process	4-account framework defines problems more broadly and focuses on the full range of water resources problems that are beyond traditional authorities. Multipurpose/ multi-agency involvement	Role includes identification and analysis of social conditions and stakeholder identification and analysis. "Consensus-forming activities" help build common definitions of problems, opportunities, and constraints, and help determine planning objectives

The pre-alternative assessment process assumes that 'one size does NOT fit all.' In each situation, not all variables are equally important. Each project or event will be different, as will each community or neighborhood. For example, one community may be focused on farming while another on fishing. Therefore, there is range of effects and a variety of methods to measure them.

Each of these effects proposed in Chapter 2 – 4 has a history in the disaster, community, or social impact literature and each method has been tested in other communities. In other words, the outcomes using these measures and methods can be compared to other research, ensuring both reliability and, to some degree, validity. However, validity will be enhanced by the input of communities who will serve as checks for the measures, the methods, and the findings.

Community engagement is a process that is well documented in the literature including several important recent works (Burroughs, 1999; Selin *et al.*, 2000 and Bryson *et al.*, 2004). As with the measures and methods, there are a variety of ways to engage the community. The model for this process usually involves: 1) identifying community residents with critical knowledge; 2) identifying the groups in the community; 3) identifying formal leaders and informal leaders in the community; and 4) providing opportunities for groups and leaders to speak about their community. Burroughs' (1999) work finds that focusing on inclusively-defined stakeholders from the beginning of the process increases participation and knowledge about the issues (both agency and local) and gives good feedback to the agency on citizen preferences. While this process appears to be, and is, labor intensive, getting the broader community invested at the beginning ensures accountability from the onset of a project or after an event. We propose it will also reduce the high degree of conflict that emerges in the Feasibility and Project Implementation phases when the unaddressed issues of the project emerge. In sum "front loading" the early effort reduces the later effort and, perhaps even more importantly, the contentious relationship between the Corps and residents that seems

to occur with great regularity around projects and their realities, which tend to be objected to later in the process of selection, implementation and outcome.

Key to the success of the process we support is its inclusionary quality. Success relies on the inclusion of representatives of all segments of the broader community, not just the leaders and those who represent formal groups and are comfortable advocating for them. Using regression statistical techniques, Selin et al.(2000) examined the components of collaborative projects that included the U.S. Forest Service. Participants perceived that successful projects had included good leadership, willingness to compromise, and a **broad** representation of stakeholders. Phrased in more negative terms, Bryson (2004: 23) states, "Failure to attend to the information and concerns of stakeholders clearly is a kind of flaw in thinking or action that too often and too predictably leads to poor performance, outright failure or even disaster."

The decision about how to define stakeholders is critical. Mitchell, et al. (1997) emphasize that equitably identifying stakeholders is consequential, as it affects *who* and *what* counts. In the case of Corps projects: who will be protected, what social and physical assets count, and to whom? Taking care to cast a broad net and to appreciate that such an effort will eventuate in the best community plan, and thus the one most accepted and advocated for, are critical.

2. Resource Partners: Creating Multiple Agency/Jurisdiction Efforts to Address the Flooding

With the Social Impact Assessment Process (SIA) of eliciting honed risk reduction goals from the community—what of the OSEs are important to them – comes the opportunity to examine a comprehensive system of protection. Needless to say, the Corps cannot, should not, be responsible for providing the entire system. This conundrum requires collaboration of the Corps' leadership and staff, with other governmental agencies at all levels and with the public themselves – all of the above being resource stakeholders.

One of the most significant challenges to solving complex water resource problems in a given area is that each governmental department/agency is in a silo/stovepipe, oftentimes working on the same challenges but failing to collaborate for the best outcome for citizens and communities. Such agencies are working under an array of authorities, rules, cultures and processes with the well-intended goal of reducing misery, economic loss, etc. Unfortunately, the increasing numbers of programs that are intended to help have actually led to an increasingly complex system of assistance not adequately synthesized at the local level to solve a water resource problem.

Post-Katrina, if not before, it became increasingly evident that reducing risk of flooding should never be approached with the one solution of a structure – levee, flood wall or dam. Rather, all possible risk-reducing "resources" should be considered. In a geographically expansive area such as the southern Louisiana coast, where it is evident that a number of risk-reduction actions are part of the overall solution, finding ways to blend the resources is in the opinion of this team, the only appropriate approach. Please refer to column four of Table 1 where mention is made of "Multi-purpose/multi-agency involvement." Dunning and Durden (2007: 27) also make reference to a "range of stakeholders and participating agencies" in the plan formulation phase (not repeated in this document).

The leadership role in a multi-agency resource partnering has been implemented by the New Orleans Corps in its coastal restoration work for the Louisiana Coastal Area (LCA) work pre- and post-Katrina and also other follow-on restoration efforts. The agencies included in this collaboration are those with a mission responsibility for coastal areas: the U.S. Environmental Protection Agency (EPA), U.S. Geological Survey (USGS), NOAA's National Marine Fisheries Service (NMFS), the U.S. Department of Agriculture Natural Resources Conservation Services

(NRCS) and the U.S. Fish and Wildlife Service. Nationally, a similar initiative coined the "Silver Jackets" is being used in other states and Corps districts to bring various federal and state entities together for collaboration and partnering. The Corps is in a key position to ensure such resource stakeholder coordination occurs as it has both rigor in its project review process and institutional expertise to undertake a broad evaluation of the effects of a proposed project.

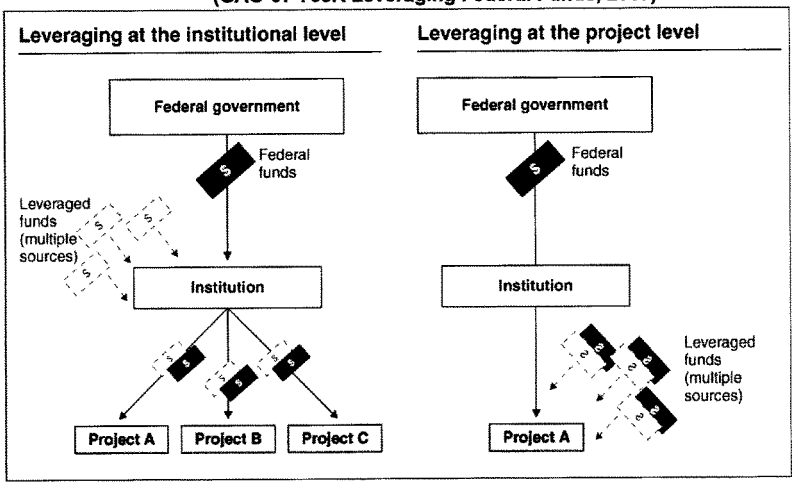
Collaboration of resource partners through interagency networking to leverage resources to respond to community flood risk-reduction issues interface the missions, authorities and programs of the multiple agencies and can offer the opportunity for unprecedented opportunities to address other social effects (OSE). Leveraging has been defined or conceptualized as using one source of funds to attract additional sources of funds. Leveraging also can be thought of broadly to mean the combining of multiple sources of funds and non-monetary resources, such as land-use planning regulations or non-structural mitigation for individual homeowners.

It is useful to pause in focusing on the details of possible collaboration to consider the broader prospect and ideas. We will weave this more general discussion in to the specifics at the end of this section.

The General Accounting Office (GAO, 2007) has considered agency partnering in depth. We describe their framing and apply it to the topic at hand. Leveraging and collaborative activities relieve the pressures on single organizations, such as the Corps, to deliver results on highly visible projects to protect and sustain community development and community capital. Collaboration, networking and leveraging the resources of federal programs make it easier for states and regions to obtain the flexibility to use federal resources effectively. It also encourages contributions from state and local governments and the citizenry. Networking and leveraging are useful tools to stretch scarce federal funds and promote partnerships between the agencies to improve outcomes of institutions and projects in communities. Networking and leveraging can occur at the institutional or at the project level.

At the institutional level, an institution or organization pools funds and other resources from multiple sources, which later are used to support individual projects. In comparison, at the project level, a community or other development authority leverages resources as necessary for discrete projects. The point is further refined by noting that the resources should include all opportunities, monetary and non-monetary such as land-use regulation, in the most creative and productive ways conceivable. Again, the experiences from the co-located coastal restoration agencies at the New Orleans Corps should give insight as to how to elicit and bundle the resources.

Figure 5.2: Leveraging at the Institutional and Project Levels
(GAO-07-768R Leveraging Federal Funds, 2007)



Source: GAO.

Leveraging of resources would be directed to all aspects of the flooding risk-reduction efforts and expand to a broader community risk reduction approach, i.e. reducing risk from social/economic and political threats as well as from flooding. After a strategy is in place, the Corps could support the process of leveraging federal resources in support of the common regional and national economic development as well as OSE goals. The GAO goes on to suggest that these resources could even be used in a significantly broader way to bolster small businesses, promote sustainable entrepreneurship, educational, research, health and social programs designed to help identify and analyze formal and informal community networks as part of the development of a resilient community better able to sustain itself if a disaster were to hit. Imagine a New Orleans that had fully benefitted from such an enhanced approach to leveraging for comprehensive community sustainability before Katrina. Interagency networking and cooperation is needed to effectively identify available resources which are available to the social capital opportunities presented by the stakeholders.

The collaboration may consist of statutory-related, geography-related, population, problem-related programs -- or any connected entities. Once the available federal agency resources are identified, proactive, collaborative efforts can bring agencies to partner with diverse stakeholders in impacted communities to mobilize existing resources (i.e., social, human, regulatory and financial resources) for the purpose of protecting communities.

The strategy for protecting critical infrastructure and community assets requires viewing the **collaboration as a system**, i.e. an integrated network and the outcome of risk reduction also as a system. The federal government has long organized agencies by functional responsibility. For example, the U.S. Department of Housing and Urban

Development is authorized to provide resources for housing and community development. Likewise, U.S. Department of Transportation is authorized to provide resources to ensure the transportation system. The Corps has an opportunity to create a matrix of resources from agencies by building upon the mosaic of functional responsibility areas which reflect the system of social interactions of transportation, education, social services, housing, and health that are impacted by critical incidents such as major floods. Identifying synergistic opportunities for federal involvement in protecting the public and infrastructures through connected functional assignments is an effective way to leverage resources for this specific project or at an institutional level. While networking and collaboration among federal agencies can take many different forms, the practices generally consist of two or more agencies.

The Corps can engage departments and administrations to identify opportunities that are consistent with agency roles (e.g. responsibilities, commitment of staff, funding resources, and other contributions) securing commitments to work collaboratively. The Corps can point out the OSE elements on which agencies can work together suggesting mechanisms to monitor and evaluate results of joint effort.[3]

To the extent permitted by law, the agencies can (a) formulate and recommend interagency compacts and cooperative agreements between Federal agencies and the City of New Orleans, or the State of Louisiana; (b) develop, on a continuing basis, a comprehensive and coordinated plan to establish priorities to promote long-term community stability, (c) identify points of synergistic collaboration for Federal programs, technical assistance, and other support.

To overcome significant differences in agency missions, cultures, and established ways of doing business, the other agencies must have a clear and compelling rationale to work together. The compelling rationale for agencies to collaborate can come from the agencies' own perceptions of the benefits they can obtain from working together. It allows agencies to identify synergistic activities to move the project forward and to articulate the common federal outcome or purpose they are seeking to achieve that is consistent with their respective agency goals and missions.

Some of the possible collaborations would require legislative or administrative changes in the Corps' roles and responsibilities. However, many could come, such as in the LCA (Louisiana Coastal Area) co-location of federal agencies at the New Orleans Corps, by sheer agreement that there are benefits to communities for the agencies, non governmental organizations and the various levels of government to try to work together. And some of the resources already are coordinated by FEMA. The point of this report is to direct thinking to the amazing array of the

[3] Examples include:

- Defining and articulating a common outcome; along with an understanding of the importance of accomplishing the goal and agreement about "success", i.e., the specific outcomes and efficiency levels it desires;
- Establishing mutually reinforcing or joint strategies to achieve the outcome along with a realistic, aggressive action plan that leads to achieving the goal;
- Identifying and addressing needs by leveraging resources;
- Agreeing upon agency roles and responsibilities;
- Establishing compatible policies, procedures, and other means to operate across agency boundaries;
- Developing mechanisms to monitor, evaluate, and report the results of collaborative efforts;
- Emphasizing that consistent with their statutory responsibility, Federal agencies (e.g. Housing and Urban Development; Health and Human Services; Labor; Transportation; Treasury; Education; the Interior; Environmental Protection Agency; Commerce; Agriculture; Small Business Administration; Social Security; FEMA; and Energy) have the opportunity to connect with the project.

possible resources that could be brought to the community's discussion of how to reduce flooding risk. This array, of course, includes the resources of the community itself as well as the county and state jurisdictions.

Will such flooding risk reduction collaborations make a difference? It depends on what resources are leveraged and how they are utilized. In terms of measuring or expressing the extent or amount or level of collaboration, leveraging that occurs at either the institutional or the project level is with a leverage ratio. A leverage ratio relates the dollars and resources agencies provide to the dollars and resources of the Corps initiative. For example, the leverage ratio for a particular project may be 1:1, meaning that the other sources collectively contributed a dollar for every program dollar contributed to the project by the Corps. In general, an institution or project with a high leverage ratio is one in which the investment of all other funds is large relative to the investment of program funds (for example, 10:1 or 25:1). Similarly, an institution or project with a low leverage ratio is one in which the investment of all other funds is reasonably small relative to the investment of program funds (for example, 2:1 or 0.5:1) (GAO, 2007).

Given the challenge of using only structures to protect communities from flooding – changing flood risk conditions due to development and impermeable surface construction, wetland takings, sea-level rise risk, aging structures, flooding greater than the magnitude of safety provided, etc. – commitment to such a resource partnering approach is advisable, if not absolutely mandatory given the expected future challenges. The latest report by the Association of State Floodplain Managers (2007) on floodplain management challenges the society to get serious about flood control (Association of State Floodplain Managers, Nov. 6-7, 2007).

One of this team's members is the floodplain manager for the state of Ohio. He is currently engaged in working with a community that would benefit from a combined program of FEMA (the Hazard Mitigation Grant Program) and the Corps (Non Structural) resources. During the committee's meetings he forcefully argued for and gave examples of the exciting ways he was imagining that such collaborations would be possible. One of the barriers to doing so is the fear that it would violate the federal prohibition of duplication of benefits (DOB) that forbids the federal government from paying twice for the same loss. Given the need for a combination of resources, there has to be a way to approach rule interpretation or modification to overcome this issue. Leveraged, combined resources should be sheltered from the accusation of duplication of benefits..

Pushed to some of the interesting extremes discussed here, such collaborations may sound "unrealistic" but consider how unrealistic "silos of influence and action" sound when their isolated, non-coordinated efforts contribute to a catastrophe such as Katrina. "Can't we all work together?" was asked by Rodney King after the Watts riots. How can we consider silos of effort reasonable when they have led to disjointed efforts that beg for system consideration? One levee alone does not provide adequate protection. Levees alone do not. The benefits to the Corps, on top of the benefits to the communities at risk, of pushing the collaboration envelope further than the coastal restoration example that is already in place at the New Orleans Corps, may be incredibly significant.

Finally, such a leveraging also might include requirements for non-monetary and/or non structural resource commitments: a levee might not be constructed if a community is not also willing to prohibit expanded development behind it, i.e. a buffer zone. Or an additional height for elevating homes might be added to the Base Flood Elevation when a levee is built rather than reductions in flood insurance requirements as is being proposed in Congress today. One act represents false security, the other reminds citizens that levees can fail. This is similar to the National Flood Insurance Program (NFIP) requiring communities to adopt the Base Flood Elevation into the housing ordinances and to enforce the regulation if the community is to be eligible for flood insurance. The levee construction could be conditional upon satisfying these additional risk-reduction requirements, just like the current local match is a monetary requirement for Corps levees. There are a myriad of risk reducing options from a myriad

of resource stakeholders that are out there to consider in a combined system of risk reduction. Isn't the lack of implementation of such risk reducing opportunities the unrealistic path?

3. Inclusion of OSEs in Risk Decision Making Processes When Large Areas Include Multiple Stakeholders

"MCDA (Multi-Criteria Decision Analysis) provides a systematic approach for integrating risk levels, uncertainty, and valuation—however, few MCDA approaches are specifically designed to incorporate multiple stakeholder perspectives or competing value systems" (Linkov, Satterstrom et al., 2006). "Furthermore, where structured approaches ... are employed, they may be perceived as lacking the flexibility to adapt to localized concerns or faithfully represent minority viewpoints. A systematic method of combining quantitative and qualitative inputs from scientific studies of risk, cost and cost–benefit analyses, and stakeholder views has yet to be fully developed for environmental decision-making. As a result, decision-makers often do not optimally use all available and useful information in choosing between identified project alternatives."

Our concerns about the use of OSE within this framework revolve around two issues. First, that the OSEs be expanded to include more than just the two currently used. At least the three proposed umbrella terms should be included – population, community capacity and community interaction capital. Second that the concepts be clearly defined to the stakeholders asked to evaluate projects using them; similarly the NED, RED and EQ also should be clearly explained. Of the four, the OSEs are likely to be the ones that are most unfamiliar to the respondents but all technical terms require clear, lay person definitions. Technical experts always presume that others are as comfortable with their favorite concepts as they are.

The following is the list of project effects the Corps currently permits the stakeholders to consider (two OSEs in bold):

- Residual Damages in dollars (NED)
- Life-cycle Cost in dollars (NED)
- Construction Time in years (NED)
- Spatial Integrity (EQ)
- Direct Wetland Impacts in acres (EQ)
- Wetlands Restored and/or Protected in acres (EQ)
- Indirect Impacts (Minimization of Impacts to the Environment) (EQ)
- Gross Regional Output Impacted in dollars (RED)
- Employment Impacted in numbers of people (RED)
- People's Earned Income Impacted in dollars (RED)
- **Residual Population Impacted in numbers of people (OSE)**
- Archeological Sites Protected in numbers of sites (EQ)
- Historic Properties Protected in numbers of properties (EQ)
- **Historic Districts Protected in numbers of districts (OSE)**

Figure 5.3 4-Account Framework

Accounts → Levels ↓	Economic	Environmental	Social
National	NED		
Regional	RED	Envt Quality	Historic Districts Residual Popln
Community		Envt Quality	Historic Districts Residual Popln

Our project team felt these could be better portrayed in the figure above which reveals the geographic dimension of the Performance Metrics, i.e. to what level – national, regional or local is the analysis most relevant. The economic indicators are aggregates of community level data from employers, workers, vendors and governments. Many of the environmental indicators are also aggregates of smaller units of analysis. In a similar manner, we propose that the Community Social Indicators are best measured for small geographic areas, such as neighborhoods and communities although some regional OSEs are important. Social science methods can be used at the community level to obtain prospective data on perceived values and vulnerabilities. Traditional cultural groups will be able to articulate what reflects the essential characteristics of their community. Although other groups may choose different indicators, a properly designed framework for aggregation should be able to blend these types of social variables into more unified metrics, which we propose to be called Community Capacity and Interpersonal Capital.

While the method of Multi-Criteria Decision Analysis has been evolving and lauded because it can capture stakeholder values efficiently and allows easy statistical calculations, the process "dictates" the basis of the project evaluation rather than giving the stakeholders the opportunity to select their own criteria. Ironically, before the actual exercise began in the summer 2008 implementations an example was presented to the participants to clarify the process that challenges the logic used in the process. A family selects a series of criteria for determining what make and model of car to buy. Once they agree on the criteria, each family member then ranks the cars and weighs the rankings based upon the agreed upon criteria. However, in the real stakeholder exercise, the Corps selects the criteria and requires that the stakeholders draw from them, not propose their own. It is exactly the family example -- the communities participating in the criteria identification -- that this report advocates.

In addition, the Corps criteria, so long used by the Corps professionals implementing the projects that they are second nature, are not only not created by the stakeholders but they are confusing to them. Some even have different signs (+/- directions of the outcomes) and thus the novice stakeholder must remember the definitions and then decide which direction is a positive or negative value. An example is that the environment can be harmed by

the structural project, the usual orientation that the choices reflect, or the project can help the environment (such as protecting wetlands from salt intrusion). No examples to clarify the reverse direction of some of the criteria were offered or warnings given that the stakeholders would encounter them. Thus, stakeholder becomes confused about what s/he is expressing in giving a particular rating on the scale. But then the answers are tabulated and analyzed statistically as if there is no confusion or confusion about sign direction. The findings that result with such problems in the administration process, must be challenged.

4. Residual and Breach Flood Damage Assessment: Applying Approach to Hurricanes Katrina and Rita

The impetus to undertake this work was the tremendous, unprecedented OSEs of Hurricanes Katrina and Rita. There was no contesting that the social effects were massive. As described generally in Chapter 1, the IPET social science team undertook examination of some of the OSEs evident at the time of their work, shortly after the events. The decisions about which impacts to consider were made by the experts impaneled to complete the report. To our knowledge no systematic process of seeking community input to that decision-making process was undertaken, although primary data was collected on the return process. It might be argued that because the impacts were so obvious such a community process was not needed.

The team for this project would propose that a post flood impact study be **required** after each major flood event and that it be done in conjunction with the community and its residents, the latter so that the learning process can be wider than just the Corps experts and officials. Second, we propose that an important part of that assessment be to examine the OSEs. Such a process would be useful for three purposes:

- To know from the position of the victims what the impacts are. The unanticipated impacts, not within the experience of the society in general, and thus the social scientists directed to determine them, cannot have emerged as important so quickly without local input. This observation became evident as the catastrophe unfolded and the frequent comment made by victims was: "The rest of the country just doesn't understand." It couldn't because of the extreme disparity of experience. That inability continues although (inter)national media reporting has reduced the incredulity of the impacts.
- To begin immediately partnering with the community to assess the impacts that occur when so high expectations are placed on one type of flood protection. By going through the assessment process with the Corps, both the agency and the community are required to ask and answer, "What harm came from emphasis predominantly on one single structural measure?" "What future decisions can be made to accomplish a system of risk reduction that facilitates less massive damage when a part fails?" When no systematic assessment is required, and then when it can haphazardly happen, and only the "experts" are called upon to make the assessment, this important reflexive process does not occur.
- Of course, the opportunity to gather data that will be beneficial to decisions about repair of the structures and for consideration of new risk reduction elements is best captured in the post-event time line that will reflect the impacts.

b. Emphasis and Prioritization

The Proposed OSEs exist as a skeleton to work from. As noted in Chapter 3, "one size does not fit all" Corps uses, nor all communities. One critical prioritized OSE list cannot be declared. What can is a comprehensive, representative list of the key components of a successful community. Then from that framework can be selected those elements most important to the assessment, determined together by the community and the agency's social science experts.

Let us consider an example applying one concept category from the Proposed OSE List in Chapter 3: *Community health risk factors* (under the heading Health and Physical Safety). For a catastrophic flood, this concept rises immediately to the top of consideration. The IPET report lists the "Human Health and Safety Consequences" observed in Katrina and Rita:

Short-Term

- Environmental health exposure
- Exposure to floodwaters
- Mold
- Heavy Metals in sediments and seafood
- Other potential environmental causes of morbidity and mortality
- Smoke from fires & debris
- Natural gas leaks
- Accidents
- Industrial fires/chemical emergencies
- Residential/commercial fires
- Specific health-related exposures
- Mortality (causes) *[Health & Physical Safety -Mortality]*

Long-Term

- Health insurance coverage *[Access to health/medical services]*
- Health care needs *[Access to health/medical services]*
- Missing children *[Health & Physical Safety – Mortality]*
- Housing and food instability *[Housing]*
- Overcrowded conditions
- Resentment *[Mental health exposure]*
- Mental health exposures
- Depression
- Substance abuse
- Interruptions in mental health service delivery *[Health & Physical Safety – Adequacy of health/medical services]*
- Suicides *[Mental health exposure]*
- Mortality (causes) *[Health and Physical Safety – Mortality]*
- Absence and discontinuity in vital records resulting in denial or long waits for services

In addition to the prime concept of *community health risk factors,* other concepts are also important. We have listed them in parentheses next to the impacts identified in the IPET report. It would be possible to list all of these OSE's in a Corps handbook or reference document but would not be easily usable. Perhaps it could be used as a reference guide, but the OSEs will emerge if the assessment process is inclusive in terms of including community observers along with the social science experts within the Corps.

C. Steps in examining OSEs in Post-Disaster Assessment

1. Public Involvement - Develop an effective public plan to involve all affected or potentially affected publics.

It is at this first stage, *in conjunction with the affected, or potentially affected, community* that the dimensions of the impacting event are defined. Social effects can vary in their duration; the number of people that have, or will be affected; the extent to which they are reversible or can be mitigated; the extent to which they lead to cumulative effects; and by the value of benefits and costs to different groups and populations. The proposed OSEs are the starting point for this determination.

Cumulative Effects: When frustration mounts

The New Orleans CityBusiness reported 11 months after Katrina that suicide rates had tripled. Since the storm, there had been 30 documented suicides, many more were likely attributed to accidents -- all this in a city that had lost more than two-thirds of its population. (Saulny, 2006). A Harvard Medical study claimed that 30 percent of residents showed some form of mental illness, a rate twice as high as pre-storm numbers (Hurricane Katrina Community Advisory Group, 2006).

Again, this is NOT a case of one size fits all. Considering the effects that Katrina had on Buras (where the eye first came ashore) virtually all of the cells in the table will deserve careful consideration. Considering the repair of an existing levee in Belle Chasse, a much smaller set of potential effects would be appropriate. The level of effort devoted to this description should be commensurate with potential or actual impacts. It is during this period that an appropriate interdisciplinary assessment team should be identified; with the size and expertise of the team commensurate with the potential or actual impacts.

In the case of proposed activities, effects start happening with the first considerations. As Gramling and Freudenburg (1992: 217) note:

> "In the biological or physical sciences, it may be true that's impacts do not take place until concrete alterations of physical or biological conditions have occurred. With the human environment, however, measurable impacts begin as soon as there are changes in social conditions – often from the time when information about a project first becomes available...Speculators buy property, politicians maneuver for position, interest groups form or redirect their energies, stress mounts, and a variety of other social and economic impacts take place..."

2. Assessment before and after the event.

Once the assessment team is established and the appropriate level of assessment is determined, then the appropriate concepts are measured before and after the event. Part of the assessment should include an historical background with the amount of effort commensurate with the effect, or potential effect, of the event. If the event is a proposed drainage canal then the identification of the historical causes of the problem, as identified by all stakeholders, is probably sufficient. If, however, the event is a serious flooding of a coastal community, then an extended analysis of the community's historical relationship to its setting will be necessary. Knowing how the community functioned in its environment prior to the event will be invaluable in addressing restoration and resiliency issues. See Appendix C for an example of how the U.S. Forest Service (Bright, Cordell, Hoover, and Tarrant 2003) approaches "historical

background."

If the event has happened (e.g. Katrina) then we must establish an historical baseline and the current conditions. If the event is a planned alteration then the current conditions must be established and projections made of post-event conditions. Reviews of the existing social science literature, public scoping, public surveys, and public participation techniques are the principal methods used by experts.. In addition to interviews of the affected population, published scientific literature, primary data, and secondary data from the affected area's historical documents, census, maps and photographs can all be used to describe the physical and human environment before and after the event.

3. Compare before and after and assess effects.

There will be gaps in the data. While current conditions are easier to assess than historical baselines or future projections, even here such gaps as out-of-date census data, and data aggregation at coarser levels than ideal will lead to imprecision. The rule of thumb here is that it is more important to identify significant change – and hence significant social effects – than it is to precisely quantify the more obvious ones (Inter-organizational Committee on Guidelines and Principles for Social Impact Assessment. 1993; 2003). In a Katrina-like situation if we know that 95 percent of the community housing stock was lost, it probably doesn't make much sense to spend a whole lot of time trying to get an exact count. Likewise, if an improved levee will potentially lead to land development behind that levee, then the exact form of development is less important than the implications of developing in that location.

4. Consider indirect and cumulative effects.

Indirect effects are those that follow from the initial, or direct effects, and cumulative effects result from the incremental impacts of past, present, or reasonably foreseeable future effects.

Considering the probable future through the inclusion of a futuring process. Futuring is an anticipatory decision-making process that leads to planning and program development (Sobrero, 2004). It looks forward 10, 20, or 30 years, while planning looks ahead just 1 to 4 years. The process assures that social, economic, political, environmental, and technological changes are analyzed using existing county, state, and national data centers as well as the voices of local stakeholders. It allows communities to identify issues as well as the perceived relevance and value of those issues. During the process, communities share perceptions of their observations of the critical indicators of change and determine current relevance. As communities look forward 10 years or 30 years, they point out external driving forces and the stakeholder assumptions related to relevancy, priorities and societal trends, as well as the mission of the project and availability of resources. A strength of the process is that it allows everyone involved to understand the community and culture before implementing any projects. Communities can develop scenarios for each OSE where change is likely to occur. The scenarios should range from a very desirable future to an undesirable or even catastrophic future. From these scenarios, estimates of resource allocation can be generated

5. Develop a mitigation plan.

Where the assessment involves a proposed action, not only can the assessment project likely determine effects, but it can be used to identify those effects that the community considers adverse. Once identified these adverse effects can be mitigated by "avoiding the impact by not taking or modifying an action; minimizing, rectifying, or reducing the impacts through the design or operation of the project or policy; or compensating for the impact by providing substitute facilities, resources, or opportunities (see 40 CFR 1508.20)" (Inter-organizational Committee on Guidelines and Principles for Social Impact Assessment.1993:18).

D. Short and Long-Term Impacts

There are dramatic differences in type and quantity of OSEs as the time distance from the flood event plays out. For purposes of anticipating emergency response and recovery activities in a flood disaster, the early-stage OSEs are extremely important. In these phases the impacts are often life threatening – evacuation, toxic contamination,

extreme emotional and physical stress from evacuation and relocation. However, the longer-term impacts are equally important as one considers the possibility of community recovery and future successful functioning. We, therefore, recommend that this dimension be definitely included in the post-flood analysis just as the Social Impact Assessment approach recommends its use to assess proposed flood risk-reduction actions.

Chapter 6: Conclusions and Recommendations

The conclusions and recommendations about the enhancement of OSEs from the experiences of the communities devastated by the flooding of Hurricanes Katrina and Rita within the levees are expressed below in a series of 12 observations and recommendations.

1. Full inclusion of other social effects is necessary in Corps project planning.

OSEs are now seen as a much more important account then when initially proposed in the P&G in the 1980s. Societal norms have shifted to place much more emphasis on the function and importance of "community" and "society" than in that era. Because the OSE account is not mandatory for analyzing Corps projects, bringing attention to the impacts represented by OSEs is made more difficult. Over the last 30 years, societal priorities have shifted. This team believes that all four Corps accounts (Other Social Effects, Environmental Effects, Regional Economic Development Effects, and National Economic Development Effects) should be considered co-equal and mandatory. Economic and environmental dimensions remain important but must be considered with the social. Otherwise, the project analysis process is incomplete and thus will result in faulty decision-making about the appropriateness of a Corps project and the best configuration of it vis-a-vis community-safety needs.

2. Capacity to do so very available.

The social sciences are more advanced in the refinement of OSEs than in the 1980s, and thus able to provide the technical assistance to do so. By combining a well-tested, internationally accepted approach such as Social Impact Assessment (SIA) with the newer focus on community capital, the Corps will be able to develop a fully supported OSE process to accompany the new planning process revisions. The OSE account should be able to be fully utilized. This team has proposed for this social account OSEs grouped into three major categories: Population Characteristics, Community Social Institution Capacity and Community Interpersonal Social Capital.

3. To accomplish successfully the implementation of the OSE account, a full social science staff must be put into place within the Corps.

As outsourcing engineering when there is inadequate engineering supervision has led to disastrous outcomes for the Corps, so too expecting any social planning process to be fully successful when the Corps has not committed to a full internal professional staff of social scientists – namely sociologists, social anthropologists,

risk mitigation planners and dispute resolution specialists – is to ignore the reason our society believes in professional training and agency leadership. No different than the engineering, hydrology and geology expertise required to build Corps projects, the social process expertise exists and must be hired. Thus, the Corps, like the other physical mission agencies such as MMS (Minerals Management Service) (Luton & Cluck, 2000) http://www.mms.gov/eppd/socecon/files/luton-cluck.pdf
http://www.gomr.mms.gov/homepg/regulate/environ/ongoing_studies/gom-se.html , NOAA, USGS, who have successfully developed applied social science capacity, should employ social scientists as well. There is no reason why the Corps cannot join these other physical mission agencies in appreciating and committing to such a professional unit within the revised planning structure. Currently, at least in the New Orleans District, the only social scientists are anthropologists, who are employed almost exclusively to satisfy the regulatory requirement that the Corps document archaeological artifacts when projects are considered, investigate environmental-justice challenges when doing the Environmental Impact Statements required by the EPA and conform to federal requirements regarding historic districts, buildings and sites. The whole idea of resurrecting the OSEs in light of the Katrina event is to bring the social effects into their own front-and-center full-fledged role, not simply to conform to specific regulations.

4. OSE process must be done very early in project conceptualization.

The timing of using the OSE analysis process is critical. When used to assess a project, it should begin at the very first stage of considering whether the Corps' resources can possibly be used to assist a community in reducing its flood risk. The reason why this team advocates such an early start is that assumptions about the appropriateness of the project (whether a Corps project will benefit the community or not) and the configurations of the structures (which alternative) begin very, very early in the process of discussion. That is one of the powerful lessons that the Social Impact Assessment process tell us. In addition, collaboration with the community should continue into each of the phases of the project so that knowledge about the project's progress can be shared and adjustments made. An example of a Corps community engagement process that includes more such community engagement than previously common is now underway for the pump stations to be placed at the lake end of the New Orleans drainage canals.

5. The finite nature of government resources begs a process to use them more effectively for flood risk reduction.

Government resources are finite and very valuable to communities to address flooding. Therefore, the OSE assessment process enables the Corps to identify with the community as a partner the best use of those resources for **the community's sustainability and resiliency.** It is very important to use these two goals – a sustainable, resilient community – to determine the impacts to be examined and then to decide how best to spend the funds and select the project based on this assessment. Especially in today's economy, no government resources should be wasted when communities need to develop flood protection.

6. The full community must be engaged for project success.

The full community, not just the geographically proximate or community leadership stakeholders, should always be involved in the assessment. Not all stakeholders have ready access to being recognized nor engaged in project development. Due to differences in wealth and political connectivity, some groups will not have equal access to the decision-making process. However, for the sake of the most successful project, social equity of participation my be a key tenant of engaging the community.

7. Building consensus will be challenging but is doable.

This team does not naïvely believe that consensus of protection goals will always come easily. While dispute resolution will likely have to be used, as indicated in the IWR manuscripts and the draft handbook, the tensions among different sub-group goals must be aired and resolved, not ignored and left to fester. When the Corps has not aggressively approached the community with the OSE conversation in the project planning process in the past, inordinate amounts of time, energy and agency prestige have been wasted in addressing the public response. These outcomes have directly threatened the projects. As has been evident with the post-Katrina public meetings, the force of the opposition or criticism will only build if the community's involvement in the process is delayed to post-project option decision making.

8. The SIA process will resolve differences if done correctly by social process specialists.

If done with care and commitment to the steps developed over the 30 years of its existence, the SIA process will facilitate consensus building for the proposed project. That is one of the reasons why interest in SIA has grown over the decades and its use has spread internationally. It works.

9. Dispute resolution specialists should be key part of social science unit.

There is a plethora of dispute resolution professionals and groups within major universities around the country and in private firms who can assist in the SIA process of early, consistent community engagement. In fact, some may be the ones currently engaged by the Corps to manage the after-alternative public meeting process currently implemented by the Corps. The involvement must be managed by a full internal social science staff.

10. There should be total commitment to post-disaster OSE assessment with the affected community(ies) of failed or protection-surpassed projects for every federally declared disaster.

The OSE factors, as well as impacts to the environment and cataloging the physical damage that occurred, should be part of that assessment. Such a post-mortem process provides an excellent opportunity to engage community and agency stakeholders in a critical analysis of community sustainability and the role of the project in enhancing or detracting from that goal. Additionally, such an assessment will provide information and data that will be extremely useful in the repair and rebuilding of the structure.

Important Example: An interesting example has been occurring with the development of alternative locations for the pump stations in canals that drain to the lake in New Orleans. As the interaction between the Corps and the community has evolved it has become evident that interest in safety over aesthetics has emerged although at first the emphasis of those who spoke was mostly the opposite. If the Corps had held only one or two meetings with the residents, that fact may not have emerged because the aesthetic concerns were expressed so loudly at first; the residents had an initial "knee-jerk" push back because of the beauty of their neighborhood. "On second thought," the residents are now requesting loudly to have the Corps place safety first. The longer community engagement process may "permit" the community to think through the values they want to achieve. Ultimately it will enable the Corps to move more quickly on the most safe

alternative – defined not only in ultimate 1/100 protection that all alternatives will have, but in the speed of being able to implement the construction and thus to protect in sooner hurricane seasons.

11. Robust, central OSEs should be added to stakeholder MCDA exercise.

When it is determined that the process of selecting from different project options is benefited by engaging stakeholders in a comparative risk-assessment process that asks them to choose weightings from among the four accounts (Multi Criteria Decision Analysis), it is imperative that all four accounts be fully represented clearly and explained fully to the stakeholder participants. Even in its recent refinement much more effort has been devoted to the calculation and computer software aspects (more relevant to engineering expertise) than to the content, i.e. what concepts are being offered to the stakeholders for their consideration, i.e. the social process aspects? Critical OSE concepts must be added to the exercise for it to have validity as a stakeholder decision tool. Currently their minimal presence strongly challenges the tools validity.

12. Expanded Corps leadership to partner and engage other relevant government agencies and the citizens -- i.e. resource stakeholders – is mandatory to achieve nation flood risk reduction.

If a true comprehensive assessment of risk reduction is undertaken using the SIA approach, a combination – a system -- of structural and non structural methods will be revealed and appreciated for their combined, interactive benefit. The structural resource will be one. Interagency collaboration is essential on large complex water resource projects in order to bring all of the potential resources to its solution, including those that local communities and citizens can contribute and those that are not monetary such as enhanced risk avoidance land use regulations and home elevation.

The Corps is poised to be the key facilitator of this effort and cannot only ensure OSEs are integrated into the analyses, but can also facilitate the coordination necessary to leverage all possible agency resources. Stovepipes for different federal program resources are hurdles that must be overcome. Efforts by the New Orleans District – in the co-location of federal agencies key to coastal restoration -- and Corps efforts elsewhere -- under the "Silver Jackets" initiative -- show the success of this type of collaboration. These best practices and agency resources must be "packaged" for each flood risk reduction project and concerns that such packaging might be seen as "duplication of benefits' overcome through agency and Congressional negotiations. This project team, which includes a national floodplain manager leader, believes that such packaging is possible with a strong commitment to do so. And it is mandatory if truly successful community flood risk reduction is to be accomplished.

Appendix A: Measuring Proposed New OSEs for Hurricane Katrina

Population Characteristics					
Dimension	**Indicators**	**Generic Operationalization**	**Generic Sources**	**Katrina Operationalization**	**Katrina Sources**
Population Patterns	Population size, density, birth & death rates	Population estimates. Number of births & deaths per 1,000 residents	US Census Bureau & Center for Disease Control	Total Population Estimates: Orleans 2006 estimate 453,726 * Orleans 2007 estimate 239,124 **Total loss of Population 214,124**	US Census Bureau & Center for Disease Control
Demographics	Gender, racial, & age distributions	Number of males per 100 females. Racial and age breakdowns of the areas population.	US Census Bureau	Gender shift from 53% female to 46% female. Before Katrina 53 females per 100 residents. After the storm 46 females per 100 residents.	"The Calm in the Storm: Women Leaders in Gulf Coast Recovery.", Women's Funding Network and the Ms. Foundation for Women, August 27,
Vulnerable Populations	Impoverished, Elderly Children, & Disabled	Number of residents living below the national poverty line. Number of residents over 65. Number of residents under 18. Number of disabled residents.	US Census Bureau	Traumatic experiences reported by children showed that 34% were separated from their primary caregiver while displaced; many attended multiple schools (average of 2 and up to 9 schools). 21% saw family members or friends injured; 14% saw family members or friends killed; and almost all saw hurricane damage to	"Resilience in Children" Katrina's Children Medscape Today by Alan Chrisman MD
Immigration & Emigration	Population trends of the community	Number of residents moving out of the area each year. Number of new people moving in each year.	US Census Bureau	Orleans Parish was already a shrinking city before Katrina. In 1990 there were 496,938 residents. By 2000 that number had fallen to 484,674 residents. And in July 2005 had reached a pre-storm low of 453,726. **Total 15 year loss = 43,212 residents**	US Census Bureau
Mortality	Increase in the death rate of the affected region	Number of deaths per 1,000 residents	Department of Health and Computer modeling	Deaths per 1,000 residents in 2004- 11.3 * Deaths per 1,000 residents in 2006- 14.3	New Orleans Department of Health
Transient Residents	Tourists & migrant workers	Number of Tourists to the community per year - Estimated number of migrant workers to area per year	Local Tourism Bureau, US Department of Labor & Statistics	On average, pre-Katrina, New Orleans N.O.; tourism industry hosted 8.5 million tourists per year. Income on locals during 2006, that number fell to 3.7 million. By the slow summers of 2007, tourism was on the rise and reached 7.1 million visitors.	New Orleans City Business by Dean
Fatalities	Deaths linked directly and indirectly to the event	Number of residents killed as direct result of the event. And the number of residents that may die as a result of: stress, suicide, pollution, contamination, impoverishment, and devastation of the health care sector.	Computer modeling	Total event direct deaths-1,723 * Total event indirect deaths- 2,358 Total deaths- 4,081	"Post Katrina Health Care: Continuing Concerns and Immediate Needs in the New Orleans Region" A testimony to the US House of Representatives by Robert Lindsay

Community Capacity

Dimension	Indicators	Generic	Generic Sources	Katrina Operationalization	Katrina Sources
Education	Educational opportunities	Number of students enrolled in school (by type). Educational Achievement (measured by standardized test scores)	Department of Education & the local universities	Public School Enrollment in Orleans Parish: Fall 2004_ 66,372 * Fall 2007_ 32,887 * Loss of 33,485 Students * Private School Enrollment in Orleans Parish: Fall 2004_ 26,008 * Fall 2007_ 18,151 * Loss of 7,857 Students *New Orleans University Enrollment: Fall 2004_ 64,348 * Fall 2007_ 47,674 * Loss of 16,674 Students Total Loss of Students: 50,016 *Orleans Parish LEAP Pass rate: Spring 2005_64% * Spring 2008_43% * Spring 2007_57%	Louisiana Dept. of Education & the Local
	Educational physical infrastructure & personnel	Number of open public schools, private schools, & universities as well as the number of educators employed	Department of Education	Number of open public schools in Orleans fell from 128 before the storm to 79 in Spring 2008 (38% reduction). Number of open private schools in Orleans fell from 93 before the storm to 63 in 2007-08 (32% reduction).	Louisiana Dept. of Education, Recovery School District, & Orleans Parish Schools
Criminal Justice	Community crime/ violence & safety	Number of violent crimes per 100,000 residents	Local Department Police	2005 Orleans violent crime rate 229.3/100,000 residents 2008 Orleans violent crime rate 282.5/100,000 residents 2007 Orleans violent crime rate 368.4/100,000 residents	NOPD
	Police, court, incarceration, domestic violence, shelter facilities, and personnel	Number of police officers and court personnel employed	Local Department and police court houses	Now at 1,470 officers -- down from the pre-flood 2005 total of 1,668 officers -- the Police Department seeks 1,600 officers by next summer and, ultimately, 1,700	Times-Picayune

Community Capacity

Dimension	Indicators	Generic Operationalization	Generic Sources	Katrina Operationalization	Katrina Sources
Neighborhood/ Housing	Housing characteristics: supply, cost, condition	Average Home Values • Number of Active Listings • Number of Home Sales Per Month • Average Monthly Rent • Breakdown by housing Type (Single-family, multi-family, etc)	US Department of Housing & Urban Development, Large Local Realtor	Avg. Home Sale Price Orleans East bank: Aug. 2005_ $244,793 * Feb. 2006_ $180,793 Home Prices fell 26% Number of Active Listings in Orleans East bank: First Quarter of 2005_1,798 First Quarter of 2006_2,527 Fair Market Rents for New Orleans MSA for a 1 bdrm apt. went from $531 in 2004 to $846 in2006	New Orleans Metropolitan Association of Realtors (NOMAR) Latter & Blum Research Division US Department of Housing and Urban Development, Fair market Rent History 2000 to 2005 and County Level Data File for 2006-06
	Residential stability	Tenancy (percentage owner-occupied and rental)	US Census Bureau	Not available	Not available
	Homelessness	Estimated number of homeless people within the area	Local Homeless centers and charitable organizations	Estimated homelessness before the event 13.22/1,000 Estimated homelessness after the event 50.18/1,000	New Orleans Mission
	Historic buildings & districts	Number of historic buildings and districts	US Department of Interior	"There are 38,000 buildings in the New Orleans' 20 historic districts, and we estimate that 8,000 to 10,000 of these were damaged by flooding. Another 2,000 to 4,000 or so buildings are eligible to be listed in the National Register districts. If you add these in, the total number of buildings that were impacted by flooding or winds is 10,000 to 12,000	Preservation Resource Center of New Orleans
Business	Commercial/ business stability & diversity	Number of Employers total and by sector	US Department of Labor	Net Change in the total number of employers in Orleans Parish: 2005 Q2_9,592 * 2007 Q2_7,482 a loss of 2,110 employers.	US Department of Labor Terrell, Dek and Ryan Bilbo "A Report on the Impact of Hurricanes Katrina and Rita on Louisiana Business"
	Small business sector	Number of small businesses in the area	Local Planning Commission	In the aftermath of Hurricane Katrina, an estimated 57,000 New Orleans small businesses are expected to have been destroyed and/or put out of business. With small business accounting for approximately 75% of all net new jobs in the United States, helping the redevelopment of this sector will be a top priority for New Orleans.	Urban & Regional Planning Economic Handbook

Community Capacity

Dimension	Indicators	Generic Operationalization	Generic	Katrina Operationalization	Katrina Sources
Income, Employment, Labor Force	Economic activity of population	Local sales tax collection	Local Government Finance Department	City of New Orleans Sales Tax Collections Jan 05 - Jan 08_$11,822,158. At it's worst a loss of $5,041,730 in monthly sales tax revenue. * Jan 05_$13,562,270 * Jan 06_$8,520,480 * Jan 07_$11,806,003 *	City of New Orleans Finance Department
	Personal/ household Income	Median Individual & household	US Bureau of Labor & Statistics	Avg. Weekly Income in New Orleans rose from $742 a week in 2005 Q3 to $987 a week in 2007 Q3	US Bureau of Labor & Statistics
	Employment/ Income dispersion & stability	Median Income by age, race, & gender.	US Bureau of Labor & Statistics	Women's Incomes in New Orleans fell from $30,284 to $28,932; Men saw an increase in income. *In 2006, 37% of Orleans residents and 24% of Jefferson residents reported their family income decreased since Katrina.	"Pay gap between genders is the worst in LA, study shows", The Times-Picayune, April 24, 2007 Susan Howells QOL Report
	Occupational diversity	Number of non-farm jobs/ Number of non-farm jobs by sector	US Bureau of Labor & Statistics	Number of Non-farm jobs in the New Orleans MSA Aug. 05_603,700 * Feb. 08_520,400 * A loss of 83,300 jobs.	Louisiana Department of Labor
	Community socioeconomic characteristics	Analysis of standard deviation of the average income	US Bureau of Labor & Statistics	not available	not available
Health & Physical Safety	Adequacy of health/ medical services	Analysis of the types of medical services offered (ex. MRI's)	Local medical centers & hospitals	not available	not available
	Access to health/ medical services	Number of hospital beds per 1,000 residents	Us Department of Health & Human Services	Nationally there are 3.26 hospital beds per 1,000 people. Before the storm in New Orleans there were 3.03 beds per 1000. In April of 2006, there were 1.98 hospital beds per 1000 New Orleanians. That's 2000 of the 4400 pre-storm beds.	"After the Storm- Health Care Infrastructure In Post-Katrina New Orleans" by Ruth E Berggren & Tyler J Curiel. The New England Journal of
	Community health risk- environmental, behavioral, vulnerable populations	Potentially harmful exposure, stress related illnesses	Centers for Disease Control	Mental Illness: In 2003 18/100 New Orleanians suffered from a mental illness. After the storm in 2005 31/100 New Orleanian residents suffered from mental illness. Suicide Rates: Before the storm the suicide rate in New Orleans was 11/100,000 per year or 0.75/100,000 per month. In the four months following the storm there were 28 suicides per 100,000 residents or 6.5/100,000 per month. Alcohol Consumption: 11% of New Orleans' residents report they have increased their alcohol consumption as a result of hurricane Katrina.	Harvard Medical School Dr. Jeffrey Rouse the Deputy Coroner, New Orleans Coroner. Kaiser Family Foundation & Secretary of the Louisiana Department of Health and Hospitals
	Health/ medical facilities and personnel	Number of hospitals, pharmacies, Health facilities, and Mental Health facilities, Nursing homes. • Number of licensed health care professionals practicing in the area.	US Department of Health & Human Services & Blue Cross/ Blue Shield, State Department	63% of the 22 pre-Katrina state licensed hospitals have re-opened. • The number of Blue Cross/ Blue Shield physicians in Orleans dropped from 2,351 in 2005 to 765 in 2006. • 65% of Orleans Parish pharmacies remain closed.	Louisiana Healthcare Redesign Collaborative: Region 1 Health Care Profile: A Health Care Needs Assessment of Orleans, Jefferson, Plaquemines and St Bernard Parishes

Community Capacity

Dimension	Indicators	Generic Operationalization	Generic Sources	Katrina Operationalization	Katrina Sources
Governmental Organization	Organizational functioning & adequacy of government	Residents satisfaction with local government	Survey the population	In 2004, 78% of residents rated local government services as fair or poor.	Susan Howell's QOL poll
Community Social Services	Availability & access to the a lo public transportation, chemical dependency treatment centers, job training centers, etc. basic range of social services	Number of childcare facilities, access	Department of Social Service, Department of Transportation	81% of Child Care Facilities remain closed. 19% reduction in the number of NOPD officers. 52% reduction in the number of bus routes in Orleans and an 81% reduction in the number of buses. Only 3 of the metro areas 5 ferries are currently running *Number of busses per resident before event 8.11/10,000 Number of busses per resident after event 2.88/10,000	Department of Social Service, Department of Transportation, Regional Transit Authority
Cultural, Historical Landmarks, Aesthetic Support	Recreational & cultural opportunities & participation	Number of county/ parish run parks, playgrounds, community centers, and & senior groups & other organizations	County/ parish parks and recreation departments	not available	not available
	Museum, sports, recreational facilities & personnel etc.	Number of Museums, parks, arenas,	Local phone directory	not available	not available
	Festival Infrastructure & Voluntary/ commercial personnel	Number of annual festivals held	Local tourism bureau	not available	not available

Community Interpersonal Capital						
Dimension	Indicators	Generic Operationalization	Generic Sources	Katrina Operationalization	Katrina Sources	
Ideal Interpersonal Conditions	Community identification/ attachment	Attachment to place, likelihood residents will leave the area	Survey the population	1/3 of area residents say they are likely to leave the area in the next two years.	Susan Howells Report 2006	QOL
	Community cohesiveness	Satisfaction with life in the area	Survey the population	In 2004, 59% of New Orleans residents were satisfied with their lives. By 2006, the number fell to 48%.	2004 and 2008 QOL Reports Dr. Susan Howell	
Interaction to Means to Achieve Conditions	Community leadership	Approval ratings of leading local officials	Local opinion polls (local newspapers)	In 2004, 84% of white New Orleanians and 47% of black New Orleanians approved of Mayor Nagin. In 2006, 23% of white residents and 81% of black residents approved of Mayor Nagin.	2004 and 2006 QOL Reports Dr. Susan Howell	
	Political organizations & citizen political involvement	Voter turn out	Local elections division	In the 2002 mayoral election voter turnout was 48% (133,601). It fell to 36% (108,348 of 297,909) in the 2006 mayoral election. • 43% of Jefferson Parish registered voters have not voted since the storm.	Louisiana Elections Division and WWLTV (Maya Rodriguez)	
	Voluntary associations & membership	Volunteer Membership rates	Survey the population	Not available	Not available	
	Religious organizations	Number of religious/ worship centers	Number of religious/ worship centers listed in the local phonebook	In April 2006, the Catholic Church announced 27 church parishes would be closed or merged with other parishes. Phone book comparisons reveal a net change in the number of religious centers.	Times Picayune	
	Friendship/ family networks	Average number of friends/ family members living in the area	Survey the population	Divorce rates are up 10% in Jefferson Parish & 7% in St Tammany Parish since Katrina.	"Unlying the Knot: Divorce filings Increase after Katrina" Fritz Esker	
	Print & electronic media array, diversity, access	Number of local TV news stations and news papers	Federal Communications Commission	Not available	Not available	

Appendix B: Vignettes from Hurricane Katrina Reported in Media

1. Population Characteristics

- *Size, density, births, deaths*
- *Ethnic, racial, age and gender composition*
- *Vulnerable populations*
- *Permanent and temporary (im/e)migration*
- *Transient residents (including tourists)*

Potential reconstitution of racial and class composition following disasters: A civil rights lawyer suggested in a news report that the dislocation of many African American residents indicated that "it's very clear that there are those who are interested in reconstituting the demographic and literally changing the face of Orleans Parish" (Tilove, 2005).

Population dislocation impacts public transportation: New Orleans' daily newspaper displayed the tension between restoring transit service and justifying its expenditures: In October 2006, the Regional Transit Authority had daily weekday average between 20,000 to 23,000 riders. Before the hurricane 125,000 people rode on weekdays and 35,000 on the weekends. Commissioner Barbara Major explained that "we need to show (FEMA) proof that the population has grown. But they (riders) can't come back if they can't ride. That leaves us stuck between a rock and a hard place" (Donze, 2006).

Restoration of the streetcar line provokes uncertainty about the return of people back to the city: A news report worried about the solvency of the reopened St. Charles Streetcar line: "Will there still be people for it in a city missing much of its population? Less than a quarter of pre-storm riders are using the transit system, buses included. On a recent morning, tourists in town for a football game packed the streetcar going Uptown. But going downtown, in the direction of the jobs, the old wooden benches were sparsely filled: a maintenance man here, a construction worker there, a housewife or two and the odd professional" (Nossiter, 2007).

Vulnerable Populations **African-American middle class dislocation:** A reporter for a national newspaper reminisces about the suburban New Orleans East neighborhood she grew up in – and yet exposes the vast uncertainty that still inundates the city two years after Hurricane Katrina: "One of my parents' favorite talk-over-the-fence neighbors, Michael Darnell, a lawyer, is not over the fence any more. (Not that there's a fence any more, either.) Mr. Darnell has been unable to repair his house because of delays hampering the Road Home, the state grant program for people who lost their homes. "From the perspective of African-American professionals, there's still a question about where this city is going," said Mr. Darnell, who is renting an apartment elsewhere in New Orleans. "I'm seeing a disintegration of what this community stood for, and people are still traumatized" (Saulny, 2007).

Vulnerable Populations **The storm's impact upon the elderly:** Recalling neighbors who have left New Orleans following Hurricane Katrina, the reporter writes: "Some of our relatives and friends were too old and feeble to rebuild. They are gone from the city for good, and we ache for them. Others were too angry to stay, overcome by the levees' unnecessary failures. We understand their need to move on" (Saulny, 2007).

Vulnerable Populations **Displacement separates teenagers from their parents:** An increasing number of students attending New Orleans public schools before the storm have returned afterwards – without their parents or

permanent guardians. One report underscores the potentially volatile consequences: "They are here on their own," Wanda Daliet, a science teacher said. "They are raising themselves. And they are angry" (Nossiter, 2006).

Vulnerable Populations **Teens with their families, too, are growing up fast:** A 17-year-old Chalmette girl, living with her family in a trailer outside their damaged home, discloses to a reporter about the emotional change in her life since Hurricane Katrina: "I don't plan anymore. I learned tomorrow may never come. I want to know, when I look back, that I had lived life to the fullest" (Bohrer, 2007).

Vulnerable Populations **Children relive the flood trauma:** Hurricane Katrina continues to a major impact upon young children – illustrating lingering fears of reliving the horror they experienced in escaping its ravaging floodwaters, or even just viewing media images of people doing so. A news report focused upon therapists utilizing art to understand this trauma: "One of the most common images in children's art is the house: a square, topped by a pointy roof, outfitted with doors and windows. So Karla Leopold, an art therapist from California, was intrigued when she noticed that for many of the young victims of Hurricane Katrina, the house had morphed into a triangle. "At first we thought it was a fluke, but we saw it repeatedly in children of all ages. Then we realized the internal schema of these children had changed. They weren't drawing the house as a place of safety, they were drawing the roof" (Dewan, 2007).

Vulnerable Populations **Disproportionate impact of Hurricane Katrina upon the elderly:** A newspaper report highlighted that over 70% of the dead were aged 60 or older, nearly half were aged 75 or older, and that post-storm housing, healthcare and services have largely failed to return, or is too expensive: "There is simply no place for them to go in New Orleans," said a Houston, Texas advocate working with more than 2,000 households displaced by last year's hurricanes (Lyman, 2006).

Vulnerable Populations **Recovery from disaster much harder for the elderly:** "At no point in your life is it easy to pick up and be displaced, but it's especially tough for senior citizens," said an elder advocate. "There are lots of evacuee issues that affect everybody, but they seem to affect seniors especially, because they can't bounce back so easily" (Lyman, 2006).

Vulnerable Populations **Disasters' impact upon house pets and companion animals:** Hurricane Katrina also profoundly affected human evacuees' animal companions. Many people thought they would only be away from home a short time, so many pets were left behind. Animal control organizations rescued thousands of these animals, according to a newspaper story. "We went with the military on their search-and-rescue," said an animal control officer. "When they went house-to-house, we went with them" (Persica, 2005).

2. Community Capacity

Education

- *Educational opportunities*
- *Educational physical infrastructure and personnel*

The long road towards recovery: A national newspaper noted: "The smell of gasoline fills the ruined gym each evening as a generator sputters to life. A string of bulbs provides thin lighting above the weight-lifting equipment that sits on a warped and abandoned basketball court. A makeshift dressing area for the South Plaquemines High football team spreads beneath one backboard, where floodwaters from Hurricane Katrina rose above the rim ten feet off the floor" (Longman, 2007).

Schools **Children carry the trauma of disaster into school:** The continuing impact of Hurricane Katrina was recounted: "Countless articles and at least five major studies have focused on the lasting trauma experienced by Hurricane Katrina survivors, warning of anxiety, difficulty in school, even suicidal impulses. But few things illustrate the impact as effectively as the art that has come out of sessions under the large white tent that is the only community gathering spot at Renaissance Village, a gravel-covered former cow pasture with high truancy rates and little to occupy youngsters who do not know when, or if, they will return home" (Dewan, 2007).

Youth return without their parents, negatively impacting education: A national news report notes that a New Orleans high school teacher and a guard "were beaten so badly that they were hospitalized. The surge hints a far-reaching phenomenon after Hurricane Katrina, educators here say. Teenagers in the city are living alone or with older siblings or relatives, separated by hundreds of miles from their displaced parents" (Nossiter, 2006).

Schools **In disaster's wake, disaster capitalism?** New Orleans' public school system was in crisis even before Hurricane Katrina devastated it. Since then said a report, a grand educational experiment has unfolded. Officials converted 43 salvaged schools to free-market charter schools – with varying levels of results. Persistent problems include the lack of instructional materials, library books, janitorial services and buses to transport students to and from school (Berger, 2007).

Schools **Public schools nevertheless emerge:** The same report analyzed that "at one such school, Lafayette Academy, the experience of a charter group with the profit-making company it hired to manage instruction offers a cautionary tale of how well-meaning trustees can easily stumble, and of how privatizing management is often far from a panacea. It also offers lessons in how a nimble, determined organization of amateurs can turn things around. Lafayette's trustees eventually booted out the national company and installed a veteran principal with New Orleans gumbo in his veins. This year Lafayette is by all appearances humming like the solid school it was meant to be" (Berger, 2007).

Schools **Resilience in the face of obstacles:** Other schools which have returned seemingly intact following Hurricane Katrina have been closed and relocated, due to the discovery of mold and safety issues. One report quoted the principal of a Treme elementary school: "The first move was unexpected, but certainly the process was seamless. It was just as if the kids went home for Thanksgiving break and that Monday morning, they were back in class" (Simon, 2008).

Schools **Higher education adversely impacted by disasters:** Uncertainty over how higher education institutions would fare following Hurricane Katrina commanded several news stories. Aside from the University of New Orleans, all colleges and universities in the city were closed for the fall 2005 semester. One university president said: "I think people realize that we have gone through an unbelievably traumatic experience, and that is

going to have an impact on us at least in the short run, perhaps academically, and for sure, financially" (Warner, 2005).

Criminal Justice

- *Community crime/violence safety*
- *Police, court, incarceration, domestic violence shelter facilities and personnel*

Domestic violence in the wake of disasters: Domestic violence escalated in the aftermath of Hurricane Katrina, yet the network of shelters and crisis support groups were also devastated by the storm. A news report quoted the executive director of one program: "People are at the end of their rope, and this storm has just made them snap" (Hunter, 2005).

Crisis lines overwhelmed: Crisis lines too were inundated with unprecedented call volumes, all the while counselors listen for unspoken pain, noted another report. A call center director defined the crisis: "Housing and financial issues, plus the lack of basic services and limited resources have made the situation here more desperate" (Bynum, 2007).

Crisis personnel empathize through their own losses: The counselors themselves empathize so well in part because the callers reflect pain they experienced themselves, said the same report. One phone representative noted: "I was a renter, but I lost my home and contents. I can relate to callers because I know what it's like to lose everything. When people call, the focus isn't on me, but in the long run, I think it helps me as well" (Bynum, 2007).

Restoration of crisis services following disasters: The crisis line in New Orleans never went down during Hurricane Katrina, said this report. But it had to be rerouted to Monroe, Louisiana and operated by volunteers from around the country. Its database had to be restored from scratch and is constantly updated. Phone counselors and callers alike continue to need the service: "We still have New Orleanians in 50 states who just want to talk to someone who understands" (Bynum, 2007).

Property crimes following disasters: In the months following Hurricane Katrina with most residents absent, a police officer remarked in a news story about thefts of the remaining possessions upstairs and the impact on their owners: "Those people out there who are stealing are taking the last of people's belongings and dignity. And that's all some people have left" (Lee, 2005).

Emotional challenges faced by rescue personnel: A report underscored the tremendous personal losses rescue workers and animal control personnel endured following the hurricane, leading to the loss of many staff, said an SPCA executive director: "We've lost our entire animal control staff. They've seen so many horrific things. They've seen dead people, dead pets, animals that are chained that drowned on the chain. And they just say, "You know, we need a break and I don't want to be here for a while'" (Persica, 2005).

Collapse of mental health services in the wake of Hurricane Katrina: A paranoid schizophrenic walked out of the Touro Infirmary ER, declining treatment from a physician, went home and "repeatedly stabbed his 77-year-old mother in the driveway of their Uptown home." Interviewed by police from her hospital bed, the mother said her 40-year-old son "had been off his medication for months." The man, "like many emotionally disturbed New Orleanians these days, ended up in jail because psychiatric services have all but collapsed since Hurricane Katrina" (Maggi, 2007).

What police face every day: "Here's a typical day at work for the NOPD Crisis Intervention Unit: A 20-year-old woman puts her 1-year-old and 5-month-old to sleep as she prepares to take her own life. A 48-year-old man, homeless and wracked by his mental illness, roams the streets naked, covered in feces. A 38-year-old man, diagnosed as a paranoid schizophrenic, barricades himself in his home after running through the streets with a knife, threatening to harm his neighbors. A young 14-year-old in utter despair and anger attempts to set his school on fire. They are all ticking time bombs, poised to harm themselves or someone else." (Tebo, 2007)

'Ticking time bomb' explodes: a man described by New Orleans police as a mentally ill vagrant allegedly wrestled a gun from a police officer and shot her to death, another news story reports. The suspect's family said he was diagnosed as a paranoid schizophrenic with violent tendencies when he was 19. Homeless and bounced around mental facilities, he's now at Orleans Parish Prison – He has plenty of company there. In post-Hurricane Katrina New Orleans, where hospitals are still not operating at capacity, the prison's 60 psychiatric beds make it the largest acute-care psychiatric facility in the city with only one full-time psychiatrist and two working part-time (Foster, 2008).

Following Hurricane Katrina, people are jailed because of the lack of psychiatric care: "We have read recently of New Orleans' lack of mental health facilities and resources, and it is with utter amazement that this particular need – and the needs of those who suffer from the medical disability of mental illness – has been met with total neglect from some hospital administrators. As it stands today, more than 300 prisoners in Orleans Parish Prison suffer from debilitating mental illnesses. As a mental health professional, I would venture to say that had they received proper treatment, most of them would not have found themselves in jail. Family members will tell you that they are not bad people, they simply are too sick to understand right from wrong. With proper treatment, they are good people and good citizens of our community" (Tebo, 2007).

Neighborhood/Housing

- *Housing characteristics: supply, cost, condition, tenancy (rent vs. own)*
- *Residential stability*
- *Community sub-area infrastructure, public service and neighborhood businesses*
- *Homelessness*
- *Historic buildings and districts*
- *Household/Family*
- *Density*
- *Dissolution*

Rents skyrocket in the wake of disasters: An attorney decried mass evictions of tenants in a news report: "throwing people out so you can raise the rents in a time of disaster and a shortage of housing clearly flies in the face of elementary fairness" (Tilove, 2005).

Homelessness **Rent hikes prompt homelessness following disasters:** Many former renters whose New Orleans-area apartments flooded or were evicted after the storm by landlords seeking higher rents, found themselves literally 'under the bridge' and homeless. Hundreds of people remain camped out in parks, backyards, and in one infamous concentration, underneath the Interstate 10 expressway towering over Claiborne Avenue (Thomas, 2008).

Damage from disasters prompt residential rearrangements: Flooding from breached floodwalls inundated the first floors of most homes and apartments, but left many second floors spared a newspaper story reported. Rather

than staying on relatives' couches, in motels or FEMA trailers, "uncounted multitudes in the New Orleans area consigned to a second-floor lifestyle" (Waller, 2005).

Homelessness **Living in part of their homes better than being homeless:** Second floor dwellers adjusted to the loss of electricity, hot water, kitchens and other areas, said an accompanying report. One man living in Broadmoor rigged up two car batteries to power fans, and brought to his electrified workplace items like laptop computers, electric razors, and battery chargers. "There was a day when I just thought, 'Tomorrow, I'm sleeping in my own bed.' I bought a bigger cooler, and that was it" (Langenhennig, 2005).

'Home' is the desired prescription following disasters: Drawings, photographs and sculptures by children recounting the storm experiences and trauma from Hurricane Katrina have been shown at the New Orleans Museum of Art and the New Orleans Jazz and Heritage Festival. They powerfully show that the storm is still continuing for these children and their families, nearly three years later: "The real prescription for these families is to get them back into a normal community," said Dr. Irwin Redlener, the co-founder of the Children's Health Fund. "We're treading water doing these things, when I'd like to take my prescription pad and write, 'Home' " (Dewan, 2007).

FEMA Trailers prompt lifelong ailments: Temporary housing supplied by the Federal Emergency Management Agency (FEMA) has been implicated into producing health ailments in adults and children – some which maybe lifelong, according to a wire service report. FEMA has acknowledged testing for formaldehyde exposure as being five times the normal levels. A young mother housed in one while pregnant now has a 15-month-old girl with severe asthma. The girl must inhale medicine through a breathing device: "If I had known it would get her sick, I wouldn't have stayed in the trailer for so long" (AP, 2008).

Finding affordable housing means renters must buy the appliances: A newspaper recalled the reaction of a couple in Mid-City which searched for months to rent half of a duplex for $950 a month – provided they purchased their own refrigerator, stove and air conditioning units: "Those were considered 'luxury items'" (Saulny, 2006).

Homelessness **Rent hikes since Hurricane Katrina prompt family to live in their business:** A national newspaper reported that a mother and four children are living in the small office of a laundry her family owns in Mid-City. "I can't afford the rent around here – it's gone up almost double," said the mother, whose three bedroom home in Broadmoor had flooded (Saulny, 2006).

The limited return of small landlords, limiting further the availability of rental housing: A newspaper noted that in addition to many homeowners awaiting insurance settlements or governmental assistance, "uninsured, small-scale landlords are also waiting for help, and their languishing properties are contributing to pockets of emptiness in almost every part of town, experts say. A shortage of affordable housing and workers is compounding the problem" (Saulny, 2006).

Housing grants premature expiration sent families back into turmoil: Expecting to have one year's support from FEMA for housing relief after losing their homes during Hurricane Katrina, a national newspaper story reported that the federal agency demanded that those who qualified for long-term assistance reapply or begin paying for their rent and utilities. Quoting one distressed parent, who had enrolled her son in school in a Houston suburb: "It's stressful, but I thought I had it together" (Dewan, 2006).

Many apartment developers after Hurricane Katrina holding tax credits lag in offering supportive housing: A national newspaper spotlighting New Orleans' intense homelessness crisis noted that "many apartment developers who applied for tax credits after Hurricane Katrina were required to set aside 5 percent of their units for supportive housing, but because of high construction costs and other factors, far fewer units than expected are in the pipeline – and without [rent] vouchers, even those units will not be affordable" (Dewan, 2008).

'Road Home' housing program effectively excluded renters, said report: A national newspaper underscored that the housing crisis in New Orleans following Hurricane Katrina was made worse by governmental failure to provide an affordable return for the majority of pre-storm residents. Quoting a local civil rights attorney who filed a federal complaint regarding the state housing program: "The state has misleadingly named its programs as 'The Road Home Housing Programs' despite the fact that the planned expenditures will not provide a realistic road home for most of the people with low and moderate incomes" (Saulny and Rivlin, 2006).

Business

- *Commercial/business stability/diversity*
- *Small business sector*
- *Informal exchange (bartering) networks*

Small Business **Insurance limitations upon small business inhibit recovery:** Many small businesses also discovered the limitations of insurance policies following Hurricane Katrina. One report quoted the owner of a plant store and garden center: "We were under the impression that the insurance company would come to your aid immediately rather than inundate you with paperwork. We paid business interruption insurance for 21 years, but as yet we haven't received a penny. We're disappointed" (Mowbray, 2005).

The ripple effect of business losses due to disasters: In many cases insurance companies requested documentation before it would pay off on claims. This same article reported that adjusters sought information that was lost in the storm. Compounding situations were losses experienced by related firms that usually would provide back-up, including tax preparers and bookkeepers – whose offices were also destroyed (Mowbray, 2005).

Small Business **Collective Vietnamese community action brings back neighborhood businesses key to recovery:** A weekly newspaper noted that "at the entrance to the subdivision, 24 businesses have sprung back to life, including restaurants, grocery stores and even a dentist office." Key to the success of the restoration was "working together, they set about gutting and restoring their homes [and businesses]." Negotiations with utility providers to provide electricity netted "500 signed requests for electrical hookups. By November [2005], Versailles had electrical power and water lines" (Hill, 2006).

Major employer relocates because of the high cost of insurance: A national newspaper reported that a major industrial employer on the Mississippi Gulf Coast is shifting its operations to Tennessee, due to the soaring cost of commercial insurance. The firm, whose headquarters is in New Orleans, having won wide acclaim because it had reopened just ten days after Hurricane Katrina's August 29, 2005 landfall, "says it cannot get enough insurance to cover its plant here, and cannot hire enough skilled workers to replace those who never returned after the storm, mostly because they had nowhere to live" (Eaton, 2007).

Small Business **Skyrocketing homeowners insurance costs impacting business owners:** The escalating cost of homeowners insurance along the Gulf Coast is impacting negatively business owners, who are considering leaving the region two years after Hurricane Katrina because the cost of insuring their own homes is becoming prohibitive, said one newspaper story. The report also underscored that policy holders are tiring in their fight to receive what they perceive as just compensation for losses incurred: "You're so worn down by everything you've been through that you just don't have the fight left in you" (Eaton & Treaster, 2007).

Small Business **Restaurant owners face daunting challenges staying in business:** Celebrated culturally for providing visitors and residents alike the food that New Orleans is acclaimed the world over for, restaurants were amongst the first businesses which reopened following Hurricane Katrina, said a national news story. Nevertheless as businesses they face indomitable odds staying in business. While finding and retaining workers with decent wages remains a challenge, returning owners also grappled with sporadic power outages and even water in natural gas lines, which threatened to damage kitchen equipment. Said one proprietor: "I know people say, 'My God, a year later and you're not any further than this?' They just don't understand. We're all taking a whipping down here" (Severson, 2006).

Small Business **Small business sector IS the economy:** One year following Hurricane Katrina, many small enterprises throughout New Orleans struggle to remain open for business. Many more had yet to reopen, or were forced to relocate, according to an assessment by a national newspaper. A proprietor of New Orleans-themed gift, spice and hot sauce shop at Louis Armstrong International Airport, who had already taken out home loans, maxed-out her credit cards and whose husband staffed the cash register each day after her one employee failed to return after the storm, worried aloud about the future and flavor of the city which these businesses sustain: "What I'm fearing now," she said, "is that we're going to lose more of the mom-and-pop places that made it so special here" (Eaton, 2006).

Small Business **Commercial business diversity at stake:** Employing watery metaphor, this news article underscored that small businesses are the backbone of New Orleans: "Even before the storm, New Orleans's economic ship was powered not by a couple of whales, but by a school of minnows. The city estimates that 95 percent of the 22,000 businesses here before Hurricane Katrina employed fewer than 100 workers (fewer than 25, in most cases). These included not just shops, but also the artists and manufacturers and wholesalers that supplied them, and the accountants and lawyers and cleaning companies that served them" (Eaton, 2006).

Level of flooding determines level of business return, report suggested: The return of stores and shops following Hurricane Katrina largely has been determined by amount of flooding a given neighborhood had endured. This report cited a geographer, who suggested that "each foot of flooding reduced the percentage of businesses that have returned by about 10 points" who then contrasted the return of businesses on relatively unscathed Magazine Street with the much more damaged St. Claude Avenue (Eaton, 2006).

Small Business **New Orleans small business entrepreneurs unite for recovery:** This special report also spotlighted efforts to unite business proprietors to harness grant funds to restart businesses as well as to share in public advocacy for government attention to their plight: "Hundreds of small business owners have formed Second

Wind, an advocacy group modeled on one that grew up in Manhattan after September 11." A specialist involved with both efforts noted however that while the government in New York allocated $500 million in grants for small businesses, "In New Orleans, almost a year later, we can't even get Baton Rouge or Washington to put real grant relief on the table. Since it accounts for more than half the economy, including most of the tourism and almost all the culture, letting the small-business community wither will only hurt long-term recovery" (Eaton, 2006).

Small Business **Reopening of ice cream shop, a sweet return after the storm, feeds the soul as well as the palate:** The reopening of Angelo Brocato's Ice Cream in New Orleans' Mid-City neighborhood was reported in a national newspaper story: "Ice cream's restorative powers are well known. Just ask any 4-year-old. But the question here is, can ice cream help restore an entire city?" Noting that it was one of the first businesses to reopen in the heavily flooded area – and considered not reopening – the grandson of the founder surmised that ice cream wasn't all that people lined up down the street arrived for: "They have a void that everyone is trying to fill. They want that comfort that everything is back to normal, some sense that their lives are back in place. They're not just coming here to shop" (Nossiter, 2006).

Income, Employment, Labor Force

- *Economic activity of population*
- *Personal/household income*
- *Employment/income dispersion/stability*
- *Occupational diversity*
- *Community socioeconomic characteristics*

Disasters' impact upon employment: The losses experienced by businesses extend to their employees, said one newspaper report. A specialty wood-working business was closed after Hurricane Katrina and had to let go its seven employees. Its owner noted: "If we don't get any kind of a loan or anything, I'm not staying in New Orleans" (Mowbray, 2005).

Impact of disasters upon scarce occupations: A newspaper photographer came across an entrepreneur whose occupation was especially scarce in the wake of Hurricane Katrina, a barber. Found under a tent canopy around the corner from his flood-damaged shop, he gave customers hair trims with his equipment powered by a portable generator. The proprietor had "been offering haircuts to anyone who stops by in exchange for 'a tip, food or whatever'" (Zdon, 2005).

Victim of post-Hurricane Katrina city layoffs: A newspaper report told the story of a laid-off supervisor of 911-emergency dispatchers, who found out firsthand about crisis when she could no longer afford to pay her $367 a month insurance premiums, all the medicines she needed to treat her high blood pressure, or the $250 it would cost to see a private doctor. A patient in one of the city's few open emergency rooms, she was told she would need transfusions to treat her anemia – and had to go eighty miles away to Baton Rouge to get treated, as there were no beds available for uninsured patients (Eaton, 2007).

Unveiled comments suggest that getting rid of the poor is an opportunity flooding from Hurricane Katrina afforded: A national newspaper noted U.S. Representative Richard H. Baker, a Republican from Baton Rouge, said just after the hurricane: "We finally cleaned up public housing in New Orleans. We couldn't do it. But God did," (Saulny, 2006).

Returning community beckoned employers seeking workers after storm: A weekly newspaper noted that one benefit of the mass collective return of the Versailles neighborhood in New Orleans East following Hurricane Katrina was "employers from around the city coming to recruit desperately needed service workers" (Hill, 2006).

Mixed report on community socioeconomic statistics after the storm: A news report highlighted the demographic and economic shifts experienced by New Orleans following Hurricane Katrina: "As a city in flux, New Orleans remains statistically murky, but demographers generally agree that the population replenishment after the storm, as measured by things like the amount of mail sent and employment in main economic sectors, has leveled off. While many poorer residents have moved back to the city, the "brain drain" of professionals that the city was experiencing before the storm appears to have accelerated" (Dewan, 2007).

Immigrants challenge substandard wages: A national newspaper reported that a group of hotel workers recruited from outside the U.S. filed suit against their employer, citing lower wages than promised: "The amount of money we're earning, it's not enough to get our investment back and send money home – it's not enough to survive," said one worker who immigrated on a special work visa from the Dominican Republic (Eaton, 2006).

Local workers charge immigrant labor has undercut wages: While some immigrant rights advocates charge that some employers failed to pay meaningful wages for meaningful work, the same report noted that "local residents have complained they are being undercut for rebuilding jobs." Said a lawyer representing both, citing the $6 to $7 an hour wages paid to the immigrants: "That is not what you have to pay a desk clerk in your luxury hotel here, and it is not a living wage to live here," (Eaton, 2006).

Day laborers face hardships amidst plentiful work after storm: A journalist from a national newspaper observed in an op-ed piece that "the money was good after Katrina, in August 2005, and the work pace was frantic. Men were recruited for jobs that were plentiful, though seldom as good as promised. Conditions were dangerous and sickening. A glut of workers soon lowered wages for everyone. Intimidation and abuse were common, often by contractors, sometimes by cops" (Downes, 2007).

Immigrant workers bailed out of jail by survivors' council repay the favor: "After 17 Latino day laborers were arrested in Gretna, a suburb, in February, they were bailed out of jail. Not by anyone they knew, but by members of the New Orleans Survivor Council, an organization of African-Americans that meets at a church in the Lower Ninth Ward" according to a news report. Organized themselves as Congreso de Jornaleros, or Day Laborers' Congress, the workers who faced charges of loitering in public repaid the favor by helping rebuild the flooded home of an elderly Survivor Council member (Downes, 2007).

New Orleans musicians return after Hurricane Katrina face challenges: "People don't think artists as a category of workers," a cultural advocate noted in a news report about New Orleans' music scene following Hurricane Katrina. While world-renowned for its music and cuisine, the city's musicians largely get by hand-to-mouth, with many traditional music venues and bars which supported their mostly meager existence failing to reopen after the storm. The city's former music industry director said that "figuring how to translate that authenticity to economic development has been the challenge for all these years," (Park, 2007).

Health and Physical Safety

- *Adequacy of health/medical services*
- *Access to health/medical services*
- *Community health risk factors – environmental, mental health exposure, vulnerable populations*
- *Mortality rates, causes*
- *Health/medical facilities and personnel*

Healthcare Access **Closure of Charity Hospital curtailed access to health and medical services:** "It is my observation that since the closing of Charity Hospital people have been coping with lower standards of health care. People without insurance had little choice but to go to Charity Hospital before Hurricane Katrina, now their choices are even more limited, and sometimes non-existent,"(Craft-Kerney, 2008).

Destruction of community: Most of New Orleans following Hurricane Katrina reflected this returning Broadmoor resident's worst fears: "Everything was dead. I was in the military and the smell reminded me of dead bodies" (Shevory, 2007).

The emotional toll of uncertainty: Families had learned of the deaths of loved ones, yet experienced months of waiting and uncertainty to reclaim their bodies for funerals, said a newspaper report, quoting the daughter of a deceased mother: "It's been a nightmare" (Scott, 2005) .

When delay becomes unconscionable: In an accompanying newspaper editorial decrying the delay of the release of a family's identified loved one's body, it noted that "hundreds of other families are suffering through the same agonizing wait. This is unconscionable. People have endured more than enough indignities since Hurricane Katrina struck. They shouldn't have to wait for months to give their loved ones the memorial they deserve" (Editorial, 2005).

Destruction of community: The return of this neighborhood though was far from certain. Most of New Orleans following Hurricane Katrina reflected returning residents' worst fears: "Everything was dead," said one resident. "I was in the military and the smell reminded me of dead bodies" (Shevory, 2007).

The aftermath of disaster limits return home: Lower Ninth Ward residents were not permitted to enter their neighborhood until early 2006, more than three months following the storm. A newspaper report quoted two officials underscoring safety concerns: "We're still finding remains. It's not free access," said one. A police official then said: "It's an unsafe environment" (Filosa, 2005).

Fire danger of temporary housing following disasters: Addressing interim housing needs with the use of travel trailers presents safety issues. Constructed mostly of metal and tightly configured, fire safety becomes a major concern. One report noted firefighters battling a blaze which engulfed one trailer and damaged two others: "They did a great job of averting disaster. But what's going to happen next time?" Another fire official quoted in the story dubbed the trailers "little matchboxes" and posed what the future might bring: "Winter's coming up, heaters could be lit, gas leaks could occur" (Hurwitz, 2005).

Disaster relief brings on anxiety?: A news report noted that many people who received "excess" government relief and would have to pay it back now endure added anxiety. Describing the climate hurricane victims felt when relief funds were accepted, even if recipients were cautioned in advance of potential overpayments, one legal aid attorney said: "It was in writing, but there were pages of documents that were shoved across the table at them to sign and return. They weren't necessarily reading the fine print. We're dealing with people who were in an extremely emotional state and were just moving waves of paper to make sure they're able to access whatever is available to them" (Heath, 2007).

Healthcare Access **Closed hospitals force patients to travel long distances for healthcare:** A front-page article reported about a 59-year-old heart patient who lost his health insurance after Hurricane Katrina has been forced to shuttle in between Charity Hospital system facilities over sixty miles away because of the continued closure of its flagship Charity Hospital in New Orleans. "Without Chabert [Medical Center in Houma], I would have no care. Without the pharmacy at Earl K. Long (Medical Center in Baton Rouge), I could not afford my prescriptions. I am grateful for all that," he said. "It's just that there is a series of dog and pony shows and hoops and fences you have to go over to get through it" (Moran, 2007).

Healthcare Access **Health conditions worsen for patients who have to travel outside the city for care:** a reporter noted that "a nurse at a neighborhood clinic says that travel can hamstring patients who do not own a car. She had a patient who she suspected was suffering from prostate cancer, and she tried to send him to the Charity Hospital in Houma for further evaluation. He had no car, and even if he did, he could not get an appointment for months" (Moran, 2007).

Healthcare Access **Patients even recommended to go outside the country for care:** The same news report suggested that maybe overseas travel might get the patient the healthcare he needed: "What he did have, however, was a niece in Nicaragua who worked as a doctor." The nurse at the St. Cecilia Clinic in consultation with her colleagues suggested that going there could afford him the support he needed with less difficulty: "I have been a nurse for 30 years," she said. "I never thought I would have seen anything like this" (Moran, 2007).

Healthcare Access **Health conditions worsen in the wake of disaster:** A man who suffered a stroke in February 2007 was treated the day it occurred at University Hospital. "Unfortunately he was not referred to physical therapy to alleviate the effects of the stroke until October 2007 [The hospital did not offer physical therapy services until then] Because of this delay it is unlikely he will ever fully recover from the stroke. He continues to have difficulty speaking and requires a cane to walk," the patient responded (LeBlanc, et al. 2008).

Healthcare Access **Even people with insurance lack hospital options:** A mother whose son suffers from asthma resides in eastern New Orleans. "Whenever he has an attack, she drives past the vacant Methodist Hospital about three miles from her home, to Children's Hospital" more than ten miles away and "about 20 minutes even in mild traffic" reports a newspaper story. "It's 20, 30 minutes, then they might not have a bed, then you have to wait for hours," she said (Reid, 2007).

Healthcare Access **The closed VA Hospital delayed healthcare for local veterans:** "If the bone fusion had disintegrated the summer before Hurricane Katrina," a front page newspaper story said that the Air Force veteran

"would have made the short drive from his home in Slidell to the veterans' hospital in downtown New Orleans to have it resealed." Instead he needed surgery after the storm. With the hospital then closed for more than a year, "his case file was shipped to the veterans' hospital in Jackson, Mississippi, where doctors tarried over it for two months before arranging for him to have the surgery – in Houston," (Moran, 2007).

Healthcare Access **Patients throughout the Gulf South impacted by closed VA hospital:** The same article disclosed that "while veterans can go to private hospitals if they have a heart attack or other emergency, they have to use veterans hospitals in Houston, Little Rock, Arkansas; Biloxi, Mississippi; or Memphis if they need elected surgery or laboratory work." Convinced that the surgery he needed would have happened quicker had the Veterans Administration Hospital been open in New Orleans, the Air Force veteran endured "every day that passed without the operation was a day he was confined to a wheelchair," (Moran, 2007).

"Don't bring your parents back if they are sick": Another article quoted a former internist there now practicing and residing in a New Orleans suburb: "I've been telling people, don't bring your parents back if they are sick," (Eaton, 2007).

Healthcare Access **Closed hospital psychiatric facility leads to death of patient:** Depressed about his brother who suffered from sickle cell anemia, a young man "tried to inhabit his sibling's world and take the mantle of his pain. He could not sleep or eat and began disappearing on rambling walks." Just days later "his family took him to the hospital for a psychiatric evaluation, initiating a tragic chain of events that would end with him becoming the latest patient to suffer or perish because of the dearth of mental health beds in the city, especially for patients without health insurance." The 23-year-old died after jumping from the back of an ambulance that carried him from University Hospital in downtown New Orleans which lacked mental health beds, to go almost fifty miles away to a state psychiatric hospital in Mandeville, according to a front-page newspaper report (Moran, 2007).

Wait times void needed healthcare in the wake of the storm: "The closure of Charity Hospital has also limited the ability of local clinics to offer life and cost-saving preventative care. At Charity Hospital [before Hurricane Katrina], we could refer patients to have a mammogram, a pap smear, or another screening procedure at no charge."... "Even when there are specialty services available through [University Hospital or other Charity system hospitals statewide], like OBG/GYN or orthopedic services, the referral process is lengthy and our patients may, without intervention on our part, wait months for appointments that they need. I have had patients who have had to wait for chemotherapy, and one patient who was told she would have to wait for months for a prenatal check up although she was already six months pregnant," (Berryhill, 2008).

Governmental Organization

- *Organizational structure and functioning of government*
- *Infrastructure of government [water, utilities, streets, public buildings]*
- *Provision of public services – planning, taxation, permitting, public transportation, etc.*

Transportation destruction, restoration: The report underscored the damaging havoc Hurricane Katrina's winds had: "The streetcar's reconquest of St. Charles Avenue after Hurricane Katrina has been fitful. The storm sent the avenue's old oak trees crashing down on the dense network of overhead electric lines that power the cars, destroying nearly 13.5 miles' worth. These had to be painstakingly rebuilt; one section on Carrollton of just over a mile, between St. Charles and Claiborne Avenues, remains out," (Nossiter, 2007).

The length of time to recover critical infrastructure: "Lake Forest Estates did not have power for five months after the storm," a reporter noted. "I remember the day the lights came on, though I was in New York City. My phone did not stop ringing with the kind of calls a person might expect from a third world country: "We got lights! We go electricity!" (Saulny, 2007).

Hurricane Katrina's devastation created millions of tons of debris which needed disposal: One report noted that the storm "created 12 million tons of debris in New Orleans, or about 34 years worth" from normal pre-storm levels. Returning residents months afterwards complained about stinking piles of refuse: "We're trying to do the right thing and move back into the city," said one resident. "But the work is not getting done. Why would you want to live here when it's like this?" (Hamilton, 2005).

Established land use plans and patterns became upended following disasters: Some industries and businesses which provided quick-fix housing for their workers were allowed to develop trailer parks without regulated oversight, sometimes leading to disastrous consequences, a fire chief recalled in a news report about a trailer fire: "There was no provision to provide us with firefighting water," he said, noting that the nearest hydrant was too far away for their hoses to reach (Hurwitz, 2005).

Neighboring communities near disaster zones face infrastructure challenges: Baton Rouge in particular was inundated with tens of thousands of people and their cars, said a university newspaper. A professor of civil engineering observed that "this traffic was predicted to be here 20 years from now, but we have it today," (Burris, 2005).

Delays in infrastructure restoration prompt tensions: One report noted the slowness of recovery from Hurricane Katrina raised public outrage during a special meeting to air resident concerns: "How come we don't have lights? All these billions of dollars and they can't get some lights in New Orleans East?" (Varney, 2005).

The collective psychic welfare of working utility infrastructure following disasters: Public officials echoed the sentiment in another report, suggesting that working streetlights were important in boosting morale of returning residents: "Residents of neighborhoods with no lights at night see nothing to show them they are part of a grand plan for the city's revival," one New Orleans city councilmember said. Underscoring residents' suspicions, said the same official, the story reported: "that situation feeds rumors that the city intends to bulldoze their neighborhoods, no matter how many times officials deny the rumors," (Eggler, 2005).

"You can kill a whole city" without restored utilities: A report linked the return of utilities to the city's very survival. One community activist suggested that "if you don't let people come back, and if you don't give them electricity, and you don't give them water – you can kill a whole city," (Hamilton, 2005).

Mail delivery interrupted following disasters: The age-old expectation that letters and other mail would be regularly delivered became undone following Hurricane Katrina, even months after the storm. One report detailed that since the mail processing plant in downtown New Orleans was out of service, sending a letter from Uptown to the French Quarter would instead make stops in Baton Rouge, Houston, Baton Rouge again and St. Rose before it could reach its original destination up to two weeks later. Expectant receivers mused regarding the whereabouts of their mail: "It's somewhere in the bowels of an Indiana Jones-style warehouse, probably beneath a mountain in Montana," one man half-jokingly said (Hunter, 2005).

Government compounds anxiety following disasters? Thousands of Hurricane Katrina victims have faced government charges of "overpayment" of disaster assistance, creating further anxiety and uncertainty when repayment was demanded. A national daily newspaper quoted a D'Iberville, Mississippi resident's response: "I haven't paid anything back because I don't have it. If I had the money to pay it back, I wouldn't have needed the rental assistance," (Heath, 2007).

Disastrous decision to keep closed Charity Hospital: A New Orleans man endured much upset as his uninsured wife endured an eight-hour transfer from a makeshift medical clinic downtown to a private hospital after her appendix burst. Testifying before a public hearing, he said that "she could have easily died during that period. This incident for [me] brings up a broader question of 'How many people have died and how much suffering has been inflicted on the people because of the closure of Charity?'" (Mozie, 2007).

Sheriff decries official decision to keep Charity Hospital closed: "As Sheriff of Orleans Parish, I have been confronted with the incredible burden of dealing with mental health issues in the criminal and prison systems. While the prison in New Orleans has a facility for mentally ill inmates and can treat inmates who are suffering from mental health issues, before the storm police officers could take people whom they suspected were exhibiting criminal behavior as a result of mental health problems to Charity Hospital. Since the closure of Charity's Crisis Intervention Unit, police officers have limited options as to where they can take people with mental health problems outside of jail," (Gusman, 2008).

Government responsibility following Hurricane Katrina: "It is my opinion that the state is responsible for the health of its people. Because this is not happening, people who once had access to personal care physicians through Charity Hospital are now reduced to emergency room care. As such, many patients are unable to adequately treat and track their illnesses, and often encounter complications," (Craft-Kerney, 2008).

Community Social Services

- *Availability and access to basic range of social services*
- *[family counseling, parenting, family violence, seniors, chemical dependency, children services including child care, disabilities, welfare benefits/job training, foster care, mental health, disabled transportation, etc.]*

The dependency upon public transit by people who cannot drive is acute: A University of New Orleans student, who has spinal bifida, cannot use her legs so she uses a wheelchair. Following the storm however, her very mobility beyond her home is in question: "Post-Katrina, it has been hard, as far as the RTA goes, because they told me they couldn't give me a ride to and from school," she said. "They couldn't guarantee that I would get to school on time. As a result, I have been taking mostly online classes" (Ott, 2006).

Lack of affordable housing and assisted living facilities acute: "There are no nursing homes — none," an elder advocate said, according to a national newspaper report. "There are no plans to rebuild the public housing where many of them lived. And those apartments that are available are priced way, way beyond the means of anyone on a low, fixed income," (Lyman, 2006).

Underscoring the need for crisis counseling: Sitting on a stoop in the Ninth Ward and ignoring a nearby parade protesting the lagging recovery, a truck driver was quoted by a national newspaper about his mental state and the state of New Orleans following Hurricane Katrina: "It's a depression going on. It's not like the '20s and '30s. It's right here," he said, tapping his temple. "Let the world know, the depression is on," (Nossiter, 2006).

Disability assistance not enough to afford high rents: A national newspaper underscored the crisis of homelessness that has inundated New Orleans such that hundreds of people are camping underneath an elevated expressway, "near enough to the French Quarter to regularly encounter tourists." According to the report, 86% were from the New Orleans area, with some receiving monthly disability checks, which are "not nearly enough to cover post-hurricane rents," (Dewan, 2008).

Supportive services in short supply in post-Katrina New Orleans: Facing the crisis of homelessness which continues to escalate, this newspaper report noted that chronically homeless people, as well as those with addictions or mental illness, "permanent housing with supportive services, like counseling, has become a preferred method." Yet the shortage of apartments, affordable or otherwise, prevents even the partial implementation of this promising solution (Dewan, 2008).

Cultural, Historical Landmarks, Aesthetic Support

- *Recreational and cultural opportunities and participation*
- *Diversity of recreational and cultural opportunities*
- *Museum, sports, recreational facilities and personnel*
- *Archaeological/Historical landmark/sites condition, access*
- *Festival infrastructure and voluntary/commercial personnel*
- *Maintenance of valued cultural characteristics*

Disasters uproot burial sites: In the aftermath of Hurricane Katrina, finding the dead and recovering and identifying their bodies commands an emotional toll. This includes people who were already deceased. A report notes the devastation in Buras, in southern Plaquemines Parish: "Sixteen coffins remain unidentified at Our Lady of Good Harbor cemetery. They rest in cement vaults, strapped to the ground so they will not float away again in another storm," (Longman, 2007).

Tradition -- When life ends, the living mourn: An editorial illuminated in one paragraph the end of life and the historical ritual of death: "The rituals of death help us grieve and allow us to start to move on and deal with the heartache of loss. Many of these families are dealing not only with the loss of a loved one but also with the loss of a home and a lifetime of possessions. They need to have an ending to at least one part of this tragedy," (Editorial, 2005).

St. Charles Streetcar is a rolling historical landmark: A national news story underscores the physical and emotional impact storm damage had upon New Orleans' historic transit system in its opening paragraph: "Like the rolling tide to seacoast residents, the low rumbling of the streetcar is a nearly internal sound for citizens here, its absence since Hurricane Katrina a painful reminder of civic ill health," (Nossiter, 2007).

Cultural heritage threatened following disasters: The human diaspora which developed following hurricanes Katrina and Rita brought into question whether significant elements of south Louisiana's diverse culture would return. Amongst the groups most challenged are French Louisianans, according to one report: "That community faces probably the greatest catastrophe in its history," said a state cultural official (Donn, 2005).

Linguistic heritage threatened following disasters: A report underscored the uniqueness of French Louisiana culture that could be lost forever if people uprooted because of Hurricanes Katrina and Rita do not return: "Home is

the place where everyone speaks French and practices their culture. And if homes are gone, that's lost," (Donn, 2005).

Cultural memorabilia lost following disasters: People's possessions amount to "cultural keepsakes," emphasized a Cajun historian in a report: "All the memorabilia, the documents, the childhood toys – it's gone. I literally cannot walk into the house," (Donn, 2005).

Community Activities **Festival infrastructure sparks reunions after Hurricane Katrina:** A national news report noted the healing power of the old Louisiana festival tradition: "Jazzfest's essence was in the gathering of a 50-woman choir from the Franklin Avenue Baptist Church, which sustained $9 million in damage and now holds services for parts of its congregation in Houston and Baton Rouge as well as New Orleans. Some choir members had not seen one another since the hurricane. They, and other performers at the festival, kept saying, "It's like a reunion," (Pareles, 2006).

Community Activities **Tourists and locals return for Jazzfest:** Defining the impact of the annual New Orleans Jazz and Heritage Festival, this news report said: "It was a fitting wrap-up for a weekend that found hope, and solace, in the continuity of tradition. Jazzfest, as everyone calls it, is itself a tradition after nearly four decades, and like Mardi Gras, it is not only a tourist magnet but also a defining event for the city. "It's bigger than just the music," said George Wein, the chief executive of Festival Productions and the executive producer of Jazzfest. "This is people's lives," (Pareles, 2006).

Community Activities **Cultural traditions persist in Katrina's wake:** "Even with much of the city's population displaced and scattered, New Orleanians are determined not to let the music and its public celebrations disappear. At Jazzfest, Mardi Gras Indians, who usually take the whole year to hand-sew their elaborate feathered and beaded suits, were resplendent. Social aid and pleasure clubs, the neighborhood associations that sponsor parades and funerals, might not have had their old neighborhoods to return to, but they showed up at Jazzfest to parade in brand-new suits. Gospel choirs exiled from their home churches regrouped to sing about unswerving faith," (Pareles, 2006).

Community Activities **Vietnamese New Year Celebration signaled successful return of community:** The opening paragraph of a weekly events calendar highlighted the fusion of culture and tradition of a neighborhood back home after Hurricane Katrina: "If the Year of the Dog rewards loyalty and vigilance, the Vietnamese community in eastern New Orleans is on its way to a championship year," (Dorrough, 2006).

3. Community Interpersonal Capital

Ideal Interpersonal Conditions

- *Community identification/attachment*
- *Community cohesiveness*
- *Distribution of resources and power*
- *Civil and human rights*
- *Environmental justice*

Diverse history transported: In celebrating the return of nearly six miles of the St. Charles Streetcar line after it was closed because of damage from Hurricane Katrina, a national news report spotlighted the unique community intersection the trolley represents: "The streetcar has represented something else besides the connections through time and space: the city's living room, a privileged spot for tentative social encounters across lines of race, class and nationality, in a place not otherwise given to them," (Nossiter, 2007).

People blocked from returning home do not understand: In an attempt to mediate New Orleans residents' desires to return home in spite of the dangers, this report noted that the city organized sightseeing tours of the devastation. Nevertheless, emotions remained high: "We would like to get out and walk around. We'd like to have more closure than right now," (Filosa, 2005).

Internal displacement of people in disasters: Human rights activists have compared the internal displacement of people from New Orleans following Hurricane Katrina to international situations in wartime, one news report noted: "The clearest articulation of a right to return is in the international arena. The United Nations Guiding Principles on Internationally Displaced Persons hold that people should be allowed "to return voluntarily, in safety and with dignity, to their homes or places of habitual residence," (Tilove, 2005).

Charges of favoritism within communities beset by disasters: Residents expressed sentiments in another newspaper story that certain areas of New Orleans were favored over others. An educator displaced to Baton Rouge from the Lower Ninth Ward exclaimed: "I'm tired of being forced out of my city. I just want to come home," (Filosa, 2005).

Returning residents still feel the loss of displaced friends and neighbors: A national news article quoted a mourner commemorating the second anniversary of Hurricane Katrina: "Most of my good friends are not here any longer. That's one of the things that's wrong. The fabric of this city will never be the same," (Nossiter, 2006).

Community identification by posting their own street signs: A national news article quoted a member of the Claiborne-University Neighborhood Association, which decided to replace missing street signs missing since the Hurricane: "We don't know when we'll have real signs, so people are banding together and taking things into their own hands," (Saulny, 2006).

Community cohesiveness by taking care of absent neighbors': An article noted that people which have returned to New Orleans following Hurricane Katrina to repair their own homes have also planted trees on neutral grounds and cleaned their neighbors' yards: "If you want people to populate the city and help make a new New Orleans, you've got to help yourself," a woman said, recently returned from Atlanta. "If the place looks like Katrina just hit it, who's going to want to come back home?" (Saulny, 2006).

Community cohesiveness through collective action: A New Orleans weekly newspaper spotlighted the early return of Versailles Village in eastern New Orleans, despite suffering flooding and storm damage from Hurricane Katrina. More than one thousand residents of the predominately Vietnamese community returned by late 2005, with a thousand more living elsewhere in metro New Orleans while their homes are repaired, making it the first residential community east of the Industrial Canal to secure restoration of electricity and water service. One man stoically replied to a question of returning despite the looming uncertainties: "Look, we fled Vietnam. We fled New Orleans. Now we're back. We're here to stay," (Hill, 2006).

Vietnamese New Year Celebration proposes new plans for neighborhood: New Orleans' daily newspaper's entertainment guide spotlighted that in addition to food, games, crafts, music and dancing, "architects will unveil their plan to develop and redevelop" the eastern New Orleans neighborhood. The parish priest where the three-day festival was held said that "people from the community who are returning will review the designs and give comments. We are expecting everyone to come back and more," (Dorrough, 2006).

Community attachment renewed by the oldest in the community: One year following Hurricane Katrina New Orleans' daily newspaper highlighted the recovery progress of various neighborhoods. In contrast with many elderly people being unable to return, the report noted that "While many New Orleanians have wrestled with the decision of whether to return and rebuild, there was no hesitation for many of the original residents of Pontchartrain Park, where about a third of all residents are retirement age." The article quoted a returning 74-year-old woman: "The older people all want to come back, but the younger people don't want to come back and deal with the hassle," (Ritea, 2006).

Churches step up to ensure equitable distribution of housing and employment resources following the storm: Recovery of their faith community from the ravages of Hurricane Katrina has been more than just repairing buildings and restoring their church sanctuaries, several New Orleans pastors have come to find, according to a national news report. They have become developers for affordable housing and creators of job-training programs. "I'd rather be doing something else," one pastor said. "But when you hear stories like the Good Samaritan or about how Jesus walks into the temple and overturns the tables of the money-changers, it charges us as a church to make sure justice is done for all people," (Banerjee, 2007).

Interaction Means to Achieve Conditions

- *Community leadership*
- *Political organizations and citizen political involvement*
- *NGO adequacy vis-à-vis community needs*
- *Voluntary associations and membership*
- *Religious organizations*
- *Neighborhood (place based) voluntary organizations*
- *Friendship/family networks*
- *Regional/national linkages*
- *Print and electronic media array, diversity, access*

Informal Networks **First steps towards neighborhood reclamation:** A news report chronicled the response of a New Orleans residential neighborhood that it be turned into a park: "Three days after the commission released its plan, residents of Broadmoor, which is west of downtown, held a protest rally. A meeting was called to work out a plan, and more than 600 people attended, many of them driving from Baton Rouge and Houston. For them, their neighborhood's future could not be left to someone else. This was where they had grown up, married and had children. "We love our neighborhood, and we had to do something," said the president of the Broadmoor Improvement Association," (Shevory, 2007).

Voluntary Associations **Day-to-day recovery for the present and the future:** The Broadmoor resurrection report detailed what residents had to do as a neighborhood while recovering their own homes: "Working out of a doublewide trailer at a local church, residents surveyed Broodmoor and designed a database on the area's 7,000 residents and selected block captains to monitor the area. Meetings were held on the best ways to revitalize the neighborhood, like deterring crime and reopening the local elementary school. At the time, many people were juggling full-time jobs and community work while they renovated their homes," (Shevory, 2007).

Voluntary Associations **Restoration of education and school sports restores community:** "The Hurricanes" defiantly faced the wreckage of their school and community, this report continued: Little has returned to normal in the two and a half years since Katrina destroyed the tiny fishing, oil and citrus villages of Port Sulphur, Buras, Boothville and Venice in lower Plaquemines Parish, where the Mississippi River runs to the Gulf of Mexico. "Football is the only thing that will bring this community together; there's nothing else here," said Corey Buie, an assistant coach and the recreation director of Plaquemines Parish (Longman, 2007).

Community wisdom about the future: "Tomorrow is not guaranteed," [Coach Cyril] Crutchfield told his players. "We don't know what will happen when the Gulf water turns warm and the wind starts to blow." (Longman, 2007)

The pull to return home: One report noted that social service advocates hear of the strong desire for many displaced elderly people to return home, despite the huge obstacles: "I had a woman tell me she had to go back because she wanted to be buried next to her husband," said the advocate. "You hear things like that a lot," (Lyman, 2006).

Catholic Church central to the successful return of neighborhood: An African-American newspaper posed the question to its readers of the resurrection of a Vietnamese neighborhood in New Orleans East, "while adjacent black neighborhoods continue to stagnate in eerie silence." It reported that "a good part of the success of Versailles owes to the Mary Queen of Vietnam Catholic Church. Before Katrina, the church was the center of religious and social life for 4000 Vietnamese who lived in approximately 950 homes located within one mile of the church," (Hill, 2006).

Priests act quickly to reclaim flood ravaged neighborhood: Leaders of Mary Queen of Vietnam Catholic Church acted quickly to bring together parishioners back to the Versailles neighborhood in New Orleans East, reported a weekly newspaper: "Church leaders kept the Diaspora Vietnamese community linked together, with Rev. Vien constantly visiting refugee sites and fellow priests dispatched to Houston and Dallas to work full-time with the displaced community," (Hill, 2006).

Media reports perpetuated "disaster myths": A weekly newspaper report recalled post-Hurricane Katrina media coverage and its continuing impact upon New Orleans recovery from the storm, suggesting that a "Katrina narrative" set in to inform that "people in New Orleans were dangerous." Racial stereotypes fueled the coverage, the report suggested, though in this instance, the Katrina myths crossed racial lines, quoting a national civil rights leader: "This is the first time I know of that black people believed the hysteria," (Reckdahl, 2006).

Reporters swallowed rumors and reported them as truth: Over one month after Hurricane Katrina and the swirling media reports of wanton looting, mayhem and killing in New Orleans following catastrophic flooding of the

city, a national newspaper story recalled that "many instances in the lurid libretto of widespread murder, carjacking, rape, and assaults that filled the airwaves and newspapers have yet to be established or proved, as far as anyone can determine. And many of the urban legends that sprang up – the systematic rape of children, the slitting of a 7-year-old's throat – so far seem to be just that," (Carr, 2005).

Project Specific Aspects

- *Internal displacement of residences, businesses and agriculture due to siting footprint*
- *Primary project interest groups/stakeholders*

Challenge to right to return to place of attachment and extra-ordinary effort required to assert that right: A newspaper report opened with the challenge of abandonment faced by a Hurricane Katrina flood ravaged New Orleans neighborhood: "Four months or so after Hurricane Katrina, and just as residents of the Broadmoor neighborhood had begun moving back into their water-logged homes, a rebuilding commission set up by the mayor delivered another shock: If Broadmoor did not bring back half its residents within four months, their homes could be razed and the land turned into parks. So Broadmoor took action," (Shevory, 2007).

Internally displaced vow to return even if unwanted public housing residents: A national newspaper recorded the return of an apartment leaseholder: "They are trying to steal New Orleans from us. Well, I will not be displaced anymore. I'll take my home any way they give it to me. It's been 10 months. They've got to know we're serious. We're going to stand here until they let us in our homes," (Saulny, 2006).

Siting footprint of market-rate housing over public complexes: A national newspaper recorded the expressions of relief of public officials exclaimed when considering the opportunity they suggested Hurricane Katrina gave them to remake public housing: "We don't need to recreate pockets of poverty," the president of the City Council, Oliver M. Thomas Jr., said. "They don't work. We want more mixed-income, working communities. I think that's really the only way," (Saulny, 2006).

Fast re-occupation of neighborhood blocks its displacement: A weekly newspaper summarized how the predominately Vietnamese neighborhood in eastern New Orleans was able to return before it could be declared uninhabitable by city planners: "From the first days of evacuation, the community began planning to return and rebuild Versailles Village. The decision to return together was key in helping overcome homeowners' fears that they might lose their investment if they rebuilt in a neighborhood that later failed to revive. The community was convinced that if they quickly rebuilt and occupied their homes, the city government and utility companies would have to provide services. The plan worked," (Hill, 2006).

'Laissez-faire' redevelopment contradicts calls against rebuilding in vulnerable areas, said newspaper report: A first anniversary report by the city's daily newspaper reviewed the rebuilding of New Orleans' neighborhoods following the devastation of Hurricane Katrina. In particular, it spotlighted 'the jack-o-lantern effect' of returning residences amidst empty lots and abandoned storm-ravaged properties. It also noted the conflicting messages city leaders, particularly the mayor, which the report quoted, gave to returning residents, especially to those residing in the Lower Ninth Ward and New Orleans East, while not specifically prohibiting rebuilding nor identifying specific neighborhoods: "I've been saying this publicly, and people are starting to hear it: low-lying areas of New Orleans east, stay away from. Lower 9th Ward. I said it in Houston; people are starting to hear it. That's what I'm telling people (in the Lower 9). Move closer to the river. That stuff from Claiborne to the lake -- we can't touch that," (Russell, 2006).

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Appendix C: Use of Historical Background in SIA

An example of indicators used by the U.S. Forest Service for historical background (Bright, Cordell, Hoover, and Tarrant 2003) is presented below..

Dimension I: Historical Background **Concept I:** Record of a community's past and present dependence on the natural resource base will reflect important social attitudes and the structures supporting them. Problems and opportunities stem from historical experience.	
Indicator 1: Historical Background	
Description	Communities are born of and evolve from key industries, migrating peoples, social attitudes, and common human behavior.
Related social assessment questions	What are human uses of natural resources
	What conflicts exist among various uses, users, stakeholders, and ecosystem managers?
	What is the nature of relationships between nearby communities, the forest or other ecosystem, and the larger encompassing ecosystem?
	What recent social and economic trends relevant to management of the ecosystem are occurring in the region?
Method of measuring indicator	Analysis of historical and archival records
Indicator 2: Recent or current experience with ecosystem management (EM) issues	
Description	Information about public response(s) to EM policies, practices, and planning is dynamic. It is important to recognize how EM issues have been addressed in the past, what political controversy surrounds those issues, which prominent individuals or major groups seem to influence management (as well as public opinion), what other events in the community are related to EM issues, and what recurrent or unresolved problems must be addressed?
Related social assessment questions	What are human uses of natural resources in the assessment area?
	What conflicts exist among various uses, users, stakeholders, and managers of the ecosystem?
	What is the nature of relationships between nearby communities, the forest or other ecosystem, and the larger encompassing ecosystem?
	What do stakeholders and the public value about the natural environment, its resources, and various uses of those resources?
	What recent social and economic trends relevant to management of the ecosystem are occurring in the region?
Method of measuring indicator	Analysis of historical and archival records and survey data research
Indicator 3: Names and characteristics of influential persons, groups, or families	
Description	Individuals, families, and other important groups influence the evolution and development of a community.
	Who are users of natural resources in the assessment area?

Related social assessment questions	What conflicts exist among various uses, users, stakeholders, and managers of the ecosystem?
Method of measuring indicator	Analysis of historical and archival records and survey data research
Indicator 4: Distinctive characteristics of the community, which are strongly valued locally	
Description	Community characteristics that serve as accepted identifiers of the personality and nature of the community. These characteristics address general values held by the community as a whole and may be manifested in the work and leisure of its residents.
Related social assessment questions	Who are users of natural resources in the assessment area?
	What conflicts exist among various uses, users, stakeholders, and managers of the ecosystem?
	What do stakeholders and the public value about the natural environment, its resources, and various uses of those resources?
Method of measuring indicator	Analysis of historical and archival records and survey data research
Indicator 5: Prominent stakeholder groups with a history in the area	
Description	Prominent groups who have a stake in management of the assessment area's natural resources
Related social assessment questions	What conflicts exist among various uses, users, stakeholders, and managers of the ecosystem?
	What is the nature of relationships between nearby communities, the forest or other ecosystem, and the larger encompassing ecosystem?
Method of measuring indicator	Analysis of historical and archival records and survey data research

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Attachment 3 –
Regional Economic Development Effects
Coastwide Plans

Louisiana Coastal Protection and Restoration

Regional Economic Development (RED) Effects Analysis

Final Array of Alternatives – Coastwide Plans

Source: Regional Economic Model, Inc. (REMI) Version 9.0

Introduction

Each of the seven comprehensive coastwide plans is associated with a unique set of regional economic impacts that takes into account more than the initial, direct loss in key sectors such as employment, output and income. The 70-sector Regional Economic Model, Inc. (REMI) Policy Insight ® input-output model, described in the economics appendix under RED Effects as a multi-regional economic and demographic model of the U.S. economy, was used to specifically analyze consequences for the regional and national economics that incorporate the secondary and induced effects of changes in key variables. In this way, the performance of each of these comprehensive plans can be illustrated in comparison to the expected economic activity that is forecast to occur under a no-action alternative.

Regional Model and Analysis

A custom, dynamic forecasting regional model was constructed by REMI for the state of Louisiana using regions defined as part of the Interagency Performance Evaluation Team regional impacts assessment and an updated 2005 post-Katrina baseline data set. Economic damages only for the "high employment" future development, dispersed land use economic scenario and high seal level rise scenario by planning sub-unit were aggregated as necessary to coincide with the regions predefined within the custom REMI model as a point of reference for relative evaluation of comprehensive plan performance. For the no-action scenario and for each of the seven comprehensive plans, equivalent annual damages, representing the expected loss to residential and non-residential capital stock, agriculture, and all other damage categories, on an annual basis due to storm surge activity, was input for each year in period of analysis. For each comprehensive plan, the results are displayed as the net change from the no-action scenario.

Summary

The following tables provide a concise summary of the relative performance of each of the comprehensive plans, CP-1 through CP-7) when compared to the no-action alternative. Table 1 shows the equivalent annual percentage change in each of nine primary regional economic indicators for the period 2010 through 2050. This means that when compared to the no action alternative, a given comprehensive plan will increase the value of a given indicator by the percent shown each year during the period. In this way the relative performance of the plans can be ranked. In table 2, the absolute magnitude of change between the years 2010 and 2050 is shown as a percentage. This approach gives a more accurate measure of performance for the alternatives collectively when compared to the no-action alternative. Table 3 shows the increase in the selected economic

variables for each of the comprehensive plans relative to the "no-action" alternative for the year 2050. The equivalent annual income and output variables are expressed using 2007 price levels.

The period for comparison, 2010-2050, was chosen to conform to the specific projection horizons of the REMI model. The equivalent annual damages estimated by the study team, used as inputs to the REMI model, spans the period 2010 to 2075. However, the base year for the comprehensive plans is 2025, and measures of the plan performance with respect to regional indicator could occur only in the succeeding 25 years, that is, to 2050, the limit of our current REMI projections. In order to ensure comparisons over the longest period possible, it was assumed that each comprehensive plan would be implemented and fully functional by 2010.

Table 1
Louisiana Coastal Protection and Restoration Study
Changes in Regional Economic Variables Compared to "No Action" Alternative
Equivalent Annual Percent Changes for the Period 2010 to 2050
Aggregated for All Planning Units

Regional Economic Variable	Coastwide Plans						
	CP-1	CP-2	CP-3	CP-4	CP-5	CP-6	CP-7
Total Employment	0.59%	1.10%	1.01%	1.03%	1.31%	0.88%	0.83%
Total Gross Regional Product (GRP)	0.76%	1.45%	1.32%	1.32%	1.54%	1.16%	1.09%
Personal Income	0.48%	0.91%	0.82%	0.83%	1.03%	0.71%	0.67%
Real Disposible Personal Income	0.45%	0.86%	0.78%	0.79%	0.98%	0.67%	0.64%
Output	0.82%	1.59%	1.44%	1.43%	1.65%	1.26%	1.19%
Relative Cost of Production	0.02%	0.04%	0.04%	0.04%	0.04%	0.03%	0.03%
Average Annual Compensation Rate-Wages & Salary	0.07%	0.14%	0.12%	0.10%	0.09%	0.10%	0.09%
Population	0.35%	0.68%	0.61%	0.62%	0.80%	0.54%	0.51%
Labor Force	0.46%	0.89%	0.79%	0.81%	1.05%	0.71%	0.66%
Rank	7	2	4	3	1	5	6

Source: Regional Economic Model, Inc. (REMI) Version 9.0

Table 2
Louisiana Coastal Protection and Restoration Study
Changes in Regional Economic Variables Compared to "No Action" Alternative
Absolute Percent Changes between the Years 2010 to 2050
Aggregated for All Planning Units

Regional Economic Variable	Coastwide Plans						
	CP-1	CP-2	CP-3	CP-4	CP-5	CP-6	CP-7
Total Employment	25.3%	24.6%	24.8%	24.8%	25.1%	24.8%	24.8%
Total Gross Regional Product (GRP)	100.5%	99.4%	99.7%	99.7%	100.1%	99.7%	99.8%
Personal Income	415.0%	414.3%	414.6%	414.6%	415.8%	414.3%	414.4%
Real Disposible Personal Income	83.1%	82.8%	82.9%	82.9%	83.4%	82.8%	82.9%
Output	155.0%	153.2%	153.7%	153.7%	154.2%	153.8%	154.0%
Relative Cost of Production	1.6%	1.6%	1.5%	1.5%	1.5%	1.5%	1.5%
Average Annual Compensation Rate-Wages & Salary	290.7%	291.0%	290.8%	290.9%	290.7%	291.0%	290.9%
Population	27.5%	28.0%	27.9%	27.9%	28.2%	27.8%	27.7%
Labor Force	19.6%	20.1%	20.0%	20.0%	20.4%	19.9%	19.8%
Rank	**2**	**7**	**3**	**3**	**1**	**3**	**3**

Source: Regional Economic Model, Inc. (REMI) Version 9.0

Table 3
Louisiana Coastal Protection and Restoration Study
Changes in Regional Economic Variables Compared to "No Action" Alternative
Equivalent Annual Values for the State of Lousiana for the Year 2050
Aggregated for All Planning Units

Regional Economic Variable	Coastwide Plans						
	CP-1	CP-2	CP-3	CP-4	CP-5	CP-6	CP-7
Total Employment (Thousands)	19.2	34.4	31.5	31.9	41.3	27.0	25.7
Total Gross Regional Product (Billions, Fixed 2007$)	2.2	4.0	3.7	3.7	4.4	3.2	3.0
Personal Income (Billions, Nominal $)	4.9	8.9	8.1	8.2	10.2	7.0	6.6
Real Disposable Personal Income (Billions, Fixed 2007$)	1.4	2.5	2.3	2.3	2.9	2.0	1.9
Output (Billions, Fixed 2007$)	4.8	8.9	8.1	8.1	9.7	7.1	6.7
Relative Cost of Production	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average Annual Compensation Rate (Thousands, Nominal $)	0.2	0.4	0.4	0.3	0.3	0.3	0.3
Population (Thousands)	33.4	60.7	55.3	56.1	70.3	48.3	45.8
Labor Force (Thousands)	20.6	37.4	34.0	34.3	41.4	30.0	28.5
Rank	**7**	**2**	**4**	**3**	**1**	**5**	**6**

Source: Regional Economic Model, Inc. (REMI) Version 9.0

LOUISIANA COASTAL PROTECTION AND RESTORATION
FINAL TECHNICAL REPORT

REAL ESTATE APPENDIX

June 2009

U. S. Army Corps of Engineers
New Orleans District
Mississippi Valley Division

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Exhibit A –General Planning Area Map
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Louisiana Coastal Protection and Restoration (LACPR) Final Technical Report
Real Estate Appendix

PURPOSE

The Louisiana Coastal Protection and Restoration (LACPR) Technical Report has been developed by the United States Army Corps of Engineers (USACE) in response to Public Laws 109-103 and 109-148. Under these laws, Congress and the President directed the Secretary of the Army, acting through the Chief of Engineers, to:

- Conduct a comprehensive hurricane protection analysis and design in close coordination with the State of Louisiana and its appropriate agencies;
- Develop and present a full range of flood control, coastal restoration, and hurricane protection measures exclusive of normal policy considerations for South Louisiana;
- Consider providing protection for a storm surge equivalent to a Category 5 hurricane; and
- Submit preliminary and final technical reports.

The purpose of this appendix is to support the main LACPR technical report by describing the related real estate issues.

LOCATION

The LACPR planning area stretches across Louisiana's coast from the Pearl River on the Mississippi state border to the Sabine River on the Texas state border. The planning area has been divided into five planning units as listed below:

PU 1 – Pontchartrain Basin – This area represents the entire Lake Pontchartrain Basin. It stretches from the East Bank of the Mississippi River to the Mississippi State Line.

PU2 - Barataria Basin – This area is a triangular-shaped area bounded by the Mississippi River, Bayou Lafourche, and the Gulf of Mexico.

PU3a – East Terrebonne Basin – This area consists of the parishes of Terrebonne, St. Mary (east), Lafourche (west), Assumption, and St. Martin (east).

PU3b – Atchafalaya Influence Area – This region extends from Bayou de West located west of Houma and south of Bay Junop, then westward to Freshwater Bayou. It covers part of Terrebone, St. Mary, Iberia and Vermilion parishes.

PU4 – Chenier Plain – This unit extends from the western bank of Freshwater Bayou Canal westward toward the Louisiana/Texas border. This includes parts of Vermilion, Cameron, Acadia, Jefferson Davis and Calcasieu parishes.

Exhibit A of this appendix includes a general planning area map.

GENERAL DESCRIPTION

The LACPR Technical Report integrates hurricane risk reduction, coastal restoration, and non-structural measures to evaluate a range of alternatives that would reduce damages associated with hurricanes in Southern Louisiana. The report describes a multiple line of defense strategy which incorporates many of the existing hurricane risk reduction project components already studied in other hurricane risk reduction and flood control project studies. Alternatives include structural measures such as constructing barriers, levees, and water control structures; nonstructural measures such as raising buildings and performing buyouts of buildings in certain areas; and costal restoration such as restoring barrier islands, marsh, and swamps. The various structural hurricane risk reduction measures under consideration for LACPR will inevitably result in unavoidable impacts to wetlands and other aquatic resources. In these cases, compensatory mitigation would be needed to ensure that such unavoidable impacts are fully offset, consistent with the policy of no-net-loss. The LACPR analysis includes a range of alternatives designed to reduce risk from a 100-year, 400-year or 1,000-year flood events.

Based on screening, and in consideration of the need to investigate a range of potential ways to reduce the risk from hurricane surge, 41 comprehensive measures or alternatives, which include all three (3) risk reduction strategies, were selected for detailed evaluation in all five (5) planning units. The sections that follow address Real Estate issues, limitations, opportunities and considerations that impact all five (5) planning units. The next section offers a brief description of the projects considered for each of the five (5) planning units.

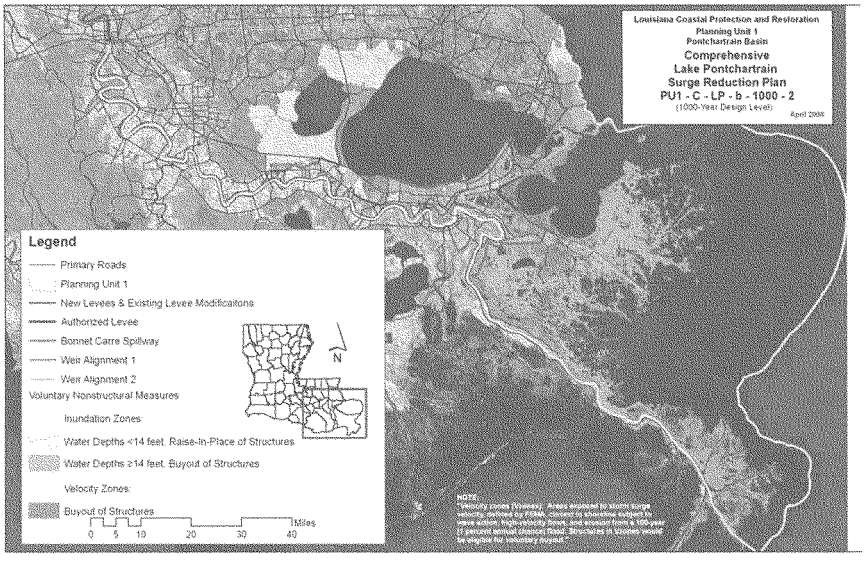
Planning Unit 1

Two structural alternative strategies were considered for Planning Unit 1. One strategy includes raising the existing levees on the south shore of Lake Pontchartrain to a higher level of risk reduction and adding structural features in Laplace and on the north shore of Lake Pontchartrain (**High Level alternatives**). By contrast, the second strategy or **Lake Pontchartrain Surge Reduction alternatives** include the construction of a weir barrier with gated structures across the two tidal passes connecting Lake Pontchartrain with the Gulf of Mexico. This alternative also includes consideration of additional structural features in Laplace and on the north shore of Lake Pontchartrain. Common to both alternatives are structural elements in New Orleans East, portions of St. Bernard Parish, upper portion of Plaquemines Parish and a floodgate across the Gulf Intracoastal Waterway (GIWW). Following the tiered screening process, 11 structural alternatives were selected for further analysis in Planning Unit 1.

Category	Alternative	Alternative Description
No Action	PU1-0	No action (without project) alternative.
Coastal Restoration Only	PU1-R1, R2, and R3	Sustain coastal landscape through restoration including shoreline protection, marsh creation, and diversions. R1 proposes steady state diversions while R2 proposes pulsed diversions. R3 is as proposed in the State Master Plan.
Coastal Restoration and Nonstructural Measures	PU1-NS-100, -400, and -1000	Sustain coastal landscape through restoration. Implement comprehensive 100-year, 400-year or 1000-year nonstructural measures.
Coastal Restoration and Structural Measures	PU1-LP-a-100-1	Sustain coastal landscape through restoration and construct barrier-weir and levees to reduce risk to the Lake Pontchartrain area. Raise upper Plaquemines levees to 100-year level of risk reduction.
	PU1-LP-a-100-2	Sustain coastal landscape through restoration and construct barrier-weir and levees to reduce risk to the Lake Pontchartrain area. Raise upper Plaquemines levees and construct new levees around Laplace and across the Northshore to the 100-year level of risk reduction.
	PU1-LP-a-100-3	Sustain coastal landscape through restoration and construct barrier-weir and levees to reduce risk to the Lake Pontchartrain area. Raise upper Plaquemines levees and construct new levees around Laplace and Slidell to the 100-year level of risk reduction.
	PU1-LP-b-400-1	Sustain coastal landscape through restoration and construct barrier-weir and levees to reduce risk to the Lake Pontchartrain area. Raise Lake Pontchartrain and Vicinity and upper Plaquemines levees to 400-year level of risk reduction.
	PU1-LP-b-400-3	Sustain coastal landscape through restoration and construct barrier-weir and levees to reduce risk to the Lake Pontchartrain area. Raise Lake Pontchartrain and Vicinity and upper Plaquemines levees and construct new levees around Laplace and Slidell to the 400-year level of risk reduction.
	PU1-LP-b-1000-1	Sustain coastal landscape through restoration and construct barrier-weir and levees to reduce risk to the Lake Pontchartrain area. Raise Lake Pontchartrain and Vicinity and upper Plaquemines levees to 1000-year level of risk reduction.
	PU1-LP-b-1000-2	Sustain coastal landscape through restoration and construct barrier-weir and levees to reduce risk to the Lake Pontchartrain area. Raise Lake Pontchartrain and Vicinity and upper Plaquemines levees and construct new levees around Laplace and across the Northshore to the 1000-year level of risk reduction.
	PU1-HL-a-100-3	Sustain coastal landscape through restoration and construct high level plan providing 100-year design level of risk reduction to Laplace, upper Plaquemines, and Slidell.
	PU1-HL-a-100-2	Sustain coastal landscape through restoration and construct high level plan providing 100-year design level of risk

Category	Alternative	Alternative Description
		reduction to Northshore of Lake Pontchartrain, upper Plaquemines, and Laplace.
	PU1-HL-b-400-3	Sustain coastal landscape through restoration and construct high level plan providing 400-year design level of risk reduction to Southshore of Lake Pontchartrain, upper Plaquemines, Laplace and Slidell.
	PU1-HL-b-400-2	Sustain coastal landscape through restoration and construct high level plan providing 400-year design level of risk reduction to the Northshore and Southshore of Lake Pontchartrain, upper Plaquemines, Laplace and Slidell.
Comprehensive (Coastal, Structural, and Nonstructural)	PU1-C-XX-x-xxx-x	Structural/coastal alternatives are made comprehensive by adding complementary nonstructural measures to reduce residual risk in areas without structural risk reduction measures. Comprehensive alternatives are noted by a "C-" in front of the structural/coastal alternative code.

Below is a map showing the areas encompassed by Planning Unit 1.



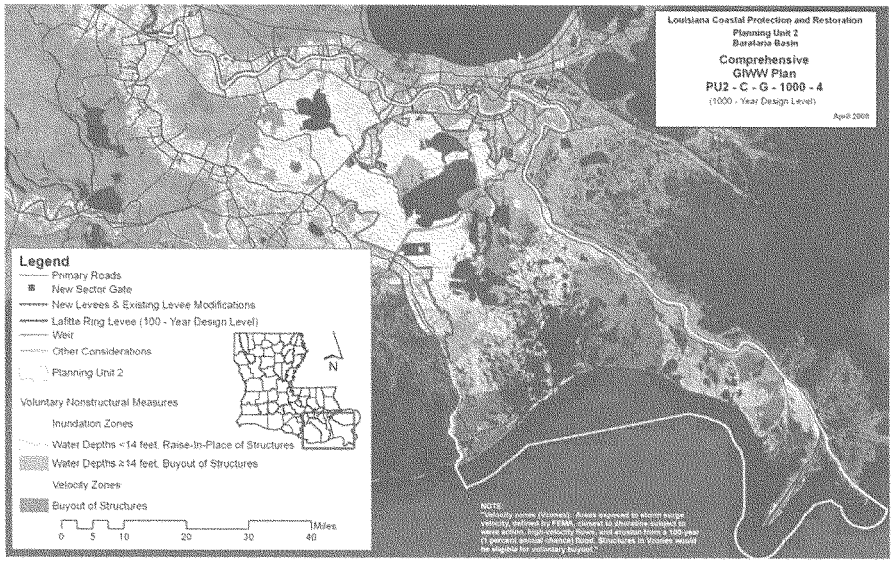
Planning Unit 2

Three primary strategies for structural risk reduction have been identified within Planning Unit 2. These strategies include the **GIWW levee alternatives**, alignments along the **West Bank Interior** (improvement to, or extension of the existing West Bank levee and construction of a sector gate on the GIWW in Bayou Barataria at the confluence with the Algiers and Harvey Canals), and **ridge alternatives**. Variations to the ridge and GIWW strategies include risk reduction to the areas of Lafitte, Boutte, Des Allemands and/or other areas. Common to the three basic alignments is a ring levee encompassing Golden Meadow and Larose. Following the tiered screening process, 13 structural alternatives were selected for further analysis in Planning Unit 2.

Category	Alternative	Alternative Description
No Action	PU2-0	No action (without project) alternative.
Coastal Restoration Only	PU2-R1, R2, and R3	Sustain coastal landscape through restoration including shoreline protection, marsh creation, and diversions. R1 proposes steady state diversions while R2 proposes pulsed diversions. R3 is as proposed in the State Master Plan.
Coastal Restoration and Nonstructural Measures	PU2-NS-100, -400, and -1000	Sustain coastal landscape through restoration. Implement comprehensive 100-year, 400-year or 1000-year nonstructural measures.
Coastal Restoration and Structural Measures	PU2-WBI-100-1	Sustain coastal landscape through restoration. Construct new sector gate on Bayou Barataria to reduce risk on the West Bank.
	PU2-WBI-400-1	Sustain coastal landscape through restoration. Construct new sector gate on Bayou Barataria to reduce risk on the West Bank. Raise West Bank and Vicinity and Larose to Golden Meadow levees to 400-year level of risk reduction.
	PU2-R-100-2	Sustain coastal landscape through restoration. Construct new sector gate on Bayou Barataria to reduce risk on the West Bank. Extend West Bank and Vicinity levees to Boutte and construct/raise Lafitte ring levees to 100-year level of risk reduction.
	PU2-R-400-2	Sustain coastal landscape through restoration. Construct new sector gate on Bayou Barataria to reduce risk on the West Bank. Extend West Bank and Vicinity levees to Boutte and raise those levees as well as Larose to Golden Meadow levees to 400-year level of risk reduction. Construct/raise Lafitte ring levees to 100-year level of risk reduction.
	PU2-R-100-3	Sustain coastal landscape through restoration. Construct new sector gate on Bayou Barataria to reduce risk on the West Bank. Extend West Bank and Vicinity levees to Boutte and construct/raise Lafitte and Des Allemands ring levees to 100-year level of risk reduction.
	PU2-R-400-3	Sustain coastal landscape through restoration. Construct new sector gate on Bayou Barataria to reduce risk on the West Bank. Extend West Bank and Vicinity levees to Boutte and raise those levees as well as Des Allemands and Larose to Golden Meadow levees to 400-year level of risk reduction. Construct/raise Lafitte

Category	Alternative	Alternative Description
		ring levees to 100-year level of risk reduction.
	PU2-R-100-4	Sustain coastal landscape through restoration. Construct new sector gate on Bayou Barataria to reduce risk on the West Bank. Construct/raise Lafitte and Des Allemands ring levees to 100-year level of risk reduction and build new levees around Boutte and up the east side of Bayou Lafourche from Larose to Highway 90 at the 100-year level of risk reduction.
	PU2-R-400-4	Sustain coastal landscape through restoration. Construct new sector gate on Bayou Barataria to reduce risk on the West Bank. Extend West Bank and Vicinity levees to Boutte; extend levees from Larose up Bayou Lafourche to Highway 90; and raise Des Allemands ring levees to 400-year level of risk reduction. Construct/raise Lafitte ring levees to 100-year level of risk reduction.
	PU2-R-1000-4	Sustain coastal landscape through restoration. Construct new sector gate on Bayou Barataria to reduce risk on the West Bank. Extend West Bank and Vicinity levees to Boutte; extend levees from Larose up Bayou Lafourche to Highway 90; and raise Des Allemands ring levees to 1000-year level of risk reduction. Construct/raise Lafitte ring levees to 100-year level of risk reduction.
	PU2-G-100-1	Sustain coastal landscape through restoration. Similar structural features as PU2-WBI-100-1 but with additional barrier-weir and levees along the GIWW to reduce risk to areas within the Barataria Basin. Also reduces risk to the Lafitte area.
	PU2-G-100-4	Sustain coastal landscape through restoration. Similar structural features as PU2-R-100-4 but with additional barrier-weir and levees along the GIWW to reduce risk to areas within the Barataria Basin. Also reduces risk to the Lafitte area.
	PU2-G-400-4	Sustain coastal landscape through restoration. Similar structural features as PU2-R-400-4 but with additional barrier-weir and levees along the GIWW to reduce risk to areas within the Barataria Basin. Also reduces risk to the Lafitte area.
	PU2-G-1000-4	Sustain coastal landscape through restoration. Similar structural features as PU2-R-1000-4 but with additional barrier-weir and levees along the GIWW to reduce risk to areas within the Barataria Basin. Also reduces risk to the Lafitte area.
Comprehensive (Coastal, Structural, and Nonstructural)	PU2-C-X-xxx-x	Structural/coastal alternatives are made comprehensive by adding complementary nonstructural measures to reduce residual risk in areas without structural risk reduction measures. Comprehensive alternatives are noted by a "C-" in front of the structural/coastal alternative code.

Below is a map showing the areas encompassed by Planning Unit 2.



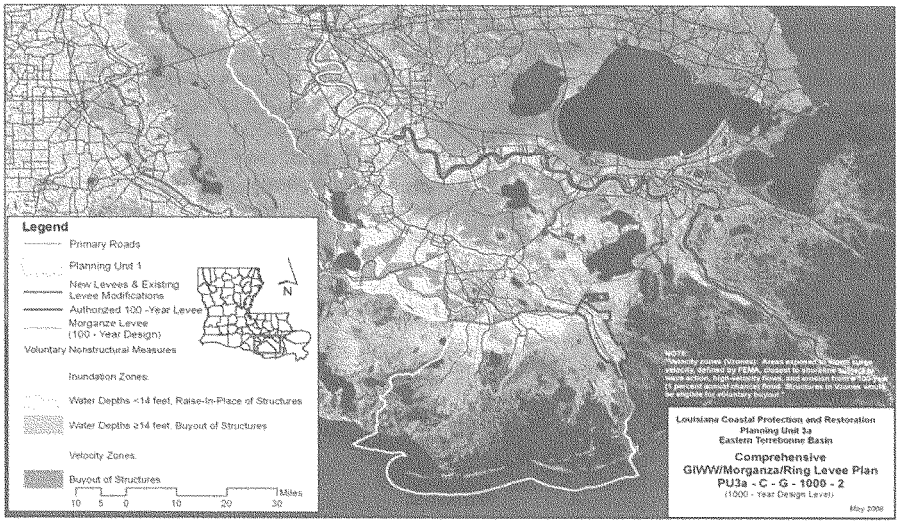
Planning Unit 3a

Levee alignment strategies included analysis of variations on the alignment and design heights for the currently proposed 100-year **Morganza to the Gulf** project, as authorized by the Water Resources Development Act of 2007. Alternative alignments include: extending the proposed Morganza alignment westward to Morgan City and into the Atchafalaya basin; tying the proposed Morganza alignment into high ground to the west of Houma with a ring levee around Morgan City; and using the Morganza levee as a first line of defense at a 100-year design level and then providing a second levee alignment further inland, along the **GIWW**, to prevent inner flooding around Houma at a 400-year and 1000-year frequency design, and again including a ring levee around Morgan City. Following the tiered screening process, four structural alternatives were selected for further analysis in Planning Unit 3a.

Category	Alternative	Alternative Description
No Action	PU3a-0	No action (without project) alternative.
Coastal Restoration Only	PU3a-R1	Sustain coastal landscape through restoration including shoreline protection, marsh creation, and diversions from the Mississippi River.
Coastal Restoration and Nonstructural Measures	PU3a-NS-100, -400, and -1000	Sustain coastal landscape through restoration. Implement comprehensive 100-year, 400-year or 1000-year nonstructural measures.
Coastal Restoration and Structural Measures	PU3a-M-100-1	Sustain coastal landscape through restoration. Construct Morganza to the Gulf levee with extension tying into high ground west of Morgan City at 100-year design level.
	PU3a-M-100-2	Sustain coastal landscape through restoration. Construct Morganza to the Gulf levee with tieback to high ground south of Thibodaux and ring levee around Morgan City at 100-year design level.
	PU3a-G-400-2	Sustain coastal landscape through restoration. Construct Morganza to the Gulf levee at the 100-year design level with a second levee along the GIWW with tieback to high ground south of Thibodaux and ring levee around Morgan City providing a 400-year level of risk reduction for Houma and Morgan City.
	PU3a-G-1000-2	Sustain coastal landscape through restoration. Construct Morganza to the Gulf levee at the 100-year design level and a second levee along the GIWW with tieback to high ground south of Thibodaux and ring levee around Morgan City providing a 1000-year level of risk reduction for Houma and Morgan City.
Comprehensive (Coastal, Structural, and Nonstructural)	PU3a-C-X-xxx-x	Structural/coastal alternatives are made comprehensive by adding complementary nonstructural measures to reduce residual risk in areas without structural risk reduction measures. Comprehensive alternatives are noted by a "C-" in front of the structural/coastal alternative code.

Louisiana Coastal Protection and Restoration (LACPR) Final Technical Report
Real Estate Appendix

Below is a map showing the areas encompassed by Planning Unit 3a.

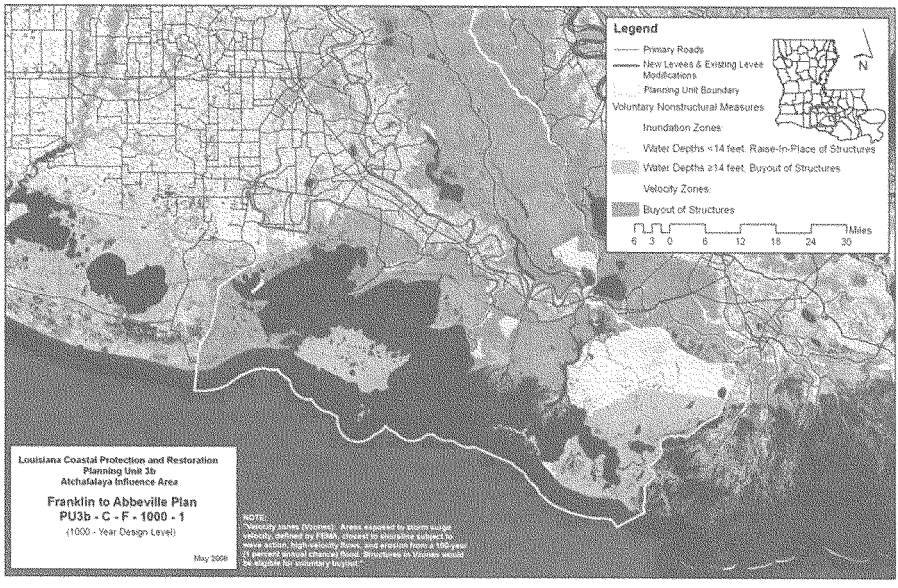


Planning Unit 3b

The primary levee alignment strategies considered in Planning Unit 3b included two parallel alignments extending from Morgan City west across Vermilion Bay. The southern alignment follows the **GIWW** and extends into Planning Unit 4. The northern alignment, designated as the **Franklin to Abbeville** alignment, provides a ring levee around Patterson and a continuous levee from Patterson, around Franklin and Baldwin and tying to high ground to the west of Abbeville. A third levee alignment strategy considers **ring levees** surrounding concentrated population centers, including Patterson, Franklin, Baldwin, New Iberia, Erath, Delcambre and Abbeville. Following the tiered screening process, six structural alternatives were selected for further analysis in Planning Unit 3b.

Category	Alternative	Alternative Description
No Action	PU3b-0	No action (without project) alternative.
Coastal Restoration Only	PU3b-R1	Sustain coastal landscape through restoration including shoreline protection, marsh creation, etc.
Coastal Restoration and Nonstructural Measures	PU3b-NS-100, -400, and -1000	Sustain coastal landscape through restoration. Implement comprehensive 100-year, 400-year or 1000-year nonstructural measures.
Coastal Restoration and Structural Measures	PU3b-G-100-1	Sustain coastal landscape through restoration. Raise ring levee around Patterson/Berwick to 100-year design level and construct levee along the GIWW west to the boundary of Planning Unit 4 at the 100-year design level.
	PU3b-F-100-1	Sustain coastal landscape through restoration. Raise ring levee around Patterson/Berwick to 100-year design level and construct levee along the edge of development north of the GIWW to high ground west of Abbeville at the 100-year design level.
	PU3b-F-400-1	Sustain coastal landscape through restoration. Raise ring levee around Patterson/Berwick to 400-year design level and construct levee along the edge of development north of the GIWW to high ground west of Abbeville at the 400-year design level.
	PU3b-F-1000-1	Sustain coastal landscape through restoration. Raise ring levee around Patterson/Berwick to 1000-year design level and construct levee along the edge of development north of the GIWW to high ground west of Abbeville at the 1000-year design level.
	PU3b-RL-100-1	Sustain coastal landscape through restoration. Raise ring levee around Patterson/Berwick to 100-year design level and construct ring levees around Franklin/Baldwin, New Iberia, Erath, Delcambre, and Abbeville at the 100-year design level.
	PU3b-RL-400-1	Sustain coastal landscape through restoration. Raise ring levee around Patterson/Berwick to 400-year design level and construct ring levees around Franklin/Baldwin, New Iberia, Erath, Delcambre, and Abbeville at the 400-year design level.
Comprehensive (Coastal, Structural, and Nonstructural)	PU3b-C-X-xxx-x	Structural/coastal alternatives are made comprehensive by adding complementary nonstructural measures to reduce residual risk in areas without structural risk reduction measures. Comprehensive alternatives are noted by a "C-" in front of the structural/coastal alternative code.

Below is a map showing the areas encompassed by Planning Unit 3b.



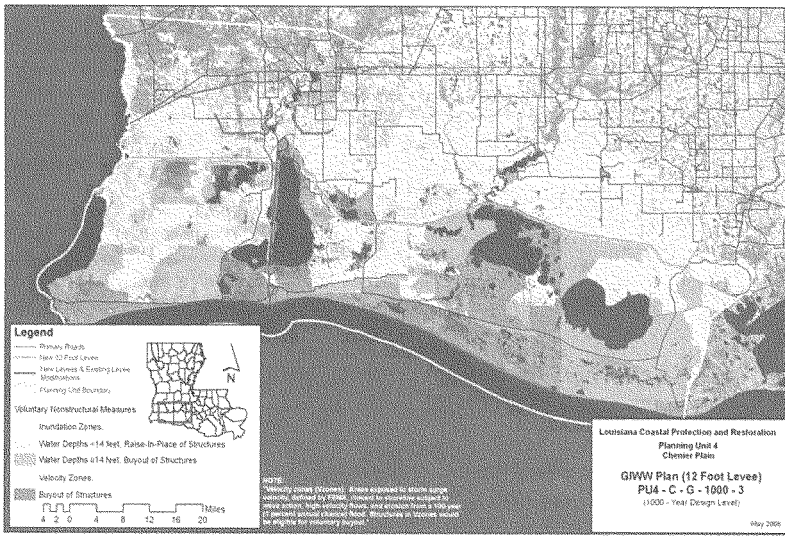
Planning Unit 4

The levee alignment strategies for this planning unit are relatively similar for the two continuous levees extending along the **GIWW** westward from near Vermilion Bay to the Calcasieu River just below Lake Charles, with a separable reach west of the river. The first of these alignments joins with the same alignment in Planning Unit 3b. The second alignment has a return to high ground to the west of the Vermilion River so that this alternative can be evaluated as "stand alone." The second alignment strategy consists primarily of a series of **ring levees** to the east and west of Lake Charles. The third alignment strategy is a hybrid of the first two strategies where a **12-foot GIWW levee** performs essentially as an overtopping weir with ring levees behind it. Common to all three strategies is a series of small levees within Lake Charles to separate the river from the land. Following the tiered screening process, seven structural alternatives were selected for further analysis in Planning Unit 4.

Category	Alternative	Alternative Description
No Action	PU4-0	No action (without project) alternative.
Coastal Restoration Only	PU4-R1	Sustain coastal landscape through restoration including shoreline protection, marsh creation, etc.
Coastal Restoration and Nonstructural Measures	PU4-NS-100, -400, and -1000	Sustain coastal landscape through restoration. Implement comprehensive 100-year, 400-year or 1000-year nonstructural measures.
Coastal Restoration and Structural Measures	PU4-G-100-1	Sustain coastal landscape through restoration. Construct a continuous levee (with gates) along the GIWW plus a ring levee to the west of the Calcasieu River and a series of levees within Lake Charles to separate the river from the land at the 100-year design level. Alignment joins with similar alignment in Planning Unit 3b.
	PU4-G-100-2	Sustain coastal landscape through restoration. Construct a continuous levee (with gates) along the GIWW plus a ring levee to the west of the Calcasieu River and a series of levees within Lake Charles to separate the river from the land at the 100-year design level. Alignment ties to high ground to the west of the Vermilion River so this alternative can be evaluated as "stand alone" from alternatives in Planning Unit 3b.
	PU4-G-400-3	Sustain coastal landscape through restoration. Construct a continuous 12-foot levee (with gates) along the GIWW plus a ring levee to the west of the Calcasieu River and a series of levees within Lake Charles to separate the river from the land. Includes small ring levees around parts of Lake Charles, Gueydan, and Kaplan to provide 400-year level of risk reduction. Alignment ties to high ground to the west of the Vermilion River so this alternative can be evaluated as "stand alone" from alternatives in Planning Unit 3b.
	PU4-G-1000-3	Sustain coastal landscape through restoration. Construct a 12-foot continuous levee (with gates) along the GIWW plus a ring levee to the west of the Calcasieu River and a series of levees within Lake Charles to separate the river from the land. Includes small ring levees around parts of Lake Charles, Gueydan, and Kaplan to provide 1000-year level of risk reduction. Alignment ties to high ground to the west of the Vermilion River so this alternative can

Category	Alternative	Alternative Description
		be evaluated as "stand alone" from alternatives in Planning Unit 3b.
	PU4-RL-100-1	Sustain coastal landscape through restoration. Construct ring levees to the east and west of Lake Charles; construct a series of levees within Lake Charles to separate the river from the land; and construct ring levees around Kaplan and Gueydan to the 100-year design level.
	PU4-RL-400-1	Sustain coastal landscape through restoration. Construct ring levees to the east and west of Lake Charles; construct a series of levees within Lake Charles to separate the river from the land; and construct ring levees around Kaplan and Gueydan to the 400-year design level.
	PU4-RL-1000-1	Sustain coastal landscape through restoration. Construct ring levees to the east and west of Lake Charles; construct a series of levees within Lake Charles to separate the river from the land; and construct ring levees around Kaplan and Gueydan to 1000-year design level.
Comprehensive (Coastal, Structural, and Nonstructural)	PU4-C-X-xxx-x	Structural/coastal alternatives are made comprehensive by adding complementary nonstructural measures to reduce residual risk in areas without structural risk reduction measures. Comprehensive alternatives are noted by a "C-" in front of the structural/coastal alternative code.

Below is a map showing the areas encompassed by Planning Unit 4.



FACILITY, TOWN AND CEMETERY RELOCATIONS

For cost shared projects, it is the responsibility of the non-federal sponsor to accomplish relocation of facilities and utilities. Costs associated with relocations are creditable as part of the non-federal sponsor's LERRD credit. The term relocation generally means providing a functionally equivalent facility to the owner of an existing facility or utility by one of the following means: alteration, lowering, raising or replacement of the facility or utility. Engineering Division used the 1990 Louisiana Pipeline and Industrial Atlas as well as information obtained from Louisiana Department of Natural Resources (LDNR) to identify oil and gas producing facilities located in the proposed planning area. State and Parish highways impacted by alternatives were also identified. Relocations must be accomplished prior to granting right of entry for construction. Utility and facility relocations are a lengthy and costly process; although the number of relocations is not known at this time, the projected acquisition schedules take into account the fact that relocations will need to be accomplished.

Prior to any relocations, an Attorney's Opinion of Compensability must be accomplished to determine the extent of the legal obligation to relocate a utility or public facility. A Preliminary Attorney's Opinion of Compensability will be performed during the feasibility phase for recommended alternatives.

Relocation of towns is not planned at this time. At this time, it is not known if cemeteries will be impacted by alternatives. It is New Orleans District's policy to avoid impact to cemeteries to the greatest extent possible. If during the feasibility phase, it is discovered that cemeteries are impacted by project features, a cemetery relocation plan will be prepared. That feature of the project will be scheduled accordingly since cemetery relocations require an extensive amount of time and effort to accomplish. The relocation of cemeteries is premised on the acquisition of a real estate interest and extinguishment of the legal right of the next of kin to visit and preserve the burial grounds for their ancestors and relatives. It is the policy of the Corps of Engineers to respect the wishes of the next of kin as to the removal and reinterment of bodies. Ordinarily just compensation for the acquisition of an existing cemetery site will consist of furnishing a new site comparable to the existing site, plus disinterment and reinterment of the bodies as well as transferring monuments and other facilities from the old to the new site. The existing cemetery will be acquired through condemnation; whereas the site for the new cemetery will be acquired through conventional means unless negotiations are unsuccessful.

ENVIRONMENTAL ISSUES

Hazardous, Toxic, and Radiological Waste (HTRW)

Due to the nature of the LACPR Technical Report, a Programmatic Environmental Impact Statement (PEIS) was not prepared. However, the Planning Units for LACPR were based upon a prior programmatic study, Louisiana Coastal Authority (LCA) Programmatic Study, in which a PEIS was prepared. Please consult section 3.21.2, Existing Conditions, of the LCA Programmatic Environmental Impact Statement, November 2004 for more comprehensive information pertaining to HTRW within the project areas.

HTRW includes any material listed as a "hazardous substance" under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and any material listed as a hazardous waste under the Resource Conservation and Recovery Act (RCRA) and other pertinent Acts & Legislation.

A review of Federal and state agencies' databases reveals numerous HTRW sites of concern within the parishes in the coastal Louisiana study area which could potentially pose a problem. The Federal agencies' databases revealed numerous sites under the National Priority List (Superfund); CERCLA; RCRA waste generators; RCRA Corrective Action (CORRACTS) list; RCRA non-CORRACTS treatment, storage or disposal facilities; and sites listed under the National Response center for incidents involving oil and chemical spills. The state databases also revealed numerous inactive and abandoned sites, landfills, and leaking underground storage tanks. In addition to these known areas of concern, a large number of unknown/unidentified environmental sites of concern are likely located within the coastal Louisiana study area.

Compilation of a list of sites of concern for the entire LACPR Study area is not practicable at this time since specific right of way alignments have not been determined. As alternative plans become more defined, detailed HTRW analyses will be performed to evaluate and eliminate, where possible, potential HTRW problem sites from consideration. Addressing existing HTRW sites of concern for proposed LACPR Plan projects will include a review of site-specific historical uses as well as soil borings. Prior to initiation of any acquisition activities, HTRW clearances will be obtained; remediation/clean up of lands needed for construction, operation and/or maintenance of any project is considered a non-Federal sponsor responsibility.

Oyster Leases

An oyster lease has been recognized as a real estate interest by both statute and case law. Should the project features impact oyster leases, the non-federal sponsor will acquire the oyster leases. With acceptance of payment for an affected lease, the lessee will execute a purchase agreement with the State of Louisiana and a receipt, release, indemnity and hold harmless agreement in favor of the United States, including the U.S. Army Corps of Engineers (USACE), and the State of Louisiana, including Louisiana Department of Natural Resources (LDNR) and Louisiana Department of Wildlife and Fisheries (LDWF); The purchase agreement will indicate that full and fair compensation has been made in complete satisfaction of all claims against the State and the U.S., related to past, present, or future damages to the affected lease.

Depending on the project schedule, the oyster lessee may be allowed to harvest the oysters at his own expense. However, if the plan schedule prevents the oyster lessee from removing the oysters, then the lessee will be compensated for the oyster crop. The lessee will not be allowed to harvest the crop if payment has been made for the oysters. Under the federal method, no payment will be made for loss of future crop. Compensation for the oysters is limited to the contributory value of the crop.

Oyster leases are located on State owned water bottoms. The designated areas are leased for $2 per acre per year. Leases are for a duration of 15 years with option to renew. The State has the right to cancel leases with written notice in the event that a public works project is planned

within leased areas. The compensation is based upon the market value of the lease at the time of the lease cancelation. *Productive o*yster leases sell in the private market for an average price of approximately $400.00/acre. Given the preliminary nature of alternative feature designs, oyster lease impacts could not be evaluated in this technical report. It is likely that hundreds of acres of oyster leases could be impacted by some of the coastal restoration and water diversion features of the LACPR projects. Because the market value of oyster leases is very comparable to the market value of privately owned marsh, in preparation of the real estate cost estimates, it was assumed that all areas impacted by the coastal restoration and water diversion features were privately owned. Therefore, the cost estimates include a portion of the costs associated with impacts to oyster leases but do not include the costs associated with business relocation. These costs will be estimated during subsequent feasibility studies when identification of oyster leases is possible.

Timber

As with Row Crops (below) determining the impact of LACPR projects on timber, timber production, timber conservation and impact on the foresting industry is unknown at this time. However, the following information, taken from the LCA PEIS from November 2004 sheds some light on the potential impacts of LACPR projects, once construction commences. Please refer to section 3.22.12 of the LCA PEIS for additional information.

Timber production in Louisiana's forested wetlands is an important renewable resource. Bottomland forests in southern Louisiana serve as a source for merchantable lumber. Presently, Louisiana's forest land covers about 13.8 million acres (5.6 million ha), which is about 2,000,000 acres (810,000 ha) less than the early 1960s forestland area. Private, non-industrial companies own over 60 percent of Louisiana's forestland, while forest-product industries and the public own the remaining 40 percent of forestland.

It is the general intent of the plan to reserve to the landowners the right to harvest timber. Where the estate prohibits timber harvesting, the landowner will be compensated for the merchantable timber. The prices paid for a specific stand of timber will vary considerably due to factors such as size, species, quality, quantity, logging conditions, distance to the mill, end product, demand and competition. Stumpage prices paid for pine sawtimber during the second quarter of 2008 averaged $290 per thousand board feet Doyle. Prices for mixed hardwood sawtimber averaged $289 per thousand board feet Doyle. Pulpwood stumpage prices averaged $28 per standard cord for pine and $19 per standard cord for hardwood. *(LA Dept of Agriculture & Forestry, Quarterly Report, April – June 2008)*

Because the impact of the LACPR alternatives on actual timber stands could not be determined at this time, the contributory value of timber was estimated in the overall value of the land.

Row Crop

It is assumed that landowners will be allowed to harvest mature crops prior to construction of the plan. In that instance, compensation would be for the impact of the easement on the value of the property. If time constraints do not permit the landowner to harvest crops, the landowner will also be compensated for the market value of the crops.

Specifically pertaining to the type of row crops in the area, stage-damage relationships were developed for the agricultural resources in the planning areas. The National Agricultural Statistics Service GIS database for the year 2005 (pre-Katrina and Rita) was used to provide the location of each of the various crops farmed in the LACPR planning area. These crops include corn, citrus, rice, soybeans, strawberries, sugar cane, and tomatoes. . There are approximately 800 acres in citrus production in planning unit 1 with a total gross farm value of $6,431,000. Strawberries and tomatoes are also a large crop in planning unit 1 with approximately 500 acres in strawberry production and approximately 136,300 acres in tomato production yielding a combined total gross farm value of $20,610,000. Major crops found in Planning units 2, 3a, 3b and 4 include corn, rice, soybeans, and sugar cane. Estimated planted acreage for these crops are as follow: corn-726,900 acres, rice – 370,100 acres, soybeans – 620,400 acres, and sugarcane – 418,933 acres. The combined gross farm value of these crops is approximately 1,315,000,000. Planning units 2, 3a, 3b and 4 also have numerous acres in aquaculture for crawfish. It is estimated that approximately 168,000 acres are farmed for crawfish yielding a gross farm value of $84,600,000.

Mitigation

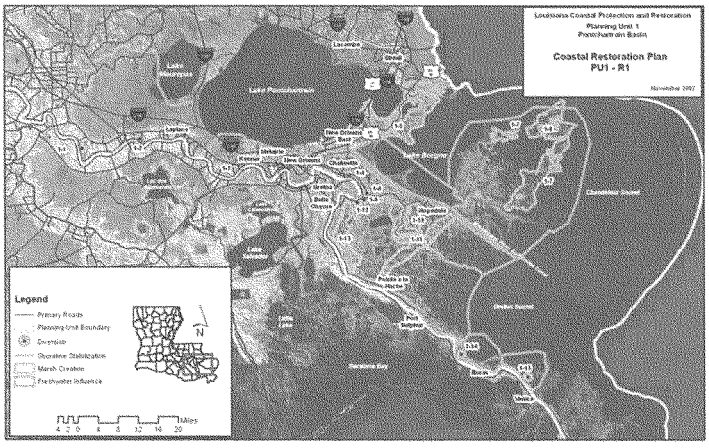
The term *compensatory mitigation* generally refers to actions taken to offset environmental impacts by replacing or providing substitute resources or environments. The various structural hurricane risk reduction measures under consideration for LACPR will inevitably result in unavoidable impacts to wetlands and other aquatic resources. In these cases, compensatory mitigation would be needed to ensure that such unavoidable impacts are fully offset, consistent with the policy of no-net-loss.

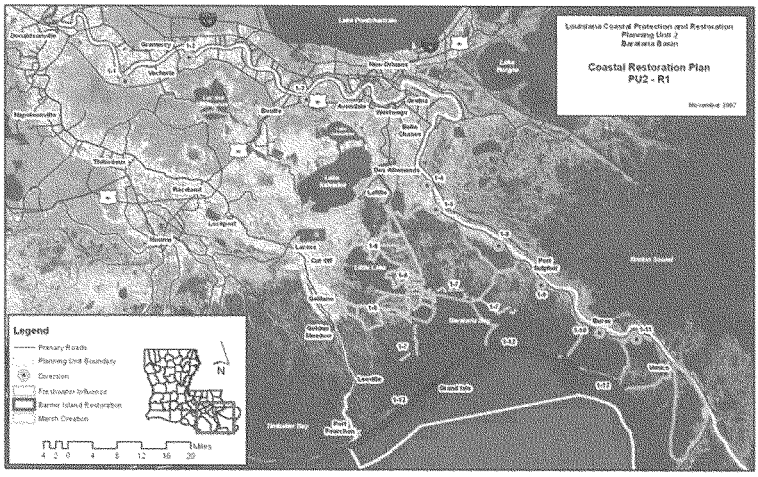
Acres of mitigation required (ratio) will vary depending upon quality functions and values of acres impacted, quality of acres of mitigation area. Furthermore the quantity of acres required to meet mitigation requirements will fluctuate depending upon length of the project analysis period (i.e., 50 or 100 years). Consistent with long-standing Federal mitigation policy, and based on extensive experience with compensatory mitigation in Louisiana, the LACPR Habitat Evaluation Team recommends use of a minimum of a 1.5:1 mitigation ratio for estimating implementation needs (e.g., cost, sediment resources, and timing).

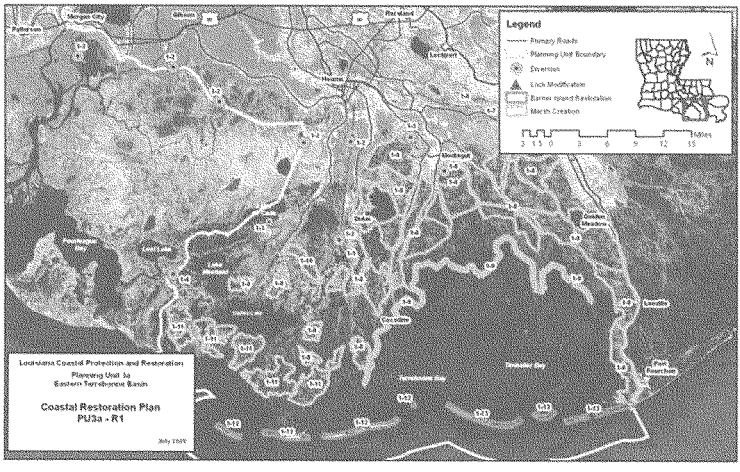
Compensatory mitigation for any future projects will be conducted in advance or concurrent with implementation of the structural hurricane risk reduction projects for which the mitigation is required. Mitigation lands will be acquired by the non-federal sponsors after cost-sharing agreements have been signed. The proposed estate is to acquire fee excluding minerals (with restrictions on use of the surface). Real estate costs will depend upon the location of the mitigation sites and the highest and best use potential of those properties.

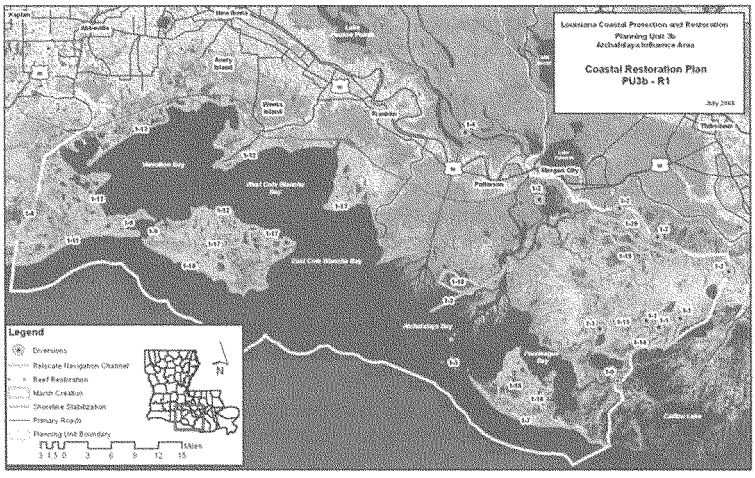
INDUCED FLOODING

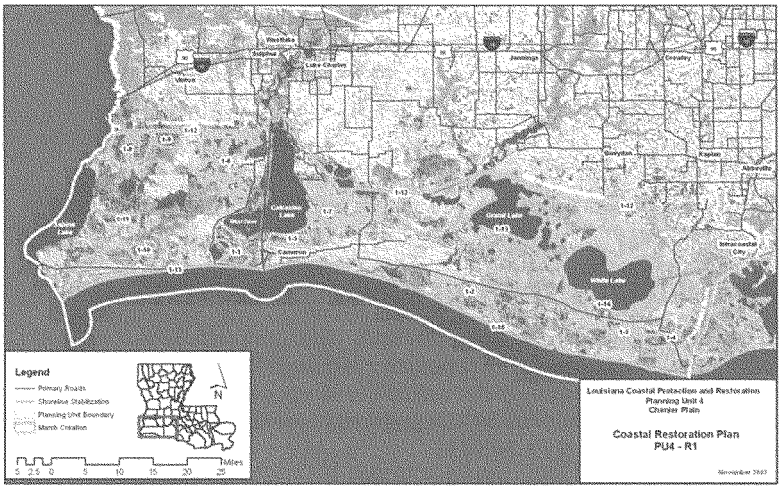
Some alternatives include freshwater diversion channels to restore wetland areas. Therefore, there is a potential that various features of LACPR may induce flooding. The diversion features will require the acquisition of a standard channel easement and a standard flowage easement. The maps below indicate the areas where diversion channels would be constructed and the areas of freshwater influence. Planning Unit 4 does not propose any freshwater diversion areas.




Louisiana Coastal Protection and Restoration
Planning Unit 2
Barataria Basin
Coastal Restoration Plan
PU2 - R1
November 2007
Legend
Primary Roads
Planning Unit Boundary
Diversion
Freshwater Influenced
Barrier Island Restoration
Marsh Creation
Miles
4 2 0 4 8 12 16 20
N


Legend
Primary Roads
Planning Unit Boundary
Diversion
Lock Modification
Barrier Island Restoration
Marsh Creation
Miles
3 1.5 0 3 6 9 12 15
N
Louisiana Coastal Protection and Restoration
Planning Unit 3a
Eastern Terrebonne Basin
Coastal Restoration Plan
PU3a - R1
July 2009


Louisiana Coastal Protection and Restoration
Planning Unit 3b
Atchafalaya Influence Area
Coastal Restoration Plan
PU3b - R1
Legend
Diversions
Relocate Navigation Channel
Reef Restoration
Marsh Creation
Shoreline Stabilization
Primary Roads
Planning Unit Boundary
Miles


Legend
Primary Roads
Shoreline Stabilization
Planning Unit Boundary
Marsh Creation
Miles
Louisiana Coastal Protection and Restoration
Planning Unit 4
Chenier Plain
Coastal Restoration Plan
PU4 - R1

MINERAL ACTIVITY

Mineral rights will not be acquired since project features at this time do not impact subsurface rights. The estates will expressly reserve to the landowner all mineral interests. Although the mineral interest owner will be allowed to continue ongoing mineral activities, in some areas there may be prohibitions or restrictions on future use of the surface of the property for mineral purposes. Alternative drilling methods may allow access to the minerals, e.g., via directional drilling. Specifically, in areas where fee title will be acquired and where permanent features would preclude surface access, e.g., channel or levee easements, the estates would expressly prohibit surface exploration or extraction. In other areas, the estates would restrict, rather than prohibit, the surface use, and would require prior written approval by the USACE and the non-federal sponsor for mineral activities on the surface. Such approval would be granted if the surface activity does not interfere with the construction, operation, or maintenance of the project.

For most project features, the restrictions of surface use would not preclude the exploration of minerals given that the right of way to be acquired will be minimal in size compared to remaining ownership size. In those situations where the majority of the ownership is impacted by an easement that restricts the use of the surface, it is assumed that remote access to the minerals would be feasible, e.g., via directional drilling or other methods.

It is common in the market for sellers to reserve mineral interests. For those properties that are not in current production, there is no market evidence that the mineral interests have any contributory value to the property value. If the project features were to impact properties encumbered by leases, the government would obtain a waiver of surface rights or a partial cancellation of the lease (for the portion of the lease in the right of way). The only instance where there could be costs associated with mineral interests is if the project were to impact conservation units (sites actively producing minerals). In those instances, an appraisal of the contributory value of the minerals to the overall property value will be estimated for compensation. The real estate costs include sufficient funds to cover negotiations with outstanding third party mineral interest holders.

ZONING ORDINANCES

No zoning ordinances are proposed in lieu of acquisition of realty interests in connection with the proposed study alternatives.

FEDERALLY OWNED AND STATE OWNED LANDS

The LACPR alternatives may impact federally owned lands. For those features that are located in federally owned property, a memorandum of agreement will be signed between the USACE and the other federal agency. For those agencies that do not accept a memorandum of agreement; acquisition/exchange documents will be prepared in coordination with the agencies to ensure that all Federal regulations are adhered to.

Features of the LACPR alternatives may also impact State of Louisiana lands. For those areas that are owned by the State of Louisiana, the State will issue a grant of particular use to the USACE providing right-of-entry to its property. For planning purposes, it is assumed that the

State owns the bed and bottoms of navigable waterways, including areas of open water. A detailed determination of ownership of the State, including any political subdivisions of the State, will be made for each particular feature. Moreover, section 3.7 of the Programmatic Cumulative Effects Report, a portion of the LACPR Main Report, specifically identifies areas within the state of Louisiana that are designated for Wildlife Management, Conservation and Recreational Opportunities, such as hunting, fishing, hiking, etc.. Figure 3.7-1 depicts the aforesaid areas and are listed in the Recreational Resources Annex (Annex B). For more details pertaining to State & Federally owned recreational areas, please consult the aforementioned sections in other portions of the LACPR Final Report. LACPR project areas are overlay Corps projects currently underway. For a list of the Corps projects within the LACPR project areas, please consult the Programmatic Cumulative Effects Analysis Appendix Annex A - Ongoing Projects in Study Area. Corps' project types include navigation, flood control, marsh creation & protection.

NAVIGATION SERVITUDE

Derived from the Commerce Clause of the U.S. Constitution, article I, section 8, clause 3, the navigation servitude is the dominant right of the United States to use, control and regulate the navigable waters and submerged lands thereunder. The applicability of the navigation servitude depends on both legal and factual determinations. If the legal determination supports assertion of the navigation servitude, then the second step is to determine the geographical area over which the servitude can be asserted. In tidal areas, the servitude extends to all lands below the mean high water mark, whereas in non-tidal areas, the servitude extends to all lands within the bed and banks of a navigable stream that lie below the ordinary high water mark. For planning purposes, the real estate cost estimates do not consider the effect of the navigation servitude, given the extensive technical analysis required for such a factual determination. The navigation servitude will be asserted where appropriate. It is the relation to navigation rather than the stated project purpose that determines whether navigational servitude should be asserted.

ESTATES

An array of both standard and non-standard estates and the typical language for each is included below. The brackets indicate optional language for rights that may need to be acquired, if necessary, for a project feature. Because LACPR is a programmatic study and does not identify a tentatively selected plan for any of the planning units or study areas, not all of the following estates will necessarily apply for all of the alternatives considered in this LACPR programmatic report; the non-standard estates are contained herein for informational purposes only. It is anticipated the LACPR study area will be partitioned into several smaller feasibility-level studies, requiring a Real Estate Plan for each authorized study. The proposed non-standard estates for each of these smaller studies will require approval from headquarters (HQUSACE).

Fee Excluding Minerals (With Restriction on use of the Surface) (Standard Estate)

The fee simple title to the land, subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; excepting and excluding all (coal) (oil and gas), in and under said land and all appurtenant rights for the exploration, development,

production and removal of said (coal) (oil and gas), but without the right to enter upon or over the surface of said land for the for the purpose of exploration, development, production and removal therefrom of said (coal) (oil and gas).

Flowage Easement (Permanent Flooding) (Standard Estate)

The perpetual right, power, privilege and easement permanently to overflow, flood and submerge (the land described in Schedule A) Tracts Nos. _____, _____ and _____), (and to maintain mosquito control) in connection with the operation maintenance of the project as authorized by the Act of Congress approved _____, and the continuing right to clear and remove and brush, debris and natural obstructions which, in the opinion of the representative of the United States in charge of the project, may be detrimental to the project, together with all right, title and interest in and to the timber, structures and improvements situate on the land [1] (excepting _____, (here identify those structures not designed for human habitation which the District Engineer determines may remain on the land)); provided that no structures for human habitation shall be constructed or maintained on the land, that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the United States in charge of the project, and that no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of. landfill; [2] the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purposes authorized by Congress or abridging the rights and easement hereby acquired; provided further that any use of the land shall be subject to Federal and State laws with respect to pollution.

Channel or Channel Improvement Easement (Standard Estate)

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (tract no. _____) for the purpose as authorized by the Act of Congress approved _____, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, building, improvements and/or other obstructions therefrom; to excavate, dredge, cut away, and remove any or all of said land and to place thereon excavated material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

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[1] Any structures existing in areas that will be allowed to remain must be evaluated using the same criteria that would be used to grant permission for a new structure to be placed in the easement, in coordination with the operational office.

[2] If sand and gravel or other quarriable material is in the easement area and the excavation thereof will not interfere with the operation of the project, the following clause will be added: "excepting that excavation for the purpose of quarrying (sand) (gravel) (etc.) shall be permitted, subject only to such approval as to the placement of overburden, if any, in connection with such excavation;"

Wetland Creation and Restoration Easement (Non-Standard Estate)

A perpetual and assignable right, servitude and easement in, on, over and across those lands to construct, operate and maintain the creation and/or restoration of wetlands and associated coastal habitats on the land hereinafter described, including the right to deposit dredged material sediment or other beneficial materials thereon; to construct dikes and to install, alter, relocate, repair or plug cuts in the banks of said dikes; to accomplish any alterations of contours on said land for the purpose of accommodating the deposition of dredged and/or other beneficial materials as necessary in connection with such works; to clear, trim, cut, fell, and remove therefrom any or all trees, timber, underbrush, obstructions and any other vegetation, structures, or obstacles as required in connection with said work; to clear, borrow, excavate and remove therefrom all soil, dirt and any other materials, including dredged material, as required in connection with said work; to construct, operate and maintain pipelines to transport and/or deposit dredged and/or other beneficial material on said lands; to place, move and utilize machinery necessary and useful in the operation of such pipelines; to place, move and utilize other equipment useful in the control of the such material and effluent; to plant or cause the growth of vegetation on said land; and to create, restore, nourish and enhance the wetlands and associated coastal habitats in, over, across and upon the said lands; provided that no structures for human habitation shall be constructed on the land but existing structures may be maintained and that no other structures shall be constructed or maintained on the land without the prior written approval of the United States, as represented by the U.S. Army Corps of Engineers, or the State of Louisiana, as represented by the Louisiana Department of Natural Resources, or authorized representative, and that no excavation shall be conducted and no disposal of any kind placed on the land without such written approval, including approval of the location and method of excavation and/or placement of disposal; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the Grantor, its successors and assigns, all such rights and privileges in said land as may be used and enjoyed without interfering with or abridging the use of the project for the purposes authorized by Congress or the rights, servitudes and easements hereby acquired, *[and expressly excepting and excluding from the taking all oil, gas and other minerals in and under said land and all appurtenant rights used in connection with the exploration, development, production and removal of said oil, gas and other minerals but without the right to enter upon or over the surface of said land for the purpose of drilling and extracting therefrom said oil, gas and other minerals].*

Flowage and Deposition Easement (Non-Standard Estate)

The perpetual right, power, privilege, and easement permanently to overflow, flood and submerge the land, including the right to deposit dredged or sediment material on, over and across the land and the continuing right to clear and remove any brush, debris and natural obstructions which, in the opinion of the representative of the United States in charge of the project, may be detrimental to the project; provided that no structures for human habitation shall be constructed but existing structures may be maintained on the land, no other structures shall be constructed on the land except as may be approved in writing by the representative of the United States in charge of the project, and no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of

landfill; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purposes authorized by Congress or abridging the rights and easement hereby acquired *[and expressly excepting and excluding from the taking all oil, gas and other minerals in and under said land and all appurtenant rights used in connection with the exploration, development, production and removal of said oil, gas and other minerals but without the right to enter upon or over the surface of said land for the purpose of drilling and extracting therefrom said oil, gas and other minerals].*

Dredged Material Pipeline Easement (Non-Standard Estate)

A temporary and assignable easement and right-of-way in, on, over and across the land described in Schedule A, for a period not to exceed ____ years, beginning with the date possession of the land is granted to the United States, for the location, construction, operation, maintenance, alteration, repair and patrol of a dredged material pipeline; together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Dredged Material Disposal Easement (Non-Standard Estate)

An assignable right and easement in, on, over and across those lands described in Schedule A, for a period not to exceed ____ years, beginning with the date possession of the land is granted to the (United States) (__{local sponsor}__, for use by the United States, its representatives, agents and contractors, to construct, operate and maintain a dredged material disposal area on the land, [including the right to construct dikes]; to deposit dredged material thereon; [to accomplish any alterations of contours on said land for the purpose of accommodating the deposit of dredged material as necessary in connection with such works]; [to borrow, excavate and remove soil, dirt and other materials, including dredged material, from said land;] [to undertake any management practice designed to enhance use of or extend the life of said land for the deposit of dredged material]; to clear, cut, fell and remove any and all trees, timber, underbrush or other obstructions therefrom; and for such other purposes as may be required in connection with said works; provided that no structures for human habitation shall be constructed on the land but existing structures may be maintained, no other structures shall be constructed on the land except as may be approved in writing by (the District Engineer of the U.S. Army Engineer District, New Orleans) (__{local sponsor}__), or authorized representative, and no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of landfill; subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the Grantors, (their heirs) (its successors) and assigns, all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purposes authorized by Congress or abridging the rights and easements herein conveyed *[and expressly excepting and excluding from the taking all oil, gas and other minerals in and under said land and all appurtenant rights used in connection with the exploration, development, production and removal of said oil, gas and*

other minerals but without the right to enter upon or over the surface of said land for the purpose of drilling and extracting therefrom said oil, gas and other minerals].

Dike (and/or Weir) Easement (Non-Standard Estate)

A perpetual and exclusive right, servitude and easement in, on, over and across those lands described in Schedule A, including all appurtenances thereto, together with all rights, title and interest in and to the structure and improvements to be situated thereon, to construct, maintain, repair, operate, patrol and replace [an earthen] [a stone]dike, including the right to clear, trim, cut, fell, borrow, excavate and remove therefrom all trees, timber, underbrush, soil, dirt, obstructions and any other vegetation, structures, or obstacles as required in connection with said work; [and to install metal box weirs in the dike]; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used and enjoyed without interfering with or abridging the use of the project for the purposes authorized by Congress or the rights, servitudes and easements hereby acquired.

Levee and Channel Easement (Non-Standard Estate)

A perpetual and assignable right and easement in the land, to construct, maintain, repair, operate, patrol and replace a levee, rock weir, drainage ditch, channel and/or channel improvement works, and all appurtenances thereto, and the right to clear, dredge, cutaway, borrow, excavate and remove any and all land, soil, dirt and other material from the land; including the right and easement to permanently overflow, flood and submerge the land, and the right to deposit dredged, excavated and sediment material on, over and across the land; with the continuing right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, structures, improvements and/or other obstructions therefrom; provided that no structures for human habitation shall be constructed, existing structures may be maintained on the land, no other structures shall be constructed on the land except as may be approved in writing by the representative of the United States in charge of the project, and no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of landfill; subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their successors and assigns all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purposes authorized by Congress or abridging the rights and easements hereby acquired.

Flood Protection Levee Easement (Standard Estate)

A perpetual and assignable right and easement in (the land described in Schedule A) (Tracts Nos, _____, _____ and _____) to construct, maintain, repair, operate, patrol and replace a flood protection (levee) (floodwall)(gate closure) (sandbag closure), including all appurtenances thereto; reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Borrow Easement (Standard Estate)

A perpetual and assignable right and easement to clear, borrow, excavate and remove soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); [3] subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

Temporary Work Area Easement (Standard Estate)

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (work area), including the right to (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

PUBLIC LAW 91-646

Note: As a conservative cost-estimating approach, both permanent and temporary relocation assistance costs are included in the cost of nonstructural measures for LACPR; however, P.L. 91-646 benefits may be applied differently during implementation of actual projects.

The United States Constitution and the State of Louisiana Constitution require that a property owner be paid just compensation when the government acquires private property for a public use. The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as amended (P.L. 91-646) was enacted to ensure uniformity in the treatment of persons displaced by a federal project. The Act requires that property owners be offered the market value of the real estate interest to be acquired; this offer is to be based upon an approved appraisal of the property. The government is required to conduct good faith negotiations with each landowner in an effort to acquire the property in an amicable manner. The government must pay the agreed purchase price for the property interest before requiring the owner to surrender possession of the property being acquired. Lastly, if an occupant is to be displaced from a dwelling or business the government must provide at least 90 days advance written notice of the date by which the move must occur and must offer relocation assistance. All acquisition of private property for this project will be done in accordance with the provisions of Public Law 91-646, as amended.

It is anticipated that numerous dwellings, farms and businesses may be impacted by the structural alternatives proposed in this technical report. For the LACPR technical evaluation, however, an assessment of the number of improvements that could possibly be impacted could

[3] The easement estate may be limited as to time, depending upon project requirements.

not be performed. As the location of structures is refined, an identification of improvements may be possible.

Likewise, the nonstructural alternatives propose the voluntary buyout and/or permanent relocation of structures and raising-in-place of structures. The technical report identifies nonstructural measures at the planning unit level. Smaller geographical boundaries would be considered during the implementation phase, and nonstructural projects would be identified according to these smaller boundaries.

Relocation of a large number of residents, farms or businesses will pose significant hurdles to the acquisition schedule. A displaced person cannot be required to move from the right of way until a replacement dwelling is found. In small towns this could create a hardship in that there could possibly not be sufficient number of comparable dwellings into which displaced persons could move. In addition, persons with special needs will require special accommodations which could require construction of new dwellings or rehabilitation of existing dwellings. Typical relocations usually take six to twelve months to accomplish.

Numerous relocations of residences, business and farms will undoubtedly also impact project costs. In addition to the costs of moving personal property for all displaced persons, qualified homeowners may receive a housing differential payment if the amount of just compensation is not sufficient to purchase a comparable replacement dwelling. Likewise, qualified tenants may receive rent differential payments to offset additional housing costs. It is expected that the relocation costs for most displaced persons will exceed the statutory amounts of $22,500 for homeowners and $5,250 for tenants. Business/Commercial & Non-for Profit organizations relocation costs are determined by two factors: reestablishment expenses & moving expenses. Reestablishment expenses are related to the operation of the business at the new location, up to $10,000 for reasonable expenses actually incurred. Moving expenses vary and depend on the following: the moving of inventory, machinery, equipment, and similar business-related property including dismantling, disconnecting, crating, packing, loading, insuring, transporting, unloading, unpacking, and reconnecting of personal property; the loss of personal property due to the inability to move or transport the material; the cost for searching for a new business location, up to $1,000. For estimated costs related to relocation and reestablishment of businesses, please consult the cost section of this appendix. The New Orleans District will seek authority for last resort housing payments on a project by project basis as needed.

All five planning units are eligible for FEMA's Federal Disaster Public Assistance Program, the Hazard Mitigation Grant Program, the Pre-disaster Hazard Mitigation, Federal Assistance to Individuals and Households, and the Flood Mitigation Assistance Program pursuant to the Robert T. Stafford Disaster Relief and Emergency Assistance Act, U.S. C, 5121 et seq., and their implementing regulations contained in Title 44, Code of Federal Regulations (CFR) Part 206, the National Flood Insurance Reform Act of 1994 and its implement regulations contained in 44 CFR Part 78, and the Disaster Mitigation Act of 2000 and its implementing regulations.

The Hazard Mitigation Grant Program and the Flood Mitigation Assistance Program cover properties that have sustained repetitive losses due to floods within a ten year period. The program provides homeowners and business owners with grants to mitigate against future losses

by way of raising structures to above the base flood elevation, incorporating dry floodproofing techniques, relocating the structure outside the floodplain, acquisition and demolition of the structure. These programs, however, are voluntary on the part of the owners. For various reasons, it is the minority of owners that participate in the program. The property must meet qualifying criteria and often the mitigation costs could exceed the grant allowance.

The only FEMA program that could possibly pose an issue for an LACPR alternative could be the Hazard Mitigation Grant Program where an alternative impacts properties that may have participated in the acquisition and demolition feature. These properties are to remain vacant. However, if such properties are encountered during the feasibility phase, reports will address this issue so that the Congressional Authority of individual projects may allow construction of the proposed alternative.

PROJECT SPONSOR(S)

The acquisition of all lands, easements, rights of way, relocations, and any other interests, including suitable borrow and dredged or excavated material disposal areas (LERRDs) for the various features of future projects will be performed by non-federal sponsors. Once feasibility studies are initiated, non-federal sponsors will be identified. Feasibility Cost Sharing Agreements will be signed and the non-federal sponsors will be part of the Project Delivery Team. As project alternatives/features are studies, the sponsor's input will be considered. At that time sponsors will be advised of Public Law 91-646 requirements and the requirements for documenting expenses during the acquisition phase for credit purposes. At that time, the sponsors will also be advised of risks associated with initiation of acquisition activities prior to Congressional authorization of projects and appropriation of funds.

During the feasibility phase, an assessment of each sponsor will be conducted to determine whether they have the capability necessary to acquire the realty interests for the various projects. For a non-federal sponsor to be deemed fully capable of performing the LERRDs acquisition, the sponsor must have the authority to acquire and hold title to the real property; must have the power of eminent domain and quick take authority. Historically if the governmental agencies where projects are located do not have such authorities, they partner with the Louisiana Department of Transportation (LADOTD) and the Louisiana Department of Natural Resources (LADNR) to do the acquisitions. If the LADOTD and LADNR do not wish to perform the acquisitions, then the non-federal sponsors will ask the Federal Government to perform the acquisition of LERRDs and reimburse the Federal Government for those costs.

In the event that the non-federal sponsor has the authorities necessary to acquire the LERDDs but does not have sufficient staff to do so, the non-federal sponsor may elect to augment its staff or contract the work. Exhibit B includes a copy of a sample "Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability."

ACQUISITION SCHEDULE

A representative acquisition schedule is presented below for the alternative within each planning unit that would require the most real estate acquisitions. As individual feasibility studies are prepared in the future for selected planning unit alignments, acquisition schedules will also be developed. Acquisition would be accomplished in reaches by feature location; however, since that is not available at this time, an overall time frame is provided.

Acquisition activities include obtaining tract ownership data, preparation of plat and legal descriptions for each impacted ownership, researching title information, appraising the realty interests to be acquired and conducting negotiations and relocations as necessary. If the government were not able to acquire realty interests amicably, those interests would be acquired through condemnation.

Planning Unit 1 – PU1-C-LP-b-1000-2 – This alternative would involve acquisition from approximately 1,500 private landowners. It is estimated that approximately one-third of the ownerships would need to be acquired through condemnation. It is estimated that it would take approximately 10 years to complete the acquisition process.

Planning Unit 2 – PU2-C-G-1000-4 – This alternative would involve acquisition from approximately 1,200 private landowners. It is estimated that approximately one-third of the ownerships would need to be acquired through condemnation. It is estimated that it would take approximately 8 years to complete the acquisition process.

Planning Unit 3a – PU3a-C-G-1000-2 – This alternative would involve acquisition from approximately 900 private landowners. It is estimated that approximately one-third of the ownerships would need to be acquired through condemnation. It is estimated that it would take approximately 6 years to complete the acquisition process.

Planning Unit 3b – PU3b-C-F-1000-1 – This alternative would involves acquisition from approximately 600 private landowners. It is estimated that approximately one-third of the ownerships would need to be acquired through condemnation. It is estimated that it would take approximately 5 years to complete the acquisition process.

Planning Unit 4 – PU4-C-G-1000-3 – This alternative would involve acquisition from approximately 300 private landowners. It is estimated that approximately one-third of the ownerships would need to be acquired through condemnation. It is estimated that it would take approximately 3 years to complete the acquisition process.

ACQUISITION COSTS

The cost estimates prepared for this technical report are preliminary in nature. They are restricted use cost estimates. The estimates do not comply with USPAP and were prepared in accordance with USACE Engineering Circular 405-1-04, Appraisal, paragraph 4-19. The costs prepared and presented in the report are not to be used for making funding decisions. The costs are sufficient in detail for comparison of plans for initial screening and for use in performing

Multi-Criteria Decision Analysis (MCDA). More detailed cost estimates will be generated for individual feasibility studies in the future.

Real estate costs associated with each plan feature were provided to Engineering Division to be included in an overall cost estimate for each alternative. Due to the large number of alternatives, a parametric matrix approach was used to combine and ratio the various individual features that were estimated into the costs for each alternative. Below is a total real estate cost for each planning unit. The estimates listed below are for real estate interests to be acquired for the structural measures and coast restoration measures associated with providing 1,000 year level of protection in each planning unit. The estimates include the costs of LERRDs (excluding improvements), contingencies (25%), and administrative costs of acquisition. .

Total Real Estate Costs

Planning Unit 1	$1,918,000,000
Planning Unit 2	$1,172,000,000
Planning Unit 3a	$376,000,000
Planning Unit 3b	$62,000,000
Planning Unit 4	$77,000,000

Real Estate worked with Economics to prepare the estimates for the buyout alternatives. Economics developed the baseline for determining how many improvements would require buyout. Real Estate provided LER costs, P.L. 91-646, Title II costs, and acquisition costs. A total cost per structure was developed per parish. Note no distinction was made by Economics between residential structures and commercial/industrial structures; all were assumed to be residential properties. The average cost was estimated to be between $220,000 and $335,000 per structure.

Non structural buyouts must include not only improved properties but also the purchase of unimproved properties to prevent future development. The average cost of buying the vacant lots ranged between $30,000 and $80,000 per lot.

Below are the assumptions and limiting conditions associated with the real estate cost estimates.

The alternative designs are preliminary. Maps were provided showing overall location of plan features; maps were of a scale of 1 inch = 126,720 linear feet. Maps of such scale do not allow for identification of improvements or accurate identification of land classes. Engineering Division estimated acreage needs per feature. It was not possible to identify existing rights-of-ways for existing levees. This will be accomplished in future studies as design details are developed. No temporary rights-of-ways for access, staging, or construction areas have been identified at this time.

No wetland determinations were available for the vacant undeveloped lands impacted by the plans.

Physical inspection of sites was not possible. Inspection of the areas was made using aerial photography with alternative alignments. Property values were determined based on comparable sales on file and the appraiser's experience in the planning areas. Due to time constraints, specific values for each plan area could not be developed. An average price per acre was estimated for each land class. That average price was applied to all alternatives without distinction of location or size of the acquisitions.

The cost estimates for structural alternatives do not include costs associated with relocation of improvements. The maps provided were of a scale of 1 inch = 126,720 linear feet which do not allow for identification of improvements. Once the number of plans are reduced and maps of a reasonable scale are produced for the various alternatives, cost estimates will be prepared for each alternative. Because the costs of improvements could not be evaluated, the costs estimated for these alternatives exclude costs associated with relocations of dwellings, businesses or farms. Numerous relocations will undoubtedly also impact project costs. In addition to the costs of moving personal property for all displaced persons, qualified homeowners may receive a housing differential payment if the amount of just compensation is not sufficient to purchase a comparable replacement dwelling. Likewise, qualified tenants may receive rent differential payments to offset additional housing costs. It is expected that the relocation costs for most displaced persons will exceed the statutory amounts of $22,500 for homeowners and $5,280 for tenants. The New Orleans District will seek authority for last resort housing payments on a project by project basis as needed. Business owners and farm operations are entitled to receive reimbursement for actual costs associated with moving personal property to another location and up to $10,000 for re-establishment costs. Relocation of businesses and farms can be very costly and take a significant amount of time depending upon the type and size of the operation as well as the size of the acquisition area versus the size of the remainder property

Ownership count is based on the location of alternatives. It was assumed that rural and wetland properties impacted by the plans were part of large acreage ownerships; whereas, urban areas impacted small lot properties.

Acquisition costs include costs for tract ownership data research, title research, appraisals, negotiations, closing and/or condemnations, and where needed relocation assistance. The acquisition costs are determined to be an average cost per ownership impacted by the plan.

LANDOWNER ATTITUDE

Public meetings have been conducted. At this time the content of the information presented to the public has been conceptual and general in nature. It is reasonable to suggest that the general public is in favor of risk reduction and environmental restoration projects; however, until more detailed alignments are available, which will more definitively determine which landowners are impacted, attempting to realize actual landowner attitudes at this time is premature.

RISK ANALYSIS

For those alternatives that are being recommended for further study, a risk analysis will be performed during the feasibility study. Possible risks associated with all alternatives are:

- Negative landowner sentiment
- Availability of dredged material for construction of levees
- Availability of replacement housing for displaced persons
- HTRW contamination within necessary right of ways

Louisiana Coastal Protection and Restoration (LACPR) Real Estate Appendix Prepared and Approved by:

_____ _____

Judith Gutierrez (date)
Chief, Appraisal & Planning Branch
New Orleans District
Mississippi Valley Division

_____ _____

Linda Labure (date)
Chief of Real Estate
New Orleans District
Mississippi Valley Division

EXHIBITS

Exhibit A –General Planning Area Map

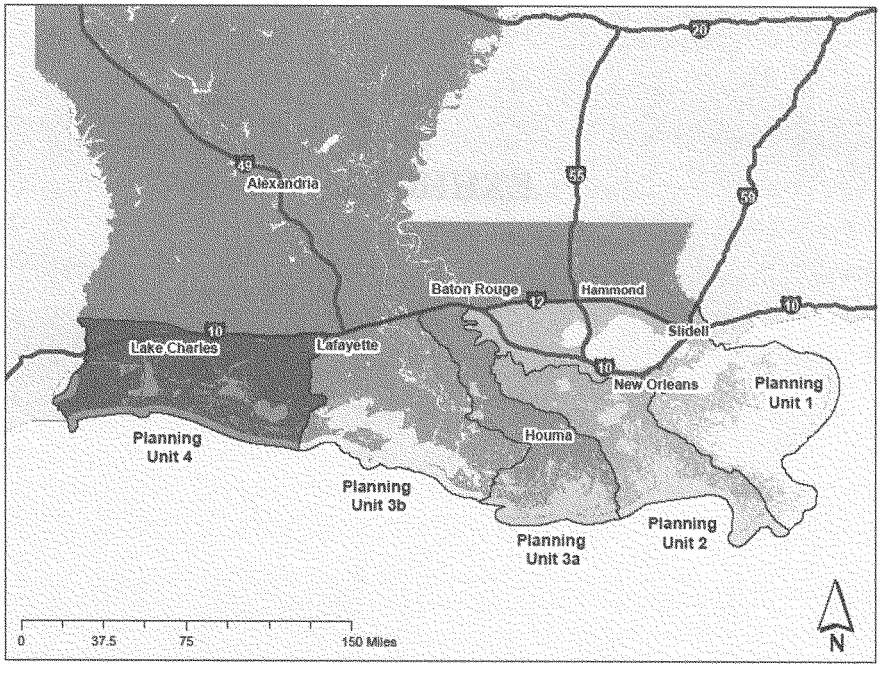

Exhibit B

ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY (name of sponsor)

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? (yes/no)

b. Does the sponsor have the power of eminent domain for this project? (yes/no)

c. Does the sponsor have "quick-take" authority for this project? (yes/no)

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary (yes/no)

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? (yes/no)

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? (yes/no)

b. If the answer to II.a. is "yes," has a reasonable plan been developed to provide such training? (yes/no)

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to

meet its responsibilities for the project? (yes/no)

d. Is the sponsor's projected in-house staffing level sufficient considering its other workload, if any, and the project schedule? (yes/no)

e. Can the sponsor obtain contractor support, if required in a timely fashion? (yes/no)

f. Will the sponsor likely request USACE assistance in acquiring real estate? (yes/no – If yes provide description)

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? (yes/no)

b. Has the sponsor approved the project/real estate schedule/milestones? (yes/no)

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? (yes/no/not applicable)

b. With regard to this project, the sponsor is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/insufficiently capable. (If sponsor is believed to be "insufficiently capable," provide explanation.)

V. Coordination:

a. Has this assessment been coordinated with the sponsor? (yes/no)

b. Does the sponsor concur with this assessment? (yes/no)

LOUISIANA COASTAL PROTECTION AND RESTORATION
FINAL TECHNICAL REPORT

CULTURAL RESOURCES APPENDIX

June 2009

U. S. Army Corps of Engineers
New Orleans District
Mississippi Valley Division

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Louisiana Protection and Restoration (LACPR) Final Technical Report
Cultural Resources Appendix

Purpose

The Louisiana Coastal Protection and Restoration (LACPR) Technical Report has been developed by the United States Army Corps of Engineers (USACE) in response to Public Laws 109-103 and 109-148. Under these laws, Congress and the President directed the Secretary of the Army, acting through the Chief of Engineers, to:

- Conduct a comprehensive hurricane protection analysis and design in close coordination with the State of Louisiana and its appropriate agencies;
- Develop and present a full range of flood control, coastal restoration, and hurricane protection measures exclusive of normal policy considerations for South Louisiana;
- Consider providing protection for a storm surge equivalent to a Category 5 hurricane; and
- Submit preliminary and final technical reports.

The purpose of this appendix is to support the cultural resources evaluation for LACPR, which is discussed in the main technical report.

Introduction

South Louisiana is subject to various levels of inundation by hurricane storm surges. These storm surges have the potential to damage or destroy numerous locally, regionally, and nationally important cultural assets. Cultural resources such as National Historic Landmarks, historic buildings and districts, archeological sites, shipwrecks, landscapes, and museums are particularly noteworthy with respect to the culture of communities in the area. In addition, the people that reside within South Louisiana derive from diverse cultural backgrounds and from numerous ethnic groups including Creole, Cajun, African American, French, Spanish, Native American, South American, Isleños, Filipino, Italian, Chinese, Vietnamese, among others. Communities of unique heritage can be found nestled within urban areas and on the rural landscape. Without hurricane risk reduction, these communities are at risk of dispersion and disintegration following inundation events. The damage to or loss of archeological sites, historic buildings, parks, and neighborhoods could lead to the loss of individual and community connection to place. Taken together, these outcomes could lead to a net loss of cultural diversity in South Louisiana.

In order to assess how different levels of risk reduction would help to preserve cultural resources, information is collected for a variety of cultural resources and compared to the structural and nonstructural plans. Environmental Systems Research Institute, Inc (ESRI) shapefiles are created for data that could be quantified easily and linked to a real world spatial location, including known archeological sites, National Register sites, and National Historic Landmarks. Given that not all cultural sites are recorded, the number of known cultural sites serves as a proxy measure of the actual number of sites that may be protected by the structural alternatives. The number of known sites protected by alternatives is computed by analyzing the location of sites and their proximity to the levees, flood zones, overtopping, and coastal erosion zones. The results are presented as the raw data, and as an index which weighs different resources by importance and standardizes the results for comparison across planning units and alternatives (See *Results, Table 2* below). Consideration of the effects on cultural resources from the

nonstructural plans involves reviewing economic and ethnic makeup of communities in order to address concerns relating to Environmental Justice as directed by Executive Order 12898. For example, the high velocity flood zones (V-zones) identified for nonstructural measures (see the *Nonstructural Plan Component Appendix*) are reviewed in order to identify possible disproportionate impacts from the implementation of nonstructural plan on low-income, minority, and traditional communities.

Goals and Objectives

The LACPR effort recognizes the important role of cultural resources to people, communities, and the Nation. Information on known cultural resources enters into the Risk-Informed Decision Framework (RIDF) in order to aid the planning process and screening of alternatives. The primary goal of this appendix involves considering how the different structural and nonstructural alternatives of LACPR have the potential to reduce risk to cultural resources. The first objective seeks to characterize and compare the level of risk reduction to cultural sites offered by each alternative. This objective is accomplished by providing cultural metrics to the multi-criteria decision analysis (MCDA). These metrics are compiled from existing inventories of known sites and serve as proxy measures to characterize the level of risk reduction each alternative would provide to cultural resources. The second objective is to preliminarily identify low income, minority, and traditional communities, populations that require consideration of Environmental Justice under Executive Order 12898, that are at a high risk from disproportionate impacts of the nonstructural alternatives.

Consideration of the National Historic Preservation Act

Several laws and executive orders establish cultural sites as a significant resource and require the Federal Government to consider the effects of a Federal undertaking on cultural resources. The National Historic Preservation Act of 1966, as amended, requires Federal agencies to consider cultural resources during the planning and implementation of Federal undertakings. Additional laws such as the National Environmental Policy Act of 1969, as amended, the Archeological Resources Protection Act of 1979, the Native American Grave and Repatriation Act of 1990, and Executive Orders 11593, 13006, and 13287 provide guidance on treating and preserving historic sites. The LACPR effort, as directed by Congress, is a government undertaking that has no potential to cause effects on historic properties as per 36 CFR 800.3(a)(1), because it is not authorized as a program nor project at this time. If the outcome of LACPR results in a program or projects that involve on the ground alterations, such as the construction of levees, restoration of wetlands, excavation of borrow, alterations to buildings, or other activities, USACE's responsibilities under Sections 106 of the National Historic Preservation Act will involve studies, surveys, and consultation to identify historic properties and traditional cultural properties as per §800.4.

Methodology Overview

The general methodology to identify effects to cultural resources uses Geographic Information Systems (GIS) to identify sites that would be protected by the structural alternatives, and to identify communities, particularly traditional and ethnic communities, that would be impacted by the nonstructural alternatives. The two types of analysis required different methodological approaches.

In order to assess the impacts from the structural alternatives qualitative data on site location is collected and encoded into GIS shapefiles. Three metrics are identified (1) archeological sites protected, (2) historic properties protected, and (3) historic districts protected. While these metrics are not a comprehensive inventory of cultural resources in South Louisiana, for this technical report they serve to represent the kinds of cultural resources protected by the alternatives. The shapefiles of known archaeological sites, known historic properties, and known historic districts are then compared with shapefiles with data on levee placement, storm surge and levee overtopping, and coastal land loss projections in order to identify how an alternative protects known sites. The number of protected sites is calculated and this summary is input into the multi-criteria decision analysis (MCDA—see the *Risk-Informed Decision Framework Appendix*).

In order to assess the impacts from the nonstructural alternatives, the location of the nonstructural impacts is observed and traditional and ethnic qualities of the communities are identified.

Evaluation of Alternatives

This section describes information on data collection, identification of impacts, and the process for calculating the metric information for input into the MCDA.

Cultural Metrics

The MCDA has three cultural metrics: (1) archeological sites protected, (2) historic properties protected, and (3) historic districts protected. *Archeological sites* are locations with buried information, including, but not limited to, prehistoric campsites, plantations, shipwrecks, and military places. *Historic properties* include properties listed or determined eligible for listing on the National Register of Historic Places and National Historic Landmarks. *Historic Districts* are districts composed of a collection of sites, buildings, and structures. In general historic districts cover a geographic scale larger than an individual site. Taken together, these categories reflect cultural resources important at the local, regional, and national level.

Criteria for Selecting Metrics

The selection of cultural metrics was guided by criteria defined for the MCDA process. Please refer to the *Risk-Informed Decision Framework Appendix* for a comprehensive presentation regarding all criteria for metric selection. Several selection criteria are extremely pertinent to the development of the cultural metrics. For example the metrics for the MCDA are to be cost-effective, verifiable, credible, and minimally redundant. Therefore existing inventories were referenced (see *Data Collection* below), thus they are cost effective. Also since LACPR attempts to characterize how alternatives would protect cultural resources; these existing inventories serve as proxy measures of all cultural resources, both known and unknown. The inventories were developed over many years of research and field investigations and provide verifiable data. These data also derive from agencies with standards and guidelines for inclusion in an inventory, such as the Louisiana Division of Archaeology and the National Park Service. Lastly, metrics for the MCDA should be viewed holistically in order to minimize redundancy. For example, a metric for "historic structures" was considered (see below). However, when the

data were reviewed it was revealed that existing inventories of historic structures did not meet some criteria as stipulated by the RIDF. Many of the historic structures are included in historic districts, thus use of historic structures would create redundancy. In addition, the inventory of historic structures in South Louisiana disproportionately emphasizes some areas because parish-wide studies have been undertaken for some parishes, but not for other parishes (see *historic structures* below).

Data Collection

A variety of sources, including an inventory of archeological sites maintained by the Louisiana Division of Archaeology and an inventory of historic properties maintained the National Park Service, provide information for the inventories of cultural resources. Table 1 below presents the data type and data source of each metric. While much of the information is publicly available, some information, such as the location of archeological sites is restricted to individuals with appropriate research qualifications, as defined by the State.

Table 1 - Summary of Cultural Metrics and Sources of Data

Metric Name (Units)	Type of Data	Source
Archaeological Sites Protected (# of sites)	Recorded Archeological Sites	Louisiana Department of Culture and Tourism, Division of Archaeology
Historic Districts Protected (# of districts)	Known Historic Districts	Louisiana Department of Culture and Tourism, Division of Archaeology, Louisiana Department of Culture and Tourism, Division of Historic Preservation, and the City of New Orleans, Historic District Landmarks Commission, National Register of Historic Places.
Historic Properties Protected (# of properties)	Determined National Register Properties	Department of Interior, National Park Service, National Register of Historic Places
	Designated National Historic Landmarks	Department of Interior, National Park Service, National Historic Landmarks

Consideration of the impacts to cultural resources leads to the designation protected sites and unprotected sites. A *protected site* is a site that is protected under an alternative from storm surge, erosion, and flooding. An *unprotected site* is a site that could be damaged or destroyed under the given alternative. The number of protected sites is the measure used for the cultural metric inputs for the MCDA.

Assumptions

The fact that biases are inherent in the cultural sites data set is worth reiterating. First, the sites included in the analysis are *known* sites, and the data set is not an inventory of *all* sites. Archeological sites, for example, tend to be recorded when a Federal undertaking has the potential for disturbing archeological sites. Other recorded archeological sites may have prominent features, such as mounds, and are easily identified. In contrast, the data set likely

under-represents deeply buried sites because they are not easily identified. In addition, the vast majority of archeological sites and historic buildings have not been evaluated to determine eligibility for inclusion on the National Register of Historic Places. Consequently the number of eligible National Register properties, is likely greater than the current inventory reflects. Therefore, the inventories of all cultural metrics comprise known or recorded sites, and are not accurate inventory of all archeological sites, historic districts, National Register Properties, or National Historic Landmarks. In many ways, it is useful to think of these inventories as proxy measures of the actual number of cultural sites. As outlined above, cultural resource inventories and assessments will be undertaken prior to construction of any elements in order to comply with the National Historic Preservation Act.

Archeological Sites

Archeological sites include the material remains of people and cultures from the historic and prehistoric past. Prehistoric sites include hunting and food processing camps, hamlets, villages, and mounds. Prehistoric and Native American groups of South Louisiana relied on hunting, fishing, and gathering plants. Archeological sites in this region tend to be located along natural waterways and in areas of relatively high elevation. Historic archeological sites include military sites, plantations, farmsteads, dwellings, commercial sites, and industrial sites. Historic archeological sites also tend to be located in areas of relatively high elevation, such as along natural levees, and on transportation routes. Shipwrecks form an additional category of historic sites and can be found throughout South Louisiana's waterways and off-shore.

Archeological sites provide important information about the past that is not available through other sources, such as historic records. Archeology is the main source of information from the prehistoric era, and of many societies that no longer exist. Information on proto-historic and historic period Native American groups survives through oral histories and ethnohistoric records. However, these sources tend not to extend far back into prehistory and the recorder's culture tends to bias ethnohistoric records. Historic archeological sites also offer information on segments of society, such as the lower classes, enslaved peoples, women, and children, not included in historic writings or not accurately depicted in writings. Archeology offers the opportunity to expand our knowledge of these components of society in order to depict how cultures were organized, explain why societies changed, and understand the region's, state's, and nation's heritage.

Archeological sites are preserved through an array of processes starting with the deposition of cultural material. Initially, a variety of factors influence site formation, such as the activities performed at a site, the number of people that occupied a site, the length of a stay, the kinds of materials used, and the rate of deposition (Schiffer 1987).

The presentation of two situations illustrates how these and other factors influence the creation and preservation of archeological sites. For example, if prehistoric hunters occupied a campsite for only few days, they may have built ephemeral shelters and left very little cultural material in a relatively small location. In addition, organic material tends to decay, which may result in little evidence of past human occupation surviving to the present day. In order to identify and collect information from the little surviving evidence, site identification requires an appropriate sampling strategy and recovery methodologies. In contrast, when many people occupy one

location for years or decades, they tend to possess a variety of objects made from a variety of materials. People living in one location for an extended length of time typically construct substantial structures, produce more trash, and may manage the trash by depositing it into trash heaps, middens, or pits. In this case, an archaeological site might be visible and easily identified from surface remains, in part due to structural remains and the concentration of cultural material. Careful excavation is still necessary in order to collect contextual information to address specific research questions. Archeologists take into consideration these types of behavioral and other natural processes when trying to identify the presence of archeological sites, ascertain past activities, and interpret what people did in the past.

Once a site is initially formed, additional factors, such as the rate of deposition, subsequent human activity, soil acidity, and climate influence site preservation. In South Louisiana, alluvium deposited from river floods and deltaic building episodes have deeply buried many sites. Many of the cultural resources located within the planning area were reported as having been disturbed in the initial site forms on file with the Louisiana Division of Archaeology. Some of these sites were impacted by construction activities conducted prior to the implementation of regulations governing the treatment of cultural resources. Unfortunately, destruction of cultural resource sites from man-made actions continues in South Louisiana. A discussion of processes that could impact cultural resources in South Louisiana is presented in a later section.

The Louisiana Department of Culture and Tourism, the Division of Archaeology archives State archeological site files and archeological reports in the State offices in Baton Rouge, Louisiana. The Division of Archaeology maintains a web accessible GIS of recorded archeological sites and this database forms the primary source of information on known archeological sites for this analysis. The Division of Archaeology granted access to the database to the USACE. A direct copy of the GIS shapefile could not be obtained by the USACE; therefore, a shapefile was created by querying information available on the web-based GIS. The Division of Archaeology's web-based GIS displays site location and a table with pertinent associated data such as site name, occupation date or period, function, associated cultural material, and other related information. In addition, the Universal Transverse Mercator Northing and Easting coordinates (UTMs) are included in this table. The data on site location and site characteristics were extracted from the web-GIS and used to create an ESRI point shapefile for use in the LACPR analysis. The shapefile includes information on 2,149 archeological sites and serves as the data set of known archeological sites in the GIS analysis.

This data set is not complete and it is a reflection of *recorded* archeological sites, and not the *actual* number of sites. Archeological sites are typically identified and recorded by archeologists prior to a ground disturbing civil works project. As a result, the inventory of sites tends to reflect areas of development. Consequently, site density may appear to be greater in developed areas, but in reality site density may be higher in undeveloped areas.

Historic Districts

For LACPR, an historic district is defined as a group of spatially-related properties sharing a common theme. Some historic districts have obtained National Register status (see below), but many of the historic districts considered for LACPR have been defined by either State or local organizations. Generally, historic districts apply to a group of buildings or structures that are

historically or architecturally significant. A group of associated archeological sites may also form an historic district. Sites, buildings, structures, and objects within historic districts are categorized as contributing and non-contributing properties. Contributing properties are any property, such as a structure or object, which adds to the historical integrity or architectural qualities that make an historic district significant. Contributing properties are integral parts of the historic context and character of an historic district. Although non-contributing elements are embedded within historic districts, the whole of an historic district is viewed as being greater than the sum of its parts. For this reason, the loss of individual elements has the potential to change the overall character of an historic district.

Louisiana Department of Culture and Tourism, Division of Historic Preservation, the Louisiana Department of Culture and Tourism, Division of Archaeology, and the City of New Orleans Historic District Landmarks Commission, and the National Register of Historic Places provide information on historic districts for this effort. The current inventory includes 69 historic districts; 56 listed on the National Register of Historic Places, and 13 listed on the New Orleans Historic District Landmarks Commission. Examples of historic districts include historic urban neighborhoods, commercial and government centers within parish seats, plantations, and military sites. These historic districts are overwhelmingly significant due to their architectural styles. Others are significant due to their association with a person or event or their ability to yield information.

Historic districts listed on the National Register of Historic Places must meet the criteria necessary for inclusion on the National Register (see *National Register Sites* below). The National Register historic districts are not counted as historic properties for the LACPR effort, because this would cause redundancy in the metrics.

The New Orleans Historic District Landmarks Commission is a regulatory agency for local historic districts in New Orleans. The New Orleans Historic District Landmarks Commission has jurisdiction over nine local historic districts, 163 individual landmark buildings, and 182 nominated landmark buildings in city neighborhoods. A goal of the New Orleans Historic District Landmarks Commission is to adaptively reuse buildings in order to retain the architectural character of an area. Although there are numerous commercial corridors, the majority of buildings reviewed by the New Orleans Commission are residential in nature. In addition, the City maintains a Central Business District Historic Landmarks and the Vieux Carre Historic District (commonly known as the French Quarter). Historic districts include Faubourg Marigny, Irish Channel, Algiers Point, Esplanade Ridge, Holy Cross, Bywater, Lower Garden District, Warehouse District, Lafayette Square, Picayune Place, St. Charles Avenue, Treme, and Canal Street.

Given that the defined historic districts in this inventory overwhelmingly includes buildings, structures, and objects, the residual effects of flooding from levee overtopping has the potential to damage contributing elements of historic properties. This information is taken into consideration in determining the number of protected historic districts under the structural alternatives.

National Register Sites

The National Register of Historic Places (National Register) is the Nation's official list of cultural resources worthy of preservation. Authorized under the National Historic Preservation Act of 1966, as amended, the National Register is part of a program to coordinate and support public and private efforts to identify, evaluate, and protect our historic and archeological resources. Sites listed or eligible for listing on the National Register are referred to as "historic properties." To be considered "historic," a property must be at least 50 years old (with certain exceptions), and possess integrity and significance. Integrity relates to a property's location, design, setting, materials, workmanship, feeling, and association. If, for example, a structure was moved from the location where it achieved its significance, then the structure no longer possesses integrity of location. Therefore, such property would not meet the criteria necessary for inclusion on the National Register of Historic Places. A property's significance may be related to a number of factors including:

- Its association with events that have made a noteworthy contribution to the broad patterns of our history
- Its relation to the lives of historically important people of our past
- It represents the distinctive characteristics of a type, period or method of construction
- It represents the work of a master
- It possesses high artistic value
- It represents a significant or distinguishable entity whose components may lack individual distinction
- It has yielded or may yield information important in history or prehistory

If an historic property is going to be adversely impacted by a Federal undertaking then the impacts must be mitigated.

An inventory of properties listed on the National Register of Historic Places is available through the National Park Service's website (www.nps.gov/nr/). Similar to the State records, information on locations is typically not available on archeological sites, but it is available for historic structures and other properties. National Register properties also include 307 structures and 42 archeological sites within the planning area.

Historic districts are also included in the National Register of Historic Places. Historic districts are a special collection of historic places where individual elements may not meet the criteria to be included on the National Register; however, when many elements are considered the whole is considered to be greater than the sum of the parts. The 56 historic districts listed on the National Register of Historic Places are included in the *Historic District* metric and not the historic properties metric (see *Historic Districts* above).

National Historic Landmarks

National Historic Landmarks are nationally significant historic places designated by the Secretary of the Interior because they possess exceptional value or quality in illustrating or interpreting the heritage of the United States. While there are many historic places across the Nation, only a small number have meaning to all Americans. Today, fewer than 2,500 historic

places bear the distinction of National Historic Landmark. National Historic Landmarks make tangible the American experience. They are places where significant historical events occurred, where prominent Americans worked or lived, that represent those ideas that shaped the Nation, that provide important information about our past, or that are outstanding examples of design or construction. National Historic Landmarks guide us in comprehending important trends and patterns in American history. They form the common bonds that tie together the many groups that settled the country and provide anchors of stability in a fast-changing world, ensuring that the Nation's heritage will be accessible to generations yet unborn. Within the planning area, 31 buildings and structures have achieved National Historic Landmark status.

Other Cultural Resources Considered

Identification of cultural resources involved considering a number of other resources including historic structures, and museums and archives. However, given the quality of the data, biases in the data, or likelihood that another metric already incorporated the data, these resources did not meet the selection criteria outlined for the risk-informed decision framework (see *Criteria for Selecting Metrics* above and the *Risk-Informed Decision Framework Appendix*).

Historic Structures

Historic structures include houses, buildings, bridges, levees, docks and other manmade structural objects. Historic structures are structures over 50 years old that possess certain unique qualities of significance. The Louisiana Department of Culture and Tourism, Division of Historic Preservation maintains an inventory of historic structures. While a total of 11,296 historic structures have been recorded for LACPR planning area, many historic structures remain unrecorded. Taken as a whole, this inventory's inherent biases result in an unreliable database for use in the MCDA. In addition, the historic nature of many of these buildings is already captured in the historic districts metric. While historic structures are not included in the MCDA, they will be inventoried and assessed, as necessary, under National Historic Preservation Act at the project implementation phase.

Two main factors influence whether structures have been recorded and are listed in the State inventory. The first factor involves efforts of local historical societies and individual preservationists. The second factor relates to Federal agencies requirement to comply with the National Historic Preservation Act of 1966, as amended.

In some parishes, historical societies and individuals have undertaken inventories of local historic buildings. For example, a comprehensive inventory of historic structures within town centers and rural landscapes was undertaken for St. Tammany Parish. This effort resulted in 1,809 historic structures recorded within that parish. Consequently, the inventory of historic structures for St. Tammany Parish closely matches the actual number of historic structures. Similar studies have not been implemented for other parishes, such as Jefferson Davis, Cameron, and Calcasieu. While the density of historic structures is expected to be low in this western, rural part of the State, the lack of inventory efforts has resulted in the documentation of only a handful of structures, and thus under-represents the true number of historic structures in these parishes.

In other parishes, the inventory of structures is a result of efforts related to Federal undertakings. For example, Orleans Parish contains 1,278 recorded historic structures. Many of these structures were badly damaged or destroyed by levee failures following hurricane Katrina. The Federal Emergency Management Agency (FEMA) recorded historic buildings that were no longer habitable following the storm and prior to demolition. As a result, roughly 30 percent of all recorded structures within Orleans Parish currently listed on the Louisiana Division of Archaeology and Division of Historic Preservation on-line database are located within the Lower Ninth Ward, one of the hardest hit neighborhoods from the 2005 floods. The available online inventory does not reveal whether recorded historic structures are still standing, but the location of the vast majority of recorded structures within Orleans Parish suggests that many of the recorded structures are no longer extant. Using the State historic structures inventory within the MCDA would therefore lead to counting some structures as protected, when in fact they do not exist. An effort to verify the status of recorded buildings would require large labor deployment, and violate a criterion for metric consideration (see *Risk Informed Decision Framework Appendix).* Furthermore, given that historic structures tend to be included within historic districts the redundancy of including historic structures would not validate the need for the cost.

Museums form an additional cultural resource that provide personal and community connection to place. Museum assets are included within the "residual damages" metric (see *Economics Appendix* and *Risk-Informed Decision Framework Appendix*).

Traditional and Ethnic Communities

In addition to archeological sites, historic buildings, and other historic properties, cultural resources also include traditional and ethnic communities. Executive Order 12898 instructs Federal agencies to consider the Environmental Justice effects of Federal actions on minority and low income populations. Many of the traditional and ethnic communities tend to be either minority or low income populations. Numerous ethnicities live within South Louisiana and include Creole, Cajun, African-American, Latinos, Isleños, Filipino, Italian, Yugoslavian, Croatians, Chinese, Vietnamese, and Native American tribes including Chitimacha, Coushatta, Choctaw, and Houma Indians. Some of these groups depend on a subsistence economy from oystering and shrimping. In general, coastal wetland loss will adversely affect these groups causing displacement and community disintegration.

Unlike the inventory of archaeological sites and National Register properties, inventories of traditional and ethnic communities do not exist. While some information regarding ethnicity is available through census data, changes in population and in community composition following hurricanes Katrina and Rita in 2005 and Gustav and Ike in 2008 is a dynamic and ongoing process.

The most comprehensive program documenting Louisiana's folk and ethnic traditions is the Louisiana Folklife Program (http://www.louisianafolklife.org). Central to the State's goals for cultural conservation, official folklorists are being assigned to cultural regions throughout the State. One of the purposes of the State program is to provide in-depth documentation of folk traditions and to facilitate the use of this information by the public and cultural tourism. These efforts will add to the existing detail on the cultural assets whose development and continued

existence depend upon the special geography and natural resources of southwestern and southeastern Louisiana.

If the outcome of this LACPR effort results in the implementation of risk reduction measures, then Environmental Justice outreach and evaluations would consider the effects of the proposed action on minority and low income communities. For the present LACPR effort, percentages of minority and low income populations are presented in the *Programmatic Cumulative Effects Analysis Appendix.*

Processes that Could Impact Cultural Resources

A variety of natural and human processes impact cultural resources in the LACPR planning area. Some impacts have a greater effect on archeological sites and site preservation, while others have greater impacts on historic structures. Natural processes, such as subsidence, erosion, storm surges, and levee overtopping, have the potential to negatively impact cultural resources. Understanding the effects of these processes is crucial when comparing the LACPR alternatives. Some alternatives include efforts to reduce some processes, such as coastal erosion, while others do not. Consequently, the ability to protect sites differs among the alternatives. The Cultural Resources section of the *Programmatic Cumulative Effects Analysis Appendix* considers the two worst case scenarios for each planning unit and potential impacts to cultural resources.

Land loss, due to processes such as coastal erosion or subsidence, forms a negative impact to all types of cultural assets. For example, eroding land also destroys the context of archeological deposits causing them to lose integrity and the ability to yield data. Erosion and subsidence of the soil underlying structures will negatively impact those structures by exposing them to the degrading effects of water or undermining the foundation. Therefore, if a site is located in an area that would be subject to land loss under any plan, then it is considered a negative impact. Land loss in the coastal zone is a particularly influential factor in the destruction of archeological sites within the LACPR planning area. Natural influences include subsidence, saltwater intrusion, and the frequency, magnitude, and duration of storms. Subsidence, compaction, and erosion accelerate the conversion of marsh to open water. Saltwater intrusion, coupled with subsidence, is resulting in the landward encroachment of the Gulf. These processes are deleterious to archeological sites located in proximity to various lakes, bays, sounds, canals, and other water bodies.

Flooding either from storm surges or levee overtopping would generally be a negative impact to historic structures, but not necessarily to archeological sites. Flooding of historic structures may undermine the structural integrity of the building by deteriorating portions of the structure or completely destroying a structure. Secondary impacts, such as mold growth, that may damage structural, architectural, or decorative elements can undermine a structure's integrity. This loss of integrity may decrease a structure's ability to meet criteria for inclusion on the National Register of Historic Places. Alternatively, the replacement of structural and decorative elements may change the character of an historic district. If the flooding from storm surges alters the ecosystem from freshwater to saltwater marsh, then the storm surge has the potential to negatively impact archaeological sites. Saltwater intrusion kills freshwater vegetation exposing soils to increased erosion. When archaeological sites are located in these areas, sites are destroyed as the soil erodes.

Other factors influencing site preservation are related to the climate and topography of the area. The climate in this area is influenced by air masses, which result in severe storms during the summer months and sporadic, high energy disturbances during the winter months. When severe winds from high energy disturbances uproot trees growing on sites, the context is disturbed, hindering the research potential of the site. Rapid rainfall and flash flooding can cause erosion, leading to the destruction of archeological sites.

Wind damage associated with hurricanes is an additional negative impact to cultural assets. For example, wind can damage structural components of buildings, exposing building interiors and contents to wind and rain damage. Wind can also uproot trees, which can damage archeological sites. Given the difficulty in estimating wind damage and the need to take local features into consideration, wind damage is not considered in the analysis.

Human activities are significant contributing factors, influencing site preservation in the area. Natural levees and their adjacent waterways represent important features in the region. For example, distributary channels formed important routes of transportation during prehistoric, historic, and modern times. The natural levees adjacent to the waterways provided suitable landforms for settlement, fortifications, and agricultural lands. Prehistoric settlements focused on these high ridges and natural levees and high ground was also preferred for historic settlements. Some of the first agricultural concessions in the area were granted along the Mississippi River and the major bayous of the planning area (Giraud 1987). Historically, settlement and development concentrated on suitable dry land adjacent to navigable watercourses. However, in the recent past, settlement has expanded to drained lowlands and natural backswamp areas. The flooding from Hurricanes Katrina and Rita in 2005 and Ike and Gustav in 2008 has heightened an awareness of the hazards associated with living in these drained lowlands, and future development has the potential to emphasize undeveloped high ground.

The construction of various flood and water control structures is another factor that has influenced site preservation in the coastal zone. Levees have been constructed to prevent flooding and to control the flow of water in some areas. Sites have been destroyed during the construction of levees and floodwalls. These water control projects also affect sediment transport and deposition in the area. Excavation and maintenance dredging of canals for the extraction of mineral resources and for navigation have accelerated erosion and disturbed archeological sites. Many archeological sites in the planning area have subsided and were exposed during dredging activities. The excavation of manmade canals divided some archeological sites. Subsequent erosion of the canal channels resulted in the loss of cultural deposits. Wakes from boats utilizing waterways forms an additional impact that negatively affects the preservation of archeological sites located along waterways.

The construction of new levees and expanding the footprints of existing levees also has the potential to damage cultural sites. Levees may be built upon archeological sites, or historic buildings may need to be moved or demolished in order to construct or expand levees. In addition, borrow material necessary for the levee improvement, expansion, and construction has the potential to impact and destroy both archeological sites and buildings present within borrow

and stockpile areas. The National Historic Preservation Act requires that cultural resources be considered prior to a Federal undertaking that has the potential to cause effects on historic properties. The opportunity to consider effects to historic properties will occur prior to the implementation of any plan.

Assessing Future Conditions

The overall LACPR technical evaluation considers future conditions; however, it is difficult to project the future conditions of cultural sites. For example, when considering the future in 50 years, structures being built today could be included on the National Register of Historic Places. However, as discussed above, historic properties must possess both integrity and significance. Both of these characteristics are difficult to predict 50 years into the future. Pre-fabricated homes constructed following Hurricane Katrina, referred to as Katrina cottages, could be eligible for the inclusion on the National Register of Historic Places. Precedence for this type of structure exists since pre-fabricated houses from the Sears and Roebuck Mail order catalog built between 1908 and 1940 have been determined eligible and are listed on the National Register. In addition, Katrina cottages are closely associated with the events of Hurricane Katrina and the rebuilding of New Orleans; therefore, it is possible that Katrina cottages will meet requirements of the National Register of Historic Places in 50 years. Consequently, predicting what may have merit in the future and inventorying such properties proves difficult. Analysis for LACPR therefore focuses on resources recorded now and did not attempt to quantify sites that could be considered cultural resources in the future.

GIS Analysis of Structural Alternatives—The Process

The cultural metrics for the MCDA are calculated with the use of GIS. The process includes identifying protected sites by overlaying and querying several shapefiles. The base layer includes information on site location. For archeological sites, the location of the proposed levee alignments and future wetlands factor into the calculation of the number of protected sites. In contrast, shapefiles with data on flooding location and depth from storm surges factor into the calculation of protected historic districts and historic properties.

Archeological Sites

The number of protected known archaeological sites is calculated with the use of three GIS shapefiles. The first shapefile includes the location of known archeological sites; the second shapefile contains the levee alignments; and the third shapefile is the Coastal Louisiana Ecosystem Assessment and Restoration (CLEAR) model (Twilley and Barras, 2003; see *Coastal Restoration Plan Component and Environmental Metrics Appendix*). The CLEAR model is an estimate of coastal land loss if no action is implemented. Three inputs are associated with each alternative and scenario, (1) the number of protected known sites, (2) the upper uncertainty limit, and (3) the lower uncertainty limit. The upper uncertainty limit is the best case, in that the greatest number of sites would be protected, however, the least amount of confidence is associated with the upper uncertainty limit. The lower uncertainty limit presents the measure with the highest confidence, but relatively fewer sites are protected. The expected number of protected sites is an average of the upper and lower uncertainty limits. Treating these figures as actual statistics is not appropriate; however, they loosely compare to a mean and associated error ranges.

The first step in calculating the number of protected known archaeological sites involves identifying the sites protected by levees. The second step involves quantifying the number of protected sites when coastal lands are preserved and not transformed to open water. Calculating the upper and lower uncertainty limit varies for the baseline and alternatives (see below). The number of protected archaeological sites for the no action alternative is calculated by simply determining the number of sites protected by existing levees. The upper and lower uncertainty limits are calculated by adding and subtracting 12.5 percent to the number of protected known sites. This percentage is chosen because it is equivalent to the range attached to the number of protected known archaeological sites with coastal wetland features (see below).

The number of protected archaeological sites for the alternatives is calculated by adding the number of sites that are protected by levees and the sites that are protected by coastal wetland features. Determining the number of known archaeological sites protected by coastal wetland features utilizes the CLEAR Model. The CLEAR Model is a raster shapefile with grid blocks covering 0.0965 square miles (0.25 sq km). The attribute table associated with this shapefile contains the estimated percentage of wetlands within each cell for future conditions in 5-year increments. The field "TOTWET50" is referenced to explore where land loss, as the result of erosion or subsidence, is expected in 50 years. Given that the model estimates the percentage of wetlands within the 0.0965 square mile cells, the precise location of water is not projected. The basic assumption for this analysis is that if archaeological sites are located within a cell that contains water, then the archaeological site could be destroyed. The process of land loss and increased wave action and erosion are processes that are likely to destroy sites. In order to capture a range of uncertainty of site loss for this analysis, the number of archeological sites is calculated twice. The lower uncertainty limit is calculated by examining cells that are estimated to be 75 percent wetland or more in 50 years with no action. Similarly, the upper uncertainty limit is calculated by examining cells that are estimated to be 50 percent or greater wetland. Once the number of sites that intersects these cell blocks is computed they are added to the number of sites protected. The midpoint for the metric value is computed by taking the average of the numbers calculated for the 50 percent and 75 percent wetlands results. While some present day land would still be lost and new land would be created in the process of coastal restoration, the use of the CLEAR model provides relative measure of how known archaeological sites could be protected.

To summarize, the archaeological sites metric includes the following:

- For the no action plan, the metric includes sites protected by existing levees,
- For the coastal restoration and nonstructural alternatives, the metric includes sites that would otherwise be destroyed by wetland loss, and
- For the structural and comprehensive plans (which incorporate wetland restoration plans), the metric includes both sites protected by levees and sites that would otherwise be destroyed by wetland loss.

Historic Properties and Historic Districts

Calculating the number of protected known historic districts and historic properties makes use of a similar process and is accomplished with the use of three GIS shapefiles. The first shapefile includes the location of known historic districts or historic properties; the second shapefile contains data on the location and depth of flooding from storm surges and levee overtopping; and the third shapefile is the CLEAR model. The CLEAR model is used in a similar manner as in the calculation of protected known archaeological sites (see above). The shapefile on the location and depth of flooding is based on hydrologic data that models storm surges, relative sea level rise, and levee overtopping. Buildings and structures form the vast majority of historic districts and properties, and buildings and structures have a greater potential than archaeological sites to be damaged or destroyed by flooding.

In order to calculate the number of historic districts and historic properties protected by the alternatives, the shapefile with flood data is queried. Three flood depths serve to define the estimated protected sites, upper and lower uncertainty numbers. The basic assumption is that when historic districts flood, the damage to buildings, structures, and other contributing elements of historic districts will cause loss of integrity. A historic property or historic district is considered protected when it lies outside of four feet of flooding. For the upper uncertainty limit, the site must lie outside of two feet of flooding; and for the lower uncertainty limit sites lay outside of six feet of flooding. In addition, the results are calculated for low and high relative sea level rise.

Results

In order to identify the worst and best performing alternatives an index is developed to incorporate the three metrics. In addition, this index serves to provide a standardized ranking of the alternatives and assists in the selection of the best and worst case scenarios for the cumulative effects analysis (see *Programmatic Cumulative Effects Analysis Appendix)*. While the cultural resource data is essentially qualitative in nature, the selection of the best and worst case scenarios needs to be reproducible and transparent. Therefore, the index provides a weighting system that takes into account general perceptions of the relative importance of the types of cultural resources included in the MCDA. For example, historic districts and historic properties are cultural resources that are recognized as important at a local, state, or national level, and must meet specific criteria in order to obtain that status. In contrast, archaeological sites in the Louisiana Division of Archaeology's inventory are recorded based on their presence. Archaeological sites are more numerous than the historic properties and historic districts, but it is highly unlikely that a large percentage of archaeological sites would be determined eligible for the National Register of Historic Places if they were to be evaluated. Therefore, a greater weight is applied to historic properties and historic districts and a lesser weight is applied to archeological sites in the index calculation. To reiterate, the weights in the index calculation are arbitrary, but the index attempts to take into account the relative importance of historic properties and historic districts as viewed by the public and as regulated by laws.

The index is calculated as follows:

$$\text{Index} = \frac{((as + as')/2)*0.2 + ((hp + hp')/2)*0.4 + ((hd + hd')/2)*0.4}{AS + HP + HD}$$

Where

AS = Total number of archeological sites within the Planning Unit
as = average archaeological sites for scenario 1&3
as' = average archaeological sites for scenarios 2&4
HP = Total number of historic properties within the Planning Unit
hp = average historic properties for scenarios 1&3
hp' = average historic properties for scenarios 2&4
HD – Total number of historic districts within the Planning Unit
hd = average historic districts for scenarios 1&3
hd' = average historic districts for scenarios 2&4

The results of the index fall within the range of 0 to 1 and allow comparison across planning units. An index of 0 indicates that the alternative would not provide any risk reduction benefit to a single cultural resource. An index of 1 indicates that the alternative would provide a risk reduction benefit to all cultural resources within the planning unit. Therefore, the higher the index, the greater the amount of risk reduction would be provided to cultural resources. Table 2 presents the index and metric data for each alternative for low (Scenarios 1 & 3) and high sea level rise (Scenarios 2 & 4). For all alternatives the index ranges from 0.016 (PU3b-0) to 0.205 (PU1-LP-b-1000-2).

Table 2. Metrics and Index for Alternatives of Each Planning Unit

Planning Unit 1		Scenarios 1 & 3 Archeological Sites (n = 488)			Historic Properties (n=165)			Historic Districts (n=54)			Scenarios 2 & 4 Archeological Sites (n = 488)			Historic Properties (n=165)			Historic Districts (n=54)		
	Index	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst
PU1-0 (No Action)	0.132	127	143	111	126	130	122	46	50	41	127	143	111	125	130	119	44	50	38
PU1-R1, R2, R3	0.175	267	313	221	130	134	126	48	51	43	267	313	221	129	134	123	45	51	40
PU1-NS-100, 400, 1000	0.175	267	313	221	130	134	126	48	51	43	267	313	221	129	134	123	45	51	40
PU1-LP-a-100-1	0.184	295	325	265	133	140	127	50	51	43	295	325	265	129	136	123	45	51	40
PU1-LP-b-400-1	0.189	297	327	267	137	142	131	50	51	48	297	327	267	133	138	129	50	51	45
PU1-LP-a-100-3	0.192	324	354	294	133	143	127	50	51	43	324	354	294	128	137	123	45	51	40
PU1-HL-a-100-3	0.188	305	335	275	133	137	126	50	51	43	305	335	275	128	134	124	48	51	40
PU1-LP-a-100-2	0.199	331	361	301	137	145	134	50	51	43	331	361	301	135	138	129	49	51	41
PU1-HL-a-100-2	0.193	312	342	282	138	141	132	50	51	43	312	342	282	135	138	129	49	51	41
PU1-LP-b-1000-1	0.189	297	327	267	137	142	131	50	51	48	297	327	267	133	138	129	50	51	45
PU1-LP-b-400-3	0.202	326	356	296	146	149	141	50	51	48	326	356	296	142	147	134	50	51	45
PU1-HL-b-400-3	0.195	307	337	277	143	143	140	50	51	48	307	337	277	141	143	133	49	51	45
PU1-LP-b-1000-2	0.205	333	363	303	159	159	156	50	52	48	333	363	303	135	138	129	49	51	41
PU1-HL-b-400-2	0.203	314	344	284	153	158	148	51	52	50	314	344	284	150	158	142	49	51	46

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Planning Unit 2		Scenarios 1 & 3 Archeological Sites (n=541)			Historic Properties (n=30)			Historic Districts (n=11)			Scenarios 2 & 4 Archeological Sites (n=541)			Historic Properties (n=30)			Historic Districts (n=11)		
	Index	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst
PU2-0 (No Action)	0.018	48	54	42	14	16	12	2	3	0	48	54	42	13	14	11	2	3	0
PU2-R1, R2, R3	0.077	213	272	154	15	16	13	6	7	4	213	272	154	14	14	12	6	7	4
PU2-NS-100, 400, 1000	0.077	213	272	154	15	16	13	6	7	4	213	272	154	14	14	12	6	7	4
PU2-WBI-100-1	0.078	213	266	160	15	17	14	7	8	6	213	266	160	14	15	13	7	7	6
PU2-G-100-1	0.160	449	502	396	26	26	24	9	9	8	449	502	396	26	26	23	9	9	8
PU2-R-100-2	0.096	266	449	160	15	17	14	7	8	6	266	449	160	14	15	13	7	7	6
PU2-R-100-3	0.096	266	449	160	15	17	14	7	7	6	266	449	160	14	15	13	7	7	6
PU2-WBI-400-1	0.079	213	266	160	26	26	25	9	9	8	213	266	160	25	26	23	9	9	8
PU2-R-100-4	0.082	224	277	171	15	17	14	7	8	6	224	277	171	14	15	13	7	7	6
PU2-R-400-2	0.079	213	266	160	26	26	25	9	9	8	213	266	160	25	26	23	9	9	8
PU2-G-100-4	0.160	449	502	396	26	26	24	9	9	8	449	502	396	26	26	23	9	9	8
PU2-R-400-3	0.098	266	449	160	26	26	25	9	9	8	266	449	160	25	26	23	9	9	8
PU2-R-400-4	0.083	224	277	171	26	26	25	9	9	8	224	277	171	13	14	11	2	3	0
PU2-S-1000-4	0.083	224	277	171	26	26	25	9	9	8	213	266	160	14	15	13	7	7	6
PU2-G-400-4	0.160	449	502	396	27	27	25	9	9	8	449	502	396	26	26	23	9	9	8
PU2-G-1000-4	0.160	449	502	396	27	27	25	9	9	8	266	449	160	14	15	13	7	7	6

Planning Unit 3a		Scenarios 1 & 3 Archeological Sites (n=303)			Historic Properties (n=19)			Historic Districts (n=1)			Scenarios 2 & 4 Archeological Sites (n=303)			Historic Properties (n=19)			Historic Districts (n=1)		
	Index	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst
PU3a-0 (No Action)	0.055	82	92	72	4	7	0	0	1	0	82	92	72	3	5	0	0	1	0
PU3a-R1, R2, R3	0.090	134	157	111	6	10	3	0	1	0	134	157	111	6	10	3	0	1	0
PU3a-NS-100, 400, 1000	0.090	134	157	111	6	10	3	0	1	0	134	157	111	6	10	3	0	1	0
PU3a-M-100-1	0.132	180	203	157	17	18	13	1	1	0	180	203	157	14	18	8	1	1	0
PU3a-M-100-2	0.110	151	174	128	14	17	10	1	1	0	151	174	128	11	15	8	0	1	0
PU-3a-G-400-2	0.107	151	174	128	11	13	5	1	1	1	151	174	128	9	11	4	1	1	1
PU3a-G-1000-2	0.115	151	174	128	16	17	16	1	1	1	151	174	128	16	16	16	1	1	1

Planning Unit 3b		Scenarios 1 & 3 Archeological Sites (n=433)			Historic Properties (n=20)			Historic Districts (n=5)			Scenarios 2 & 4 Archeological Sites (n=433)			Historic Properties (n=20)			Historic Districts (n=5)		
	Index	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst
PU3b-0 (No Action)	0.016	17	19	14	10	13	6	1	1	0	17	19	14	8	11	3	0	1	0
PU3b-R1, R2, R3	0.067	130	154	106	10	13	6	2	2	0	130	154	106	10	15	5	1	2	0
PU3b-NS-100, 400, 1000	0.067	130	154	106	10	13	6	2	2	0	130	154	106	10	15	5	1	2	0
PU3b-G-100-1	0.146	288	312	264	19	20	18	5	5	5	288	312	264	18	20	18	5	5	4
PU3b-F-100-1	0.093	178	202	154	15	16	14	3	3	1	178	202	154	15	16	14	2	3	0
PU3b-F-400-1	0.099	178	202	154	19	19	18	5	5	5	178	202	154	19	19	18	5	5	4
PU3b-F-1000-1	0.099	178	202	154	19	19	18	5	5	5	178	202	154	19	19	18	5	5	4
PU3b-RL-100-1	0.076	147	171	123	12	15	11	3	3	0	147	171	123	12	13	8	1	3	0
PU3b-RL-400-1	0.080	147	171	123	16	17	15	3	3	3	147	171	123	15	15	13	3	3	2

Planning Unit 4		Scenarios 1 & 3 Archeological Sites (n=274)			Historic Properties (n=4)			Historic Districts (n=0)			Scenarios 2 & 4 Archeological Sites (n=274)			Historic Properties (n=4)			Historic Districts (n=0)		
	Index*	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst	Ave	Best	Worst
PU4-0 (No Action)	0.024	33	37	29	0	1	0	0	0	0	33	37	29	0	1	0	0	0	0
PU4-R1, R2, R3	0.067	83	107	58	3	3	2	0	0	0	83	107	58	2	3	1	0	0	0
PU4-NS-100, 400, 1000	0.067	83	107	58	3	3	2	0	0	0	83	107	58	2	3	1	0	0	0
PU4-G-100-1	0.092	116	140	91	3	3	3	0	0	0	116	140	91	3	3	3	0	0	0
PU4-G-100-2	0.083	115	139	90	0	2	0	0	0	0	115	139	90	0	2	0	0	0	0
PU4-G-400-3	0.086	115	139	90	1	1	1	0	0	0	115	139	90	1	1	0	0	0	0
PU4-G-1000-3	0.086	115	139	90	1	1	1	0	0	0	115	139	90	1	1	1	0	0	0
PU4-RL-100-1	0.063	85	109	60	1	1	0	0	0	0	85	109	60	0	1	0	0	0	0
PU4-RL-400-1	0.064	85	109	60	1	1	1	0	0	0	85	109	60	1	1	0	0	0	0
PU4-RL-1000-1	0.064	85	109	60	1	1	1	0	0	0	85	109	60	1	1	1	0	0	0

* Given the lack of historic districts in Planning Unit 4, historic properties were given a weight of 0.8.

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All structural and comprehensive alternatives would provide some benefit toward reducing the risk to cultural resources. However, the amount of risk reduction to cultural resources varies among the planning units. In general the alternatives of the eastern planning units provide greater benefits to cultural resources than do the alternatives of the western planning units. History and geography are two important factors influencing this outcome. There are more historic properties and historic districts in Planning Units 1 and 2. Many of these historic properties and districts tend to be located within cities and towns with a long continuous settlement (e.g. New Orleans), on natural levees, and within existing levees. Improvements to the existing levee systems will result in creating additional storm damage risk reduction to these cultural resources. The no action alternative for PU 1 (index = 0.132) is equal to or greater than the best index for PU 3a (PU3a-M-100-1 = 0.132), PU 3b (PU3b-400/1000-1 = .099) and PU 4 (PU4-G-100-1 = .092). This result reflects the fact that metropolitan New Orleans is already provided some hurricane and risk reduction from the existing West Bank and Vicinity and Lake Pontchartrain and Vicinity levee system.

For all planning units, the no action alternative provides the least amount of risk reduction. This alternative allows the greatest amount of flooding within levees and the lack of coastal restoration measures would lead to the loss of cultural resources sites, mostly archaeological sites, located within wetlands and marshes. The two worst case structural alternatives for each planning unit are selected for evaluation in the *Programmatic Cumulative Effects Analysis Appendix*. In some cases the first and second worst case structural alternative based on the index is the same structural alignment but at a different levee height (e.g. 100-year vs. 400-year). In order to provide some variation for the worst case alternative selection in the Cumulative Effects Analysis, the next worst case for a different structural strategy was selected for the second worst case scenario (see footnote below table). Table 3 presents the selected worst case alternatives examined in the Cumulative Effects Analysis Appendix.

Table 3. Summary of Worst Performing Structural Alternatives for Each Planning Unit.

Planning Unit 1	Planning Unit 2	Planning Unit 3a	Planning Unit 3b	Planning Unit 4
PU1-LP-a-100-1	PU2-WBI-100-1	PU3a-G-400-2	PU3b-RL-100-1	PU4-RL-100-1
PU1-HL-a-100-3	PU2-R-400-2	PU3a-M-100-2	PU3b-F-100-1*	PU4-G-100-2*

*In Planning Unit 3b, PU3b-F-100-1 was selected rather than PU3b-RL-400-1 in order to have a worst performing structural alternative from different strategies represented. In Planning Unit 4, PU4-G-100-2 was selected rather than PU4-RL-400-1 or PU4-RL-1000-1 for the same reason.

In summary, the metrics and the index illustrate that all of the alternatives would provide some benefit to the protection of cultural resources when compared to the no action alternative.

Consideration of Nonstructural Alternatives

In addition to the structural alternatives, the implementation of nonstructural alternatives has the potential to impact cultural resources. The *Nonstructural Plan Component Appendix* presents a full discussion of the nonstructural measures. To summarize, nonstructural measures seek to identify secondary flood risk reduction measures that will reduce the risk of property damage and make communities safer from future hurricanes. Nonstructural measures target specific areas that are at a high risk of flooding or critical facilities necessary for community health and safety, particularly during an emergency event. The buy-out and relocation of communities forms a

potential undertaking that will have impacts on communities. Given that this undertaking may apply to low-income or minority populations Environmental Justice issues emerge. Measures to improve critical facilities may involve altering buildings or adding to existing buildings. Some of the targeted critical facilities may be eligible for or listed on the National Register of Historic Places and will need to be considered under the National Historic Preservation Act and National Environmental Policy Act. For the purposes of this technical report this initial assessment of the impacts to cultural resources from the implementation of the nonstructural alternatives aims to identify the types of resources that could be affected. In addition, a program for identifying low-income and minority populations and for identifying, assessing, and mitigating cultural resources impacted by nonstructural alternatives would be developed as part of the Section 106 of the National Historic Preservation Act process.

Buy-outs and Relocations

Voluntary buy-out and relocation are the two nonstructural measures that could influence the most qualitative cultural impacts and severe effects on communities. Cultural impacts are changes to the "norms, values and beliefs" that guide individuals and help them to locate themselves in society (Barrow, 1997: 226). Assessing cultural impacts prior to implementation of a nonstructural program will help planners identify how buy-out or relocation may alter people's norms, values, and beliefs when faced with new situations such as immigration, contact with new groups, changes in economic opportunities, and so on.

Possible Communities Impacted by Relocation or Raising Structures in Place

Community cohesion could be adversely affected by proposed buyouts in many locations in South Louisiana. Some possibilities include cultural impacts to subsistence fishermen of Yugoslavian heritage in Plaquemines Parish, and Isleños communities of Yscloskey, Regio, St. Bernard, and Toca in St. Bernard Parish. Grand Bayou in Plaquemines Parish is another community that will likely need to be assessed under Environmental Justice consideration prior to the implementation of nonstructural measures. Grand Bayou is an intercultural community of about 125 individuals that is composed of Atakapa, Houma, and Cajun heritage. Although this community is geographically dispersed along the coastal waterways and bayous, the Grand Bayou residents are a close-knit community built on familial and community networks that date back more than 300 years. Many of the residents rely on aquatic extractive activities such as shrimping, oystering, and trapping. Coastal erosion has threatened the economic options for many of the residents. The Louisiana State University Interdepartmental Disaster Science and Management program has been working with Grand Bayou in order to help preserve this traditional community and learn about local knowledge regarding disaster response. Additional communities that may need to be evaluated in terms of Environmental Justice include several Cajun fishing communities such as Il Caminada, that live within the vicinity of Grand Isle, and Native American groups such as the Lacombe Choctaw.

Critical Facilities

Nonstructural alternatives also include improving critical facilities in order to provide secondary flood risk reduction, especially during emergencies. Improvements may involve relocating critical facilities, raising structures in place, wet or dry flood proofing, re-facing exteriors with

brick, increasing the number of doorways or windows, transforming a ground floor to a lobby, or moving generators from the ground floor to an elevated floor. Since the nonstructural alternatives are unlikely to provide risk reduction to cultural resources in a comparable method as the structural measures, the potential impacts of nonstructural alternatives are not quantified and not factored into the cultural metrics in the MCDA. For the most part, historic buildings and historic districts form the cultural resources that have the greatest potential to be impacted by these types of building modifications.

The potential actions listed above have the potential to change the character of a structure. Prior to implementing these actions, the effects of these actions on historic properties must be evaluated as per 36 CFR 800.3(a). While some of the measures may change the character of a building, modifications and additions can also be developed in order to retain historic character. If a proposed action relating to improving a facility has the potential to cause effects to historic properties then mitigation measures will need to be employed. Depending on the effects mitigation as specified in a Memorandum of Agreement developed under 36 CFR 800.6 could involve documenting the structure with a Historic Architectural Building Survey and/or a Historic Architectural Engineering Record (HABS/HAER); using construction materials that meet both flood requirements and provide in-kind replacement; or implementing other mitigation measures.

Review

The cultural resources appendix presents an analysis of cultural resources within the LACPR planning area. The location of cultural resources, such as archeological sites, historic districts, National Historic Register Properties, and National Historic Landmarks, are examined in proximity to structural alternatives in order to determine a number of known sites protected by each alternative. This information is then incorporated into the MCDA. In addition, the impact of nonstructural alternatives are explored in order to identify affects to traditional and ethnic communities within the LACPR planning area. This exploration suggests that the no action alternative would provide the least benefit toward the protection of cultural resources. Coastal restoration measures would reduce risk to cultural resources, and a combination of coastal restoration and structural measures would provide the most benefits toward reducing risks to cultural resources.

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SEE PART 2