Coastal Restoration Terrebonne Parish

Comprehensive Plan

Office of Coastal Preservation & Restoration

May 2009

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Executive Summary

Terrebonne Parish is at the heart of coastal Louisiana. It supports thriving oil & gas and fishing industries; it has one of the strongest economies in coastal Louisiana; and it is the epicenter of land loss that threatens the sustainability of its unique communities.

Between 1956 and 2004, Terrebonne Basin lost 321 square miles of land and an additional 17 square miles of coastal land was lost in 2005 due to the effects of Hurricanes Katrina and Rita. Compounding this extreme and continuing rate of land loss, the Parish is without a functional hurricane protection system. Taken together, the economic and cultural sustainability of the region is at risk.

It is recognized that to truly resolve the problems faced by Terrebonne Parish, a large-scale strategy worth billions of dollars for the coastline would need to be implemented. At the present time, those funds are not available to the Parish. Until they are, it is possible for the Parish to make small local-scale changes through the implementation of projects in the next 5-10 years that can be funded with local sources.

This CPCR provides an inventory of all the possible projects that would help to solve the problem of coastal land loss. A rigorous planning process has allowed the separation of the projects that fit into the large-scale strategy for the Parish from those that can be completed in the immediate future. Primarily, the plan makes recommendations for the projects that will contribute to sustainable coastal restoration and could be funded through local sources.

The Parish recognizes the need to shift the dominant restoration philosophy in the region from a defensive strategy to an offensive strategy. Continuing to wall off vast expanses of coastal wetlands in the hope that it will preserve them indefinitely is no longer an option. Simply writing off aggressive action to restore ecosystem structures and functions at a scale commensurate with their ongoing loss as "too expensive" is no longer acceptable. Rather, the Parish must seek to optimize the influence of all available freshwater resources, rebuild critical landscape features which help to maintain an estuarine gradient, and lay the ground work for restoration activities beyond the scale at which they are currently practiced. This must be accomplished without isolating wetlands from sediment sources and important fishery species. This Comprehensive Plan for Coastal Restoration in Terrebonne Parish (CPCR) is a vital first step in a long process to realize the conceptual vision articulated in the State's Comprehensive Master Plan for a Sustainable Coast. It will enable the Parish to take an increased leadership role in planning and decision making for activities affecting the Parish.

This CPCR has four objectives: increase integrity of barrier island systems; increase vertical accretion of wetland soils; maximize habitat diversity of coastal wetlands; and ensure development in the Parish is consistent with this plan. A strategic planning process was developed and implemented, resulting in the analysis of over 170 strategies, concepts and projects, and development of a priority list of projects for immediate implementation.

Recommendations are also made to update this plan in the future, establish additional capacity to undertake restoration projects, fully implement non-structural flood protection programs, advocate for critical advances in science, engineering, and effective mechanisms for improved regional planning.

It is clear that increasing the sustainability of the coastal ecosystem in Terrebonne Parish is a daunting challenge. It is also clear that if the Parish wishes to ensure a sustainable future and remain at the heart of coastal Louisiana, this challenge must be met.

By taking a leadership role in future coastal restoration efforts, the Parish can maximize the chances of realizing a vibrant future for "The Good Earth."

1 Introduction and Framework

1.1 Introduction

Terrebonne Parish is located in central Louisiana and is home to one of Louisiana's strongest economies, with very low unemployment and rapid population growth, mainly supporting the oil and gas, medical and fishing industries **(Figure 1.1). The Parish also experiences the highest rate of land loss in coastal Louisiana and is currently without a functional hurricane protection system.** With this continually increasing risk experienced by the Parish's communities, the strong economy will not be sustainable unless aggressive coastal restoration action on relevant time and spatial scales is taken.

The Terrebonne Parish Consolidated Government (the Parish), through its Office of Coastal Restoration and Preservation, and acting on recommendation of its Coastal Zone Management and Restoration Advisory Committees, have therefore developed this Comprehensive Plan for Coastal Restoration (CPCR) for Terrebonne Parish.

The goal of the CPCR is to promote and facilitate preservation and sustainable restoration of the coastal ecosystem in Terrebonne Parish. The CPCR identifies coastal restoration projects throughout Terrebonne Parish, potential funding sources for these projects, and specific actions to be taken by the Parish to facilitate implementation of these projects. The scope of this plan does not include planning, engineering and design, construction, or maintenance of hurricane protection projects, although it is recognized that a sustainable landscape contributes to reducing risk of inundation from hurricanes.

A dredge discharges sediment onto Wine Island.

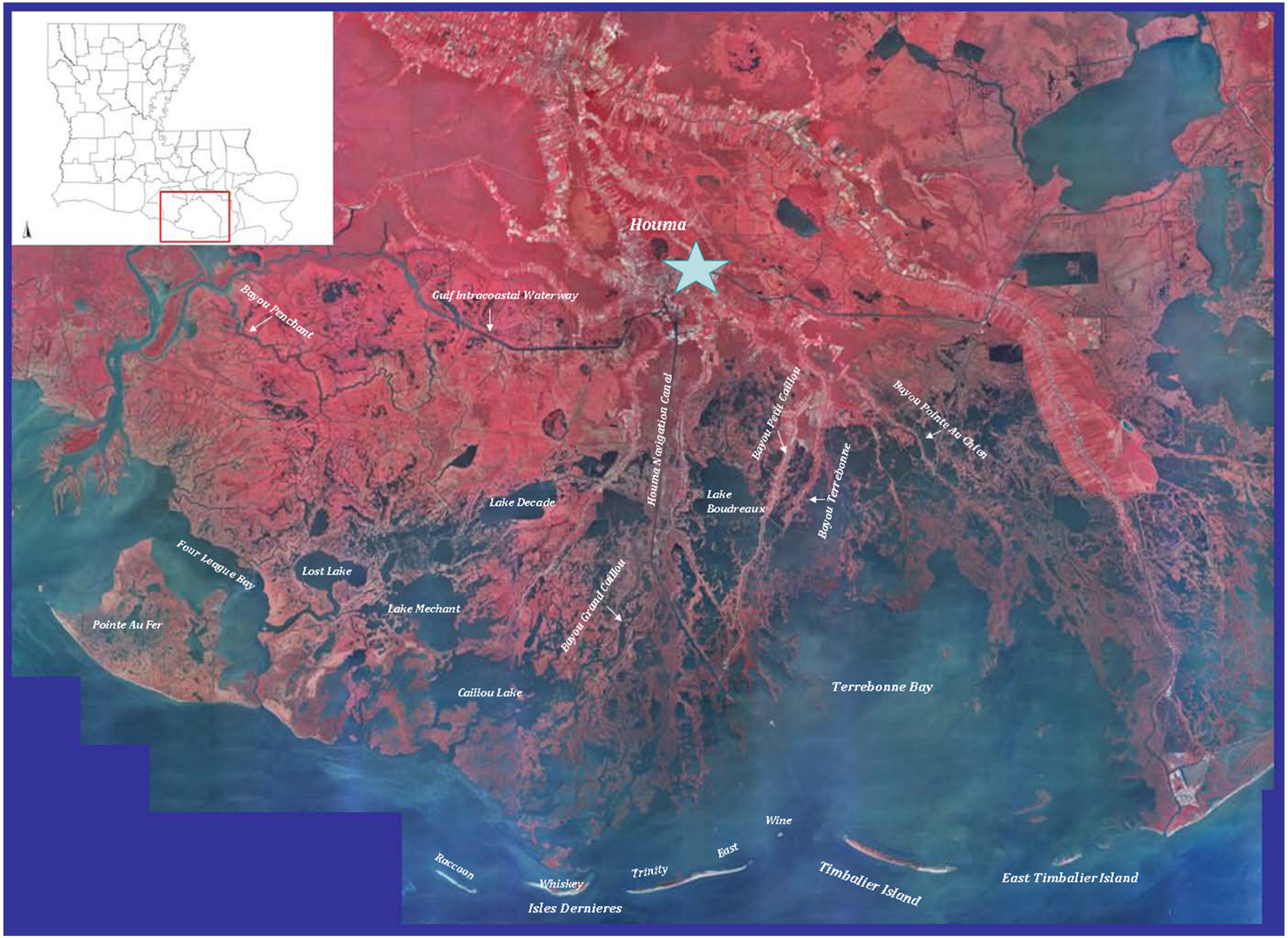
The focus of this plan is to:

- identify critical restoration projects throughout Terrebonne Parish that can be implemented within the next three to five years through the use of stakeholder engagement and additional technical assessments
- identify existing programs and potential funding sources for these projects
- prioritize restoration projects in Terrebonne Parish, including ongoing and additional projects
- identify specific programmatic actions to be taken by the Parish to facilitate implementation of these projects

The CPCR is intended to work within the framework of *Integrated Ecosystem Restoration and Hurricane Protection: Louisiana's Comprehensive Master Plan for a Sustainable Coast* **(the Master Plan).** The Master Plan is a technically sound regional strategy for ecosystem restoration, but it lacks critical implementation details at the project level. This plan builds on objectives, principles, and projects from other restoration plans (discussed in Section 1.1), provides additional technical assessments, and incorporates stakeholder views to provide state and federal staff with Terrebonne Parish's perspectives and priorities.

It should be noted that time is required for certain projects to be planned, designed, and constructed, and that benefits of the plan may not be felt immediately. This plan, however, will provide a clear route to a coastal ecosystem that is more sustainable than it is today.

Figure 1.1 Study Area



1.2 Strategic Management Planning and Terrebonne Parish

1.2.1 History of Planning in Terrebonne Parish

A summary of the history of planning along the Louisiana coastline is provided within this section, but focus is placed on events and documents pertaining to Terrebonne Parish.

- *Coastal Zone Management Act, 1972* – This act was reauthorized as the Coastal Zone Reauthorization Act of 2008 and provides a basis for regulating activities in the coastal zone that may have impacts on coastal ecosystems. It mandated that all local entities seeking to assume regulatory authority shall develop a Coastal Zone Management Plan as guidance to assess the impacts of proposed development activities. The Parish's CZM Plan was prepared and approved in 2000 (see below).

- *Coastal Wetland Planning, Protection, and Restoration Act (CWPPRA), 1990* – This federal/state partnership has allocated an average of $50-60 million per year over the history of the program to fund small to moderate coastal restoration projects throughout Louisiana. Project decisions are made on an annual basis, with little to no long-term programmatic direction. The program is currently authorized through 2019.

- *Barataria-Terrebonne National Estuary Program Comprehensive Conservation and Management Plan (CCMP), 1996* – The CCMP was developed to provide a consensus vision to guide preservation and restoration efforts throughout the estuary through 2021. It serves as a guidance document to evaluate project proposals arising within other programs, but is not funded to implement significant projects on its own.

- *Coast 2050: Toward a Sustainable Coastal Louisiana, 1998* – This landmark document was adopted by federal and state oversight authorities as the official plan for coastal restoration. Although the strategies were modified in 2001, it remains the official restoration plan of the CWPPRA program. For the first time, this document compiled and reconciled strategies from several plans to present actions that would operate at the system-level to improve ecosystem sustainability.

- *Terrebonne Parish Coastal Zone Management Plan, 2000* – This plan was prepared to allow the Parish to take a stronger leadership role in regulatory program decision making within the Parish. It defines specific goals and objectives for defined Environmental Management Units and provides a backdrop for restoration and protection project implementation.

- *Terrebonne Parish Strategic Plan for Coastal Restoration, 2004* – This plan was developed and approved by the Parish to provide clarifying policy guidance to the Parish's Coastal Zone Management Plan as it relates to coastal restoration. It also provides strategic project goals for pursuit of restoration projects and clarifies roles and responsibilities of the various Parish governmental entities to foster clear and effective working relationships for restoration and management of the Parish's coastal resources.

- *Louisiana Coastal Area, Louisiana – Ecosystem Restoration Study (LCA), 2005* – The LCA study was undertaken by the State and the US Army Corps of Engineers (USACE) to further define the vision of the Coast 2050 Plan, and it provides a detailed implementation plan for activities over a ten year period. It was authorized by the Water Resources Development Act (WRDA) of 2007, and the State and USACE are currently working to initiate the program in accordance with the legislation.

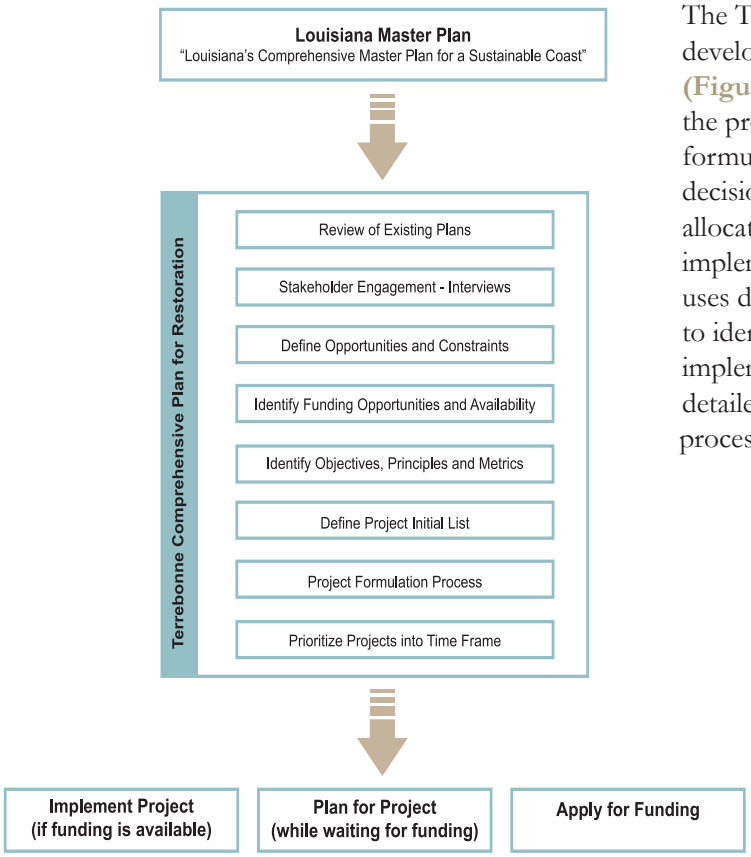
» *Coastal Impact Assistance Program (CIAP), 2005* – The CIAP was authorized in the Energy Policy Act of 2005, and provides approximately $520 million to Louisiana and its coastal parishes over four years to implement projects to mitigate for the impacts of off-shore oil and gas development activity. The required CIAP plan, including the Parish plans, was approved for implementation by the Minerals Management Service in 2007.

» *Gulf of Mexico Energy Security Act (GOMESA), 2006* – Greater sharing of outer continental shelf oil and gas revenues was approved in 2006, with revenue sharing of new leases allocated in a manner similar to that defined by the CIAP. Although revenues are expected to be relatively small in the first ten years of the program (approximately $20 million per year), they are expected to rise by at least a factor of 10 after that.

» *Integrated Ecosystem Restoration and Hurricane Protection: Louisiana's Comprehensive Master Plan for a Sustainable Coast (the Master Plan), 2007* – The Master Plan was passed unanimously by the Legislature in 2007, and provides a technically sound strategy for restoring and protecting Louisiana's coastal areas. It integrates an updated understanding of coastal restoration needs/opportunities with plans for hurricane protection. Although additional analyses are required to define the project-specific details needed to implement projects, the Master Plan is the official state restoration and protection plan, and according to Executive Order BJ 2008-7, all activities undertaken by state agencies must be consistent with this plan.

» *Louisiana Coastal Protection and Restoration Report (LaCPR)* – This report was initiated by the USACE in December 2005, and is required to present a full range of options for comprehensive hurricane risk reduction from "category 5" hurricanes. Although the scope is similar to the Master Plan, it is unclear when the final report will be completed, and what actions may be taken by the US Congress in response.

Figure 1.2 Terrebonne Strategic Planning Process



1.2.2 Strategic planning approach

The Terrebonne Parish CPCR has been developed using a strategic planning process (Figure 1.2). Strategic planning is essentially the process by which a plan or vision is formulated to solve an identified problem; decisions are then made on how to best allocate funds and resources to achieve and implement that plan. This planning process uses defined objectives, principles, and metrics to identify and assess projects and develop an implementation plan. Chapter 4 includes a detailed discussion of the strategic planning process as applied in the CPCR.

1.2.3 Application of Strategic Management Planning to Terrebonne Parish

Use of a strategic planning approach for the development of a CPCR for Terrebonne Parish is suitable for a number of reasons (adapted from Defra, 2001):

- A large-scale conceptual plan has already been identified for the area (the Master Plan).
- There is an advantage to considering problems and solutions in the longer-term and over a large geographical area.
- Implementation of the program is to be carried out over a long time scale (greater than five years).
- There are process connections and interactions between different sections of coast, and there is a hydraulic or process connection between physically separate locations within the planning area. For example, construction of an erosion control structure on a barrier island may interrupt long-shore sediment drift to adjacent coastline.
- There is a physical interconnection between benefit areas, for example, situations where loss of landscape elements hastens loss of others.
- Several smaller problems can be considered in an integrated way.
- Environmental or other implications extend outside of the immediate project area.

The use of strategic planning for the purpose of the Terrebonne Parish CPCR has a number of benefits, including:

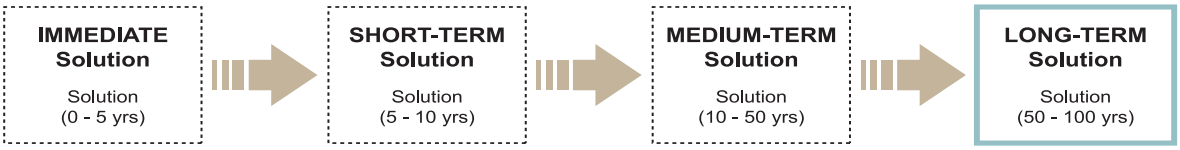
- Formally defining planning goals, objectives, and principles provides a sound basis for developing and prioritizing projects that best meet the various needs of the Parish, enables the Parish to articulate its needs to others who would act on their behalf, and provides a valuable interface to other parish planning efforts, such as for land use planning and flood and hurricane protection projects.
- Implementing a participatory planning process fosters understanding and ownership of the process, leading to support for the inevitable difficult decisions.
- Developing and utilizing an objective and transparent mechanism for making funding and regulatory decisions, including quantifiable decision metrics wherever possible, garners support from agencies and stakeholders.
- A well-developed plan will allow the parish to match prioritized project proposals to funding opportunities (LCA, CWPPRA, mitigation programs, federal grant-based programs, etc.), and to identify the most effective agency advocate for each project to be implemented within the Parish.
- Incorporation of external technical review can ensure that projects incorporate an adequate understanding of current scientific theory and technical practice, which reduces potential implementation delays.
- A fully formulated plan can assist with identifying funding gaps and sources to fill those funding gaps.
- An adaptive plan implementation process will allow the Parish to deliberately and thoughtfully modify plan implementation based on changing environmental and fiscal realities and evolving science and technology.

1.2.4 Timeframe

Key to the assessment of development of the preferred long-term plan for restoring the coastal ecosystem is the consideration of the steps that are needed to achieve the long-term solution without committing to unsustainable restoration practices or triggering unintended consequences. This approach recognizes that immediate changes to existing coastal restoration and management may not be appropriate or possible in the very short-term, as abrupt changes in program implementation may slow construction of vital projects. Instead, strategic management provides a 'route map' (i.e. the time to plan) for decision makers to move from the present situation towards the future long-term solution as shown in **Figure 1.3**. The focus of the Terrebonne CPCR is to identify solutions that can be achieved in the immediate and short-term, i.e. within the next 10 years; but also looking ahead to the medium-term and long-term.

Key to the assessment of development of the preferred long-term plan for restoring the coastal ecosystem is the consideration of the steps that are needed to achieve the long-term solution without committing to unsustainable restoration practices or triggering unintended consequences.

Figure 1.3 Coastal restoration 'Route Map'.



1.2.5 Stakeholder Engagement

This strategic approach provides an effective framework for wide consultation in relation to the key coastal restoration issues within the strategy area. Successful strategic planning is based on the balance of competing interests to best manage the demands on the coastline with respect to coastal restoration, navigation, flood control, and recreational and commercial fishing via one solution.

In completing the CPCR, it was important that the approach adopted to develop the Plan was transparent to the stakeholders and the public. To achieve transparency, initiation of the CPCR was advertised at the Terrebonne Parish Coastal Zone Management Committee meeting on 7th October 2008 and progress updates were provided at each subsequent committee meeting. Interviews were also conducted with Parish Government, state and federal resource agencies, and other key stakeholders. In engaging with stakeholders at the outset of the project, and continually throughout development of the Plan, the views and opinions of the Stakeholders were used to identify and address problems that need to be addressed by the CPCR. Details of the Stakeholder Engagement process are presented in **Appendix A**.

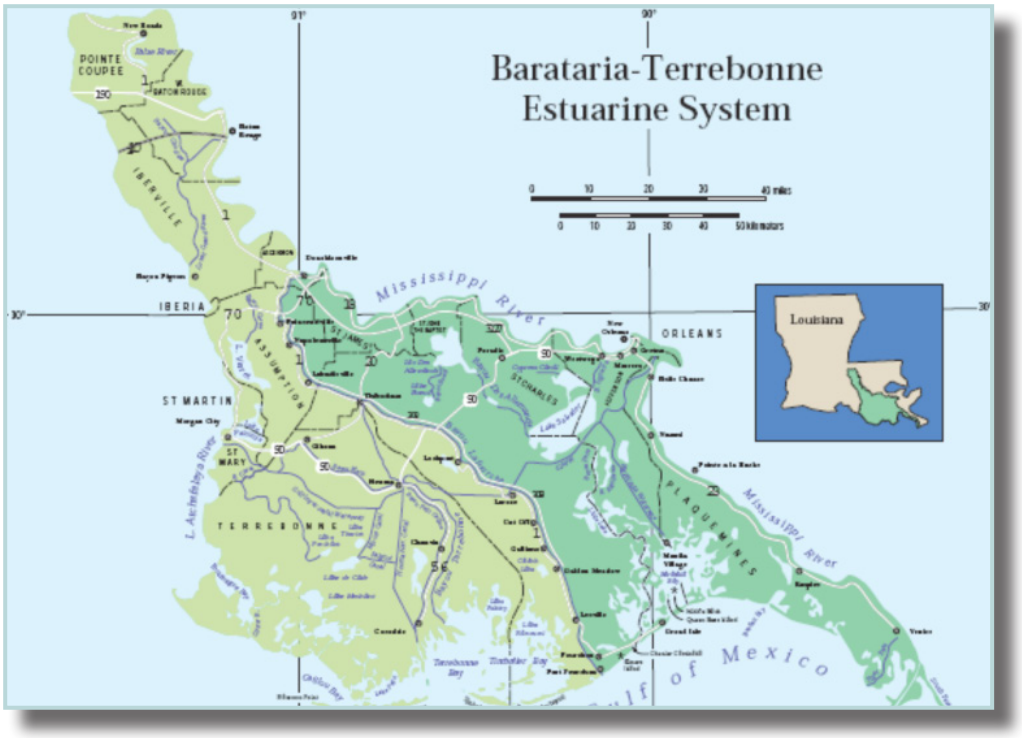
Acceptance of CPCR will require compromise from all agencies and stakeholders; it is impossible to develop a plan that meets the aims of every authority, agency, and stakeholder. Therefore opportunities were provided for stakeholder and public engagement in the process.

2 Environmental Setting

The Terrebonne Basin covers approximately 1,712,500 acres in south central Louisiana (LCWRCTF, 1993). Terrebonne Parish is located within the Terrebonne Basin, which itself is located within the larger Barataria-Terrebonne Estuarine System and includes parts of St. Mary, Lafourche, Ascension, Assumption, and Iberville parishes **(Figure 2.1)**. The extreme north portion of the basin is primarily agriculture lands, which continue south along its eastern edge within the flood plains of the Mississippi River and Bayou Lafourche. The western half of the basin consists of bottomland hardwood forests and cypress-tupelo and black gum swamps. The coastal zone transitions from fresh and intermediate marsh inland to brackish and salt marsh near the bays and gulf (LCA, 2005). This Chapter includes:

- An overview of the existing conditions, including a description of the geology, geomorphology and environmental characteristics of Terrebonne Basin
- A description of what could happen to Terrebonne Basin in the event that no further attempts are made to restore the coastal wetlands and barrier islands
- Constraints to achieving a comprehensive restoration plan for coastal restoration

Figure 2.1



Terrebonne Parish is in the Barataria-Terrebonne Estuary (Modified from Barataria-Terrebonne National Estuary Program, 1995)

2.1 Existing Conditions

The Terrebonne Basin is bordered by Bayou Lafourche on the east, the Atchafalaya Basin floodway on the west, the Gulf of Mexico on the south, and the Mississippi River to the north (LCA, 2005). The basin includes all of Terrebonne Parish as well as parts of Lafourche, Assumption, St. Martin, St. Mary, Iberville, and Ascension parishes. The Terrebonne Basin is sub-divided into four sub-basins: Timbalier, Penchant, Verret, and Fields. This plan focuses on the coastal ecosystem of the basin, generally south of the Gulf Intracoastal Waterway (GIWW).

2.1.1 Sub-basin Description

LCA (2005) describes the Terrebonne Basin as:

> *"The Terrebonne Basin is an abandoned delta complex, characterized by a thick section of unconsolidated sediments that are undergoing dewatering and compaction, contributing to high subsidence, and a network of old distributary ridges extending southward from Houma. The southern end of the basin is defined by a series of narrow, low-lying barrier islands (the Isles Dernieres and Timbalier chains) separated from the mainland marshes by a series of wide, shallow lakes and bays (e.g., Lake Pelto, Terrebonne Bay, Timbalier Bay)".*

The **Verret Sub-basin** is located north of Bayous Beouf and Black and west of Bayous Terrebonne and Lafourche. It contains forested wetlands and lakes and receives fresh water from the Atchafalaya River and Bay.

The **Penchant Sub-basin** is located south of Bayous Beouf and Black, east of the Atchafalaya River and Atchafalaya Bay, west of Bayou Dularge, and includes Pointe Au Fer Island. Major habitats of this sub-basin include large areas of highly organic fresh floating marsh and mineral brackish marsh. Fresh water from the Atchafalaya River flows into this system from the Atchafalaya River, Atchafalaya Bay, and the GIWW through a number of bayous and canals.

> *"In recent years, the Penchant and Verret Sub-basins have experienced significant freshwater impacts from the Atchafalaya River. Historic wetlands loss resulting from subsidence, saltwater intrusion, and oil and gas activity appears to have moderated, but areas of cypress swamp (Verret) and flotant marsh (Penchant) are experiencing stress from high water levels in the Penchant Subbasin, the use of freshwater and sediment resources is not being maximized" (LCA, 2005).*

The **Fields Sub-basin** is located north and east of Bayou Terrebonne and north of Bayou Blue. It consists primarily of fresh marshes. This sub-basin receives fresh water through rainfall events.

The **Timbalier Sub-basin** is located south of Bayous Terrebonne and Blue, east of Bayou Dularge and west of Bayou Lafourche. Timbalier's major habitat types range from organic fresh marsh through saline marsh. This sub-basin also includes barrier islands. The Timbalier Sub-basin receives fresh water from rainfall events as well as from Atchafalaya River inflow to the GIWW by way of the Houma Navigation Canal (HNC) and Grand Bayou Canal.

2.1.2 Basin Habitat Distribution

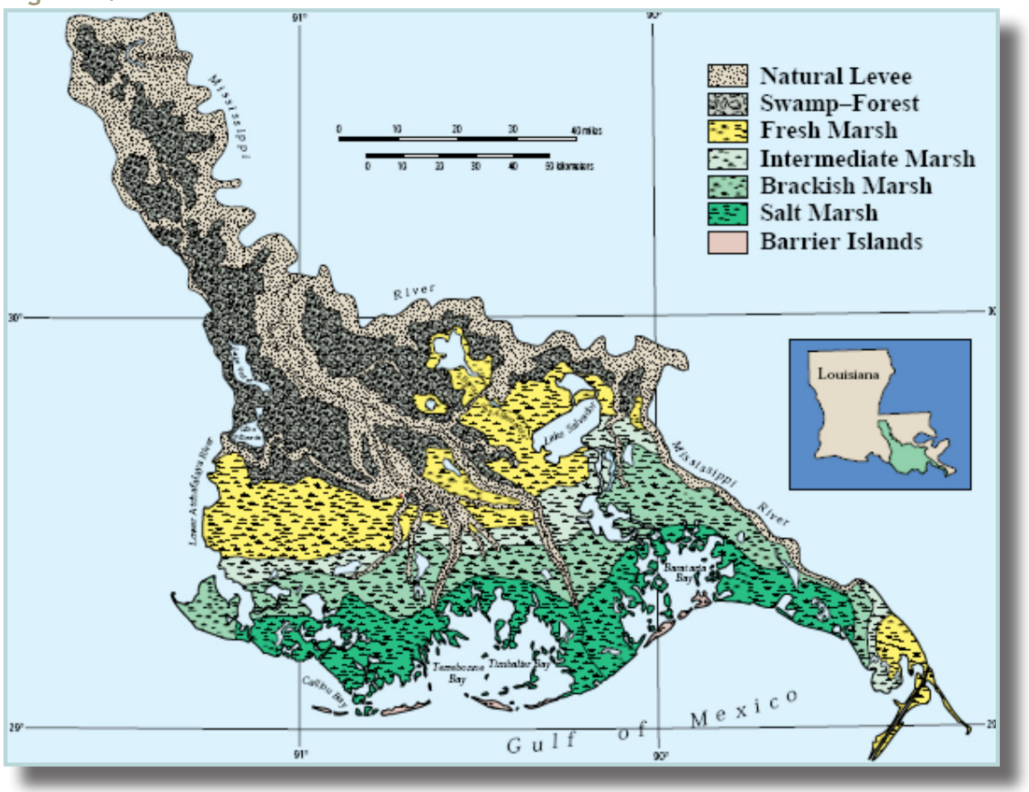
The habitat distribution in Terrebonne Basin (adapted from LCA, 2005) is shown in **Table 2.1 below**. Habitat distribution within the Barataria-Terrebonne Estuarine System is shown in **Figure 2.2**.

Table 2.1

Sub-basin	Acreage of Swamp	Type of Swamp located in Sub-basin	Acreage of Marsh	Type of Marsh Located within Sub-basin
Verret	118,000	Cypress		
Penchant			166,000	Fresh with predominance of flotant marshes & brackish marsh
			98,000	Intermediate & brackish
			17,000	Saline
Fields			23,000	Fresh
Timbalier			71,000	Brackish
			153,000	Saline

The Terrebonne Basin supports about 155,000 acres of swamp and almost 574,000 acres of marsh, grading from fresh marsh inland to brackish and saline marsh near the bays and the gulf (LCA. 2005).

Figure 2.2



Physical environments of the Barataria-Terrebonne estuaries (modified from Barataria-Terrebonne National Estuary Program 1995).

2.1.3 Basin Habitat Condition

The **Timbalier Sub-basin** loses more acreage of wetlands per year than any other sub-basin within Terrebonne Basin due to its isolation from freshwater and sediment input and its substantial rate of subsidence. Natural deterioration of barrier islands contributes to the increased influence of marine tidal processes (including erosion, scour, and saltwater intrusion). For barrier island shorelines, complex interactions between storm events, long shore sediment supply, coastal structures, and inlet dynamics contribute to erosion and migration of islands and beaches (LCA, 2005).

Breaching and overwash deposits on Whiskey Island after Hurricane Lili

The **Penchant Sub-basin** suffers from salt water intrusion and subsidence on its eastern reaches. These problems are aggravated by landscape modifications such as the (HNC, GIWW, and oil and gas activities which have caused substantial hydrologic changes to the basin. Impediments to natural distribution and retention of sediments and freshwater have caused significant problems and severely reduced freshwater movement to these western Terrebonne wetlands. In addition, the increasing influence of the Atchafalaya River has introduced higher velocity turbid water to fresh marshes having extremely fragile organic soils, including flotant marshes, in the western reaches of this sub-basin. Over geologic time, this initiation of delta-building processes would likely result in significant land gains, but in the near term, these changes are felt as "impacts" to a fragile coastal ecosystem.

Losses in the **Verret Sub-basin** are minor in comparison to Penchant, Fields, and Timbalier Sub-basins. The cypress swamps of the Verret Sub-basin have been affected negatively by the high water levels found in the Penchant Sub-basin due to significant backwater flooding from the Atchafalaya River.

Within the **Fields Sub-basin**, losses are primarily the result of land use changes and hydrologic isolation from sources of freshwater, nutrients, and sediments. Past rates of marsh loss have been fairly steady, but are small in comparison to Timbalier and Penchant Sub-basins. Adverse impacts on remaining wetlands appear to be minor and relate to matters such as impoundments and shoreline erosion.

2.2 Mississippi River Deltaic Functions and Implications

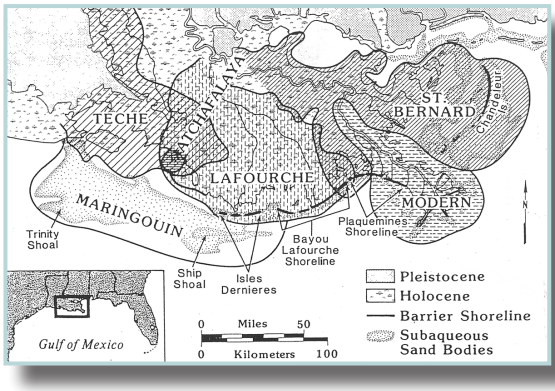
2.2.1 Delta Cycle

Terrebonne Basin is characterized by the influence of degrading (eastern Terrebonne Basin) and prograding (western Terrebonne Basin) delta cycles. Over 7,000 years, the Mississippi River has built a deltaic platform comprising numerous individual delta lobes and groups of related lobes known as delta complexes (Russell, 1936; Fisk, 1944; Kolb and Van Lopik, 1958, Coleman, 1988). The Atchafalaya delta complex became an emergent feature after the 1973 flood (van Heerden and Roberts, 1988). Fisk (1952) predicted a natural relocation of the main Mississippi River distributary to the present Atchafalaya River course due to its shorter path to the Gulf of Mexico. To avoid this natural relocation, a series of control structures have been built north of Baton Rouge at the confluence of the Red, Atchafalaya, Old, and Mississippi rivers to maintain the flow conditions of Mississippi River in its present condition.

Figure 2.3 shows the distribution of delta lobes and complexes. The eastern part of the Terrebonne Basin is part of the abandoned Lafourche complex and is in the transgressive phase of the delta cycle. Marine forces are becoming predominant over riverine processes, indicating that regular sediment introduction from riverine sources has been reduced leading to an inability to accrete marsh soils at a pace to compensate for the effects of subsidence and sea-level rise. The resulting geomorphology exhibits sandy barrier shorelines backed by expanding bays and lagoons (Penland et al., 1981). Figure 2.4 depicts various forces at play during delta cycle and stressing processes and responses as described by Roberts (1997).

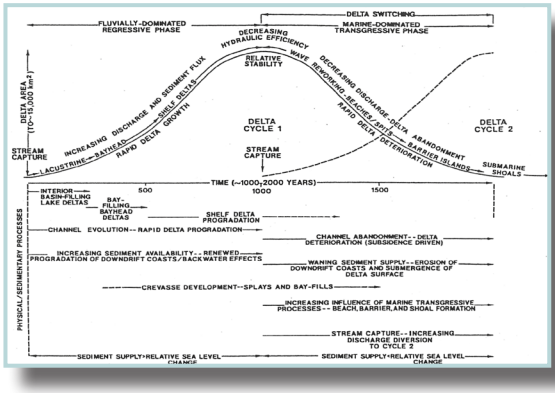
The overlapping active (Atchafalaya, approximately 20% of the entire delta plain (Penland et al., 1990)) and abandoned (Lafourche) delta lobes present opportunities as well as constraints for the Terrebonne Basin. While Atchafalaya River sediments, nutrients, and freshwater are the most important commodity for the majority of the eastern Terrebonne Parish marshes, flotant marshes and other highly organic marsh soils are vulnerable to loss due to nutrient rich water and increased riverine and tidal energy. In addition, backwater flooding due to the Atchafalaya River's influence is a significant issue in the western part of Terrebonne Basin, as it may cause prolonged inundation and stress in vegetated ecosystems if water levels are artificially held too high for too long. Therefore, achieving sustainability in the region in the long term may require either acceptance of short-term negative effects or advance planning to take advantage of opportunities arising from sudden changes in ecosystem states.

Figure 2.3



Frazier's (1967) model of the Mississippi River delta plain depicting the location of the transgressive barrier shorelines and shoals.

Figure 2.4



Timing of various process-response relationships exhibited at a given location throughout the "delta cycle" (Roberts, 1997).

2.2.2 Barrier Shoreline Evolution

Terrebonne Basin contains barrier shorelines representing different stages of the delta cycle. According to Penland et al. (1988), as the Lafourche delta lobe was abandoned, marine processes began to dominate the Terrebonne Basin resulting in coastal land loss. Relict channel sand deposits have been reworked by wave energy, supplying coarse sediments to the nearshore areas resulting in formation of an erosional headland with flanking barrier spits (Stage 1; Figure 2.5). The Timbalier Islands to the west of Bayou Lafourche headland and Grand Isle to the east represent a Stage 1 barrier system (Penland et al., 1990).

Whiskey Island after restoration

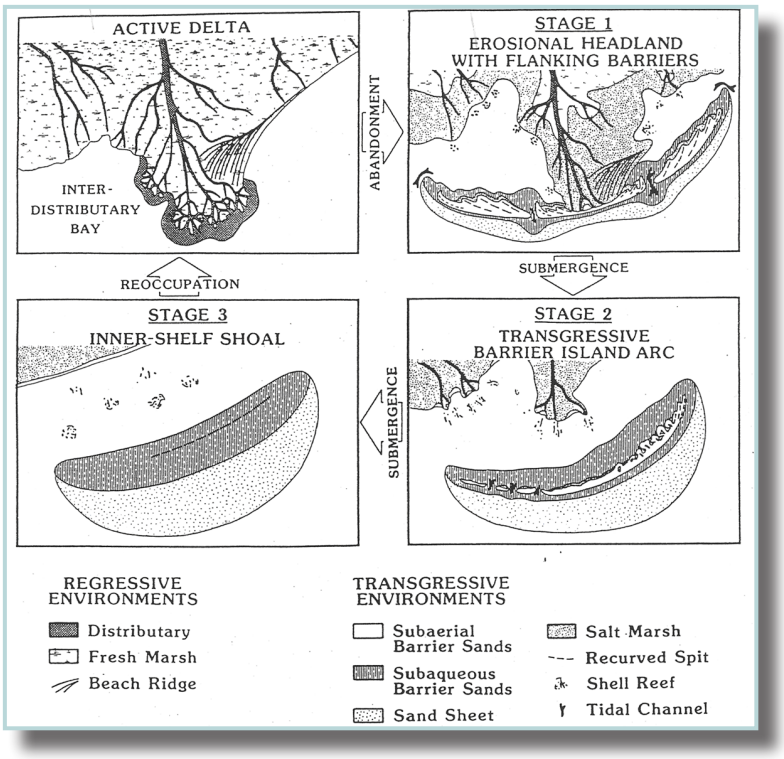
Average erosion rates on the central headland of the Bayou Lafourche delta lobe are 65.5 feet annually, reaching over 164 feet in hurricane years (Ritchie and Penland, 1988). Stage 2 is characterized by marine water intrusion as a result of increased subsidence into the back barrier marshes. The resulting lagoons separate barrier islands from the mainland marshes forming barrier island arcs. The best example for Stage 2 in Terrebonne Basin is the Isle Dernieres Islands. With continued subsidence, coarser grained mouth bar and channel deposits are depleted for the sustenance of Stage 2. At this stage, waves and storms continue to rework barrier island sediments and the degradation of the islands continues. The emergent island area decreases as sands are lost to an inner shelf sand sheet by overwash, extension of sub-aqueous sand spits, or captured in tidal inlet sinks. Ultimately, the barrier system loses its emergent integrity and forms an inner shelf shoal (Penland et al., 1989).

Louisiana's barrier island system, in general, and Terrebonne Basin's barrier island system in particular, protects the marshes and bays from offshore wave conditions and may help maintain estuarine salinity gradients. They provide important habitat for endangered and/or migratory species. The disappearance of barrier islands may hasten the deterioration of the large estuarine bay systems.

USGS and LSU studies (USGS Fact Sheet, 1995; List et al., 1997) on morphometry of Louisiana barrier islands and long-term erosion rates reveal that the principle cause of barrier island erosion is both long-shore movement of sediment and the general absence of sand-sized sediments. This may be exacerbated by relative sea level rise, as the relict channel sand deposits critical to sustaining barrier island systems are effectively removed from the system when wave action is unable to introduce them into the littoral system. The available sediment resources are dominated by silts and clays introduced by river outfalls or re-suspended during storm events; these sediments are not suitable to build beaches, dunes, and spits, which are the geomorphic features associated with healthy barrier islands. In addition, long shore currents redistribute available sands from headland areas to embayments depriving the sand needed for sustaining barrier islands.

Experience also suggests that utilization of hard and fixed structures is a less effective strategy for preserving barrier islands, especially when dealing with high rates of shoreline and bathymetric changes. These structures may over very short time scales reduce erosion rates in a particular project area, but as they introduce no additional sand resources, subsidence and severe storms will eventually result in loss of the islands if not carefully designed and sited.

Figure 2.5



Barrier Island Model (Penland et al., 1988)

2.3 Coastal Land loss

If unchecked, the estuarine water bodies will ultimately be converted to less productive open Gulf of Mexico conditions.

Barras (2006) estimates that approximately 340 square miles of land has been lost in Terrebonne Basin between 1956 and 2005, including the effects of Hurricanes Katrina and Rita. Terrebonne Basin continues to lose land at the staggering rate of approximately 10 square miles per year. According to Penland et al., (1990), coastal changes are a set of processes driving the conversion of one geomorphic habitat type into another. Terrebonne Basin is a typical example of this definition and is characterised by the conversion of vegetated wetlands and barrier islands to an estuarine water body. If unchecked, the estuarine water bodies will ultimately be converted to less productive open Gulf of Mexico conditions. Coastal land loss in Terrebonne Basin is also caused by:

- coastal erosion/retreat of the shorelines along the exposed coasts of large lakes, bays, and the Gulf of Mexico
- the development of ponds and lakes within interior wetlands and the expansion of large coastal bays behind the barrier islands and mainland shoreline
- the conversion of vulnerable habitats such as floating marsh and other highly organic marsh soils to open water, due to increased flow of nutrient rich water and increased riverine energy from the Atchafalaya River and/or tidal influence

Several causal factors of this loss are discussed in the following pages.

2.3.1 Sea Level Rise and the Louisiana Coastline

Scientific observations and stratigraphic relationships suggest that whenever relative sea level rise rate exceeds 2 cm/yr (0.78 inches/yr) for several centuries, the delta cycle growth of the Mississippi River stops and wetlands, estuarine bays, and barrier islands disappear (Penland et al., 1991). The implication of this observation in the light of future sea level rise scenarios is very significant while considering restoration of coastal landscape. Eustatic sea level is currently expected to rise approximately 1-3 cm/yr (0.39-1.18 inches/yr) by the year 2100, and is compounded with the current subsidence rate of approximately 0.5 cm/yr to 1 cm/yr (0.197 inches/yr to 0.39 inches/yr); acceleration in land loss is expected to occur. Restoration approaches must recognize this sediment/soil accretion deficit if project objectives are to be achieved and result in a sustainable ecosystem in the long term.

Overwash and breaching of East Timbalier Island, showing limited effectiveness of the breakwater during extreme storm events.

2.3.2 Tidal Prism and Coastal Sustainability

Another aspect of coastal processes to consider is the tidal prism/tidal inlet relationship, which affects the form of barrier islands and tidal inlet sediment dispersal (Penland et al., 1988). Tidal prism is the total volume of water exchanged through a tidal pass in a tidal cycle, and is proportional to the area of open water on the flood tide side of an inlet. It is generally observed that increasing tidal prism leads to larger tidal passes either in a barrier island or inland tidal basins.

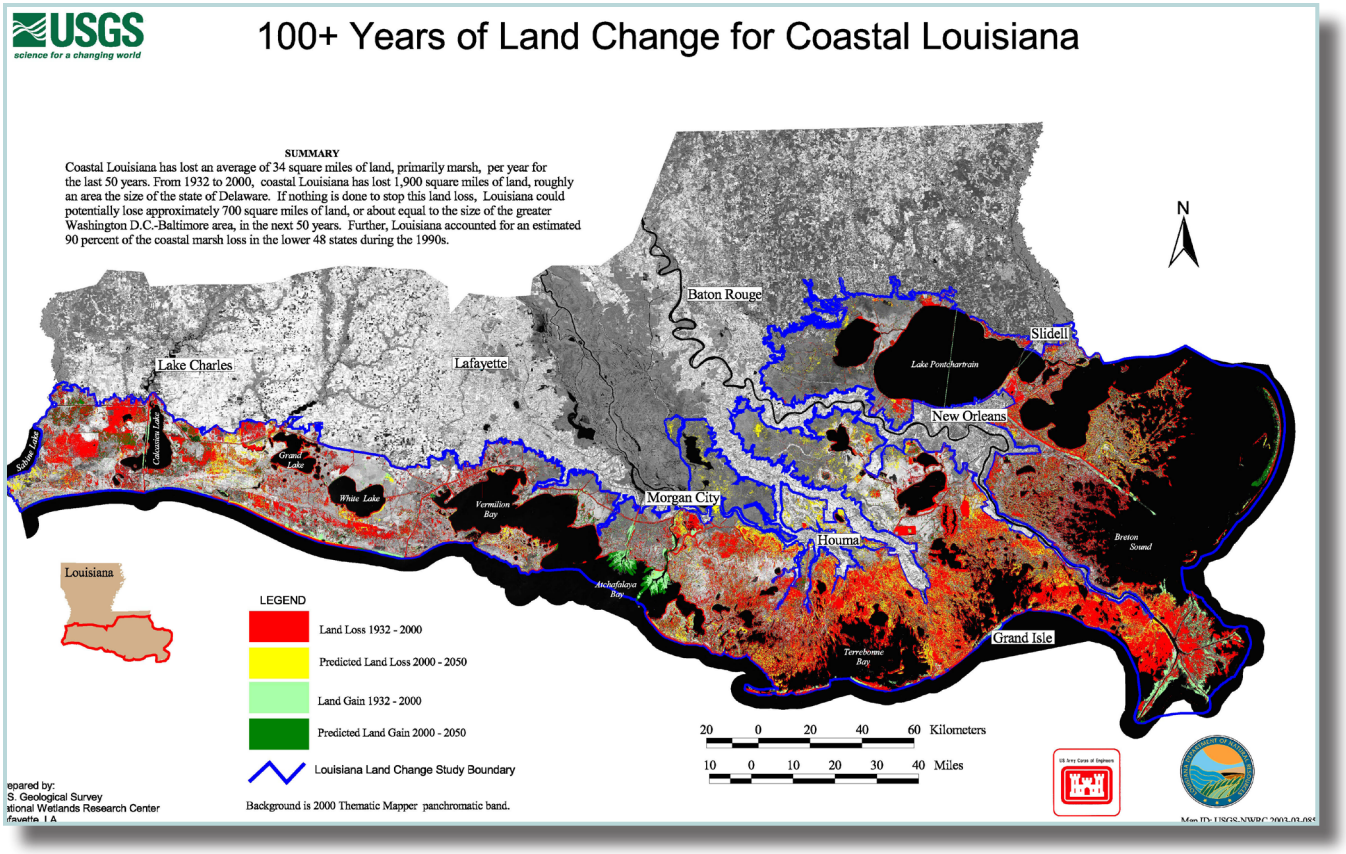
A long-term increase in tidal prism brought about by rapid land loss may eventually result in more sand in the barrier island system being present in ebb or flood tidal shoals, hastening the transition from an emergent island feature to a submerged shoal. It is important to note that simply narrowing tidal passes between barrier islands will likely result in deepening of the tidal pass or breaching of the island in nearby low or narrow locations. Control of tidal passes must therefore be carefully planned and designed as part of a comprehensive barrier island restoration effort.

2.3.3 Dynamic versus Static Salinity Regime

A resilient estuarine ecosystem is characterized by a dynamic physical environment that supports diverse fish and wildlife populations. This dynamic physical system is characterized by fluctuating salinity and water levels throughout the system, which enables the introduction of nutrients and mineral soils to a large portion of the total estuary, as well as access to vital wetland habitats for various commercially and recreationally important animal species. A healthy estuarine system should have a gradual change in gradient from freshwater ecosystems at the head of coastal basins to saline ecosystems in the Gulf of Mexico (Reed and Wilson, 2004). The challenge is to ensure this dynamic balance between the salt water and fresh water to provide habitats characterized by a variety of salinities and substrate types. There have been efforts to maintain freshwater wetland systems in the face of saltwater intrusion, promoting a static water level and salinity regime; as a result, wetlands in these project areas typically have more fragile organic soils, are less productive from a fisheries standpoint, and are less sustainable over the long-term. The inevitable saltwater pulses of hurricanes are more damaging to freshwater wetland areas with organic soils, especially those isolated areas where rapid drainage of the salty storm surge and flushing from rainfall or river inputs is not possible.

2.3.4 Vertical Accretion and Land loss

During the natural cycle of land building and land loss, marshes have built vertically to counteract deltaic subsidence either through riverine inputs of sediments or via the delivery of reworked coastal sediments during storms (Reed, 1995). The combined rate of increased subsidence and interruption of natural processes have resulted in the deficiency of the required sediment input into the system. For ecosystem sustainability, vertical accretion of soils via multiple means should be achieved. The natural system in Terrebonne Basin should be revitalized by re-plumping the hydrology to maximize the influence of the Atchafalaya River and introducing more sediment by mechanical means.



2.3.5 Sediment Composition and Restoration

Wetland soils in coastal Louisiana vary widely in terms of the ratio of mineral, organic, and water components; these differences have a profound effect on the ability of wetland soils to be resilient under dynamic estuarine conditions. For example, fresh marsh soils range from highly mineral soils present in actively accreting delta areas such as the Atchafalaya River Delta to highly organic soils present in flotant marsh systems, such as in northern Terrebonne marshes. Mineral content of soils is a critical factor for Louisiana's wetlands, as soils with higher mineral content are generally more resistant to erosion from wave energy. In addition, the presence of higher concentrations of mineral sediments provides some protection for wetland plants from sulphide toxicity which may occur after saltwater intrusion events. In general, then, marshes with highly organic soils are more susceptible to loss from a number of stressors from increased wave, tidal, or current energy to rapid oxidation due to increases in pore water nutrient and sulphate concentrations. Adoption of restoration techniques should consider this important aspect while developing ecosystem sustainability practices.

2.4 Scientific and Technical Challenges/ Opportunities and Constraints

Volunteers work to plant wetland vegetation at a restoration project site

Planning restoration activities for Terrebonne Parish is challenging. The Parish area is quite large and many regions are far removed from the Mississippi and Atchafalaya Rivers. Utilizing the river resources such as water, nutrients, and sediments to initiate new land building is perceived to be infeasible for Terrebonne Parish due to very high costs and greater impacts on both human and natural systems. A variety of poorly understood mechanisms contributes to continual land loss in the basin including basin tectonics, sediment loading, subsidence, fluvial processes, changes in sediment deposition pathways, and changes in sea level. Several other constraints discussed below will need to be considered as the CPCR is formulated and implemented.

2.4.1 Development versus Restoration

A great deal of infrastructure is required to support the current level of economic activity in coastal Louisiana, especially for Terrebonne Basin. The activities to develop and sustain infrastructure within the Basin have resulted in changes to the hydrology and ecological processes within this area. In addition, residential development adjacent to or in wetlands south of the GIWW may increase the cost and technical complexity of coastal restoration projects. The challenge is to strike a balance between both development and restoration priorities.

The challenge is to strike a balance between both development and restoration priorities.

Flooding has always been a part of life in South Louisiana and throughout the Gulf Coast, whether caused by rivers, by intense rainfall events, or by a combination of storm surge and rainfall associated with hurricane events. The 2007 Consensus Intergovernmental Panel on Climate Change (IPCC) report concluded that there is a greater than 60% chance that the current century will experience an increased number of severe hurricanes thus leading to increased flood events for the Gulf Coast.

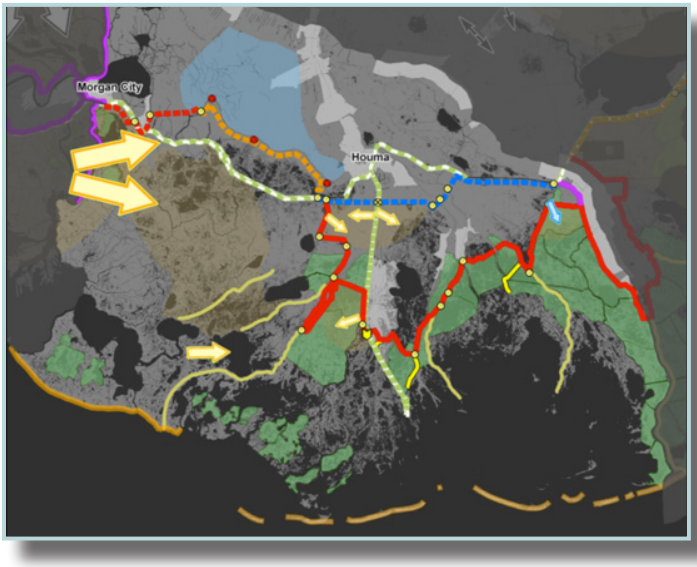
Construction of new hurricane protection systems can introduce additional challenges to sustainability of coastal wetlands if not properly designed and implemented. These projects by nature limit the areas where storm surge may inundate; it has been shown, however, that introduction of sediments to wetlands by resuspending bay-bottom sediments and flooding this turbulent water over marsh surfaces is a critical source of sediment, enabling some wetlands to accrete and maintain their elevation relative to the water's surface. Construction and operation of hurricane protection systems to allow for continued tidal fluctuations in all but the most extreme situations in coastal wetlands is necessary to minimize impacts.

According to Twilley et al., (2008), "*An integrated approach of structural and non-structural measures will be needed to provide comprehensive risk reduction for the area (Terrebonne Parish).*" Non-structural measures for hurricane risk reduction include raising existing structures and building new structures above expected flood heights. In addition, restoration of coastal wetlands may be vital to reducing wave energy attacking levees or providing storage for flood water inside any hurricane protection system. To fully realize the benefits of these "ecosystem services" wetlands provide, to provide for increased non-structural hurricane protection, and to facilitate vital restoration efforts, it may be necessary to limit further development in strategic wetland areas.

Morganza, Louisiana to the Gulf of Mexico Hurricane Protection Project (Morganza to the Gulf)

Morganza to the Gulf is an integral part of the Hurricane and Storm Damage Risk Reduction System (HSDRRS). Approved by Congress as part of the 2007 Water Resources Development Act, this project is expected to reduce hurricane flood damages in an environmentally sustainable manner. The project will protect over 120,000 people and 1,700 square miles of marsh and farmlands, as well as industrial and residential areas (USACE, Project Fact Sheet). The project consists of:

- 72 miles of earthen levee
- Ten 56-foot-wide navigable flood gates
- Three 125-foot-wide navigable flood gates
- 13 multi-barrel tidal exchange structures
- A lock complex in the Houma Navigation Canal consisting of a 110 ft x 800 ft lock and an adjoining navigable flood gate measuring 250 ft wide



This map articulates the State's Master Plan vision for integrating restoration and protection in the Parish.

These structural features are integrated into the levee alignment to provide flood protection, drainage, environmental benefits, and navigation (USACE, Project Fact Sheet). As of 2007, this project was estimated to cost approximately $912 million and would be cost shared 65% Federal/35% Terrebonne Levee and Conservation District. The current cost estimate for project completion has increased substantially.

Morganza to the Gulf presents a unique challenge: integration of flood protection and coastal restoration. This levee, if improperly designed, may hinder natural wetland processes. However, structures integrated into the levee alignment, such as environmental structures to re-establish or maintain tidal exchange structures, help to maintain or enhance ecosystem sustainability. Siting the levee alignment along natural ridges, roadbeds, or existing drainage levees, effectively following existing hydrologic barriers, minimizes additional disruptions to wetland hydrology and helps to achieve integration of protection and restoration. Post Katrina design modifications have been incorporated, and adaptive implementation and management may require additional modifications during the construction phase of this project to ensure that the project achieves is flood risk reduction objectives and maximizes the project's environmental benefits.

Since the USACE is currently reanalyzing the project, it is difficult to make firm recommendations on certain restoration activities. Increased levee footprints, future decisions on mitigation actions, and redesign of environmental structures will all affect the future of restoration in the Parish. Decisions on certain marsh creation and freshwater diversion projects, therefore, have been deferred in the CPCR until such time as these issues are resolved.

Oil well blowout in Timbalier Bay. Continued land loss will result in increased risk to oil and gas infrastructure.

2.4.2 Subsidence and Sea Level Rise

The total change in land surface elevation in relation to sea level is termed relative sea level rise (RSLR) and incorporates the changes related to subsidence of the land, vertical accretion of wetland soils, and changes in global sea level. Terrebonne Basin wetlands are subject to high levels of RSLR, which has led to accretion deficits and contributed to land loss in the basin.

Recent research has indicated that subsidence rates may be variable in time due to human activities. The production of large volumes of oil and gas from subsurface reservoirs has been shown to increase subsidence of the land surface due to depressurization of the reservoir. Recent studies in South Louisiana have also documented the presence of many previously unrecognized surface fault zones. Production of oil and gas may initiate or increase movement in these fault zones, accelerating subsidence and loss of interior wetlands.

The Intergovernmental Panel on Climate Changes (IPCC) projects an increase in global mean sea level of up to 26 inches by 2100, representing an increase of up to three times the historic rate of sea level rise. Global sea level rise has historically contributed to approximately 10% of observed RSLR in coastal Louisiana, and such a dramatic rate increase further challenges our ability to ensure wetland soil accretes at an adequate pace to prevent land loss.

2.4.3 Use of Erosion Control Structures on Barrier Islands

Barrier islands separate the Gulf of Mexico from more inland habitats, helping to establish salinity gradients, providing habitat for migratory and threatened and endangered species, and reducing wave energy in lakes and bays within the estuary. Hard erosion control projects (breakwaters, jetties, etc, collectively referred to as "rocks for the shoreline") have been implemented in coastal Louisiana with mixed results. In areas such as Raccoon Island in Terrebonne Basin, segmented breakwaters appear to have been effective in trapping sand and stabilizing the eastern end of the island. On the other hand, it is likely that construction of the Belle Pass jetties on the Caminada Headland has accelerated the loss of East Timbalier Island due to interruption of long shore transport and nourishment of the island. Clearly, erosion management operations may result in undesirable impacts on the ecology and geomorphology of barrier islands.

Decisions on the most appropriate management approach should be driven in part by the desire to optimize impacts so as to preserve the natural characteristics of the islands. Successful functioning of the barrier island as a natural system is largely based on the movements of sediments from one point to another. Any development, including structural approaches to barrier island restoration, upsets this balance and contributes to erosion on other parts of the coast resulting in a new set of management problems that must be resolved. Restoration efforts of barrier islands have to reflect this dynamic nature, while protecting those areas considered of the utmost importance. Therefore, while considering optimum restoration efforts for barrier islands, utilization of hard structures for protecting barrier islands are to be considered with much caution. Throughout the United States, there are a number of coastal states that have now imposed significant restrictions on the building of hardened erosion control structures, thereby allowing natural process to occur.

2.4.4 Ability to acquire land rights

Approximately 85% of the land in coastal Louisiana is owned by private landowners. Restoration efforts on these lands sometimes create problems in terms of land rights. As detailed in the Master Plan, the State is considering a comprehensive array of methods to ensure that surface land rights for design and construction of coastal restoration projects may be obtained in a timely manner. Terrebonne Parish must be ready to assist the State in obtaining these land rights.

2.4.5 Lack of dedicated funding sources

Identifying and securing funding to implement projects is a constraint to project initiation in all areas of coastal Louisiana—there is simply not enough funding available to meet all restoration needs in a timely manner. Terrebonne Parish has been very fortunate with their efforts to secure significant funding for restoration projects in the past, and other areas of the coast are now being seen as more co-equal in importance. With the funding required for Morganza to the Gulf, this creates a challenge when trying to seek out further funding for restoration projects. In addition, many funding decisions for Federal Programs are largely out of the Parish's control; although the Parish actively participates in the process, Federal and State agencies make the actual funding decisions. In doing so, restoration needs of the parish are weighed against restoration needs elsewhere on the coast. A funding source under the control of Terrebonne Parish, such as that provided by the Gulf of Mexico Energy Security Act or Coastal Impact Assistance Program, is vital to ensuring that the Parish can move forward expeditiously on their priorities.

Clearly, erosion management operations may result in undesirable impacts on the ecology and geomorphology of barrier islands.

3 Funding Opportunities and Availability of Funding

There are a number of sources of funds that are made available for the purpose of coastal restoration projects, including but not limited to:

- The State Coastal Protection and Restoration Fund
- State capital outlay funds
- Coastal Wetland Planning, Protection, and Restoration Act (CWPPRA)
- Federal appropriations through the Water Resources Development Act (WRDA) process
- North American Wetlands Conservation Act
- Coastal Impact Assistance Program
- Gulf of Mexico Energy Security Act
- Community-Based Restoration Program

3.1 The State Coastal Protection and Restoration Fund (Fund)

The Fund can be used for state-only work and to match federal and parish efforts. There are four major deposits that contribute to the Fund (State of Louisiana, 2007):

- Recurring Deposits – a dedication of a percentage of the State's mineral revenues. The value is dependent on the price of oil and gas, but is generally $25 million per year.
- Non-Recurring Deposits – monies received from mineral settlements or judgements deposited into the Mineral Revenue Audit and Settlement Fund; and non-recurring state revenues following legislative authorization.
- Coastal Impact Assistance Program – monies received by the federal government from revenue raised from offshore mineral extraction is put into the CIAP program. CIAP funds are administered by the federal Minerals Management Service (MMS), and distributed among the Outer Continental Shelf (OCS) producing states and their coastal political subdivisions (i.e. counties and parishes). In the state of Louisiana, the state's portion of CIAP funds is administered by the Department of Natural Resources (DNR), and the coastal parishes their portion. Both the state and its subdivisions need to apply for CIAP funding via non-competitive grants over a period of 1-4 years.
- Gulf of Mexico Energy Security Act (GOMESA) – 37.5% of revenues derived from the sale of oil and gas is given directly to the state, of which 20% is then divided amongst the Parishes. Presently, the state is due to receive approximately $16,000,000 per year for the next 10 years. In the case of Louisiana, the choice has been made to dedicate this funding to the Fund.

3.2 State Capital Outlay Funds

Annual requests for State Capital Outlay funds are made through the annual appropriations process to secure state monies for planning, engineering & design, and construction of coastal restoration projects (State of Louisiana, 2007).

3.3 Coastal Wetland Planning, Protection, and Restoration Act (CWPPRA)

CWPPRA was signed into law in 1990, providing funds for the purpose of coastal restoration. A CWPPRA task force (represented by those parties listed below) is responsible for creating an annual priority project list of coastal restoration projects that are funded by CWPPRA.

- The US Army Corps of Engineers (Chair of the Task Force)
- The Governor of Louisiana
- US Department of Agriculture
- US Department of the Interior
- US Department of Commerce
- The Environmental Protection Agency

The costs for CWPPRA projects are shared between the State and Federal government at a cost share ration of 85% Federal: 15% State. The CWPPRA Task Force agencies are responsible for operating, maintaining, and monitoring projects over their lifetime.

Development of CWPPRA projects are carried out in three phases:

- Phase 0 is the creation of an annual priority list of projects. Up to three projects may be nominated in Terrebonne Basin each year for analysis, but only four projects drawn from across the coast may advance to the next phase of project development each year.
- Phase 1 is the engineering and design phase. State and Federal partners perform all engineering and environmental analyses and secure the necessary land rights to construct projects. This phase is intended to be accomplished in less than two years.
- Phase 2 (construction, operations, and maintenance) occurs upon approval of funding from the Task Force. When considering the entire project timeline, it can take up to four years for individual restoration projects to move from concept to construction.

3.4 Water Resources Development Act

Federal projects for environmental restoration are typically implemented in a phased process, the central step being authorization of the project in a Water Resources Development Act (WRDA). Although a WRDA is intended to be passed every two years, in practice the frequency is less regular. The most recent WRDA was passed in 2007—seven years after its predecessor in 2000. In coastal Louisiana, the WRDA process is largely implemented by the US Army Corps of Engineers (USACE) with various local sponsors. After rigorous analysis of the engineering, environmental, and socio-economic issues associated with a project, the USACE recommends to the U.S. Congress that the project be authorized for construction in the next WRDA. Upon authorization, the USACE and its local sponsor must then complete the design of the project and construct it with funding that is subject to annual

appropriations decisions. The typical cost share ratio for WRDA projects is 50% Federal: 50% Local Sponsor for feasibility studies (pre-authorization), 65% Federal: 35% Local Sponsor for engineering& design and construction, and 100% Local Sponsor for operations, maintenance, repair, rehabilitation, and replacement.

3.5 NAWCA

The North American Wetlands Conservation Act (NAWCA) of 1989 provides matching grants to organizations and individuals who have developed partnerships to carry out wetlands conservation projects in the United States, Canada, and Mexico for the benefit of wetlands-associated migratory birds and other wildlife. There is a Standard and a Small Grants Program. Both are competitive grants programs and require that grant requests be matched by partner contributions at no less than a 1-to-1 ratio. Funds from US Federal sources may contribute towards a project, but are not eligible as match.

The Standard Grants Program supports projects in Canada, the United States, and Mexico that involve long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats. In Mexico, partners may also conduct projects involving technical training, environmental education and outreach, organizational infrastructure development, and sustainable-use studies.

The Small Grants Program operates only in the United States; it supports the same type of projects and adheres to the same selection criteria and administrative guidelines as the US Standard Grants Program. However, project activities are usually smaller in scope and involve fewer project dollars. Grant requests may not exceed $75,000, and funding priority is given to grantees or partners new to the Act's Grants Program.

The Congressional appropriation to fund the Act's Grants Program in FY 2008 was $40.3 million. Additional program funding comes from fines, penalties, and forfeitures collected under the Migratory Bird Treaty Act of 1918; from Federal fuel excise taxes on small gasoline engines, as directed by amendments to the Federal Aid in Sport Fish Restoration Act of 1950, to benefit coastal ecosystem projects; and from interest accrued on the fund established under the Federal Aid in Wildlife Restoration Act of 1937. A total of $84.4 million was available to fund grants in FY 2008.

3.6 Gulf of Mexico Energy Security Act

As previously mentioned, a portion of the Gulf of Mexico Energy Security Act funding will be appropriated directly to coastal parishes for their use.

3.7 Coastal Impact Assistance Program

As mentioned previously, a portion of the Coastal Impact Assistance Program funds are available to coastal parishes under non-competitive grants through the Minerals Management Service.

3.8 Community-Based Restoration Program

The National Oceanic and Atmospheric Administration's Restoration Center typically makes matching grants available to entities, including coastal parishes, to implement smaller projects to improve habitats for fish and wildlife.

4 Plan Development

In developing the CPCR it became clear that there was a vast array of potential projects that were considered to be the solution for coastal restoration in Terrebonne Parish. All existing planning documents, including their aims, objectives, principles, and goals, have been taken into account when developing the CPCR. In addition, public and stakeholder engagement has led to the identification of additional projects that have not yet been included in existing State or Federal Programs. The strategic planning process for the CPCR, described below, was specifically designed to provide an overarching framework within which to assess the technical merits of these projects and to devise a plan that would allow the parish to prioritize and sequence projects in the near-term.

GOAL of the Comprehensive Plan for Coastal Restoration:

'Promote and facilitate preservation and sustainable restoration of the coastal ecosystem in Terrebonne Parish.'

Sustainable coastal preservation and restoration planning is the derivation and implementation of coastal policies and projects that are economically viable, technically feasible, and environmentally and socially acceptable.

Today, this is achieved through strategic planning, including: the consideration of natural coastal processes such as longshore sediment linkages and saline/fresh water marsh evolution; a transparent and well-defined decision-making framework; and public and stakeholder engagement to foster understanding and ownership of a coastline that can benefit future generations.

In developing the CPCR, Terrebonne Parish aims to:

- **Restore the coastal ecosystem**
- **Preserve natural coastal processes, by ensuring that sediment can be moved alongshore by wave and tidal energy**
- **Minimize loss of natural ecosystem services (e.g. flood water storage).**
- **Ensure availability of a diverse array of natural goods and services (e.g. hunting and fishing).**

4.1 Objectives, Principles and Metrics

Fundamentally, achievement of the goal of the Terrebonne Parish Comprehensive Plan for Coastal Restoration (CPCR) is based on a series of objectives and principles:

» **Objectives** are measurable outcomes that are intended to be achieved through implementation of the plan.

» **Metrics** are how the objective will be physically measured. These fall into two categories:

- Desirable characteristics
- Objective-specific performance metrics

» **Planning principles** are statements concerning how the objectives should be implemented, and are based on sound scientific and technical knowledge. These "value statements" provide critical inputs and constraints on what will and will not be considered a viable action while developing the plan.

» **Programmatic principles** identify the critical manners in which implemented plans and measures may ultimately interrelate with and alter the activities and assets within the coastal landscape.

» **Projects** are means by which the objectives can be achieved.

» **Opportunities** and constraints are boundary conditions within which the plan is developed (these are described in Section 2).

The successful development of a strategy for the CPCR for Terrebonne Parish is dependent on the derivation of a series of principles and objectives that are all encompassing, drawing from existing plans and program at local, state, and federal government levels (refer to **Appendix B**). The principles and objectives set out in this CPCR have been derived largely through the coordination of the concepts presented in the Master Plan, the Terrebonne Parish Strategic Plan for Coastal Restoration, and the views of resource agencies and stakeholders (refer to **Appendix A**).

Four primary objectives have been set for the CPCR in no particular order:

» Increase integrity of barrier island systems

» Increase vertical accretion of wetland soils

» Maximize habitat diversity of coastal wetlands

» Minimize flood risk in local communities

The objectives, metrics, planning principles and projects for the CPCR are presented in Table 4.1 below.

Table 4.1

Objective	Principles	Metric
1. Increase integrity of barrier island systems.		
1a	Barrier island integrity may be enhanced by adding new sand to the island, allowing for sand transport across tidal passes, and or/ increasing the width of the island.	Volume of sand placed on the island. Acreage of barrier islands.
1b	Avoid placing erosion control structures on barrier islands, except in situations where sand would otherwise be lost to the littoral system.	Restoration method.
1c	Sand should not be dredged from ebb/flood tidal shoals.	
2. Increase vertical accretion of wetland soils.		
2a	For wetlands to be increased sustainably, soil accretion needs to be equal or greater than relative sea level rise.	New sediment introduced into the wetlands (qualitative).
2b	Sediment input to wetlands occurs by regular flooding of turbid water; projects that limit natural fluctuation of water levels on wetlands should be avoided.	Effect on land/water ratio (qualitative).
2c	Nutrient rich water (from rivers pumps/ sanitary systems) should be routed over vegetated wetland surfaces to stimulate organic matter productivity.	
2d	Limited sediment availability is one of the constraints on system rehabilitation, therefore: - Mechanical sediment retrieval and placement may be considered where landscape objectives cannot be met using natural processes. - Because sediment mining can contribute to ecosystem degradation in the source area, such alternatives should, to the extent practicable, utilize material from renewable sources (i.e. rivers), navigation channels, and/or offshore areas.	
3. Maximize habitat diversity of coastal wetlands.		
3a	In establishing and maintaining salinity gradients, projects should promote a dynamic system rather than fixing isohalines and actively managing salinity. This is best achieved by allowing fluctuating freshwater inputs to the head of the estuary.	Volume of freshwater (annual cubic feet/second) introduced to projects areas (or routed through wetlands).
4. Ensure development in the Parish occurs in consistency with the CPCR.		
4a	Use non-structural solutions to minimize risk. - Use smart growth: development should be encouranged within buffer zones and near levees. - Construction should take place through the consistent enforcement of Parish building codes.	Acres impacted per year by residential development.

Objectives, metrics and principles underpinning the CPCR.

4.2 Programmatic Principles

Programmatic principles describe the range of critical considerations required to develop appropriate and effective plans and plan components. These principles, set out below, represent the rules by which the program implementation, including the plan formulation process, is conducted.

A sluice gate alleviates flooding and allows freshwater to be introduced into stressed swamps.

» Mineral extraction shall be conducted in a manner consistent with the Guidelines of Louisiana Coastal Resources Program and should be consistent with the Goals of the Terrebonne Parish Coastal Zone Management Program and individual management units (Terrebonne Parish, 2004).

» No new canals shall be dredged, nor existing canals be widened or deepened when existing routes can be used to gain access to a particular site (Terrebonne Parish, 2004). The best available technologies shall be encouraged when dredging oil and gas pipeline access channels canals and inland bayous.

» Activities that lead to land loss shall be avoided to the maximum extent practicable (Terrebonne Parish, 2004).

» Any activity that could lead to an increase in the rate of land loss of Terrebonne Parish shall be tested against Guideline 1.8 of the State Coastal Use Guidelines, other Guidelines and the overall benefit to the people of Terrebonne Parish before a local coastal use permit is granted (Terrebonne Parish, 2004).

» Any new activity requiring a local coastal use permit shall be judged, on a case by case basis, in relation to the management unit it occurs in and to the coastal zone as a whole, in order to avoid cumulative impacts and avoid detrimental impacts on the coastal zone (Terrebonne Parish, 2004).

» Whenever a coastal use permit and a development permit are both required for a particular activity, the Parish shall not issue, nor recommend to the State the issuance of, a coastal use permit, until applicant's development permit has been processed (Terrebonne Parish, 2004).

» The plan should encourage educational activities that increase public awareness of coastal zone management issues and the magnitude and severity of the problem of coastal land loss in Terrebonne Parish (Terrebonne Parish, 2004).

» Projects will be based on best available scientific and engineering practice.

» The plan must be seen to "speak with one voice", providing a strategy that all key stakeholders will sign-up to and promote willingly.

4.3 Plan Formulation Process

4.3.1 Description of the process

Identify an initial list of projects (implementable actions), strategies (restoration methods proposed with no identified location), and concepts (proposed restoration methods with an identified location but lacking critical implementation details) that have been proposed through public and stakeholder interaction and ongoing programs (e.g. CWPPRA). Finalize this initial list by:

- Removing duplicate projects
- Where possible, defining projects which implement technically sound concepts
- Where possible, incorporating technically sound strategies into projects
- Performing a "gap analysis" to ensure that projects have been defined to implement all measures from the State Master Plan

Develop a short-list of 'viable projects' by screening the initial list: Does the project help achieve the objectives (the project must meet at least one objective to be a viable project) and not violate any planning or programmatic and principles (violating any principles eliminates the project from further consideration)?

Develop a shorter-list of 'best projects' on the basis of project performance against desirable characteristics and objective-specific performance metrics (**Table 4.2**).

Prioritization and sequencing of highest-performing projects on an analysis of:

- Synergies with other projects – i.e. the project functions to improve the performance of other projects in addition to the benefits realized from the project itself
- Independent utility – i.e. the project is not dependent on the completion of another project to achieve its full benefits
- Conflicts – i.e. the project diminishes the effectiveness or limits the opportunities to implement of other priority restoration and protection projects
- Whether the project is an Urgent Early Action as defined by the State
- Cost
- Implementation status, including issues such as: current stage in the project life cycle and whether or not the project is being actively developed in an ongoing restoration program
- Total potential restoration benefits

SCORING EXAMPLE:
PROJECT FD9 LAKE DECADE MARSH CREATION AND NOURISHMENT (PPL18)

What objectives and principles does the project meet?
(+ indicates objective met, 0 indicates no impact on that principle, and – indicates violation of principle)

Obj. 1	Barrier Island integrity may be enhanced by adding new sand to the island, allowing for sand transport across tidal passes, and or increasing the width of the island.	Avoid placing erosion control structures on barrier islands, except in situations where sand would otherwise be lost to the littoral system.	Sand should not be dredged from ebb/flood tidal shoals.
0	Principle not scored, as Objective scored "0"	Principle not scored, as Objective scored "0"	Principle not scored, as Objective scored "0"

Obj. 2	For wetlands to be increased sustainably, soil accretion needs to be equal or greater than relative sea level rise.	Sediment input to wetlands occurs by regular flooding of turbid water; projects that limit natural fluctuation of water levels on wetlands should be avoided.	Nutrient rich water (from rivers pumps/ sanitary systems) should be routed over vegetated wetland surfaces to stimulate organic matter productivity.	Limited sediment availability is one of the constraints on system rehabiltation, therefore: Mechanical sediment retrieval and placement may be considered where landscape objectives cannot be met using natural processes because sediment mining can continue.
+	**+**	**0**	**0**	**+**

Obj. 3	In establishing and maintaining salinity gradients, projects should promote a dynamic system rather than fixing isohalines and actively managing salinity. This is best achieved by allowing freshwater inputs to the head of the estuary.
0	Principle not scored, as Objective scored "0"

Obj. 4	Residential development in wetlands south of GIWW has the potential to limit implementation of projects that seek to restore natural processes and should be avoided whenever possible.
0	Principle not scored, as Objective scored "0"

Score against desirable characteristics and Score against Objectives Matrix:

Precaution	Robustness	Cost-effectiveness	Adaptability	Timeliness
5	**4**	**4**	**4**	**5**

Objective 1: Increase integrity of barrier island 'systems'.	Objective 2: Increase vertical accretion of wetland soils.	Objective 3: Maximize habitat diversity of coastal wetlands.	Objective 4: Minimize residential development in wetlands south of the Intracoastal Waterway	**SUM: 5 + 4 + 4+ 4 + 5 + 1+ 5 + 3 + 3**
1	**5**	**3**	**3**	**34**

	Desirable characteristics					Objective Metric			
Score	Precaution – is there a full awareness of the implications and negative impacts associated with the project? Is there is risk associated not understanding the implications and impacts of the project?	Robustness – ability for the project to remain effective under various conditions, or evolve to meet conditions. The synergies with the Morganza to the Gulf projects are also considered within this characteristic.	Cost effectiveness – measure of the economic efficiency to achieve the metrics, i.e., how much does it cost to achieve the benefit?	Adaptability – synergies between measures and ability to develop in response to future needs and constraints.	Timeliness – ability to deliver benefits in a timescale commensurate with the need.	Objective 1: Increase integrity of barrier island 'systems'.	Objective 2: Increase vertical accretion of wetland soils.	Objective 3: Maximize habitat diversity of coastal wetlands.	Objective 4: Minimize residential development in wetlands south of the Intracoastal Waterway
						Volume of sand placed on the island. And/ or Acreage of barrier islands.	Effect on land/water ratio (qualitative). And/or New sediment introduced into the wetlands (qualitative).	Volume of freshwater (annual cubic feet/second) introduced to projects areas (or routed through wetlands) And/or Impact of saline intrusion on wetland diversity.	Acres impacted per year by residential development.
5	Sufficiently well understood to ensure successful implementation.	The project is highly unlikely to fail under extreme events, and can be implemented and deliver desired benefits under all reasonably anticipated future scenarios.	The project is highly cost-effective with substantial net benefits	The project has strong synergies and can be readily modified in the future to address changed circumstances/ requirements and monitoring outputs	The project rapidly delivers benefits to address immediate (or time-limited) need.	Project places new sand on the island and restores the back-marsh platform.	Best case = land gain is greater than today Best case = new sediment is sourced via dredging techniques	Freshwater introduction is greater than 1000 CFS.	No residential development in wetlands south of the GIWW.
4	The project-associated implications, negative impacts and risks are highly unlikely to occur.	The project can be implemented under all reasonably anticipated future event scenarios, but benefits will be reduced in several scenarios.	The project is cost-effective with some benefits	The project displays synergies between measures and can be modified to meet future needs.	The project delivers benefits to prevent further deterioration of issue/risk.	Project places new sand on the island, but does not restore the back marsh platform.	Best case = land gain is greater than today Neutral case = new sediment is sourced from turbid water	Freshwater introduction is between 0 and 1000 CFS.	
3	The project-associated implications, negative impacts and risks are likely to occur, but can recover functionality quickly,	The project can be implemented and deliver desired benefits under some future event scenarios, with limited or no dis-benefits under alternative scenarios	The project is marginally cost-effective Or The project is costly, but there are a significant number of benefits.	The project works largely independently and can be designed to allow modifications to meet future requirements.	The project delivers benefits within first time horizon (i.e. 0 to 20 years).	Project restores the back-marsh platform but does not place new sand on the island.	Neutral = there is no change in the land/water ratio from today Neutral case = new sediment is sourced from turbid water	Restores or preserves a lake rim or ridge which establishes an estuarine gradient without increasing the isolation of wetlands from normal tidal exchange.	Acres impacted by residential development south of the GIWW remain the same.

Desirable characteristics							Objective Metric		
2	The project-associated implications, negative impacts and risks are highly likely to occur, with irreversible consequences.	The project will be successfully implemented and deliver benefits under a ‘status quo’ scenario, and delivers dis-benefits under several scenarios.	The project is costly and benefits are limited	The project has little scope for future adaptation and may create some conflicts in the future.	Issue/risk likely to deteriorate significantly before project benefits are realized.	Project does not place new sand on the island or restore back marsh platform, but does encourage sediment retention through use of segmented breakwaters, vegetation plantings, or sand fencing.	Neutral = there is no change in the land/water ratio from today Worst case = no new sediment is introduced into the wetlands	No change to existing lake rim or ridge habitat, and tidal fluctuations/exchange remains the same.	
1	Very uncertain of implications.	Fragile approach likely to fail under extreme events, with significant effort to reinstate. The project offers strong dis-benefits under most future scenarios.	The project is costly and benefits are unlikely to be realized.	The project cannot be changed once implemented, restricts potential for alternative approaches and creates conflicts in future.	Issue/risk unlikely to be addressed in sufficient time for project to work.	No activity to restore a barrier island.	Worst case = there is continued loss of land Worst case = no new sediment is introduced into the wetlands	Project further isolate wetlands from tidal exchange.	Acres impacted by residential development in wetlands south of the GIWW remains the same.

5 The Plan and Sequencing of Projects

During the initial planning process, projects, strategies, and concepts were identified during through stakeholder engagement and combined to form a list of projects. For the purposes of this plan, if two similar projects were proposed for a particular project area with minor differences in proposed location but equivalent restoration actions, they were treated as duplicate projects. The remaining initial list of projects is split into Ongoing Projects, Marsh and Ridge Restoration projects, Freshwater Introductions/Pump Stations and Barrier Islands, listed respectively in **Table 5.1**, **Table 5.2**, **Table 5.3** and **Table 5.4**. Project descriptions for the initial list of projects is provided in **Appendix B**.

After assessing this initial list of projects, four projects were determined to either not meet any plan objectives or to violate at least one planning or programmatic principle (see **Table 5.5**). The remaining projects were assessed against the desirable characteristics and objective-specific performance metrics to determine their relative performance. Each project was awarded a score and ranked accordingly. Through a process of Prioritization and Sequencing (Stage 4 of the Plan Formulation Process), a list of priority projects were identified for Terrebonne Parish to pursue for funding. These projects are shown conceptually in **Figure 5.1**. Priority projects are grouped programmatically under:

- The LCA program
- Project type
  - Freshwater introduction to the Terrebonne Marshes
  - Atchfalaya River influence
  - Marsh creation/restoration
- Beneficial use
- Sediment pipeline conveyance

Each project varies in size, scope, and complexity, with each benefiting targeted areas within the Parish that must be preserved in order to ensure sustainability for the future.
The priority projects are described in the following sections, along with an accompanying project fact sheets at the end of this section.

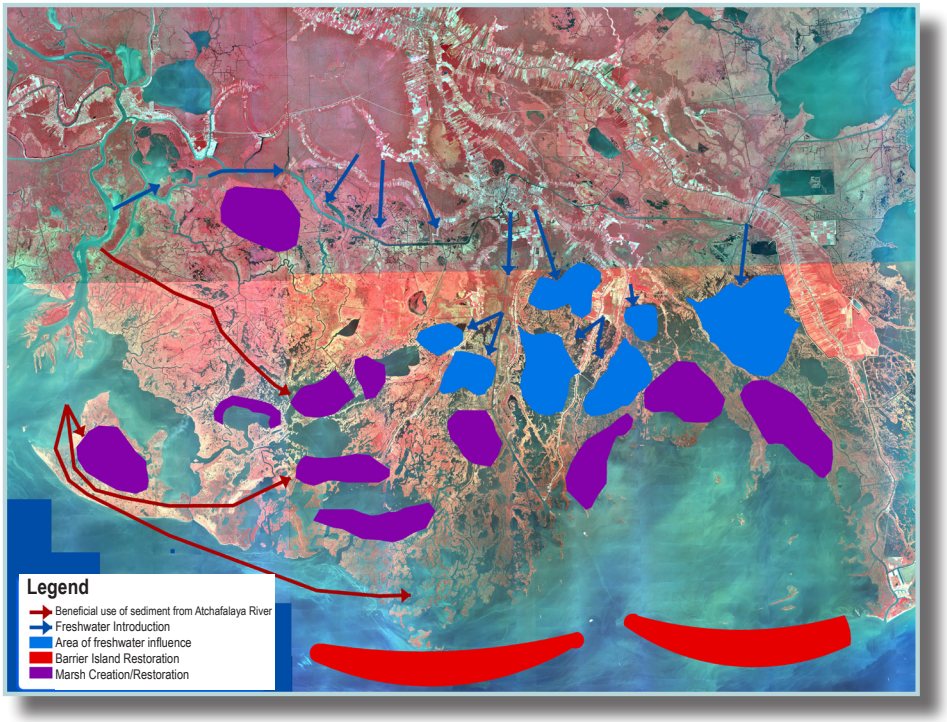


Table 5.1 Ongoing Projects

Ongoing Projects	Status of Implementation	FINAL PLAN Project No.	Score
Raccoon Island	LCA	F39	36
Whiskey Island	LCA	F40	36
Trinity Island	LCA	F41	36
East Timbalier Island	LCA	F45	36
Ship Shoal: Whiskey West Flank Restoration (TE47)	CWPPRA - Awaiting funding for construction	F47	36
West Belle Pass Barrier Headland Restoration (TE52)	CWPPRA - Ready for construction	F54	36
Whiskey Island Back Barrier Marsh Creation (TE50)	CWPPRA - Ready for construction	F49	35
North Lost Lake Marsh Creation/Enhancement Project-Phase 1 And Phase 2	CIAP Tier 2	F30	34
Madison Bay Marsh Creation And Terracing (TE51)	CWPPRA - In engineering and design	F29	33
Raccoon Island Shoreline Protection/Marsh Creation (TE48b)	CWPPRA - Ready for construction	F52	33
Avoca Island Diversion And Land Building (TE49)	CWPPRA – this project has been deauthorized, but the concept of diverting freshwater should continue to be considered in LCA.	F83	33
Central Terrebonne Freshwater Enhancement Project (Neck Down Grand Pass)	Authorised by CWPPRA (PPL18)	F5	29
Houma Navigation Canal Lock (State And Parish Cost Shared) (TE62)	CWPPRA - In engineering and design and CIAP Tier 1	F2	28
GIWW Bank Restoration Of Critical Areas In Terrebonne (TE43)	CIAP - Ready for construction	F4	28
Implementation Of The Penchant Basin Plan (TE34)	CWPPRA - Ready for construction	F86	28
Enhancement Of Barrier Island Vegetation Demonstration (TE53)	CWPPRA - In engineering and design and CIAP Tier 1	F51	27

Table 5.2 Marsh/Ridge Restoration Projects

Marsh/Ridge Restoration Projects	Final Plan Project No.	Score
South-West Shore Lake Decade	F8	36
East Island Dune And Marsh Restoration	F42	36
Marsh Creation To The North Of Lost Lake	F6	35
West Shore Lake Decade	F7	35
Lake Decade Marsh Creation And Nourishment (PPL18)	F9	34
North Shore Lake Mechant	F10	34
Marsh Creation East Of Lake Boudreaux	F28	34
Marsh Creation North Raccourci Bay	F11	33
Bayou Dularge To Grand Pass Ridge Restoration	F35	33
Bayou Decade Ridge Restoration From Lake Decade To Raccourci Bay	F36	33
Marsh Creation Bush Canal	F12	32
Lake Boudreaux-Lake Quitman Shoreline Protection And Marsh Creation	F13	32
Marsh Creation North Shore Lake Tambour	F15	32
Terrebonne Bay Shoreline Protection/Marsh Creation Comprehensive Plan Project (Was PPL18 Modified For PPL 19) PPL19	F16	32
Marsh Creation East Of Felix Lake	F27	32
Bayou Terrebonne Ridge Restoration - Below Bush Canal	F34	32
Lake Mechant South-West Shoreline Protection And Bayou Dularge Ridge Protection (PPL18)	F87	32
HNC Beneficial Use Of Dredge Material (Bay Tambour And Terrebonne Bay)	F88	32
Madison/Terrebonne Bays Marsh Creation (PPL19 Nominee)	F89	32
Marsh Creation North Shore Lake Chien	F14	31
Bay Raccourci Marsh Creation And Terracing Project	F19	31
Rebuild The East Bank Of The Bayou Terrebonne - Integrity For Freshwater Conveyance	F20	31
Marsh Creation North Deep Saline	F25	31
Marsh Creation West Of Four Point Bayou	F26	31
Lost Lake Shoreline Protection And Hydrologic Restoration (PPL 18 R3-TE-01) PPL19	F31	31
Marsh Restoration South-West Of Four League Bay (Phased Implementation)	F63	31
North Lake Boudreaux Basin Freshwater Introduction And Hydrologic Management (TE32a)	F69	31
Bank Stabilization Along Bush Canal And Bayou Terrebonne	F84	31
Dulac Bayou - Marsh Terracing	F17	30
South Montegut - Marsh Terracing	F18	30
Sediment Introductions At South Shore Sister Lake	F37	30
Marsh Creation North Stump Canal	F21	27
Marsh Creation School Board Property South Of Swing Bayou	F22	27
Marsh Creation North-East Toilet Bowl Canal	F23	27
Marsh Creation North East Of Bayou Penchant	F24	27
Brady Canal Hydrological Restoration Project	F70	24

Table 5.3 Freshwater Introduction/Pump Station Projects

Freshwater Introduction/Pump Stations	Final Plan Project No.	Score
Dredge Bayou Terrebonne From Company Canal To Humble Canal	F57	35
Dredge Minors Canal (GIWW To Lake Decade)	F58	35
Dredge Company Canal To Convey Freshwater Flow To Terrebonne Marshes	F62	35
Connect St. Louis Canal To Petit Caillou	F59	34
Large Pump Station At Bayou Terrebonne	F65	34
Pump Station At Bayou Petit Caillou For Freshwater Diversion To Ward 7	F66	34
Bayou Terrebonne Freshwater Diversion Project (PPL19)	F79	33
South Lake Decade Freshwater Enhancement And Shoreline Protection	F68	32
Ashland Freshwater Introduction And Wetland Assimilation Project (PPL18)	F71	32
Woodlawn Ranch Road	F77	32
Reconnect Grand Bayou To GIWW	F85	32
Freshwater Introduction Via Blue Hammock Bayou	F33	31
Falgout Canal Freshwater Enhancement (Phase I)	F67	31
Freshwater Diversion Using The Bayou Terrebonne Flood Gate	F80	31
Lower Bayou Dularge Pump Station	F72	30
Upper Bayou Dularge	F73	30
Mayfield	F74	30
Lower Grand Caillou	F75	30
Upper Grand Caillou	F76	30
Pointe-Aux-Chenes	F78	30
Remove Constrictions/Dredge GIWW From Bayou Black To Bayou Wallace	F60	29
Installation Of Flap Gated Culverts Under Highway 57 Between Dulac And Highway 56	F82	29
Plugs Leaks In GIWW (Bankline Protection For GIWW)	F3	28
Break In Avoca Guide Levee, North Of Horse Shoe To Convey Freshwater To Terrebonne Marshes	F61	27
Chacahoula Basin Plan (Pump Stations Etc)	F32	26
Carencro Bayou Freshwater Introduction Project	F64	26

Table 5.4 Barrier Island Projects

Project Name	Final Plan Project No.	Score
Wine Island	F43	36
West Timbalier Island	F44	36
Beach And Back Barrier Marsh Restoration, East And Trinity Islands (CIAP Tier 2)	F50	36
Barrier Shoreline Restoration Pointe Au Fer Island	F56	36
Wine Island Rookery	F46	35
West Racoon Island Shoal Enhancement And Protection (PPL18)	F48	26
Rock (Breakwaters) For Whiskey Island	F38	21

Table 5.5 Projects that did not meet objectives or violated principles

Project Name	Final Plan Project No.	Score
Shoreline Protection Of The Houma Navigation Canal, Mile 12-31.4 *Score Explanation: No objectives met*	F1	0
Coastal Bay Sediment Trapping (PPL18) *Score Explanation: No objectives met*	F53	0
Create Oyter Reef As An Extension To Pointe Au Fer *Score Explanation: No objectives met*	F55	0
Installation Of A Structure Containing A Large Boat Bay In Robinson Canal Near Highway 56. *Score Explanation: Violation of principal 2b*	F81	0

5.1 LCA Projects

Barrier islands are cornerstone ecosystem structures in Terrebonne parish, and a comprehensive restoration approach is recommended. In addition, the Atchafalaya River's resources could play significantly enhanced roles in restoring wetlands throughout the Parish if increasing the volume of flow beyond the natural levels can be balanced against its effects on flooding of communities and potential to increase the rate of land loss in flotant marsh areas. Given the relatively large cost and level of technical complexity to assess and implement these priority projects, they should be implemented under the ongoing LCA program. It is more likely that these projects will be completed in a timely manner if left within the LCA program. The State and USACE have initiated feasibility studies that may implement the actions listed below if they are found technically feasible and cost effective.

F3 Plug Leaks in GIWW (Bankline Protection for GIWW)

F39 Raccoon Island

F40 Whiskey Island

F41 Trinity Island

F43 Wine Island

F44 West Timbalier Island

F45 East Timbalier Island

F60 Remove Constrictions/Dredge GIWW from Bayou Black to Bayou Wallace

F61 Break in Avoca Guide Levee, North of Horseshoe to Convey Freshwater to Terrebonne Marshes

F58 Dredge Minors Canal (GIWW to Lake Decade)

F37 Caillou Lake Landbridge which includes project number 37. Sediment Introduction at South Shore of Sister Lake

5.2 Priority Projects

5.2.1 Freshwater Introduction to Terrebonne Marshes

The projects discussed below may be achieved through funding opportunities available to the Parish such as CWPPRA, CIAP, NAWCA and Parish funds. Terrebonne Parish currently pumps stormwater into bayous, thus limiting the potential for reusing this water for nourishment of the marsh system. There are a number of pump stations that are located throughout Terrebonne Parish within the vicinity of degraded wetlands. Through modification of these pump stations and associated components, a number of relatively low cost projects can contribute significant positive impacts to the local wetlands.

The following is a list of Freshwater Introduction projects listed in order of priority. A brief explanation for each selection is provided.

F77 Woodlawn Ranch Road Pump Station
This pump station project is the largest among those considered at 1350 cfs Utilizing storm water drainage from the Houma area, freshwater will be introduced to the marshes north of Lake Boudreaux to enhance freshwater flows and support a dymanic estuarine salinity regime. This project works in conjunction with Ashland Freshwater Introduction and Wetland Assimilation.

F71 Ashland Freshwater Introduction and Wetland Assimilation Project
This freshwater introduction project will incorporate wastewater treatment effluent and freshwater from the GIWW by way of St. Louis Canal to the Terrebonne Marshes north of Lake Boudreaux. Nutrients added to the system in the effluent will promote plant growth and any sediment introduced from Atchafalaya River water in the HNC will promote accretion to an area at risk for further deterioration.

F65 Large Pump Station at Bayou Terrebonne
Storm water drainage will be used to introduce freshwater to an area of marsh west of Bayou Terrebonne currently experiencing saltwater intrusion and a high rate of subsidence to enhance soil building and enhance freshwater flows to support a dynamic estuarine salinity regime.

F72 Lower Bayou Dularge Pump Station
Pump station D19 will divert approximately 200 cfs. of freshwater east of Bayou Dularge into an area of marsh currently experiencing high rates of land loss.

F73 Upper Bayou Dularge Pump Station
Pump station D18 will be used to introduce approximately 200 cfs. of freshwater to the marshes north of Falgout Canal which will benefit adjacent marshes.

5.2.2 Atchafalaya River Influence

Most Terrebonne Parish marshes are distant from sediment, nutrient, and fresh water sources. However, opportunities exist for maximizing freshwater influence though implementation of strategic projects. Implementation of these projects are intended to optimize freshwater distribution without increasing the volume of Atchafalaya River water flowing into the Parish.

The following is a list of projects which utilize Atchafalaya River Influence resources to increase for future sustainability of Terrebonne Parish marshes. Listed in order of priority, a brief explanation for each selection is provided.

F67 Falgout Canal Freshwater Enhancement (Phase I)
Many factors, including subsidence and hydrologic isolation from land building resources, have led to rapid deterioration of marsh within the marshes located adjacent to Falgout Canal, between Bayou Dularge and the Houma Navigation Canal. This project will allow for re-establishment of Atchafalaya River influence and stimulate the re-growth of marshes in the system.

F85 Reconnect Grand Bayou to GIWW
Dredging as needed of Grand Bayou will be added in order to increase the amount of water available and optimize flow to this region of Terrebonne Parish. Increased supply of freshwater and nutrients will assist in vegetation enhancement and accretion in an area of marsh that is rapidly deteriorating. Installation of a water control structure between the GIWW and Grand Bayou will be evaluated if the potential to increase flooding in residential areas is projected.

F62 Dredge Company Canal to Convey Freshwater Flow to Terrebonne Marshes
Dredging Company Canal between the GIWW and Bayou Terrebonne will result in an increase in the amount of freshwater available for eastern Terrebonne Parish marsh sustainability.

F57 Dredge Bayou Terrebonne from Company Canal to Humble Canal
Dredging Bayou Terrebonne will result in an increase in the amount of freshwater available to eastern Terrebonne Parish marshes. The road bridge that crosses Company Canal/Bayou Terrebonne is due to be replaced by the LADOTD. Replacement of the bridge should account for an increased flow of water in the channel below that would result from this project. Environmental structures placed as part of the Morganza to the Gulf Hurricane Protection Project should minimize flooding and excess marine influence in these fragile areas.

F79 Bayou Terrebonne Freshwater Diversion Project
Through the use of an existing drainage ditch, removal of an earthen plug between the Montegut and Pointe-Aux-Chenes drainage systems, construction of 3 small pump stations, and construction of a screw gate water control device near the removed plug location, increased volumes of freshwater can be made available to the marshes of Montegut and Pointe-Aux-Chenes within the Wildlife Management Areas. Over 9,000 acres of brackish and intermediate marsh will benefit from this freshwater resource that is currently channeled to the lower estuary.

Note: A synergy exists among Dredge Company Canal to Convey Freshwater Flow to Terrebonne Marshes, Dredge Bayou Terrebonne from Company Canal to Humble Canal, and Bayou Terrebonne Freshwater Diversion Project. It is suggested that all 3 of these projects be planned and implemented in a manner that maximizes incremental benefits as each project is constructed.

5.2.3 Marsh Creation/Restoration

Opportunities to create, restore, and sustain marshes in Terrebonne Parish through natural riverine processes are very challenging due to the distance from the Atchafalaya and Mississippi Rivers. However, it is important to restore marshes in strategic locations utilizing dredged materials. Where possible, these created and restored wetlands should be nourished with through small scale freshwater diversions of river water as these natural processes are essential to long-term sustainability.

The following is a list of suggested marsh creation projects for Terrebonne Parish. Each project should be implemented on a scale large enough to restore significant structural functions to the ecosystem. These are not in order of priority as each is of equal importance for the Parish.

F9 (South) Lake Decade Marsh Creation and Nourishment (PPL19)

F20 Rebuild the East Bank of Bayou Terrebonne – Integrity for Freshwater Conveyance

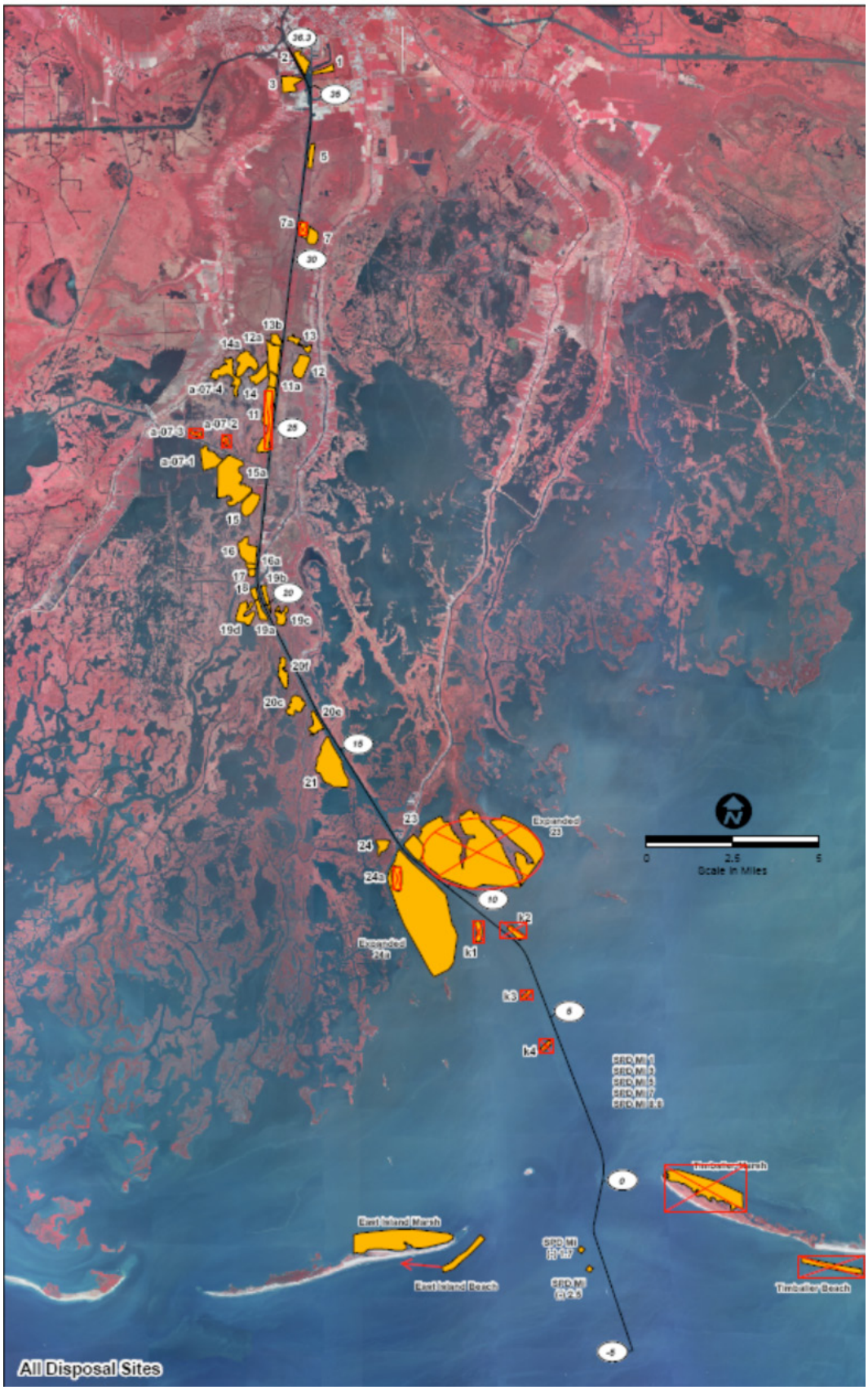
F31 Lost Lake Shoreline Protection and Hydrologic Restoration

F63 Marsh Restoration South-West of Four League Bay (Phased Implementation)

5.3 Beneficial Use

The approved dredge disposal sites for the deposition of material removed from the HNC is shown in **Figure 5.1**. The following is a list of Beneficial Use projects for Terrebonne Parish. It is suggested that these projects be constructed from the dredge material obtained through maintenance dredging of the Houma Navigation Canal. Each is of equal importance and these are not in order of priority.

Figure 5.1 Beneficial Use Sites in Terrebonne Parish.



FD27 Marsh Creation East of Felix Lake

FD26 Marsh Creation West of Four Point Bayou

FD25 Marsh Creation North Deep Saline

FD46 Wine Island (Dredge material obtained through dredging of the Houma Navigation Canal Channel located within Terrebonne Bay)

5.4 Sediment Pipeline

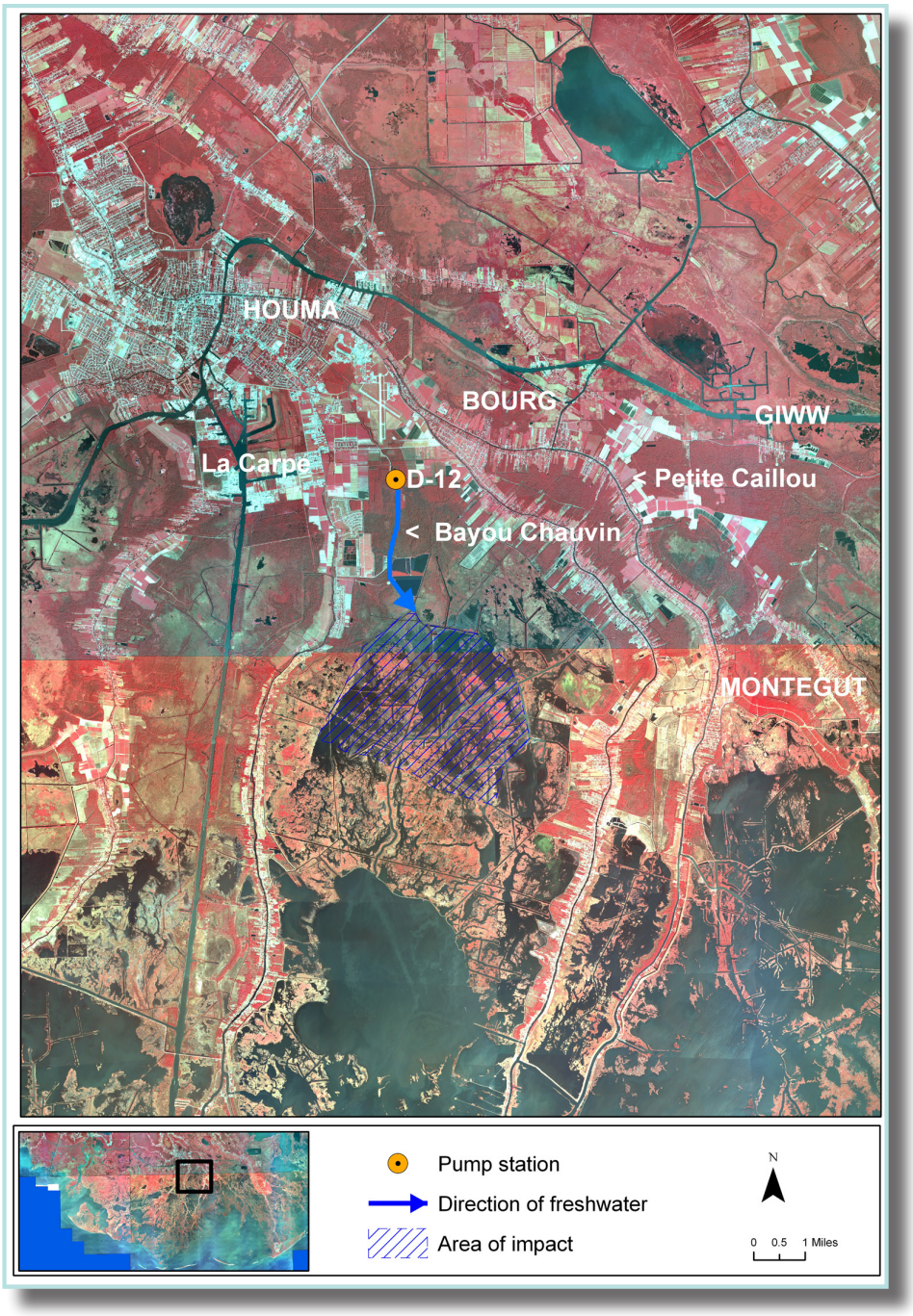
The topic of pipeline sediment conveyance is one that is often discussed as an option for Atchafalaya River sediment introduction into the marshes of Terrebonne Parish. The goal of this approach should be to maximize the use of material dredged to maintain navigation in the Atchafalaya River and Bayous Chene, Beouf, and Black projects, including agitation dredging in inland areas and dredging of the bar channel. Sediment Conveyance to Lost Lake and the area South of Bayou Dularge from inland reached is one possible project incorporating pipeline conveyance. The existing Tennessee Gas Transmission Company pipeline right-of-way could be used for placement of a sediment pipeline. This right-of-way extends into the areas of interest north of Lost Lake and South of Bayou Dularge. In addition, materials dredged from the Atchafalaya Bar Channel could be used beneficially on Pointe Au Fer Island or in lower Terrebonne Marshes south of Caillou Lake. This provides a prime opportunity for Terrebonne Parish to partner with St Mary Parish and the Port of Morgan City to leverage resources already being expended to maintain the channel. All previous feasibility studies undertaken in relation to management and beneficial use of material dredged from the area's waterways should be used as a basis for future beneficial use activities. These studies should be updated wherever possible to ensure maximum use to benefit wetlands.

The goal of this approach should be to maximize the use of material dredged to maintain navigation in the Atchafalaya River and Bayous Chene, Beauf, and Black projects, including agitation dredging in inland areas and dredging of the bar channel.

Project No. F77
Woodlawn Ranch Road Pump Station

Project Description

This pump station (D12) project is the largest among those considered at 1350 cfs. Utilizing storm water drainage from the Houma area, freshwater will be introduced to the marshes north of Lake Boudreaux to enhance freshwater flows and support a dynamic estuarine salinity regime. This project works in conjunction with Ashland Freshwater Introduction and Wetland Assimilation.



Project Cost
Less than $500,000

Potential Funding Source
Parish and State funding

Project Schedule
Planning:
Less than 1 year

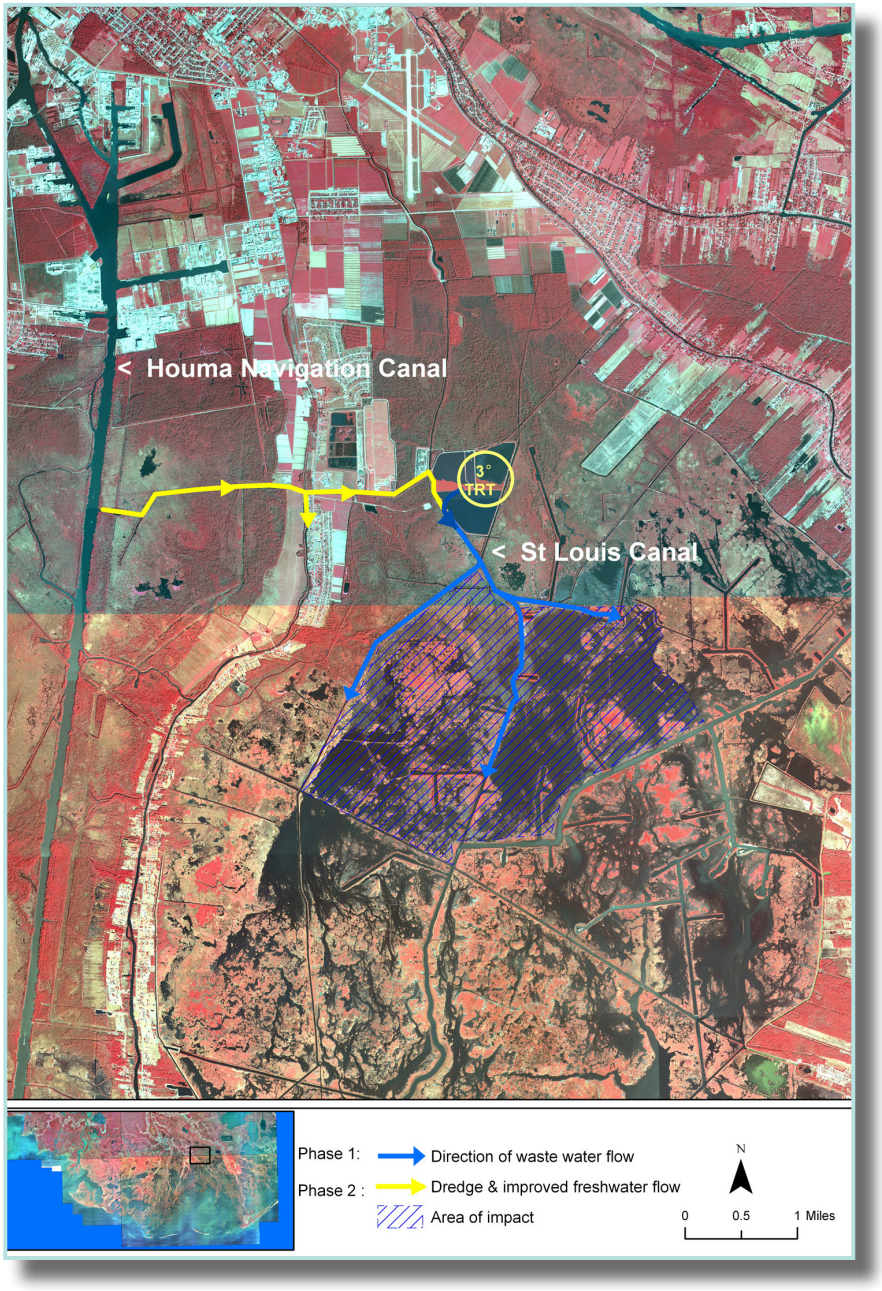
Design:
Less than 1 year

Implementation:
Less than 1 year

Project No. F71
Ashland Freshwater Introduction and Wetland Assimilation Project (PPL18)

Project Description

This freshwater introduction project will incorporate wastewater treatment effluent and freshwater from the GIWW by way of St. Louis Canal to the Terrebonne Marshes north of Lake Boudreaux. Nutrients added to the system in the effluent will promote plant growth and any sediment introduced from Atchafalaya River water in the HNC will promote accretion to an area at risk for further deterioration. The project takes advantage of the pre-existing canals linked to the HNC by dredging them out to improve the efficiency of freshwater flow to the marshes. Other considerations on the project are to modify force drainage pumps to increase flow from the north into the project area, for example Woodlawn Ranch Road (pump station D12).



Project Cost
$5 million construction

Potential Funding Source
CWPRA

Project Schedule
Planning:
Less than 1 year

Design:
Less than 1 year

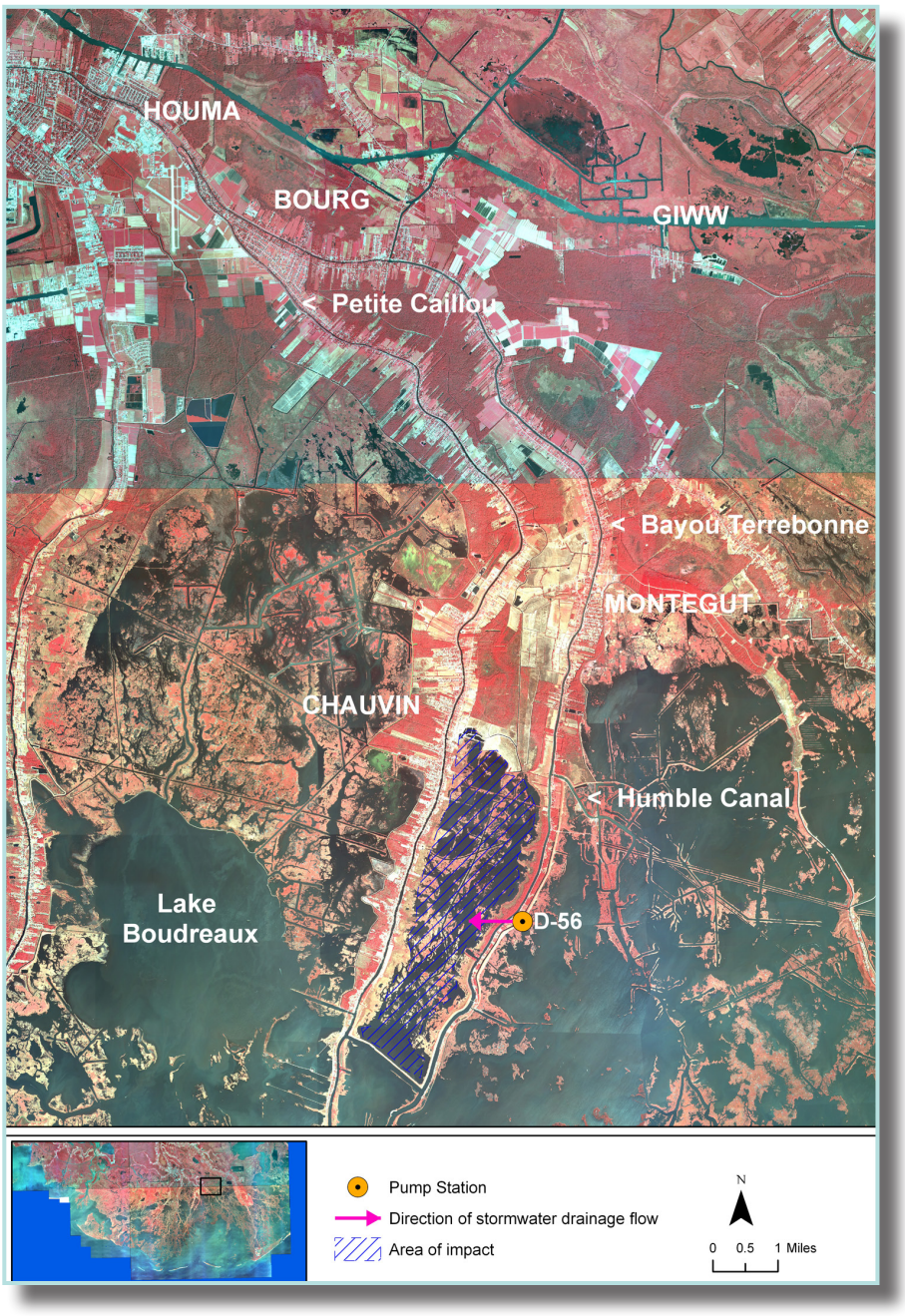
Implementation:
1 - 2 years

Project No. F65
Large Pump Station at Bayou Terrebonne

Project Description

The primary objective of the projects is to redistribute freshwater runoff from the watershed to the marshes. Storm water drainage will be used to introduce freshwater to an area of marsh west of Bayou Terrebonne currently experiencing a high rate of subsidence to enhance soil building and enhance freshwater flows to support a dynamic estuarine salinity regime. This redistribution is expected to replace lost overland flow, reduce ponding in coastal wetlands, and work against intruding salinity in Terrebonne Parish.

Dredge material could be used for the construction of banks to protect the shoreline and prevent erosion.



Project Cost
Less than $500,000

Potential Funding Source
Parish and State funding

Project Schedule
Planning:
Less than 1 year

Design:
Less than 1 year

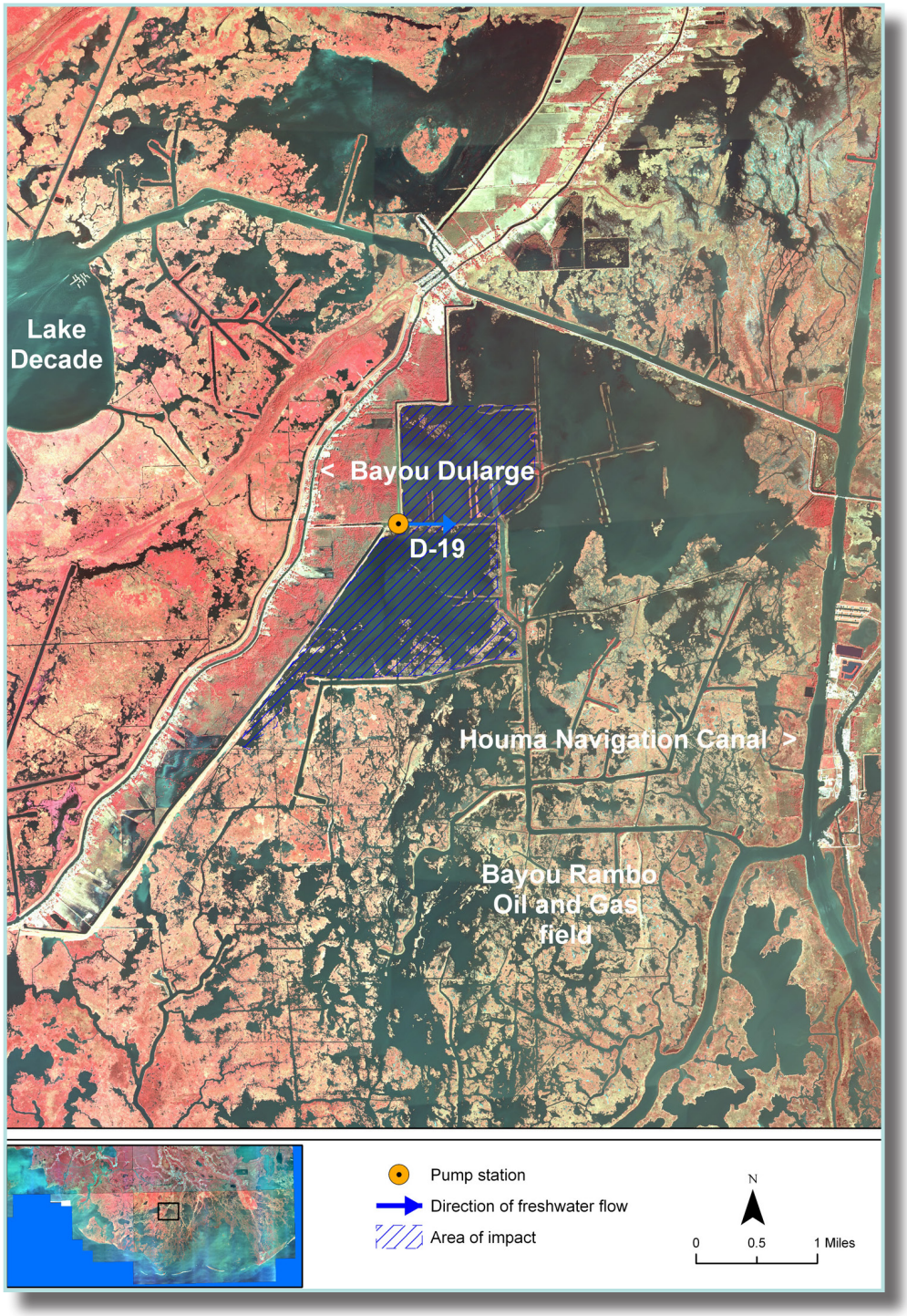
Implementation:
Less than 1 year

Project No. F72
Lower Bayou Dularge Pump Station

Project Description

Use of pump station D19 to divert approximately 200CFS of freshwater to the east from the drainage the levees to Bayou Dularge.

SYNERGIES: TO BE COMPLETED IN CONJUNCTION WITH PROJECT 73.



Project Cost
Less than $500,000

Potential Funding Source
Parish and State funding

Project Schedule
Planning:
Less than 1 year

Design:
Less than 1 year

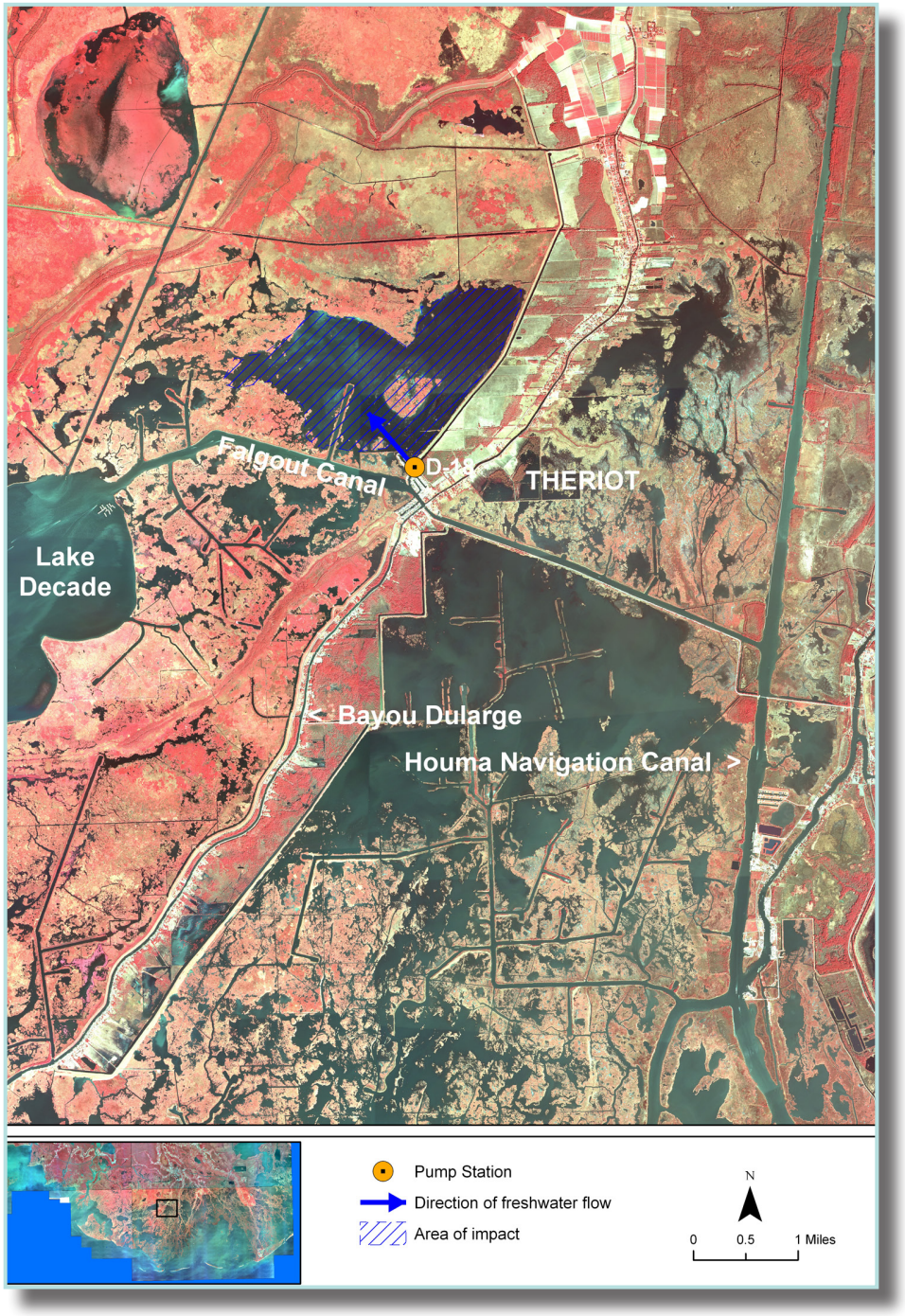
Implementation:
Less than 1 year

Project No. F73
Upper Bayou Dularge Pump Station

Project Description

Pump station D18 will be used to introduce approximately 200 cfs. of freshwater to the marshes north of Falgout Canal. Marshes in this area are at risk of further deterioration due to saltwater intrusion.

SYNERGIES: TO BE COMPLETED IN CONJUNCTION WITH PROJECT 72.



Project Cost
Less than $500,000

Potential Funding Source
Parish and State funding

Project Schedule
Planning:
Less than 1 year

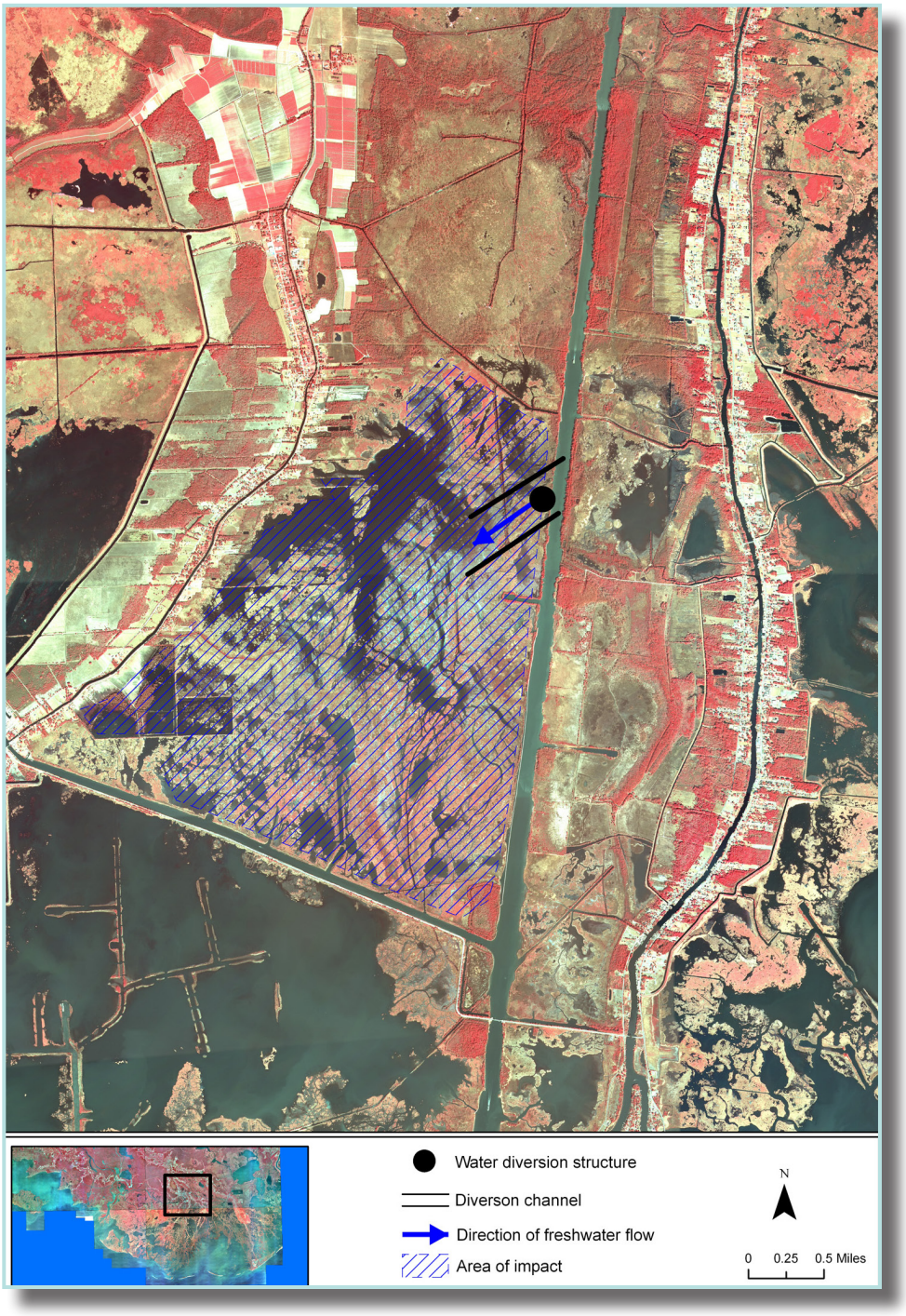
Design:
Less than 1 year

Implementation:
Less than 1 year

Project No. F67
Falgout Canal Freshwater Enhancement (Phase 1)

Project Description

Many factors, including subsidence and hydrologic isolation from land building resources, have led to rapid deterioration of marsh within the marshes located adjacent to Falgout Canal, between Bayou Dularge and the Houma Navigation Canal. This project will allow for re-establishment of Atchafalaya River influence and stimulate the re-growth of marshes in the system. Freshwater flow could potentially be optimized through the construction of new outfall structures.



Project Cost
$10,000,000

Potential Funding Source
CIAP Tier 1

Project Schedule
Planning:
Complete

Design:
Current

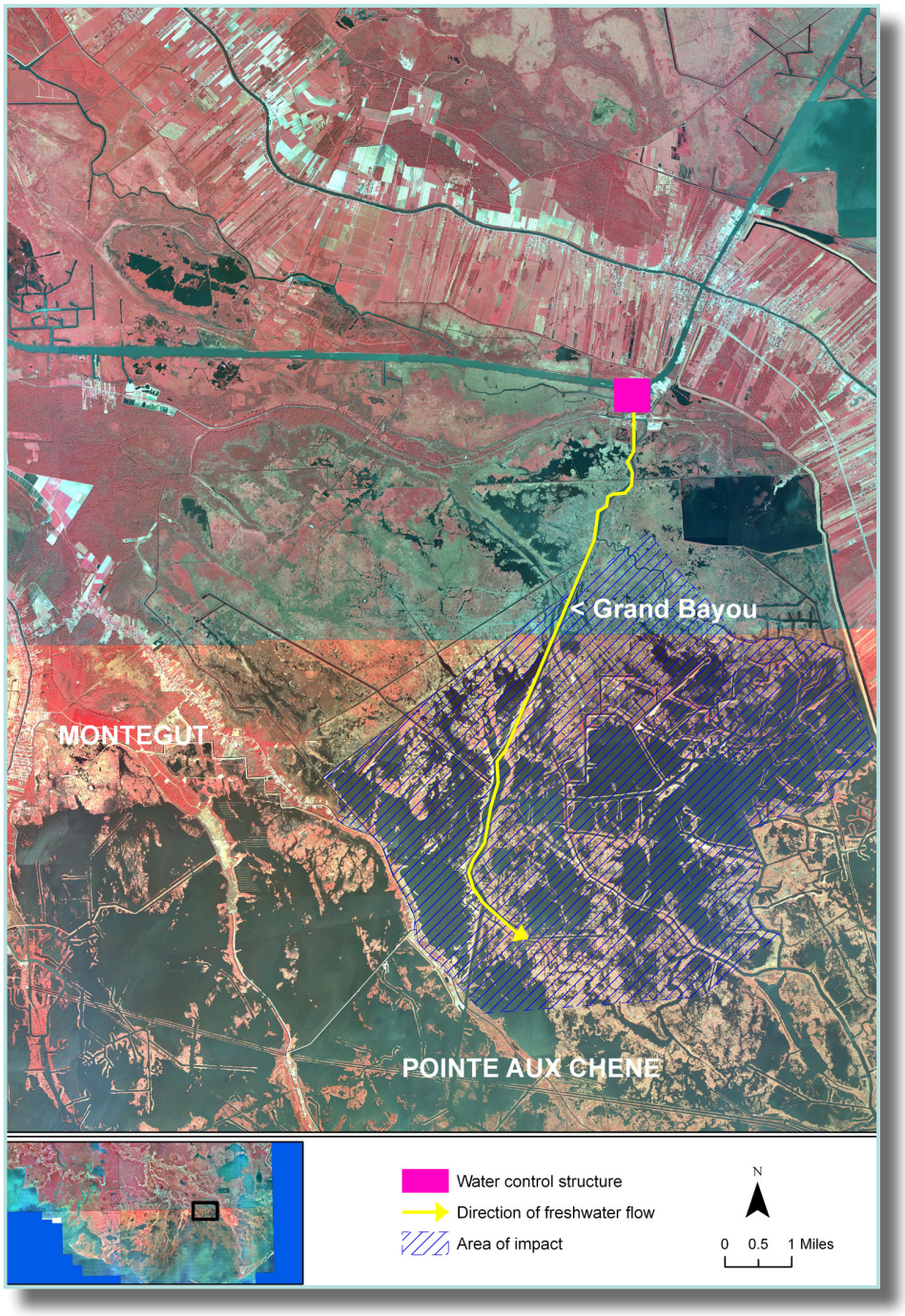
Implementation:
2-3 years

Project No. F85
Reconnect GIWW to Grand Bayou

Project Description

Dredging as needed of Grand Bayou will be added in order to increase the amount of water available and optimize flow to this region of Terrebonne Parish. Increased supply of freshwater and nutrients will assist in vegetation enhancement and accretion in an area of marsh that is rapidly deteriorating. Installation of a water control structure between the GIWW and Grand Bayou will be evaluated if the potential to increase flooding in residential areas is projected.

SYNERGIES: TO BE COMPLETED IN CONJUNCTION WITH PROJECT 62 AND 57



Project Cost
$5 - 20 million

Potential Funding Source
CWPPRA

Project Schedule
Planning:
1 year

Design:
1 year

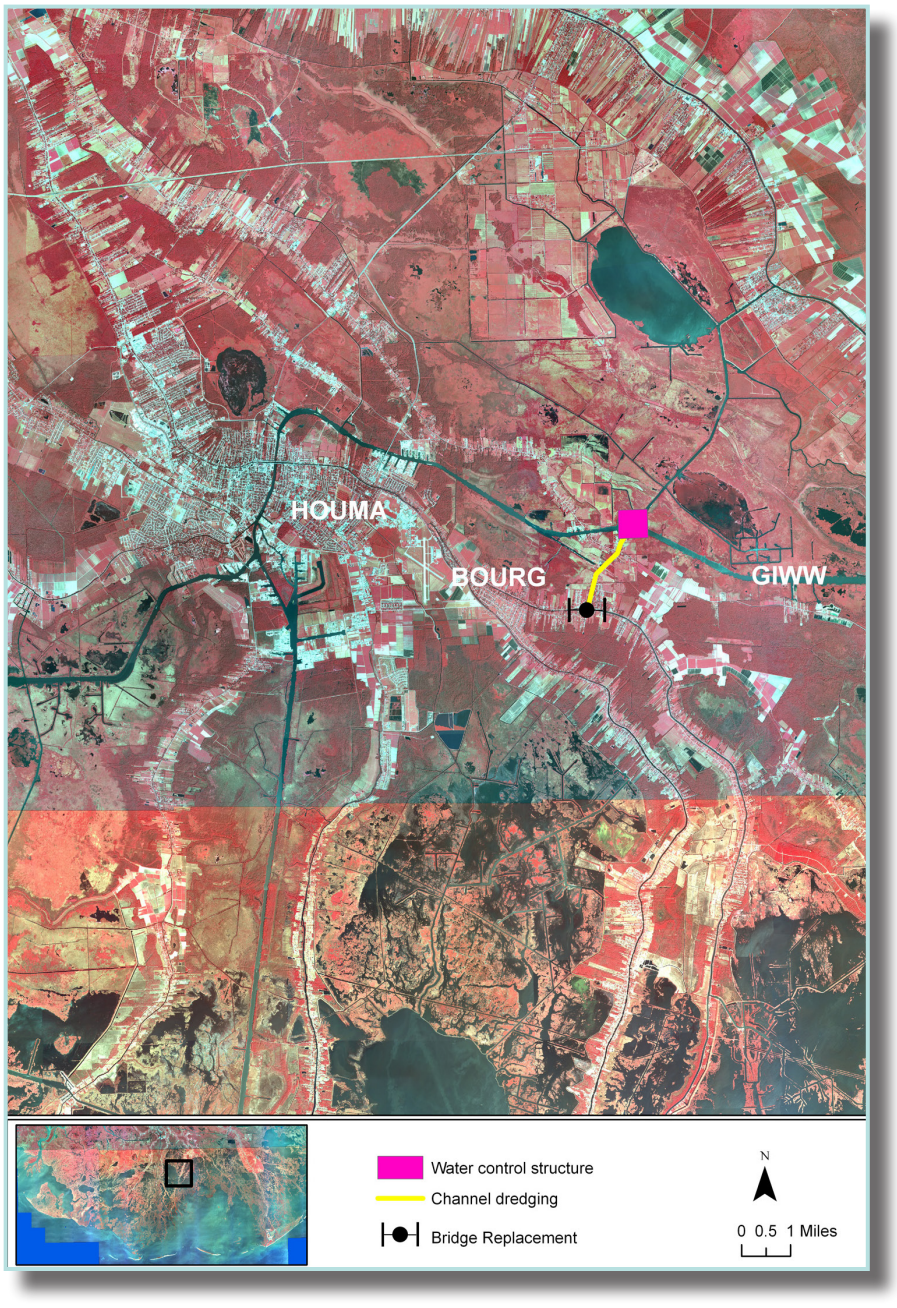
Implementation:
3-4 years

Project No. F62
Dredge Company Canal to Convey Freshwater to Terrebonne Marshes

Project Description

Dredging as needed of Grand Bayou will be added in order to increase the amount of water available and optimize flow to this region of Terrebonne Parish. Increased supply of freshwater and nutrients will assist in vegetation enhancement and accretion in an area of marsh that is rapidly deteriorating. Installation of a water control structure between the GIWW and Grand Bayou will be evaluated if the potential to increase flooding in residential areas is projected.

SYNERGIES: TO BE COMPLETED IN CONJUNCTION WITH PROJECT 57 AND 85.



Project Cost
$ 5-20 million

Potential Funding Source
CWPPRA

Project Schedule
Planning:
1 year

Design:
1 year

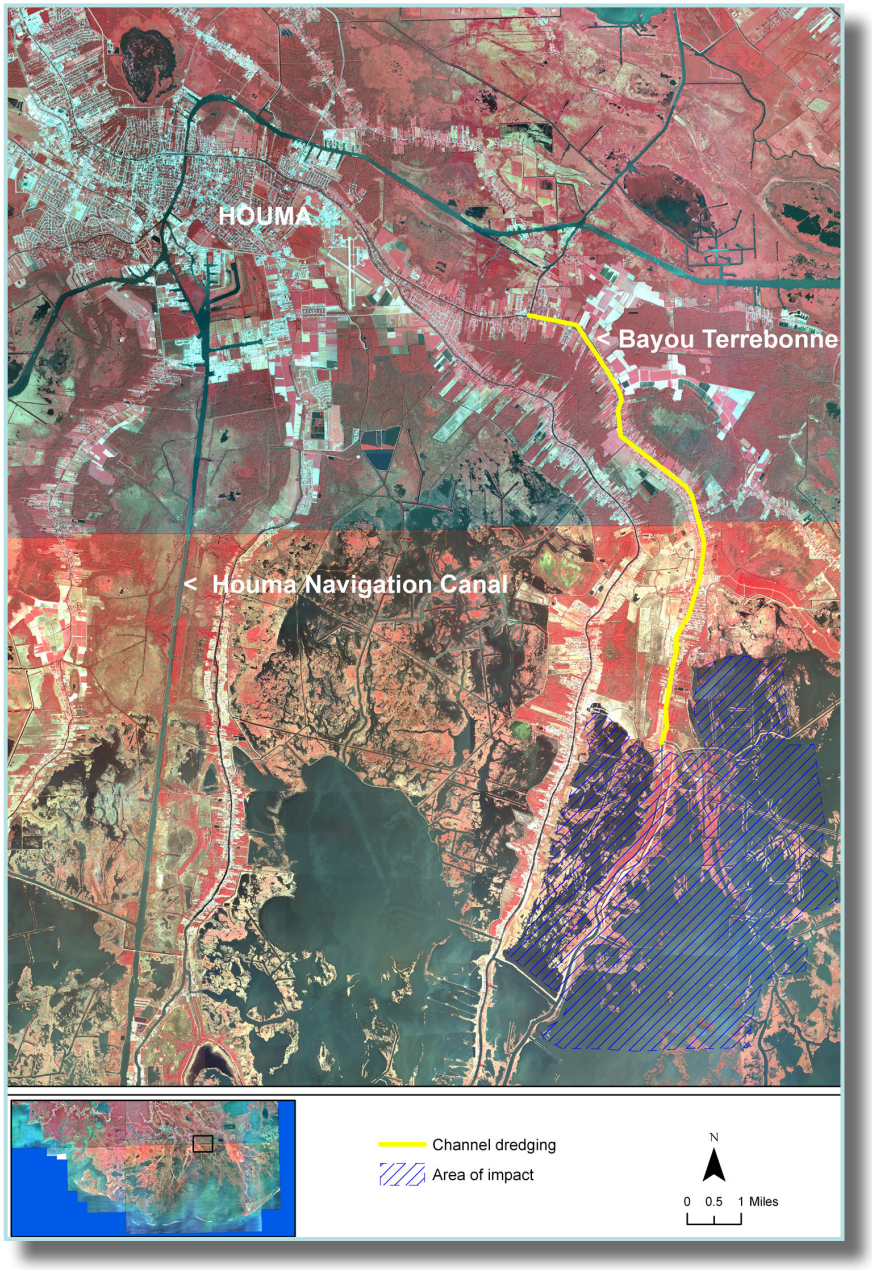
Implementation:
3-4 years

Project No. F57
Dredge Bayou Terrebonne from Company Canal to Humble Canal

Project Description

Dredging Bayou Terrebonne will result in an increase in the amount of freshwater available to eastern Terrebonne Parish marshes. The road bridge that crosses Company Canal/Bayou Terrebonne is due to be replaced by the LADOTD. Replacement of the bridge should account for an increased flow of water in the channel below that would result from this project. Environmental structures placed as part of the Morganza to the Gulf Hurricane Protection Project should minimize flooding and excess marine influence in these fragile areas.

SYNERGIES: TO BE COMPLETED IN CONJUNCTION WITH PROJECT 62 AND 85.



Project Cost
$5-20 million

Potential Funding Source
CWPPRA

Project Schedule
Planning:
1 year

Design:
1 year

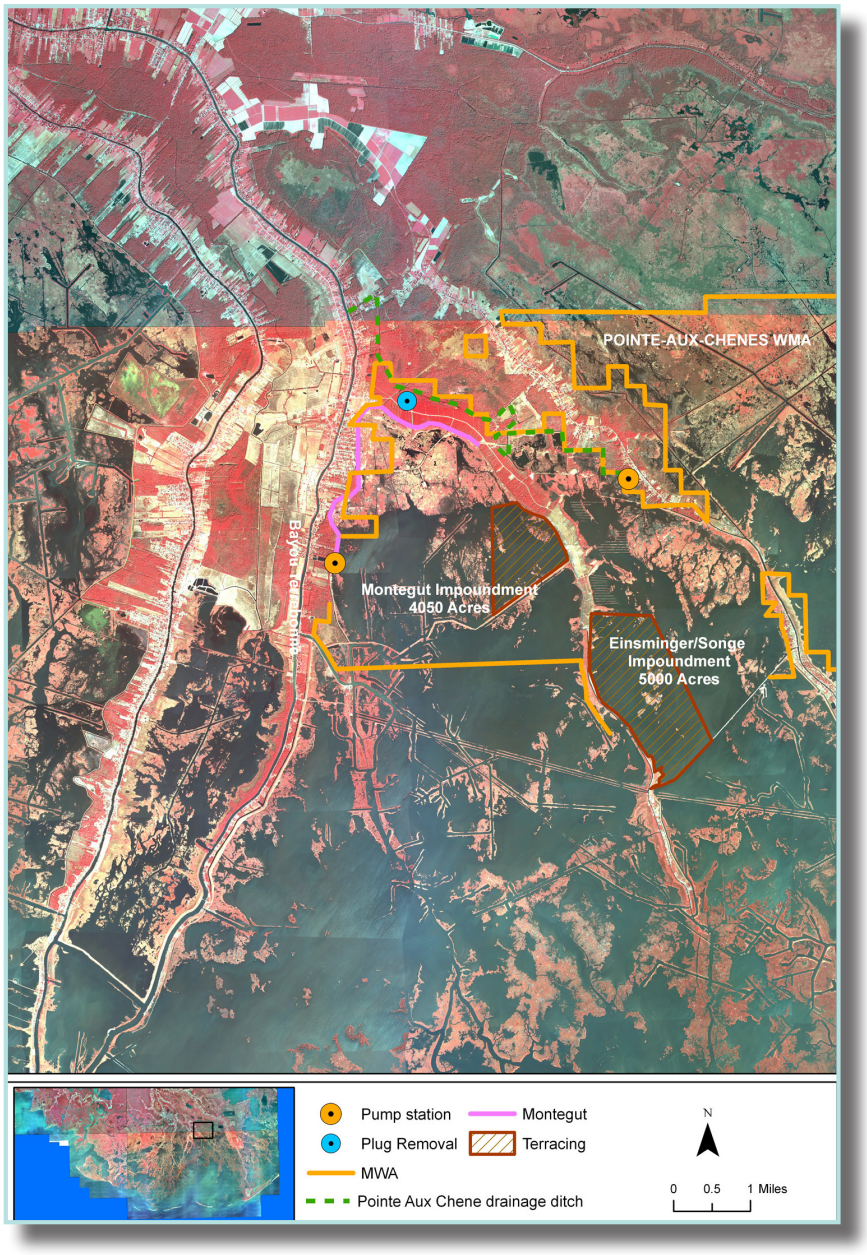
Implementation:
3-4 years

Project No. F79
Bayou Terrebonne Freshwater Diversion Project (PPL19)

Project Description

Through the use of an existing drainage ditch, removal of an earthen plug between the Montegut and Pointe-Aux-Chenes drainage systems, construction of 3 small pump stations, and construction of a screw gate water control device near the removed plug location, increased volumes of freshwater can be made available to the marshes of Montegut and Pointe-Aux-Chenes within the Wildlife Management Areas. Over 9,000 acres of brackish and intermediate marsh will benefit from this freshwater resource that is currently channeled to the lower estuary.

SYNERGIES: A synergy exists among Dredge Company Canal to Convey Freshwater Flow to Terrebonne Marshes (F62), Dredge Bayou Terrebonne from Company Canal to Humble Canal (F57), and Bayou Terrebonne Freshwater Diversion Project (F79). It is suggested that all 3 of these projects be planned and implemented together.



Project Cost
$2-5 million

Potential Funding Source
CWPPRA

Project Schedule
Planning:
1 year

Design:
1 year

Implementation:
2-3 years

Project No. F9
South Lake Decade Marsh Creation and Nourishment (PPL19)

Project Description

Sediment would be dredged from Lake Decade and placed in a semi-confined manner in strategic locations along the lake shoreline to create and nourish intertidal intermediate and fresh marsh. Approximately half of the created marsh would be planted with appropriate wetland vegetation. The borrow area in Lake Decade would be located and designed in a manner to avoid and minimize potential environmental impacts to the maximum extent practicable.

Project Cost
$21,000,000

Potential Funding Source
CWPPRA

Project Schedule
Planning:
1 year

Design:
1 year

Implementation:
2-3 years

Project No. F20
Rebuild the East Bank of Bayou Terrebonne

Project Description
Marsh creation on the east bank of Bayou Terrebonne from Madison Canal to Grand Bayou to improve the integrity of the channel to convey freshwater.

Project Cost
$5-20 million

Potential Funding Source
CWPPRA

Project Schedule
Planning:
1 year

Design:
1 year

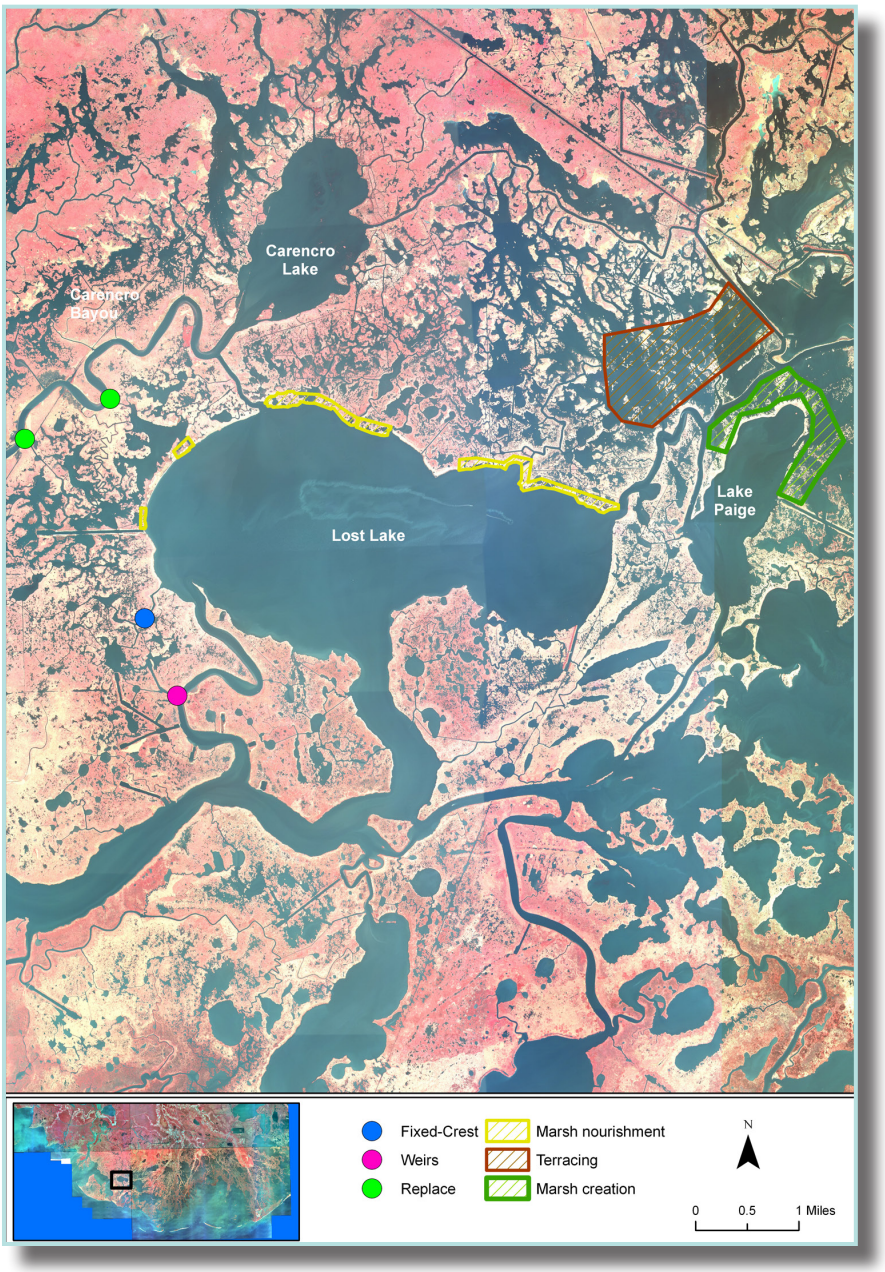
Implementation:
2-3 years

Project No. F31
Lost Lake Shoreline Protection and Hydrologic Restoration (PPL19)

Project Description

The proposed project consists of several features to protect the marsh, create marsh and extend the landbridge function of the North Lost Lake Mechant Landbridge Project to the west. Marshes north, east, and west of Lost Lake serve an important function as an intermediate zone buffering fresh marshes to the north from higher salinities to the south. Features include:

- 160 acres marsh nourishment along the northern and western shoreline of Lost Lake
- 30 acres terracing to reduce fetch in the north-east of Lost Lake
- 300 acres of marsh creation between Lake Paige and Bayou Decade
- Removal of weirs and installation of more open structures to increase the flow of freshwater and sediment delivery



Project Cost
$26,000,000

Potential Funding Source
CWPPRA

Project Schedule
Planning:
1 year

Design:
1 year

Implementation:
3-4 years

Project No. F63
Marsh Creation South-West of Four League Bay

Project Description
Use of material dredged from the Atchafalaya River to create marsh on Pointe Au Fer Island.

Project Cost
$5 -20 million

Potential Funding Source
CWPPRA

Project Schedule
Planning:
1 year

Design:
1 year

Implementation:
2-3 years

6 Program and Recommendations

The Parish recognizes that the restoration needs of the Terrebonne Basin far exceed the funding available to implement necessary projects. Indeed, Louisiana's master Plan for a Sustainable Coast depicts tens of billions of dollars worth of coastal restoration activities which the Parish fully supports. This first CPCR should therefore be viewed as the initial step in altering the restoration approaches in the Parish from a defensive to an offensive philosophy. The Plan effectively provides an inventory of all existing projects, which has highlighted that there are a lot of existing concepts for implementing coastal restoration in Terrebonne Parish. The outcome of this plan is a flexible list of projects that can be funded locally and implemented in the short-term.

The projects prioritized in Chapter 5 are a good start, but additional projects are certainly needed, and programmatic action is required to ensure that the Parish is ready to take full advantage of future opportunities. This chapter sets out specific recommendations that will allow the Parish to take a stronger leadership role in restoring the Parish's coastal ecosystem.

6.1 Update and Adapt the CPCR in the Future

As noted above, there are significant activities being undertaken by the State and USACE that will ultimately affect the restoration activities in the Parish. Even as the State and Terrebonne Parish Levee and Conservation District (TLCD) begin the construction of a first lift of the Morganza to the Gulf Hurricane Protection project and initiating work on the Houma Navigation Canal Lock Complex, the USACE is re-evaluating the project and may modify the projects final recommended features of these projects. This will affect the total acreage of impacted wetlands, the wetland mitigation plans, and location, size, and operational plans for environmental structures. For this reason, this initial CPCR has limited its recommendations to areas that will not likely be significantly affected by potential alterations of Morganza to the Gulf project features. It is imperative, however, that the Parish work with the State, TLCD, and the USACE to ensure that the objectives of this CPCR are fully considered in any project reevaluation and redesign. For example, construction of the levee will need to allow for the inclusion of outfalls and pump stations to ensure that the estuarine circulation in major water bodies, such as Lake Boudreaux, is sustained. Once a final decision is reached on the project features, this CPCR should be modified to incorporate those features and to make any necessary changes to other projects that are recommended herein.

In addition, the LCA program makes recommendations to advance restoration activities on at least six projects to be implemented, at least in part, in the Parish:

- Convey Atchafalaya River water to northern Terrebonne marshes
- Multi-purpose operation of the Houma Navigation Canal Lock
- Terrebonne Basin barrier shoreline restoration
- Maintain landbridge between Caillou Lake and the Gulf of Mexico
- Stabilize Gulf shoreline at Pointe Au Fer Island
- Beneficial use of dredged material program

Most of these projects are expected to be fully evaluated and recommendations for implementation to be made, prior to December 2010. The Parish should work closely with the State and USACE to ensure that the recommendations are fully consistent with the

CPCR. As LCA recommendations are made, the CPCR should be evaluated to ensure that the recommendations made herein remain viable. A full revision to the CPCR, however, should not occur until the reevaluation of Morganza to the Gulf is complete, or five years from initial adoption of the CPCR, whichever comes first.

6.2 Establish Additional Capacity to Implement Restoration Projects

As noted previously, the Parish plays an important role in all restoration activities in the Parish, helping to shape activities undertaken by federal and state resource agencies. Programs such as CWPPRA and LCA are now, and will remain, critical programs to restore the Parish's diminishing wetlands. The funding decisions associated with these programs are made, however, by entities other than the Parish. It is evident that federal and state decision-makers are respectful of the inputs and views of the Parish, but also that these decision-makers have a broader set of objectives that must be met. This may mean that Parish priorities are not fully met as funding decisions are made. For this reason, the Parish must be prepared to implement certain restoration activities with funds under their own control.

Any new funding sources for coastal restoration should be dedicated specifically to implementation of the CPCR or future updates of this plan.

Gulf of Mexico Energy Security Act funds will eventually be made available to the Parish, enabling more significant independent restoration activities, but other sources may be required as well to bridge the gap between current needs and future funds availability. Any new funding sources for coastal restoration should be dedicated specifically to implementation of the CPCR or future updates of this plan.

In addition to identifying additional funding sources that the Parish can utilize more independently, other steps could be taken to increase the pace of restoration activity in the Parish. Among them is the potential for the Parish to invest in dredging equipment that can be used to restore critical landscape features in a timelier manner than has been possible in the past. This investment can be made either by purchasing a small dredge or establishing incentives for private industry that will ensure the availability of equipment capable of working in shallow coastal waters and discharging material into fragile wetland environments. Future drainage and sanitary system improvements should maximize the beneficial influence of discharged materials to wetlands.

6.3 Fully Implement Non-Structural Flood Protection Strategies

Although recommendations for flood risk reduction were outside the scope of the CPCR, it is clear that flood risk reduction efforts and coastal restoration efforts are related and should be undertaken in a synergistic manner. The Parish should therefore maximize its participation in non-structural flood protection programs and other hazard mitigation grants programs to reduce flood risk in the parish and to facilitate restoration efforts. As the Coastal Protection and Restoration Authority more fully develops its programs for non-structural flood risk management, the Parish should seek every opportunity to participate in these programs and provide opportunities for pilot project implementation. Establishing the Parish as a leader in non-structural flood risk management integrated with coastal restoration will facilitate implementation of levee projects and achievement of sustainable communities.

6.4 Advocate for Critical Scientific and Technological Advancements

Even with the implementation of critical restoration projects in the Parish over the last 20 years, a significant range of scientific and technical uncertainties remain. The Parish must recognize these uncertainties and actively promote resolution in order to advance critical restoration activities in a timelier manner. Technological advancements in barrier island and flotant marsh restoration and preservation techniques are both needed.

Several concepts have been proposed in recent years that may reduce the overall cost of introducing sand to the barrier island system and promote re-establishment of barrier islands in open water areas. The Coastal Bay Sediment Trapping Project proposed on PPL-18 and the Benefits of Limited Design/Unconfined Beach Fill for Restoration of Louisiana Barrier Islands Demonstration Project approved on PPL-18 may be evaluated in a more timely manner with laboratory experiments on scaled physical models than with full-scale field testing. Creating an "existing conditions" physical model of all or portions of the Parish's barrier island systems will enable the testing of these and other concepts using well-tested methodology prior to developing field scale projects. Compressing the time required for validating these concepts can speed implementation of full-scale projects and give decision-makers confidence in innovative technology before spending large amounts of funding for demonstration projects.

Flotant marshes in northern Terrebonne Parish are among the more unique and fragile ecosystems in the coastal zone. Their value for wildlife habitat is unquestioned; their sustainability in the face of relative sea level rise and increasing Atchafalaya River influence, however, is less certain. As forces acting on these marshes increase over the coming decades, it is imperative that a better understanding of how to restore lost marsh or prevent the loss of existing flotant marsh is developed. Two CWPPRA projects, Floating March Creation Demonstration (LA-05) and Thin Mat Floating March Enhancement Demonstration (TE-36) are ongoing. If it is shown that restoring flotant marsh is not technically feasible, adaptation and recovery plans can be developed for implementation should large expanses of flotant marsh be lost in the future (due to effects of hurricanes or increased river/tidal influence).

6.5 Develop Mechanisms to Facilitate Future Regional Planning

Terrebonne Parish has an excellent working relationship with its neighboring coastal parishes and the State of Louisiana when it comes to coordinating and implementing restoration projects. It is recognized, however, that coordination can be improved, especially as it relates to prioritizing state funding for protection, restoration, and economic development activities. The State has proposed the establishment of three "Regional Planning Teams" in its Draft Fiscal year 2010 Annual Plan for Hurricane Protection and Ecosystem Restoration. The purpose of these teams is to "review proposed planning and project details" and "report back on the plan's progress to their communities and bring any concerns to the OCPR". This activity builds upon the successful inclusion of the Interdisciplinary Technical Team into the Master Plan process. Terrebonne Parish should actively participate on its Regional Planning Team in order to convey vital details to the State as it develops its own sense of sequencing and priority of Master Plan projects. Fully participating and developing a two-way dialogue and full partnership will ensure the Parish's objectives are met.

Additionally, planning tools are needed to fully understand and guide future coastal activities, including coastal restoration, hurricane protection, and economic development. The most basic need is a basin-scale hydrodynamic model which is capable of integrating the effects of restoration and protection projects, changes in regional hydrology due to climate change, and changes to navigation projects, such as deepening the HNC. Only if the effects of these projects are analyzed together within a common model will it be possible to plan for the sustainable future of the Parish. The potential for synergies and conflicts of these activities must be acknowledged and analyzed early in the process in a manner that reduces the overall time to implement them.

Only if the effects of these projects are analyzed together within a common model will it be possible to plan for the sustainable future of the Parish.

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